



# South West Environmental Snapshot

## BACKGROUND DOCUMENT AND SUMMARY PAPER

A statement on the current condition and trend of the environment, natural resources and communities in the South West NRM Region.

June 2018



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# 1 Foreword

A five-year vision of creating a ‘one-stop-shop’ for environmental information on the South West region has come to fruition for the South West Catchments Council (SWCC).

The *South West Environmental Snapshot* is an online resource that provides a contemporary overview of the region’s greatest challenges and opportunities together with insights into how important environmental assets have changed between 2001 and 2017.

The dedicated website **southwestsnapshot.com.au** aims to foster greater community appreciation, understanding and participation in improving and maintaining the unique south west environment as well as a sense of place.

A steering committee, technical advisory panels and leading experts identified, prioritised and developed 33 indicators across key Natural Resource Management (NRM) themes including terrestrial and aquatic biodiversity, land and water resources, coastal and marine assets, as well as Noongar and non-Aboriginal culture and history.

A series of case studies were then developed for each theme to provide more comprehensive examination of some of the most pertinent indicators and the associated conservation actions and on-ground activities implemented regionally to address them.

Key partners who supported the development of this product include:

- Birdlife Australia
- Curtin University
- Department of Biodiversity, Conservation and Attractions
- Department of Primary Industries and Regional Development
- Department of Water and Environmental Regulation
- Edith Cowan University
- Murdoch University
- Murdoch Freshwater Fish Group and Fish Health Unit
- The University of Western Australia
- The Western Australian Biodiversity Science Institute
- South West Ecology Study
- Western Whale Research
- Oceans Blueprint
- Tangaroa Blue
- WABSI
- Water Corporation

## PROJECT PARTNERS



Department of Biodiversity,  
Conservation and Attractions



Department of Water and Environmental Regulation  
Department of Primary Industries and Regional Development



THE UNIVERSITY OF  
WESTERN AUSTRALIA



Freshwater Fish Group &  
Fish Health Unit  
Centre for Fish & Fisheries Research



Murdoch  
UNIVERSITY

The Western Australian  
**Biodiversity**  
SCIENCE INSTITUTE



Department of  
Primary Industries and  
Regional Development



South West  
Ecology  
Study



## 2 Executive summary

Western Australia's South West region is within an internationally renowned biodiversity hotspot featuring unique plants and animals found nowhere else on Earth.

The region is experiencing increasing pressures from population growth, development, water demand, tourism and climate change which will continue to test the area's environmental and social capital.

The future of this region, community and economy are all dependent on how citizens collectively care for and manage their environment and natural resources.

This document provides an overview of the purpose, framework, approach and methodology behind the *South West Environmental Snapshot*.

### **WHY HAVE AN ENVIRONMENTAL SNAPSHOT FOR THE REGION?**

Natural Resource Management (NRM) is about managing nature-based resources, such as water, soil, plants and animals, and supporting the community through engagement and education to ensure quality of life for both present and future generations. NRM considers the sustainable use of these environmental resources and their long-term profitable management, as well as maintaining resilience in the communities relying on those resources.

With its mission to be a change-maker, SWCC works collaboratively with State Government, local government, industry bodies, community groups, and land managers towards the shared objective of a sustainable environment. Multiple factors including climate change, land use, conservation efforts and management approaches are causing the condition and status of natural resources and community to change over time. The challenge remains to adequately monitor and plainly communicate the condition and status of the region's precious assets and natural resources at a regional scale, and how they are changing or trending over time.

The *South West Environmental Snapshot* aims to provide clarity and foster community understanding and participation in improving and maintaining the unique and precious South West environment. It aims to encourage active discussions amongst citizens, community leaders, all tiers of government, businesses, landholders, and other key stakeholders on the state of the natural environment and prompt further action.

### **HOW WAS THE SNAPSHOT DEVELOPED?**

A steering committee, several technical advisory panels and leading experts identified, prioritised and developed 33 key indicators across the NRM themes (including terrestrial biodiversity, marine and coastal, aquatic biodiversity, water resources, communities and culture, climate change and population growth) for the region. These 33 indicators were included in the *South West Environmental Snapshot* poster. A range of sub-indicators were also developed for each theme and featured on the *South West Environmental Snapshot* website.

The indicators were chosen to best represent the most pressing and compelling environmental points for the region as well as where data was available and/or interpretable at the regional scale.

The selected indicators were then summarised into a selection of trends, conditions and facts based on the most updated available data, research and analysis. A series of case studies were also developed for each theme to provide more comprehensive examination of specific pertinent indicators as well as conservation actions and on-ground projects recently implemented regionally.

See Page 9 for further information on the panels and experts, methods used, data sources and analysis, references, limitations and disclaimers for each of the respective indicators.

## 3 Introduction and background

The South West environment is facing numerous threats as highlighted in the *South West NRM Strategy* (*Christensen and MacMahon, 2012*), and these are placing increasing pressures on the local environment (EPA, 2007). The lack of understanding and awareness about the threat implications and the status of the region's assets is causing some community members and decision makers to be complacent about emerging issues and to perceive the associated risks as less urgent than they are.

SWCC chose the snapshot-style of communication product to collate and translate complex ecological information and provide greater clarity on the condition of key assets. This knowledge is a prerequisite for improved decision making and future management of these assets.

### 3.1 Background

SWCC made a commitment in its South West Environment Program 2013-2018 MERI plan to deliver two regional report cards under the 'Building NRM' skills theme. The regional report cards were to be developed over the 2013-2018 investment period. SWCC met its deliverables in partnership with Department of Water by delivering four waterways 'Snapshots'. These included the Snapshot conditions of the Rushy Creek, McLeod Creek, Chapman Brook and Upper Chapman Brook. See these Snapshots at the SWCC NRM Strategy website <http://www.swnrmstrategy.org.au/regional-report-cards/>. SWCC met its deliverable to the Australian Government with some funds remaining to deliver and develop a larger regional report card.

A detailed 'Reports cards' literature review was undertaken and provided in the "*Literature review and assets prioritisation for SWCC's regional report card program*" (Hugues dit Ciles, E., 2014) report. The desktop study investigated if SWCC could develop its own report card based on a consistent conceptual framework such as the Australian Government 2011 State of the Environment (SOE) (see <http://155.187.2.69/soe/2011/report/index.html>). The SOE 2011 report card uses the 'condition-pressure-response' (also referred to as pressure-state-response (PSR) framework to be reportable in most Australian jurisdictions. Regionally developed SOE report cards could then allow for aggregation to both state and national SOE levels. The SOE 2011 datasets provided for each SOE themes and indicators very sparse and limited information OR data set transferrable for use in the South West NRM region context. A gap analysis of report cards relevant to the region as well as limitations and recommendations was provided to investigate all frameworks and report cards on which SWCC could base and develop its own. The document further provided a priority assets list to guide the selection of assets around which the regional report card program could be formulated. In May 2016, the SWCC Board selected the development of a regional report card on Threatened Species and Ecological Communities.

The Senior Scientist investigated the development of a ‘Threatened Species Report Card’ working with Department of Biodiversity, Conservation and Attractions (DBCA) and examining the “2012 Biodiversity Audit” and associated data sets. After meeting with DBCA on 28 March 2017, it was made clear that the 2012 Biodiversity Audit data was not digitalized nor interpretable at a regional scale as the data for species and TEC was analyzed and populated in an excel format at the DBCA district scale area.

