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# SOUTH COAST SNAPSHOT

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A situation statement on the current state and trend of natural resource condition in the Western Australian South Coast Natural Resource Management region. June 2016.

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The South Coast Natural Resource Management region has a rich biodiversity,  
much of which is recognised as being internationally significant.

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A specialist sub committee provided useful advice on indicator development and review of the final report:

Klaus Braun and Nathan McQuoid (Biodiversity Reference Group), Julia Fry (Community Involvement and Change Reference Group), Paul Close (Water, Coastal & Marine Reference Group), Tim Overheu (Land Reference Group), Paul Beattie and Lester Coyne (Aboriginal Reference Group).

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# FOREWORD

Welcome to the 'South Coast Snapshot'. I commend South Coast Natural Resource Management on initiating this project through the Australian National Landcare Programme, and all who have assisted by providing data that contributed to this report.

As a landowner, farmer and an active community member in several natural resource managements groups along the South Coast of Western Australia, it is very useful to have a snapshot of information providing evidence of the state of the environment in our region at this time, as well as for our regional capacity. It allows all to see what environmental changes have occurred over the past few years, to make decisions accordingly and will allow comparisons to be made in the future.

The regional strategy for natural resource management, Southern Prospects 2011-2016, has been used to guide investment in natural resource management to care for the natural assets of this region. It is now very timely, and provides good governance, to have this report as a baseline on the current state and trend of natural resource condition across this region.

This report provides the user with relevant, credible and valuable information of natural assets which will assist in understanding the present state of the environment, identifying gaps in knowledge and assisting to determine priorities for efficient use of limited funding.

I am sure this report will be well received and I encourage decision makers, planners and the community to use this document to prioritise and develop projects. This document will greatly benefit South Coast NRM and the stakeholders who are continuing to care for the natural assets of our region when funds and resources are limited.

Rhonda Williams  
South Coast farmer and 2015 WA Individual Landcarer Award Recipient  
Australian Government Individual Landcarer Award 2016  
June 2016





A unique moment - Napoleon Skinks on flowering Banksia solandri, Bluff Knoll, Stirling Range

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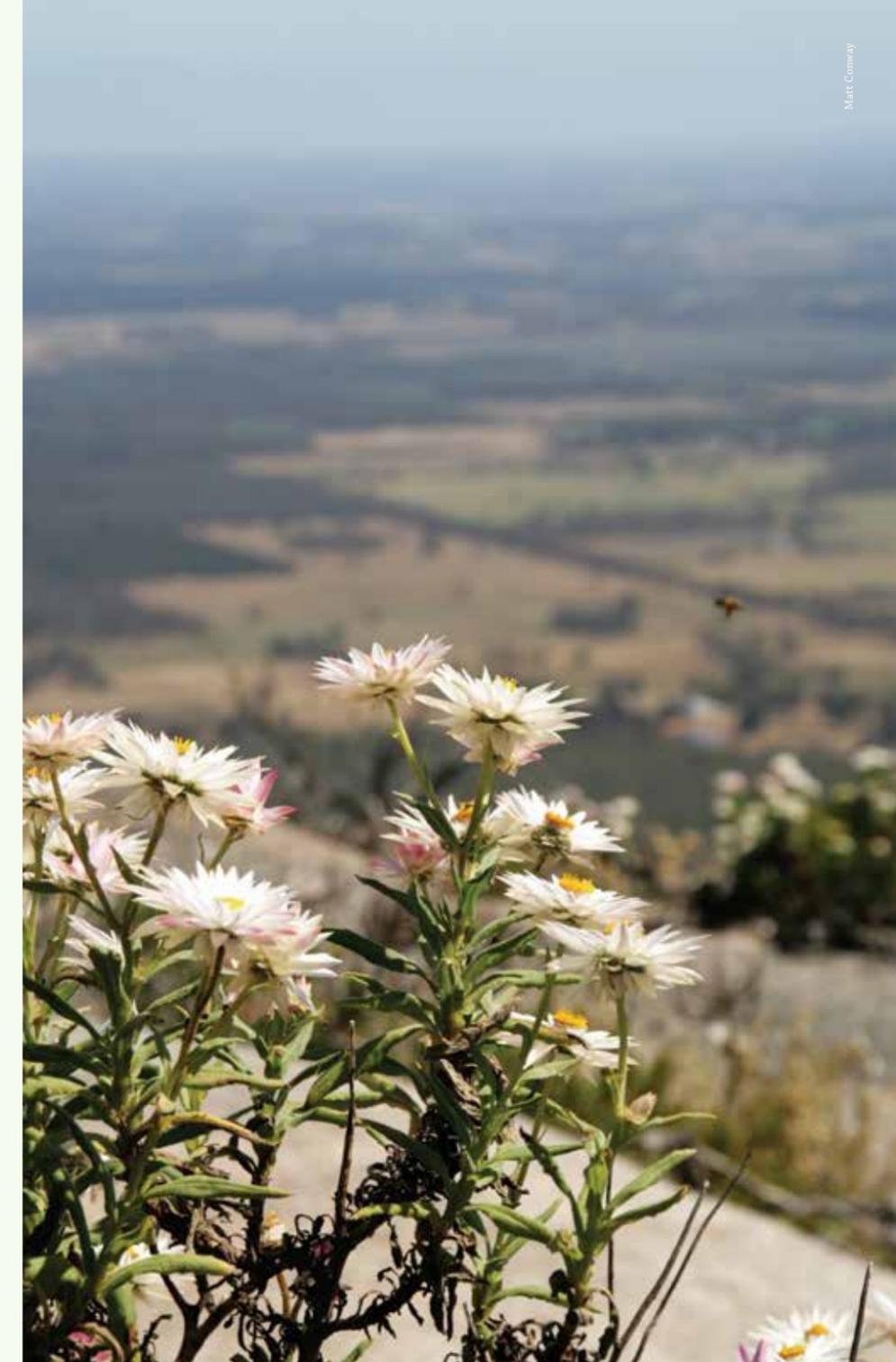
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Dusk on Toolbrunup Peak, Stirling Range

# 1 BACKGROUND

## 1.1 AIM/PURPOSE

The purpose of this report was to capture and present available information on the condition and trend of key natural assets of the South Coast Natural Resource Management (South Coast NRM) region of Western Australia. This is portrayed by a variety of indicators provided by specialists within the fields of their expertise.

Initially the analysis was to be represented in a 'report card' format, which typically communicates asset condition at a given point in time using a grading scale (for example 'traffic light' system). As the project progressed, it became apparent that a report card layout that could be applied across the whole of the region was not the most suitable method of expressing the data. This was primarily because of limitations outlined in section 2.4 (page 15), and, in particular, because of the great

diversities of climate, geology, habitat and land use that occur across the region.

Instead, information regarding the current state and trend of the region's assets is described and illustrated through mapping.

It is intended that the report:

- provides relevant, credible and useful information of natural assets that can be quickly comprehended
- creates awareness and promotes discussion, through a greater understanding of our environment
- identifies gaps in knowledge, and
- is used to inform priorities for efficient use of limited funding.

Ideally, further, enhanced reviews of the state of these and/or other refined indicators will be undertaken every five years as funding permits.



Goode Beach, Albany



## 2 METHODOLOGY AND APPROACH

### 2.1 CONSULTATION - INDICATORS

The organisational structure for the delivery of this report comprised a project team and a sub-committee. The South Coast NRM project team was made up of the monitoring and evaluation coordinator, land program leader, community & cultural program leader and the project officer. The sub-committee was made up of subject matter specialists from each of the reference groups (Land, Biodiversity, Coastal & Marine and Water, Aboriginal and Regional Capacity) and their respective program leaders.

The regional strategy *Southern Prospects 2011-2016* identified indicators for each asset theme, together with corresponding measure recommendations. Theme based reference groups considered those identified indicators for their suitability, relevance and data availability in a reporting context. As the project progressed, a framework of potential indicators for each theme for which data was likely to be available was developed (Table 1).

Collectively the information gathered was presented to the sub-committee to decide the most appropriate indicator/s to use. There were some indicators which could not be used in a regional context but the sub-committee advised were too important to exclude, and these have been included as case studies.

### 2.2 TARGETED CONSULTATION – SPECIALISTS

Using the Framework developed in 2.1, specialists in the field of study were contacted to obtain advice and associated project data that could be used to illustrate status and

trend of the asset. Further information, including full methodologies for project derived data, can be found through a review of the relevant project reports as referenced.

### 2.3 GEOGRAPHIC INFORMATION SYSTEMS (GIS) METHODOLOGY

Data provided by specialists and agencies or located through online sources was analysed with ArcGIS™ 10.1 software to produce maps to illustrate presented data, including condition and trend where possible. In general, existing datasets were used in unaltered form, however, in some instances manipulation of data was required to create spatial data for presentation. Methodology details are provided within the indicator overview.

Maps have been produced for data where appropriate, to visually enhance understanding and the ability to see patterns of distribution and change. In some instances available data was limited to particular areas, or provided at coarse scales.

### 2.4 LIMITATIONS

Within the resources available, the project relied on collation of existing data, publications and specialist opinion. In some instances the data was not current, however, most recent data made available has been utilised.

Applying datasets from unrelated individual projects for the purpose of illustrating an indicator was not always easy or appropriate. Data collected for other specific project aims was often not readily transferable for other purposes. Also, individual projects implemented across the region utilised different methodologies which were not comparable.

The South Coast region is very diverse in terms of climate, geology, habitat and land use. This variety restricted the ability to apply the existing data to inform the process across all sub regions.

## 2.5 READING THIS REPORT

This report identifies and discusses several indicators of our current knowledge of the status and trend, where known, of the natural resources and community assets of the South Coast region of Western Australia (the region). In some instances the data is baseline, and it is envisaged that future reports may use this data for comparison.

The diversity of themes and the regional environment through which they function are influenced by complex interactions of processes, each affected by factors including climate, land characteristics, land uses and management. The processes within the themes are often interconnected and each should not be viewed in isolation. The reader is reminded to take a holistic and integrated approach to viewing the information.

Table 1: Indicator Framework by Theme

ASSET	INDICATOR	SOURCE	DATA SET
Region	<ul style="list-style-type: none"> <li>Rainfall</li> <li>Temperature</li> </ul>	Commonwealth Scientific and Industrial Research Organisation (CSIRO) Department of Water	Climate Change in Australia reports Streamflow trends in south west Western Australia Surface Water Hydrology Series
Regional Natural Resource Management capacity	<ul style="list-style-type: none"> <li>Population growth</li> <li>Community groups involved in natural resource management membership</li> <li>Education, training and awareness in natural resource management</li> <li>Regional body revenue</li> </ul>	South Coast Natural Resource Management	Climate Adaptation Addendum to Southern Prospects 2011-2016 (Duxbury, L. and Hodgson, N. 2014) South Coast NRM Inc., November 2013, 'NRM Community Group Survey 2013'. South Coast NRM Inc. South Coast NRM Inc., June 2015, 'Education and Training Framework Report'. South Coast NRM Inc. South Coast NRM Inc., Annual Reports
Soil	<ul style="list-style-type: none"> <li>Soil organic carbon</li> <li>Water repellence</li> <li>Wind erosion</li> <li>Salinity risk</li> <li>Groundwater</li> </ul>	Department of Agriculture and Food, Western Australia	Report Card on Sustainable Agriculture
Specific native species and ecological communities	<ul style="list-style-type: none"> <li>Native vegetation extent</li> <li>Fire frequency</li> </ul>	Department of Parks and Wildlife and Department of Agriculture and Food, Western Australia Sandiford and Barrett, 2010 Neville, S., 2014	Native vegetation extent shapefile (Department of Parks and Wildlife cleaned, based on Department of Agriculture and Food, Western Australia) Albany Regional Vegetation survey Fire Frequency Map Product based on Parks and Wildlife Fire History Mapping)

ASSET	INDICATOR	SOURCE	DATA SET
Specific native species and ecological communities (cont.)	<ul style="list-style-type: none"> <li>Phytophthora Dieback distribution</li> </ul> CASE STUDIES <ul style="list-style-type: none"> <li>Status of threatened flora</li> <li>Critical weight range fauna</li> <li>Bird diversity – response to revegetation</li> </ul>	Department of Parks and Wildlife - Vegetation Health Service Department of Parks and Wildlife Department of Parks and Wildlife Bush Heritage Australia	Positive <i>Phytophthora cinnamomi</i> dataset Department of Parks & Wildlife records and expert opinion Department of Parks & Wildlife records and expert opinion Environmental Outcomes Monitoring – Bird diversity in revegetation at Monjebup North
Aquatic ecosystems: rivers, wetlands	<ul style="list-style-type: none"> <li>Catchment, rivers and wetland condition</li> </ul>	Department of Water Centre of Excellence in Natural Resource Management.	Framework for Assessment of River and Wetland health Ecological values of waterways in the South Coast Region
Estuarine habitat	<ul style="list-style-type: none"> <li>Estuary condition</li> </ul>	Department of Environment and Conservation, South Coast Natural Resource Management & South West Catchments Council Australian Geological Survey Organisation	South Coast Marine GIS Information and Resource Compilation Project (2007-2009) Australian Estuaries and Coastal Waterways: A geoscience perspective for improved and integrated resource management
Water resources	<ul style="list-style-type: none"> <li>Total volume annual streamflow</li> <li>Water resource allocation</li> <li>Water quality</li> </ul>	Department of Water	Streamflow trends in south west Western Australia Surface Water Hydrology Series Water resources inventory 2014
Coastal and Marine	<ul style="list-style-type: none"> <li>Coastal vegetation extent</li> <li>Diversity of benthic habitat</li> <li>Sea level, sea surface temperature and acidification</li> <li>Seabirds</li> </ul>	Department of Parks and Wildlife and Department of Agriculture and Food, Western Australia Radford et al., 2008 CSIRO/ Bureau of Meteorology Lavers, 2014	Derived from Native vegetation extent 2015 Securing WA's Marine Futures (2006 – 2008) <i>Climate Change in Australia</i> reports Population status and threats to Flesh-footed Shearwaters ( <i>Puffinus carneipes</i> ) in South and Western Australia
Aboriginal cultural places of significance	<ul style="list-style-type: none"> <li>DAA registered sites</li> <li>Management plans</li> <li>Cultural heritage surveys</li> </ul>	Department of Aboriginal Affairs South Coast Natural Resource Management Inc.	Department of Aboriginal Affairs Registered sites Register database 2010 South Coast NRM Region Cultural Heritage Land and Sea Management Plan



A range of land uses: Stirling Range National Park and canola crop

### 3 REGIONAL CHARACTERISTICS

The South Coast NRM region of Western Australia (Figure 1) extends over more than 8.6 million hectares. It includes the catchments of all southerly-flowing rivers from Walpole in the west to beyond Cape Arid in the east, as well as some internally drained areas north east of Albany and north of Esperance. The region also extends seaward to three nautical miles, including approximately 8,000 ha of islands and one million hectares of State waters. Because of numerous islands, State waters can extend up to 70km off shore, especially to the east of Esperance.

Noongar Aboriginal people were the first humans to occupy the South Coast region. Their lands extended to the west of a line drawn from Jurien Bay on the west coast to Esperance on the south coast (Bates, 1966 as cited in South Coast NRM, 2011).

*The South Coast NRM region is internationally recognised as being part of one of the world's 34 biodiversity 'hot-spots'. It includes... more than 20% of the State's floristic diversity, and numerous unique and threatened flora and fauna species.*

Agricultural landscapes now make up around 70% of the region, and there is a strong economic reliance within the regional community on agricultural production, farm forestry and related service industries. The primary business and service areas are Albany and Esperance, with many businesses established to service the needs of the timber, agricultural, mining and fishing industries. Tourism is also a significant industry in the region.

The South Coast region is renowned for its spectacular landscapes, including tall forest areas in the west, the southern coastline and many offshore islands, all of the south western mountain peaks, and many inlets, estuaries, waterways and wetlands.

It has extremely high levels of biodiversity, with more than 20% of the State's floristic diversity, and numerous unique and threatened flora and fauna species. The region is internationally recognised as being part of one of the world's 34 biodiversity 'hotspots'. Some of the most significant areas are contained in the network of conservation reserves including iconic areas such as the Fitzgerald River and Stirling Range National

Parks and the Two Peoples Bay Nature Reserve.

Figure 1 illustrates the South Coast region and sub-regions, with a base layer of native vegetation. This figure forms the basis of maps in the report, although sub-regions are denoted by label only in subsequent figures for clarity of presented data. Where no data is available for a sub-region, only the base native vegetation layer will be present.

The geographical, biological and land use characteristics of sub-regions vary considerably across the region, creating a diverse landscape. These are more fully described in South Coast NRM, 2011.

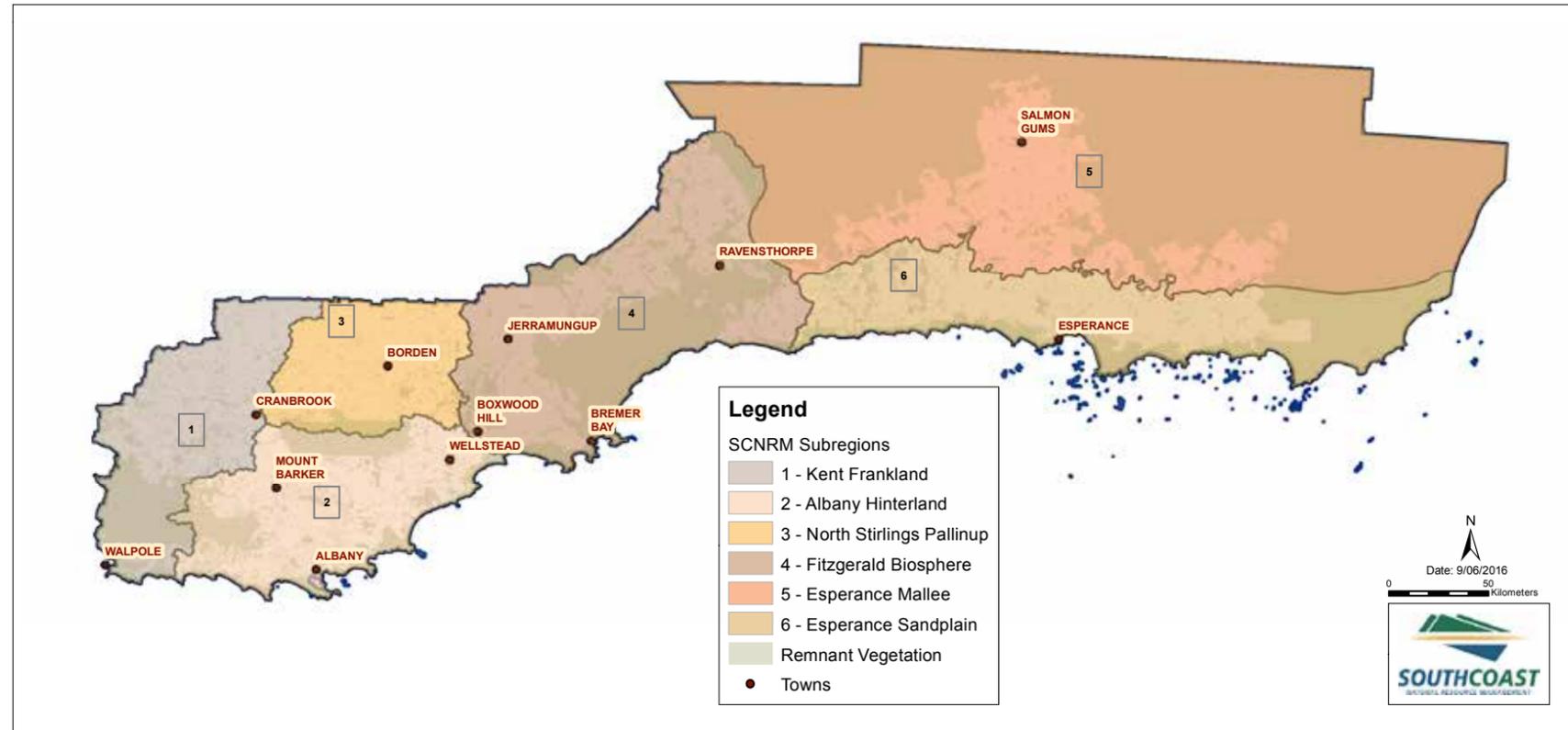


Figure 1: South Coast NRM region with sub-regional areas



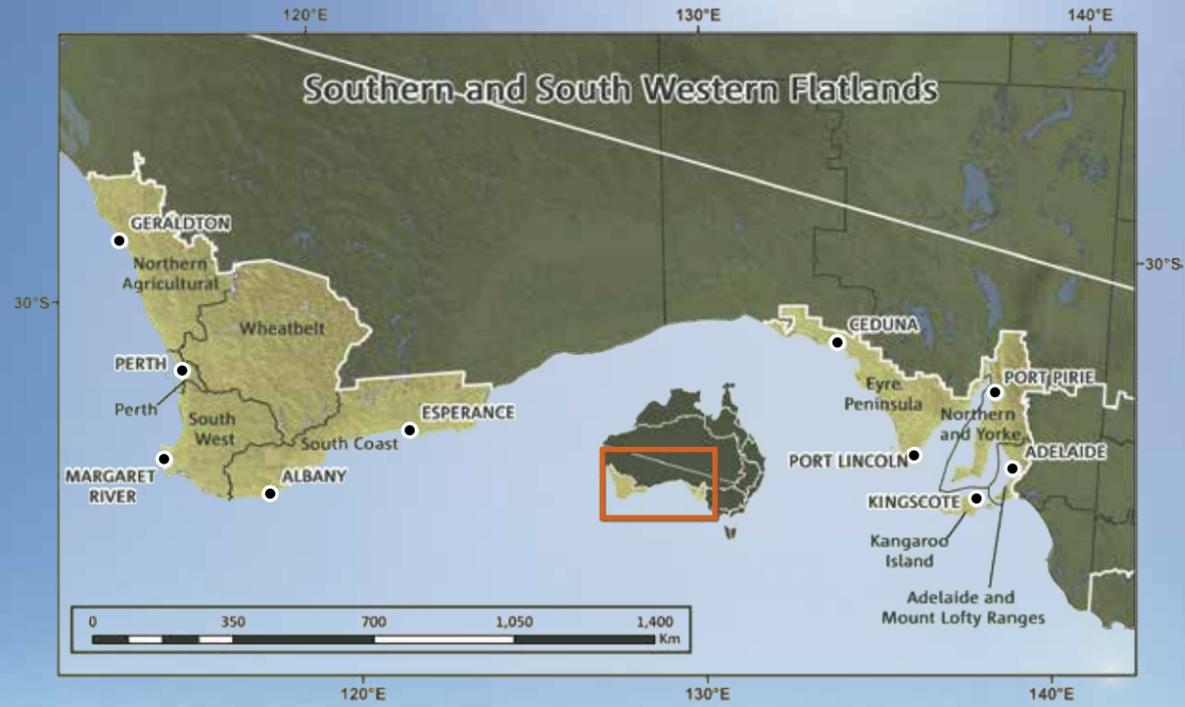


Figure 2: The Southern and South-western Flatlands (SSWF) NRM cluster and main localities. The sub-clusters west (SSFW) and east (SSWE) are separated by coastline of the Great Australian Bight (from Hope et al 2015)



View from Porongurup Range

## 4 NATURAL RESOURCE ASSET INDICATORS – RESULTS AND DISCUSSION

### 4.1 REGIONAL CLIMATE

Two indicators were selected by the sub-committee to describe changes in regional climate.

- Rainfall
- Temperature

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM) have prepared region specific *Climate Change in Australia* reports which detail current and projected climatic data for NRM regions across Australia. The South Coast NRM region is included in the Southern and South-western Flatlands (SSWF) cluster, which has a predominantly Mediterranean climate. Hope et al (2015) describe the methodologies and rigorous analyses involved in assessing data relating to current and projected climate trends.

*Average winter rainfall in southwest Western Australia has declined by 17% since 1970.*



#### 4.1.1 RAINFALL

Average winter rainfall in southwest Western Australia has declined by 17% since 1970, with a significant reduction in 1975. Since that time the decline has continued, although without uniform trends (CSIRO and BOM, 2014, DOW, 2009). From the 1990s to the present, the region has experienced extensive drying particularly in autumn and early winter (Hope et al, 2015). Declines in rainfall are projected with high confidence to drive drought events that become increasingly pronounced by the end of the century.

Hope et al (2015) predict with high confidence further decreases in winter and spring (and annual) rainfall. Physical mechanisms driving the change include the southward shift of winter storm systems and greater prevalence of high pressure systems. It is less clear how rainfall patterns will alter in autumn and summer. Year to year variability in the intensity and position of the sub-tropical ridge can influence the amount of rainfall that falls over the SSWF cluster.

*Declines in rainfall are projected with high confidence to drive drought events that become increasingly marked by the end of the century.*

Models of projected change suggest with medium confidence that the intensity of heavy rainfall events will increase. This is despite the overall reduction in mean rainfall projected. There is less confidence, however, of understanding the magnitude of change in comparison to natural variability (Hope et al, 2015).

For example, analysis of rainfall data in the Esperance region indicates changing rainfall patterns across the region including a 5-10% increase in annual rainfall over the last three decades. Further, in 1999, 2000 and 2007 the Esperance region experienced unseasonal episodic rainfall events of the intensity not usually expected more than once in 50 to 100 years (DEC, 2009).

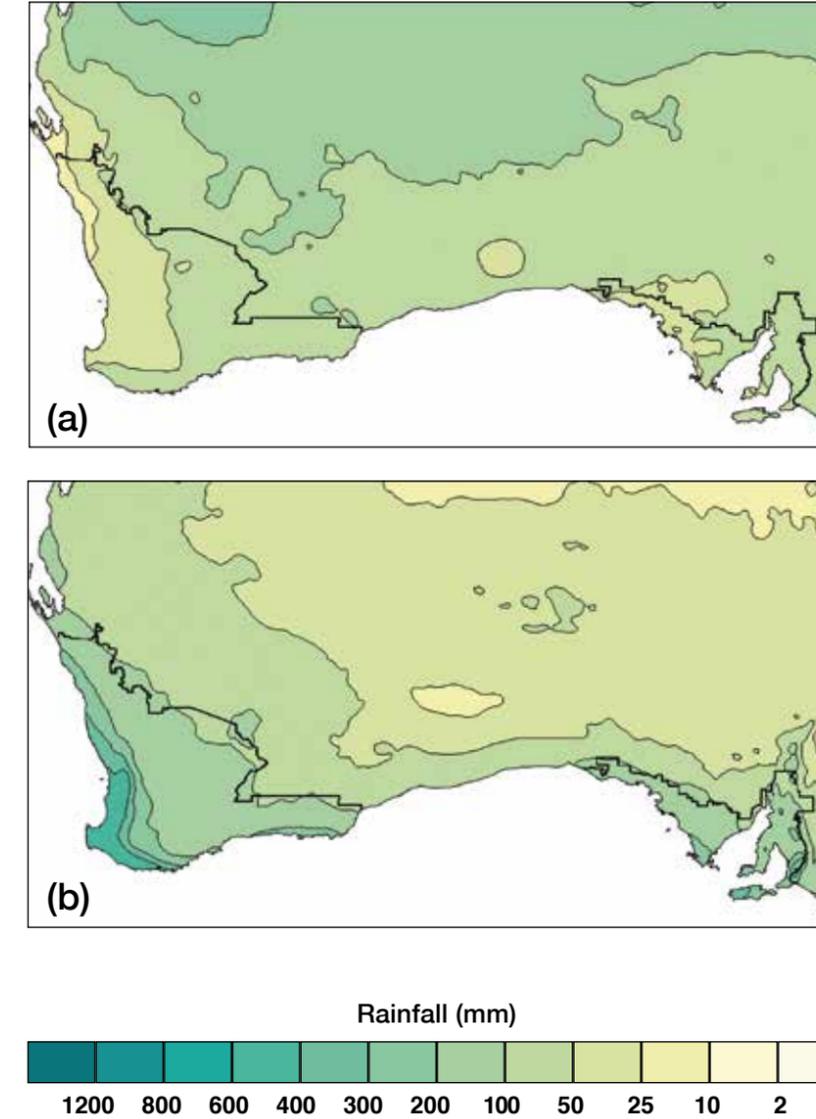


Figure 3: For the 1986-2005 period, average rainfall for (a) summer (Dec to Feb) and (b) winter (June to Aug) (from Hope et al 2015)

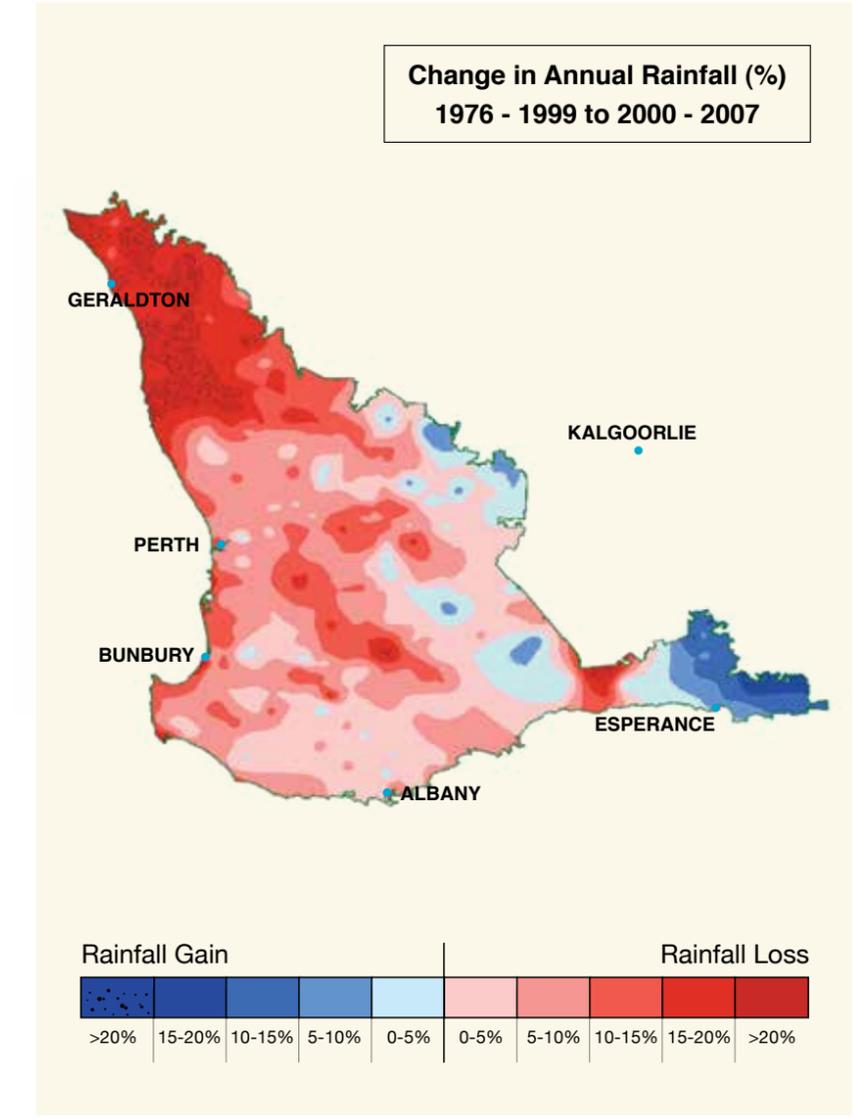


Figure 4: Change in Annual rainfall (from George et al 2008, cited in Dec, 2009)

## 4.1.2 TEMPERATURE

Surface air temperatures have increased markedly in our region's cluster, particularly in the decades since 1960. Mean surface air temperatures in the western SSWF cluster have increased by 1.1°C with a linear trend. Mean, maximum and minimum temperatures are forecast, with very high confidence, to continue to increase, with substantial increases in the maximums of the hottest days. Similarly, the frequency and duration of hot days is forecast, with very high confidence, to increase. Correspondingly, the frequency of frost days is predicted, with high confidence, to decrease.

