THE UNIVERSITY of ADELAIDE

MISA marineinnovationsa

CRICOS Provider Number 00123M

Coastal, marine and land biodiversity adaptation to unlock economic development

Eyre Peninsula NRM Board Adapt NRM grant

Coastal, marine and land biodiversity adaptation to unlock economic development

Eyre Peninsula NRM Board Adapt NRM grant

Bronwyn M. Gillanders[1], Ayesha I.T. Tulloch[2], Vivitskaia Tulloch[3], Simon Divecha[1]

[1]University of Adelaide, [2]Australian National University, [3]University of Queensland

This publication may be cited as:

Gillanders BM, AIT Tulloch, V Tulloch, S Divecha. 2016. Coastal, marine and land biodiversity adaptation to unlock economic development. Eyre Peninsula NRM Board Adapt NRM grant. The University of Adelaide, Adelaide. 67 pages.

Disclaimer: The authors warrant that they have taken all reasonable care in producing this report. Although all reasonable efforts have been made to ensure quality, the University of Adelaide does not warrant that the information in this report is free from errors or omissions. The results and comments contained in this report have been provided on the basis that the recipient assumes the sole responsibility for the interpretation and application of them. The University of Adelaide does not accept liability for the contents of this report or any consequences arising from its use or any reliance placed upon it.

© 2016 University of Adelaide

This work is copyright. Apart from any use as permitted under the Copyright Act 1968 (Cth), no part may be reproduced by any process electronic or otherwise, without the specific written permission of the copyright owner. Neither may information be stored electronically in any form whatsoever without such permission.

Printed in Adelaide: June 2016

Contents

Tables

Port Lincoln

Streaky Bay

Tumby Bay

Whyalla

Wudinna

Figures

Kimba

Lower Eyre Peninsula

Port Lincoln

Streaky Bay

Tumby Bay

Whyalla

Wudinna

Abbreviations

CNES	Community of national environmental significance
DEWNR	Department of Environment, Water and Natural Resources
EP	Eyre Peninsula
EPBC	Environment Protection and Biodiversity Conservation
LGA	Local government association
NERP	National Environmental Research Program
NRM	Natural Resource Management
SDM	Species distribution models
SPRAT	Species profile and threats
SNES	Species of National environmental significance

Acknowledgments

This research was funded via an Eyre Peninsula NRM Board Adapt NRM grant. We are grateful to the numerous LGA and NRM personnel who attended workshops in November 2015 and April 2016 to provide input and feedback on the project. We also thank the Eyre Peninsula Local Government Association for allowing us to present at the Whyalla LGA conference.

Executive Summary

Background

Understanding biodiversity alongside council planning and policy can facilitate economic opportunities. Morevoer, valuable environment services may be better protected, against rising sea levels by avoiding or removing barriers to the movement of species inland.

Aims/objectives

The objectives of this project were to:

(1) Integrate coast, marine and land biodiversity with planning triggers and adaptation pathways such that councils can form action plans and objectives to protect biodiversity and facilitate development;

(2) Identify barriers to coast and marine species and their ability to adapt under future climate change;

(3) Assist councils to set adaptation pathways which identify key decision points with respect to coastal, marine and terrestrial species and ecological communities, and the ecosystem services they provide;

(4) Communicate and embed available knowledge such that it is useable by regional communities.

Methodology

All species listed under Australian (*Environment Protection and Biodiversity Conservation Act 1999*) or SA legislation (*National Parks and Wildlife Act 1972*) were identified in the Eyre Peninsula Natural Resources Management Board region. Spatial data for threatened species were obtained as point locations from various databases or as polygons. Distribution and prioritisation software were used to identify areas of high conservation priority.

The distribution of barriers to dispersal of key coastal communities (seagrass, saltmarsh, mangroves) was mapped by identifying existing infrastructure, which might act as barriers to movement of coastal communities under future sea level rise.

To assist Eyre Peninsula councils to set adaptation pathways the biodiversity, coastal and marine benefits, along with potential barriers to the movement of such species and communities, were discussed at a range of meetings. These meetings were conducted as formal and informal consultations, across Eyre Peninsula, and all coastal councils were consulted.

Results/key findings

There were 303 listed species of which 149 had greater than 50% of their EP NRM range in a LGA on Eyre Peninsula. The eleven local government areas (LGA) of Eyre Peninsula had between 114 (Whyalla) and 217 (Lower Eyre Peninsula) threatened species. All local government areas had threatened species with greater than 50% of their EP NRM range in the respective LGA. Lower Eyre Peninsula (LEP) had 72 threatened species with greater than 50% of their EP NRM range in the LGA, whereas the other LGAs had between 2 (Port Lincoln) and 11 (each of Cleve, Tumby Bay and Kimba) threatened species. Information for each local government area is detailed in this report.

The existing road network creates the most prominent barriers that may impinge on intertidal saltmarsh followed by reef, seagrass and saltmarsh. The most at-risk areas are Ceduna and Franklin Harbour.

Implications & Recommendations

This report, the consultations and existing regional and council planning systems open the potential for Eyre Peninsula to take further steps in becoming an economic and environmental climate change solutions leader. Strategic planning and awareness building opportunities are identified that can position councils and the region to access adaptation funding. Further, the progressive policy options may be low cost (such as prioritising avoiding adding additional barriers), may support economic development (by guiding such activities into areas less likely to require lengthy investigations) and may make the region more attractive to the growing carbon investment markets.

Keywords

Spencer Gulf, local government areas, conservation, sea level rise

Introduction

Background

Significant effects on species and ecosystems as a result of global climate change are occurring, and there is an increasing need to identify strategies that may reduce or ameliorate negative effects (Mawdsley et al. 2009). Many possible adaptation strategies in relation to wildlife management and biodiversity conservation exist – these strategies have been grouped in relation to land and water protection and management, direct species management, monitoring and planning, and law and policy (Mawdsley et al. 2009). Traditional approaches focused on single-species management, but increasingly strategies focus on increasing the extent of protected areas representing all of biodiversity to ensure that there is a comprehensive network of reserves encompassing all ecosystem types (Mawdsley et al. 2009). Additional strategies relate to facilitating and maximising resilience, protecting movement corridors, stepping stones and refugia, and improving the broader landscape connectivity and permeability to species movement (Mawdsley et al. 2009).

Conservation of biodiversity under global change requires an understanding of the distribution of species within the landscape. Species distribution models are a means of examining spatial patterns of species diversity that can be used to support conservation planning. They estimate the likelihood of observing a species in a given area based on the environmental conditions in that area relative to those occurring where the species is known to exist (Phillips and Dudik 2008). Conservation planning software can then be used to prioritise the occurrence of biodiversity across the landscape. Such prioritisation has the potential to identify areas for economic development to ensure there is limited impact on priority areas in terms of biodiversity. In addition, although more difficult, it is also possible to use spatial conservation planning and prioritisation tools to address issues related to climate change (Di Minin and Moilanen 2014).

The key effect of climate change addressed in this study is the direct loss of habitat associated with sea level rise. Rising sea level will impact the coast and has potential to affect listed ecological species/communities, coastal development and infrastructure including ports (Siebentritt et al. 2014), but there has been no assessment of potential impacts. In this study we aim to investigate potential barriers to inland movement of saltmarsh, seagrass and mangrove communities. Since high resolution digital elevation models do not exist for the region we focus on assessing infrastructure barriers such as roads, rail, pipelines that may prevent inland migration of such species.

Eyre Peninsula forms a triangular-shaped peninsula and is primarily an agricultural area bounded by the Great Australian Bight, Spencer Gulf and the Flinders ranges. It is also an area of increasing mining interest. A number of national parks and conservation areas already exist in the region, but there has been no assessment of priority areas across the entire landscape based on the distributions of threatened species.

Objectives

The objectives are:

(1) Integrate coast, marine and land biodiversity with planning triggers and adaptation pathways such that councils can form action plans and objectives to protect biodiversity and facilitate development;
(2) Identify barriers to coast and marine species and their ability to adapt under future climate change;
(3) Assist councils to set adaptation pathways which identify key decision points with respect to coastal, marine and terrestrial species and ecological communities, and the ecosystem services they provide;
(4) Communicate and embed available knowledge such that it is useable by regional communities.

Methods

Species occurrence and environmental data

All species listed under Australian (*Environment Protection and Biodiversity Conservation Act 1999*) or SA legislation (*National Parks and Wildlife Act 1972*) were identified in the Eyre Peninsula Natural Resources Management Board region. Terrestrial data had been previously identified by the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). Marine data were identified from the Department of the Environment's Species Profile and Threats (SPRAT) database which maps the distributions of all Species of National Environmental Significance (SNES) listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

The distributions of reef, coastal saltmarsh, samphire, mangrove, *Melaleuca*, sedge and cyanobacterial systems were obtained from the South Australian State Benthic Habitats database (Department of Environment, Water and Natural Resources, DEWNR). Comprehensive benthic habitat mapping in marine waters is restricted to inshore areas.

Mapping and evaluating the extent and condition of listed threatened ecological communities and species

Spatial data for all terrestrial (i.e. non-marine) threatened species identified above were obtained as point locations from online public databases (Atlas of Living Australia, eBird) and the Biological Databases of South Australia (BDBSA), and EPBC Act-listed threatened species and ecological community data were provided as Species of National Environmental Significance (SNES) and threatened ecological community (LEC) polygons by the Department of the Environment.

Species distribution models (SDMs) were produced for 177 species using MaxEnt (Phillips et al. 2006; Elith et al. 2011). The outputs were 250-m resolution rasters representing the likelihood of observing a species in each cell, given the environmental conditions that exist there relative to the environmental conditions in cells where the species is known to occur (Phillips and Dudik 2008). To reduce the influence of observed biases in the species occurrence data (with data heavily biased towards populated areas and roads), we manipulated the background data used in the modelling process by introducing a sampling bias layer that mimics the biases in the occurrence data (Phillips et al. 2009). Further details of the modelling methodology can be found in the National Environmental Research Program (NERP) Environmental Decisions Hub Upper Spencer Gulf modelling project (Tulloch et al. 2014).

There were 34 species with fewer than 20 occurrence points in the study region for which models could not be produced due to too few data for accurate predictions, but for which SNES maps were available. For these species, we reclassified the SNES maps produced at a 1-km resolution across Australia to rasters with 250-m resolution. The polygon data representing the listed threatened ecological communities (LEC) were converted to rasters using the same method. We used the following classification to convert qualitative mapping to quantitative distribution predictions:

1. Known to occur = Probability of occurrence 1
2. Likely to occur = Probability of occurrence 0.75
3. May occur = Probability of occurrence 0.5

Finally, there were 90 State-listed species for which there were no SNES maps, and for which there were too few occurrence points to derive models. For each of these species, point occurrence data were converted to a 250-m resolution presence-absence raster.

We used the conservation prioritisation software Zonation v.3.1 (Moilanen et al. 2005; Moilanen et al. 2012) to identify areas of high conservation priority within the Eyre Peninsula NRM region. Zonation uses information about biodiversity features, their relative occurrences, and biological needs, to create a hierarchal conservation ranking of sites across any given landscape. This approach allows the diversity of important land and marine species and communities to be considered alongside potential stressors and actions that may protect priority areas or species. The hierarchal ranking of sites is created through a removal process in which all sites (grid cells) in the landscape are initially assumed to be protected. Cells that cause the smallest marginal loss in conservation value are progressively removed until no cells are left, i.e. the least valuable grid cells are removed first and the most valuable cells are retained until the end, producing a priority value for each cell. We included the 303 250-m resolution rasters described above as biodiversity features in a Zonation prioritisation across the entire study area. We used default settings for core-area Zonation, which removes the cell with the smallest value for the most valuable occurrence over all species in the cell. In this setting, a cell gets high value if even one species has a relatively important occurrence there. Priority areas for conservation were identified by taking the top 30% of the landscape with the highest priority ranks.

Connectivity requirements for biodiversity

We explored the distribution of barriers to dispersal of marine species and key coastal communities of interest (seagrass, saltmarsh, mangroves). We mapped all existing infrastructure – roads, pipelines, railway, and powerline easements, which might act as barriers to movement of coastal communities under the influence of future sea level rise. An infrastructure 'effect zone' (Forman and Deblinger 2000) was developed from this map, by buffering the infrastructure based on results of a previous expert elicitation that derived the likely area of impact of infrastructure (Tulloch et al. 2014). Because different species are affected differentially by infrastructure, we calculated an average effect zone across all the communities of interest. This was based on the distance from infrastructure at which the environmental suitability might be reduced by at least 50% or more, and resulted in buffering the infrastructure by 500m. For the purposes of this analysis, we took a worst-case scenario, assuming that within this infrastructure effect zone, coastal communities would not be able to colonise when moving to avoid sea level rise. This was a reasonable assumption, as results of the previous expert elicitation in the report on the effects of infrastructure on the whole of the Spencer Gulf and surrounding area showed that plant species would most likely have their habitat suitability reduced to 22 to 46% of their current habitat suitability within 500 m of the infrastructure development (Tulloch et al. 2014).

Adaptation pathways

To assist Eyre Peninsula councils to set adaptation pathways, the biodiversity, coastal and marine benefits, along with potential barriers to the movement of such species and communities, were discussed at a range of meetings. These meetings were conducted as formal and informal consultations, across Eyre Peninsula, and all coastal councils were consulted. Primarily, these consultations were:

(1) At an early stage of the project, for input on the likely, most useful and usable information that could be generated from the research (November/December 2015); and,

(2) After biodiversity and barriers information and maps were complete, close to the end of the project (March/April 2026).

Additional informal and formal presentations and discussions were held. In particular these focused on the potential for biodiversity and adaptation planning to facilitate better economic and environmental outcomes while addressing future climate change. Such discussions included the Spencer Gulf Ecosystem and Development Initiative board (comprising representatives from major industries such as BHP Billiton, Santos, Arrium, Flinders Ports, Fishing and Aquaculture industries), Regional Development Australia, NRM and the Eyre Peninsula 2016 LGA conference / development meetings.

This section will be addressed under implications and recommendations.

Results & Discussion

Eyre Peninsula NRM region

Overall, there were 303 species listed on either the SA threatened species list or the EPBC list. Of the 303 threatened species identified, 149 had greater than 50% of their EP NRM range in a LGA on Eyre Peninsula (see individual LGA sections for species). The eleven local government areas (LGA) of Eyre Peninsula had between 114 (Whyalla) and 217 (Lower Eyre Peninsula) threatened species (Figure 1). All local government areas had threatened species with greater than 50% of their EP NRM range in the respective LGA. Lower Eyre Peninsula (LEP) had 72 threatened species with greater than 50% of their EP NRM range in the LGA, whereas the other LGAs had between 2 (Port Lincoln) and 11 (each of Cleve, Tumby Bay and Kimba) threatened species (Figure 1). The species with a high proportion of their EP NRM range in the various EP LGAs may be useful as iconic species and have high conservation value due to their endemicity.

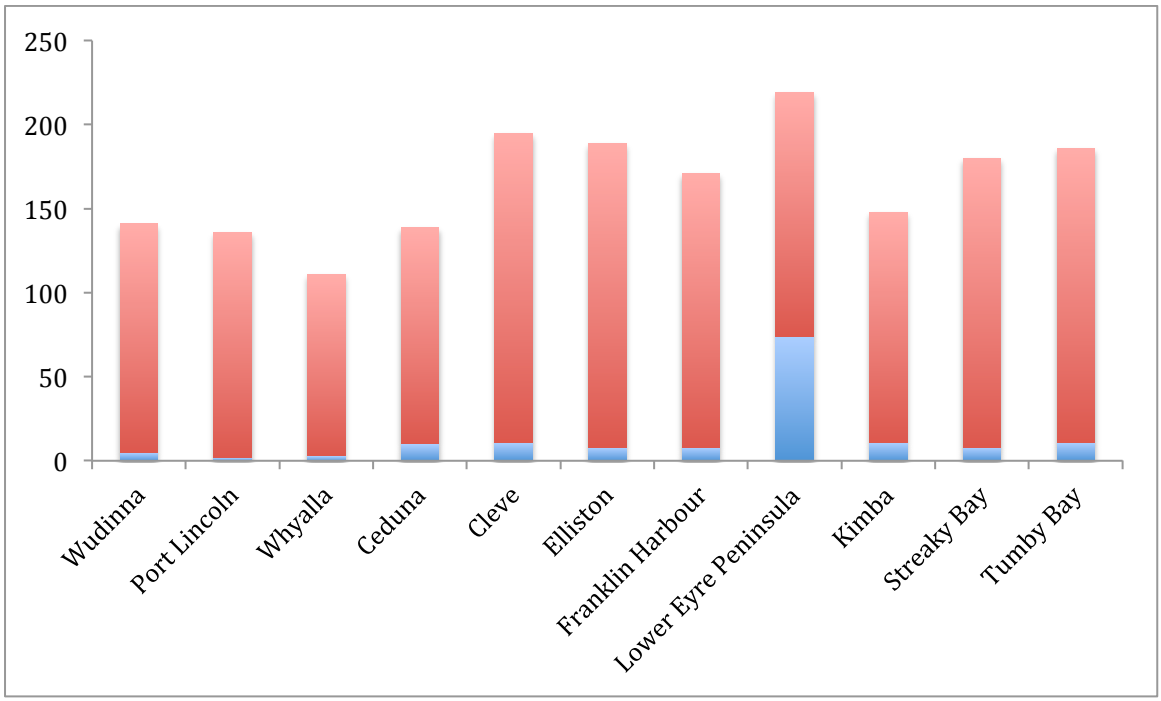

Figure 1. Number of species on the SA threatened species list or EPBC list for local government areas of Eyre Peninsula. Red bars represent total number of species and blue bars represent species with greater than 50% of their Eyre Peninsula distribution that that local government area.

Priority areas occurred throughout the Eyre Peninsula (Figure 2). As expected based on the number of species with greater than 50% of their Eyre Peninsula distribution, the Lower Eyre Peninsula area had a high value based on the zonation ranking. Most LGAs had areas of high ranking (Figure 2). Maps of the top 30% of priority value from zonation rankings overlaid with existing conservation areas suggested that a number of high priority areas occurred in existing conservation areas (Figure 3). Numerous small areas of high priority occurred throughout the landscape.

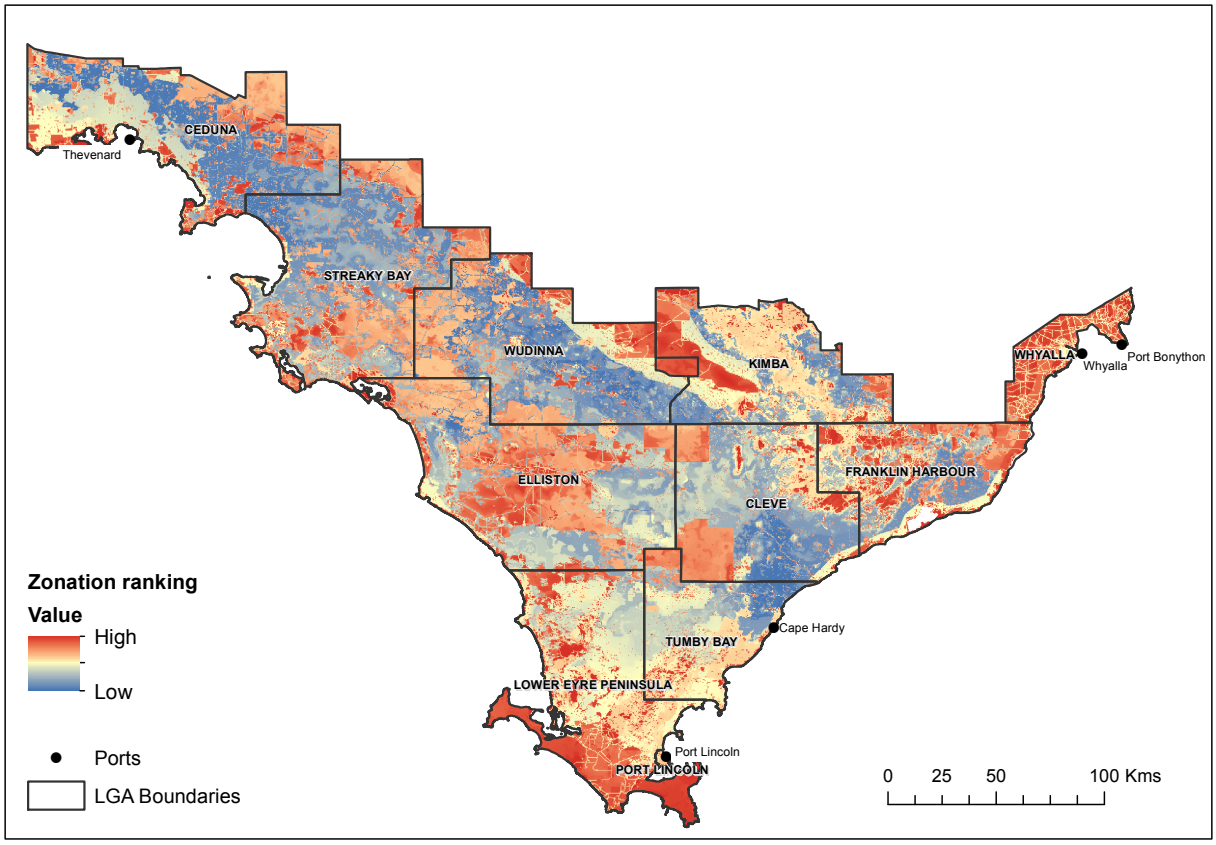

Figure 2. Zonation ranking for the Eyre Peninsula region showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

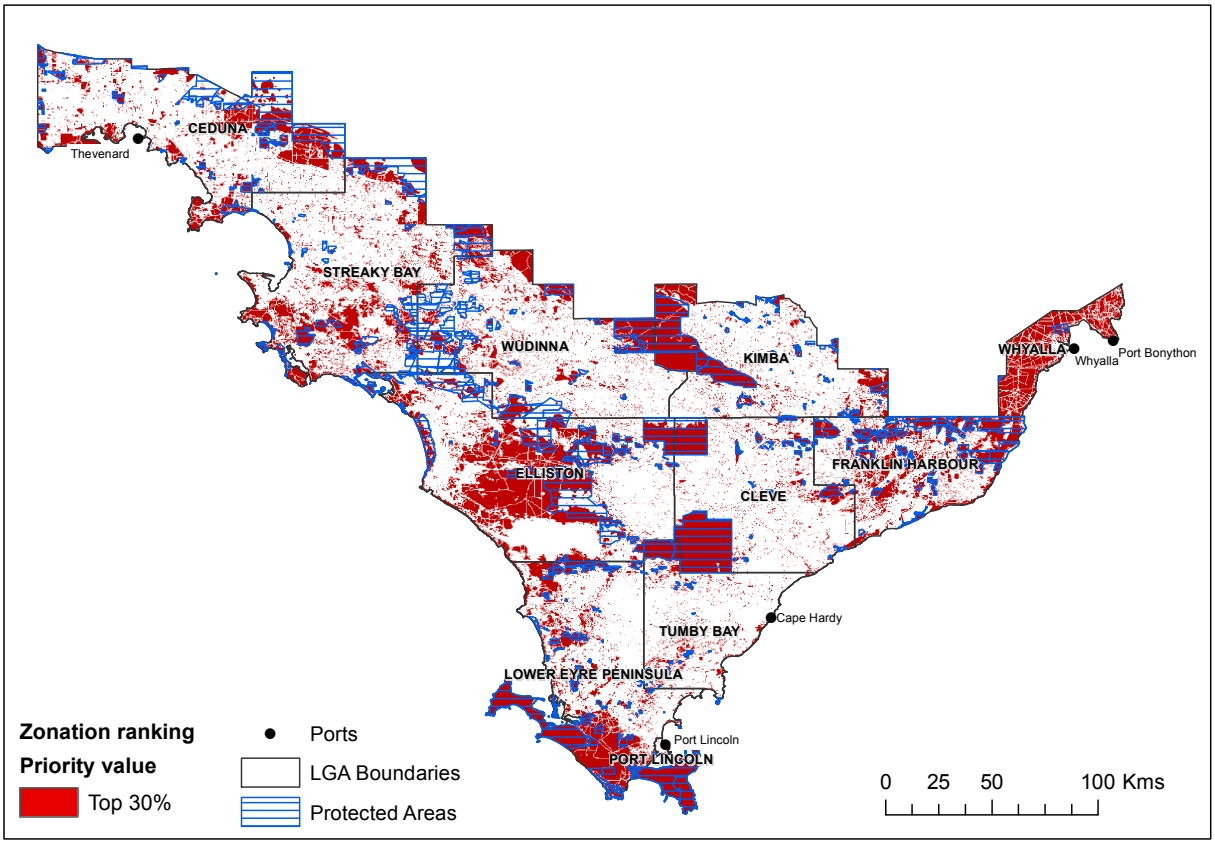

Figure 3. Zonation ranking for the Eyre Peninsula region showing areas within the top 30% (coloured red) in terms of conservation priority. Also shown are existing protected areas (hatched blue).