In August 2017, the SWCC CEO and Operations Manager decided to investigate a regional report card based on the Australian Government’s ‘2016 SOE Report Card’. The Senior Scientist reviewed all datasets available for the South West NRM region and contacted the SOE office to find and access all available and reliable data sets for our NRM region.

It is important to note that in the 2016 SOE report card, the indicators are interpreted at the whole of the South West Coast region while for other indicators, this was done at the South West Coast Region component level (such as but not limited to: Swan Coastal Plain, Darling Range, Yilgarn Plateau, Western Coastlands and Warren–Denmark Slopes, Leeuwin Peninsula and Donnybrook Lowland). There is no data analysis made at the regional NRM scale and the NRM region fits between sub components which makes data and inferences difficult.

A search of the SOE 2016 indicator summary assessments resulted in only 33 results for the SOE’s ‘South West Coast Region’ (please refer to Appendix A). When refining the search further to look at datasets and information where sufficient level (from limited, somewhat limited and adequate) of confidence in grade and trends existed, the indicators list reduced to only 29 results where assessment summaries were made. The seven indicators available include:

- [State and trends of soil erosion by water and wind](#)
- [State and trends of soil carbon](#)
- [State and trends of soil acidification](#)
- [State and trends of inland water ecological processes and key species populations](#)
- [State and trends of water quality](#)
- [State and trends of inland water flows and levels](#)
- [State and trends of groundwater resources](#)

Some of the components are zones/areas defined on geomorphological or geological criteria, provinces or areas used by different agencies relevant to their assets where they have responsibilities. As the SOE 2016 provides analyses at a much larger scale and does not provide analyses at the regional NRM scale, making inferences for the South West NRM Region was not possible. SWCC also investigated the opportunity to digitalise and reinterpret the SOW data at the regional scale, however it was advised by the SOE office that this could not be achieved due to the lack of data for the South West NRM Region and the fact that the analyses is done at a larger scale.

With the limited South West NRM Region data available and limitations of relevant accessible datasets and interpretable summaries around the 2016 SOE report card data, SWCC decided at a meeting of its executive team on 18 August 2017 that it would not be able to develop a meaningful and theme-based regional report card.

The executive team determined that the report card approach should be modified to a *South West Environmental Snapshot* similar to the New Zealand Minister for the Environment’s “*New Zealand Fresh Water at a Glance*” environmental snapshot report (refer to section 2.8) with additional case studies. The snapshot tells a simple story of values, assets, threats, pressures, risks and assets condition as well as calls for action on how people can help. Simple indicators relevant to the South West NRM community and stakeholders and where data is available at the regional scale can be used to tell a holistic story of the South West environment and communities.

## 3.2 Aims and Objectives of the Environmental Snapshot

### 3.2.1 Aims

As the regional NRM body and non-government organisation, SWCC has a unique position and important role in making a case on key pressing issues affecting the South West NRM Region and in improving the general public's understanding of critical matters. One of SWCC's missions identified in the South West NRM Strategy is for SWCC to be "community change-makers on behalf of the natural environment and develop appropriate awareness raising tools" (Christensen and MacMahon, 2012).

The primary purpose of the *South West Environmental Snapshot* is to capture and present the best available information on the current condition (or risk to condition) and trend of the environment, natural resources and communities in the South West NRM Region. This is provided by a variety of relevant, contemporary and scientifically robust indicators identified by specialists.

The aims of the Snapshot are to:

- Highlight any issues and threats which impinge on the sustainable use of this resource,
- Provide tangible case studies,
- Discuss the implications of these findings where applicable,
- Provide recommended calls for actions where appropriate.

### 3.2.2 Objectives

The *South West Environmental Snapshot* will outline key environmental issues, including the condition, key trends and pressures relating to unique and important natural assets. The objectives include but are not limited to:

- Inform the general public on key issues regarding South West assets,
- Provide the general public with an understanding of the diverse pressures on natural resources, including changing climatic conditions and development pressures,
- Provide an early warning of potential problems,
- Help the community understand what is happening and what might happen, as well as the interactions between climate changes and other stressors such as habitat loss, land use change, water extraction, pollutants, introduced species, pest and disease,
- Encourage active discussions amongst citizen, stakeholders, business and community leaders to prompt action and drive change in their communities,
- Provide call for actions so people can make a difference, and
- Help community members and decision makers to make informed judgments about the broad environmental consequences of social, economic and environmental policies and plans.

## 4 SWCC approach to Environmental Snapshot

### 4.1 Consultation on indicators

SWCC established a steering committee comprising program managers and the executive team which oversaw the framework and provided technical input for each theme/driver (applying the SWCC NRM strategy themes). Each program manager was allocated a theme and/or driver to oversee and each established an advisory panel for their respective themes.

SWCC then engaged independent scientific advisory panels under each theme to assist with the *South West Environmental Snapshot*'s development and provide scientific backing and accuracy. It was recommended that experts (including academics and/or agencies staff) were to be included in the advisory panels where possible to help identify relevant key indicators and case studies under each theme. More specifically, the scientific advisory panels role was to:

- Select a minimum of two and up to eight indicators for each respective theme,
- Identify and assist with a minimum and up to two case studies per theme,
- Identify and provide a '*calls for action*' for each indicator (including the indicator, sub-indicators and case studies),
- Identify gaps in our collective knowledge for each indicator,
- Assist with the sourcing of datasets and reference materials for each indicator,
- Determine reference benchmarks to guide the assessment of the selected indicators
- Record all limitations and assumptions made for each indicator,
- Assist with indicator data analysis, 'trend' and 'condition' calculation and summary assessments where appropriate,
- Provide all scientific documentations and references to back up statements and assessments made for each indicator, and
- Review summary assessments with scientific backing and accuracy.

## 4.2 Panel members and other contributors

### 4.2.1 Coastal

Key Contributors	Organisation	Role	Contribution
Jen Mitchell	SWCC	Theme leader Coastal	Author of Hooded Plover case study
Marcus Singor	BirdLife WA	Volunteer	Input and contribution to Hooded Plover case study
Christine Taylor	DBCA	Conservation Officer, Southwest Region, Parks and Wildlife Service	Input and contribution to Hooded Plover case study
Kim Onton	DBCA	Policy Officer, Office of the Director General Department of Biodiversity, Conservation and Attractions (DBCA)	Input and contribution to Hooded Plover case study
Wally Smith	Tangaroa Blue	Database manager	Case study Author: Plastic Strapping bands and the ban  Infographic: Marine Debris
Other key contributors	Organisation	Role	Contribution
Matt Eliot	Damara WA Pty Ltd	Consultant	Input into Coastal erosion risks
Joanne Ludbrook	Peron Naturaliste Partnerships	Peron Naturaliste Partnership, Coastal Adaptation Coordinator	Input and contribution towards Coastal erosion risks indicator
Dr Nic Dunlop	Conservation Council WA	Adjunct Senior Lecturer Environmental Science & Policy Coordinator Conservation Council (WA)	Input and contribution towards the sub indicator on Sentinel Seabirds
Dr Belinda Cannell	UWA	Research Fellow School of Biological Sciences UWA	The Little Penguin- investigating many aspects of Little Penguin ecology for over two decades, including