*Mean, maximum and minimum temperatures are forecast, with very high confidence, to continue to increase.*

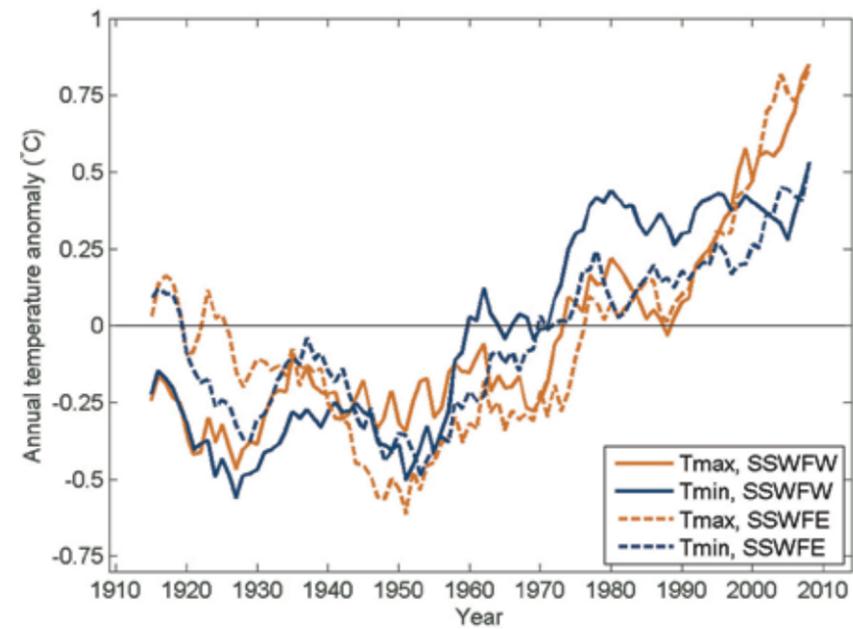


Figure 5: Observed annual mean of daily maximum (orange line) and minimum (blue line) temperature (°C, 11-year running mean), presented as anomalies relative to their respective 1910–2013 mean value (acorn-sat); SSWFW is in solid lines (from Hope et al, 2015)

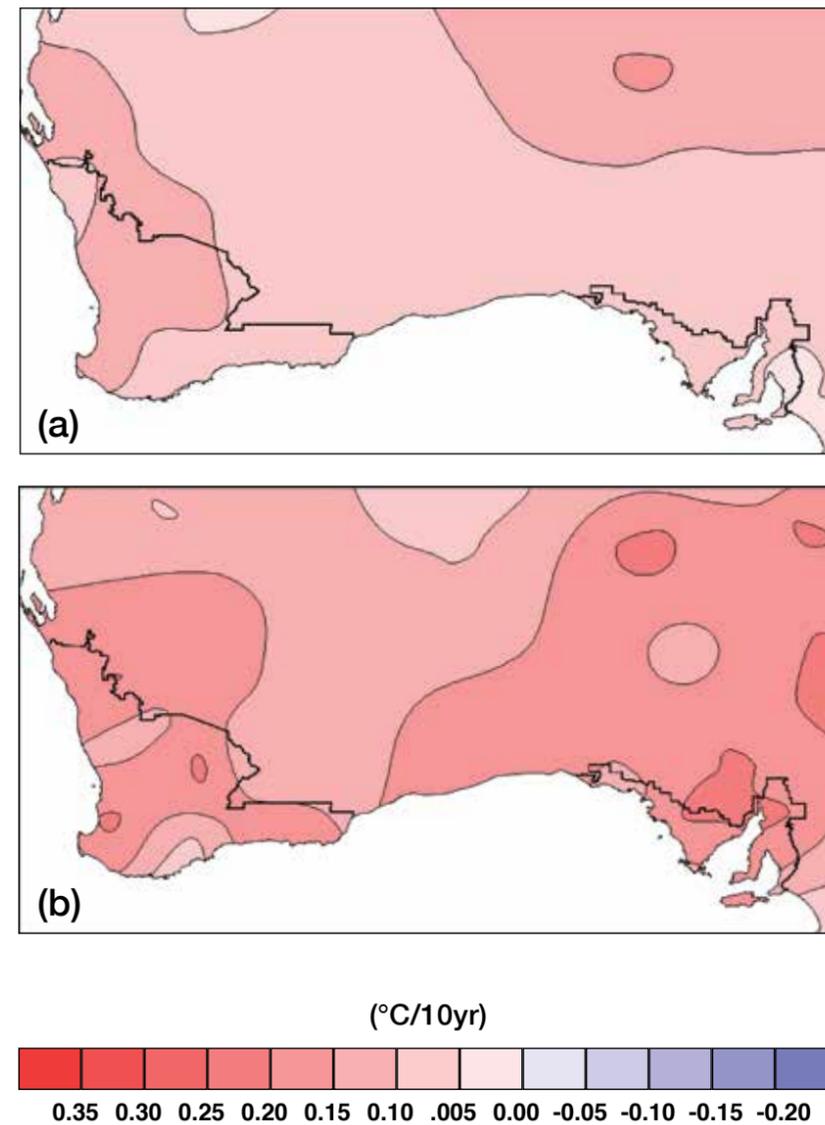


Figure 6: Maps of trend in mean temperature (°C/10years) for (a) 1910–2013 and (b) 1960–2013 (acorn-sat) (from Hope et al, 2015)



Telegraph track, Fitzgerald River NP



## 4.2 REGIONAL CAPACITY

Regional capacity indicators are described as follows:

- Population trends
- Community groups involved in natural resource management
- Education, training and awareness in natural resource management
- Regional body revenue

### 4.2.1 POPULATION TRENDS

Population trends data is abridged from the background paper for the Climate Adaptation Addendum to *Southern Prospects 2011-2016* (Duxbury, L. and Hodgson, N. 2014).

Trends in population growth are important in rural communities as maintenance of a population means that schools, health services, service clubs, local businesses and local governments are more stable and able to provide baseline services.

Rural population decline is often the catalyst for the search for employment in regional centres. On the other hand communities that experience population growth, particularly sudden increases in population, face challenges in meeting housing, service and infrastructure needs.

The coastal City of Albany and towns of Esperance, and Denmark all experienced sustained levels of population growth over the twenty year period to 2011. Esperance experienced a growth of 29%, Denmark’s population grew by 61%, and Albany’s population grew by 32.7%.

The inland local government areas of Jerramungup, Gnowangerup and Cranbrook all experienced declining populations over the period. Jerramungup experienced a decline in population of 27.6%, Gnowangerup a decline of 30% and Cranbrook a decline in population of 6% over the twenty year period. Ravensthorpe had an overall growth of 64% since 1991, with an even higher fluctuation in 2006 but declined thereafter. The growth, associated with the mining industry, is predominately in the male population. Plantagenet’s population grew by 18% associated with a growth in the winery and forestry industries and the proximity to the regional centre of Albany,

Further to the Climate Adaptation Addendum (South Coast NRM, 2016), the Great Southern Development Commission, Great Southern Regional Investment Blueprint 2014 projects a regional population of 100,000 people by the year 2040.

The Goldfields-Esperance Development Commission, Goldfields-Esperance Regional Investment Blueprint 2016 projects a regional population for the Esperance and Ravensthorpe areas of ~24,360 by 2050.

### 4.2.2 GROUPS INVOLVED IN NATURAL RESOURCE MANAGEMENT

South Coast NRM has identified 72 groups involved in natural resource management in the region. The groups include community and grower groups, industry and local and state governments (see table 2 below).

In 2013<sup>1</sup>, South Coast NRM surveyed community groups to examine membership and needs, with a response rate of 37%. Summaries of the survey are as follows:

#### 4.2.2.1 MEMBERSHIP

Group membership ranged at that time from 10 to 700 financial members per group, with over 1,200 non-financial members. Total membership of groups who responded was over 2,900. Group contact lists were extensive ranging from as few as 41 individuals through to 1,200. Combined, groups had a total contact list of over 6,100. As people forward information through other personal networks it is likely that information is shared beyond this figure and includes individuals not formally subscribed. It is also possible that individuals may be affiliated with more than one group.

**Table 2: Category and Number of Groups involved in Natural Resource Management in the South Coast region**

CATEGORY	NUMBER
Sub-regional community groups	8
Other community groups	13
State or National level not for profit groups	6
Aboriginal groups	4
Industry and educational groups	5
Industry/Grower groups	6
Other funding bodies	1
Local Government	11
State Government	14
Australian Government	4

<sup>1</sup> A similar survey was completed in 2015, however, the response rate was not high enough to create a valid assessment of group health.



Community restoration of Yakamia Creek



Wumbudin koul-ye-rah 'Strong and Proud' participants

#### 4.2.2.2 GENERAL COMMUNITY GROUP INFORMATION

Less than half the groups surveyed had a strategic plan (49%) and most of those plans were due to expire by 2015. Most groups (76%) had a constitution; however 17% of these hadn't been updated during the last decade. Very few groups had a succession plan in place (27%). Twenty seven per cent of groups surveyed did not have written policies and procedures. Of the 51% of groups that do have written policies and procedures most included occupational safety and health policies.

#### 4.2.2.3 INSURANCE

Most groups had public liability insurance. Few groups had either personal accident insurance for volunteers or workers compensation and fewer still had directors and officers insurance.

#### 4.2.2.4 TRAINING

Grant writing was the most popular need highlighted for training. Other training needs identified by the groups included first aid, marketing, IT courses (including creating web pages), weed management, pest control, herbicide usage and plant propagation. Most groups (71.4%) indicated that they do not have the capacity to self-fund training.

#### 4.2.2.5 SUPPORT

Additional support areas identified by groups included:

- Industrial relations and insurance advice
- Funding/financial support for specific projects
- Volunteer membership and capacity building
- Sharing of information (to avoiding reinventing the wheel), specialist speakers for community events
- On ground support e.g. support by local government, including in kind
- More support on industry research and best practice in agriculture
- More support for organisational development, planning
- Committee succession planning
- Specialist workshops, including website development and maintenance
- Membership and event advertising and media usage

Source: November 2013, 'NRM Community Group Survey 2013'. South Coast NRM Inc.

### 4.2.3 EDUCATION, TRAINING AND AWARENESS IN NATURAL RESOURCE MANAGEMENT

Researching information of those educational institutions with education and/or training programmes which incorporate natural resource management was outside the scope of this report. However, the Australian Curriculum from Foundation to Year 10 now has sustainability as one of the three cross-curriculum priorities to be taught through each of the eight learning areas of the national curriculum. The first stages of implementing the curriculum commenced in 2013. Accreditation of programmes and related assessment requirements and processes remain the responsibility of the Government of Western Australia.

South Coast NRM implement a range of natural resource management education, training and awareness programmes through various mechanisms including schools, tertiary institutions and community workshops. An example of the range of outreach topics delivered by South Coast NRM through the National Landcare Programme is included in table 3 below.

Future iterations of this report could investigate how many programmes are being delivered through the Western Australian curriculum, tertiary institutes and adult learning.

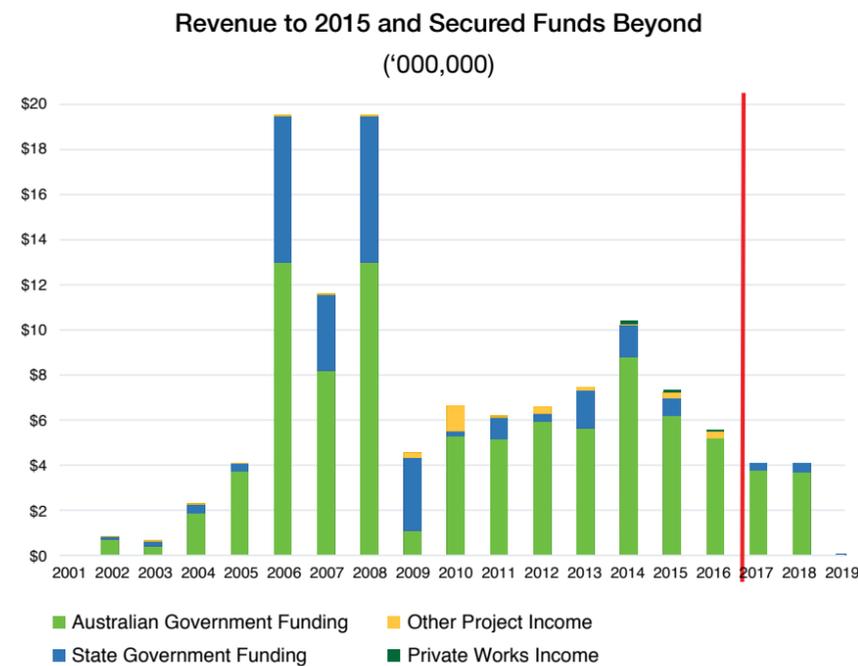
### 4.2.4 REGIONAL BODY REVENUE

In this indicator, revenue refers to funds received by South Coast NRM. It is noted that there are several instances where grant funding by the Australian Government and the State Government of Western Australia was received by state government agencies, educational institutions and community groups for natural resource management purposes, however, this information was not available for the analysis opposite.

Historically, revenue has been irregular, changing as government priorities and programmes change. This creates challenges in the maintenance of recurrent budgets and uncertainty around forward planning of capability and capacity. Most employee contracts have durations of engagement of twelve months or less. Employee contracts up to two years duration are rare. Empirical evidence indicates a significant decline over time of the ratio of full time positions to part time positions. During the last five years (2011-2015) \$38M was received compared to the previous 5 year period (2006-2010) \$61.8M (Figure 7).

“...2015 has been a very challenging year for fund acquisition. In summary, we prepared 20 funding submissions (our long-term average is 17) worth \$4.1M (compared with \$17.8M). We were successful in 70% of our applications which exceeds our target in the business process manual (goal is 65%), but we didn't meet our expected return from funding applications of 75% (we expect to get a return of 75 cents in every dollar applied for). This is because some large grants were unsuccessful, due in part to us pushing outside of our traditional funding sources. We are fortunate that we still have a number of competitively acquired grants still in place.”

South Coast NRM, Operations Manager



**Figure 7: Regional body revenue**  
**Source: Financial statements within the South Coast Regional Initiative Planning Team (SCRIPT) annual reports for 2002 to 2006 and South Coast NRM annual reports for 2007 - 2015**

**Table 3: An overview of awareness, education and training activities planned for the South Coast NRM region (2015-2018) and funded by the National Landcare Programme, grouped by theme areas** NB: other awareness, education and training activities funded by other programmes or delivered by external organisations are not included

### NATIONAL LANDCARE PROGRAMME SUB-PROJECTS PROJECT OUTPUTS

Legend of Activity Types: **A** = Awareness **E** = Education **T** = Training

PROJECT OUTPUT PROFILE	REGIONAL CAPACITY	CULTURAL HERITAGE	BIODIVERSITY	LAND	WATER & COASTAL	COASTAL
	<ul style="list-style-type: none"> <li>Building Capacity of the Landcare Sector for South Coast Region</li> <li><b>A</b> Landcare activity case studies</li> <li><b>A</b> Calendar of events</li> <li><b>A</b> Activities linked to national and international days</li> <li><b>A</b> Youth engagement activities</li> <li><b>A</b> YouTube Landcare competition</li> <li><b>A</b> Science Rocks (career forum)</li> <li><b>E</b> Esperance Education Programme</li> <li><b>E</b> Education Roadshow</li> <li><b>T</b> Training for chairs of sub regional groups</li> <li><b>T</b> Training for project officers</li> <li><b>T</b> Training for community Landcare groups</li> <li><b>T</b> Behaviour change network</li> <li><b>T</b> Catchments, Corridors and Coasts</li> </ul>	<ul style="list-style-type: none"> <li>Cultural Connections</li> <li><b>A</b> Cultural awareness events</li> <li><b>A</b> Family field workshops</li> <li><b>E</b> Indigenous enterprise forums</li> <li><b>T</b> Support Aboriginal enterprises based on NRM</li> <li><b>T</b> Aboriginal engagement training</li> <li><b>T</b> Training for Aboriginal groups</li> <li><b>T</b> Field days for Aboriginal land managers</li> </ul>	<ul style="list-style-type: none"> <li>Protecting EPBC Species</li> <li><b>A</b> Activities to promote EPBC habitat protection</li> <li><b>E</b> Fitzgerald River Revegetation Guide</li> <li><b>T</b> Invasive species workshops</li> <li><b>T</b> Threatened species workshops</li> </ul>	<ul style="list-style-type: none"> <li>Southern Soils</li> <li><b>A</b> Climate predictions meetings</li> <li><b>A</b> Bluegum conversion case studies</li> <li><b>A</b> Climate action on farms communication activities</li> <li><b>E</b> Forums with climate scientists</li> <li><b>T</b> Soil erosion workshops</li> <li><b>T</b> Soil Biology workshops</li> <li><b>T</b> Soil acidity workshops</li> <li><b>T</b> Soil health workshops for wine grape growers</li> <li><b>T</b> Maximising soil carbon workshops for Bluegum Conversion</li> </ul>	<ul style="list-style-type: none"> <li>Coastal Waterways and Ramsar Wetlands</li> <li><b>A</b> Salty Summer Coastal Education</li> <li><b>A</b> Coastal communication events</li> <li><b>A</b> Traditional elders sharing cultural values of Ramsar wetlands</li> <li><b>A</b> Communication activities and community events for Ramsar wetlands</li> <li><b>E</b> Albany Coastal and Marine Science Programme</li> <li><b>T</b> Coastal field days</li> <li><b>T</b> Migratory bird surveys</li> </ul>	<ul style="list-style-type: none"> <li>Commercial Fisheries</li> <li><b>A</b> Sustainable fishing practices events</li> <li><b>E</b> Environmental Management Systems (EMS), Codes of Practice (CoP) and sustainability practices</li> </ul>



Perennial pastures have been widely adopted across the region

### 4.3 LAND

The land theme asset of soil was assessed through the indicators:

- Soil organic carbon
- Water repellence
- Wind erosion
- Salinity risk
- Groundwater

Agriculture contributes strongly to the region's economy and social fabric, and is the largest land use within the region. Primary production in the South Coast region is one of the most diverse agricultural sectors in Western Australia. Farms are mainly livestock (e.g. sheep, cattle, pigs and chickens), grain (e.g. wheat, barley or canola) or mixed enterprises, and the region also hosts viticulture, horticulture, farm forestry, orchards and other small scale, high return businesses. Working with the region's farmers and supporting industry with investment into sustainable agriculture is critical to ensure farming techniques adapt to changing environmental, social and economic conditions.

The adoption of sound, sustainable agricultural principles benefits producers through maximising the productive capacity of the land while also mitigating impacts on the environment. Sustainable agriculture has been defined as 'the efficient production of safe, high quality agricultural products in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species' (Sustainable Agriculture Initiative 2016). Sustainable agriculture reflects stewardship of the land, conserving the resources that will enable both present and future generations to meet their needs.

*Sustainable agriculture reflects stewardship of the land, conserving the resources that will enable both present and future generations to meet their needs.*

South Coast NRM's Land Program is currently focussed on soil health initiatives and climate change adaption. Specifically, major aspects of investment include:

- soil health projects that address soil acidity, erosion, salinity, water logging and water repellence



Full moon rising over farm

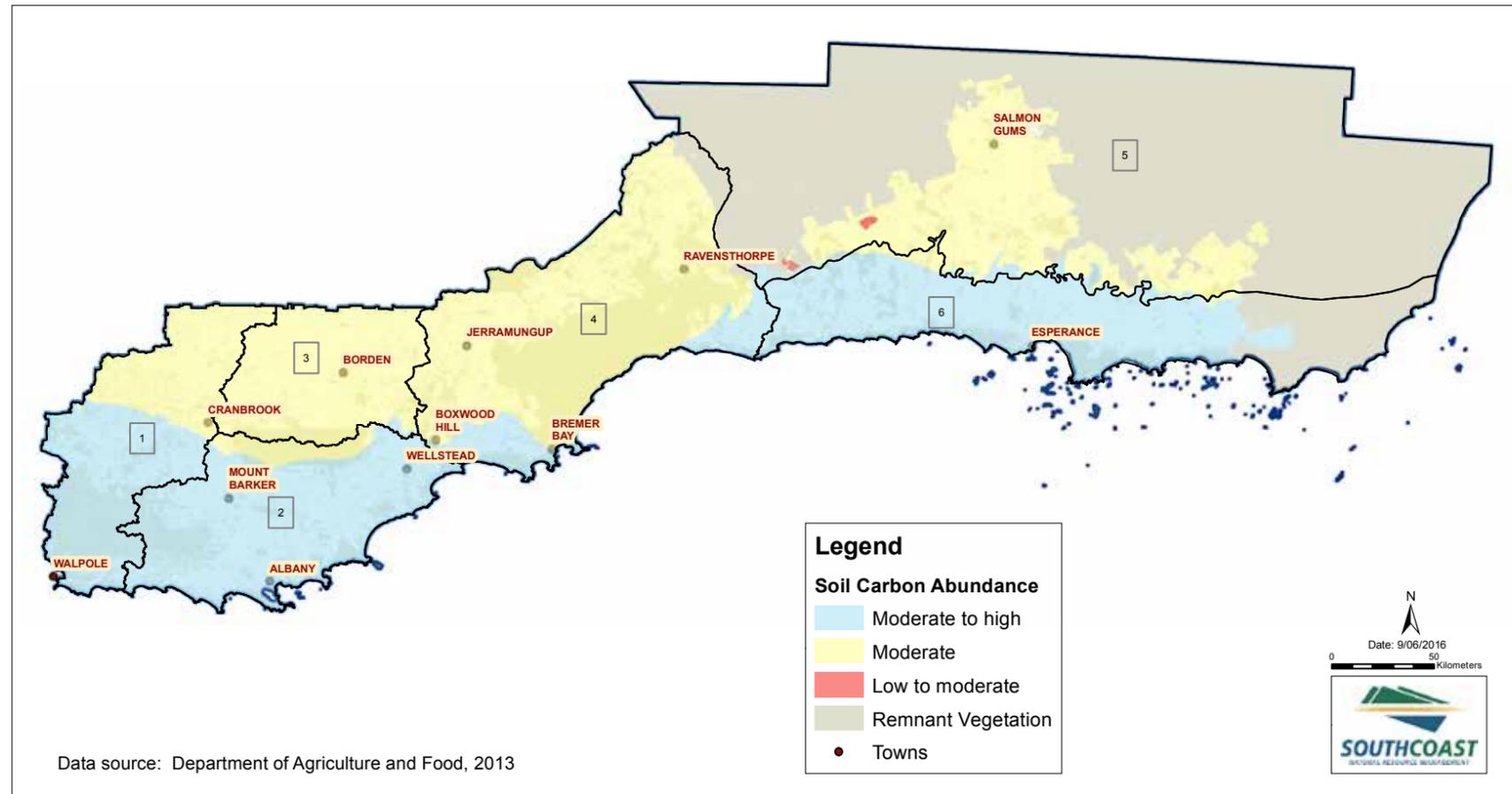


Figure 8: Soil organic carbon abundance



- Educational activities to promote sustainable agriculture options for farmers adapting to a variable climate
- Trials and demonstrations relating to soil health, climate change, soil organic carbon and methane emissions
- Best practice methods for reverting tree plantations back to pasture or grain production
- Access to information and support relating to sustainable agriculture

Data for the land theme indicators is abridged from the thorough and informative 2013 Department of Agriculture and Food Western Australia (DAFWA) *Report card on sustainable natural resource use in agriculture*. Further information and methodologies of data collection and analyses can be found in that document.

Many physical, chemical and biological processes occur within soils, functioning at different rates across the landscape according to the climate, soil characteristics and land use. Having an understanding of the diversity and capabilities of soil to support different land uses is necessary to appreciate the current state and condition of South Coast soils. It also requires an appreciation of human impacts, both recent and historic.

#### 4.3.1 SOIL ORGANIC CARBON

Soil organic carbon (SOC), derived from organic matter that is either living or decayed, or charcoal, benefits the physical, chemical and biological processes that are fundamental to soil. Typically, Western Australian soils are low in soil organic carbon. This is because of both natural influences including climate and soil type, but also land management practices which may impact SOC content. Soil function and fertility, and therefore increased agricultural productivity, can be improved through enhancement of SOC.

*Soil function and fertility, and therefore increased agricultural productivity, can be improved through enhancement of soil organic carbon.*

SOC levels vary with rainfall gradients, with soils in the higher zones tending to have higher SOC due to the ability of the land to support greater biomass. Generally, perennial pastures support higher SOC.

### 4.3.2 SOIL ACIDITY

While a natural process, soil acidification is accelerated by agricultural practices.

DAFWA (2013) consider soil acidity a major threat to agricultural production, and note that the pH of over 70% of surface soil samples collected since 2005 were rated poor. Acidic top soil impedes nitrogen fixation and nutrient availability. Similarly, almost half of the subsurface samples (10-20cm and 20-30cm) were rated as poor, being more acidic than recommended. Subsurface soil acidification increases aluminium solubility, an element that is toxic to plant roots. It results in poor root growth and ability to absorb nutrients and soil moisture.

Soil acidity may severely limit crop and pasture production, although the extent and severity varies throughout the region and with soil type. It can be managed through the application of lime, however, DAFWA estimate current lime application to be 40% of that required to treat ongoing acidification of soils. The quality of lime, for example particle size and neutralising value, may also affect remediation value, and this may vary between pits.

Therefore, at present, the trend in soil acidification is that of a static or worsening condition.

*Water repellent soils can result in poor crop establishment, increased wind and water erosion and poor nutrient and water uptake.*

### 4.3.3 WATER REPELLENCE

Water repellent soils prevent the infiltration of water into the soil profile, which may occur even to the extent that significant rainfall events fail to wet the soil. It is caused by organic hydrophobic coatings, often waxes, on the soil particles or component soil organic matter. Water repellence is particularly of issue on soils with low clay content (less 1%) or high organic matter within topsoil, and in the medium to high rainfall areas.

Water repellent soils can result in poor crop establishment, increased wind and water erosion and poor nutrient and water uptake. Early sown crops, and those dry sown, are more likely to be affected than later sown crops.