Connectivity requirements for coastal communities in the Eyre Peninsula

We found that the "infrastructure effect zones" in the Lower Eyre Peninsula are predominantly a result of the existing road network (Table 1). The most-impacted communities are intertidal saltmarsh followed by reef, seagrass and saltmarsh (Table 1). More than 28km^2 of the landscape within 500m of saltmarsh and reef coastal communities is covered in roads (Table 1) – this figure increases to more than 50km^2 of roads at distances of a kilometre from these communities. The LGAs with the highest area of infrastructure barriers to intertidal saltmarsh community movement inland in the face of sea level rise are Ceduna and Franklin Harbour (see each individual LGA section).

More than 46km^2 of the landscape within 1km of seagrass is also impacted by roads, railways and pipelines (Table 1). The LGAs with the highest area of infrastructure barriers to seagrass community movement inland in the face of sea level rise are Ceduna, Streaky Bay and Whyalla (up to 16.2 km^2 of infrastructure in Ceduna within 1km of the seagrass community), with Lower Eyre Peninsula and Elliston also having up to 10km^2 of infrastructure within 1km of seagrass. These barriers are likely to prevent movement of seagrass, samphire and other coastal communities inland with rising sea level.

Both intertidal and supratidal mangroves are little affected by infrastructure at a very fine local scale, with little of the landscape within 500m of existing mangrove communities covered by infrastructure (Tables 1). The amount of the landscape covered by infrastructure increases dramatically between 500 and 1000m from

mangroves (predominantly roads, followed by powerlines), indicating that if sea level is predicted to encroach distances greater than 500m, mangrove communities will face large barriers to dispersal as a result of infrastructure. The LGAs with the highest area of infrastructure barriers to mangrove community movement inland in the face of sea level rise are Ceduna and Whyalla (see each individual LGA section).

Table 1. Barriers to movement of coastal communities inland under potential future sea level rise.

	Area of landscape within 500m of community covered by infrastructure (km^2)					***Area of landscape within 1km of community covered by infrastructure (km^2)***				
Coastal community	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Seagrass	19.68	0.02	4.03	0.03	**23.76**	37.80	0.26	8.28	0.14	**46.48**
Saltmarsh										
- Stranded tidal	9.11	0.21	0.64	0.19	**10.15**	15.85	0.28	1.45	0.29	**17.87**
- Supratidal	23.04	0.34	3.92	0.03	**27.33**	40.86	0.49	8.71	0.05	**50.11**
- Intertidal	28.29	0.56	6.03	0.02	**34.90**	52.98	0.93	11.91	0.17	**65.99**
Mangrove										
- Supratidal	0.11	0.07	0.00	0.00	**0.18**	0.21	0.10	0.08	0.00	**0.39**
- Intertidal	0.26	0.00	0.00	0.00	**0.26**	31.92	0.87	9.30	0.16	**42.25**
Sedge										
- Supratidal	0.49	0.00	0.12	0.00	**0.61**	1.34	0.00	0.29	0.01	**1.64**
- Intertidal	0.15	0.00	0.16	0.00	**0.31**	0.27	0.00	0.23	0.00	**0.50**
Reef										
- High Profile	1.14	0.00	0.01	0.00	**1.15**	2.95	0.01	0.30	0.00	**3.26**
- Medium Profile	2.76	0	0.22	0	**2.98**	5.92	0.00	0.63	0.03	**6.58**
- Low Profile	28.39	0.03	4.39	0.00	**32.81**	52.90	0.10	9.89	0.08	**62.97**
Macroalgal communities	4.72	0.00	0.77	0.00	**5.49**	13.76	0.05	2.30	0.01	**16.12**

The following sections focus on each individual LGA.

Ceduna local government area

Ceduna local government area has 130 listed species of which 9 had greater than 50% of their Eyre Peninsula distribution in the Ceduna LGA (Table C 1). These comprised 5 bird and 4 plant species. The most widely distributed species was Major Mitchell's cockatoo (Figure C 1). Four other bird species occupied between 36 and 50 km^2, whereas all four plant species only occurred in small areas and were known from point data only (Table C 1, Figure C 1). Four species with greater than 50% of their EP NRM distribution in Ceduna only occurred in the Ceduna LGA (Table C 1). The other species occurred in between 3 (2 bird species) and 8 LGA regions. A number of areas of highest conservation priority were already included in protected areas (Figure C 2). In general, highest priority areas tended to be coastal (Figure C 2).

Ceduna LGA has the highest area of intertidal saltmarsh limited by infrastructure barriers in terms of movement inland in the face of climate change. Almost 45km^2 of intertidal saltmarsh occurs with 1km of infrastructure, primarily roads and almost 15km^2 is within 500m of infrastructure (Table C 2, Figure C 3). Mangroves are slightly less affected especially by infrastructure within 500m. Seagrass was less affected by infrastructure.

Table C 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Ceduna LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Cacatua leadbeateri	Major Mitchell's Cockatoo	BIRD	2947.5	8	Ce
Calidris ferruginea	Curlew Sandpiper	BIRD	48.89	6	Ce
Charadrius leschenaultii	Greater Sand Plover	BIRD	36.00	3	Ce
Charadrius mongolus	Lesser Sand Plover	BIRD	36.19	3	Ce
Chondropyxis halophila	Salt Button-daisy	PLANT	0.06	1	Ce
Eremophila praecox	*Eremophila praecox*	PLANT	0.44	1	Ce
Leiocarpa pluriseta	*Leiocarpa pluriseta*	PLANT	0.06	1	Ce
Templetonia battii	Spiny Templetonia	PLANT	0.31	1	Ce
Vanellus miles	Masked Lapwing	BIRD	48.44	6	Ce

Table C 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Ceduna LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	12.13	0.10	2.44	0.06	**14.73**	34.70	0.65	7.14	0.15	**42.64**
Seagrass	4.64	0.07	1.31	0.04	**6.07**	11.72	0.41	3.97	0.14	**16.24**

Mangroves	6.55	0.11	1.48	0.06	**8.20**	30.27	0.53	4.98	0.18	**35.95**

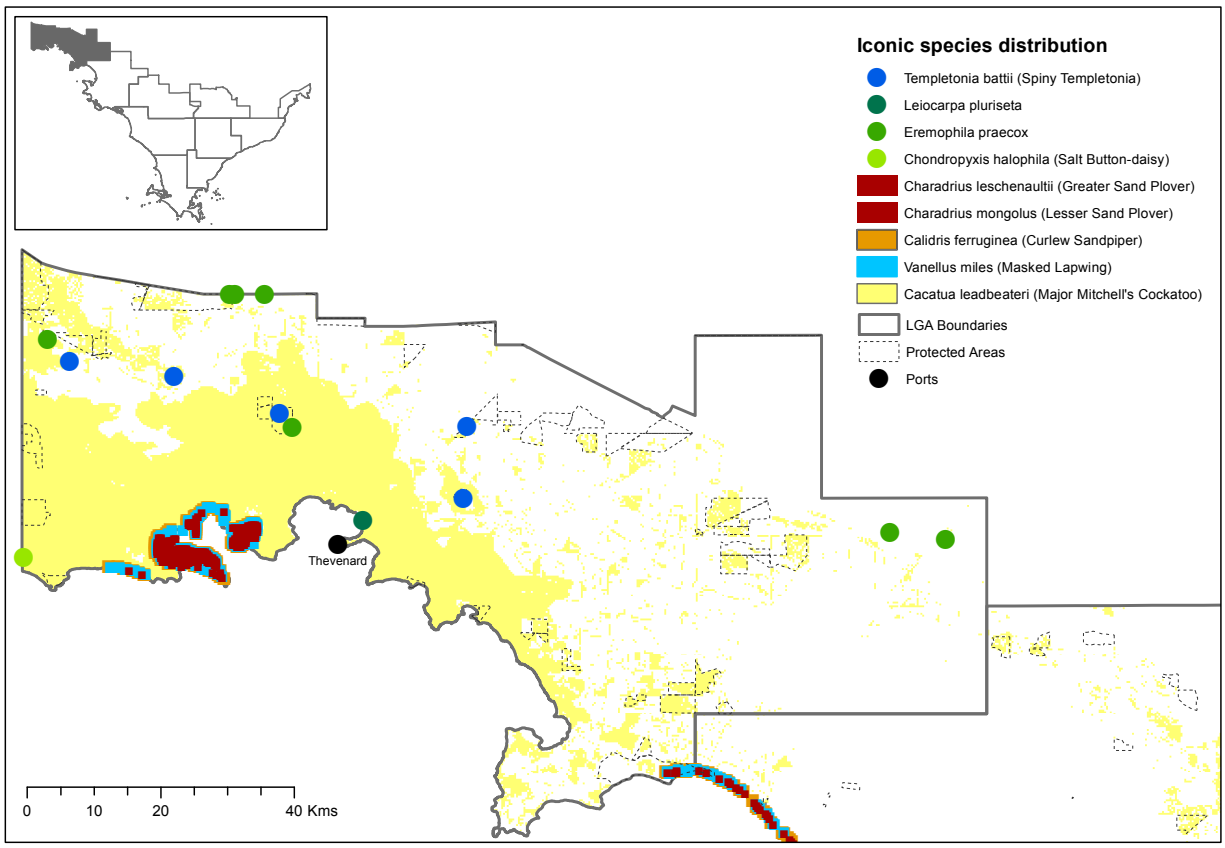

Figure C 1. Map of species occurring in the Ceduna LGA with more than 50% of their distribution in that area. The inset map shows the position of Ceduna LGA within the Eyre Peninsula NRM region.

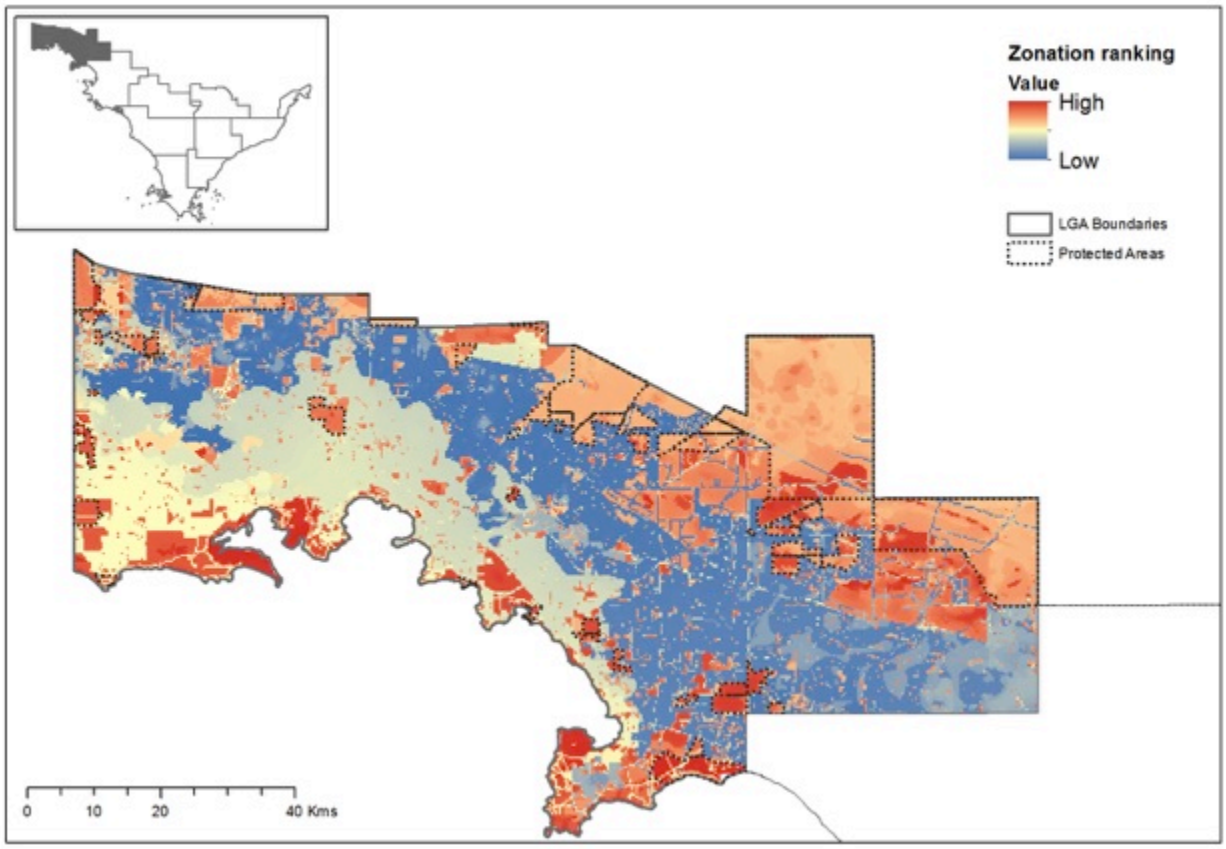

Figure C 2. Zonation ranking for the Ceduna LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

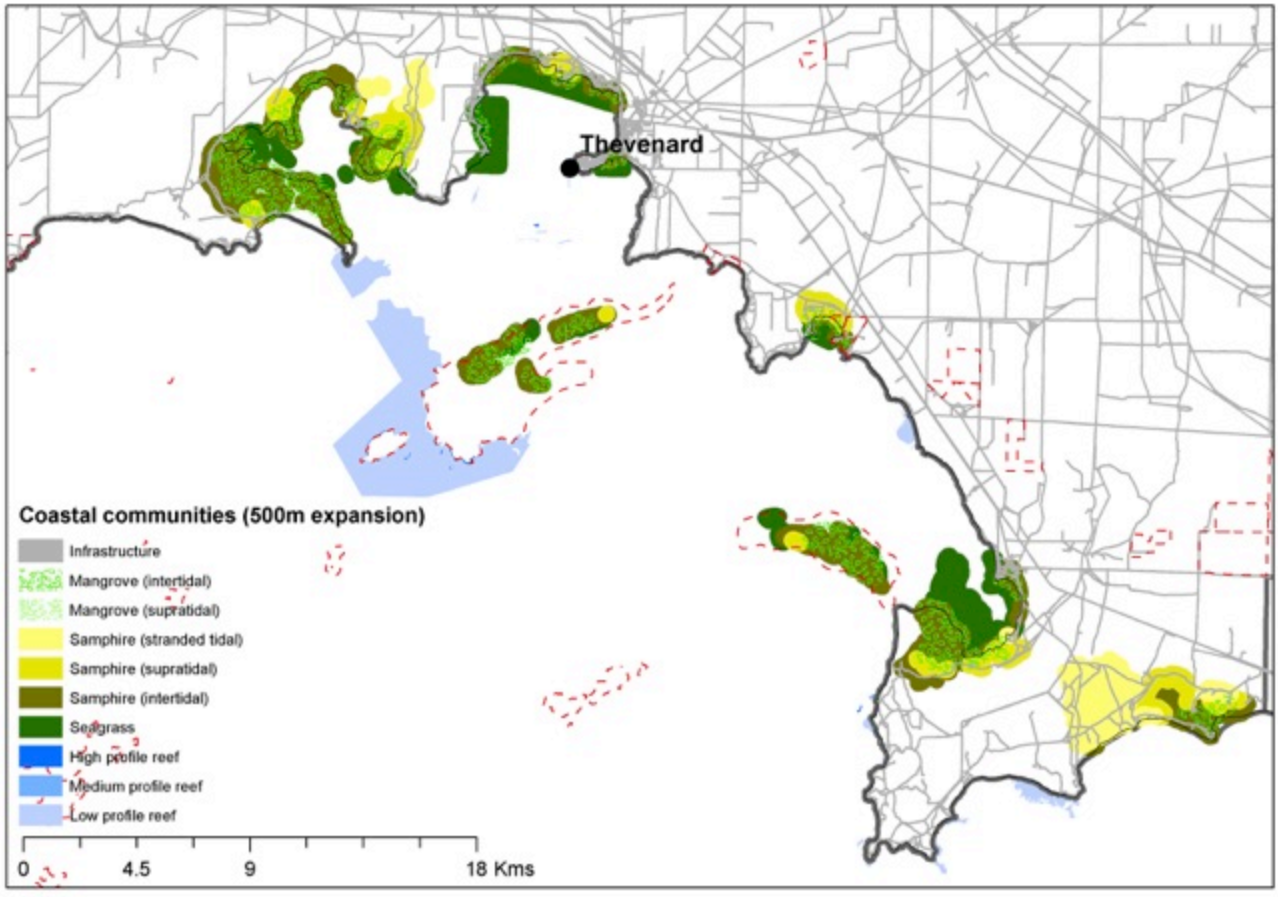

Figure C 3. Mapping of potential barriers to inland dispersal of coastal habitats for Ceduna LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Streaky Bay local government area

Streaky Bay local government area has 189 listed species of which 9 had greater than 50% of their Eyre Peninsula distribution in the Streaky Bay LGA (Table SB 1). These comprised 6 bird, 2 plant and a mammal species. The most widely distributed species was the bird, the plains wanderer (Figure SB 1). The other bird species had a range less than 11.5 km^2, whereas the two plant species only occurred in small areas and were known from point data only (Table SB 1, Figure SB 1). The greater bilby (mammal) historically occurred in South Australia and is listed as occurring in the Streaky Bay LGA, but is unlikely to be found there (Kerr, Natural Resources Eyre Peninsula, pers. comm.). The 9 species with greater than 50% of their distribution within the Eyre Peninsula NRM region only occurred in Streaky Bay (5 species) or 1-2 other LGA regions (Table SB 1). A number of areas of highest conservation priority were already included in protected areas (Figure SB 2).

Streaky Bay LGA has between 10.25 and 17.71km^2 of coastal habitat (saltmarsh, seagrass and mangroves) within 1km of infrastructure, reducing to between 3.70 and 6.39 km^2 within 500m of infrastructure (Table SB 2, Figure SB 3). Infrastructure preventing inland movement of these coastal communities is primarily roads.

