Threatening Processes

Coastal Disturbance - Motorbikes
Photographed by Jacob Nicolson

Acacia cyclops
Photographed by Ron Sandercock

Coastal Impact
Photographed by Alison Eaton

4 THREATENING PROCESSES

Selected threatening process layers are elaborated below. A general regional discussion of climate change is included in this section; climate change was not suitable for the GIS based analysis, but local potential impacts of projected regional changes were placed in cell descriptions, in section 5.

Planning, Development and Land Use

Development Zoning

Viewscape Analysis (increasing threat due to aesthetics of the coastal zone)

Dumps & Wastewater Treatment Plants

Vegetation Dynamics

Distribution of known environmental weeds

Hazards

Dune Stability

Cliff Stability

Coastal Acid Sulfate Soils

Climate Change

4.1 Development

Development was used in the analysis of threatening processes as it was seen as having the potential to lower the conservation priority values through the ability to develop the land through zoning regulations. Where zoning allowed urban development, high threat scores were allotted; where zoning principles and objectives sought to conserve, low threat scores were given. Mean values for cells are high where a large proportion of the cell is zoned to allow urban or industrial development. Outside the coastal townships, the values for this variable were usually under 4; more than half of the cells in the analysis had a score under 1.

This assessment gives high threat scores for the existing urbanised South Coast areas, with the exception of the coastal reserves: here the lack of a zoned reserve at Horseshoe Bay and Freeman Knob stands out. The coastal townships of Yankalilla appear on this map; however, the lack of a coastal reserve at Lady Bay, Cape Jervis and Myponga are highlighted by this analysis. The Wirrina Tourist Zone gives an extensive area of high threat, and a kilometre of coast with no coastal reserve.

4.2 Coastal Viewscape Analysis

In 2004/5 a South Australian analysis of the scenic value of coastal lands was undertaken by the Department for Environment and Heritage. Where coastal areas had a high score for visual amenity, this was regarded as a pressure for urban development, and hence given a high threat score. The mean threat values for cells in the threats analysis are shown in the graph below.

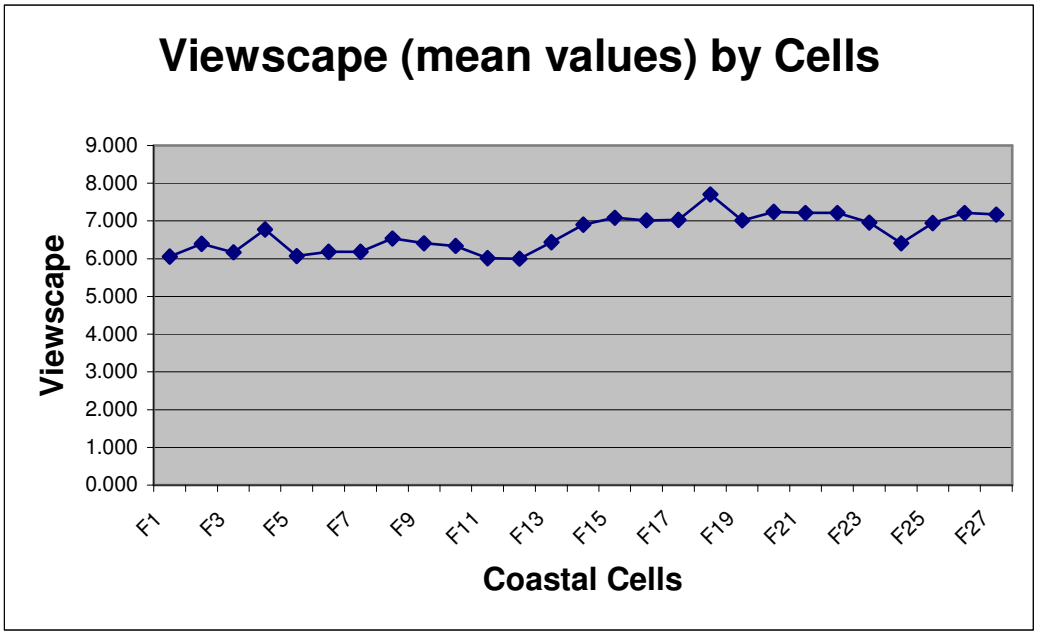

Figure 22. Mean Viewscape values by cells

Figure 22 shows that all parts of the Fleurieu coast have very high coastal landscape values: for all parts of each coastal cell to average scores between 6 and 8 is remarkably high. Within this though, there is a regional contrast: cells along the open cliffs west and north of The Bluff (cell 13) show slightly higher values (7.0 +), than the urbanised coastal plain, cells 1 to 12, averaging 6 to 6.5.

4.3 Dump Sites

Dump sites and waste water treatment plants within or adjacent to the coastal boundary were taken from the digital map, sourced from the EPA by Environmental Information DEH. Thus, the Victor Harbor WWTP on the Inman floodplain, and the dumps at Goolwa, Morgans Beach, Wirrina, and inland from Kings Head are shown.