Farming techniques that increase soil carbon levels, including minimal tillage and



Water repellent soils are widespread in the region



Managing soil acidity improves crop production

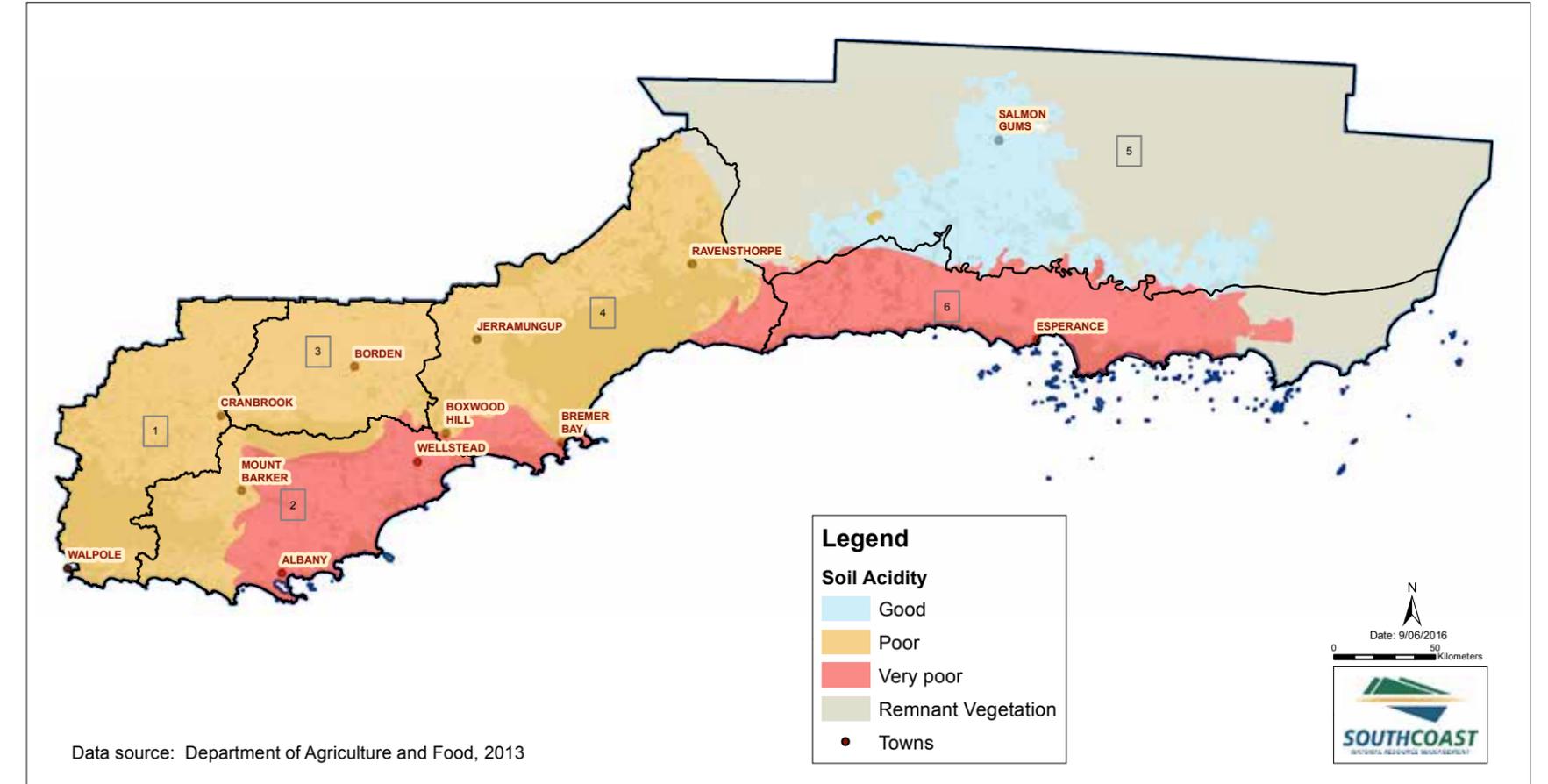


Figure 9: Soil acidity within South Coast region

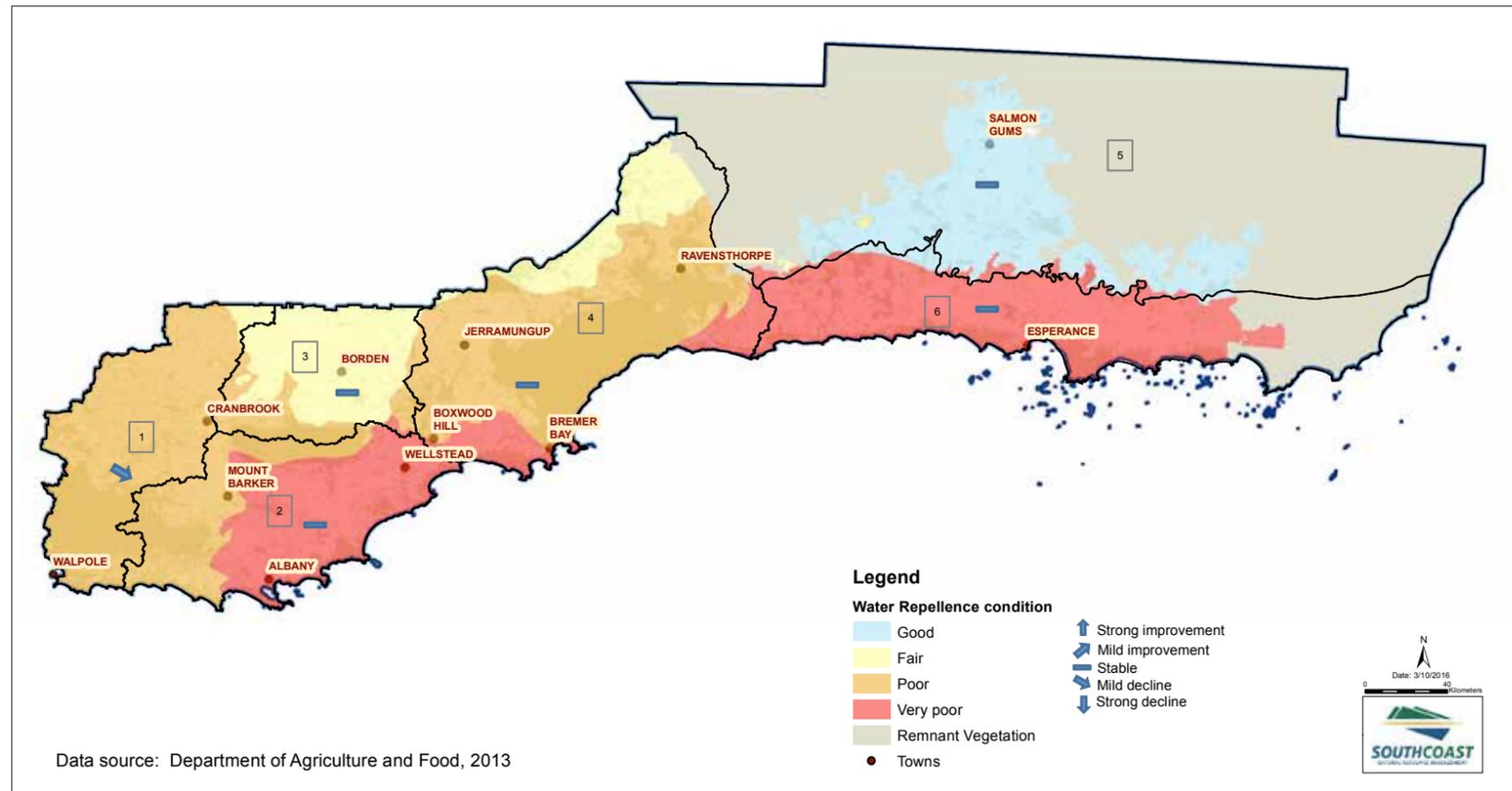


Figure 10: Water repellence in South Coast region



stubble retention may exacerbate soil water repellence, however, research indicates water infiltration may still occur through plant root channels from previous crops, and that yields are not necessarily affected.

#### 4.3.4 WIND EROSION

Wind erosion is measured by the potential for soil to be lost through wind action, with the particle movement through suspension, saltation or creep. It is a seasonal threat, occurring when the soil surface is susceptible and when sufficient wind speed exists that may dislodge particles.

*It is expected that climate variability including reduced rainfall will increase wind erosion risks.*

In Western Australia, the wind erosion threat has been reduced by the implementation of improved cropping and stubble practises. Generally in the South Coast region, the hazard is very low to moderate, with the risk enhanced by below average rainfall limiting protective ground cover establishment or high stock numbers on poor pasture.

It is expected that climate variability including reduced rainfall will increase wind erosion risks and that continued improvements in management practices will be required. Practical measures to prevent soil and nutrient loss through stable ground covers also improve soil organic carbon and profitability.

#### 4.3.5 SALINITY RISK AND GROUNDWATER TRENDS

Clearing of native vegetation for agriculture over the past 100 years and its replacement with shallow rooted annual crops and pastures has resulted in soils within non-irrigated regions becoming saline over time. Without the presence of deep rooted vegetation, groundwater tables rise and mobilise naturally stored salt in the soil profile. As these salts concentrate on the soil surface, plant growth is inhibited.

Land degradation through dryland salinity has widespread implications including lost agricultural production through lessened yield, area of available arable land and land capability. Dryland salinity also impacts rural infrastructure, public and private water resources and biodiversity with substantial costs both physical and economical.

Despite a decline in annual rainfall, most water tables in areas cleared for agriculture continue to rise.

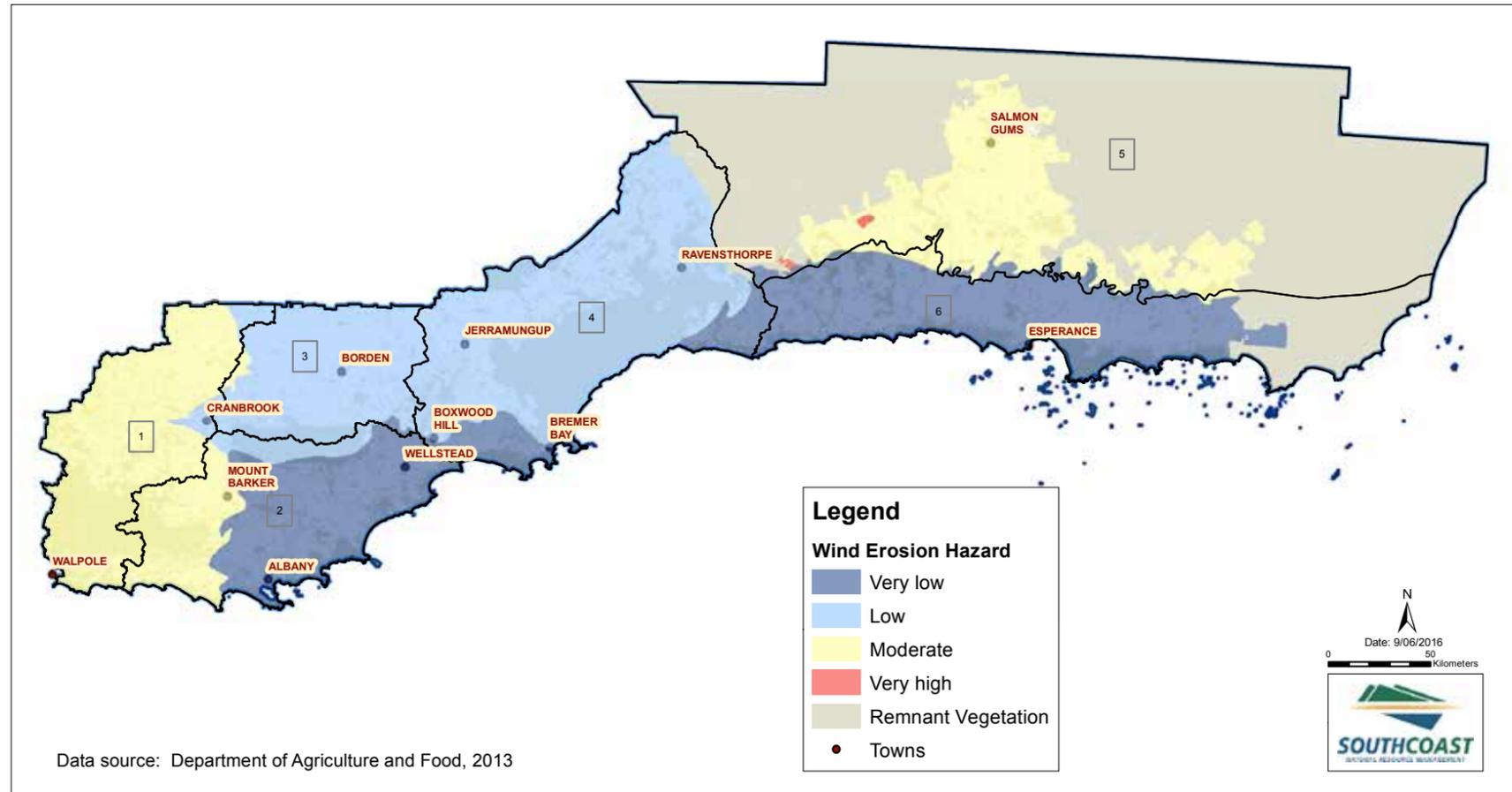


Figure 11: Wind erosion hazard within South Coast region

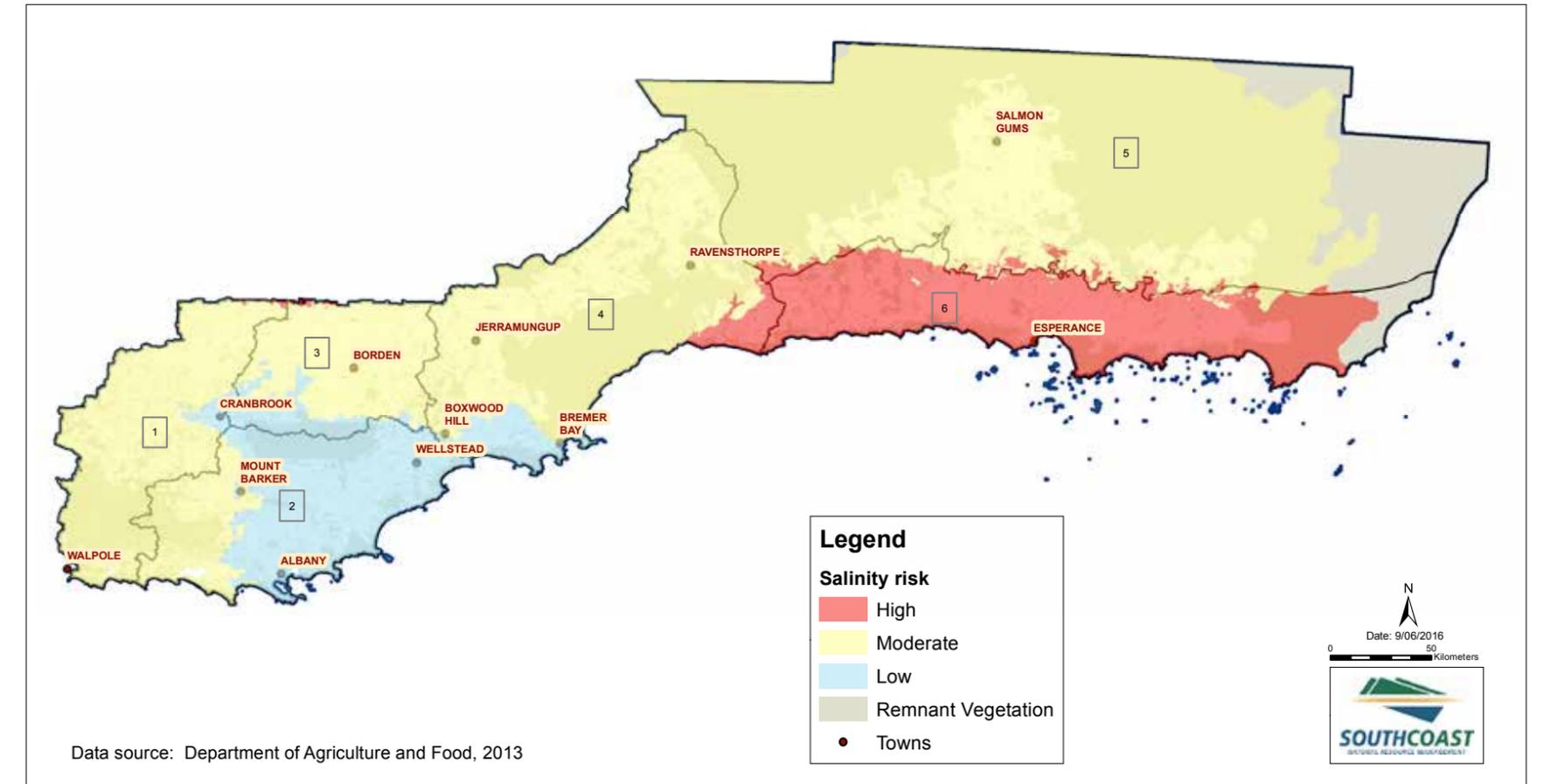


Figure 12: Salinity Risk in South Coast region

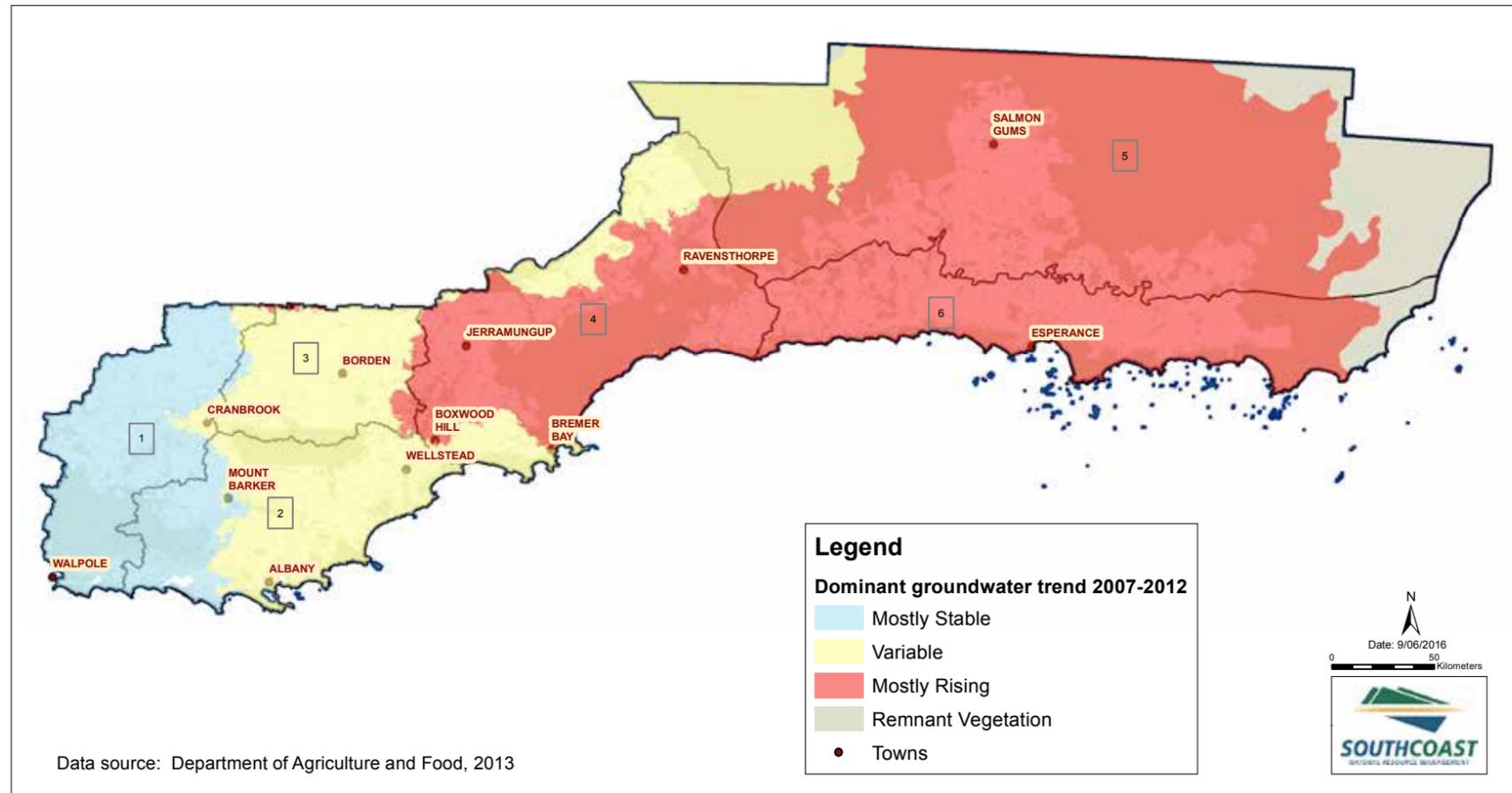


Figure 13: Dominant groundwater trends in South Coast region



## 4.4 BIODIVERSITY

The biodiversity theme asset of Native vegetation was assessed through the indicators:

- Native vegetation extent
- Fire frequency
- Phytophthora Dieback distribution

Case studies illustrate the asset of native species and ecological communities:

- i. Status of threatened flora
- ii. Critical weight range fauna
- iii. Bird diversity – response to revegetation

Biodiversity is the variety of life – ecosystems, the species and populations they support including the genes they contain. It encompasses complex interactions and processes which are fundamental for a range of ecosystem services and to maintain the health and productivity of the land. Biodiversity is essential for life, both literally through these interactions and processes, and by provision of resources utilised by humans. The South Coast NRM region has a rich biodiversity, much of which is recognised as being internationally significant.

Major threatening processes affecting terrestrial biodiversity include the spread and impact of Phytophthora Dieback, inappropriate fire regimes, introduced animals and environmental weeds. Unsustainable land use practices and conflicts between biodiversity conservation and utilisation of land resources also threaten biodiversity. Coupled to this are critical knowledge gaps, particularly understanding of ecological processes and interactions, which hamper efforts to conserve biodiversity. A changing climate may further impact on the region's biodiversity, and efforts have been made to model potential change in order to enhance management and mitigation of threats. Independent movement of species into new regions is limited by the capacity of a species to disperse. Changing climatic conditions may favour certain species over others, and it is possible that some native species may become invasive in their distribution (Van der Wal, 2014).

Most flora and fauna have limited capacities to adapt to rapid climate change, with habitat loss a primary factor in limiting opportunities for adaption (Climate Commission, n.d.). Further, much is unknown regarding potential species response to changes in climate. For example, studies of *Banksia* species endemic to the South West Australian Floristic Region indicate that a delicate balance exists between moisture and temperature requirements for seed germination success,



Carnaby Cockatoo female in hollow

and that variances occur not only between species but also between populations. Reproductively, *Banksia* species may therefore be vulnerable to climatic changes, as windows for germination become more restricted (Science Network WA, 2015). A high proportion of the South Coast region is dominated by Proteaceous species, including *Banksia*.

Some plants and animals are already responding to climate change. For example bird migrations (arrivals and departures), which are cued by temperature, have been found to be significantly altered in ways consistent with patterns of changing climate. Further, extreme heat wave events have resulted in mortality of bird species including the endangered Carnaby's Cockatoo (Climate Commission, n.d.).



Strappy gum



Peak Charles

#### 4.4.1 NATIVE VEGETATION EXTENT

Native vegetation is essential for maintaining ecological functions including hydrological processes and nutrient cycling, and provides shelter and habitat for flora and fauna.

According to 2015 native vegetation extent mapping (Parks and Wildlife, 2015a), approximately 60% of the South Coast NRM region includes remnant native vegetation. This data is based on Department of Agriculture and Food WA spatial mapping which has been 'cleaned' by the Department of Parks and Wildlife to remove known inaccuracies including plantations and other areas previously classified as native vegetation. It is based on large and small parcels of native vegetation identified from aerial imagery.

There are, however, several limitations that exist with regard to the mapping, including the age of the imagery used to determine some vegetation extent. In some instances the underlying imagery was captured up to 17 years ago and may therefore now be an inaccurate representation of current remnant vegetation extent. Other limitations are cited in Department of Environment and Conservation, 2013 and DAFWA, 2014. These limitations prevent the direct comparison of the 2015 dataset with historic native vegetation extent spatial mapping data. Future comparisons with this dataset may be more relevant due to factors including greater GIS expertise, however, differences will also need to consider dates of underlying source imagery.

The presence of native vegetation does not, however, necessarily equate to vegetation in good ecological condition. While approximately 21% of remnant vegetation in the South Coast region occurs in protected estate and may therefore be less likely to have been subjected to unmanaged threatening processes, the remainder may be subject to processes that limit viability. For example, the Albany Regional Vegetation Survey (Sandiford and Barrett, 2010) classified 12% of the remnant vegetation in the survey area as Transformed, meaning that the structure, composition and regenerative capacity of the remnant vegetation was significantly altered and unlikely to recover naturally.

*The presence of native vegetation does not, however, necessarily equate to vegetation in good ecological condition.*



The stunning Rhubarb Bolete *Boletellus obscurecoccineus*

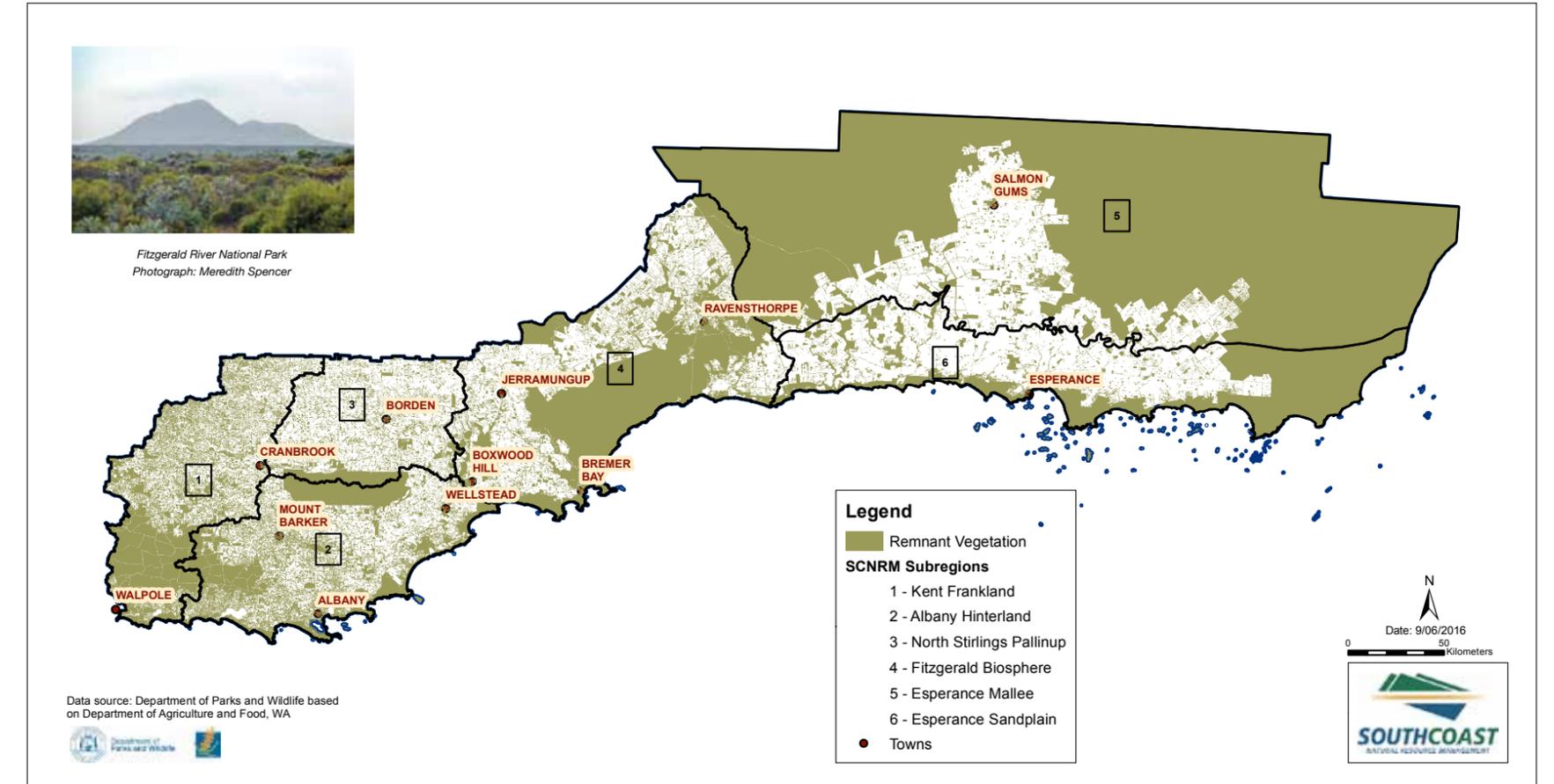


Figure 14: Native Vegetation extent in South Coast NRM region

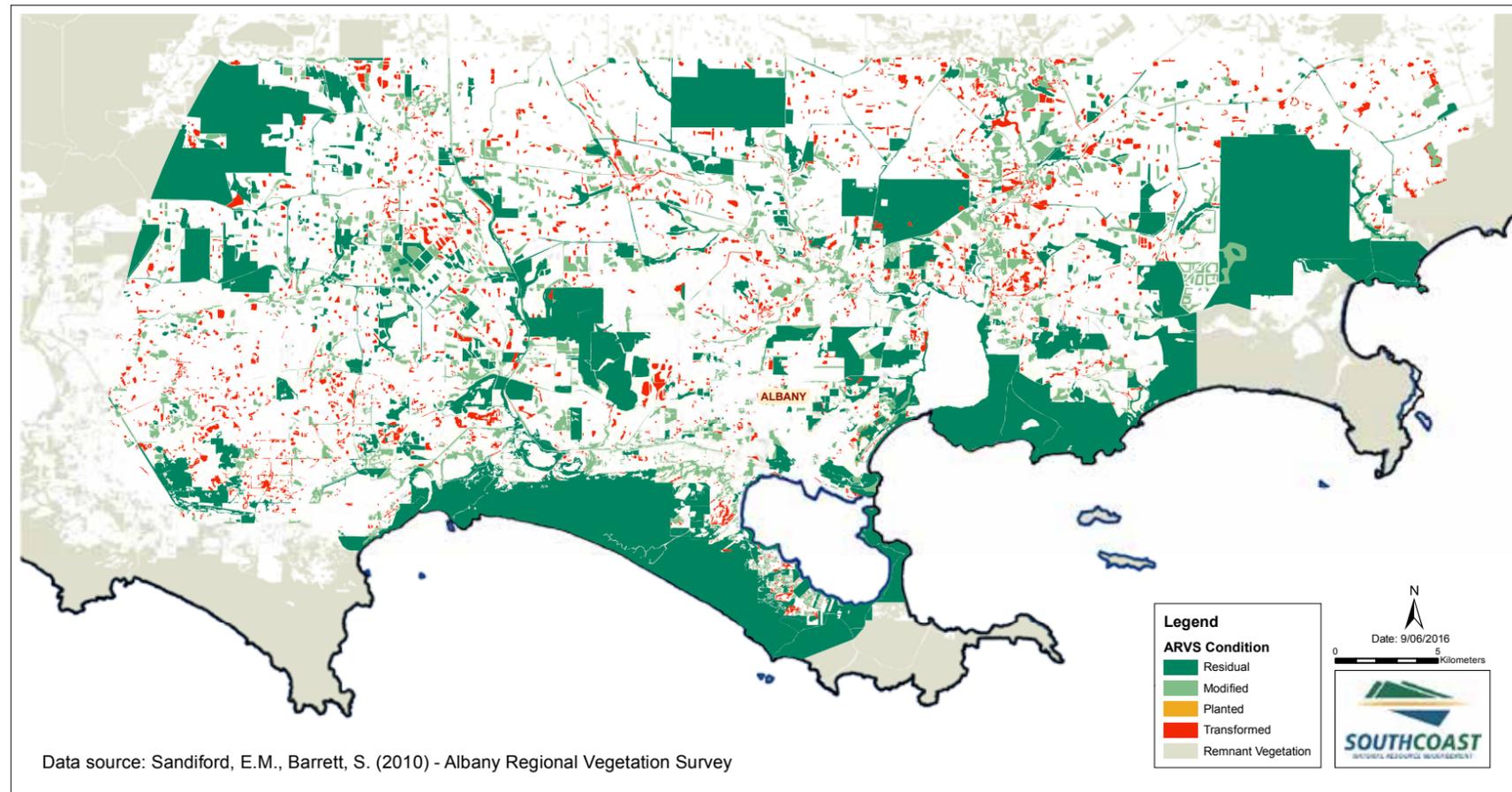


Figure 15: Albany regional vegetation survey area indicating regions classed as Transformed





Mount Gardner, Two Peoples Bay

#### 4.4.2 FIRE FREQUENCY

Inappropriate fire regimes impact biodiversity through direct and indirect influences and are considered a significant threatening process to fire sensitive ecosystems, many of which occur within the South Coast region (Barrett et al, 2009). Where the vegetation community structure includes component species killed by fire with reliance on seed to regenerate and, in particular, serotinous species, frequent fire may impact the dynamics and persistence of the community. If fire intervals are shorter than the time necessary for seed banks to re-establish, vegetation communities and the habitats they support may be significantly altered (Barrett and Yates, 2014). Factors such as rainfall and site productivity influence the timing of when populations reach these threshold values, with ecosystems in the east of the region tending to require longer periods for seed maturity (up to 20 yrs). As a result, longer duration fire free intervals are optimum for these systems compared to ecosystems in the west of the region.