Table SB 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Streaky Bay LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Austrostipa vickeryana	Vikery's Spear-grass	PLANT	0.13	1	SB
Charadrius melanops	Black-fronted Dotterel	BIRD	2.25	1	SB
Gallinago megala	Swinhoe's Snipe	BIRD	0.09	1	SB
Gallinago stenura	Pin-tailed Snipe	BIRD	5.92	3	SB
Gratwickia monochaeta	*Gratwickia monochaeta*	PLANT	0.06	1	SB
Himantopus himantopus	Black-winged Stilt	BIRD	11.5	2	SB
Macrotis lagotis	Greater Bilby (Bilby)	MAMMAL	54.13	2	SB
Numenius minutus	Little Curlew	BIRD	0.09	1	SB
Pedionomus torquatus	Plains Wanderer	BIRD	4255.5	3	SB

Table SB 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Streaky Bay LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	5.52		0.87		**6.39**	15.09		2.62		**17.71**
Seagrass	4.30		0.54		**4.84**	9.50		1.42		**10.92**
Mangroves	3.29		0.41		**3.70**	8.63		1.63		**10.25**

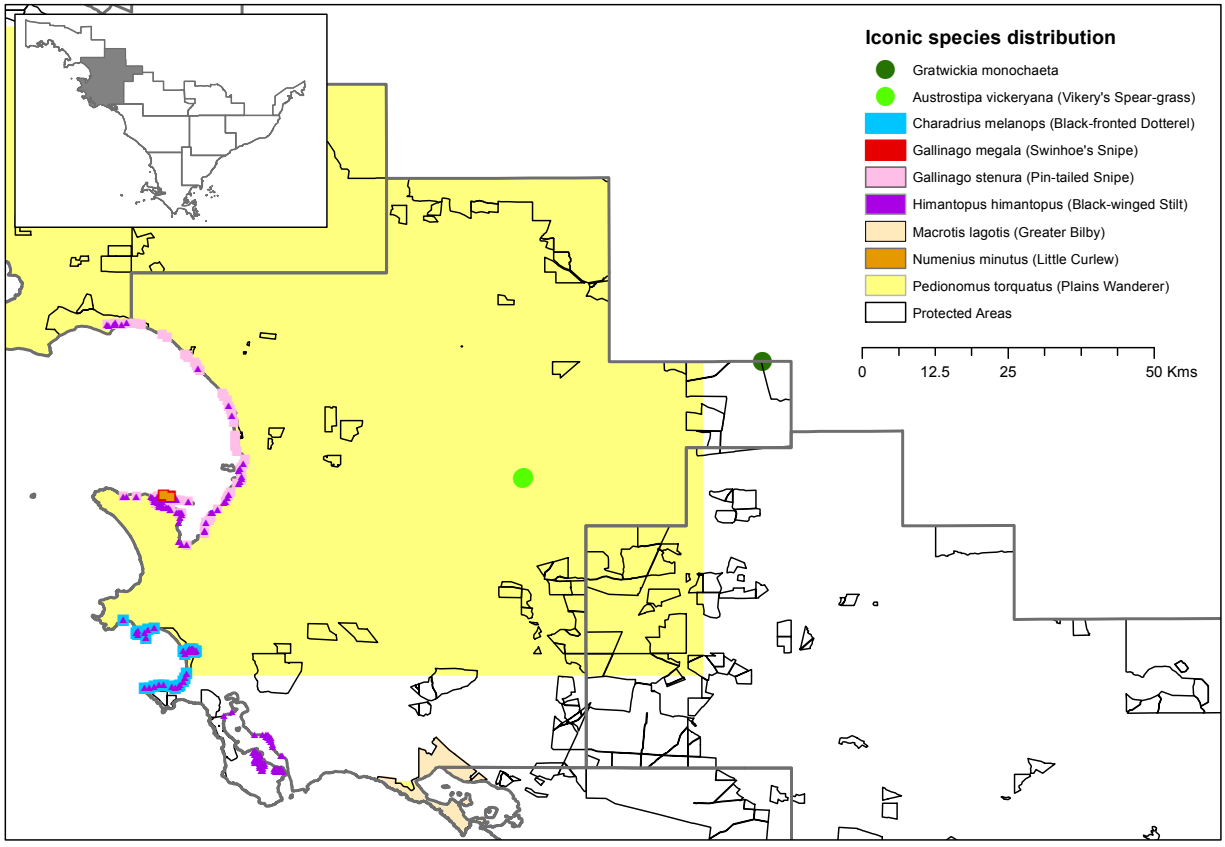

Figure SB 1. Map of species occurring in the Streaky Bay LGA with more than 50% of their distribution in that area. The inset map shows the position of Streaky Bay LGA within the Eyre Peninsula NRM region.

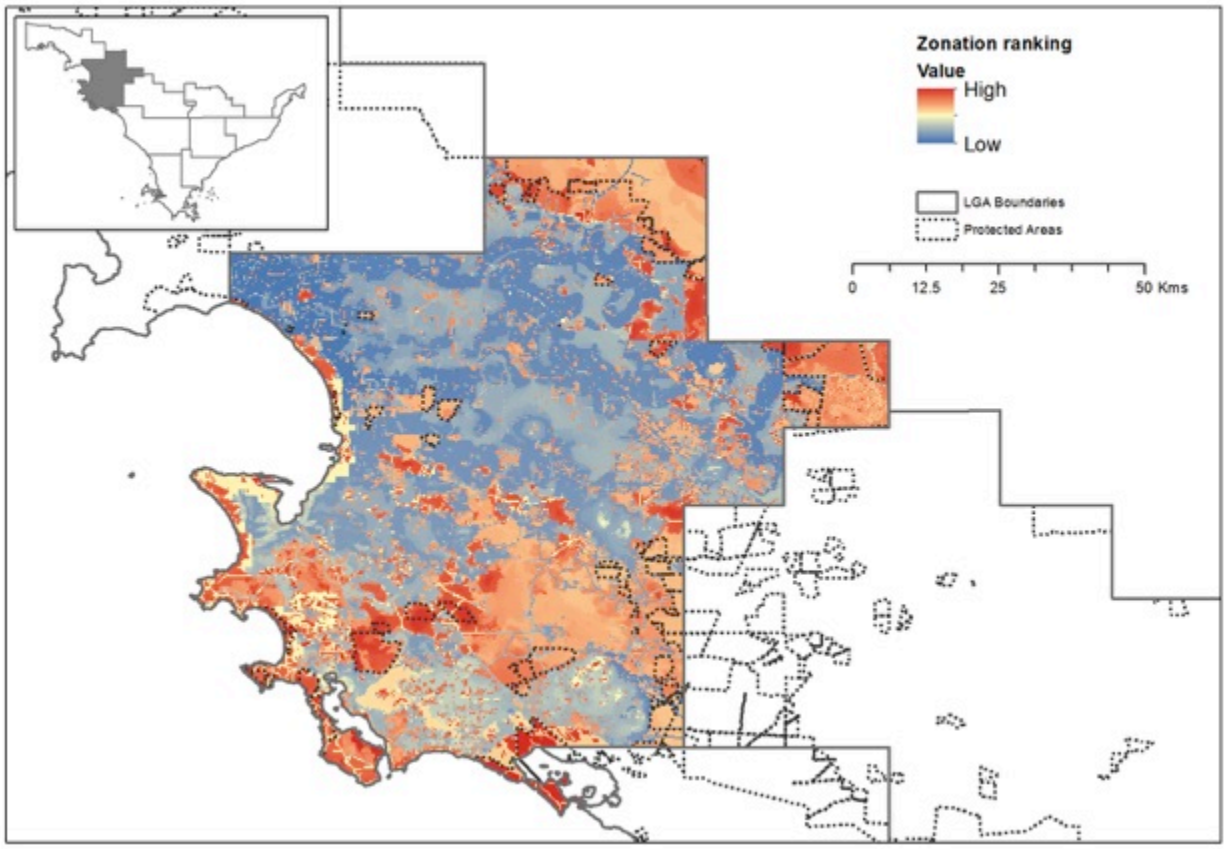

Figure SB 2. Zonation ranking for the Streaky Bay LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

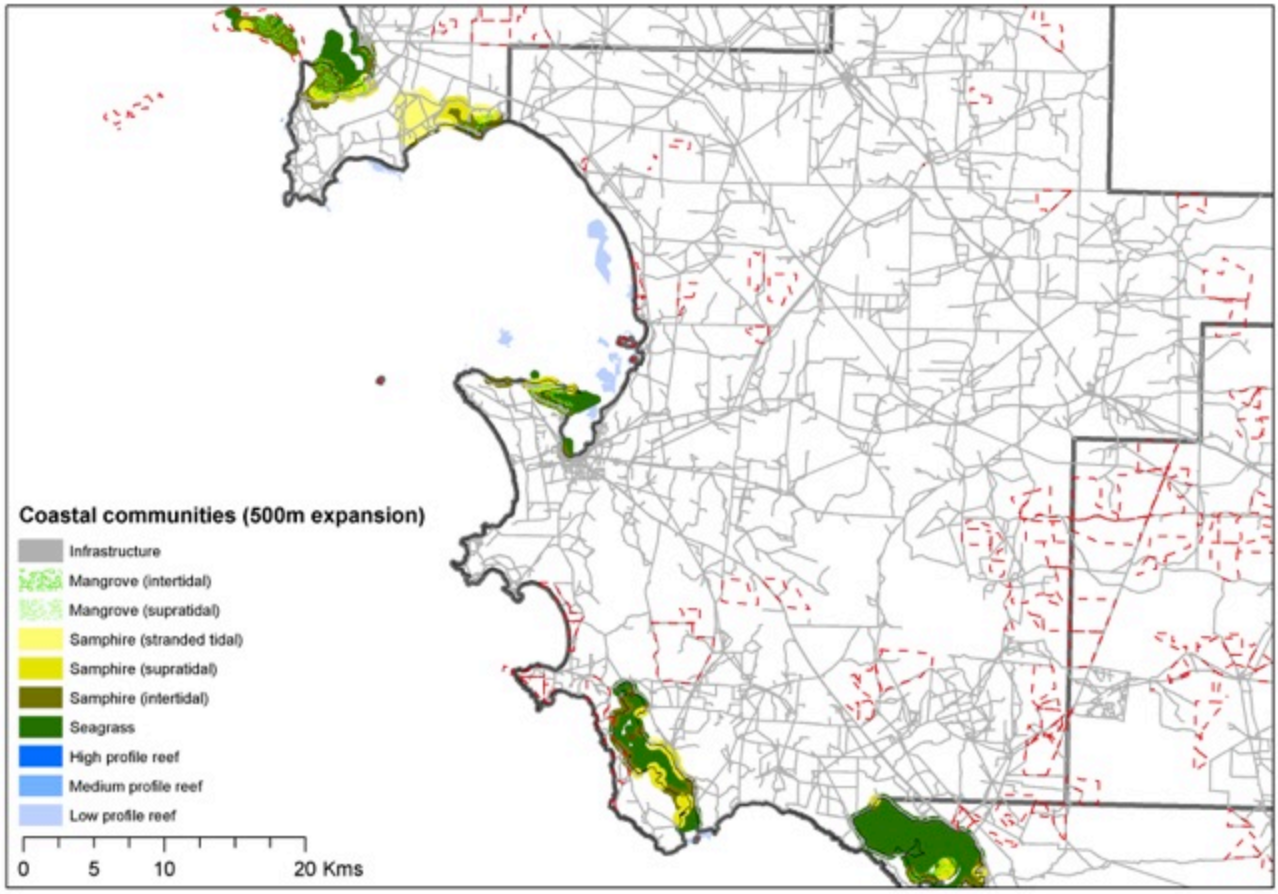

Figure SB 3. Mapping of potential barriers to inland dispersal of coastal habitats for Streaky Bay LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Wudinna local government area

Wudinna local government area has 146 listed species of which 5 had greater than 50% of their Eyre Peninsula distribution in the Wudinna LGA (Table Wu1). These only comprised plant species. Only one of these plant species, granite mudwort, occurred over a large enough area to be mapped (Table Wu 1; Figure Wu 1). Two plant species with greater than 50% of their EP NRM distribution only occurred in the Wudinna LGA, two more occurred in Wudinna LGA and one other LGA and a single species occurred in Wudinna LGA and 4 other LGA regions (Table Wu 1). In general, highest priority areas tended to be along the northeast boundary of the Wudinna LGA (Figure Wu 2).

Wudinna LGA does not have a coastal region therefore there was no requirement to investigate potential infrastructure barriers to coastal habitat movement under climate change.

Table Wu 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Wudinna LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Austrostipa plumigera	*Austrostipa plumigera*	PLANT	0.38	2	Wu
Cardamine tenuifolia	Slender Bitter Cress	PLANT	0.06	1	Wu
Limosella granitica	Granite Mudwort	PLANT	105.97	5	Wu
Pterostylis xerophila	Desert Greenhood	PLANT	4.27	1	Wu
Stypandra glauca	Nodding Grass-lily	PLANT	0.25	2	Wu

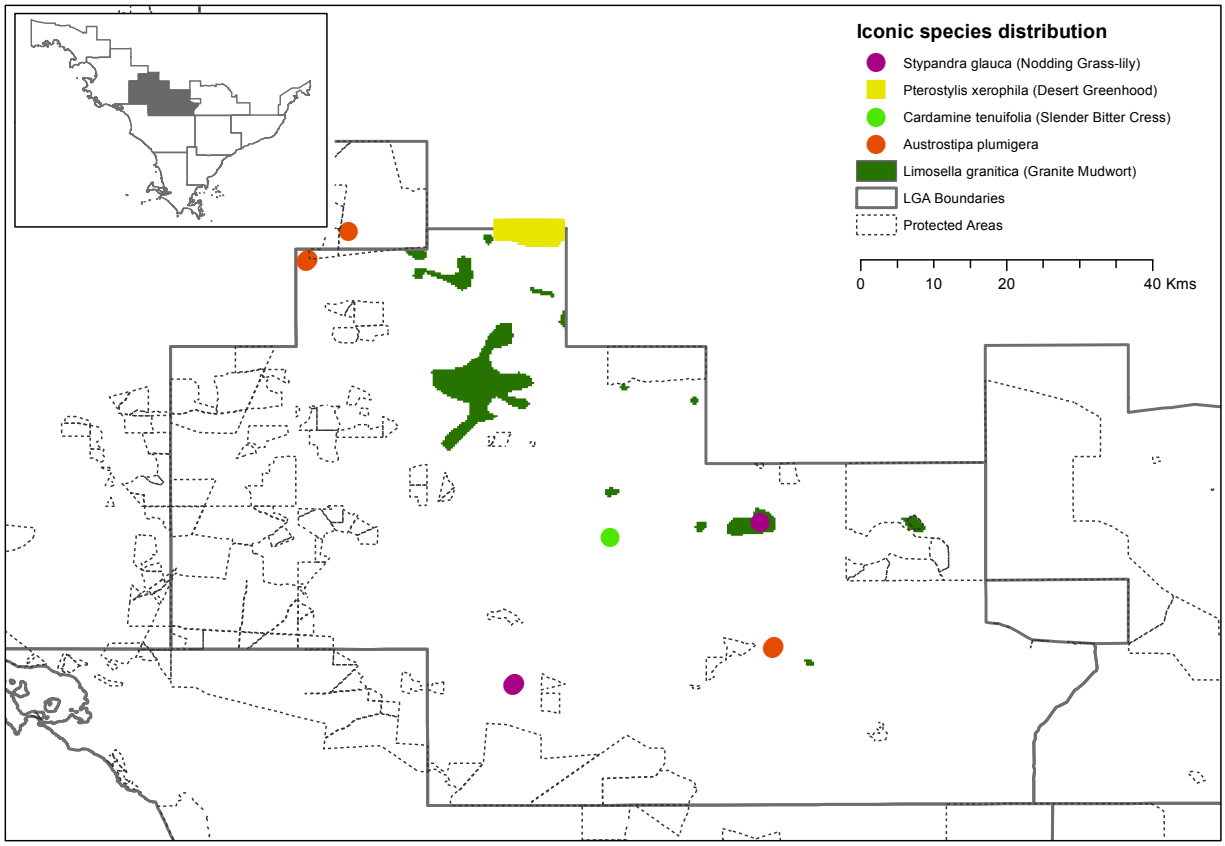

Figure Wu 1. Map of species occurring in the Wudinna LGA with more than 50% of their distribution in that area. The inset map shows the position of Wudinna LGA within the Eyre Peninsula NRM region.

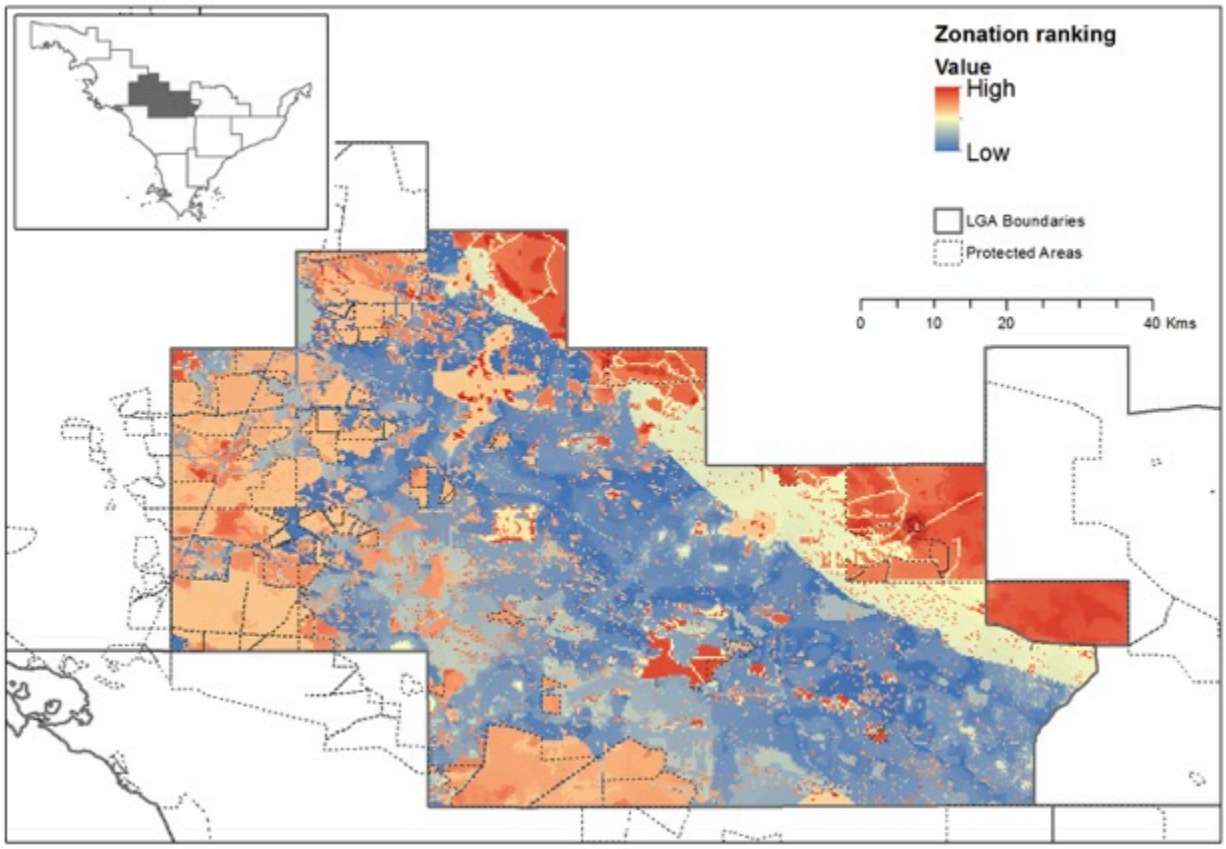

Figure Wu 2. Zonation ranking for the Wudinna LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Elliston local government area

Elliston local government area has 197 listed species of which 8 had greater than 50% of their Eyre Peninsula distribution in the Elliston LGA (Table E 1). These comprised 7 plant and a single bird species. The bird species, striped honeyeater, occupied >3000 km^2 of EP NRM occurring in 9 other LGAs in the region (Table E 1; Figure E 1). All other species are known from point distribution data only (Figure E 1). A number of areas of highest conservation priority were already included in protected areas (Figure C 2). In general, highest priority areas tended to be coastal and throughout the central part of the Elliston LGA (Figure E 2).

Elliston LGA has between 3 and 5 km^2 of saltmarsh and seagrass habitat within 500m of infrastructure respectively (Table E 2; Figure E 3). This increases to between 10 (seagrass) and 11.24 km^2 (saltmarsh) of habitat within 1km of infrastructure, which is primarily roads. Mangrove habitats do not occur in the Elliston LGA. These coastal habitats are primarily around Waterloo Bay.

Table E 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Elliston LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Austrostipa tenuifolia	Long-awn Spear-grass	PLANT	0.06	1	El
Calandrinia sphaerophylla	Bead Purslane	PLANT	0.06	1	El
Crassula sieberiana	Sieber's Crassula	PLANT	0.06	1	El
Olearia microdisca	Small-flower Daisy-bush	PLANT	0.06	1	El
Plectorhyncha lanceolata	Striped Honeyeater	BIRD	3085.44	10	El
Taraxacum cygnorum	Native Dandelion	PLANT	0.13	1	El
Tecticornia lepidosperma	*Tecticornia lepidosperma*	PLANT	0.25	2	El
Wurmbea sinora	Wurmbea sinora	PLANT	0.06	1	El

Table E 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Elliston LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	2.64		0.44		**3.09**	9.35		1.89		**11.24**
Seagrass	3.75		1.17		**4.92**	7.80		2.19		**9.99**

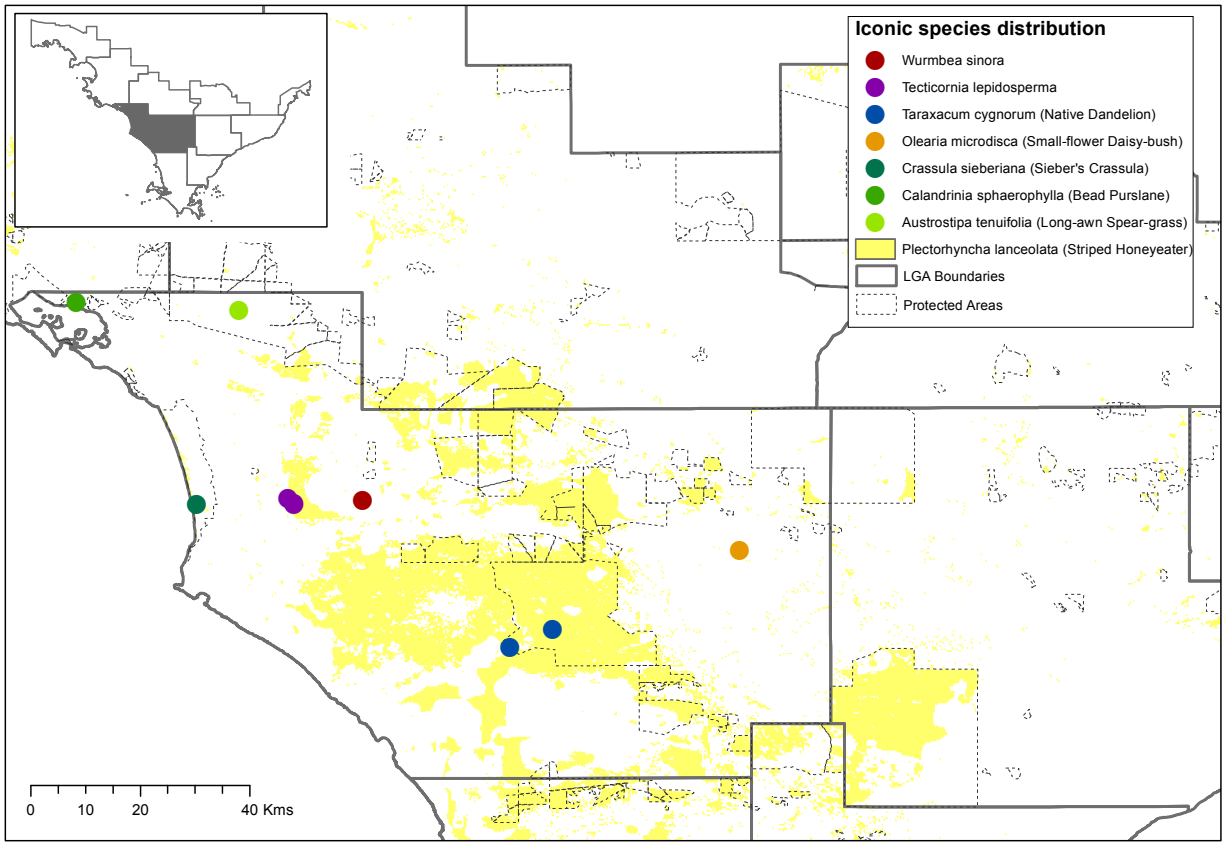

Figure E 1. Map of species occurring in the Elliston LGA with more than 50% of their distribution in that area. The inset map shows the position of Elliston LGA within the Eyre Peninsula NRM region.