Key Contributors	Organisation	Role	Contribution
			variation in annual reproductive success and body condition

#### 4.2.2 Marine

Panel Members	Organisation	Role and expertise	Contribution
Dr Emily Hugues-Dit-Ciles	SWCC	Theme leader Marine	Project manager on the South West Environmental Snapshot Marine website theme page
Prof Euan Harvey	Curtin University	Marine fishes and how physical (both natural and man-made) structures and oceanographic processes influence their composition and distribution.  Effects of anthropogenic activities such as fishing, increases in sedimentation, climate change, increases in marine noise (eg. seismic surveys) are areas of active research.	Key input and advice on at the initial panel meeting to select indicators
Prof Gary Kendrick	UWA	Marine landscape ecology and spatial ecology of seagrasses has identified appropriate descriptors of landscape/spatial structure, modelled species distributions, quantified extensive historical losses of seagrass habitat due to human impacts and modelled emergent landscape-scale phenomena related to the clonal growth of seagrasses at the shoot scale and the evolution of seagrass landscapes	Key input and advice on at the initial panel meeting to select indicators
Prof Chari Pattiaratchi	UWA	Coastal physical oceanography and coastal sediment transport, with emphasis on field experiments and numerical modelling. Examining climate change effects in coastal regions of Western Australia and particularly in terms ocean currents, wind and wave climate, sea level variability, coastal flooding and beach stability	Key input and advice on at the initial panel meeting to select indicators.
Dr Katherine McMahon	ECU	Main streams of research include coastal biology and ecology largely focusing on seagrass ecosystems. Other expertise, Human impacts in coastal ecosystems, Seagrass-grazing interactions and Seagrass evolution and taxonomy.	Key input and advice on at the initial panel meeting to select indicators  Development of Seagrass indicator and seagrass case study
Ben French	DBCA	Marine parks and Aquatic ecology	Key input and advice on at the initial panel meeting to select indicators  Development of Marine Park indicator

<b>Panel Members</b>	<b>Organisation</b>	<b>Role and expertise</b>	<b>Contribution</b>
Kevin Bancroft	DBCA	<p>Community ecology, habitat mapping, mangrove communities, marine biodiversity survey, marine ecology, marine invertebrates, marine monitoring shallow water benthic habitats, sponges and water quality.</p> <p>Establishment of long-term monitoring programs in WA's representative system of marine protected areas; and</p>	Key input and advice on at the initial panel meeting to select indicators
<b>Other key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Chris Burton	Western Whale Research	Director & Principal Researcher of Western Whale Research (WWR), Adjunct Researcher with Curtin University. Consultant.	Case Study Author: Whales of the South West Whales Observed Indicator
Dr Chandra Salgado Kent	ECU	<p>Adjunct Assoc. Prof. at ECU &amp; Curtin University Adjunct Researcher</p> <p>Marine mammal ecology and bio-acoustics and applications to conservation and management.</p>	Case Study Author: Whales of the South West Whales Observed Indicator Dolphins and sea lions sub indicator
Dr Gary Jackson	Department of Primary Industries and Regional Development	<p>Principal Scientist</p> <p>Fisheries Science &amp; Resource Assessment</p>	South West Recreational Fish indicator West Coast bioregion recreation catch indicator Shark and Rays sub indicator Interesting observations and frequently seen species sub indicator

#### 4.2.3 Aquatic biodiversity

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Joanna Hugues-dit- Ciles	SWCC	Theme Leader	Aquatic theme page and coordination
Gill white	Department of Water and Environmental Regulation (DWER)	Senior Scientific Officer River Science Section – Water Science Branch	Infographic – Fish kill
Dr Tim Storer	DWER	Principal Scientist Manager River Science	Infographics – Fish kill
Dr Adrian Pinder	DBCA	Principal Research Scientist Program Leader, Wetlands Conservation Biodiversity and Conservation Science	Infographic – Aquatic invertebrates in forest And case study on “Muir-Byenup Wetlands acidification”. Case study: The enigmatic Salamander fish: living on borrowed time.
Amy Mutton	DBCA	Zoologist	Infographic - Threatened aquatic species

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
		Species and Communities Branch, Biodiversity and Conservation Science	
Dr Jane Chambers	Murdoch University	Wetland Ecologist Environmental and Conservation Sciences, VLS Murdoch University	Input during technical reference group meeting
Dr Steve Beatty	Murdoch University	Senior Research Fellow Freshwater Fish Group and Fish Health Unit Centre for Sustainable Aquatic Ecosystems, Harry Butler Institute School of Veterinary and Life Sciences	Infographics:  Freshwater mussel And author of the case studies: - "Carter's freshwater mussel"; - Native freshwater fish under siege; - Smooth Marron - The enigmatic Salamander fish: living on borrowed time.
<b>Other key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Melita Pennifold, Jasmine Rutherford, & Jim Lane	DBCA		Contribution towards the writing of the Case study "Muir-Byenup Wetlands acidification"
Associated professor David Morgan	Murdoch University	Researcher	Contribution towards the case study " Native freshwater fish under siege".
Dr Rodney Duffy	DPIRD	Senior Research Scientist Finfish Sustainability and Biosecurity	Contribution and input into " Smooth marron case study".

#### 4.2.4 Water resources

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Joanna Hugues-dit-Ciles	SWCC	Theme leader	
<b>Other key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Adrian Goodreid	DWER	A/Section Manager Environment Water Planning	Input and review on indicators and infographics, review of water resources theme page
Daniel Ferguson	DWER		Input and review into indicators.
Dr Kieryn Kilminster	DWER	Research Scientist	Author of case study " Seagrasses in the Leschenault estuary".

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Adam Maskew	DWER	South West Regional Manager	Input on process and key points of contacts, review and inputs of indicators and infographics
Bev Thurlow	DWER	Strategic Project Manager South West Region	Review and feedback of Water resources theme page

#### 4.2.5 Terrestrial biodiversity

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Kim Williams	Department of Biodiversity, Conservation and Attractions	Leader Nature Conservation (South West)	Advisor for Terrestrial Biodiversity Theme Indicators; and contribution towards the case study "Busselton Ironstone"
Pip Marshall	SWCC	Project manager	Theme Leader; and Author of Busselton Ironstone case study
Associate professor Guy Boggs	Western Australian Biodiversity Science Institute (WABSI)	Program Director, Restoration and Ex-Situ Conservation	Advisor
<b>Other Key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Simon Neville	Ecotones & Associates	Environmental Geographer	GIS data analysis to produce statistics for vegetation indicators
Andrew Webb	DBCA	Botanist	Contribution towards the case study "Busselton Ironstone"
Derani Sullivan	SWCC	Project manager	Contribution towards the case study "Busselton Ironstone"
Georgina Anderson & Amy Mutton	DBCA	DBCA Threatened Species Branch	Advice and assistance with the threatened fauna analysis to produce statistics for 'Fauna at Risk' indicator
Stephen Newby	SWCC	Project manager	Analysis of threatened flora data to produce statistics for 'Flora at Risk' indicator

#### 4.2.6 Land resources

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Mike Christensen	SWCC	Theme Leader	Wrote the messages and documentation for the theme, convened meetings
Dr Paul Raper	DPIRD	Hydrologist	Main DPIRD contributor, went through all soil issues and provided reports and data supporting theme documentation.
Dr Richard George	DPIRD	Senior Hydrologist	In the end, was unable to take part in meetings or provide feedback as had been assigned to major project up north