*Analysis by CSIRO of the occurrence and severity of daily fire weather indicates... that extreme fire-weather days have become more prevalent.*

An analyses of fire frequency from 1973 to 2008 indicated that wildfire was responsible for the majority of fires in the eastern portions of the region, while prescribed fire accounted more widely for fire events in western areas and those with greater human use. The Fitzgerald River National Park and Great Western Woodlands had relatively low frequency of fire including areas of no fire event. More frequent fire was evident in the Stirling Range and Cape Arid National Parks (16% and 12% experiencing three fires during the period, respectively). There appeared in the study to be an upward trend in fire incidence, particularly in the Great Western Woodland (Barrett et al, 2009).

Fire activity is sensitive to various factors including wind speed, humidity, temperature and drought, and changes in climate may exacerbate fire events in the region. Analysis by CSIRO of the occurrence and severity of daily fire weather indicates increases in these and that extreme fire-weather days have become more prevalent (Hope et al, 2015).

Bushfires in 2015 had significant impacts on threatened species throughout the region. In the east fires started by lightning storms in Cape Arid National Park mid-October and mid-November collectively resulted in the loss of approximately 90% of the known

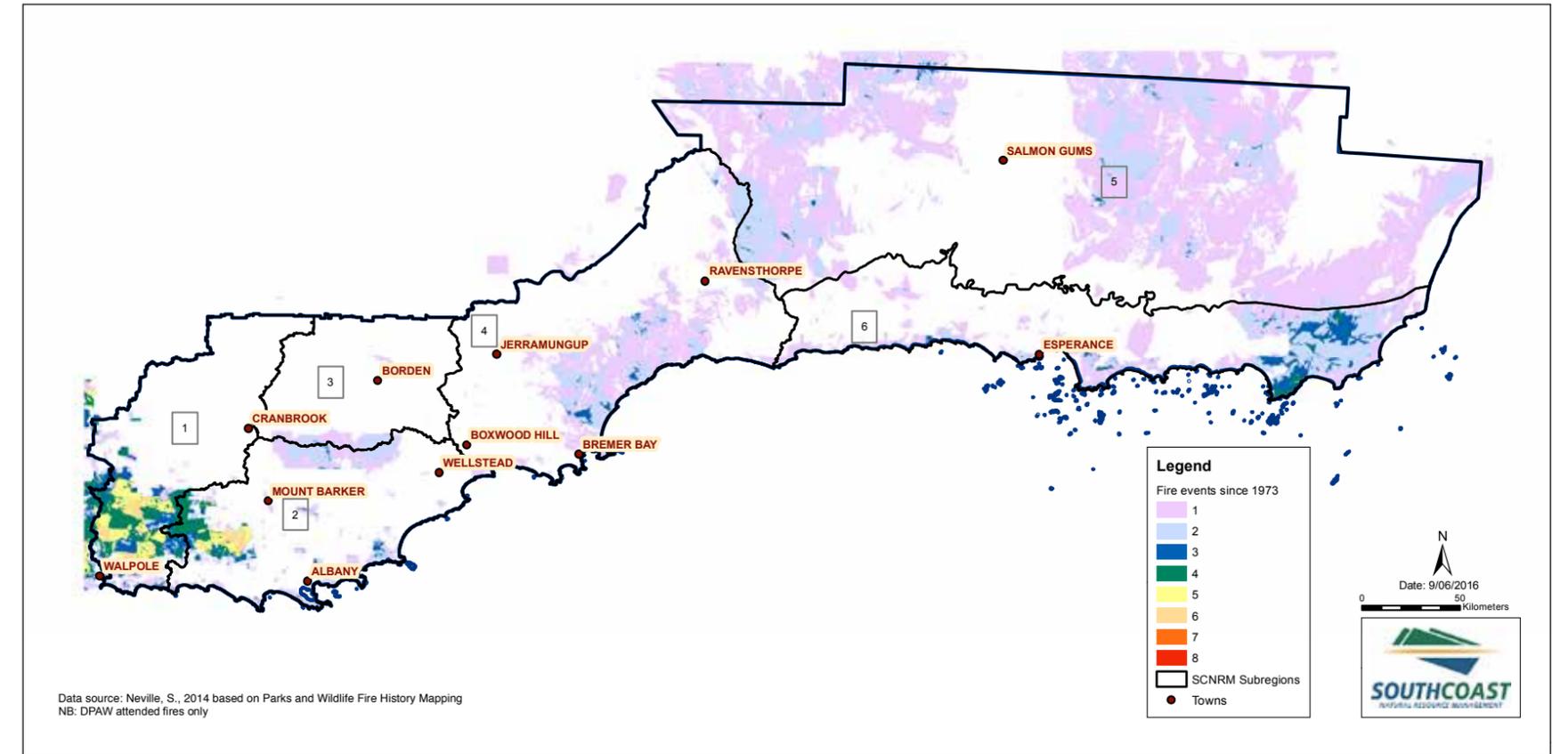


Figure 16: Number of fire events across the South Coast region since 1973 to 2008

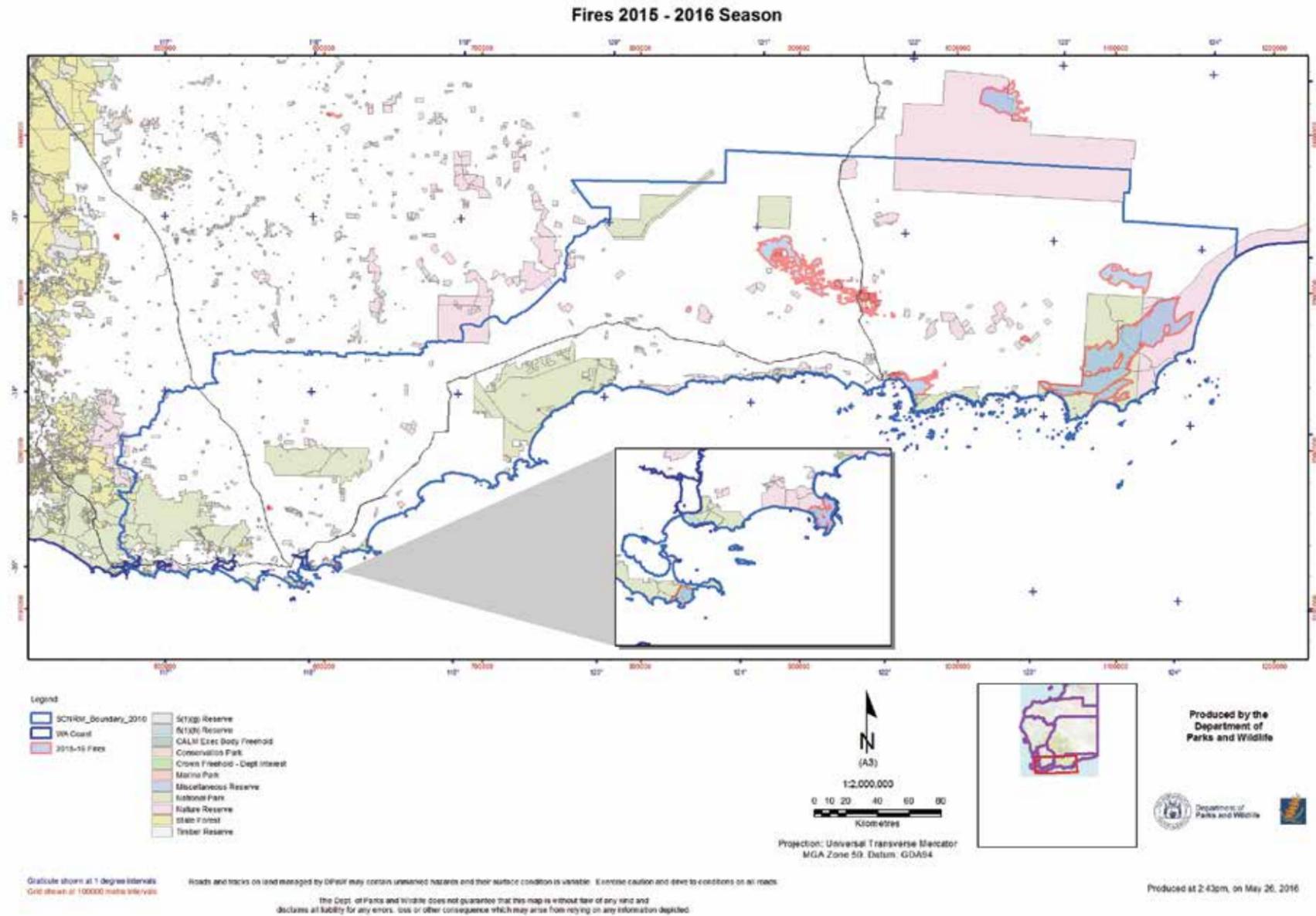


Figure 17: Fire events in South Coast region 2015/16 season (map courtesy of Parks and Wildlife)



Western Ground Parrot habitat. In November storms also resulted in a number of bushfires in the Albany area, with significant threatened species habitat impacted in Two Peoples Bay Nature Reserve and Torndirrup National Park (including significant impacts on threatened flora in this reserve). Of particular significance for fauna was the Two Peoples Bay fire, which burnt through 90% of the Mt Gardner headland and impacted on 90% of the habitat for the Critically Endangered Gilbert's potoroo and Endangered noisy scrub-bird. Other threatened fauna affected in Two Peoples Bay include the western bristlebird, quokka, western ringtail possum and western whipbird (heath ssp).

Hope et al (2015) indicate with high confidence a harsher fire-weather climate in the future, however, the magnitude of change is less clear as this is dependent on rainfall projections.

#### 4.4.3 PHYTOPHTHORA DIEBACK DISTRIBUTION

Phytophthora Dieback is a plant disease caused by *Phytophthora cinnamomi*, an introduced, soil borne plant pathogen that can devastate plant communities. Up to 40% of native species within the south-west are susceptible to the disease. The pathogen can irreversibly alter plant communities, killing susceptible species, many of which are both iconic and fundamental to the ecosystems they support. It should also be recognised that other *Phytophthora* species may also adversely impact vegetation communities to varied degrees.

*There is currently no effective elimination technique for Phytophthora Dieback.*

Phytophthora Dieback infestations within the South Coast region impact directly on susceptible species including many from the Proteaceae, Fabaceae and Ericaceae families and some taxa from the Myrtaceae family (Shearer et al. 2007). This can result in losses of susceptible species, reductions in growth of these species, altered plant species abundance and richness as well as changes in community composition and structure. These changes trigger a suite of indirect impacts on the associated flora and fauna species that use these environments for habitat and important food sources (Parks and Wildlife 2013)

Phytophthora Dieback occurrence largely reflects spread of the disease through human vectoring – movement of infested soil, plant material and water. This may occur when infested soil is moved on machinery, often from off-road vehicles through mud on tyres and wheel arches, or by plant machinery involved in construction works. Use of infested gravel in construction projects is another source of infestation in the region.



The Critically endangered *Andersonia axilliflora* is highly susceptible to Phytophthora Dieback

Phytophthora Dieback is also spread by walkers transferring infested soil by boot, as can be seen in the peaks of the Stirling Range National Park. The disease can further spread through surface and sub-surface water movement, animals and root to root transmission.

There is currently no effective elimination technique for Phytophthora Dieback. Preventing further spread is critical to protecting the unique ecosystems of the South Coast region. Treatment with the chemical phosphite may provide some level of immunity to the disease and this has been undertaken since 1997 on selected threatened species and communities to reduce disease spread and impact, and has been effective in reducing species decline.

*Predicted higher summer rainfall in the east of the region, together with increasing trends in temperature, may provide conditions conducive to the spread of Phytophthora Dieback.*

In 2014 South Coast NRM developed a Dieback Management and Investment Framework (Dieback Framework) which identified the most significant examples of ecosystems supporting plant species and communities vulnerable to Phytophthora Dieback within the south-west of Western Australia. The Framework provides a process and operational toolkit to develop specific management actions for a given area. These include on-ground activity, planning, engagement, communication and training to prevent the further spread of the disease at a landscape scale. The Framework facilitates a standardised approach for targeted management and investment across tenure.

Comparison of *Phytophthora cinnamomi* occurrence in the region between 2010 and 2015 indicates an increase in known distribution. The increase is likely to reflect both vectoring of the disease and increased sampling efforts, as greater emphasis is now placed by governing bodies on pre-development survey and dieback hygiene management planning.

Predicted higher summer rainfall in the east of the region, together with increasing trends in temperature, may provide conditions conducive to the spread of Phytophthora Dieback and enhance the potential risk of infection and level of potential impact of the disease.

In addition, through the Dieback Framework, a rapid appraisal strategy was developed which involved intense collection of soil samples for Phytophthora Dieback analysis in order to inform management strategies. It is therefore likely that these samples will be apparent in future iterations of the report should this indicator be considered again.

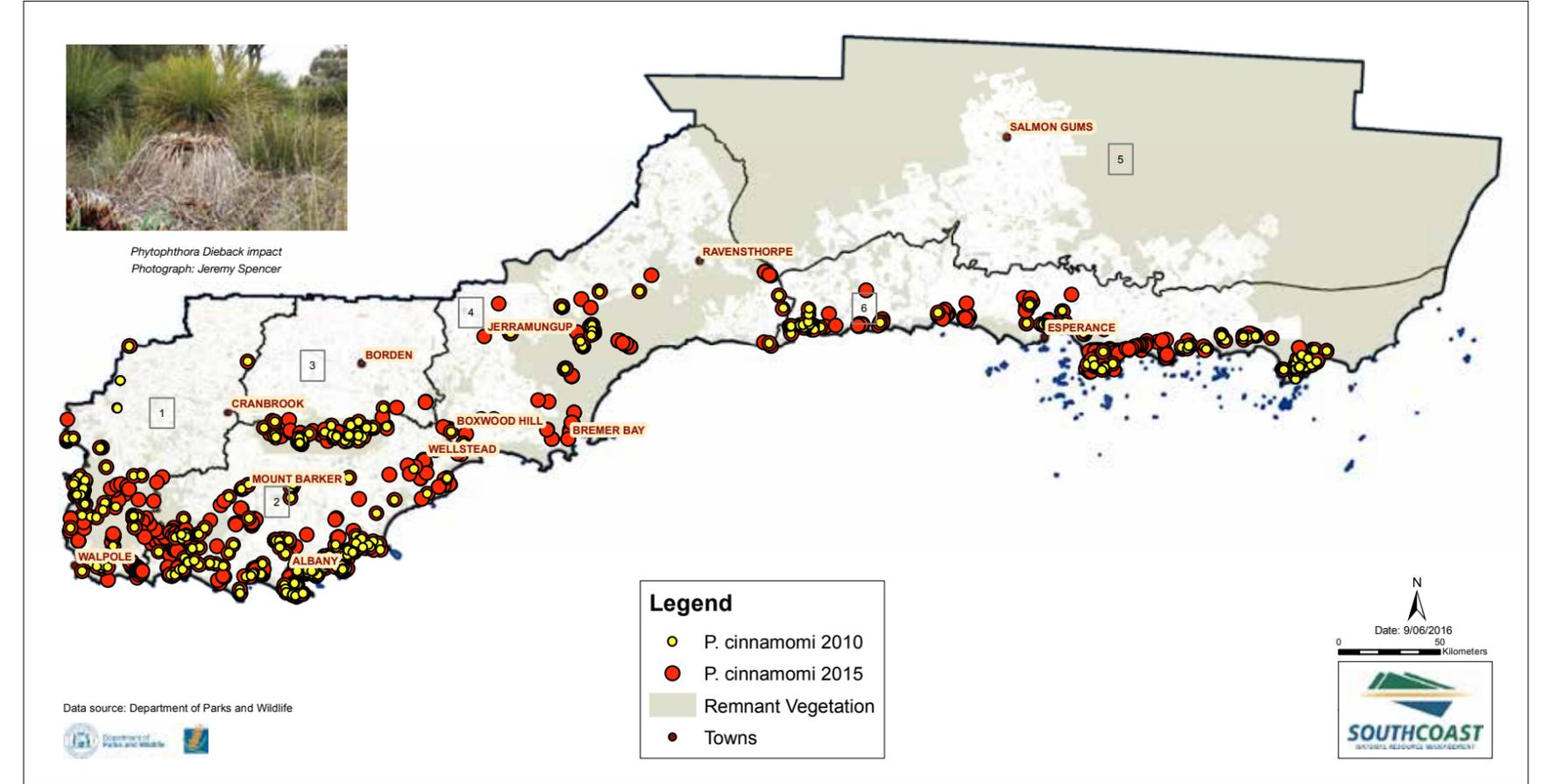


Figure 18: *Phytophthora cinnamomi* distribution comparison - 2010 to 2015

## CASE STUDY 1

### 4.4.4 STATUS OF THREATENED FLORA

The flora of Southwest Botanical Province is particularly rich and unique. Over 8,000 plant species are estimated to occur in the province, with 80% of them being endemic (Danks, et al, 2013).

Within the South Coast NRM region, two 'Centres of Plant Endemism' exist, based on the analysis of herbarium flora specimens. These are the Stirling Range (82 endemic species) and the Ravensthorpe Range-Fitzgerald River National Park (75 endemic species) (Danks, et al 2013). Over the region there are also several areas from Walpole to Ravensthorpe where mapping of flora data indicates high species richness.

The Department of Parks and Wildlife (Parks and Wildlife) categorise threatened flora according to criteria including known threats, rates of decline, population size, extent and area of occupancy. Significant threats include Phytophthora Dieback and aerial canker disease, inappropriate fire regimes, grazing by introduced and native fauna, weeds, climate change, drought and clearing of vegetation. Declared Rare Flora are species that have been well surveyed and are known to be rare, at risk of extinction or in need of special protection. These species are protected under Western Australia's *Wildlife Conservation Act (1950)* and the *Commonwealth Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act).

Because of the diversity of flora in Western Australia, there are many species for which adequate survey may not have been undertaken, but which may also be rare or threatened. These flora species are included on a supplementary conservation list known as the Priority Flora List. There are three categories of Priority flora (Priority 1 to 3), arranged to indicate priority for further survey and a fourth, Priority 4, describing rare

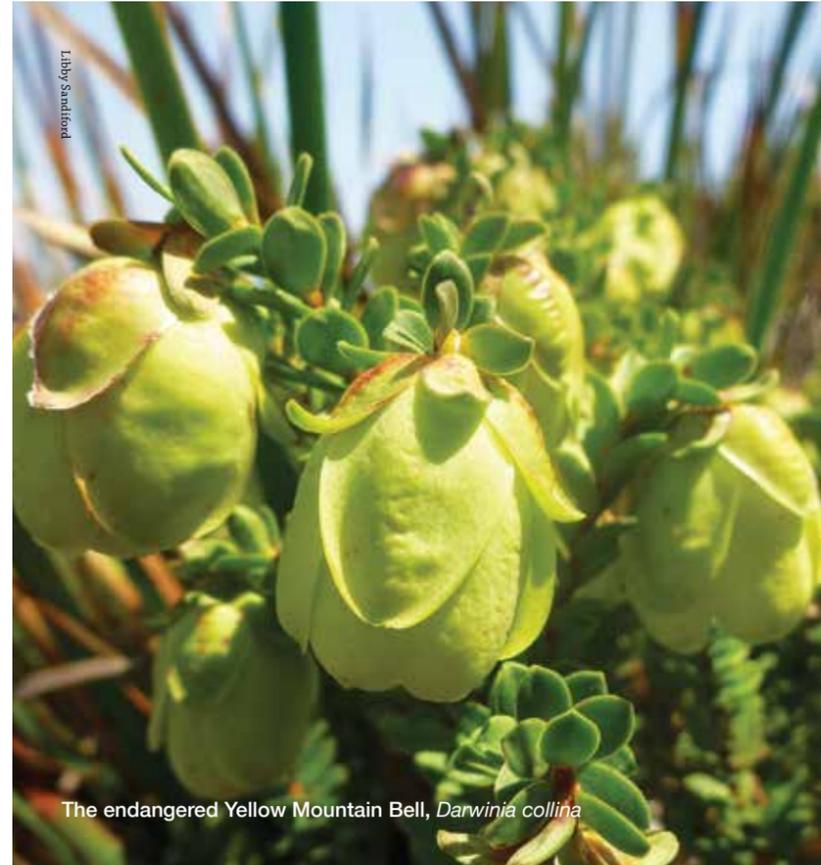


Table 4: Threatened flora in South Coast Region (from Danks et al, 2013, source Naturemap, 2010 and Goia 2015)

YEAR	NO. OF TAXA	ENDEMIC	EXTINCT	THREATENED			PRIORITY 1- 4					
				Total	Critically Rare	Endangered	Vulnerable	Total	P1	P2	P3	P4
2015	7380	703	4	125	38	34	53	845	145	257	266	177
2010	5472	694	1	121	37	33	51	739	127	222	239	151
2004	4687	400	1	94	26	33	35	547				

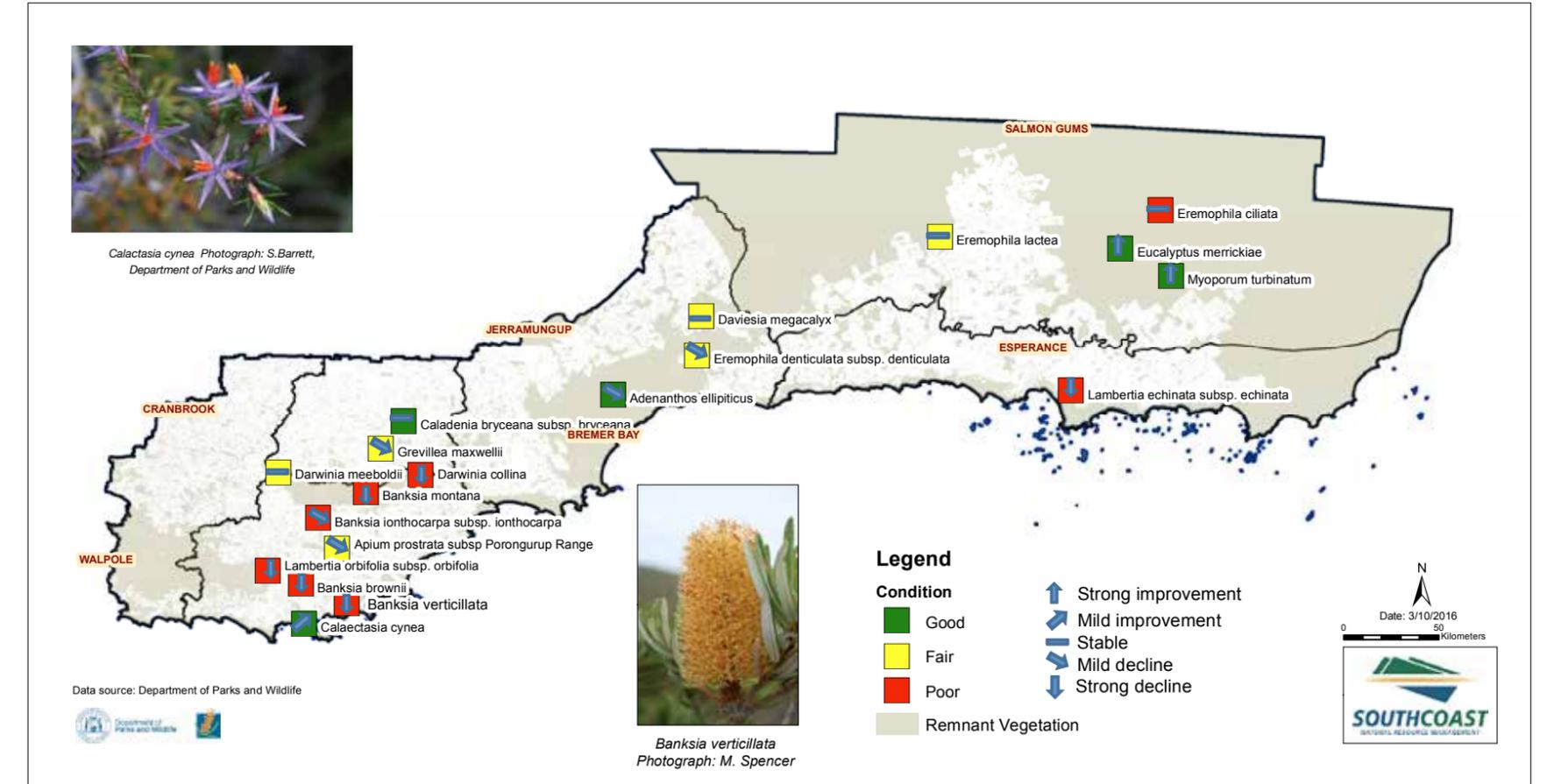


Figure 19: Condition and trend of selected Declared Rare Flora species across South Coast Region



The critically endangered Blue Tinsel Lily, *Calectasia cynea*



Protecting threatened ecological communities from grazing by rabbits and native species including quokka

species for which adequate survey has been undertaken, but which are not considered to be currently threatened. Priority species have conservation significance and are managed accordingly.

Species may be rare or threatened due to human induced threats, and/or they may be naturally limited in distribution, aligned with specific environmental preferences which are often associated with the underlying geology. The flora of the region is also often closely related, taxonomically determined to subspecies level or hybridised (Danks et al 2013). As shown in Table 4, ongoing survey effort and taxonomic revisions continue to enhance known flora diversity in the region.

Ecological communities, composed of associations and interactions of plants, animals and other organisms, may also be listed as threatened where they are considered to be under threat of extinction, rare or otherwise in need of special protection. The South Coast NRM region has 6 Threatened Ecological Communities and 39 Priority Ecological Communities. Threatened Ecological Communities may be protected under Western Australia's *Wildlife Conservation Act (1950)* and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act)*.

### *The flora of Southwest Botanical Province is particularly rich and unique.*

In 2015, Parks and Wildlife undertook a biodiversity audit (Parks and Wildlife 2015b) of conservation assets including extent, distribution and trends over the past ten years. Using the audit and specialist opinion, a matrix was created to assign values to the results, culminating in an overall condition and trend score for selected Declared Rare Flora across the region. It should be noted however that, by definition, all species shown are rare and therefore any condition scale is relative to threatening processes. Improvements in population numbers or extent may result from enhanced survey effort or translocation of species to regions with reduced threat. Species with strong decline are those threatened by the plant disease *Phytophthora Dieback* (see section 4.4.3) and aerial canker. The data shows that the status and trend of some species has improved due to management intervention including survey whereas others remain critically endangered and dependent on management intervention.

*Significant threats include Phytophthora Dieback and aerial canker disease, inappropriate fire regimes, grazing by introduced and native fauna, weeds, climate change, drought and clearing of vegetation.*



## CASE STUDY 2

### 4.4.5 CRITICAL WEIGHT RANGE FAUNA

Critical weight range fauna have been recognised as those that are easy prey for introduced predators such as the fox and feral cat. These are generally in the 35 gram to 5.5 kilogram weight range and across Western Australia more than 30 species of mammals in this weight range have declined to the point where they are at serious risk of extinction. A number of birds are also highly vulnerable, with many of these in the same weight distribution and having ecological traits such as nesting on the ground that increase vulnerability to predation.

Parks and Wildlife has been addressing the threat of introduced predators in South Coast reserves through the Western Shield Programme since 1996, when fox baiting commenced in a large number of National Parks and Nature Reserves. Standardised native fauna monitoring programmes were also established to demonstrate native fauna recovery.

Since 2010 trials of the cat bait *Eradicat*® were completed in the Fitzgerald River National Park and Cape Arid National Park (Comer et al., 2013) in response to the dramatic decline in the population of the critically endangered Western Ground Parrot *Pezoporus flaviventris*. Since 2014, the Two Peoples Bay Nature Reserve, Waychinicup National Park and Manypeaks Nature Reserve complex have also been included in this work.

In addition to the ground parrot a further 17 EPBC listed vertebrate species occur in the reserves that have been targeted for integrated predator control. Parks and Wildlife monitoring of these and other native species continues, both through standardised Western Shield fauna monitoring and more specialised surveys for specific species.

While there have been some positive responses to integrated predator control across the reserves, further work is required to establish optimal times and techniques for control programmes, and the combined impacts of inappropriate fire regimes on the impacts of introduced predators.

*Parks and Wildlife has been addressing the threat of introduced predators in South Coast reserves through the Western Shield (fox control) Programme since 1996 and through Eradicat® cat baiting trials since 2010.*



Red fox, captured by remote camera



Feral cat with Quenda (Southern Brown Bandicoot, *Isodon obesulus*)



Honey possum, *Tarsipes rostratus*



Marbled gecko *Christinus marmoratus*



Echidna, *Tachyglossus aculeatus*



Western Pigmy possum, *Cercartetus concinnus*

#### 4.4.5.1 CHUDITCH

The Chuditch, *Dasyurus geoffroi*, is one of Australia's largest mainland carnivorous marsupials, with mature adults from the Fitzgerald River National Park as large as 2kg. Since the mid-20th century the species, which formally occupied around 70% of the Australian mainland, has been confined to the south-west of Western Australia and is now listed as vulnerable.

The Ravensthorpe Range and northern sandplain of the Fitzgerald River National Park is recognised as housing an important population of this species, and targeted monitoring in recent years has seen the populations increasing to the point where animals have been used to supplement the reintroduction into the Flinders Range in South Australia.

#### 4.4.5.2 WESTERN GROUND PARROT

The Western Ground Parrot, *Pezoporus flaviventris*, is one of only five ground nesting parrots in the world. Since 2004 the Parks and Wildlife led recovery programme has worked with volunteers and the community based Friends of the Western Ground Parrot to try to find more populations of this species, which by 2014 had declined to less than 140 birds in Cape Arid and Fitzgerald River National Parks. The population in Waychinicup National Park has been considered extinct since 2004.