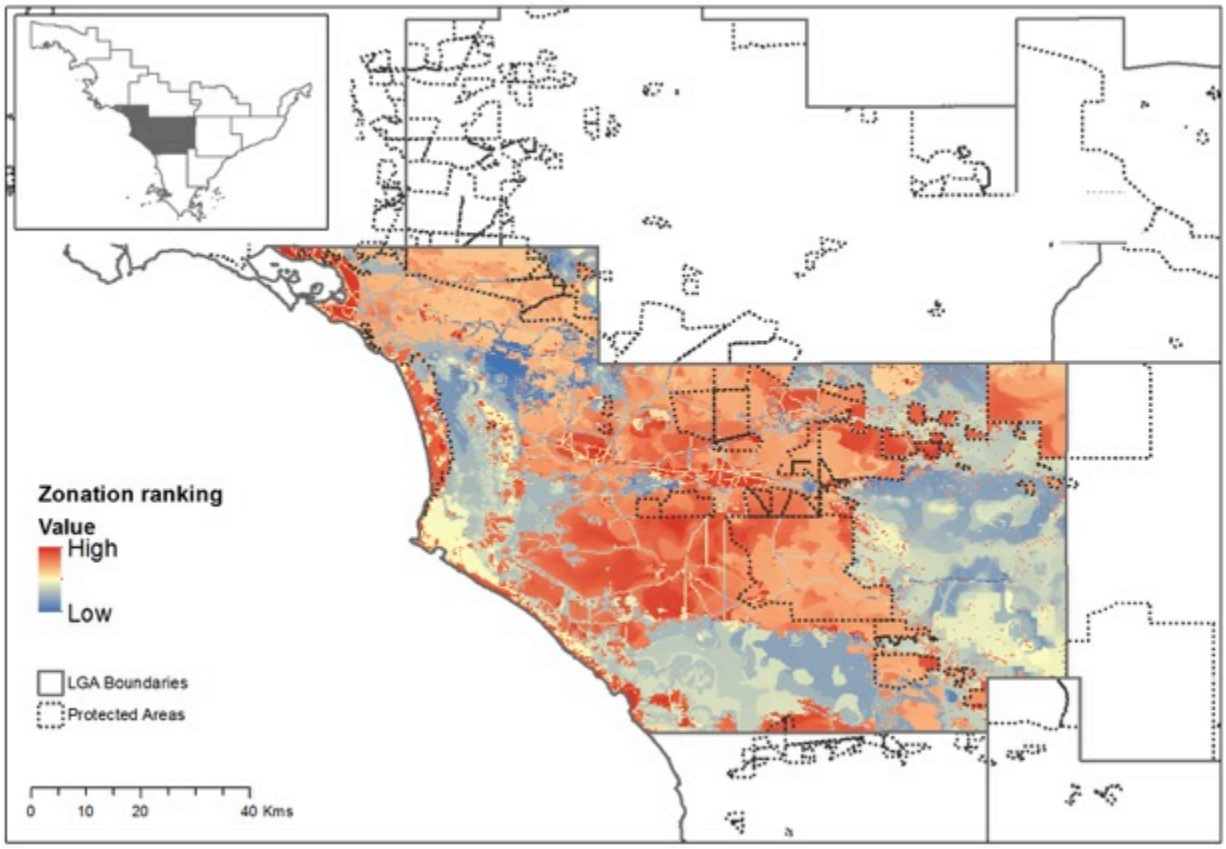

Figure E 2. Zonation ranking for the Elliston LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

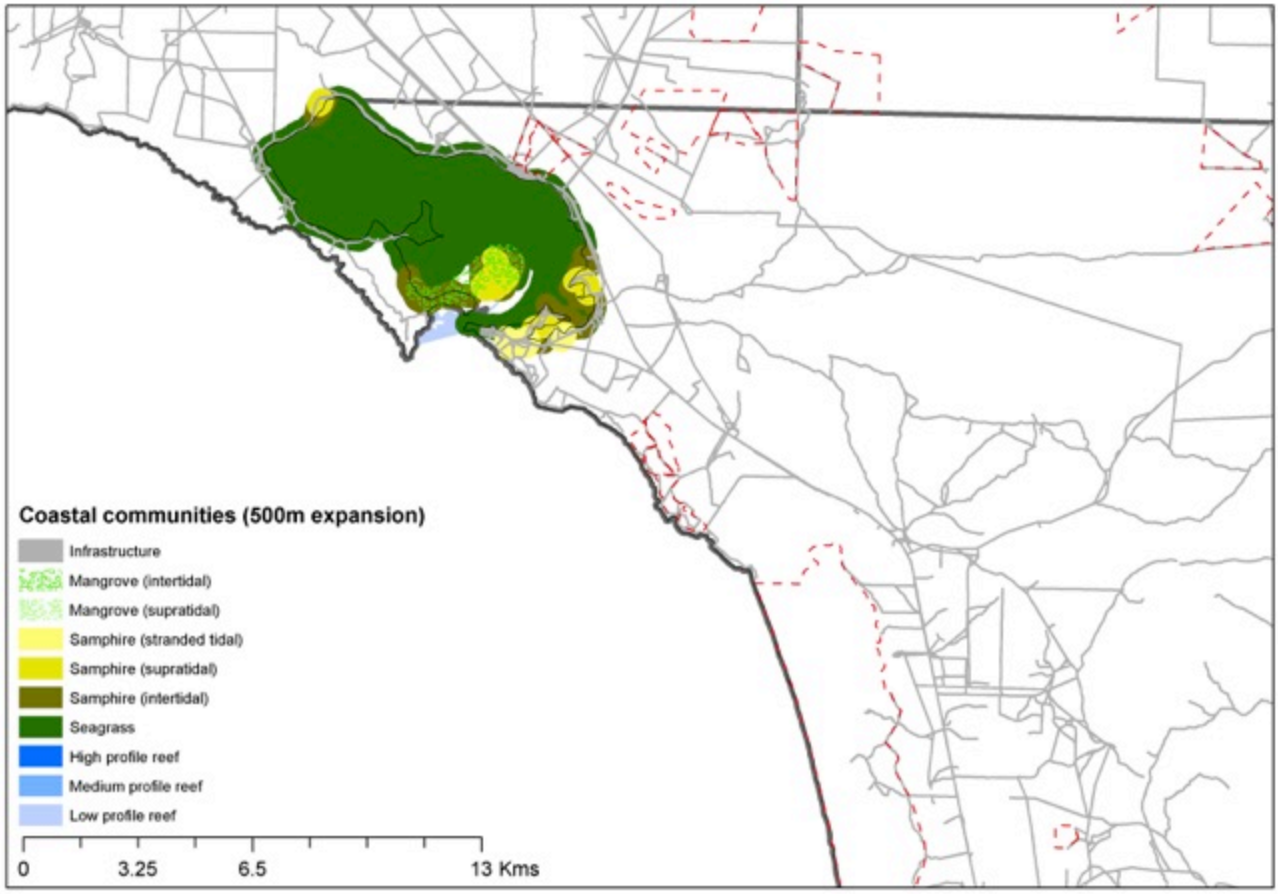

Figure E 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Elliston LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Lower Eyre Peninsula local government area

Lower Eyre Peninsula local government area has the largest number of listed species (n=291) for the EP NRM. Of this number 72 species had greater than 50% of their Eyre Peninsula distribution in the Lower Eyre Peninsula LGA presumably reflecting the National and Conservation parks in the region (Table LEP 1, Figure LEP 1). These comprised 12 bird, 1 frog, 4 mammal, 4 reptile and 51 plant species. The majority of species are known only from point distribution data (Figure LEP 2). Species in which mapped distribution data were possible ranged from a single species in the north of the LEP NRM through to 14 species along the coastal and inland region from Coffin Bay through to Port Lincoln (Figure LEP 2). The zonation priority map shows a similar pattern to the iconic species distribution map with the high priority areas largely occurring between Coffin Bay and Port Lincoln (Figure LEP 3).

Lower Eyre Peninsula LGA has around 3.8 to 4.59 km^2 of saltmarsh and seagrass that would be prevented from moving inland by infrastructure under rising sea level (Table LEP 2; Figure LEP 4). This increases to between 9.01 (seagrass) and 15.35 km^2 when infrastructure within 1km of the habitat is examined (Table LEP 2). Mangroves of significant note do not occur in the Lower Eyre Peninsula LGA.

Table LEP 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Lower Eyre Peninsula LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Acacia alcockii	Alcock's Wattle	PLANT	3629.63	5	LEP
Acacia dodonaeifolia	Hop leaved Wattle	PLANT	3227.25	7	LEP
Acacia imbricata	Imbricate Wattle	PLANT	3918	6	LEP
Acacia pinguifolia	Fat-leaf Wattle	PLANT	4863	6	LEP
Anthocercis anisantha ssp. anisantha	Port Lincoln Ray-flower	PLANT	0.25	1	LEP
Ardenna carneipes	Flesh-footed Shearwater	BIRD	792.55	6	LEP
Bassiana trilineata	Western Three-lined Skink	REPTILE	0.63	1	LEP
Billardiera sp. Yorke Peninsula (P.C.Heyligers 80164)	Lehmann's Apple-berry	PLANT	0.06	1	LEP
Bossiaea peninsularis	Bossiaea	PLANT	0.19	2	LEP
Burhinus grallarius	Bush Stonecurlew	BIRD	2520.69	6	LEP
Caladenia macroclavia	Large-club Spider-orchid	PLANT	994.22	5	LEP
Caladenia pusilla	Pigmy Caladenia	PLANT	0.06	1	LEP
Caladenia sp. Southeast (R.Bates 66283)	Sand Spider-orchid	PLANT	0.06	1	LEP
Calidris subminuta	Long-toed Stint	BIRD	2384.63	9	LEP
Cereopsis novaehollandiae	Cape Barren Goose	BIRD	7323.63	7	LEP
Dasyurus geoffroii	Western Quoll	MAMMAL	0.06	1	LEP
Dianella longifolia var. grandis	Pale Flax-lily	PLANT	432.25	9	LEP
Dodonaea procumbens	Trailing Hop-bush	PLANT	603.69	3	LEP
Drosera stricticaulis	Erect Sundew	PLANT	5995.75	6	LEP

Eragrostis infecunda	Barren Cane-grass	PLANT	104.81	1	LEP
Eucalyptus behriana	Broad-leaf Box	PLANT	2993.88	7	LEP
Eucalyptus calycogona ssp. spaffordii	Spafford's Square-fruit Mallee	PLANT	0.19	1	LEP
Eucalyptus conglobata ssp. conglobata	Cong Mallee	PLANT	1429.75	2	LEP
Eucalyptus macrorhyncha ssp. macrorhyncha	Red Stringybark	PLANT	76.88	2	LEP
Eudyptula minor	Little Penguin	BIRD	5749	10	LEP
Euphrasia collina ssp. osbornii	Osborn's Eyebright	PLANT	7126.13	7	LEP
Gerygone fusca	Western Gerygone	BIRD	3643.06	4	LEP
Grevillea halmaturina ssp. laevis	Prickly Grevillea	PLANT	0.31	1	LEP
Haeckeria cassiniiformis	Dogwood Haeckeria	PLANT	0.38	3	LEP
Hydrurga leptonyx	Leopard Seal	MAMMAL	0.06	1	LEP
Isotoma scapigera	Salt Isotome	PLANT	3259.88	5	LEP
Larus dominicanus	Kelp Gull	BIRD	0.06	1	LEP
Levenhookia stipitata	Common Stylewort	PLANT	8514.38	8	LEP
Lophoictinia isura	Square-tailed Kite	BIRD	0.06	1	LEP
Mirounga leonina	Southern Elephant Seal	MAMMAL	0.06	1	LEP
Mitrasacme pilosa var. pilosa	Hairy Mitrewort	PLANT	0.06	1	LEP
Notechis ater	Black Tiger Snake	REPTILE	0.06	1	LEP
Olax obcordata	*Olax obcordata*	PLANT	144	1	LEP
Olearia pannosa ssp. cardiophylla	Velvet Daisy-bush	PLANT	0.06	1	LEP
Orobanche cernua var. australiana	Australian Broomrape	PLANT	3985.56	6	LEP
Pandion haliaetus	Osprey	BIRD	4522.94	8	LEP
Petroica boodang	Scarlet Robin	BIRD	3859.88	8	LEP
Phyllanthus calycinus	Snowdrop Spurge	PLANT	7520.06	7	LEP
Phylloglossum drummondii	Pigmy Clubmoss	PLANT	0.06	1	LEP
Pleuropappus phyllocalymmeus	Silver Candles	PLANT	4910.38	5	LEP
Podolepis muelleri	Button Podolepis	PLANT	637.31	8	LEP
Polypogon tenellus	*Polypogon tenellus*	PLANT	0.06	1	LEP
Prasophyllum fecundum	Self-pollinating Leek-orchid	PLANT	8752.44	7	LEP
Prasophyllum goldsackii	Goldsack's Leek-orchid	PLANT	123.02	4	LEP
Prasophyllum occultans	Hidden Leek-orchid	PLANT	0.44	1	LEP
Prasophyllum sp. Enigma (R.Bates 2350)	Goldsack's Leek-orchid	PLANT	0.06	1	LEP
Pseudemoia baudini	Bight Coast Skink	REPTILE	0.13	1	LEP
Pseudophryne bibronii	Brown Toadlet	FROG	767.75	8	LEP
Psophodes nigrogularis leucogaster	Western Whipbird (Eastern subspecies)	BIRD	1358.25	2	LEP
Ptilotus beckerianus	Ironstone Mulla Mulla	PLANT	2827.44	3	LEP
Pultenaea kraehenbuehlii	Tothill Bush-pea	PLANT	293.5	8	LEP
Pultenaea trichophylla	Tufted Bush-pea	PLANT	3231.25	7	LEP

Schoenus laevigatus	Short-leaf Bog-sedge	PLANT	0.13	1	LEP
Schoenus sculptus	Gimlet Bog-rush	PLANT	1.06	4	LEP
Sphaerolobium minus	Leafless Globe-pea	PLANT	0.63	2	LEP
Spyridium bifidum ssp. bifidum	Marble Range Spyridium	PLANT	0.25	1	LEP
Spyridium bifidum ssp. wanillae	Wanilla Spyridium	PLANT	0.06	1	LEP
Spyridium spathulatum	Spoon-leaf Spyridium	PLANT	0.88	4	LEP
Stackhousia annua	Annual Candles	PLANT	1847.94	5	LEP
Stipiturus malachurus parimeda	Southern Emu-wren (Eyre Peninsula ssp)	BIRD	2767.75	3	LEP
Thelymitra epipactoides	Metallic Sun-orchid	PLANT	1153.41	3	LEP
Thelymitra flexuosa	Twisted Sun Orchid	PLANT	3037.88	4	LEP
Thelymitra ixioides	Dotted Sun Orchid	PLANT	0.06	1	LEP
Trichosurus vulpecula	Common Brushtail Possum	MAMMAL	2872.63	8	LEP
Triglochin minutissima	Tiny Arrowgrass	PLANT	0.13	1	LEP
Varanus rosenbergi	Heath Goanna	REPTILE	1777.69	2	LEP
Xanthorrhoea semiplana ssp. tateana	Tate's Grass-tree	PLANT	0.81	3	LEP

Table LEP 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Lower Eyre Peninsula LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	3.67		0.92		**4.59**	12.04		3.32		**15.35**
Seagrass	3.16		0.65		**3.80**	7.10		1.91		**9.01**

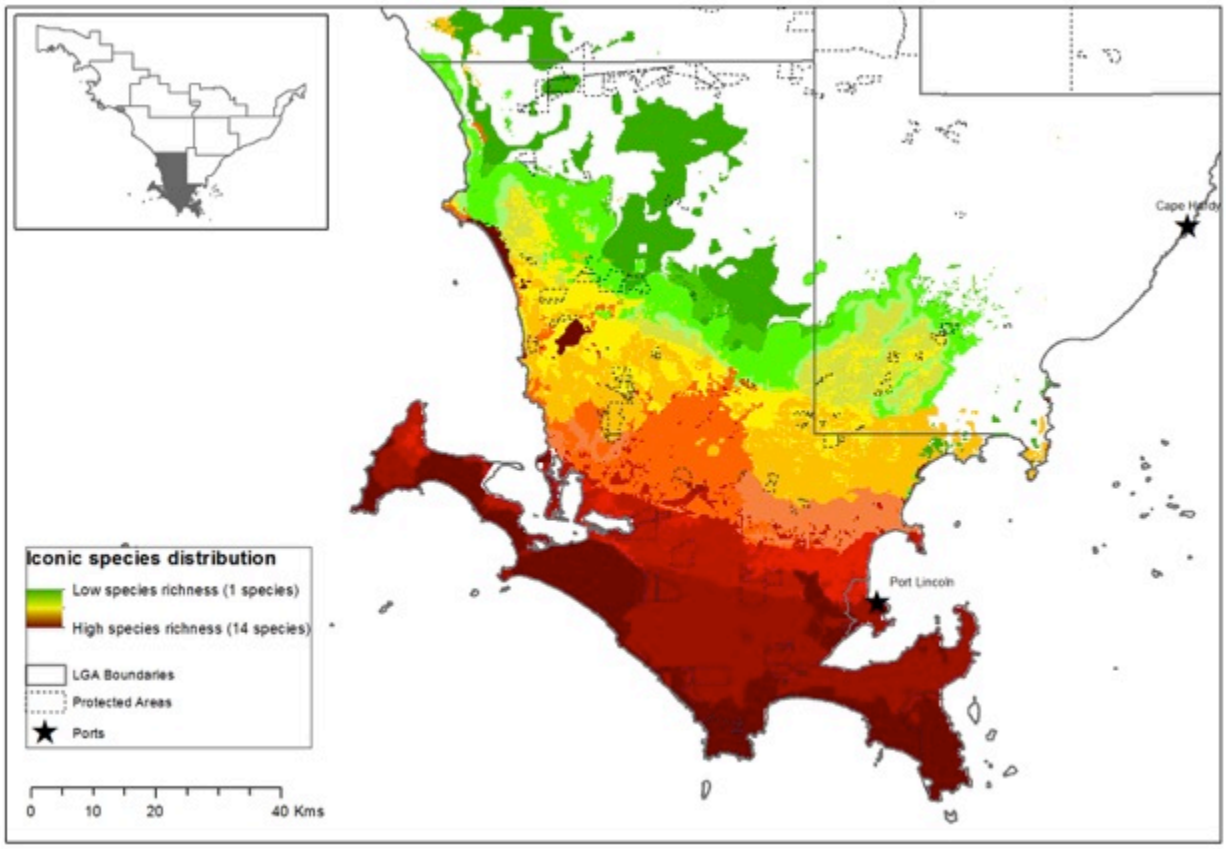

Figure LEP 1. Map of iconic species with more than 50% of their EP NRM distribution occurring in the Lower Eyre Peninsula LGA showing the species richness. The inset map shows the position of Lower Eyre Peninsula LGA within the Eyre Peninsula NRM region.