#### 4.2.7 Community and cultures

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Jacqueline Lahne	SWCC	Theme leader	Support to the C&C theme coordination, indicator selection and collection of technical reference and research material to support the theme, indicators and case studies.
Nerilee Boshammer	SWCC	Theme leader	The overall coordination and design of the C&C theme, panel liaison, indicator selection, Liaison with Senior Scientist and collection of technical reference and research material to support the theme, indicators and case studies.
Prof. Pierre Horwitz	Edith Cowan University	Professor, School of Science	Key input and advice on; theme scope, indicator selection, sourcing supporting raw data and technical reference material, case study final review ongoing advice and assistance, specifically in relation to 'sense of place', Regional wellbeing and other relevant social science.
David Collard	Collard & Associates	Director, David Collard & Associates	Key input and advice on; theme scope, indicator selection, sourcing supporting raw data and technical reference material, case study final review ongoing advice and assistance, specifically in relation to the Noongar cultural context and cultural education.
<b>Other Key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Lance McGuire	SWCC	Cultural Connections Officer	Proof reading and advice on the wording of the information presented, to ensure it was culturally appropriate and that it could be easily interpreted by the layman.
Dr Sandra Wooltorton	Notre Dame University	Director, Nulungu Research Institute	Advice and assistance about appropriate cultural technical reference and research material to use to support the theme, indicators and case studies.
Professor Len Collard	UWA	Professor, School of Indigenous Studies	Advice and assistance about appropriate cultural technical reference and research material to use to support the theme, indicators and case studies.
Nicole Hodgson	Murdoch University	Lecturer in Sustainability, School of Management and Governance	Raw data from WALN 'State of Landcare in WA' research and report and advice on the scope and methodology of the WA-wide research, so that it could be replicated for the South West.
Blair Darvill	WA NRM network	Executive Officer	Raw data from WALN 'State of Landcare in WA' research and report and collaboration on the future presentation of the data.

#### 4.2.8 Climate change

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Mike Christensen	SWCC	Theme leader	Wrote the messages and documentation for the theme, convened meetings
Dr Barbara Cook	ERNM, UWA		In the end, was unable to provide input due to prior commitments, handed over to Ben Ford
Ben Ford	CENRM, UWA		Provided the updated species modelling under various climate scenarios
<b>Other Key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Simon Neville	Ecotones & Associates	Environmental Geographer	GIS data analysis and updated climate projections for the region

#### **4.2.9 Population and development growth**

<b>Panel Members</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Dr Emily Hugues dit Ciles	SWCC	Senior Scientist	Theme leader
Pip Marshall	SWCC	Project manager	Contributor to the development of population indicators
<b>Other Key contributors</b>	<b>Organisation</b>	<b>Role</b>	<b>Contribution</b>
Simon Neville	Ecotones & Associates	Environmental Geographer	Analysis of ABS data and GIS data to produce statistics for population indicators

## 1. Indicators and sub-indicators selected by panel members

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
Threatened Aquatic Species	<p>DBCA records on threatened fauna occurrence are maintained by the Species and Communities Branch and are made publicly available through NatureMap  <a href="https://naturemap.dpaw.wa.gov.au/">https://naturemap.dpaw.wa.gov.au/</a></p> <p>Wildlife Conservation (Specially Protected Fauna) Notices are published in the Western Australian Government Gazette. This is the formal publication of the threatened fauna list; those species which have been declared to be fauna that is rare or likely to become extinct under the <i>Wildlife Conservation Act 1950</i>.  <a href="https://www.slp.wa.gov.au/gazette/gazette.nsf">https://www.slp.wa.gov.au/gazette/gazette.nsf</a></p> <p>DBCA Species and Communities Branch maintain the threatened fauna list and keeps copies of the published Fauna Notices.</p>	YES	<p>Most threatened fauna occurrence records within SWCC are opportunistic or are from single one-off surveys at a specific site.</p> <p>Fauna survey and monitoring across the SWCC is not conducted systematically or frequently for all species groups. Although Murdoch University have been doing surveys and monitoring of freshwater fish at some locations.</p>	The public assumes that all fauna species ranges, subpopulations and location are known. However there is bias towards records being where the human population occurs or frequents. A lack of sightings in an area may not necessarily be an absence of the species.
Smooth Marron	<p>Department of fisheries information supplied by Rodney at DPIRD</p> <p>Beatty S.J., De Graaf M., Duffy R., Nguyen V., Molony B. (2016). Plasticity in reproductive biology of the large freshwater crayfish <i>Cherax cainii</i> (Decapoda: Parastacidae) in south-western Australia. <i>Fisheries Research</i> 177: 128-136.</p> <p>Beatty, S., de Graaf, M., Molony, B., Nguyen, V., Pollock, K. (2011). Plasticity in population biology of <i>Cherax cainii</i> (Decapoda: Parastacidae) inhabiting lentic and lotic environments in south-western Australia: Implications for the sustainable management of the recreational fishery. <i>Fisheries Research</i> 110: 312-324.</p> <p>De Graaf, M., Beatty, S. and Molony, B.M. (2010). Evaluation of the recreational marron fishery against environmental change and human interaction. Baxter, D. and Larsen, R. (editors) Final report to Fisheries Research and Development Corporation on Project No. 2003/027. <i>Fisheries Research Report No. 211</i>. Department of Fisheries, Western Australia. 188pp.</p> <p>Fletcher, W.J. and Santoro, K. (eds). (2013). <i>Status Reports of the Fisheries and Aquatic Resources of Western Australia 2012/13: The State of the Fisheries</i>. Department of Fisheries, Western Australia.</p> <p>Morgan, D.L., Hambleton, S.J., Gill, H.S. &amp; Beatty, S.J. (2002). Distribution, biology and likely impacts of the introduced redfin perch (<i>Perca fluviatilis</i>) (Percidae) in Western Australia. <i>Marine &amp; Freshwater Research</i> 53: 1211-1221.</p>		Unknown	<p>Long term fishery dependent and independent data to underpin fishery status. Reasonable levels of other scientific surveys that have demonstrated past range declines mostly due to salinisation. Reasonable biological information on population and reproductive biology across the range. Knowledge gaps still include quantifying effects of flow declines and temperature increase on populations and interactions of climate change with other factors (such as physiological tolerance to salinity, dissolved oxygen).</p>
Fish Kill events -- south-west WA	<p>DWER Fish kill register - record of fish kill events in freshwater and estuarine waterways (not marine events) since 2000          (Note: marine events are recorded by DPIRD)</p> <p>Links:          FISHWATCH...          Common causes of fish kills: see <a href="http://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/fish-kill-events">http://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/fish-kill-events</a></p>		<p>No published literature on the number of fish kill events in the state or south-west</p> <p>We assume that the majority of events are caused or exacerbated by anthropogenic activity. Some events are natural such as lifecycle (e.g. lamprey die after spawning) – where this is known these natural events will be excluded from the indicator.</p> <p>NOTE: need to ensure there is an 'indicator description' that includes the caveats about causes and magnitude</p>	<p>Indicator description:</p> <ul style="list-style-type: none"> <li>- Fish kills events are where 10 or more fish are reported in an area where the cause is believed to be common.</li> </ul> <p>The indicator does not include events due to natural causes (e.g. life-cycle events such as mortality of adults following spawning, e.g. pouched lamprey) or from dumping of by-catch (unwanted species caught by fishermen)</p>