Improving introduced predator control and sound fire management are key to conservation of this species in the wild. More recently a small number of birds have been taken into captivity, and these birds are now housed in Perth Zoo in the hope that a captive breeding population can be established to reintroduce this species into areas where it previously occurred. The impact of bushfires in October and November 2015 has had a significant impact on the known population, however, there are signs that some birds may have been able to escape these fires.

*Improving introduced predator control and sound fire management are key to conservation of this species in the wild.*

Further work is required to update population estimates, but the impact of the 2015 fires was undoubtedly significant. Post-fire control of introduced predators and protection of the remaining unburnt pockets of suitable habitat is critical for this species.



Chuditch *Dasyurus geoffroi*



Western Australia's rarest bird, the Western Ground Parrot *Pezoporus flaviventris*

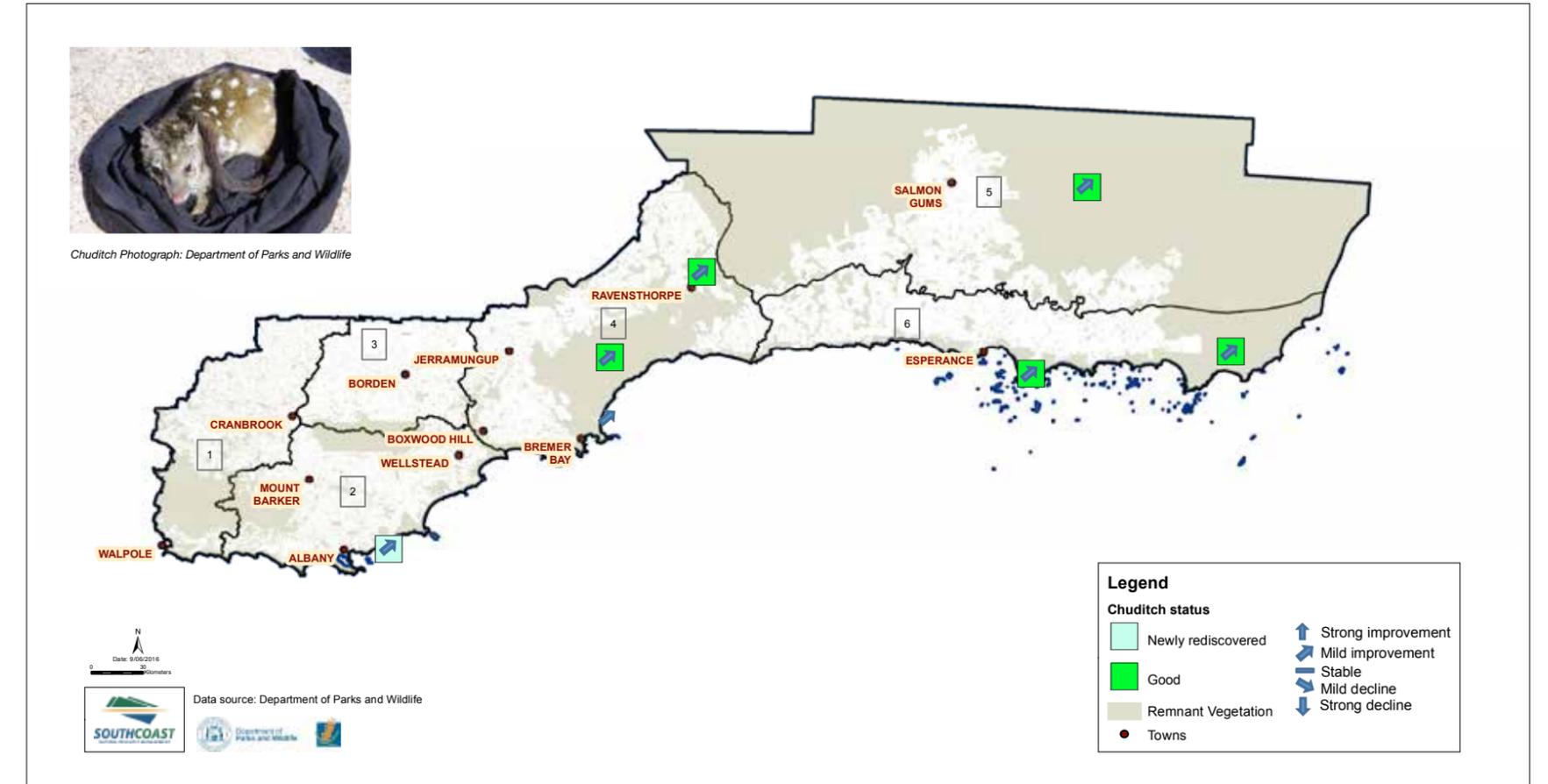


Figure 20: Chuditch status and trends in South Coast Region

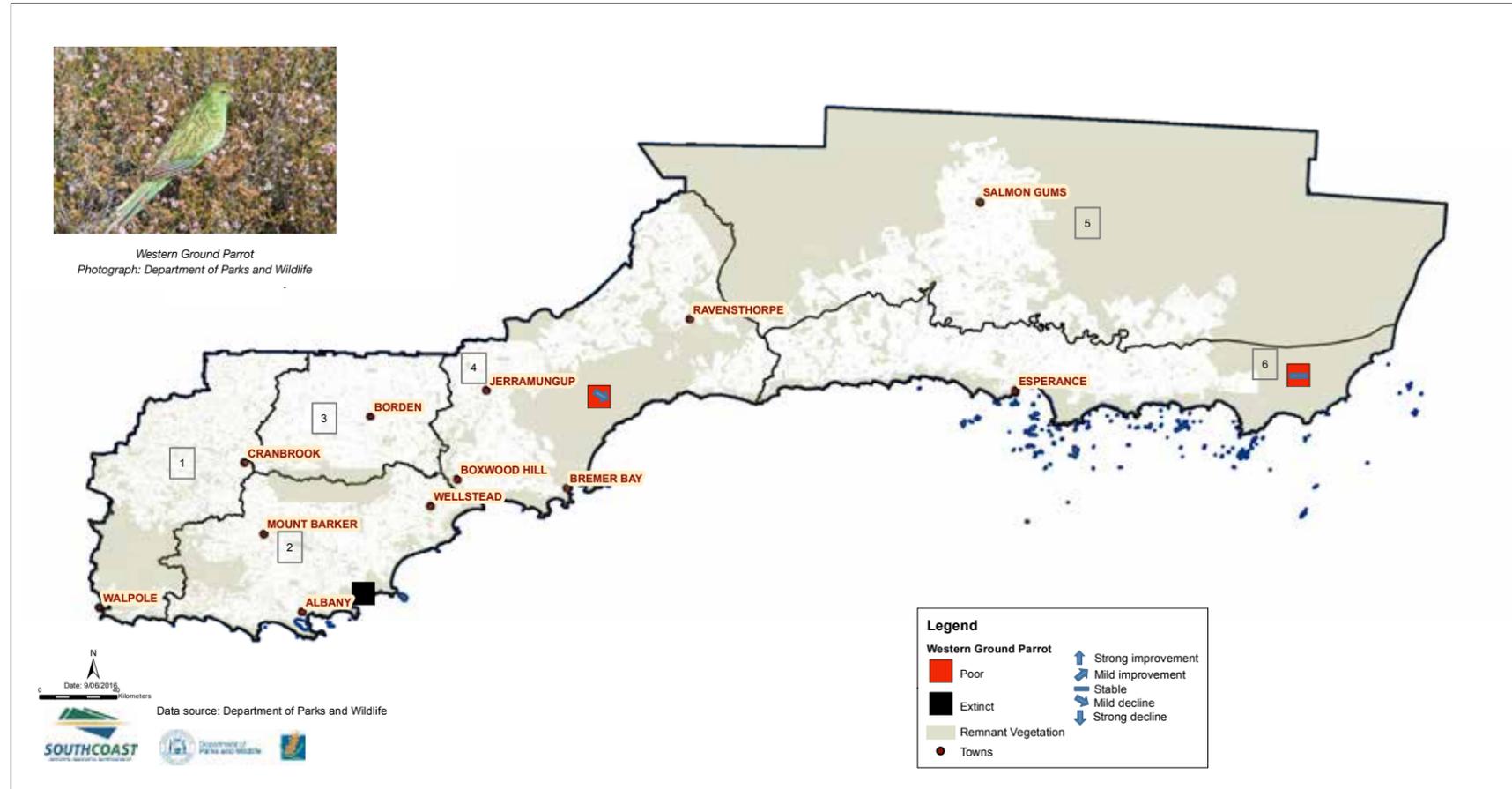


Figure 21: Western Ground Parrot status and trends in South Coast Region



#### 4.4.5.3 DIBBLER

The Dibbler, *Parantechinus apicalis*, is one of the Dasyurids, the group of carnivorous marsupials. The stronghold of the Dibbler is in the South Coast region, with good numbers of animals still found in the Fitzgerald River National Park. This area has also been part of the Parks and Wildlife Integrated Fauna Recovery Project sites trialling the *Eradicat*® baits since 2010. Good numbers of animals have been found in several new areas of the Park over this time.

A translocation to Peniup Nature Reserve has been successful, and more recently a small number of animals were released into a fenced enclosure in the western end of Waychinicup National Park and to Gunton Island near Esperance.

#### 4.4.5.4 QUENDA

The Quenda, *Isodon obesulus*, is a medium size marsupial weighing up to 1.8 kg. Quenda forage in dense healthy vegetation, digging food from the topsoil. Given they are still relatively widespread throughout the region. Quenda are a priority listed species, and a good indicator of effective predator management across the region.

*The consistent presence of both foxes and cats... indicates predation is possibly the major cause of the decline.*

While numbers in Cape Arid National Park have increased significantly since the Parks and Wildlife trials of the *Eradicat*® bait started in 2011, trends in Frankland Western Shield sites indicate a decline. The consistent presence of both foxes and cats in this particular monitoring site indicates predation is possibly the major cause of the decline.



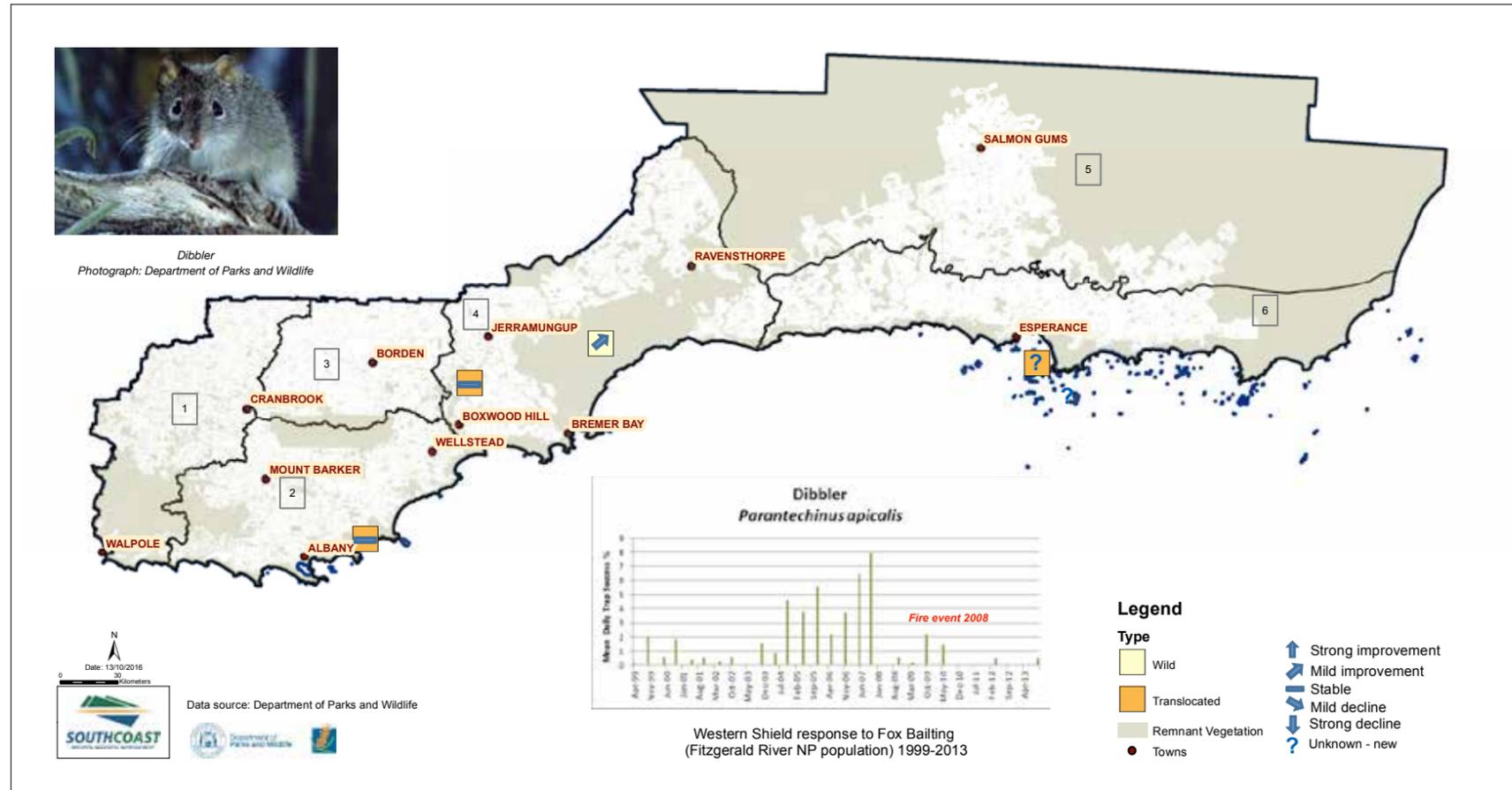


Figure 22: Dibbler status and trends in South Coast region

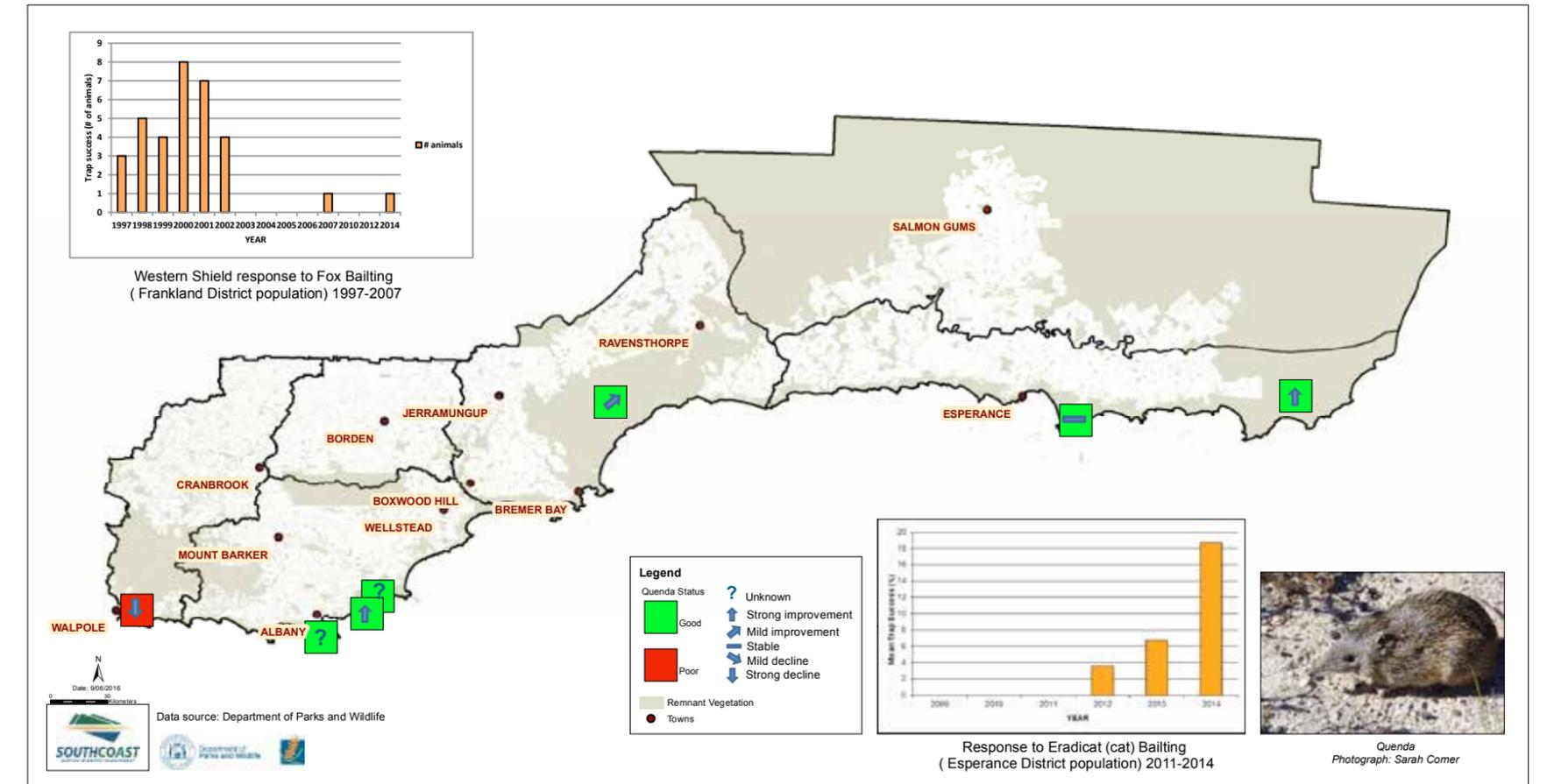


Figure 23: Quenda status and trends from autumn monitoring carried out at the Cape Arid Pasley site (Western Shield) in South Coast Region



### CASE STUDY 3

#### 4.4.6 BIRD DIVERSITY - RESPONSE TO REVEGETATION

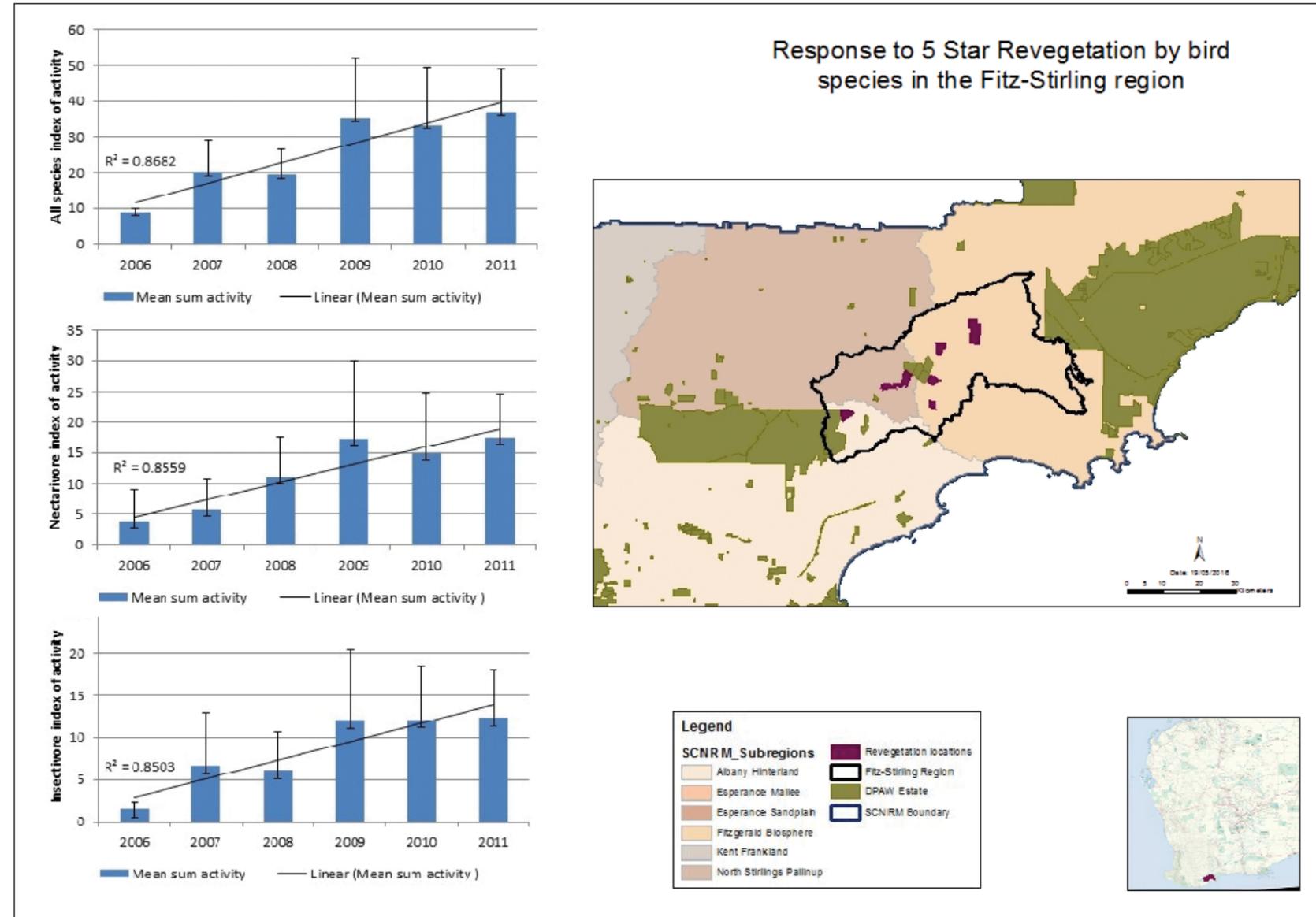
By Angela Sanders, Ecologist, Bush Heritage Australia

Revegetating, restoring and protecting habitat linkages are recognised as key strategies in biodiversity conservation as plants and animal populations that are divided or isolated by habitat loss and fragmentation are less likely to persist long term. Restoring ecological connectivity for the benefits of biodiversity is occurring at various scales across the region.

A comparison of bird species richness and activity in mallee heath remnant vegetation, regenerating mallee heath and revegetated sites was undertaken across several 5 star, high biodiverse revegetation projects implemented by Bush Heritage Australia in the Fitz-Stirling region. The monitoring and evaluation found that from 2007 onwards, insectivore activity and species richness in revegetation was equivalent to that in remnant and regenerating habitat. From 2009 onwards results of nectarivore activity indicate that the revegetated sites are actually performing better than remnant or regenerating sites. There was also a trend for higher richness of nectarivores in revegetated sites than remnant or regenerating sites across all years of the analysis (2007 to 2011). Methodologies for monitoring and analysis are provided in Sanders 2012.

*...the revegetated sites are actually performing better than remnant or regenerating sites.*

The trends indicate an increase in resource availability since the cessation of farming activities and the active planting and subsequent development of native vegetation on the sites. Prior to acquisition the cleared land on the properties had minimal resources available for birds - the growth of native plants has provided more energy for birds in the form of nectar, pollen, seed and invertebrates. This energy now stays in the system and is not harvested, as were the crops on the cleared land, which provides long-term sustainable resources for birds and other fauna. In addition it is likely that the revegetated sites provide more resources for birds than the long unburnt (at least 60 years for most remnant vegetation) mallee heath habitat.



## 4.5 WATER

Waterways are extremely significant features of the region, being integral to ecological, social and economic values for the community. The region includes 107 rivers and tributaries, 33 estuaries and over 300 conservation category wetlands.

Waterways are of particular importance to land and biodiversity values, as each of these is dependent on and influence protection and management of waterways. They provide essential ecological services, are used extensively by agriculture and provide critical water supplies including drinking water for the community. Waterways also have important recreational value for tourism, boating, recreational and commercial fishing and other industry uses, together with high intrinsic value for communities.

Waterways are also of central importance to Aboriginal spirituality, culture and identity, being an intricate part of the landscape used and valued in many interrelated ways.

### *Healthy waterways are critically important to sustaining a healthy environment.*

Threats to the health and condition of the waterways in the region include clearing, increased salinity, erosion, sedimentation and nutrient enrichment. Loss of riparian vegetation, pollution from various land uses, over-extraction and physical alteration of systems and floodplains will also impact water quality and availability.

Healthy waterways are critically important to sustaining a healthy environment. South Coast river, estuaries, wetlands and water resources are recognised as precious and it is important in a changing climate that they are maintained, protected, and/or restored. This will involve the community embracing the social, cultural, economic and environmental values of waterways and water resources.

The current condition of aquatic ecosystems was assessed using condition indicators for:

- Catchments, rivers and wetlands
- Estuaries

The current condition of water resources was assessed through the indicators:

- Total volume annual streamflow
- Water resource allocation
- Water quality



## 4.5.1 AQUATIC ECOSYSTEMS

### 4.5.1.1 THE FRAMEWORK FOR THE ASSESSMENT OF RIVER AND WETLAND HEALTH (FARWH)

In 2011 the Department of Water (DOW) released the project summary and results of the Framework for the Assessment of River and Wetland Health (FARWH) for south west Western Australia (SWWA). The framework was developed in order to provide a nationally standardised approach to freshwater river and wetland health assessment, to enable comparability between regions. Six themes of river and wetland health were considered.

Trials of the Framework were implemented through 2008 to 2010. These provide a baseline assessment of freshwater river health in the south west systems of the region and offer a protocol for further studies. Methodologies including indicator development, comparisons to existing assessments, score weightings/scaling and limitations are described in Storer et al, 2010.

Within the South Coast region the FARWH study assessed the Albany Coast and Denmark River South West Management Areas (SWMA). As such, the study does not represent the South Coast NRM Region systems at a regional scale.



Table 5: Description of FARWH Indices assessed in SWWA

FARWH indices	FARWH sub-indices	FARWH components
<b>Catchment Disturbance (CDI)</b>	<ul style="list-style-type: none"> <li>Infrastructure</li> <li>Land cover change</li> <li>Land use</li> </ul>	
<b>Water Quality (WQI)</b>	<ul style="list-style-type: none"> <li>Total nitrogen</li> <li>Total phosphorous</li> <li>Turbidity</li> <li>Salinity</li> <li>Diel dissolved oxygen</li> <li>Diel temperature</li> </ul>	
<b>Hydrological Change (HCI)</b>	<ul style="list-style-type: none"> <li>Flow stress ranking</li> </ul>	<ul style="list-style-type: none"> <li>Low flow</li> <li>High flow</li> <li>Portion of zero flow</li> <li>Monthly variation</li> <li>Seasonal period</li> </ul>
<b>Physical Form (PFI)</b>	<ul style="list-style-type: none"> <li>Longitudinal connectivity</li> <li>Erosion</li> <li>Artificial channel</li> </ul>	<ul style="list-style-type: none"> <li>Major dams</li> <li>Minor dams</li> <li>Gauging stations</li> <li>Road-rail crossings</li> <li>Erosion extent</li> <li>Bank stabilisation</li> </ul>
<b>Fringing Zone (FZI)</b>	<ul style="list-style-type: none"> <li>Extent of fringing zone</li> <li>Nativeness</li> </ul>	<ul style="list-style-type: none"> <li>Fringing vegetation width</li> <li>Fringing vegetation length</li> </ul>
<b>Aquatic Biota (ABI)</b>	<ul style="list-style-type: none"> <li>Macroinvertebrates</li> <li>Fish and Crayfish</li> </ul>	<ul style="list-style-type: none"> <li>WA Spring Channel Model O/E (AUSRIVAS)</li> <li>Expectedness                             <ul style="list-style-type: none"> <li>- O/E metric</li> <li>- O/P<sub>1</sub> metric</li> <li>- O/P<sub>2</sub> metric</li> </ul> </li> <li>Nativeness                             <ul style="list-style-type: none"> <li>- P<sub>Ab</sub> metric</li> <li>- P<sub>Sp</sub> metric</li> </ul> </li> </ul>