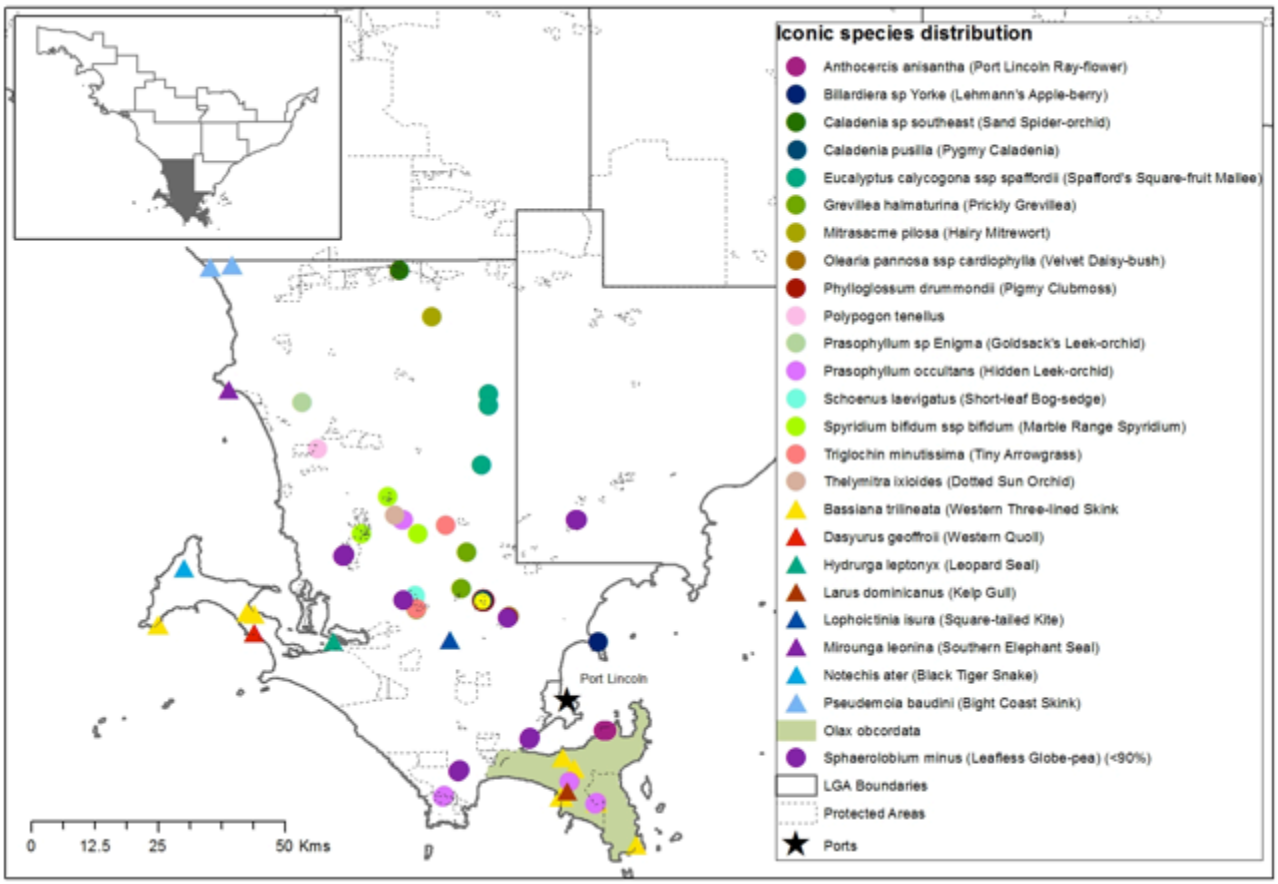

Figure LEP 2. Map showing distribution of species with only point distribution data occurring in the Lower Eyre Peninsula LGA. Only species with more than 50% of their distribution in the LEP LGA are shown. The inset map shows the position of Lower Eyre Peninsula LGA within the Eyre Peninsula NRM region.

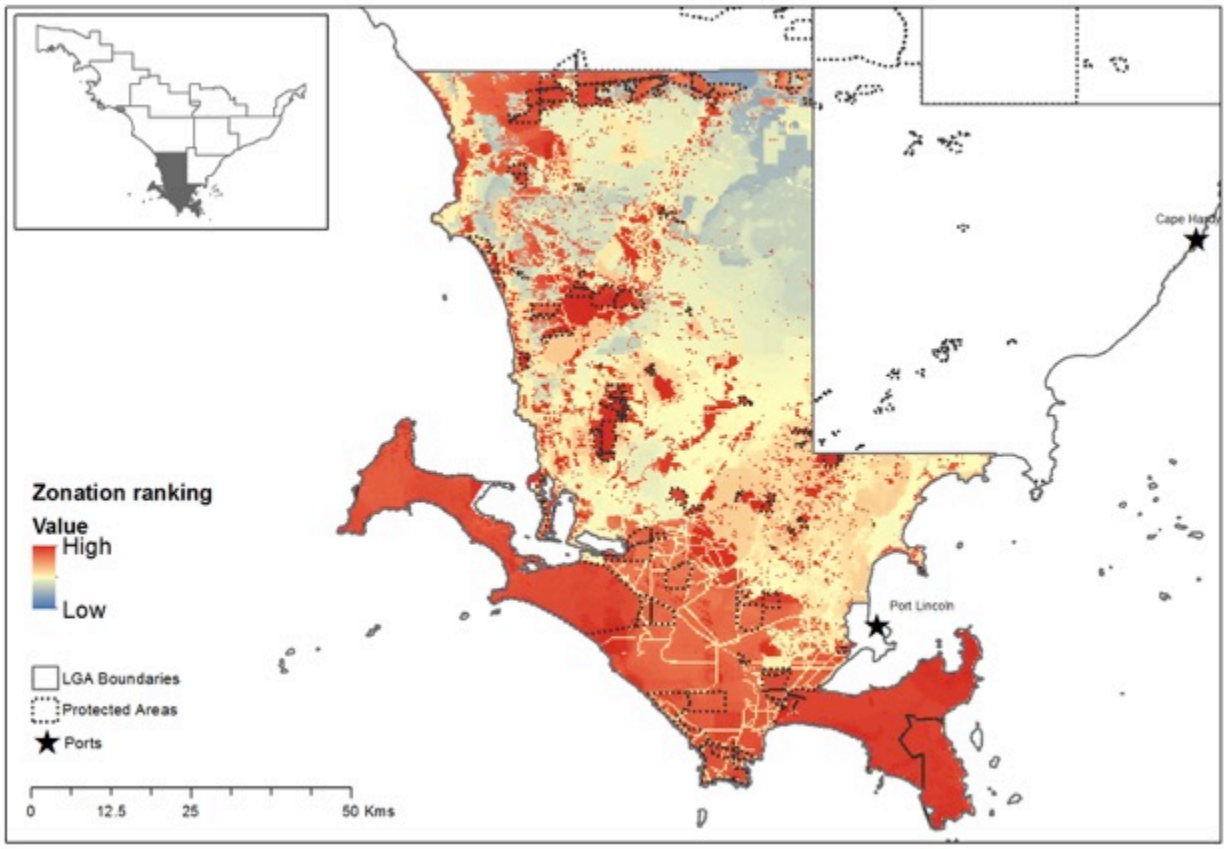

Figure LEP 3. Zonation ranking for the Lower Eyre Peninsula LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

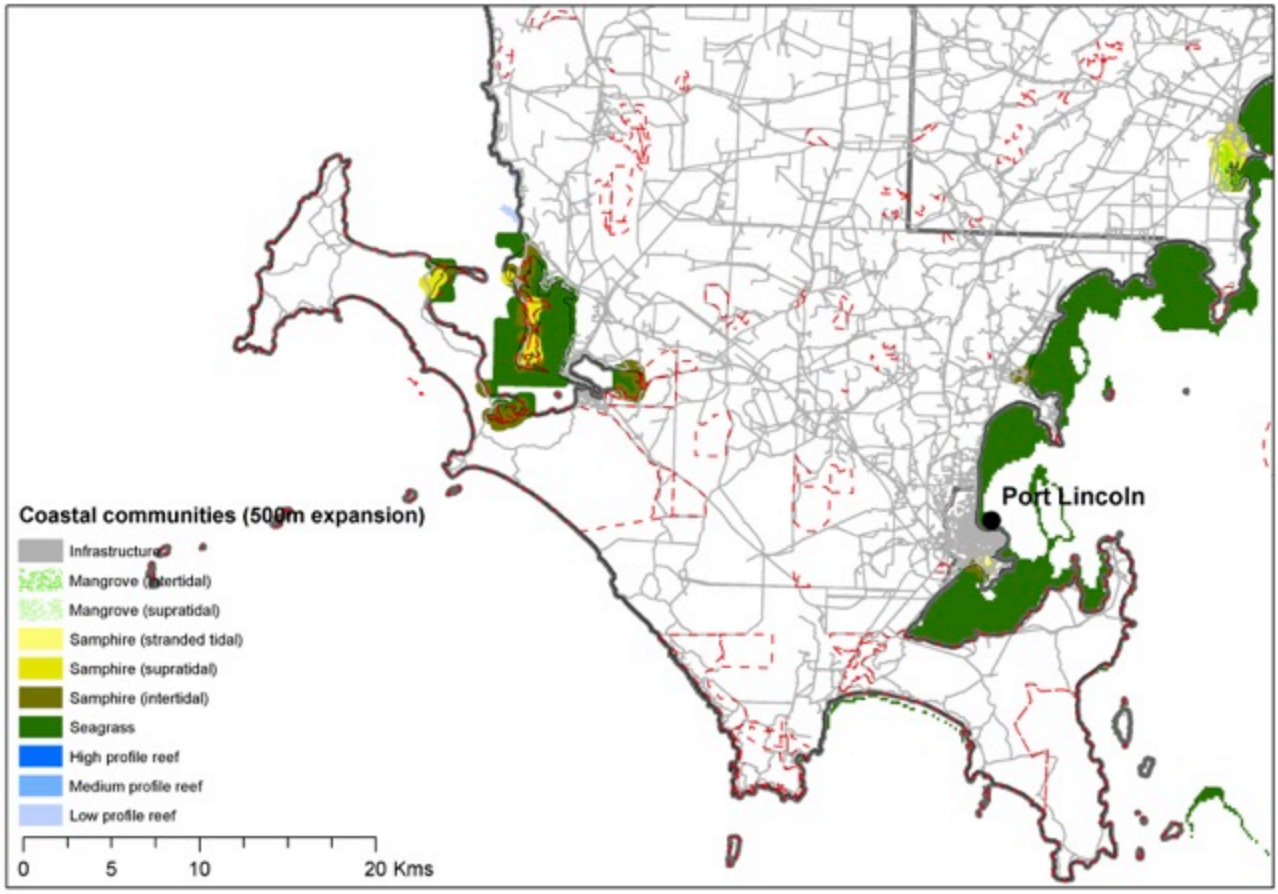

Figure LEP 4. Mapping of potential barriers to inland dispersal of coastal habitats for the Lower Eyre Peninsula LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Port Lincoln local government area

Port Lincoln local government area is a small city council surrounded by the Lower Eyre Peninsula LGA. Port Lincoln LGA has 138 listed species of which 2 had greater than 50% of their Eyre Peninsula distribution in the Port Lincoln LGA (Table PL 1). These comprised a single plant (green mintbush) and a single insect (small orange-spotted sun moth). The small orange-spotted sun moth occurs throughout the Port Lincoln LGA whereas the green mintbush occurs in a small area occupying just 0.13km^2 (Figure PL 1). Port Lincoln LGA is also the only LGA on Eyre Peninsula that the green mintbush occurs in. The moth also occurs in another LGA within the EP NRM. The zonation ranking map shows mid level rankings for the Port Lincoln LGA (Figure PL 2). While there are some high rankings these generally occur for a single pixel within the zonation map (Figure PL 2).

Small areas of seagrass (between 0.81 and 2.39 km^2 for infrastructure within 500m and 1km respectively of the habitat) are restricted from moving inland under a changing climate (Table PL 2; Figure PL 3). Around 4.71km^2 of saltmarsh is restricted from movement by infrastructure within 500m of the habitat, but this increases significantly when infrastructure within 1km is mapped (Table PL 2). Mangroves do not occur in a large enough area to be mapped for the Port Lincoln LGA.

Table PL 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Port Lincoln LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Prostanthera chlorantha	Green Mintbush	PLANT	0.13	1	PL
Synemon discalis	Small Orange-spotted Sun Moth	INSECT	13.5	2	PL

Table PL 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Port Lincoln LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	3.95		0.76		**4.71**	17.11	0.16	6.17		**23.44**
Seagrass	0.62	0.0004	0.19		**0.81**	1.74	0.15	0.5		**2.39**

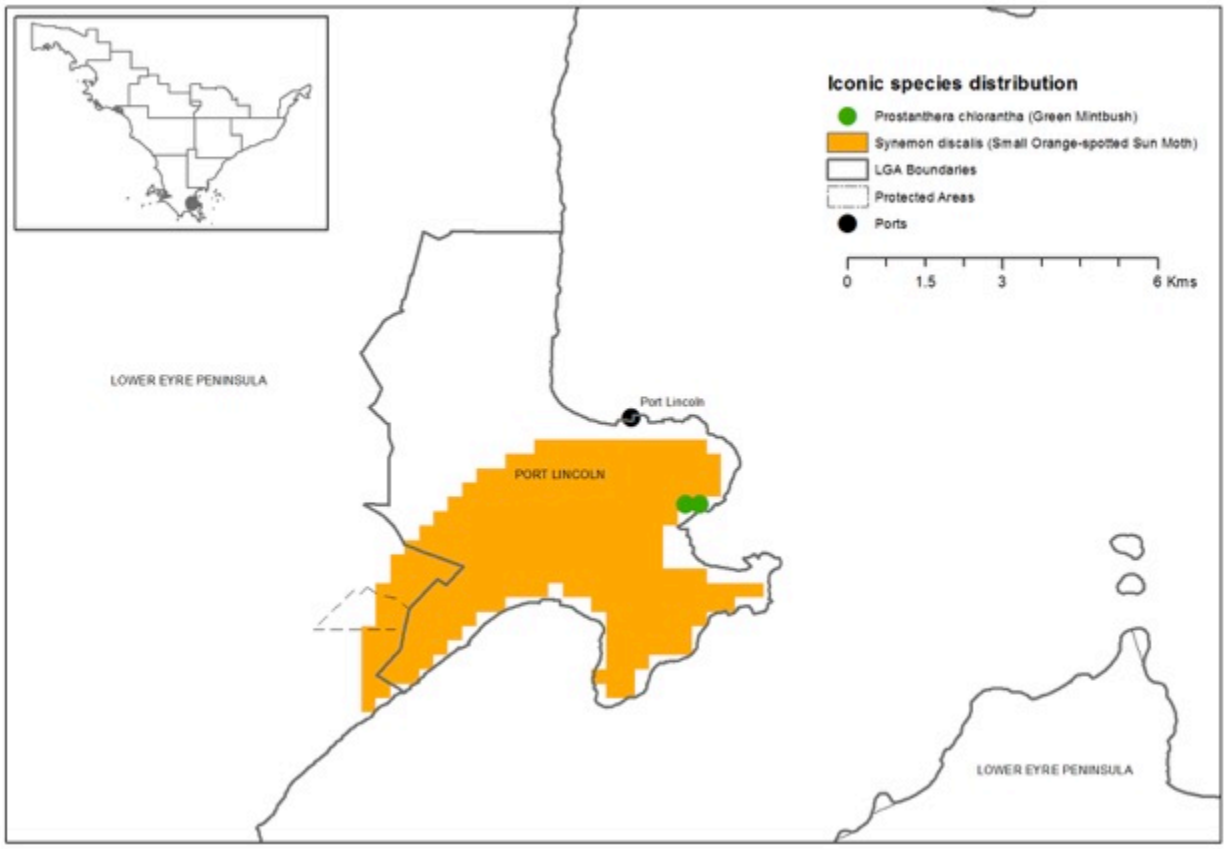

Figure PL 1. Map of species occurring in the Port Lincoln LGA with more than 50% of their distribution in that area. The inset map shows the position of Port Lincoln LGA within the Eyre Peninsula NRM region.

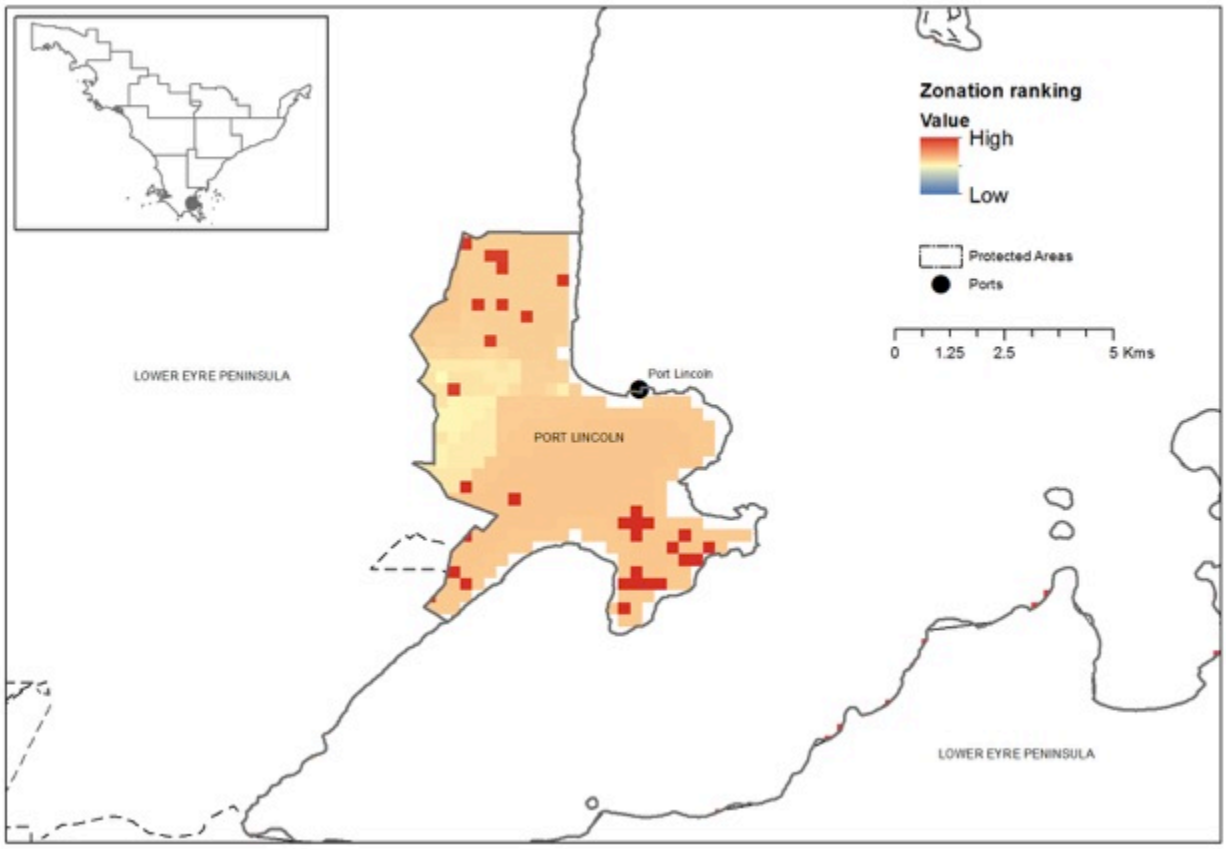

Figure PL 2. Zonation ranking for the Port Lincoln LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

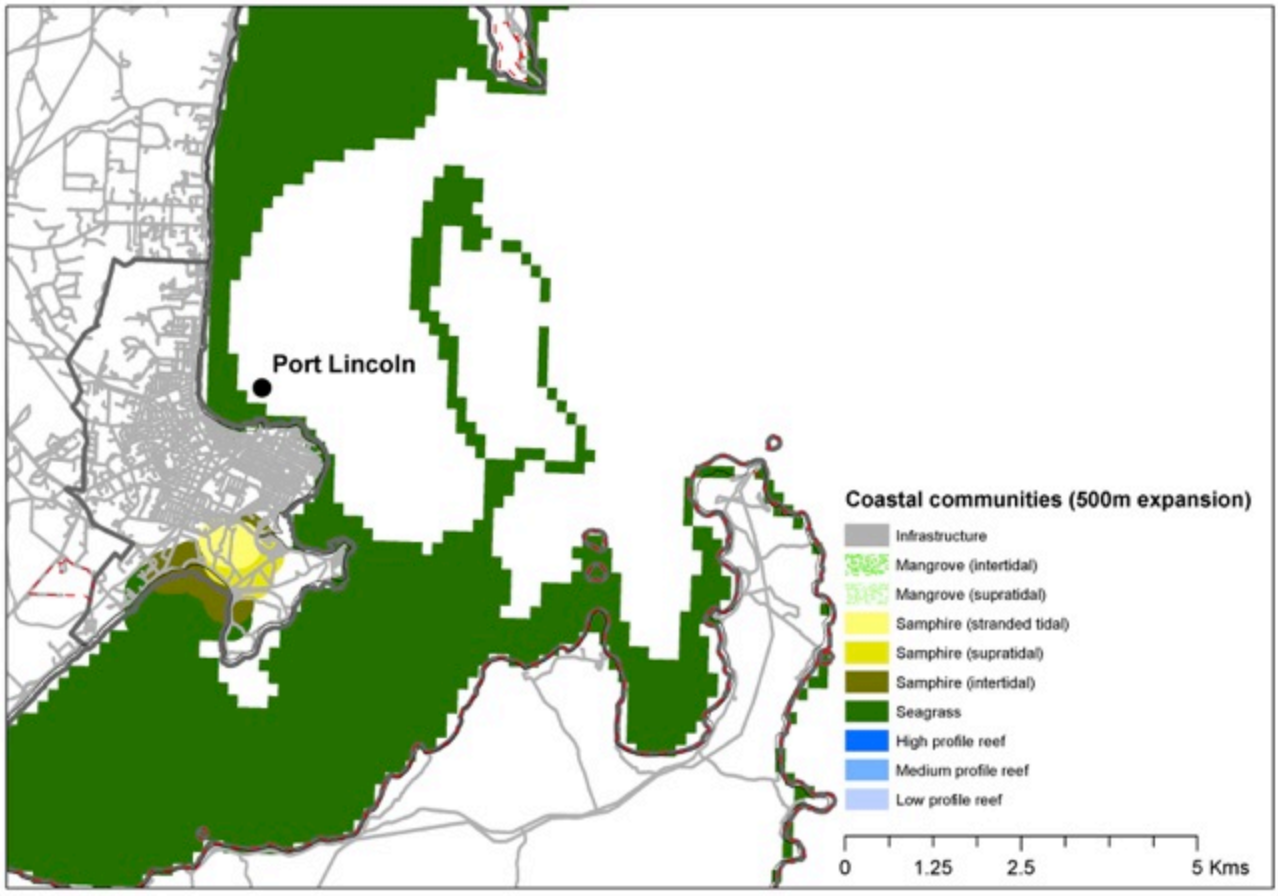

Figure PL 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Port Lincoln LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Tumby Bay local government area

Tumby Bay local government area has 197 listed species of which 11 had greater than 50% of their Eyre Peninsula distribution in the Tumby Bay LGA (Table TB 1). One of these 'species' was a community of national environmental significance, namely peppermint box grassy woodlands, which occupies just 11.63 km^2 of the EP NRM region. This community also occurs in one other EP LGA. Six of the plant species only have point occurrence data (Figure TB 1). The small leaved emu bush is the most widely distributed species with more than 50% of its distribution in the Tumby Bay LGA (Figure TB 1). The main area of conservation significance occurs within a protected area (Figure TB 2). With the exception of this area, other high conservation priority areas are relatively small and occur throughout the Tumby Bay LGA (Figure TB 2).