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
Freshwater mussel	<p>Caraco, N. F., Cole, J. J., &amp; Strayer, D. L. (2006). Top-down control from the bottom: Regulation of eutrophication in a large river by benthic grazing. <i>Limnology and Oceanography</i>, 51, 664-670.</p> <p>Greenwood, K. S., Thorp, J. H., Summers, R. B., &amp; Guelda, D. L. (2001). Effects of an exotic bivalve mollusc on benthic invertebrates and food quality in the Ohio River. <i>Hydrobiologia</i>, 462, 169-172.</p> <p>Idrisi, N., Mills, E. L., Rudstam, L. G., &amp; Stewart, D. J. (2001). Impact of zebra mussels (<i>Dreissena polymorpha</i>) on the pelagic lower trophic levels of Oneida Lake, New York. <i>Canadian Journal of Fisheries and Aquatic Sciences</i>, 58, 1430-1441.</p> <p>IUCN. 2018. Downloaded: <a href="http://www.iucnredlist.org/details/23073/0">http://www.iucnredlist.org/details/23073/0</a></p> <p>James, M.R., Ogilvie, S.C., &amp; Henderson, R. (1998). Ecology and potential use in biomanipulation of the freshwater mussel <i>Hyridella menziesii</i> (Gray) in Lake Rotoroa. NIWA Client Report HCC9020/1.</p> <p>Klunzinger, M. W., Beatty, S. J., Morgan, D. L., Pinder, A. M., &amp; Lymbery, A. J. (2015). Range decline and conservation status of <i>Westralunio carteri</i> Iredale, 1934 (<i>Bivalvia : Hyriidae</i>) from south-western Australia. <i>Australian Journal of Zoology</i>, 63, 127-135.</p> <p>Klunzinger, M. &amp; Walker, K. F. (2014). <i>Westralunio carteri</i>. The IUCN Red List of Threatened Species 2014: e.T23073A58526341.</p> <p>Ogilvie, S., &amp; Mitchell, S. (1995). A model of mussel filtration in a shallow New Zealand lake, with reference to eutrophication control. <i>Archives of Hydrobiology</i>, 133, 471-481.</p> <p>Mackie, G. L., &amp; Claudi, R. (2009). Monitoring and Control of Macrofouling Mollusks in Fresh Water Systems (2nd ed.). Boca Raton, FL: CRC Press.</p> <p>Strayer, D. L. (2014). Understanding how nutrient cycles and freshwater mussels (Unionoida) affect one another. <i>Hydrobiologia</i>, 735, 277-292.</p>	<p>Yes, held by Murdoch for Klunzinger datasets. Le Ma from Murdoch also has an ongoing PhD on the species.</p> <p>DBCA has records in the Threatened and Priority Fauna database that are publicly available through NatureMap.</p>	N/A	Peer reviewed distributional surveys complemented with laboratory derived salinity tolerance experiments (Klunzinger et al., 2015).
Wetlands of international importance	<p>Department of Water. 2010. Vasse Wonnerup Wetlands and Geographe Bay Water Quality Improvement Plan, Perth, WA.</p> <p>Department of Biodiversity, Conservation and Attractions, 2017, Toolibin Lake Recovery Plan 2015–35, Department of Biodiversity, Conservation and Attractions, Perth.</p> <p>Farrell, C. and Cook, B. 2009. Ecological Character Description of the Muir-Byenup System Ramsar Site South-west Western Australia: Report prepared for the Department of Environment and Conservation, CENRM085. Centre of Excellence in Natural Resource Management, University of Western Australia. September 2009.</p> <p>Gibson, N. &amp; Keighery, G.J. 1999. Assessment of the nature conservation values of the Byenup-Muir peat swamp system, south western Australia: flora and vegetation, Unpublished report for Environment Australia prepared by Department of Conservation and Land Management.</p> <p>McMahohn, 2006. Ecological Character Description of Toolibin Lake, Western Australia. Department of Conservation and Land Management. Perth, WA.</p> <p>WRM (2007) Ecological Character Description for the Vasse-Wonnerup Wetlands Ramsar Site in South-west Western Australia. Unpublished report to the Department of Environment and Conservation and Geographe Catchment Council Inc. by Wetland Research &amp; Management. September 2007.</p> <p>Gibson, N. &amp; Keighery, G.J. 1999. Assessment of the nature conservation values of the Byenup-Muir peat swamp system, south western Australia: flora and vegetation, Unpublished</p>	No	N/A	N/A

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
	<p>report for Environment Australia prepared by Department of Conservation and Land Management.</p> <p>Smith, M. 2010. Hydrogeology of the Lake Muir–Unicup Catchment, Western Australia: an ecologically important area experiencing hydrologic change. Curtin University Department of Applied Geology, unpublished Doctor of Philosophy Thesis 274p.</p> <p>Toolibin Lake Recovery Team 1994. Toolibin Lake Recovery Plan. Unpublished report prepared for the Department of Conservation and Land Management and the National Parks and Nature Conservation Authority.</p> <p>Information sheets for each Ramsar site taken from the environment.gov.au eg:  <a href="http://www.environment.gov.au/water/topics/wetlands/database/pubs/37-ris.pdf">http://www.environment.gov.au/water/topics/wetlands/database/pubs/37-ris.pdf</a></p>			
How we use water	Annual water abstraction dataset	Yes	N/A	N/A
Effects of rainfall decline to date	DOW, 2015. Securing water for the south west.  <a href="https://www.water.wa.gov.au/__data/assets/pdf_file/0007/6784/Securing-water-resources-for-the-South-West.pdf">https://www.water.wa.gov.au/__data/assets/pdf_file/0007/6784/Securing-water-resources-for-the-South-West.pdf</a>	no	Government publication	N/A
Water availability	Water allocation limit data is from the Department of Water and Environmental Regulation's Enterprise Data Warehouse and accessed via the Enterprise Information Program reporting tools.  Western Australia's Water Inventory (2014)	Yes	Allocation limits do not necessarily represent the volume of water available to be taken.	N/A
Vegetation cover changes since 2000	<p>Land Monitor Veg Mask data 1988-2017 (DBCA) raster layers. [Accessed from DBCA in Mar 2018].</p> <p>Ecotones (2018). Environmental Snapshot GIS &amp; Data Analysis. Report for South West Catchments Council.</p>	<p>A zonal cell count was made of vegetation cover in Vegetation Masks for 2000 and 2017, using the Coastal Region of Interest shapefile as the count zone. The number of cells returned was multiplied by 625 to give m2 (25x25m cells) then divided by 10,000 to convert to hectares. Note that this counts ALL vegetation cover, including plantations. (Ecotones, 2018)</p>	<p>Veg Change Analysis includes all vegetation cover ie: native and non-native vegetation therefore including vegetation cover such as orchards and plantations.</p> <p>Given the way these numbers are calculated, the increases in vegetation cover in the Jarrah and Wheatbelt IBRA Regions, include plantations, new native vegetation, and/or woody weeds etc.</p> <p>It is important to use the term "vegetation cover" for this indicator to ensure it is distinguished from and not confused with remnant native vegetation.</p> <p>All geo-referenced files are provided in map projection MGA50 or MGA51 with datum GDA94. The pixel resolution is 25 metres. which classifies veg change (and ignores small patches) therefore what has been lost or what is remaining is likely to be understated.</p>	N/A
Vegetation fragmentation	<p>DPIRD Remnant Vegetation shapefile (updated August 2017).</p> <p>Ecotones (2018). Environmental Snapshot GIS &amp; Data Analysis. Report for South West Catchments Council.</p>	<p>Ecotones 2018 study: after consulting, we have decided to measure fragmentation using a histogram of area by patch size. The bin sizes proposed are relatively arbitrary but understandable: &lt;2, 5, 10, 22, 50, 100 250, &gt;250 ha.</p> <p>The dataset used was the DPIRD Native Vegetation Extent vector layer (digitised from aerial imagery) updated August 2017. The vegetation was clipped to the SWCC area, and patch areas re-calculated. We then intersected this layer with the IBRA sub-regions layer, to update each polygon with its IBRA location, to allow us to compare fragmentation across IBRA sub-regions.</p> <p>Areas were again re-calculated (as some polygons were</p>	N/A	N/A