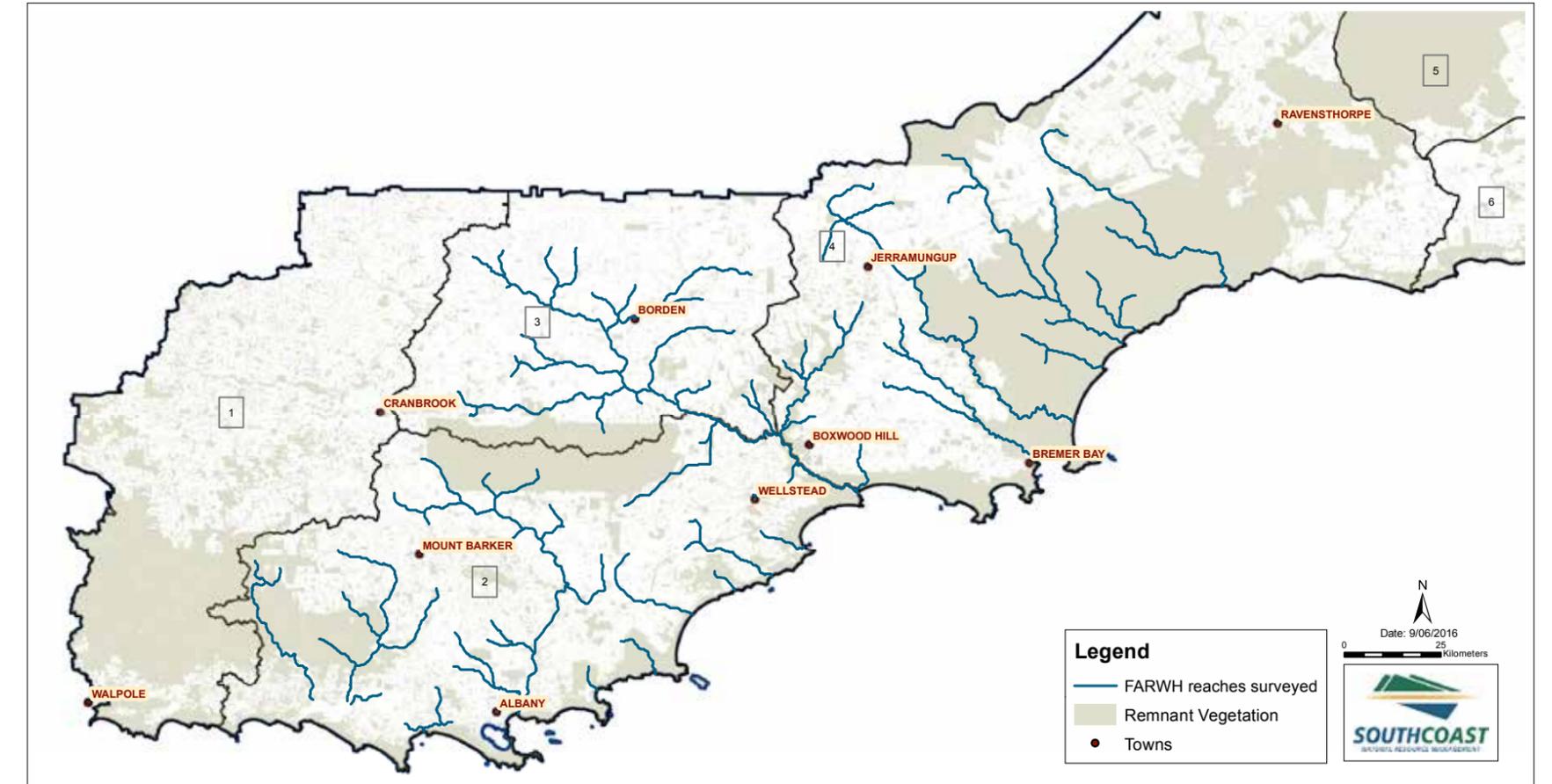
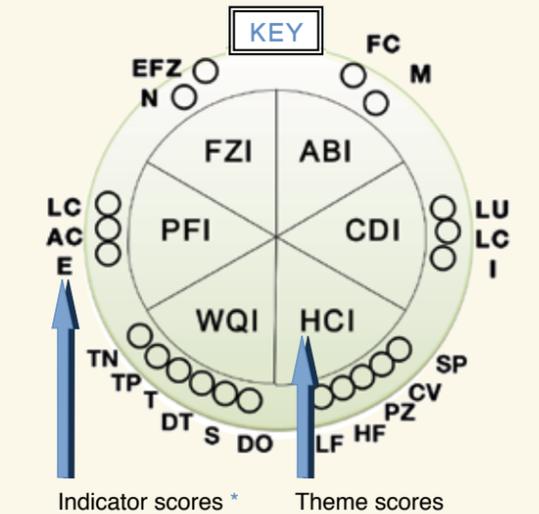
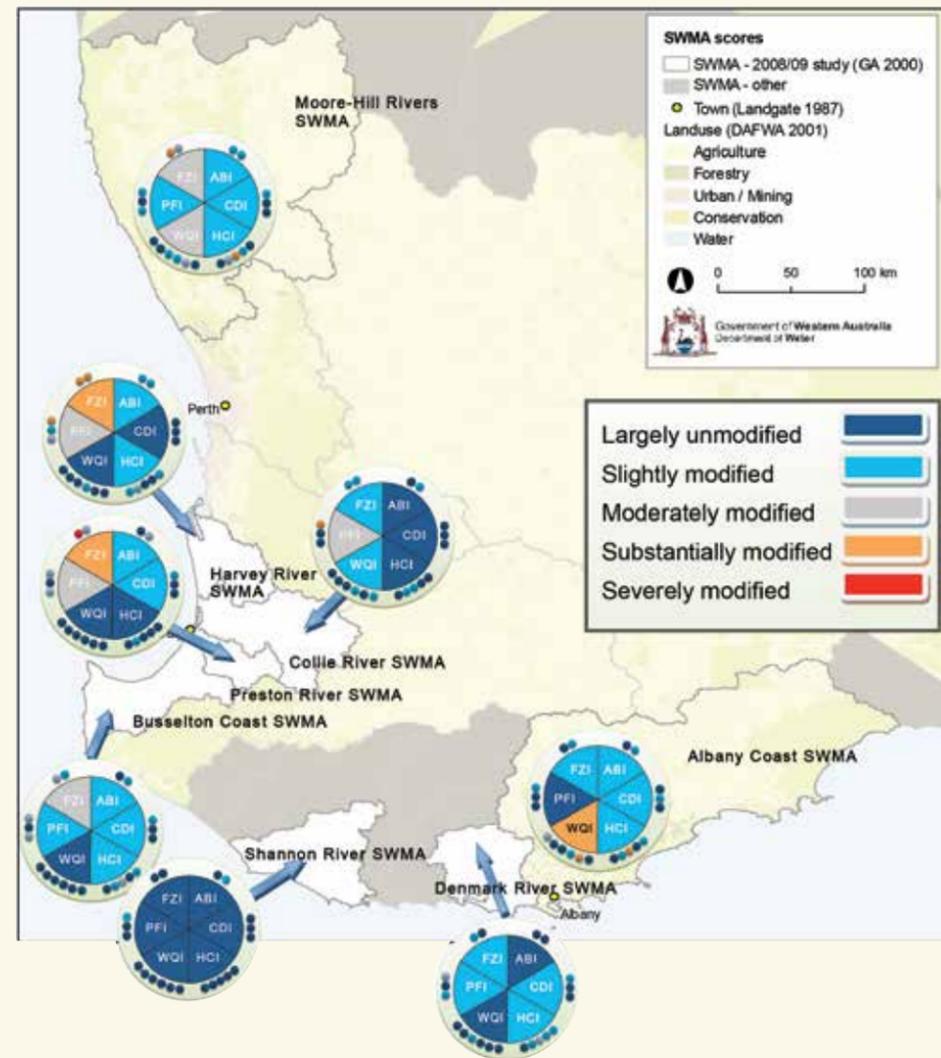


Figure 25: South Coast region reaches studied in the FARWH 2008-2010 survey



\* INDICATORS: PFI: LC (longitudinal continuity), AC (artificial channel), E (erosion). WQI: TN (total nitrogen), TP (total phosphorus), T (turbidity), DT (diel temperature), S (salinity), DO (dissolved oxygen). HCI: LF (low flow), HF (high flow), PZ (period zero flow), CV (coefficient of variation), SP (seasonal period). CDI: I (infrastructure), LC (land-cover change), LU (land use). ABI: FC (fish-crayfish), M (macroinvertebrates). FZI: N (nativeness), EFZ (extent fringing zone).

SWMA scores, assessed during the SWWA-FARWH trials (2008–10)

Figure 26: SWMA scores assessed during the FARWH surveys 2008-2010 (from Storer et al, 2011)

No one indicator was found to represent river health, supporting the benefits of a multi-parameter approach.

Looking more closely at the indicators from Figure 26 opposite, it can be seen that the Denmark River SWMA indicators\* for the themes of Water Quality and Aquatic Biota showed the systems largely unmodified, while analysis of the indicators for the themes of Physical Form, Fringing Zone, Catchment Disturbance and Hydrological Change showed slight modification.



Within the Albany Coast SWMA, river system analysis of indicators for the theme of Physical Form indicated largely unmodified, with Fringing Zone, Aquatic Biota, Catchment Disturbance and Hydrological Change all showing slight modifications. Assessment of indicators for Water Quality showed this theme to be substantially modified in the Albany Coast SWMA.

*No one indicator was found to represent river health, supporting the benefits of a multi-parameter approach.*



Cooper Bullock

#### 4.5.2 ECOLOGICAL VALUES REVIEW

In 2008, the Centre of Excellence in Natural Resource Management (CENRM) produced the results of studies of the ecological values of waterways in the South Coast Region (Cook, et al, 2008). This review included the development of a framework of criteria, indicators and measures of specified ecological values and survey of sites within 33 river catchments, and reflects current knowledge at the greatest regional scale available at present.

**Table 6: Developed Framework of criteria and indicators for assessing ecological value of water-ways - those used in the study are italicised (based on Cook, et al 2008)**

CRITERION	INDICATORS
<b>Naturalness (condition)</b>	<i>Level of catchment disturbance</i> <i>Level of riparian zone disturbance</i> <i>Level of river channel disturbance</i> <i>Level of flow modification</i> <i>Variation from natural state of water chemistry</i> <i>Variation from natural temperature regimes</i> <i>Variation from natural state of in-stream biota</i>
<b>Diversity or richness</b>	<i>Hydrological diversity</i> <i>Channel heterogeneity</i> <i>In-stream habitat heterogeneity</i> <i>Invertebrate diversity</i> <i>Vertebrate diversity</i> <i>Floral diversity</i>
<b>Rarity</b>	<i>Unusual hydrological regimes</i> <i>Unusual water quality types</i> <i>Rare geomorphological and habitat features</i> <i>Presence of threatened and priority species and communities</i> <i>Presence of 'flagship' species</i> <i>Presence of rare or endemic species</i>

Based on macro invertebrate data, the study classified the South Coast region into two broad bioregions:

(i) Western South Coast, consisting of river systems lying from the Gardner River in the west to Bluff River, and

(ii) Eastern South Coast, consisting of the Pallinup River through to the Thomas River in the east.

It was found that river systems of the Eastern South Coast (ESC) aquatic bioregion were significantly more saline, slightly more alkaline, and had higher levels of total nitrogen than those in the Western South Coast (WSC) aquatic bioregion. Levels of turbidity, dissolved oxygen and total phosphorus levels were similar in both bioregions.

Analysis of macro invertebrate species indicated greater species richness in the WSC bioregion compared to the ESC bioregion (29-135 species and 15-79 species, respectively). Average total species richness was significantly higher in the WSC bioregion, however, there were 'hotspots' of species richness in both regions. In the west these occurred within the Frankland Gordon, Kent, Hay and Marbellup river systems, while in the east within the Bremer and Phillips West river systems.

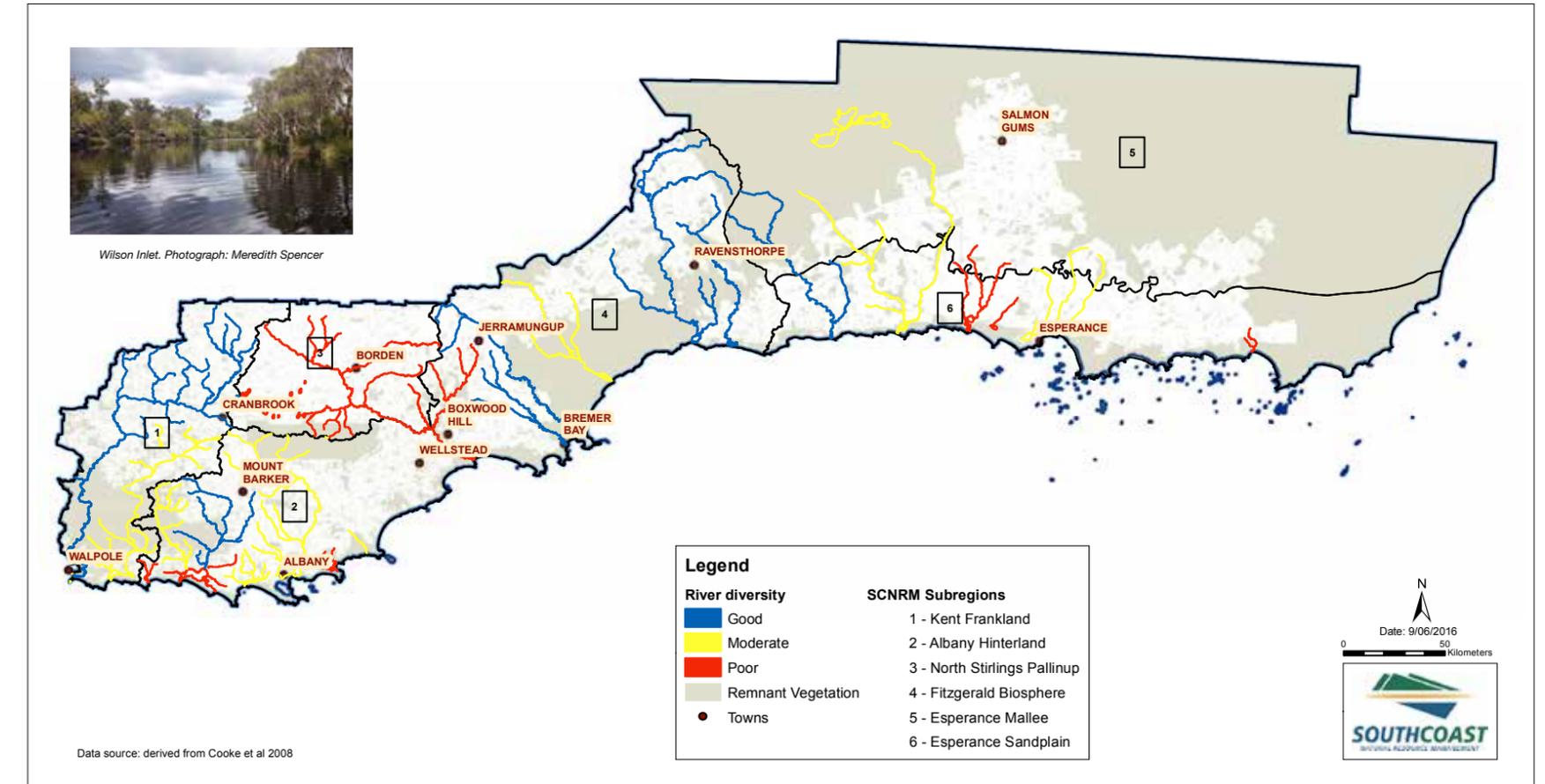
In the WSC bioregion, the rivers ranked highest for 'naturalness' were the Shannon, Deep and Denmark Rivers with the lowest ranked waterway in that bioregion being the Sleeman River. The Oldfield, Jerdacuttup and Gairdner Rivers were the highest ranked in the ESC bioregion, with Coobidge Creek ranked lowest.

The Shannon, Frankland Gordon and Gardner River systems were found to be the most diverse of the waterways in the WSC bioregion with Seven Mile Creek, Bluff Creek and Goodga River being least diverse. The Oldfield, Bremer and Jerdacuttup Rivers were the most diverse of the ESC systems, and again Coobidge Creek ranked lowest.

River systems in the WSC bioregion that ranked highest for rarity were the Shannon and Deep Rivers and Marbellup Brook while those in the ESC bioregion ranked highly for rarity were the Bremer, Gairdner, Fitzgerald and Phillips West Rivers.

Combining weighted scores for Naturalness, Diversity and Rarity and grouping them by percentage, three classifications of good (top 68-100%), moderate (34-67%) and poor (1 to 33%) were determined to illustrate overall catchment rankings (Neville, S., 2014).

Both the FARWH and CENRM assessments of river and wetland health considered similar indicators, however, the two studies covered different geographic scopes. Future investigations should consider both studies and synergies between the methodologies to produce one study at a regional scale that may be implemented to further assess desired indicators.



**Figure 27: South Coast waterway - diversity indicator (based on Cook et al 2014)**

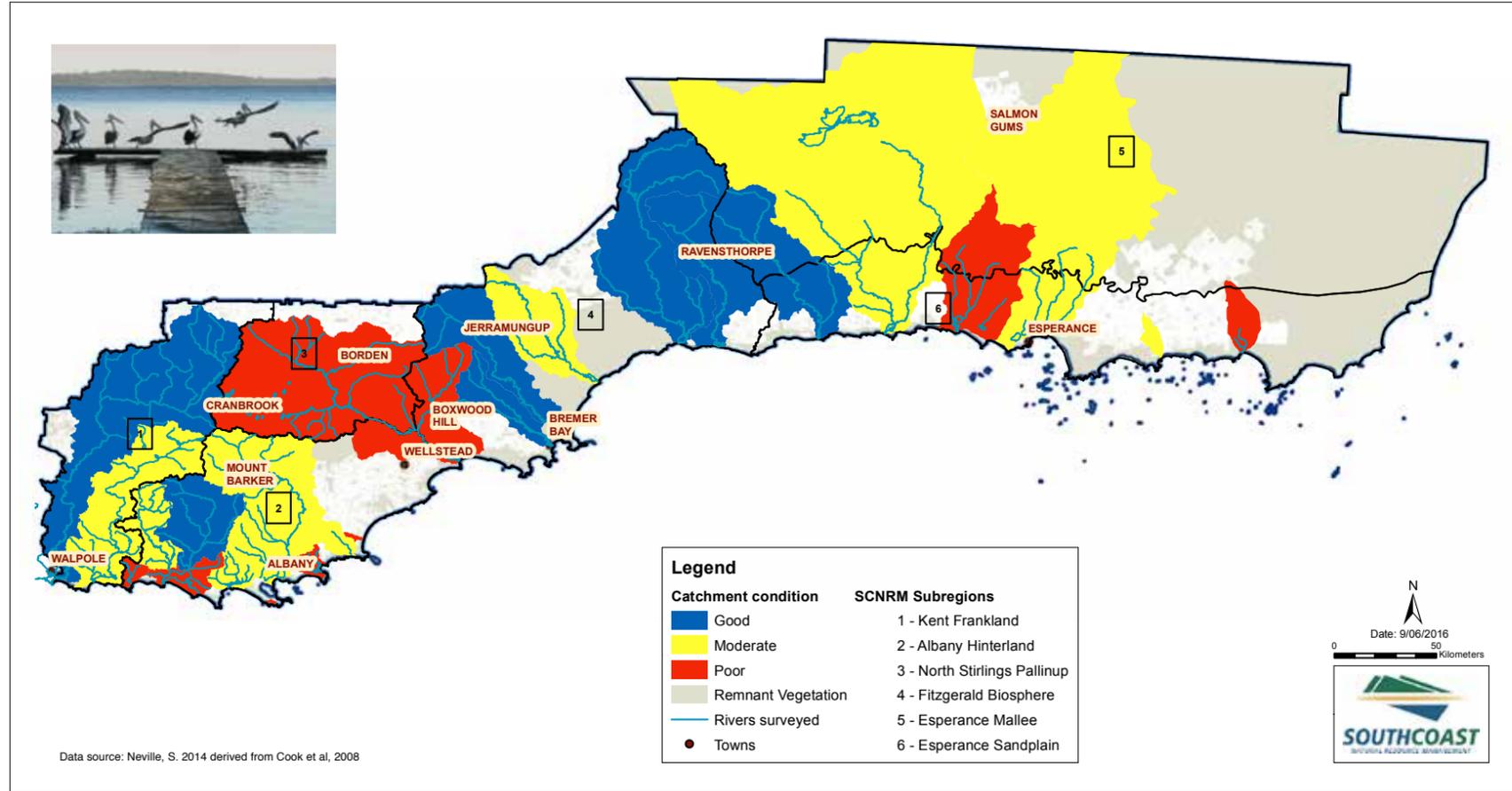


Figure 28: Overall catchment health (Neville, S., 2014, Cook et al, 2008)



### 4.5.3 ESTUARIES

Of the region's 33 estuaries and inlets, most are generally closed and only open to the Southern Ocean after heavy rainfall events or high seasonal water levels. Manual bar openings occur in some locations. Most are also wave dominated and classed as 'modified' based on Ozcoasts 2015 datasets. Predominant threats to estuary condition in the region are salinization, sediment runoff and substantial clearing of riparian and

adjacent vegetation. Classification methodologies are outlined in Heap et al, 2001.

Climate change modelling indicates that wave dominated bar heights may rise and there may be further reductions in natural openings. Greater sediment movement, reduced and more erratic river flows, heightened upstream salt wedges and de-oxygenation events, algal blooms and subsequent fish deaths are also forecast (South Coast NRM, 2011).

Table 7: Estuary classifications, condition and condition modifiers in South Coast region (Ozcoasts 2015)

BIOTA	CLASSIFICATION	CONDITION	CONDITION MODIFIERS
Barker Inlet	wave dominated	modified	salinisation, sediment runoff, substantial clearing
Beaufort Inlet	wave dominated	modified	nutrient loads, pesticides, substantial clearing, fish kills, periodic algal blooms, pest macro algae
Cheyne Inlet	wave dominated	modified	substantial clearing
Culham Inlet	wave dominated	extensively modified	
Dempster Inlet	wave dominated	modified	salinisation, sediment runoff, substantial clearing
Fitzgerald Inlet	wave dominated	largely unmodified	sediment runoff
Gordon Inlet	wave dominated	modified	salinisation, sediment runoff, substantial clearing, fish kills, pest macro algae
Hammersly Inlet	wave dominated	modified	salinisation, sediment runoff, substantial clearing
Irwin Inlet	wave dominated	largely unmodified	nutrient loads, salinisation, substantial clearing
Jerdacuttup Lakes	other	modified	salinisation, sediment runoff, substantial clearing
Normans Inlet	wave dominated	modified	sediment runoff, substantial clearing
Oldfield Estuary	wave dominated	modified	no data
Oyster Harbour	wave modified	extensively modified	nutrient loads, pesticides, substantial clearing, fish kills, periodic algal blooms, pest macro algae, seagrass loss
Parry Inlet	wave dominated	largely unmodified	nutrient loads, substantial clearing
Princess Royal	tide dominated	modified	nutrient loads, pesticides, substantial clearing, fish kills, periodic algal blooms, pest macro algae, seagrass loss
Saint Marys River	wave dominated	no assessment	
Stokes Inlet	wave dominated	modified	salinisation, sediment runoff, substantial clearing
Taylor Inlet	wave dominated	modified	nutrient loads, salinisation, substantial clearing
Torbay Inlet	wave dominated	modified	sewage treatment plant, pesticides, sediment runoff, substantial clearing, seagrass loss
Torrakup River	wave dominated	modified	salinisation, sediment runoff, substantial clearing
Waychinicup Inlet	tide dominated	modified	substantial clearing
Wellstead Estuary	wave dominated	modified	substantial clearing, algal blooms
Wilson Inlet	wave dominated	modified	nutrient loads, substantial clearing, weed infestation

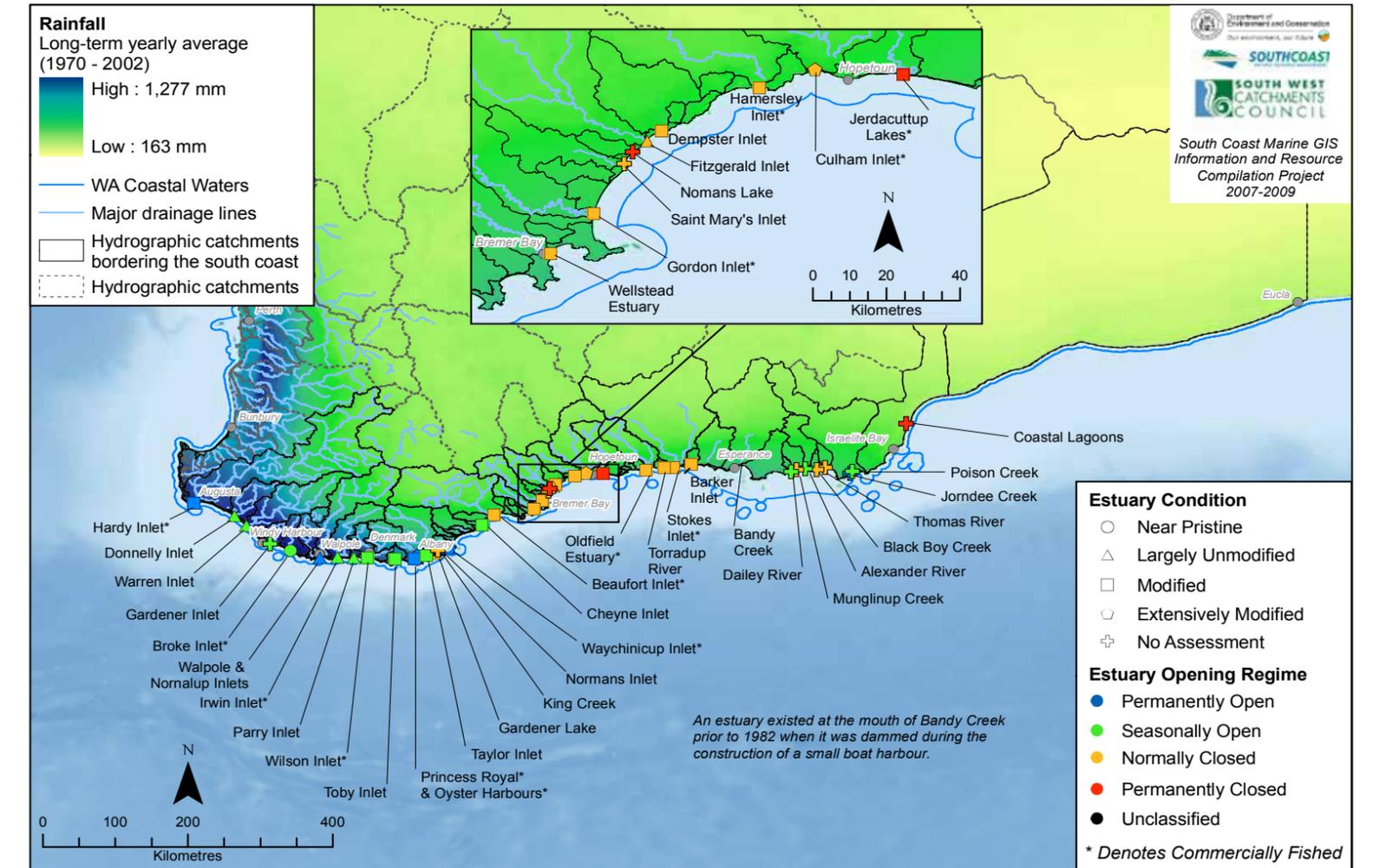


Figure 29: Estuary location classification (from Department of Environment & Conservation (DEC) 2009)

## 4.5.4 WATER RESOURCES

### 4.5.4.1 STREAM FLOW

The indicator of total annual streamflow was assessed for the water resources condition. Reductions in rainfall and runoff have been observed since the 1970s and have influenced declining streamflow over the southwest Western Australia. Typically, a 1% change in mean annual rainfall may result in a 2-3% change in mean annual runoff (DOW 2010). Understanding and assessing the changes in mean annual streamflow is important for water planning and therefore several studies have been undertaken to identify trends and causal factors. Alteration to the natural flow regimes of rivers and streams is also recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems.

During the 1970s a significant reduction in rainfall occurred. Analysis of data does not appear to show a further significant reduction in rainfall since that time, although the situation is complex with no uniform trend. Further, while the rainfall reductions may not be large, rainfall distribution and intensity may affect streamflow.

*Reductions in rainfall and runoff have been observed since the 1970s and have influenced declining streamflow over the southwest Western Australia.*

Using data from stream gauging stations collected since 1975, the Department of Water (DOW) determined that, while a majority of stations experienced a decline, most were not statistically significant and some showed slight increases in flow. The selected gauging stations reflect those monitored for water supply purposes (rather than environmental) and therefore in the South Coast region include those from Walpole to Waychinicup as shown. The methodologies used are reported in DOW (2009) and effects of climate change on streamflow are discussed in DOW (2010).

The research also indicated a shift in the peak flow month to one month later than average across all sites in the southwest.

In addition to rainfall decline, other factors may impact streamflow including:

- Increased surface-water and groundwater use
- Declining groundwater levels – from abstraction and/or reduced rainfall and association infiltration

- Land use change – Disturbances including drought, fires, clearing and plantations
- Farm dams and regulated catchments - dams or rivers with manipulated/managed flow releases may inhibit natural streamflows

*The research also indicated a shift in the peak flow month to one month later than average.*

This assessment has used total annual streamflow volumes, however, a more sensitive array of hydrological indicators that indicate change in streamflow volumes over time (e.g. frequency, duration, magnitude, timing, predictability and variability of flow events) should be considered for future indicator development. These form a component of the FARWH assessment and it is suggested that the hydrological change indicators be assessed for potential region wide application.

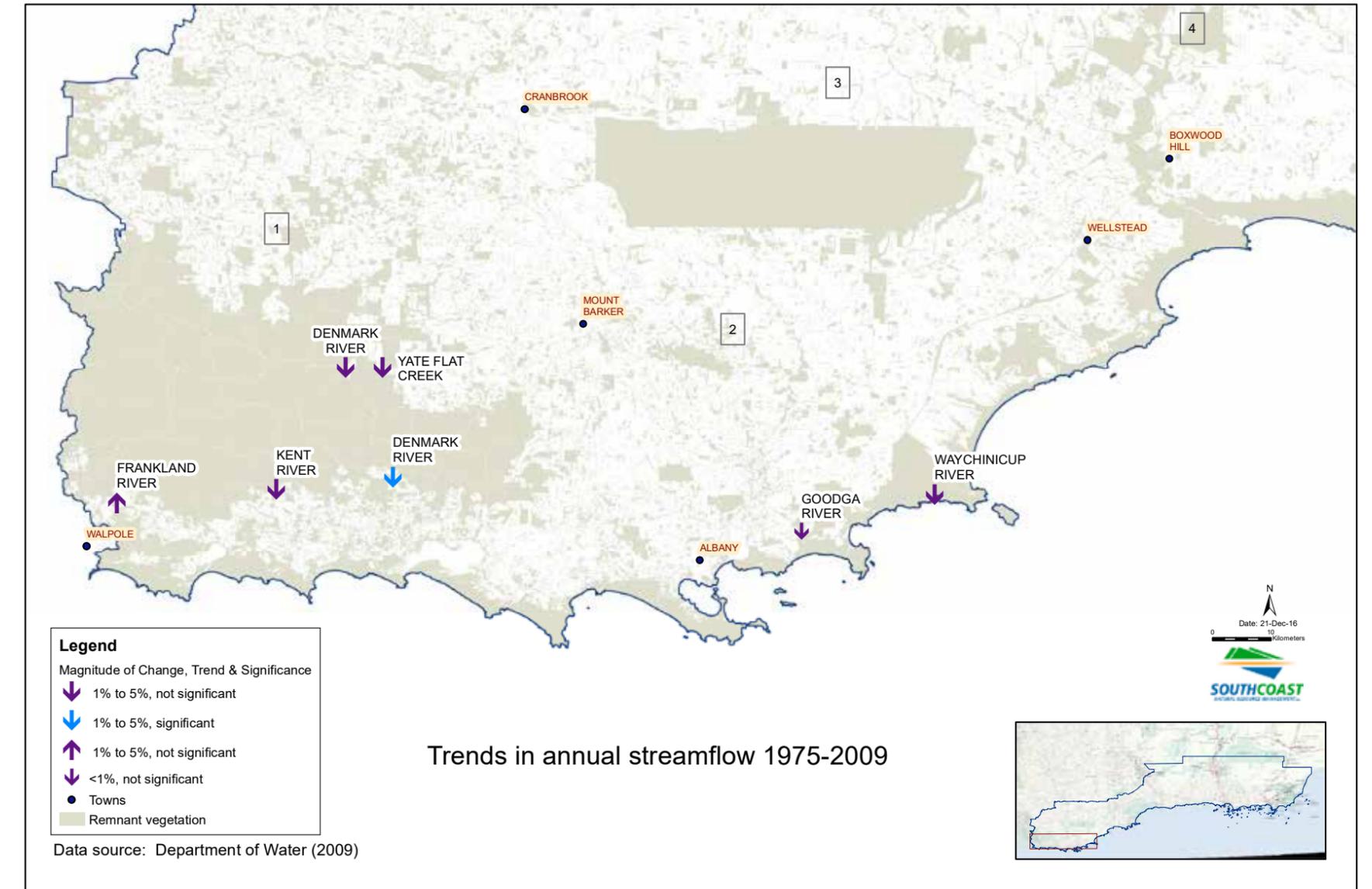


Figure 30: Streamflow trends in South Western Australia

## 4.5.5 SURFACE AND GROUND WATER ALLOCATION

### 4.5.5.1 SURFACE WATER

This indicator is assessed by the level of allocation relative to allocation limits.