Mangroves are the main habitat limited by infrastructure in terms of inland movement for the Tumby Bay LGA (Table TB 2). Seagrass and saltmarsh habitats are also impeded from inland movement by infrastructure, primarily roads, and around 3-4x the amount of habitat is affected by infrastructure within 1km of the habitat than within 500m (Figure TB 3).

Table TB 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Tumby Bay LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in. CNES, community of national environmental significance

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Acacia simmonsiana	Desert Manna Wattle	PLANT	0.06	1	TB
Acacia whibleyana	Whibley Wattle	PLANT	0.69	1	TB
Brachyscome breviscapis	Short-stem Daisy	PLANT	0.06	1	TB
Brachyscome xanthocarpa	Yellow-fruit Daisy	PLANT	0.19	2	TB
Caladenia conferta	Coast Spider-orchid	PLANT	9.38	1	TB
CNES 36	Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia	CNES	11.63	2	TB
Eremophila parvifolia ssp. parvifolia	Small-leaved Emubush	PLANT	599.31	7	TB
Lachnagrostis limitanea	Spalding Blown-grass	PLANT	3.38	2	TB
Microtis eremaea	Slender Onion-orchid	PLANT	0.06	1	TB
Spyridium leucopogon	Silvery Spyridium	PLANT	0.69	2	TB
Swainsona behriana	Behr's Swainson-pea	PLANT	3.19	3	TB

Table TB 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Tumby Bay LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	2.31		0.74		**3.05**	6.30		2.02		**8.32**
Seagrass	1.63		0.85		**2.48**	4.23		1.80		**6.03**
Mangroves	2.94		1.15		**4.09**	12.42		3.90		**16.33**

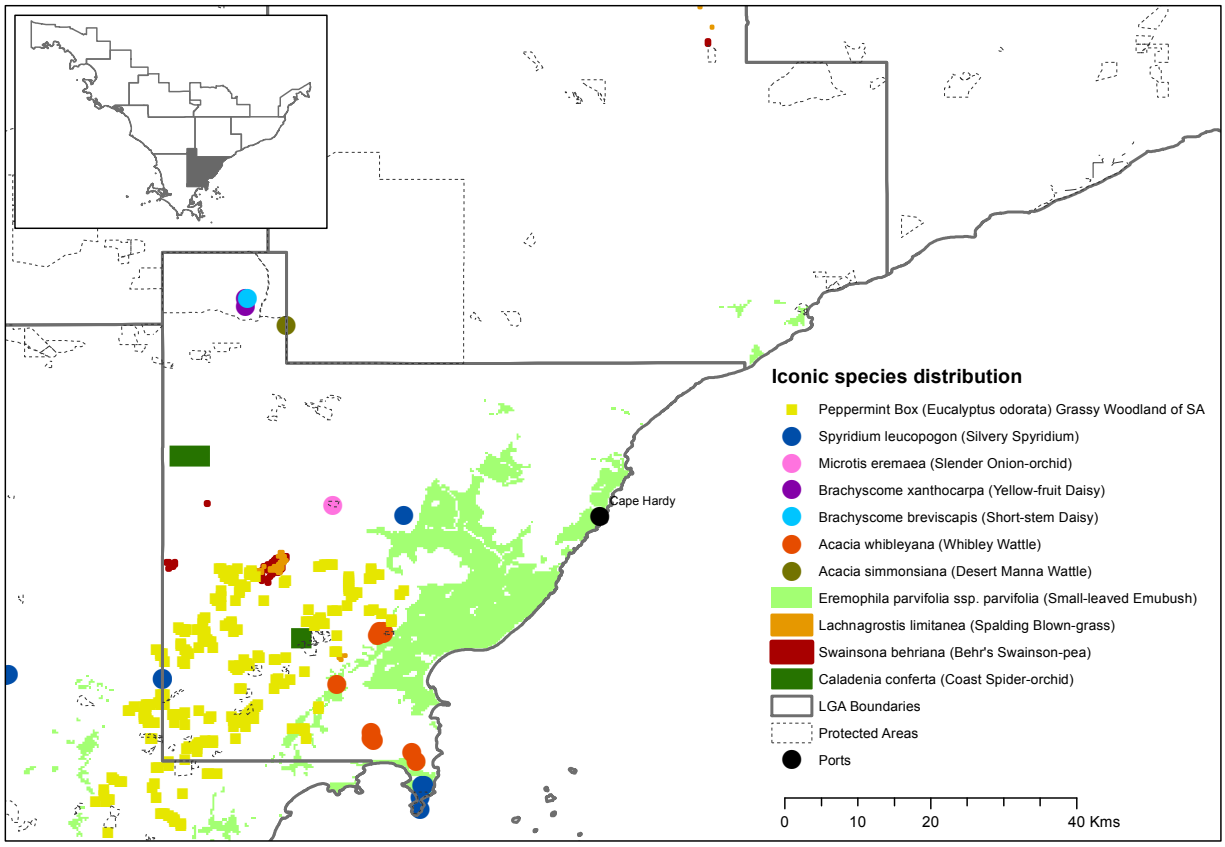

Figure TB 1. Map of species occurring in the Tumby Bay LGA with more than 50% of their distribution in that area. The inset map shows the position of Tumby Bay LGA within the Eyre Peninsula NRM region.

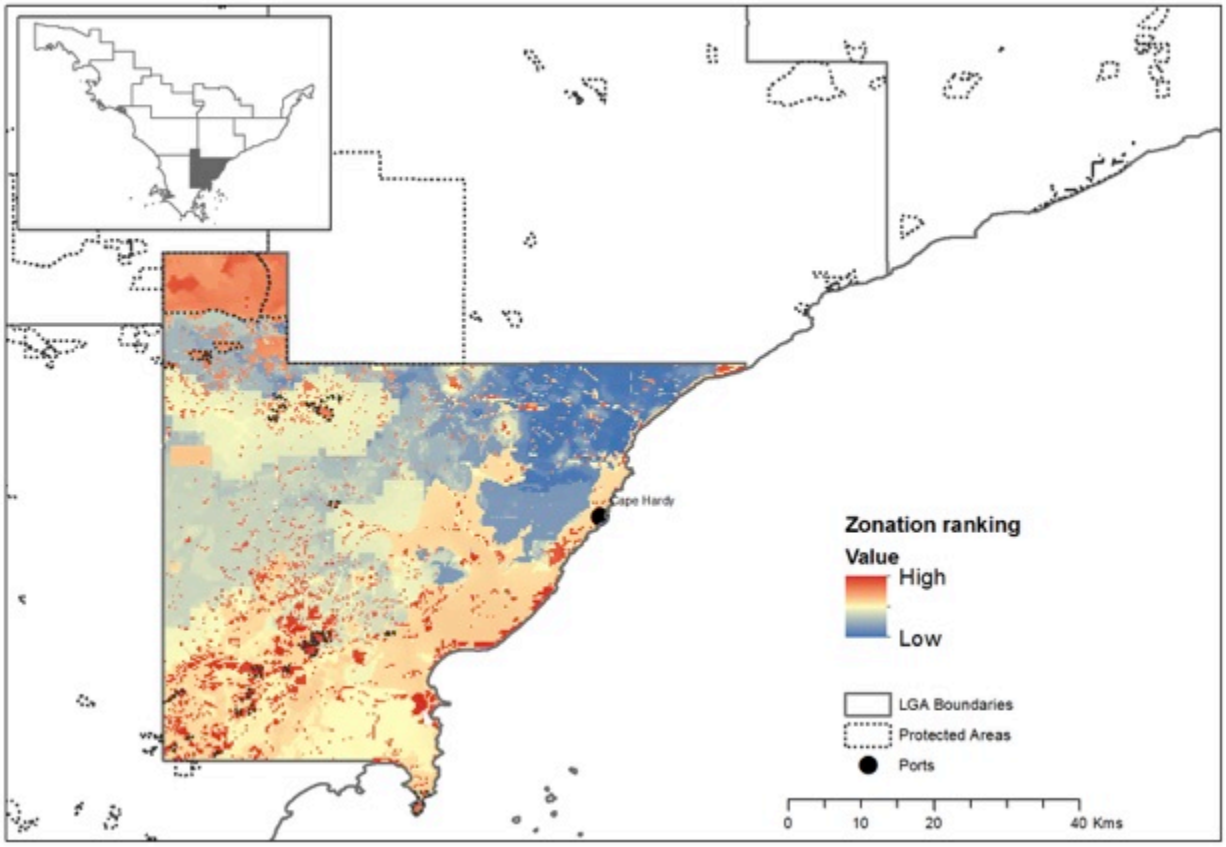

Figure TB 2. Zonation ranking for the Tumby Bay LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

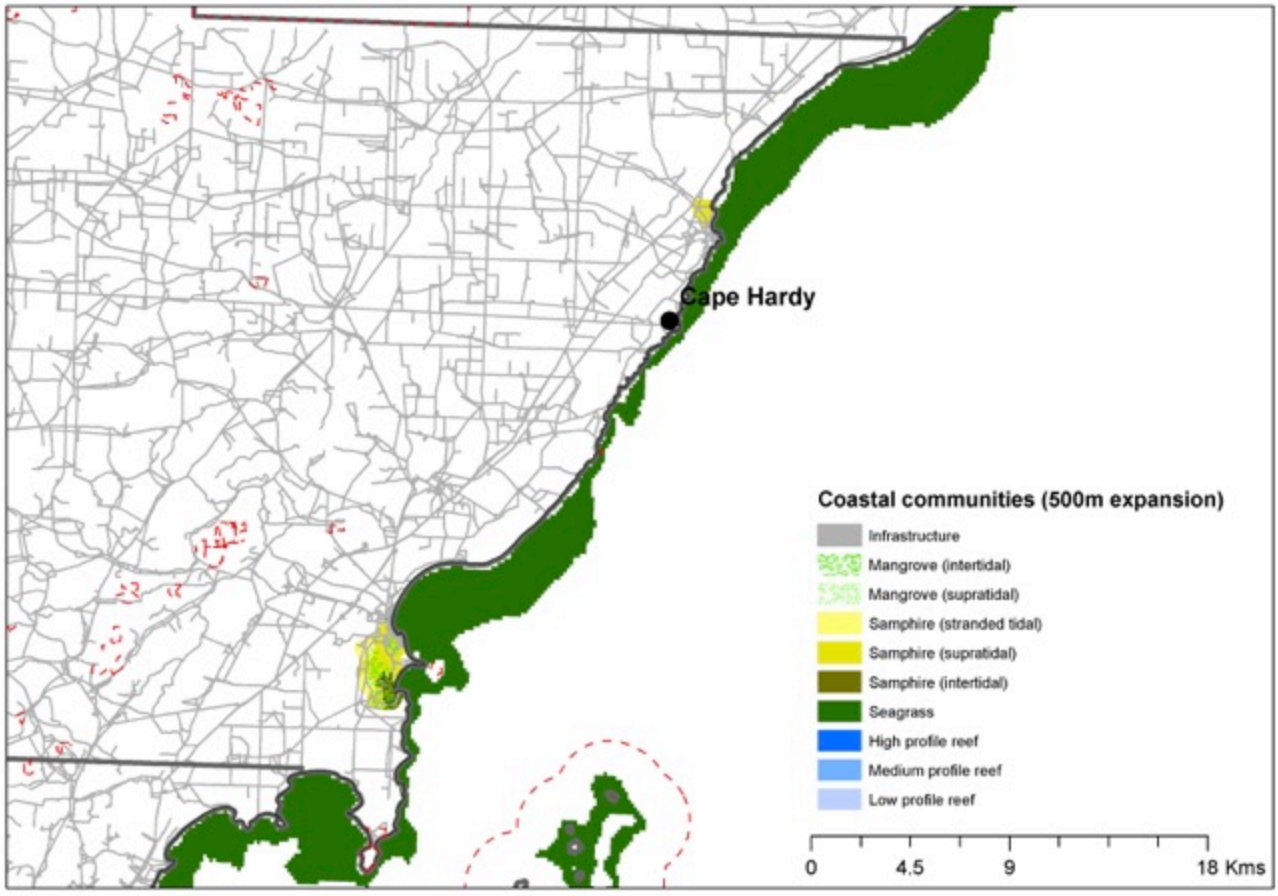

Figure TB 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Tumby Bay LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Cleve local government area

Cleve local government area has 206 listed species of which 11 had greater than 50% of their Eyre Peninsula distribution in the Cleve LGA (Table Cl 1). These comprised 10 plant and a single bird species most of which occurred in less than 3 LGAs including Cleve (Figure Cl 1). The only species with more than 50% of its EP NRM distribution in Cleve that occurred in 4 other LGAs was the plant, white box. The zonation map showed that a number of high priority areas were already included in protected areas (Figure Cl 2).

Only small areas (<1.5km^2) of saltmarsh, seagrass and mangroves were limited from inland movement by existing infrastructure (Table Cl 2; Figure Cl 3). Within 1km of coastal habitats, greater amounts of mangroves (6.42km^2) than saltmarsh (4.86km2) were restricted from inland movement by infrastructure, predominantly by roads and power lines (Table Cl 2). Less than 1km^2 of seagrass was restricted from inland movement when infrastructure within 1km of the habitat was investigated.

Table Cl 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Cleve LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Anogramma leptophylla	Annual Fern	PLANT	0.19	2	Cl
Austrostipa gibbosa	Swollen Spear-grass	PLANT	0.25	2	Cl
Calochilus pruinosus	Mallee Beard Orchid	PLANT	0.13	1	Cl
Centrolepis cephaloformis ssp. cephaloformis	Cushion Centrolepis	PLANT	0.19	2	Cl
Echiopsis curta	Bardick	BIRD	0.19	2	Cl
Eremophila barbata	Blue Range Emubush	PLANT	0.5	1	Cl
Eucalyptus albens	White Box	PLANT	4.44	5	Cl
Lawrencia berthae	Showy Lawrencia	PLANT	0.19	2	Cl
Lepidosperma gahnioides	*Lepidosperma gahnioides*	PLANT	0.19	1	Cl
Pimelea williamsonii	Williamson's Riceflower	PLANT	0.69	3	Cl
Prasophyllum constrictum	Tawny Leek-orchid	PLANT	0.13	1	Cl

Table Cl 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Cleve LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	0.76		0.55	0.01	**1.31**	2.74		2.03	0.1	**4.86**
Seagrass	0.21		0.14		**0.35**	0.53		0.32		**0.84**
Mangroves	0.43		0.47		**0.90**	3.43		2.9	0.08	**6.42**

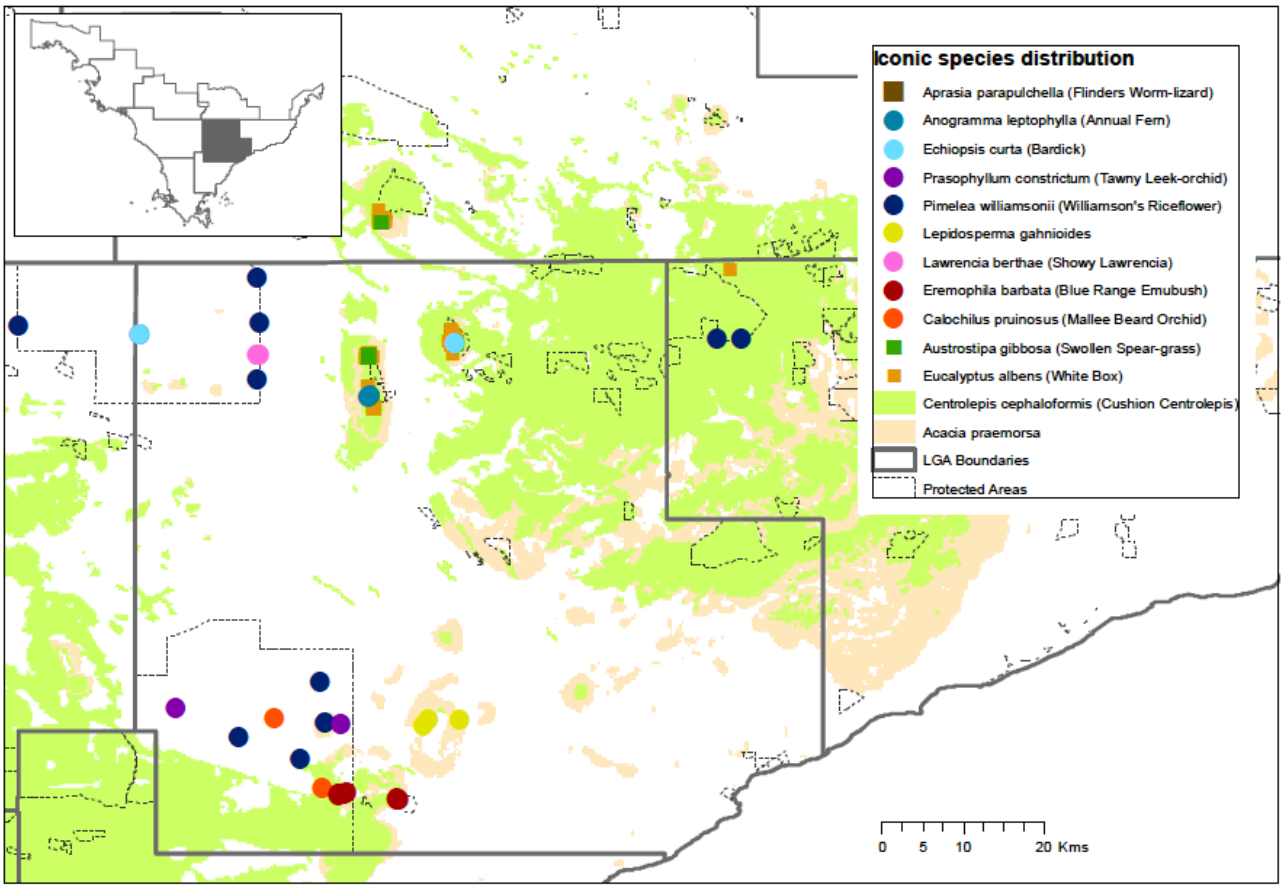

Figure Cl 1. Map of species occurring in the Cleve LGA with more than 50% of their distribution in that area. The inset map shows the position of Cleve LGA within the Eyre Peninsula NRM region.