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
		<p>split across IBRA regions), but we retained the original patch area for each polygon for size classification purposes. A column was created to indicate the original patch size.</p> <p>We then exported the data table into Excel and used pivot tables to group patches according to IBRA region, summarise area by area class, and extract patch count.</p> <p>Data from Ecotones 2018 report was then reinterpreted into the number of patches as a percentage of total patches &lt;2ha and total patches &gt;1000 (as per advice from Kim Williams).</p>		
Remnant vegetation	Government of Western Australia. (2018). 2017 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of December 2017. WA Department of Biodiversity, Conservation and Attractions, Perth, <a href="https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics">https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics</a>	DBCA Statewide Vegetation Statistics>filtered by Local Governments which occur in the SWCC Region (as per LGA list in Ecotones 2018 Report)>Filter out the "Bare areas" Veg Associations (e.g salt lakes)>then stats are produced automatically from the DBCA Statewide Vegetation Statistics basic fields to calculate percentages.	IUCN categories I-IV do not include State Forest, however State Forest makes up a significant proportion (38%) of vegetation in the SWCC Region, has high ecological values and houses many threatened species.	N/A
Native vegetation approved for clearing	DWER Clearing Permit data [Accessed Mar. 2018]	GIS analysis using the SWCC boundary and the DWER clearing permit data was undertaken by DWER.	<p>Permitted/ clearing regulation only began in 2004.</p> <p>Does not indicate if the clearing has occurred or not.</p> <p>Does not include exempt or illegal clearing</p>	N/A
Loss of Native vegetation	DPIRD Remnant Vegetation shapefile (updated August 2017).  Ecotones (2018). Environmental Snapshot GIS & Data Analysis. Report for South West Catchments Council.	Using the DPIRD Native Vegetation Extent vector layer (2017), the vegetation layer was clipped to the boundary of SWCC (2014). Vegetation areas were re-calculated to reflect altered boundaries, and summarised for the region (See also Ecotones, 2018).	The dataset used for this analysis was the DPIRD Native Vegetation Extent vector layer, latest update (Feb 2018). The digitising is done at reasonably fine scales, mostly (83%) at 1:20,000, but also (14%) at 1:10,000 and a small amount finer. However, the date of digitising varies, as only a portion of the area is digitised each year from the most recent aerial photography. The data therefore varies significantly in currency. Almost all the vegetation on the coastal plain was digitised in the last 5 years. However significant areas of the inland regions were digitised in the early and mid 2000's, so are at least 10 years out of date, hence it is possible that figures for these regions underestimate clearing. These shortcomings need to be kept in mind when using this data. (See also Ecotones, 2018).	N/A
Fauna at risk	DBCA (2018) threatened fauna GIS records [Accessed 22 Mar. 2018.]	<p>DBCA threatened and priority fauna Point data set clipped to SWCC Region&gt; exported to excel&gt; records where the certainty was recorded as "unsure" were removed duplicate species records were removed to produce list of individual fauna species&gt; conservation code rankings used to produce indicators.</p> <p>METHODTYPE Field checked and record excluded if "Fossil" is the only sample existing geographically within the Region to produce # of fauna locally extinct from SWCC Region.</p>	<p>Additions to the threatened species list or downgrades in rankings could include species where their threats have increased but also could include species where knowledge has increased about the species therefore leading to the species being added or downgraded on the list.</p>	<p>NB: total includes all cons codes from the [SWCC NRM sub-set] WA List, except does not include extinct species OR locally extinct species.</p> <p>Two locally extinct species in "recent living memory" NB: (3 additional Fossil cave recorded spp not included as there are no live records in the region)</p>

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
		2001 threatened species data for SWCC Region was provided by DBCA fauna data species branch in excel format and the numbers of threatened species were compared to the 2017 threatened species data which was also provided by DBCA.		
Flora at risk	DBCA (2018) Statewide Threatened Flora List [Accessed Mar. 2018.]  Government of Western Australia, Department of Premier and Cabinet (2001). Government Gazette, WA. Perth: State Law Publisher, Wildlife Conservation Rare Flora Notice 2001, pp.4246-4251.	DBCA WA flora list used to determine # of Threatened flora  Threatened flora GIS data set clipped to SWCC Region > exported to excel > duplicate species records removed to produce list of individual flora species > conservation code rankings used to produce indicators.  2001 government gazette flora notice used identify changes in rankings. Name changes also manually checked.	Additions to the threatened species list or downgrades in rankings could include species where their threats have increased but also could include species where knowledge has increased about the species therefore leading to the species being added or downgraded on the list.	N/A
Land for Wildlife	Land for Wildlife shapefile layer (DBCA) [Accessed Mar. 2018]	Land for Wildlife property shapefile clipped to SWCC Region. Number of properties and hectares counted using geo-processing.	Hectares include property boundary and are not necessarily 100% vegetated, therefore may also include degraded land.	N/A
South Coast bioregion recreational catch	Ryan, K.L., Hall, N.G., Lai, E.K., Smallwood, C.B., Taylor, S.M. and Wise, B.S. (2017). Statewide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287. Department of Primary Industries and Regional Development, WA.	No	The West Coast region is larger than the South West Zone	N/A
Interesting observations and frequently seen species	<a href="http://www.redmap.org.au">www.redmap.org.au</a>	No	N/A	N/A
South West recreational fish	Ryan, K.L., Hall, N.G., Lai, E.K., Smallwood, C.B., Taylor, S.M. and Wise, B.S. (2017). Statewide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287. Department of Primary Industries and Regional Development, WA.	No	N/A	N/A
Marine Parks	Department of Environment and Conservation 2009. WALPOLE AND NORNALUP INLETS MARINE PARK MANAGEMENT PLAN 2009–2019 Management Plan Number 62. Department of Environment and Conservation, Perth.  Department of Environment and Conservation 2013, Ngari Capes Marine Park management plan 2013–2023, Management plan number 74. Department of Environment and Conservation, Perth.	No	N/A	N/A
Sharks and rays	Last P and Stevens J (2009) Sharks and rays of Australia (2 <sup>nd</sup> edition), CSIRO Publishing	No	The West Coast region is larger than the South West Zone	N/A
Sentinel birds	Australian Government, 2012. Species group report card – Seabirds. Supporting the marine bioregional plan for the South-West Marine Region prepared under the Environment Protection and Biodiversity Conservation Act 1999. Commonwealth of Australia.	No	The work is generic to the whole South Marine Region of WA. This information is not at our regional scale	N/A
Geographe Bay seagrass meadows	DEC. (2006) Indicative management plan for the proposed Geographe Bay/Leeuwin-Naturaliste/Hardy Inlet Marine Park.  Elscot, S. V. & Bancroft, K. P. (1999) A review of existing ecological information for the proposed Geographe Bay-Capes-Hardy Inlet marine conservation reserve. Literature Review MRI/CF/GBC-19/1999. December 1998. Marine Conservation Branch, Department of Conservation and Land Management, Fremantle, Western Australia, 6160. (Unpublished report). Perth.	No	Various datasets ranging from recently established programs to programs running since 2012	N/A