The South Coast region includes over 50 small, southward flowing rivers that are generally fresh and perennial in the west and more intermittent and saline towards the east and inland.

In the South Coast region surface water use is relatively low and few surface waterbodies are proclaimed (and licensed). Albany, Denmark and Walpole town water supplies use local surface water. For Albany and Mount Barker surface water supplements the principally groundwater sourced Lower Great Southern Town Water Supply Scheme.

### *The South Coast region includes over 50 small, southward flowing rivers...*

Smaller Hinterland towns rely on harvested surface water (bitumen or roaded catchments) and may require cartage of water during dry seasons. A number of inland towns are connected to the Great Southern towns water supply scheme which is supplied from Harris Dam, near Collie. Surface water is also used for irrigation in some

areas, however, these are not currently proclaimed (DOW, 2014).

In unproclaimed areas a sustainable diversion limit methodology is applied to determine abstraction volumes.

Data was limited to that collected by the DOW (2014) and only available for the southwest of the region.

### 4.5.5.2 GROUNDWATER AND SALINITY

This indicator is assessed by level of allocation relative to allocation limits and groundwater salinity.

Across the region groundwater resources occur within the Bremer Basin, a narrow and relatively small, layered sedimentary basin. Groundwater quality varies, and is either stable or with slight declining trends, although these fluctuate seasonally. Groundwater abstraction is licensed in proclaimed areas under Western Australia's *Rights in Water and Irrigation Act 1914*.

Investigations are underway into the potential use of the superficial and sedimentary (Middle Sand and Werrillup) aquifers of the Bremer Basin for future supplies (DOW, 2014). It is noted that data is limited to the south west of the region, although regional groundwater trends determined by DAFWA (2013) are shown in Section 4.3.5, Figure 13.

Table 8: Great Southern Region surface water resources and their status (from DOW, 2014)

SURFACE WATER MANAGEMENT AREA	RESOURCE DESCRIPTION	ALLOCATION LIMIT (SUM OF ALL COMPONENTS) ML/YEAR	FURTHER WATER AVAILABLE ML/YEAR	AVERAGE STREAM SALINITY RANGE WITHIN PLANNING UNIT mg/LTDS	AVERAGE ANNUAL STREAMFLOW TREND	LEVEL OF TECHNICAL INFORMATION
Albany Coast	Rivers & tributaries	Not set	-	0 - 35000	Declining	Initial
Nornalup	Rivers & tributaries	Not set	-	0 - 35000	Declining	Initial
Kent	Rivers & tributaries	Not set	-	0 - 35000	Declining	Initial
Denmark	Rivers & tributaries	Not set	-	0 - 35000	Declining	Medium
<b>Totals</b>		<b>Not set</b>	-			





Table 9: Shallow groundwater resources and their status (from DOW, 2014)

GROUNDWATER SUBAREA	AQUIFER	ALLOCATION LIMIT (sum of all components) ML/YEAR <sup>1</sup>	FURTHER WATER AVAILABLE ML/YEAR <sup>2</sup>	SALINITY RANGE Mg/L TDS	WATER LEVEL TREND	LEVEL OF TECHNICAL INFORMATION
<b>Bremer Bay Groundwater Area</b>						
Bremer Bay	Bremer West - Superficial	200	21	500 - 1000	Stable	Medium
<b>Albany Groundwater Area</b>						
Marbelup	Bremer West - Superficial	135	0	No Data	No Data	Medium
Grassmere	Bremer West - Superficial	75	2	0 - 500	Stable	Medium
Racecourse	Bremer West - Superficial	850	0	No Data	No Data	Medium
Prison	Bremer West - Superficial	1205	113	No Data	No Data	Medium
Sandpatch	Bremer West - Superficial	1750	3	No Data	No Data	Medium
Frenchmans Bay	Bremer West - Superficial	30	12	No Data	No Data	Medium
<b>Totals</b>		<b>4245</b>	<b>151</b>			

<sup>1</sup> Allocation limits are under review following recent resource investigations. <sup>2</sup> Water available for general purpose licensing from the general allocation limit component as of June 2012

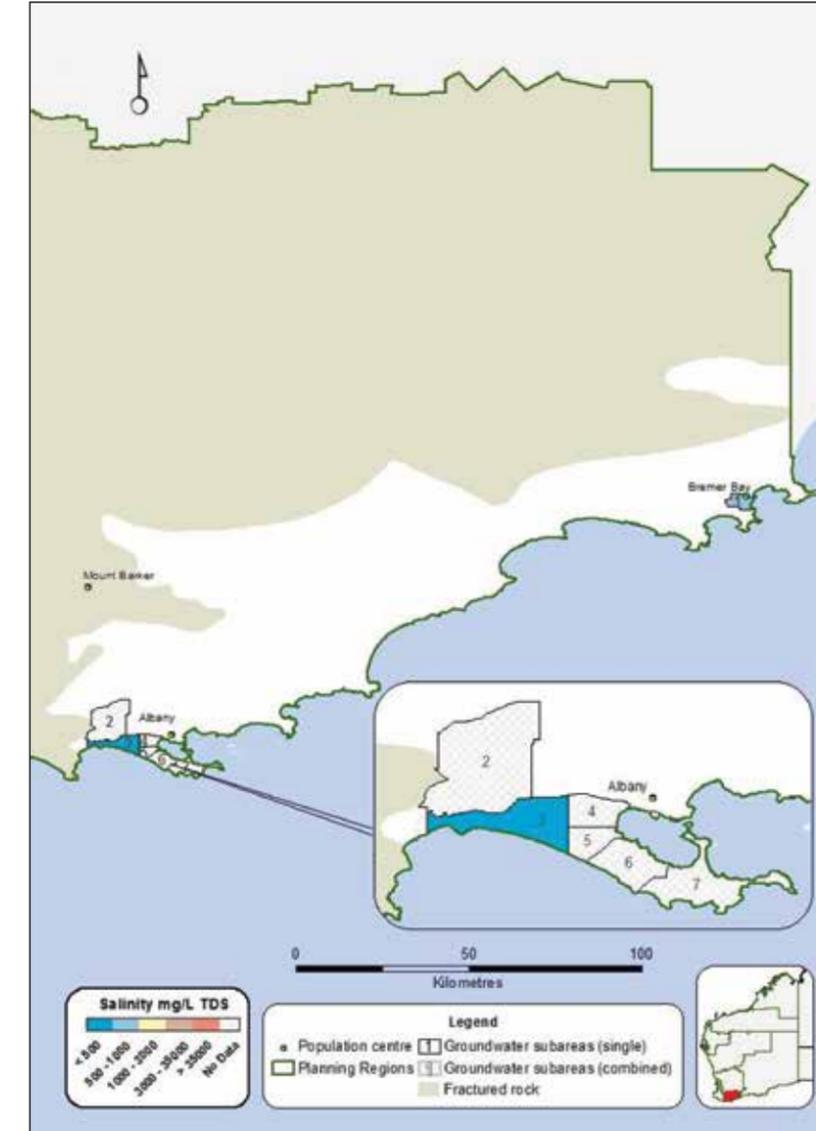


Figure 31: Great southern region shallow groundwater resources and water quality (from DOW 2014)





Table 10: Middle groundwater resources and their status (from DOW, 2014)

MAP LEGEND	GROUNDWATER SUBAREA	AQUIFER	ALLOCATION LIMIT (sum of all components) ML/YEAR <sup>1</sup>	FURTHER WATER AVAILABLE ML/YEAR <sup>2</sup>	SALINITY RANGE Mg/L TDS	WATER LEVEL TREND	LEVEL OF TECHNICAL INFORMATION
<b>Bremer Bay Groundwater Area</b>							
1	Bremer Bay	Bremer West - Sedimentary	30	30	500 - 1000	Stable	Medium
<b>Albany Groundwater Area</b>							
2	Marbelup	Bremer West - Sedimentary	Not set	-	No Data	No Data	Initial
3	Grassmere	Bremer West - Sedimentary	1500	0	0 - 500	Stable	Medium
4	Racecourse	Bremer West - Sedimentary	Not set	-	0 - 500	Stable	Medium
5	Prison	Bremer West - Sedimentary	Not set	-	0 - 500	Stable	Medium
6	Sandpatch	Bremer West - Sedimentary	Not set	-	0 - 500	Stable	Medium
7	Frenchmans Bay	Bremer West - Sedimentary	900	0	No Data	No Data	Medium
<b>Totals</b>			<b>2430</b>	<b>30</b>			

<sup>1</sup> Allocation limits are under review following recent resource investigations. <sup>2</sup> Water available for general purpose licensing from the general allocation limit component as of June 2012

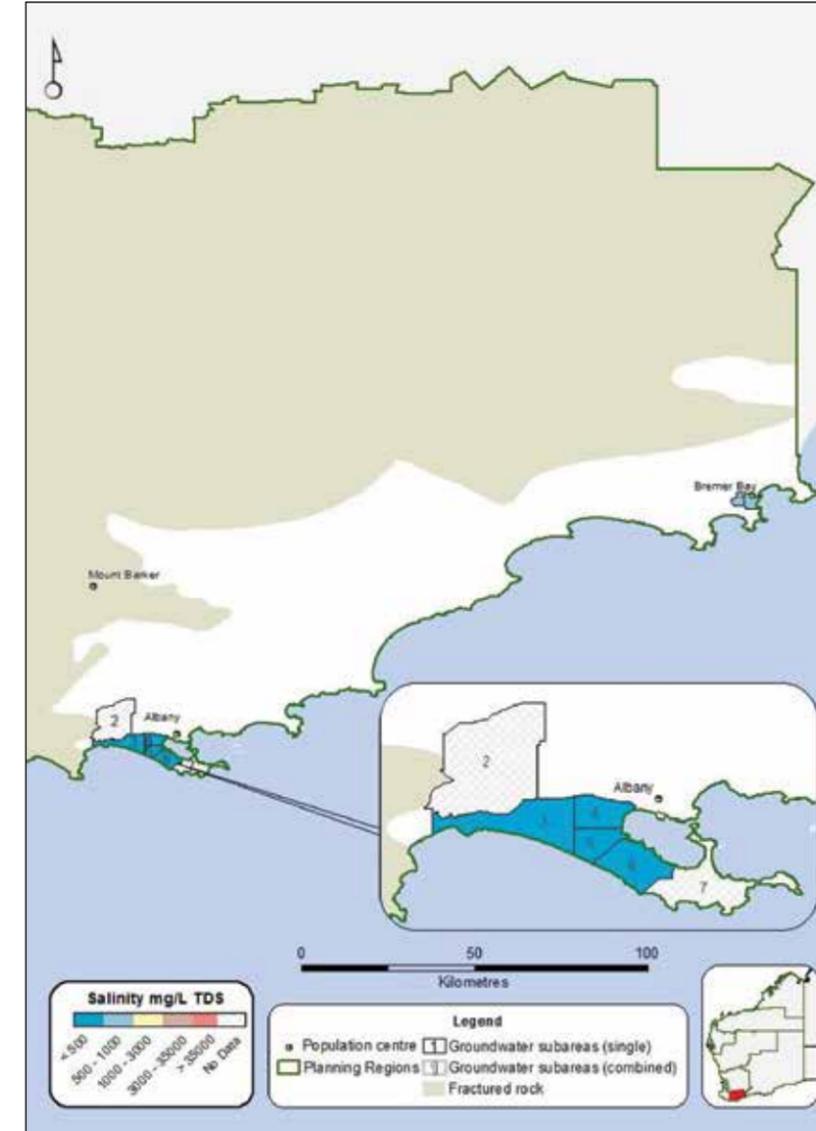
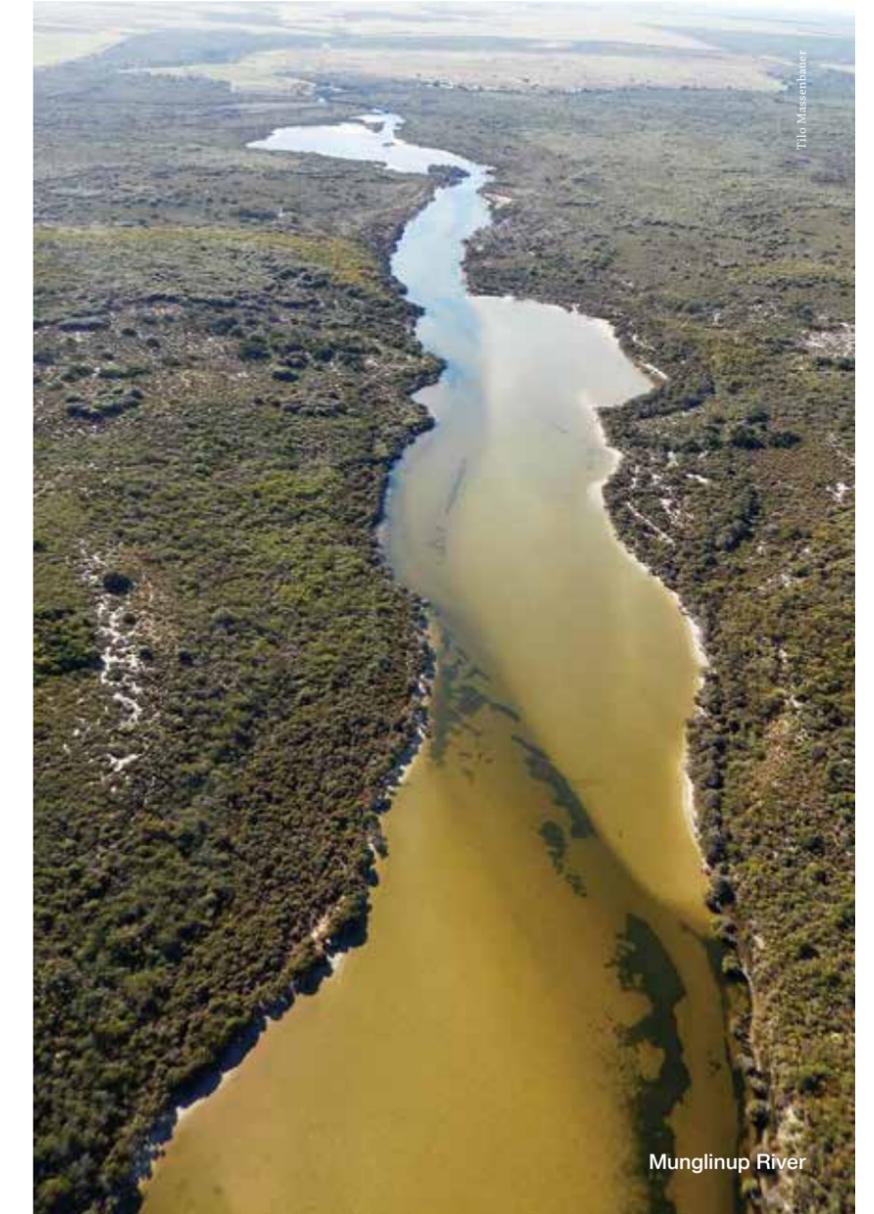


Figure 32: Great southern region middle groundwater resources and water quality (from DOW 2014)



Munglinup River

## 4.6 COASTAL AND MARINE

The coastal and marine theme asset was assessed through the indicators:

- Coastal vegetation extent
- Diversity of benthic habitat
- Sea level, sea surface temperature and acidification
- Seabirds

The coastline of the South Coast region is spectacular, extending for approximately 1,000 kilometres and encompassing a great diversity of landforms and marine environments. The greatest densities of population within the region occur within the coastal settlements of Albany, Esperance, Denmark, Bremer Bay, Hopetoun and Walpole (South Coast NRM, 2011).

Offshore islands provide critical habitat, breeding and resting sites for many species of seabirds including albatross, petrels, shearwaters, penguins and the endangered Cape Barren goose, together with two species of marine mammals (the Australian sea lion and New Zealand fur seal). They are highly valued culturally from both Indigenous and European perspectives (South Coast NRM, 2011).

### 4.6.1 COAST VEGETATION EXTENT

The coastal and marine environments of the South Coast region include a high proportion of reserved land, with approximately 70% of the coastal strip included in conservation estate. The almost continuous strip of intact coastal native vegetation along the south coast is a very high priority east-west corridor, significant in spatial scale and its links between areas of high conservation value. The coastal corridor is only broken at the City of Albany and town of Esperance, and to a lesser extent at Denmark, Bremer Bay and Hopetoun (South Coast NRM, 2011).

*At least 7 of the 10 priority ecological communities occurring with the South Coast coastal corridor are in decline.*

The coastal terrestrial reserves represent very significant habitat refuges. In particular Two Peoples Bay Nature Reserve, Cape Arid and Fitzgerald River National Parks provide habitat for a high number of endemic and threatened species and communities. These include Gilbert's Potoroo, Dibbler and the Western Ground Parrot (section 4.4.5).



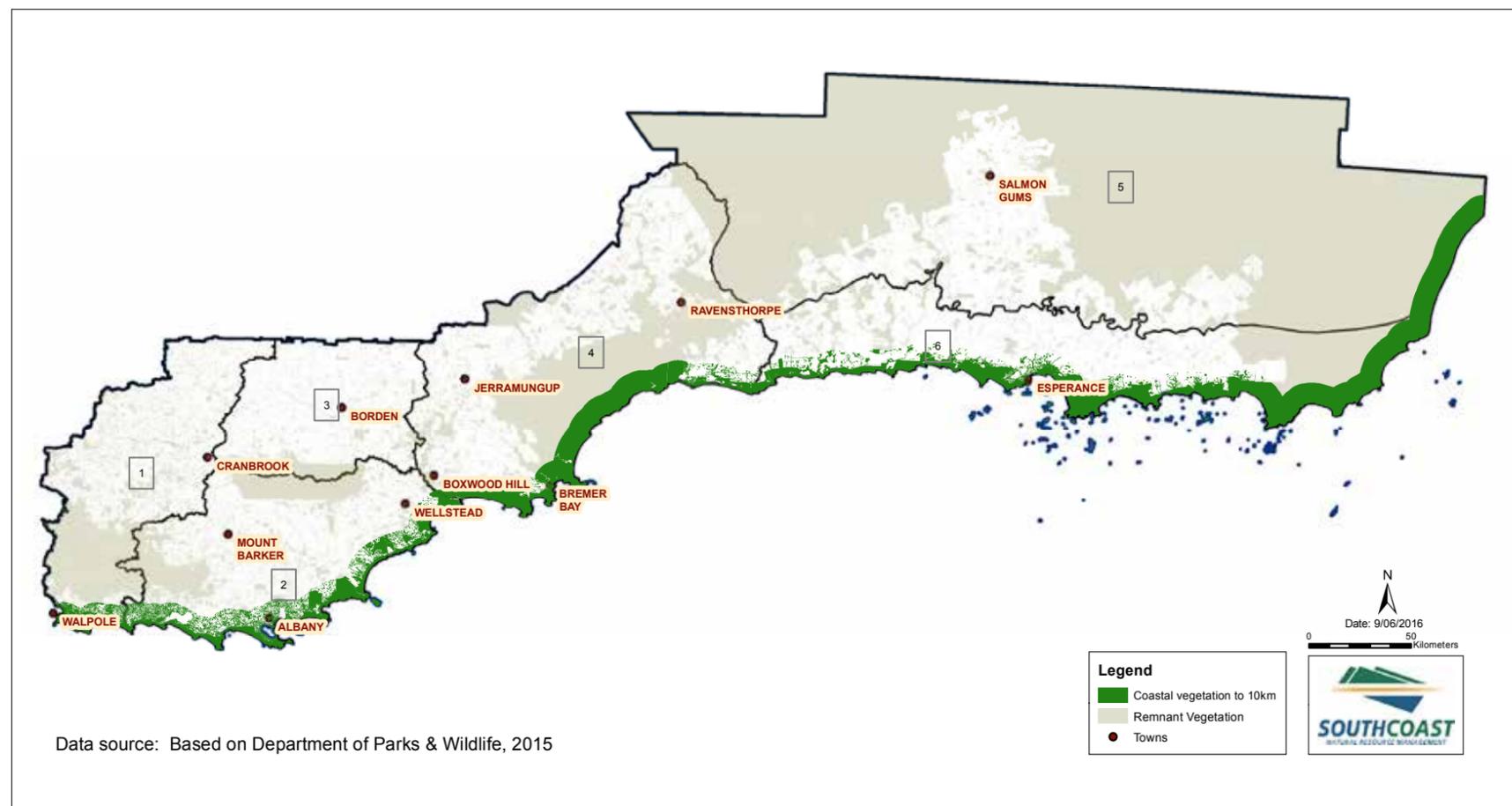


Figure 33: Coastal vegetation extent to 10 kilometres, extracted from the native vegetation extent layer



The coastal corridor also includes threatened flora and vegetation communities including the nationally protected 'Subtropical and Temperate Coastal Saltmarsh' and 'Proteaceae Dominated Kwongan Shrubland of the southeast floristic province of Western Australia' threatened ecological communities, together with 10 priority ecological communities. At least 7 of the priority ecological communities occurring with the South Coast coastal corridor are in decline (Sarah Barrett, pers. comm., 2015).

All coastal environments are part of a fragile but dynamic ecosystem. Because of this, removal of vegetation can have far reaching effects. The integrity of the corridor is threatened by Phytophthora Dieback (section 4.4.3), *Armillaria luteobubulina*, aerial canker, degradation from recreational use (e.g. coastal erosion, fragmentation and spread of disease by off-road vehicles), grazing, inappropriate fire, changes to hydrology and the introduction of exotic plant and animal species. Alternative land use pressures (e.g. clearing for development) also reduce the ecological values of the coastal corridor.

#### 4.6.2 DIVERSITY OF BENTHIC HABITAT

A comprehensive broad-scale scientific research project, 'Securing WA's Marine Futures (2006 – 2008)' (Radford et al., 2008), mapped and surveyed 510km<sup>2</sup> of benthic habitat across four sites (Broke Inlet, Mount Gardner, Point Anne and Middle Island) along the South Coast during 2006-2008. Quantitative biodiversity assessments of primary producers, invertebrates and fish were undertaken through towed video, drop cameras, Baited Remote Underwater Videos (BRUVs) and benthic trawls. The quantity and quality of baseline information gathered through this project has set a benchmark of resource condition and will allow effective and strategic monitoring of marine community assemblages (South Coast NRM, 2011).

The project demonstrated that the temperate marine environment of the South Coast has high biodiversity values. Endemism is also high, particularly amongst invertebrates such as sponges (e.g. 78 of the 156 sponge species recorded were new discoveries) (South Coast NRM, 2011).

*The temperate marine environment of the South Coast has high biodiversity values. Endemism is also high, particularly amongst invertebrates such as sponges.*

Table 11: Percentage proportions of component benthic biota at location

% OF VIDEO IDENTIFICATIONS	SITE			
	BROKE INLET	MIDDLE ISLAND	MOUNT GARDNER	POINT ANNE
BIOTA				
Invertebrates	54.30%	27.20%	75.30%	22.90%
Invertebrates Hard Coral	0.15%			
Subtotal	54.45%	27.19%	75.32%	22.88%
Kelp	12.20%	0.49%	13.70%	8.70%
Kelp Hard Coral			1%	
Kelp Invets	0.22%	0.01%	0.30%	
Kep Other Algae	6.70%	0.71%	0.19%	0.10%
Kelp Other Algae Invertebrates	0.50%	0.04%	0.02%	
Kelp Rhodoliths				
Kelp Seagrass				
Subtotal	19.10%	1.26%	15.23%	8.75%
No Biota				
Other Algae	10.70%	45%	2.20%	17.30%
Other Algae Hard Coral				
Other Algae Invertebrates	10.70%	17%	2.10%	6.50%
Other Algae Rhodoliths		2.40%		0.10%
Other Algae Rhodoliths Invertebrates		0.40%		0.10%
Other Algae Seagrass		0.60%	0.26%	1.40%
Other Algae Seagrass Invertebrates				
Subtotal	21.37%	65.40%	4.56%	25.32%
Rhodoliths	3.70%	5%	1%	30.60%
Rhodoliths Invertebrates	1%	0.20%		1.10%
Subtotal	4.67%	5.21%	1.01%	31.70%
Seagrass		0.80%	3.9	11.30%
Seagrass Invertebrates		0.20%		
Subtotal		0.95%	3.87%	11.35%
Total N	64807	61739	53515	38052

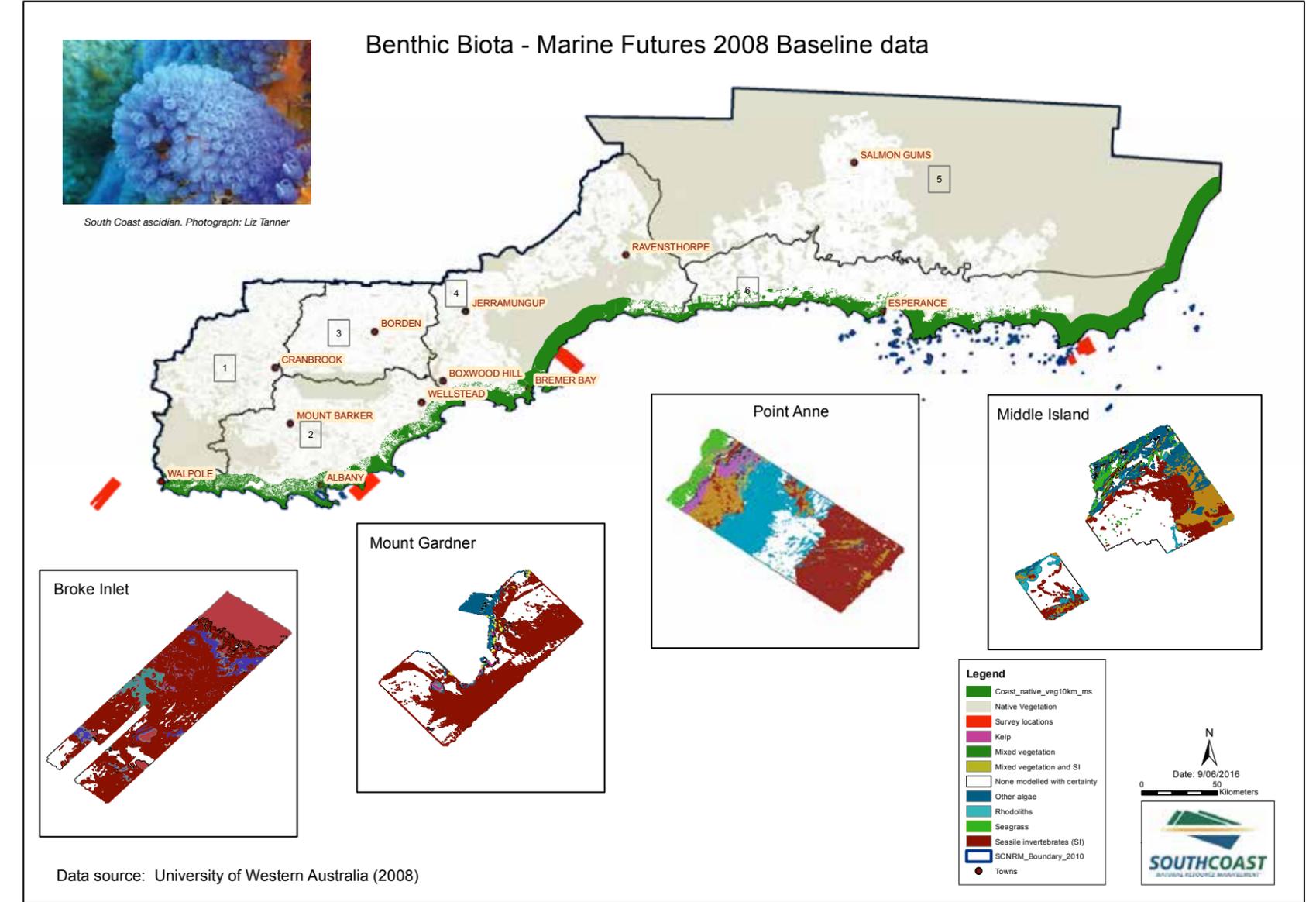


Figure 34: Benthic habitat mapping at four locations within the South Coast region

### 4.6.3 SEA LEVEL, SEA SURFACE TEMPERATURES AND ACIDIFICATION

#### 4.6.3.1 SEA LEVEL RISE

Hope et al (2015) note that between 1966 and 2009 relative sea level has risen nationally at an average 1.4mm/year and that there is a very high confidence that sea levels will continue to rise. Rising sea levels lead to large increases in coastal flooding and beach erosion. In the South Coast region, a rise of approximately 4.6mm between 1990 and 2010 has been identified.

Modelling predicts rises of 0.28m to 0.84m by the end of the century with a likelihood of 66% probability. It is noted, however, that should the marine based sections of the Antarctic ice sheet collapse, sea level rises could be significantly higher (Hope et al, 2015).