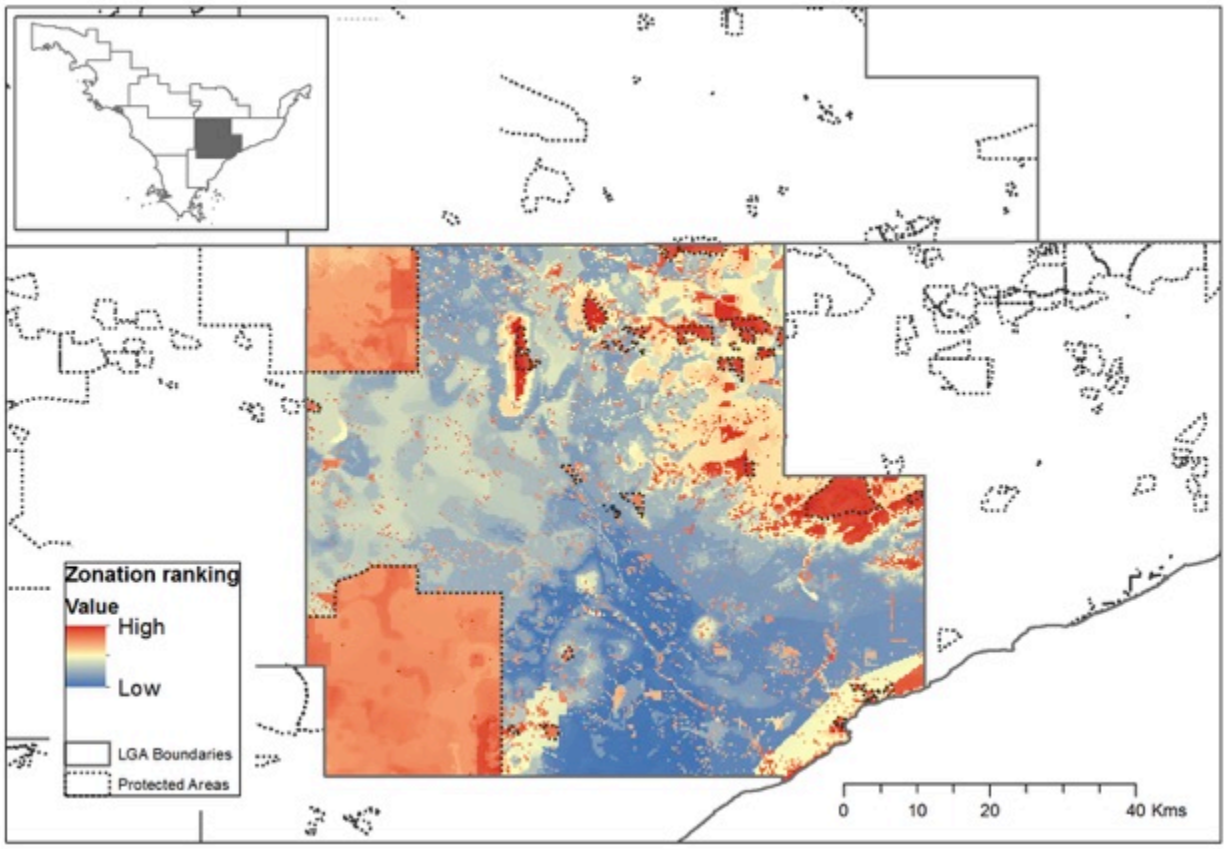

Figure Cl 2. Zonation ranking for the Cleve LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

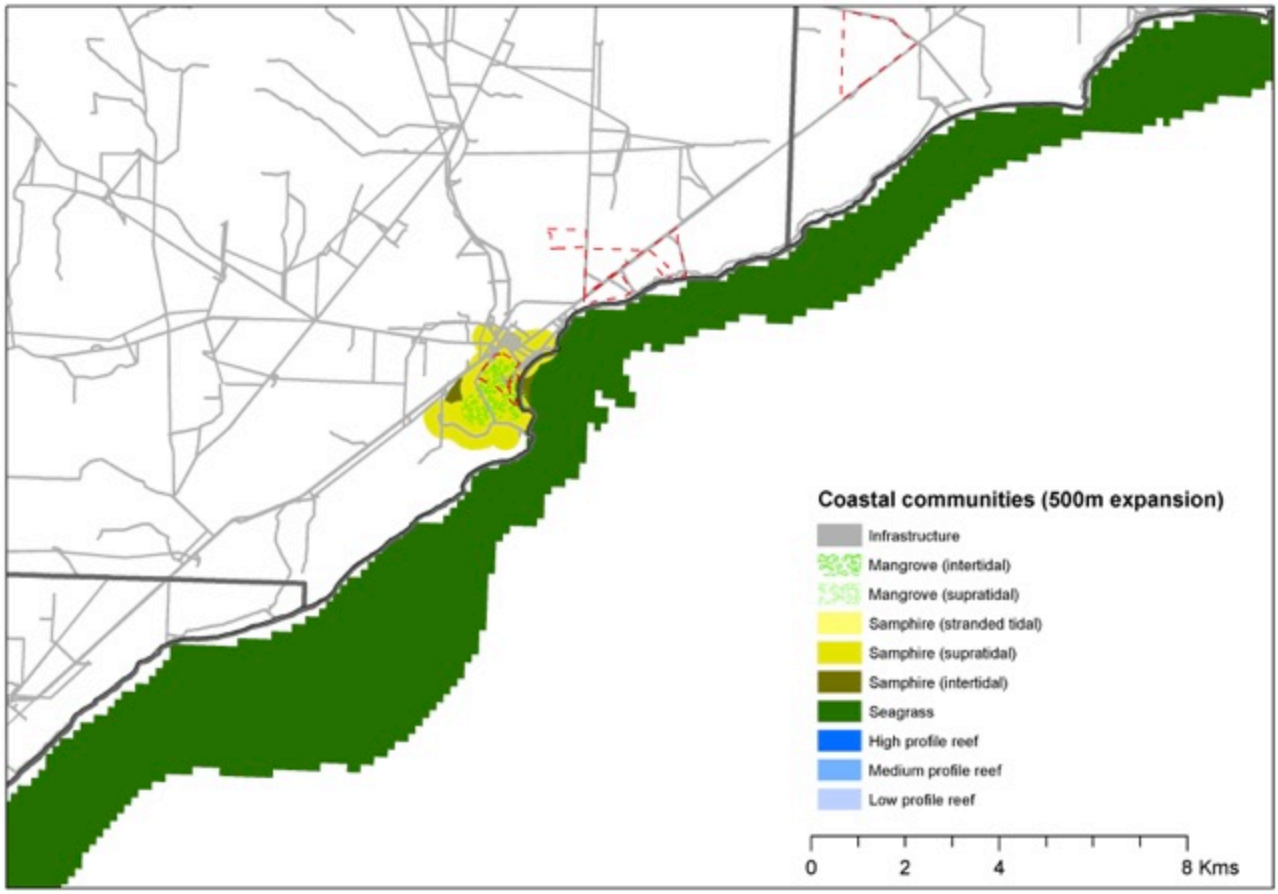

Figure Cl 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Cleve LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Franklin Harbour local government area

Franklin Harbour local government area has 179 listed species of which 8 (7 plant and 1 bird species) had greater than 50% of their Eyre Peninsula distribution in the Franklin Harbour LGA (Table FH 1). The majority of these species occurred only in the Franklin Harbour LGA within EP NRM. Exceptions were the small-leaf *Goodenia* which occurred in one other LGA and pointer-leaf honey myrtle which occurred in 3 other EP LGAs (Table FH 1). Seven of the eight species were mapped using point data, and the eighth species, chalky wattle, was mapped using species distribution modelling which suggested that it occurred in a relatively discrete area of Franklin Harbour LGA (Figure FH 1). High conservation priority areas occurred throughout the Franklin Harbour LGA, some of which were already included in protected areas (Figure FH 2).

Franklin Harbour LGA has large areas of intertidal saltmarsh limited by infrastructure barriers in terms of movement inland in the face of climate change. Almost 30km^2 of intertidal saltmarsh occurs with 1km of infrastructure, primarily roads and almost 9km^2 is within 500m of infrastructure (Table FH 2, Figure FH 3). Mangroves are slightly less affected followed by seagrass habitats.

Table FH 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Franklin Harbour LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Acacia cretacea	Chalky Wattle	PLANT	12.47	1	FH
Amytornis striatus	Striated Grasswren	BIRD	0.06	1	FH
Commersonia multiloba	Trailing Commersonia	PLANT	0.25	1	FH
Goodenia benthamiana	Small-leaf Goodenia	PLANT	0.38	2	FH
Maireana suaedifolia	Lax Bluebush	PLANT	0.06	1	FH
Melaleuca oxyphylla	Pointer-leaf Honey-myrtle	PLANT	0.56	4	FH
Olearia adenolasia	Musky Daisy-bush	PLANT	0.44	1	FH
Phlegmatospermum eremaeum	Spreading Cress	PLANT	0.06	1	FH

Table FH 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Franklin Harbour LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	7.23		1.66		**8.9**	23.04		5.26	0.02	**28.31**
Seagrass	2.4		0.55		**2.95**	6.70		1.23	0.004	**7.94**
Mangroves	3.59		0.87		**4.45**	11.93		3.11	0.01	**15.04**

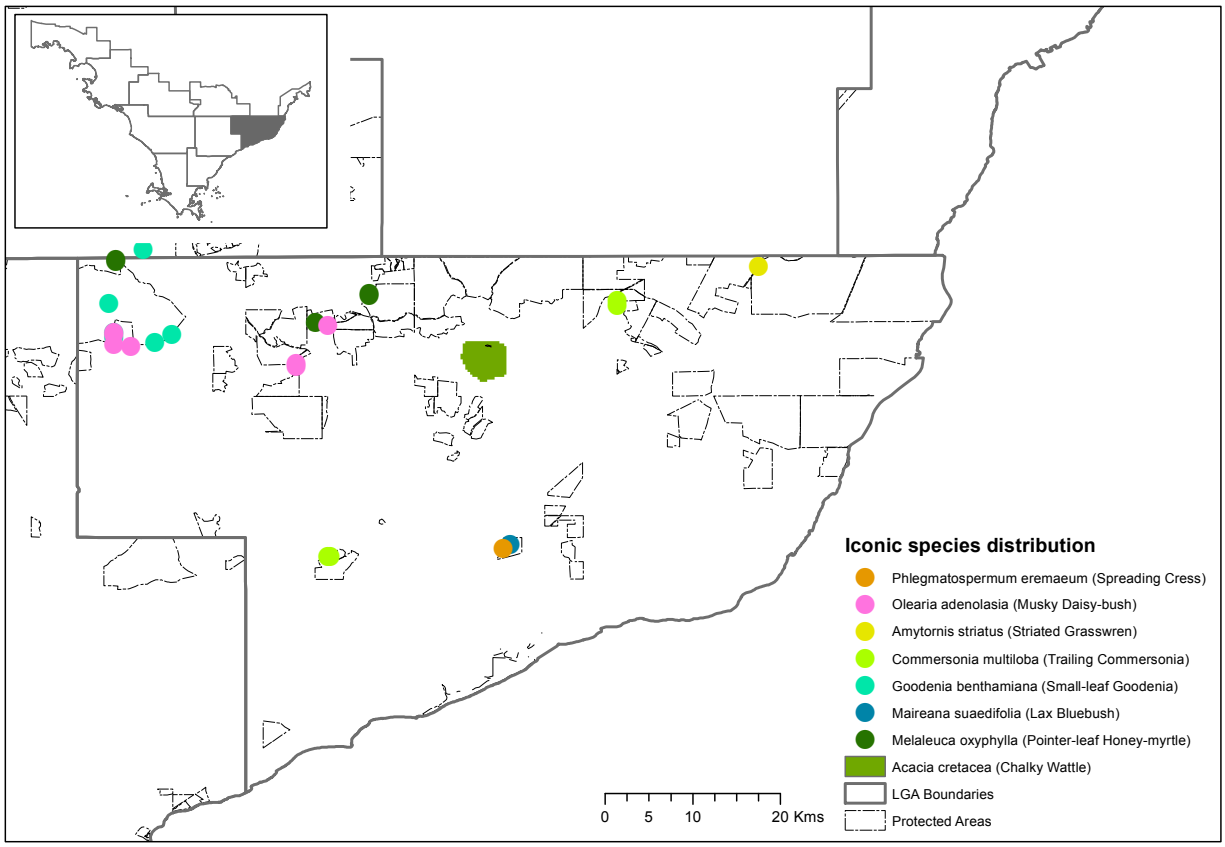

Figure FH 1. Map of species occurring in the Franklin Harbour LGA with more than 50% of their distribution in that area. The inset map shows the position of Franklin Harbour LGA within the Eyre Peninsula NRM region.

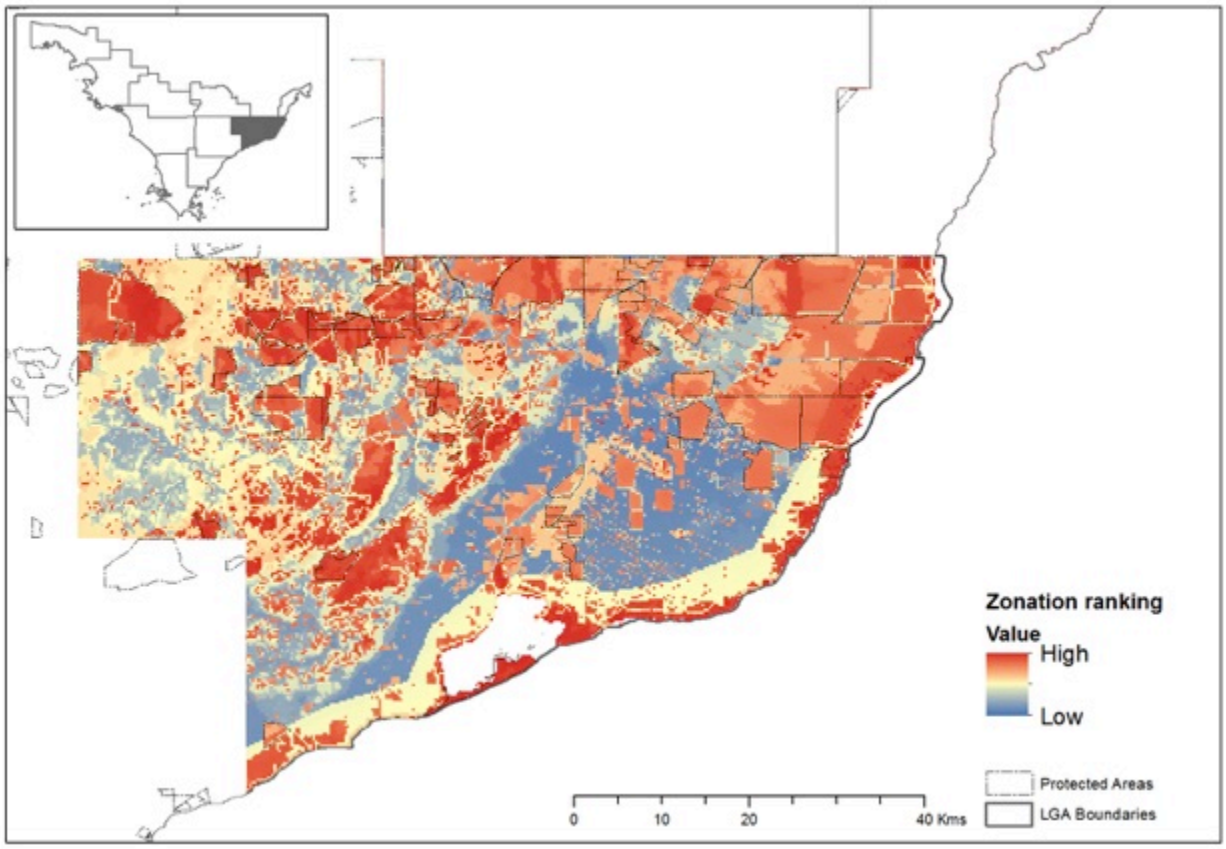

Figure FH 2. Zonation ranking for the Franklin Harbour LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

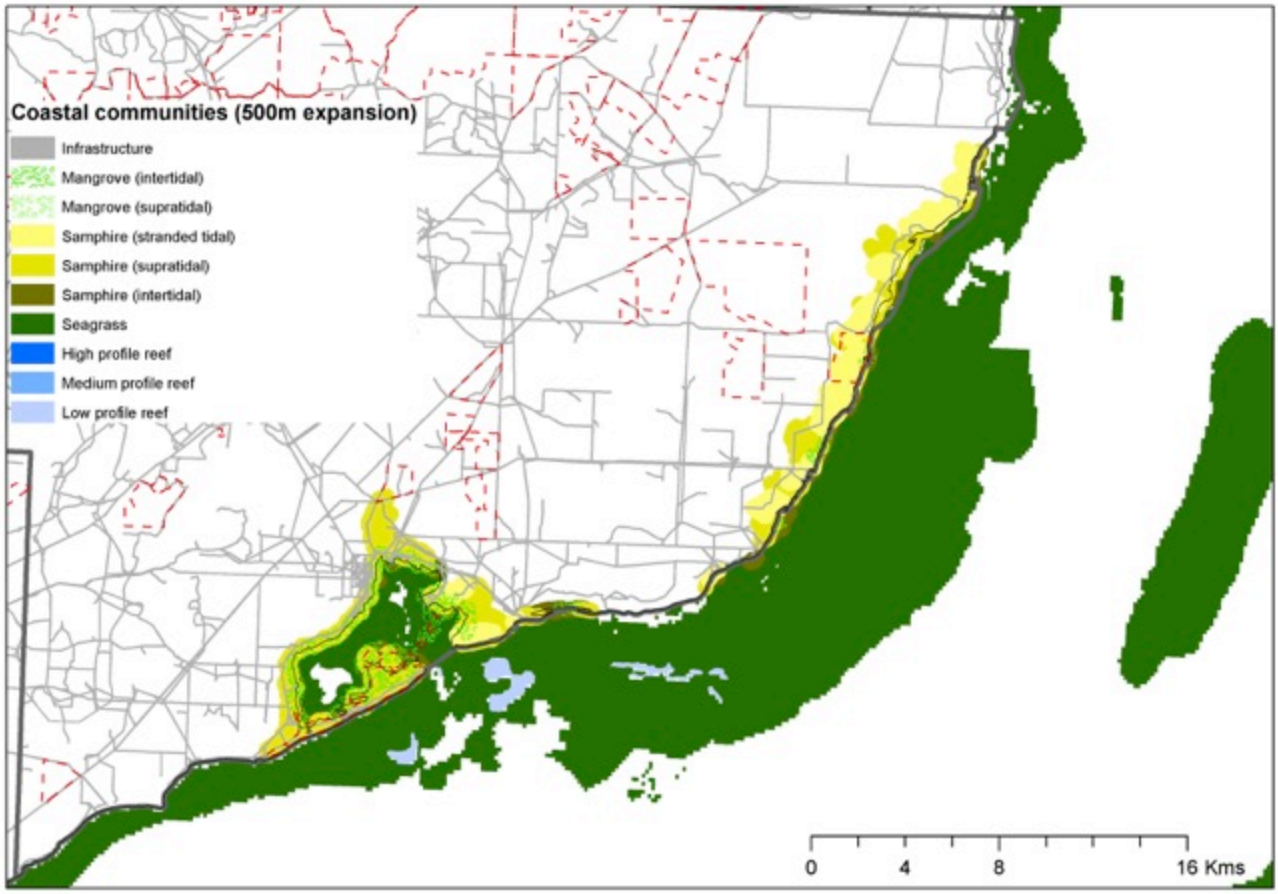

Figure FH 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Franklin Harbour LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Kimba local government area

Kimba local government area has 159 listed species of which 11 had greater than 50% of their Eyre Peninsula distribution in the Kimba LGA (Table K 1). These comprised 7 plant, 3 reptile and a mammal species. The most widely distributed plant species were small scurf-pea and bottle fissure-plant (Figure K 1). The lace monitor was the most widely distributed reptile (Figure K 1). The high priority areas based on zonation were generally areas already in existing protected areas (Figure K 2).

Kimba LGA does not have a coastal region therefore there was no requirement to investigate potential infrastructure barriers to coastal habitat movement under climate change.

Table K 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Kimba LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Brachyscome ciliaris var. subintegrifolia	*Brachyscome ciliaris var. subintegrifolia*	PLANT	90	2	Ki
Commersonia craurophylla	*Commersonia craurophylla*	PLANT	0.06	1	Ki
Cullen parvum	Small Scurf-pea	PLANT	822.06	4	Ki
Grevillea anethifolia	Siny Cream Spider-flower	PLANT	0.13	1	Ki
Maireana excavata	Bottle Fissure-plant	PLANT	833.75	4	Ki
Neelaps bimaculatus	Western Black-naped Snake	REPTILE	0.06	1	Ki
Notoryctes typhlops	Southern Marsupial Mole (Itjaritjara)	MAMMAL	21.28	1	Ki
Pycnosorus globosus	Drumsticks	PLANT	35.75	3	Ki
Rumex dumosus	Wiry Dock	PLANT	15.75	4	Ki
Tiliqua adelaidensis	Pygmy Bluetongue	REPTILE	62.94	4	Ki
Varanus varius	Lace Monitor	REPTILE	1113.25	5	Ki

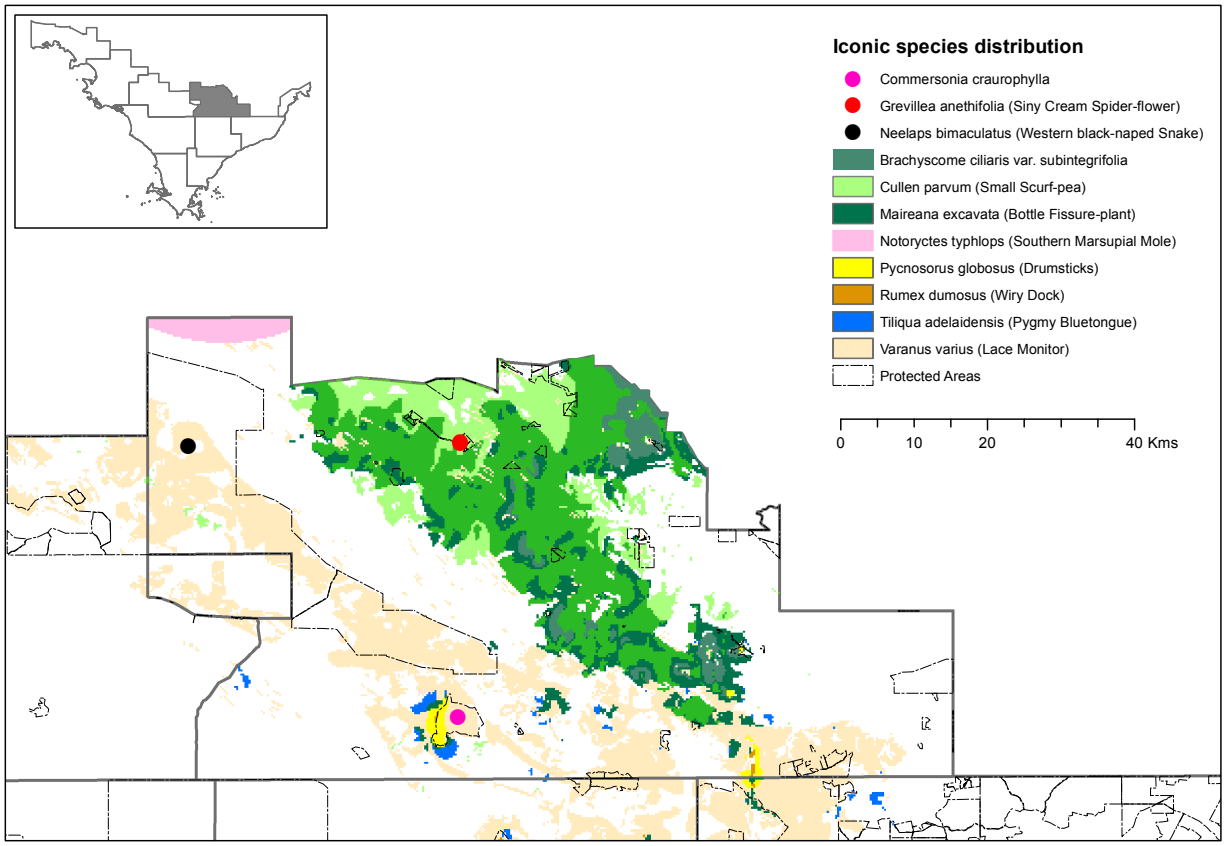

Figure K 1. Map of species occurring in the Kimba LGA with more than 50% of their distribution in that area. The inset map shows the position of Kimba LGA within the Eyre Peninsula NRM region.