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
	<p>McMahon (2017). Keep Watch Seagrass Monitoring, 2017. Report to GeoCatch. Centre for Marine Ecosystems Research, Edith Cowan University 31 pages.  <a href="https://geocatch.asn.au/resource/keep-watch-seagrass-monitoring-2017/">https://geocatch.asn.au/resource/keep-watch-seagrass-monitoring-2017/</a></p> <p>Walker, D., McMahon, K., Cosgrove, J. &amp; Whittemore, R. (1994) Geographe Bay: Seagrass, algal and water quality studies, Summer 1993-1994. Perth</p>			
Whales	Burton, C. 2018. Preliminary analysis of the long term data set of land based whale monitoring in Geographe Bay for 13 years (from 2005-2017). Unpublished	No	Data is for Geographe Bay only	N/A
Dolphins and sea Lions	<p>Goldsworthy, S. D 2015. Neophoca cinerera. The IUCN Red list of Threatened Species, Version 2015.2. Available at:<a href="http://www.iucnredlist.org">www.iucnredlist.org</a></p> <p>Groomm C. Jand Coughran, D. K.2012. Three decades of cetacean strandings in Western Australia:1981 to 2010. Journal of the Royal Society of Western Australia. 95:63-77</p> <p>Salgado Kent, pers. comm. 2015</p> <p>Wiese, pers. comm. 201</p>	No	N/A	N/A
Marine debris	<p>Jenna R Jambeck et al 2015, Plastic Waster inputs from land into the ocean  Science/Sciencemag Vol 347 Issue 6223 pp768-771</p> <p>Tangaroa Blue database from over 10,000 clean-ups</p> <p>World Economic Forum,2016 The New Plastics Economy-Rethinking the future of Plastics</p>	Yes	N/A	<p>Ref: By weight. 2015-2050 projection of plastics in the ocean as described in Endnote 22. 2015-2050 projections of fish stocks based on an estimated 812 million tonnes (S. Jennings et al., Global-scale predictions of community and ecosystem properties from simple ecological theory (Proceedings of the Royal Society, 2008) and in line with Stemming the Tide). The stock of fish is assumed to stay constant between 2015 and 2050 (a conservative assumption given that fish stocks could decline as a result of overfishing.)</p>
Coastal erosion risks	Peron Naturaliste Partnership (2016). Developing Flexible Adaptation Options for the Peron Naturaliste Coastal Region of Western Australia. [online] Available at: <a href="https://www.peronnaturaliste.org.au/projects/caps-project/">https://www.peronnaturaliste.org.au/projects/caps-project/</a> . [Accessed 15 Feb. 2018].	<p>Y, Shoreline Explorer  <a href="http://coastadapt.com.au/coastadapt-interactive-map">http://coastadapt.com.au/coastadapt-interactive-map</a></p> <p>CoastAdapt, Data and datasets for coastal adaptation, information manual</p>	<ul style="list-style-type: none"> <li>There is some uncertainty in projection (between 150-300metres) by 2110 on a scenario of 1 metre of SLR.</li> <li>the model assumes the coast is all sand. Hence the erosion rates are ignoring rock (i.e. rocky areas and existing sea wall structures will not erode as fast and are not an indicator).</li> <li>Areas that are not built up will become the indicator areas of erosion rates.</li> </ul>	N/A
Coastal Vegetation Loss within 1 km of beach	<p>DPIRD Remnant Vegetation shapefile (updated August 2017).</p> <p>Ecotones (2018). Environmental Snapshot GIS &amp; Data Analysis. Report for South West Catchments Council.</p>	<p>Using the DPIRD Native Vegetation Extent vector layer (2017), the vegetation layer was clipped to the boundary of SWCC (2014). Vegetation areas were re-calculated to reflect altered boundaries, and summarised for the region (See also Ecotones, 2018).</p> <p>A zonal cell count was made of vegetation cover in Vegetation Masks for 2000 and 2017, using the Coastal Region of Interest shapefile as the count zone. The number of cells returned was multiplied by 625 to give m<sup>2</sup> (25x25m cells) then divided by 10,000 to convert to ha. Note that this counts ALL vegetation cover, including plantations.</p>	N/A	N/A