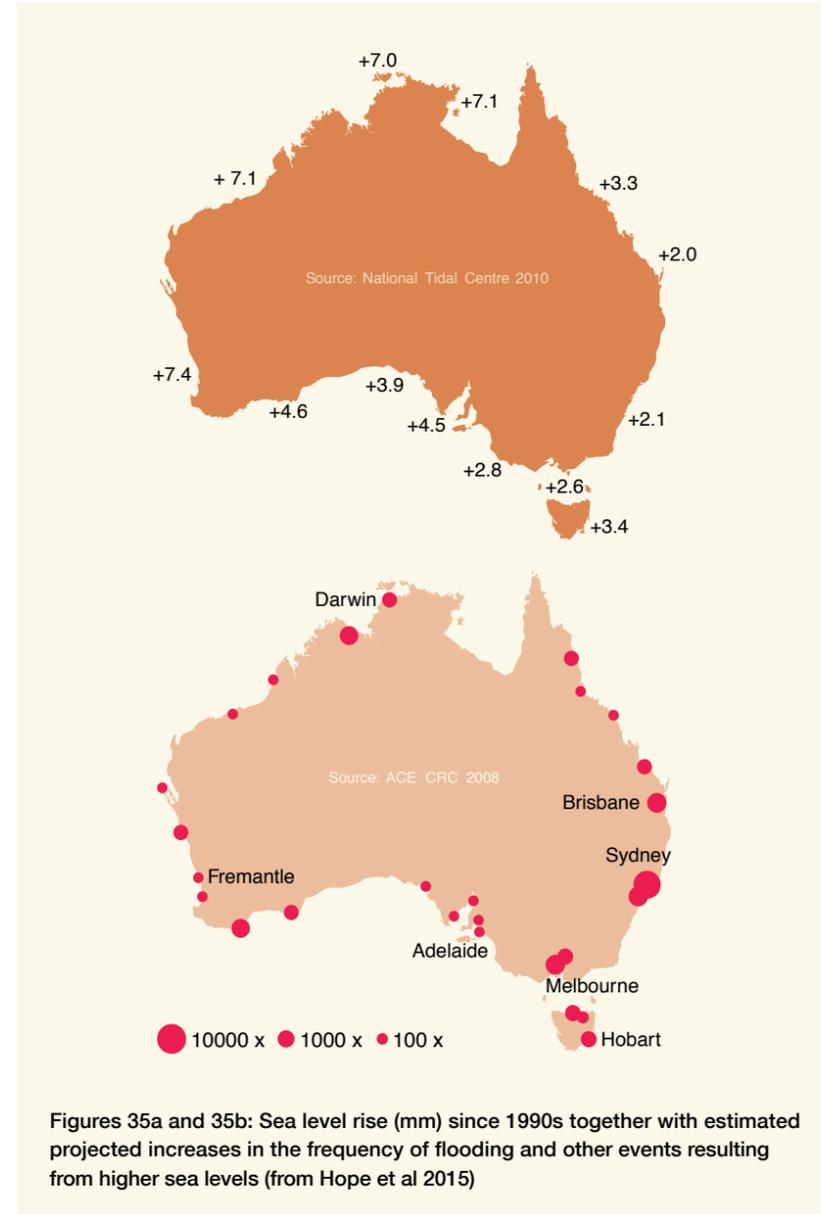
Because of uncertainty regarding the magnitude of sea level change, Hope et al (2015) suggest an indicative extreme sea level 'allowance', being the vertical distance along the coastline necessary to protect assets from potential rising sea level impacts. These range from 11cm in 2030 to 76cm by 2090.

*Rising sea levels lead to large increases in coastal flooding and beach erosion.*



#### 4.6.3.2 SEASURFACE TEMPERATURE

Sea surface temperature has risen significantly over recent decades and is projected, with very high confidence, to continue to increase. In our region, forecasts indicate warming in the range of 1.5 to 3.9°C by 2090. Increases in sea surface temperature threaten the marine environment through impacts to marine species through changes in distribution, abundance and community structure of marine life (Hope et al, 2015)



Figures 35a and 35b: Sea level rise (mm) since 1990s together with estimated projected increases in the frequency of flooding and other events resulting from higher sea levels (from Hope et al 2015)

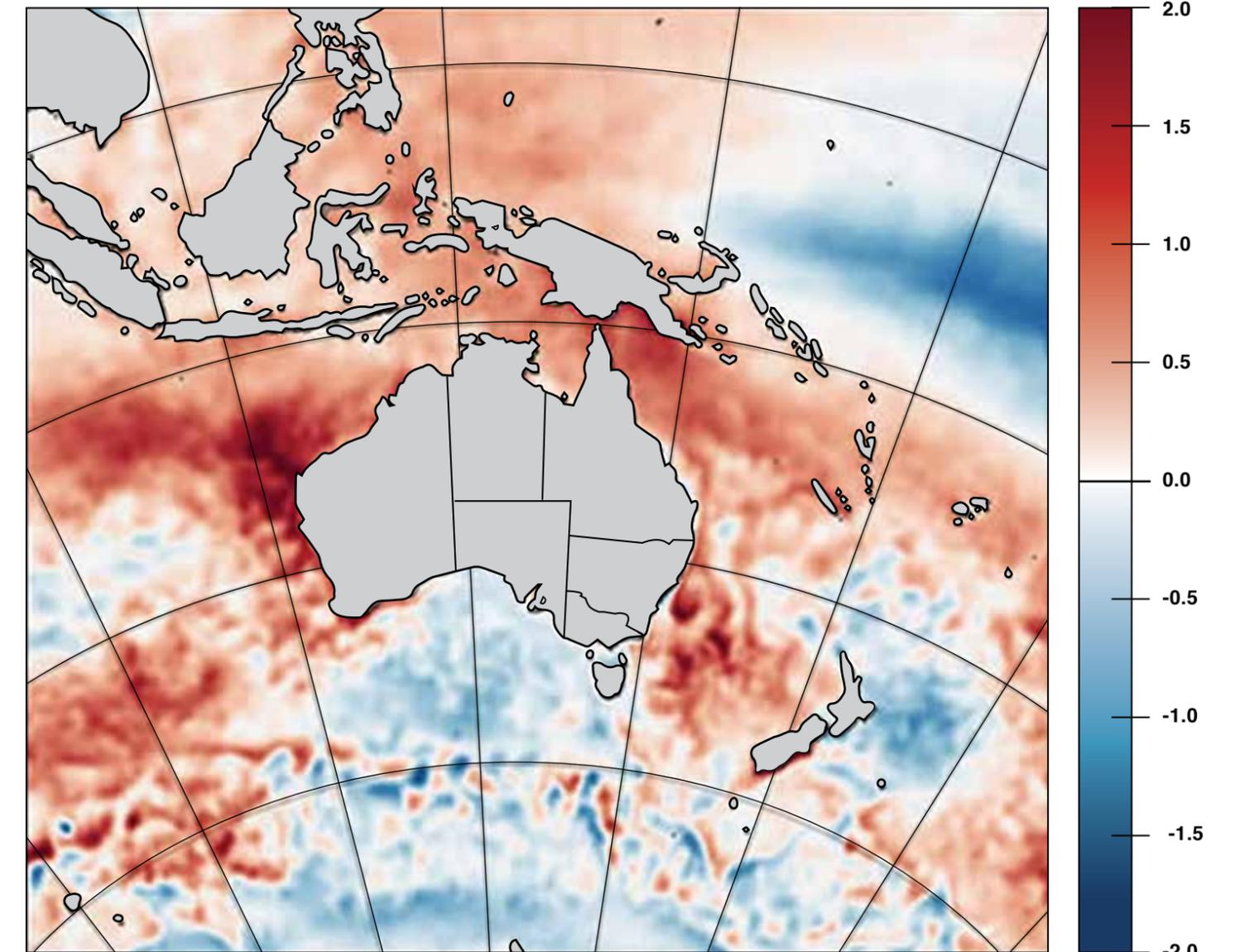


Figure 36: Sea surface temperature anomalies (°C) in the Australian region, May 2010 to April 2011 (BOM, nd)

### 4.6.3.3 ACIDIFICATION

Acidification of the oceans caused by absorption of anthropogenic carbon dioxide has led to a 0.1pH fall in oceanic surface water pH, which equates to a 26% increase in acidity (Hope et al, 2010). Acidification threatens the ability of marine organisms such as corals, oysters and some plankton to form shells or skeletons. Shellfish fisheries, aquaculture, tourism and coastal protection may all be impacted by acidification of ocean waters. There is a very high confidence that oceans around Australia will become more acidic.

*Acidification threatens the ability of marine organisms such as corals, oysters and some plankton to form shells or skeletons.*

In the coastal waters of the South Coast region, predictions are that pH will fall by up to an additional 0.8 units by 2030. By the end of the century pH declines of from 0.15 to 0.33 are predicted, representing an additional 40% and 110% increase in acidity, respectively.

There is a high confidence that the rate of ocean acidification will be proportional to carbon dioxide emissions (Hope et al 2015).

### 4.6.4 SEABIRDS

Because of their top order predator status, sensitivity to and reliance on marine resources, seabirds are considered reliable indicators of marine health. Bird populations, and seabirds in particular, have declined over the past 20 years, however, understanding the changes in population trends is hampered by lack of consistent and complete data.

Research (Lavers, 2014) of Flesh-footed Shearwater (FFSH) (*Puffinus carneipes*) on breeding islands including those in the South Coast region, together with analysis of historic data, indicates that the current global population may have historically been significantly overestimated. Reductions in the population estimates are due to both historic mis-reporting and increasing threats to FSSH populations. As a result, Australian FFSH populations have been upgraded from 'Least Concern' to 'Near Threatened' (Lavers, 2014). Estimated population levels are subject to survey effort and population trends as shown have been determined from 2014 survey data (Lavers 2014) and expert opinion (Jennifer Lavers, pers. comm).

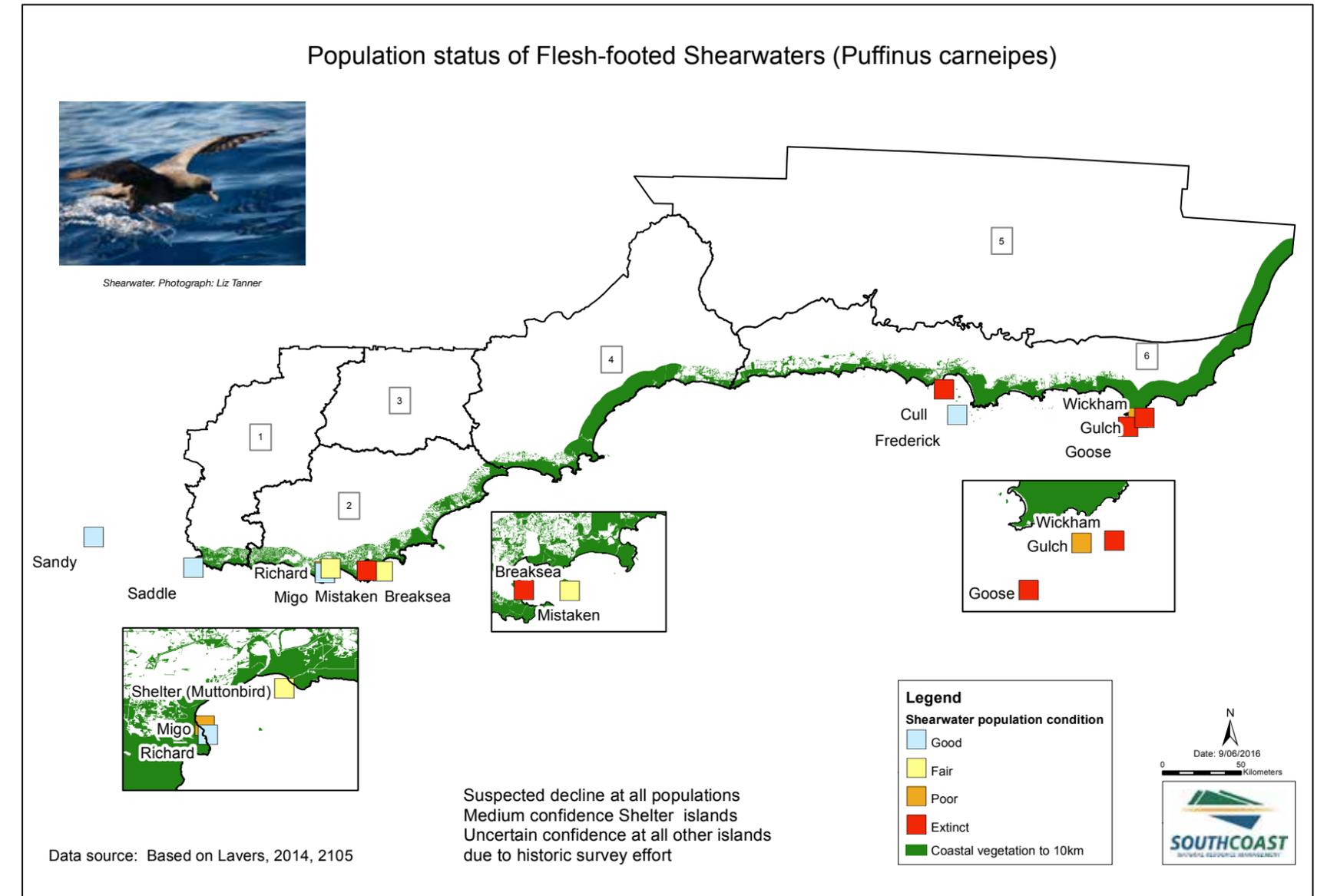


Figure 37: Status of Flesh-footed Shearwater breeding populations on South Coast offshore islands

Because of their top order predator status, sensitivity to and reliance on marine resources, seabirds are considered reliable indicators of marine health.

Lavers (2014) suggests possible threats to FFSH populations in the South Coast region are both natural and human induced, from land and sea, and include:

- Fisheries – significant numbers of bycatch have been reported. The suspected population decline at Breaksea Island is considered likely to be driven by fisheries activities.
- Introduced species – the ground nesting habit of FFSH makes them vulnerable to impact by black rats and rabbits that have invaded some islands.
- Plastic ingestion – studies of the species on Lord Howe Island indicate FFSH is the most affected seabird impacted by plastic entanglement and/or ingestion. 90% of chicks sampled contained considerable levels of plastic (Lavers, 2014). Ingestion of plastic significantly reduces fledging body mass and wing length, lowering survival by at least 11%. Studies investigating the extent and impact of plastic ingestion on seabirds are currently being undertaken in areas including the South Coast region (Harriet Paterson, pers. comm, 2016) and these results should be considered in future versions of this report.
- Contamination – elevated and toxic levels of mercury across the breeding range of FFSH are among the highest recorded for any seabird.
- Climate Change/extreme weather – because FFSH have strong instincts to return to breeding and feeding grounds, shifts in distribution, size and abundance of preferred prey that have occurred with altered weather patterns greatly impact populations. Further, the ‘tropicalisation’ of the Indian Ocean, where rising sea temperatures exceed the average, may increase competition between FFSH and other more tropical seabirds (e.g. Wedge-tailed Shearwater) as they extend their distribution.
- Flooding – because FFSH breed on many low-lying islands in our region they are particularly vulnerable to storm flooding of burrows with subsequent significant mortality of eggs and chicks. Climate change predictions forecast increased storm surges, both in frequency and severity.



Flesh-footed Shearwater, *Puffinus carneipes*



Photo and analysis: Lauren Roman

Figure 38: Plastic contents of seabirds on the South Coast - each number is a bird and each piece from the bird is labelled alphabetically

## 4.7 CULTURAL HERITAGE

The South Coast NRM region has a rich Aboriginal cultural heritage with many recognised sites of importance to local Aboriginal people. These sites are defined as places of significance to Aboriginal people because they contain elements of Aboriginal beliefs, be they ceremonial, spiritual or mythological and/or have historical and/or archaeological elements that reflect and reveal the past use and/or occupation of and by Aboriginal people.

Culturally significant sites include both those listed on the Department of Aboriginal Affairs (DAA) register and protected through the Aboriginal Heritage Act 1972, and those identified by the Aboriginal community. Cultural heritage survey reports and management plans have been prepared for many of these sites and captured in South Coast NRM's Cultural Heritage Land and Sea Management Plan for easy reference and interrogation.

*South Coast NRM region has a rich Aboriginal cultural heritage with many recognised sites of importance to local Aboriginal people.*

The Cultural Heritage theme asset was assessed with the indicators of protection status of culturally significant sites and locations. Following are the three levels of protection:

- Registration – sites listed on the Department of Aboriginal Affairs (DAA) register that have been registered and protected under the 1972 Native Title Act
- Management Plans – cultural sites and locations that have management plans identifying the need for protection and restoration works
- Cultural Heritage Surveys - surveys undertaken to record the significance and recommendations of protection of locations and presented in a cultural heritage survey report



### 4.7.1 REGISTRATION WITH DEPARTMENT OF ABORIGINAL AFFAIRS

As of 2010, 795 sites of significance to Aboriginal people were listed with the DAA register and protected through the Aboriginal Heritage Act 1972 with 307 registered sites occurring within the South Coast region. Presently, registered sites are being reviewed as a result of the Aboriginal Heritage Amendment Bill 2014. The Bill proposes changes to clarify the way sites are assessed and recorded on the Register of Aboriginal Sites and Objects to ensure that appropriate and accurate information is collected and shared, and that there are more robust, transparent and accountable assessment processes. This will initially result in fewer registered sites.

**Table 12: Aboriginal cultural heritage registered site listing by Local Government Area (LGA) as of 2014**

LOCAL GOVERNMENT AUTHORITY	NUMBER OF REGISTERED SITES
Denmark	18
Albany	40
Cranbrook	15
Plantagenet	17
Broomhill/Tambellup	5
Ravensthorpe	17
Gnowangerup	14
Jerramungup	46
Esperance	135
<b>TOTAL</b>	<b>307</b>

### 4.7.2 MANAGEMENT PLANS AND CULTURAL HERITAGE SURVEYS

South Coast NRM has, since 2003, coordinated or had involvement in the preparation of 27 management plans and/or cultural heritage surveys for approximately 25 locations through the Restoring Connections and Cultural Connections projects in partnership with the Aboriginal community and land managers.

Table 13 lists cultural heritage survey reports and management plans that have been prepared with South Coast NRM involvement:



### 4.7.3 CULTURAL HERITAGE LAND AND SEA MANAGEMENT PLAN

The newly developed South Coast NRM Region Cultural Heritage Land and Sea Management Plan (LSMP) aims to be an overarching document that will ensure all significant cultural heritage locations within the South Coast NRM region have a management plan to ensure the protection of their cultural heritage values.

This plan will articulate the aspirations of the Aboriginal people and guide strategic management of their locations of significance. The plan's focus is on the development of an interactive electronic platform (Google Earth map - see figures 40 and 41) on the South Coast NRM website. The plan enables the Aboriginal community to identify and record new sites of cultural significance. A prioritisation system has been developed using the traffic light system to assist with implementing management actions:

- Red - High (Action needed in next 5 years)
- Amber - Medium (Action needed in next 5-10 years)
- Green - Low (Action needed in 10+ years)

For each significant cultural heritage location, a strategic snapshot has been prepared to provide a description of the significance of the area, information on existing management plans and recommendations.



Table 13: Existing Management Plans and Cultural Heritage Survey Reports

MANAGEMENT PLANS (10)
Anderson Lake Cultural Management Plan, 2008
Kwoorabup Walk Trail Cultural Heritage Management Plan, 2009
Lake Pleasant View Cultural Heritage Management Plan, 2009
Maxwell Reserve Heritage Management Plan
Nightwell Community Management Plan, 2008
Nullaki-Wilson Inlet Management Plan
Oyster Harbour Fish Traps Community Management Plan, 2011
Stockyard Creek Management Plan, 2007
Wilson Inlet Cultural Management Plan, 2008
Windermere and Yoorl Park Aboriginal Heritage Restoration Plan, 2009
Cultural Heritage Survey Reports(17)
Anderson Lake Archaeological Survey Report, 2009
Bindup Heritage Report, 2008
Culham Inlet Cultural Heritage Survey Report, 2011
Gnowangerup Springs Heritage Survey Report
Lake Jasper Aboriginal Heritage Survey Report, 2007
Middle Island Archaeological Report, 2007
Mt Lindsay Cultural Heritage Report, 2013
Nightwell Archaeological Survey Report
Nornalup Townsite Cultural Heritage Assessment, 2009
Quaranup (Vancouver) Peninsula Heritage Assessment Report, 2011
Stokes Inlet Pilot: identifying historical heritage values
Tooklejenna Cultural Heritage Assessment Report
Twin Creeks Reserve Aboriginal Heritage Survey Report, 2015
Two Peoples Bay Cultural Values Report
Wagin Lakes Cultural Heritage Report
Warriup-Pallinup Cultural Heritage Assessment, 2012
Wellstead Estuary Cultural Values Report, 2012
Desktop Cultural Heritage Reports (3)
Aboriginal Cultural Values of Water Resources for the South Coast Region Report, 2008

MANAGEMENT PLANS (10)
European Cultural Heritage Values of Regional Estuaries
Cultural Heritage Values Desktop Review Report for Cultural Connections Project, 2013
Twin Creeks Reserve Aboriginal Heritage Survey Report, 2015
Two Peoples Bay Cultural Values Report
Wagin Lakes Cultural Heritage Report
Warriup-Pallinup Cultural Heritage Assessment, 2012
Wellstead Estuary Cultural Values Report, 2012
Desktop Cultural Heritage Reports (3)

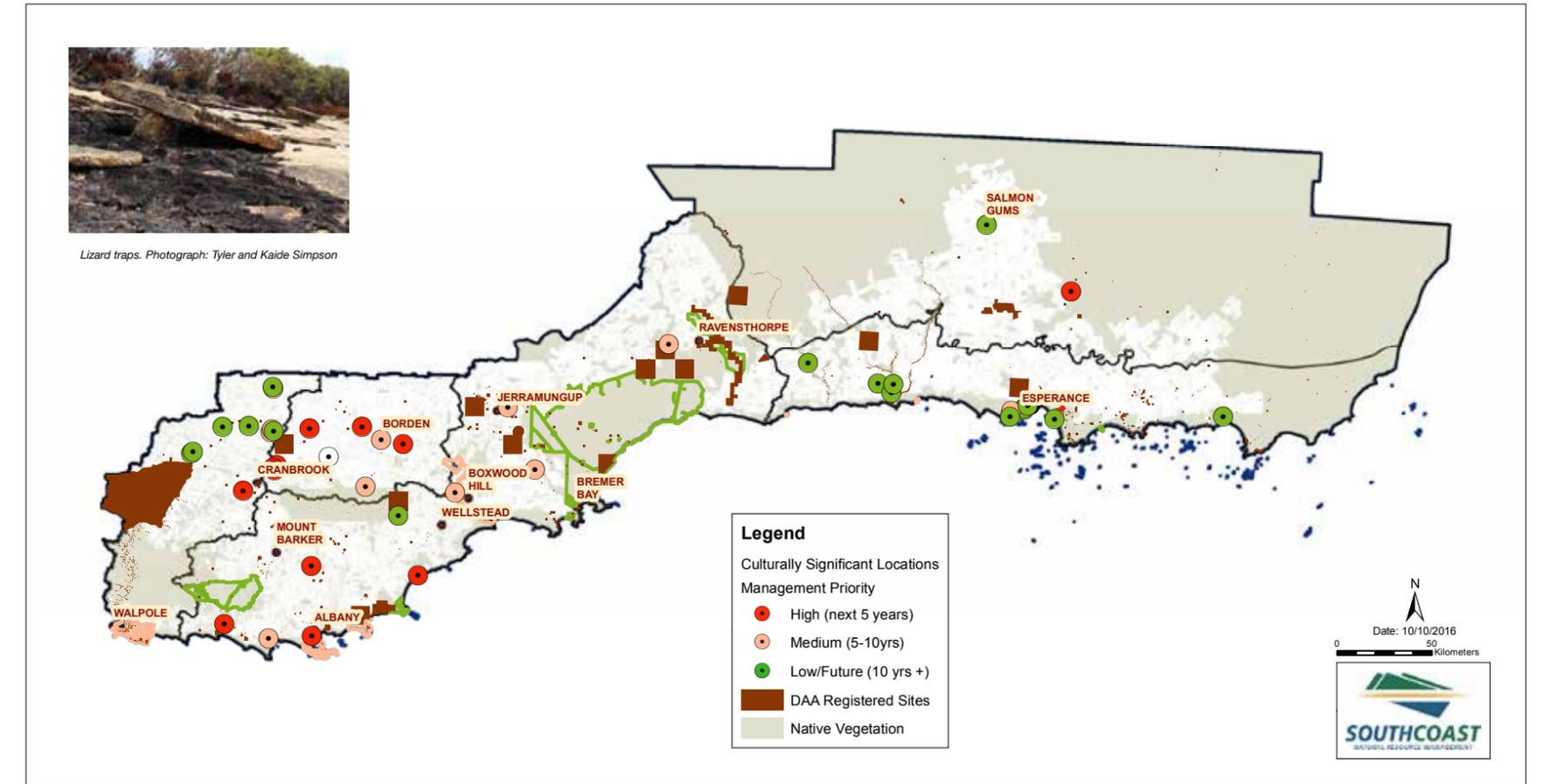


Figure 39: Distribution of some Department of Aboriginal Affairs Registered sites with culturally significant sites determined by the Aboriginal community through the initial consultation phase in the development of the Land and Sea Management Plan

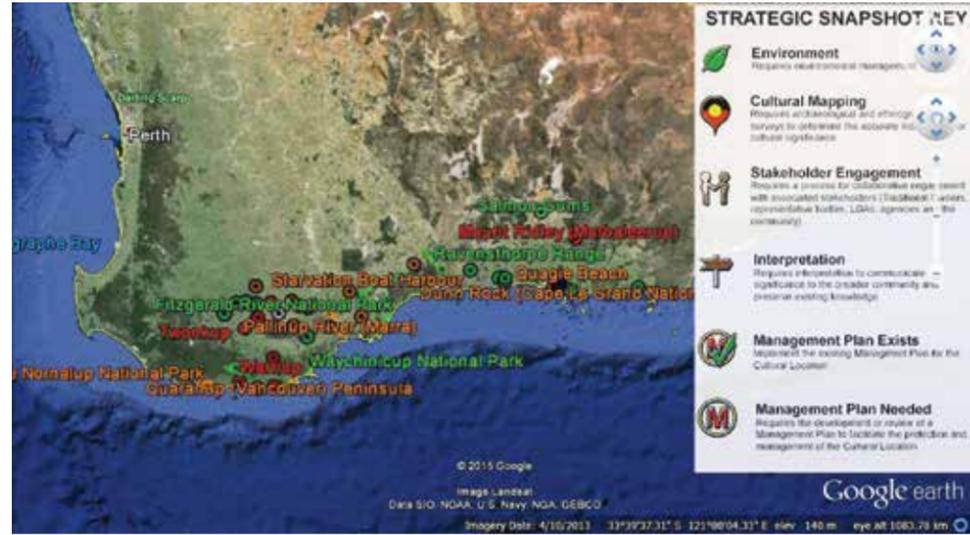


Figure 40: Screen grab of the interactive LSMP Google Earth map as of June 2015

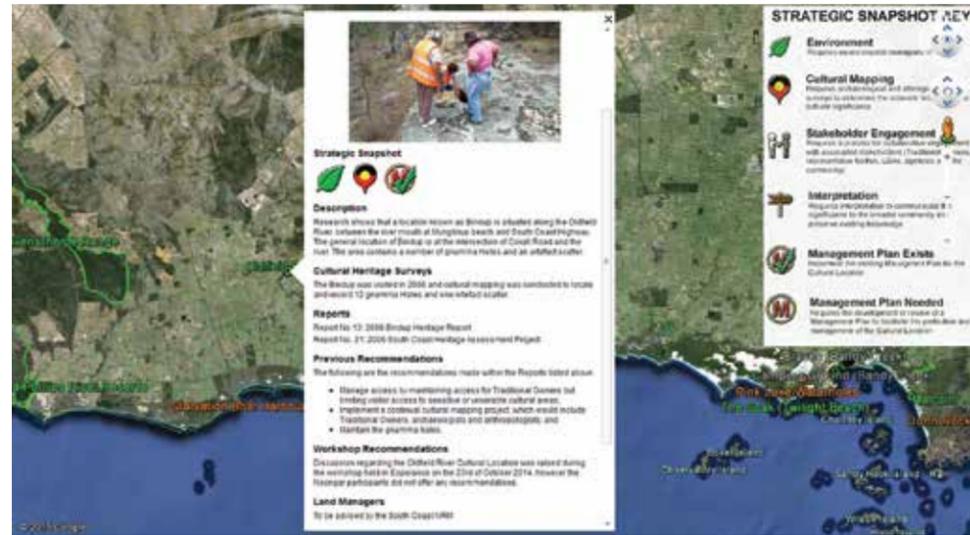


Figure 41: Example strategic snapshot of a cultural location in the south coast region as of June 2015



Gnamma holes, nature's water tanks



Waterwall near Waterbay Point

## 5 RECOMMENDATIONS

This project relied on sourcing and collating existing data, publications and specialist opinion. In some instances the data was not current to date, however, most recent data made available has been utilised.

Applying datasets from unrelated individual projects for the purpose of illustrating an indicator was not always easy or appropriate. Data is collected for specific project aims and was not always readily transferable for other purposes. Also, individual projects implemented across the region utilised different methodologies which were not comparable.

Development of appropriate indicators for the specific aims of the report coupled with designed research to then illustrate these would provide clearer insight for future investigations of asset condition. In the current fiscal setting, resources to do this are unlikely to be available, so each theme should again consider what to use as an indicator, how readily it may show change, data required and how frequently monitoring should occur.

### 5.1 KNOWLEDGE PRIORITIES

- As a priority, ongoing data collection to inform each of the indicators referred to in this document. Each indicator requires significant, ongoing data collection including extension of data collection and analysis, and use of data collection methodologies that can inform the whole of region.
- Continue to explore appropriate indicators sensitive to the changes expected to occur across the region.
- Establishment of benchmark targets to guide land manager practices and mitigate the impact of potential threats, particularly in light of changing climatic conditions.

- Support innovative research, modelling and communication of best available information for natural resource management.
- Funding for capture of updated ortho-photography for the south coast region to facilitate more accurate baseline native vegetation extent analysis.
- Resourcing further vegetation survey including condition analysis.
- Implementation of fire ecology research for fire sensitive ecosystems and species in the region.
- The need for further disease distribution mapping is identified as a requirement across the entire region.
- Undertake research to improve understanding of potential climate change and habitat modification implications on biodiversity and fisheries.



Conserving rare flora on Isongorup Peak, Stirling Range

Parks and Wildlife



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Seal on Cheynes Beach



Rugged southern coastline

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# SOUTH COAST SNAPSHOT

A situation statement based on data collated in June 2016



South Coast NRM coordinates and administers funding provided by the Australian Government and the Government of Western Australia specifically allocated for natural resource management (NRM).