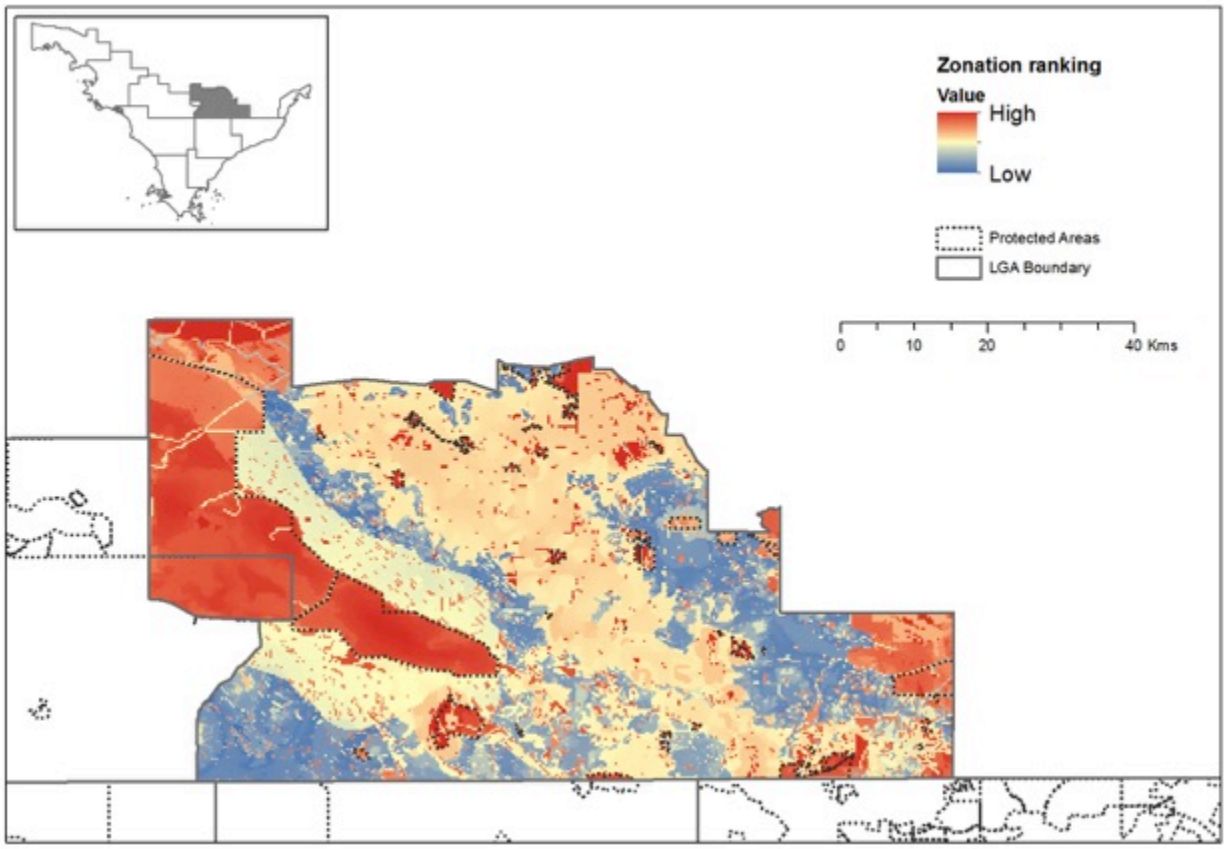

Figure K 2. Zonation ranking for the Kimba LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Whyalla local government area

Whyalla local government area has 113 listed species of which 3 had greater than 50% of their Eyre Peninsula distribution in the Whyalla LGA (Table W 1). Two birds which had Whyalla LGA as the main EP LGA also occurred in 3 and 9 other LGAs and had a total range that exceeded 1000 km^2 in the EP NRM (Table W 1; Figure W 1). The third species was a plant, long-flower *Cryptandra* which occurred throughout the Whyalla LGA and in one other EP LGA (Figure W 1). Much of the Whyalla LGA was ranked high priority based on the zonation analysis (Figure W 2).

The key infrastructure preventing inland movement of coastal communities under future sea level rise were roads for the Whyalla LGA (Table W 2). Between 4 and 5.5 km^2 of habitat was impeded from movement inland by infrastructure within 500m of the habitat but this increased to between 11.96 and 21km^2 within 1km (Table W 2, Figure W 3). Mangroves were the main habitat affected followed by saltmarsh.

Table W 1. Species with greater than 50% of their Eyre Peninsula distribution occurring in the Whyalla LGA. Shown are the species (scientific and common names and taxonomic group), total range in the Eyre Peninsula LGA, and number of LGAs on Eyre Peninsula that the species occurs in.

Scientific name	Common Name	Taxonomic group	Total range in Eyre Peninsula LGA (km^2)	No of EP LGAs	Main EP LGA
Acanthiza iredalei iredalei	Slender-billed Thornbill (western ssp)	BIRD	1130.94	10	Wh
Amytornis textilis myall	Thick-billed Grasswren	BIRD	1109.95	4	Wh
Cryptandra campanulata	Long-flower Cryptandra	PLANT	1.25	2	Wh

Table W 2. Barriers to movement of coastal communities inland under potential future sea level rise for the Whyalla LGA.

	Area of landscape within 500m of community covered by infrastructure (km^2)					Area of landscape within 1km of community covered by infrastructure (km^2)				
Habitat	Road	Rail	Power line	Pipeline	Total within 500m	Road	Rail	Power line	Pipeline	Total within 1km
Saltmarsh	4.99		0.33	0.04	**5.37**	16.10		1.56	0.23	**17.89**
Seagrass	3.22		0.88	0.12	**4.22**	8.77		2.74	0.44	**11.96**
Mangroves	4.09		0.71	0.19	**4.99**	16.99	0.003	3.17	0.57	**20.74**

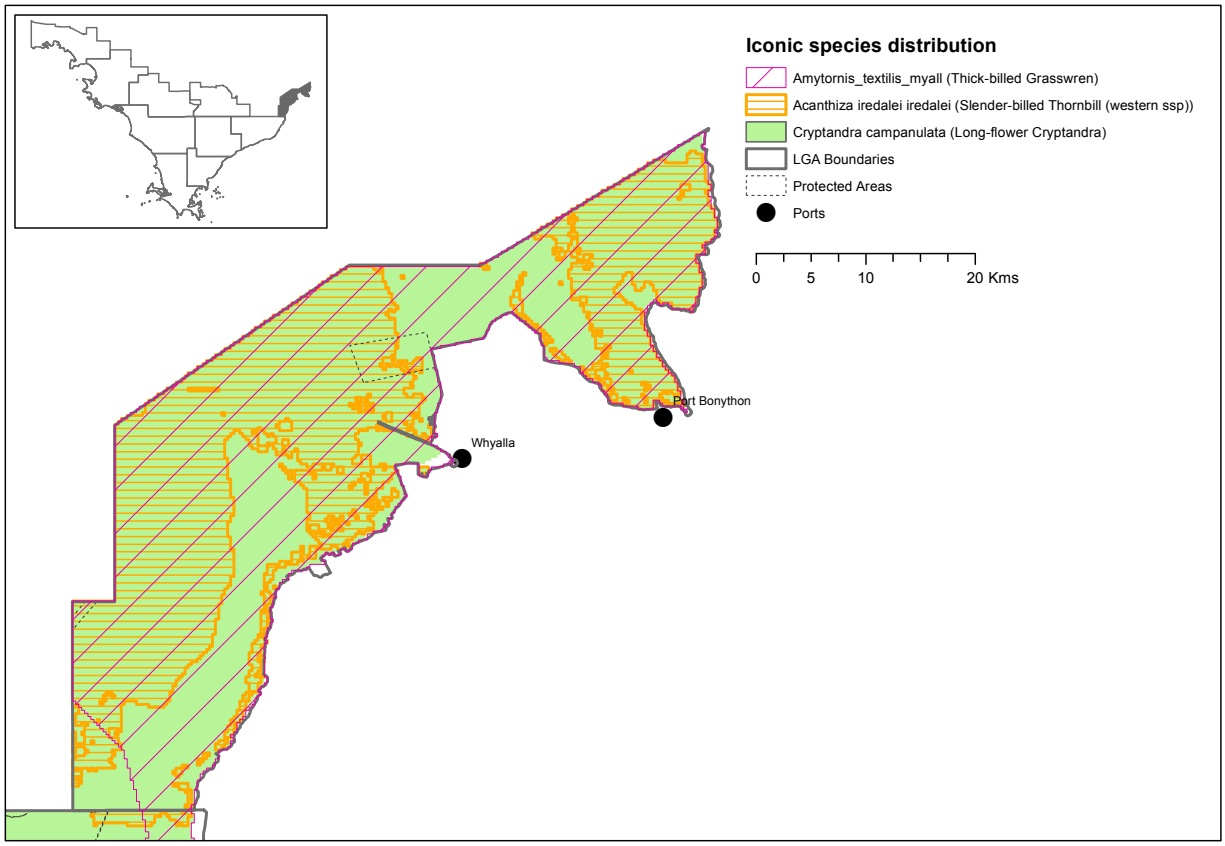

Figure W 1. Map of species occurring in the Whyalla LGA with more than 50% of their distribution in that area. The inset map shows the position of Whyalla LGA within the Eyre Peninsula NRM region.

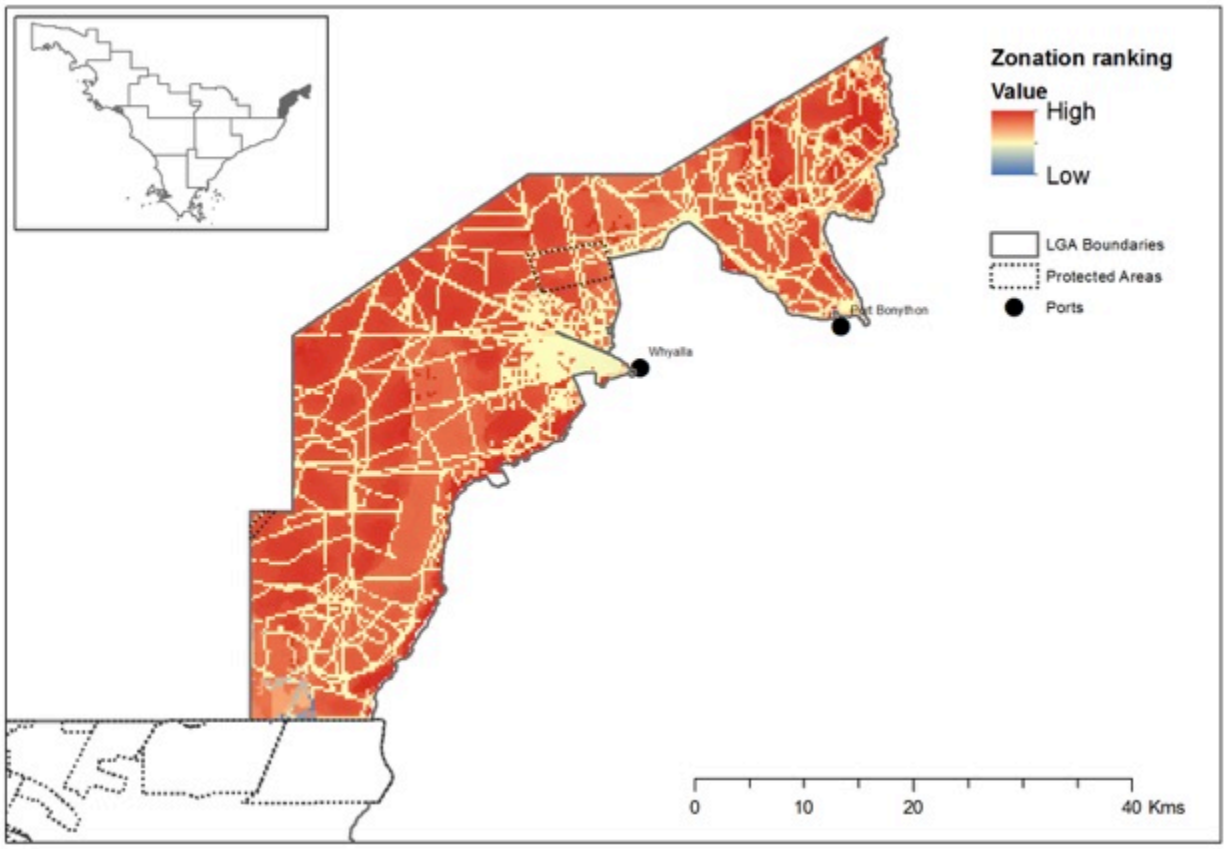

Figure W 2. Zonation ranking for the Whyalla LGA showing scores for each cell in the landscape scaled between low (blue) and high (red) values.

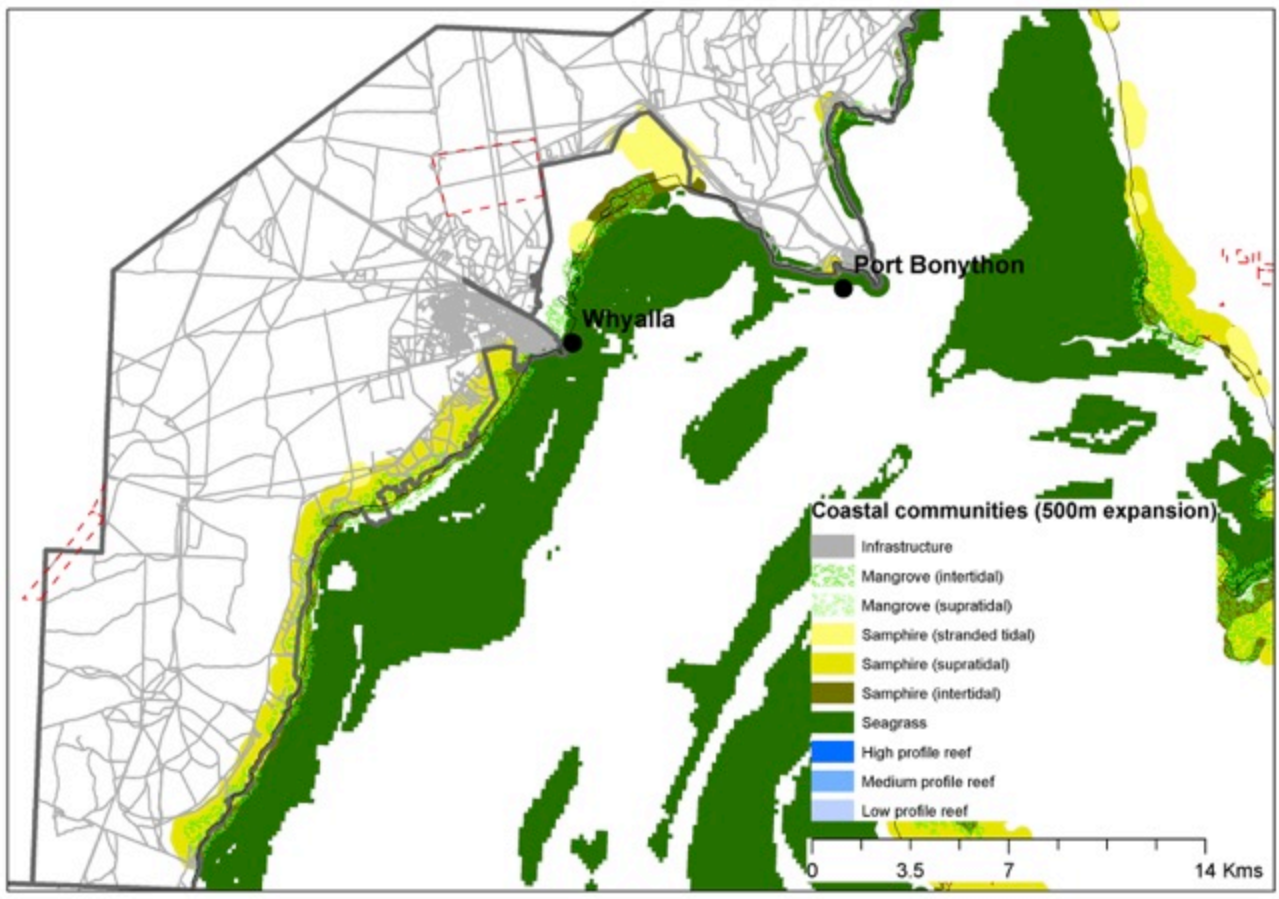

Figure W 3. Mapping of potential barriers to inland dispersal of coastal habitats for the Whyalla LGA. Grey areas represent infrastructure. Dotted red lines represent the boundaries of the protected areas.

Disclaimer: Data for threatened species were obtained from existing databases and had been previously approved via expert consultation as part of the National Environmental Research Program (NERP) Environmental Decisions Hub (Tulloch et al. 2014). No fieldwork was undertaken as part of the current project to check the actual occurrence or distribution of any species. Ground truthing of such data should be undertaken.

Implications & Recommendations

Consultations highlighted that council pathways, for high impact biodiversity and barrier actions, were primarily via links to and expanding existing strategic documents and planning to recognise and integrate the research into local government priorities. Such existing strategic documents include the local government's:

- Strategic plan - material from this report can be used to highlight the risks and opportunities (such as economic and development activities supported by prioritising avoiding barriers to coastal and marine species movement as the climate changes) in such plans.

- Infrastructure and asset plan - biodiversity and the ecosystems services it provides (e.g. prawn and fish nursery habitat) are key regional assets that have significant tangible economic implications.

- Insurance risk planning - a regional approach to insurance has the potential to incorporate the value of protecting habitat and maintaining barrier free coastal species movement. For example, seagrass is known to be a significant carbon sink and it is likely the insurance premiums may recognise and reward regional approaches that enhance or asset to protect such stores (Stern 2007).

- Climate risk plans - local governments will be called on and are developing such plans. Recognising opportunities alongside risks is important within such planning.

- Section 30 review reports

In addition to such strategic planning it is important to recognise individual values and collective motivation. Successful climate action and adaptation planning requires supportive individuals, community and organisational cultural awareness (Divecha 2014). A key opportunity, to build such awareness while simultaneously increasing economic tourism potential, is for councils to highlight the unique species that exist in each local government region (see individual LGA sections of the report). This could be in the form of an Eyre Peninsula wide 'biodiversity trail'. Note that such an approach needs to cater for very rare species that can be 'loved to death' or targeted by collectors (e.g. rare orchids) – the locations of these are not always made publicly available.

In summary the strategic planning and awareness building opportunities that can be built into the relevant policy and programs include:

- Council statement of support recognising ecology climate risks and action benefits

- Identification of priority areas, priorities for avoiding additional barriers by council within relevant planning documents

- Biodiversity/iconic species 'trail' planning - this has the potential to deliver a greater share of the export tourism market to EP and expand this market.

- Planning changes or policy that prioritises addressing barriers to coastal species movement and/or maintaining barrier free regions while highlighting the opportunities and benefits from such an approach

- Regional approach, collaboration across councils, such as to generate collective benefits from insurance premiums or access carbon markets (markets that will include buyers of carbon offsets)

- Ensuring that the knowledge base, biodiversity and barrier mapping plus the digital information base that generates the maps in this report, remains available to future council employees and interested developers/community.

- Protected pathways for coastal ecology (communities) to migrate inland as the sea level rises.

- Positioning councils, through such planning, to access future climate change adaptation funding - e.g. funding that is likely to become available or priories over the next decade.

The extensive range of council consultations demonstrated that setting adaptation pathways is likely to be most effective if it is done within existing council strategic documents - i.e. by identifying specific local risks and opportunities and then building up the planning to address these. A standalone approach, such as a specific adaptation pathway report document for each council, is likely to have less impact and engagement.

References

Di Minin E, Moilanen A (2014) Improving the surrogacy effectiveness of charismatic megafauna with well-surveyed taxonomic groups and habitat types. J Appl Ecol 51: 281-288 doi 10.1111/1365-2664.12203

Divecha S (2014) A climate for change: an exploration towards Integral Action Loops to apply our knowledge for sustainability success, PhD thesis, University of Adelaide, Adelaide

Elith J, Phillips SJ, Hastie T, Dudik M, Chee YE, Yates CJ (2011) A statistical explanation of MaxEnt for ecologists. Diversity and distributions 17: 43-57 doi10.1111/J.1472-4642.2010.00725.X

Forman RTT, Deblinger RD (2000) The ecological road-effect zone of a Massachusetts (USA) suburban highway. Conserv Biol 14: 36-46 doi 10.1046/j.1523-1739.2000.99088.x

Mawdsley JR, O'Malley R, Ojima DS (2009) A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. Conserv Biol 23: 1080-1089 doi 10.1111/j.1523-1739.2009.01264.x

Moilanen A, Franco AMA, Early RI, Fox R, Wintle B, Thomas CD (2005) Prioritizing multiple-use landscapes for conservation: methods for large multi-species planning problems. Proc R Soc B-Biol Sci 272: 1885-1891 doi10.1098/Rspb.2005.3164

Moilanen A, Meller L, Leppanen J, Pouzols FM, Arponen A, Kujala H (2012) Spatial conservation planning framework and software Zonation. Version 3.1. User manual. University of Helsinki, Department of Bioscience, Helsinki.

Phillips SJ, Anderson RP, Schapire RE (2006) Maximum entropy modeling of species geographic distributions. Ecol Model 190: 231-259 doi 10.1016/J.Ecolmodel.2005.03.026

Phillips SJ, Dudik M (2008) Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31: 161-175 doi 10.1111/j.0906-7590.2008.5203.x

Phillips SJ, Dudik M, Elith J, Graham CH, Lehmann A, Leathwick J, Ferrier S (2009) Sample selection bias and presence-only distribution models: implications for background and pseudo-absence data. Ecol Applic 19: 181-197 doi 10.1890/07-2153.1

Siebentritt M, Halsey N, Stafford-Smith M (2014) Regional Climate Change Adaptation Plan for the Eyre Peninsula. Prepared for the Eyre Peninsula Integrated Climate Change Agreement Committee

Stern N (2007) The economics of climate change: the Stern review. Cambridge University Press, Cambridge

Tulloch AIT, Gordon A, Rhodes JR (2014) Identifying conservation priorities and evaluating scenarios of cumulative impacts of mining infrastructure in the Upper Spencer Gulf Region in South Australia. Report prepared for the Australian Department of the Environment by the NERP Environmental Decisions Hub.