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
Extent of water repellence	<p><b>Department of Agriculture and Food, 2013.</b> Report card on sustainable natural resource use in agriculture: Status and trends in the agricultural areas of the south west of Western Australia. <i>Department of Agriculture and Food, Western Australia.</i> 188 pages.</p> <p>Carter D, Davies S, Blackwell P and Schoknecht N (2013). 'Water repellence'. In: Report card on sustainable natural resource use in agriculture, Department of Agriculture and Food, Western Australia.</p> <p>DAFWA (2013) Report card on sustainable natural resource use in agriculture. Department of Agriculture and Food, Western Australia. 188 pages</p> <p>Hoyle FC, Baldock, JA and Murphy DV (2011) Soil organic carbon: Role in Australian farming systems. In: P Tow, I Cooper, I Partridge and C Birch (Eds). Rainfed farming systems. Springer. pp 339–61</p> <p>Montgomery, DR (2017) Growing a revolution: Bringing our soil back to life. WW Norton &amp; Company, New York. 320 pages.</p> <p>Roper, MM (2006) Potential for remediation of water repellent soils by inoculation with wax-degrading bacteria in south-western Australia. <i>Biologia</i>, 61 (Supp 19):358-62.</p>	If map required, needs to be clipped to SWCC region	<ul style="list-style-type: none"> <li>• Lack of baseline data.</li> <li>• Assessing water repellence hazard was done using the soil-landscape mapping technique. The resultant hazard map is a prediction of the likelihood of water repellence occurring and is not based on actual measurements.</li> </ul>	N/A
How serious is acidity?	<p>Department of Agriculture and Food, 2013. Report card on sustainable natural resource use in agriculture: Status and trends in the agricultural areas of the south west of Western Australia. <i>Department of Agriculture and Food, Western Australia.</i> 188 pages.</p> <p>Bolland, M, Russell, B, Staines, M, Morris, R, Lucey, J, and Bennett, D L. (2011), Greener pastures 6 - Managing soil acidity in dairy pastures. Department of Agriculture and Food, Western Australia, Perth. Bulletin 4813.</p> <p>DAFWA (2013) Report card on sustainable natural resource use in agriculture. Department of Agriculture and Food, Western Australia. 188 pages</p> <p>Gazey C, Andrew, J and Griffin E (2013) Soil acidity. In: Report card on sustainable natural resource use in agriculture, Department of Agriculture and Food, Western Australia</p> <p>Gazey, C, S Davies and R Master (2014a) Soil acidity: a guide for WA farmers and consultants. Department of Agriculture and Food, Western Australia, Perth. Bulletin 4858:111 pages.</p> <p>Gazey C, Oliver Y, Fisher J, Andrew J and Carr S (2014b) Twenty years of soil acidity R,D&amp;E in Western Australia – what have we learnt? 2014 Perth Crop Updates.</p> <p>Glencross, RN and MG Clarke (1984) Soil acidity and liming in the Lower Great Southern. <i>J Dept Agriculture WA</i> 25(4):142-5</p> <p>Hughes, B, T Herman and A Harding (2017) Soil acidity and arresting the impact of this yield thief. Grains Research and Development Corporation, GRDC Update Papers.</p> <p>Montgomery, DR (2017) Growing a revolution: Bringing our soil back to life. WW Norton &amp; Company, New York. 320 pages.</p> <p>Mueller, ND, L Lassaletta, B Runck, G Billen, J Garnier and JS Gerber (2017) Declining spatial efficiency of global cropland nitrogen allocation. <i>Global Biogeochem. Cycles</i> 31:245–257</p> <p>Staines M, L Paszkudzka-Baizert, RP McDonnell and M Bolland (2016) Soil pH and pasture dry matter responses following two different methods of lime application at varying levels in south-western Australia. <i>Proceedings of the Australian Society of Animal Production</i>.</p>	<p>The assessment methodology used by DPIRD has potential biases that may both overestimate and underestimate soil P fertility. Soil test datasets may represent data from producers who are motivated to undertake soil testing, and soil fertility may be higher for those who are motivated to test compared to those who are not. This may overestimate soil P fertility.</p> <p>In contrast, most early research on the response of pasture to P was based on clover pasture. Consequently, the critical soil test values used in pasture soils, and this assessment, are based on the P requirements of clovers.</p>	N/A	N/A
Salinity and agriculture	Department of Agriculture and Food, 2013. Report card on sustainable natural resource use in agriculture: Status and trends in the agricultural areas of the south west of Western Australia. <i>Department of Agriculture and Food, Western Australia.</i> 188 pages.	N/A	<p>Great south west region not specific to the South West NRM region. No data available for our regional boundaries</p> <p>Dryland salinity severely impacts public and private water resources and biodiversity These costs are difficult to determine and therefore poorly documented.</p>	<p>This indicator is probably one of the best understood of all the indicators and there are no major assumptions associated with the conclusions discussed here.</p>

Indicator	Supporting literature and references	Data analysis undertaken	Limitations	Assumptions
Projected rise in temperature	Cluster report (Hope et al)  Hope, P, D Abbs, J Bhend, F Chiew, J Church, M Ekström, D Kirono, A Lenton, C Lucas, K McInnes, A Moise, D Monselesan, F Mpelasoka, B Timbal, L Webb and P Whetton 2015 Southern and South-Western Flatlands Cluster Report. Climate Change in Australia Projections for Australia's Natural Resource Management Regions. Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia	No	All modelling, such as the modelling used to develop the scenarios discussed in the literature, are based on a range of assumptions and limitations that are discussed in depth in the literature and are beyond the scope of this document.	Beyond the scope of this document, as the modelling work and the underlaying data required is being tackled at a national scale
Projected decline in rainfall	Hope, P, D Abbs, J Bhend, F Chiew, J Church, M Ekström, D Kirono, A Lenton, C Lucas, K McInnes, A Moise, D Monselesan, F Mpelasoka, B Timbal, L Webb and P Whetton 2015 Southern and South-Western Flatlands Cluster Report. Climate Change in Australia Projections for Australia's Natural Resource Management Regions. Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia  Garnaut, R 2008 The Garnaut climate change review. Cambridge University Press, Port Melbourne. 634 pages.	No	All modelling, such as the modelling used to develop the scenarios discussed in the literature, are based on a range of assumptions and limitations that are discussed in depth in the literature and are beyond the scope of this document.	Beyond the scope of this document, as the modelling work and the underlaying data required is being tackled at a national scale
Population growth	Ecotones (2018). Environmental Snapshot GIS & Data Analysis. Report for South West Catchments Council.  ABS Census QuickStats (UCL) and ABS Statistical Geography (UCL Boundaries, SA1 & SA2 boundaries). (online) [Accessed Mar 2018]  WA Planning Commission (n.d) Projections for 2026 <a href="https://www.planning.wa.gov.au/publications/6194.aspx">https://www.planning.wa.gov.au/publications/6194.aspx</a> : Western Australia Tomorrow, Population Report No. 10, Medium-term Forecasts for Western Australia 2014-2026 and Sub-regions 2016-2026).	This was done using ABS Census Quickstats data by LGA for 2001 and 2016. The use of the 'Quickstats' section was required because 2001 census results are no longer available from the main, 'Census Tablebuilder' section. In Table 21 below we have added projected 2026 population from the WA Planning Commission (WA Planning Commission (n.d)) to allow a comparison. (See also Ecotone 2018 Repot for method).	For full explanation of limitations see Ecotone 2018 Report.	N/A
Mining in the south west	Department of Mines, Industry Regulation and Safety <a href="https://dasc.dmp.wa.gov.au/dasc/">https://dasc.dmp.wa.gov.au/dasc/</a> [Accessed Mar 18, 2018]	Shapefile downloaded from Department of Mines>clipped to SWCC Region># of active mines counted within the SWCC Region polygon	Does not indicate the number of hectares subject to mining as the data set provided only point locations.	N/A
Aboriginal Heritage places	South West NRM Region heritages places query of DPLH (DAA) heritage places database [raw data]. Collected by GAIA Resources for SWCC.  DPLH (DAA) Heritage Inquiry System link: <a href="https://maps.daa.wa.gov.au/AHIS/">https://maps.daa.wa.gov.au/AHIS/</a>	Undertaken by GAIA Resources and SWCC.	Specific to the South West NRM Region	Specific to the South West NRM Region
Changes faces of Landcare	WA Landcare Network. 2017. State of Landcare in WA 2016: Version 1.0. (Ed. Nicole Hodgson, Keith Bradby and Louise Duxbury) WA Landcare Network Inc., Albany, WA.  State of Landcare in WA 2016/17 database of landcare groups [raw data]. Collected and compiled by Hodgson, N., Murdoch University for WALN.  SWCC CRM Database  ORIC site; ABN Lookup site; and ACNC (Australian Charities and not-for-profits Commission) on-line register	No (done by SWCC)	Specific to the South West NRM Region	Specific to the South West NRM Region
Community groups	Fenton, M. 2013. <i>South West Catchments Council Social Benchmarking: Community Groups Survey</i> . South West Catchments Council, Bunbury.	Reference data used was already specific to South West NRM Region  NOTE: This is the pre-2014 boundary however, which still includes data for the Peel-Harvey Catchments Council, which should be factored in to future comparative survey work here.	Specific to the South West NRM Region	Specific to the South West NRM Region