This layer illustrates the value and the problems of this analysis. The mapped data draws attention to the location of these features, which may be adjacent to sensitive features. For example, the Goolwa dump is adjacent to a valuable conservation site at Tokuremoar reserve, to which it presents threats of fire danger, and also ground and surface water contamination. It is not possible, however, to buffer these features in a way that adequately represents their influence; that is to assign GIS raster point scores in a way that consistently represents their potential threat. On the other hand, an arbitrary choice of a buffer represented in the analysis scores does serve to flag the issue.

4.4 Environmental Weeds Affecting the Southern Fleurieu Coast

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4.4.1 Introduction

Weeds are a major threat to our coast. The coastal strip is particularly vulnerable and accessible to invasion and weed species continue to be an insufficiently recognised ecological problem. The coast supports a range of plants that do not occur naturally in the region. Populations of introduced plants are expanding and pose a threat to the values of the coast, causing major declines in native plant and animal communities.

Weed Threat

Weeds cause many impacts on the coast. Just as in any other natural environment they often grow faster than native plants and successfully compete for sunlight, water, nutrients and pollinators. They also prevent or interfere with natural regeneration. Their capacity to establish and spread, leads to the invasion and displacement of native plant communities, thereby reducing biological diversity and threatening the viability of many plant communities. Floristically and structurally diverse natural vegetation can be changed dramatically to a much-simplified state where one or several weeds may dominate. Coastal heath and native grassland which naturally hold sand dunes together are some of the plant communities, which have been crowded out by weeds, contributing to destabilisation of coastal dune systems. Native fauna is also adversely affected by

the loss of plants that provide shelter, food and nesting habitat, or by animals that thrive in response to the changed conditions. Exotic plants have been introduced to the coast accidentally, often in ballast, or purposely for agricultural or ornamental use. Their spread to the coast has been generally accidental, as a result of various human activities, although spread by fauna, particularly by birds is common. The use of the coast as dumping grounds for domestic garden refuse is a common cause of weed invasion. It is the many disturbances of the coast, which have accelerated the spread of exotic plants within the coastal zone.

Weeds also cause a number of other potential problems such as:

- Providing habitat or a food source for feral animals.
- Altering nutrient content of low fertility soils.
- Altering hydrological cycles.
- Altering dune sand mobility by changing the vegetation cover eg. creating a weed monoculture and increasing beach erosion.
- Increasing fire risk by raising available fuel levels in fire danger periods.
- Reducing visual amenity and aesthetics of natural landscapes.
- Loss of representative examples of original coastal plant communities.

(Adapted from *A Manual of Coastal Dune Management and Rehabilitation Techniques*, NSW Department of Land and Water Conservation, 2001)

4.4.2 Purpose

Weeds are a sign of coastal health. More than 500 weeds species have been recorded in the South Australian coastal zone, which equates to over 30% of the total coastal flora recorded. The Southern Fleurieu coastal region has a high number of exotic flora present, with over 360 species being recorded. The high number of species recorded can also in part be attributed to the extensive surveys undertaken in the region by coastal ecologist Ron Taylor.

In the analysis of 'Conservation Values' the proportion of weeds against natives was used to assess the health or condition of vegetation and to highlight areas that require conservation priority.

Weed species have also been assessed for their threatening values. The following sections identify the highest priority environmental weeds and assign values to weed species to scale threat. The resulting information has been incorporated into the analysis of threatening processes within the Southern Fleurieu coastal region.

4.4.3 Methodology for Determining Priority Weeds & Values

Compilation of Weeds Data

Weed lists for the Southern Fleurieu coastal region were obtained from the State Biological Survey and from local flora expert, Ron Taylor. The lists were amalgamated and consolidated (duplications removed) to produce a single list containing 362 weeds.

A separate weed ratings list was concurrently developed detailing:

- Weeds of National Significance (WONS).
- Alert List of Environmental Weeds.
- Declared Weeds.
- The most common and threatening environmental weed species in the Southern Mt Lofty Ranges, as featured in Nature Conservation Society's (NCS) Bushland Condition Monitoring Manual (both inland and coastal editions).

The ratings list was matched to the regional weed list, which was subsequently worked through to eliminate non-threatening weeds and to assign values to species considered common and threatening.

Assigning Threat Values

To display the weeds as a GIS threat layer for this study, it was necessary for individual species to be allocated a threat value on a scale of between 1 and 9, with 1 being the lowest and 9 being the highest. Values were designed to align with the five threat categories outlined in the NCS Field Guide to Bushland Condition Monitoring Manual: Coastal Vegetation Communities (Croft *et al*, 2006).

Table 8 outlines the five invasive threat categories featured in the Bushland Condition Monitoring manual. The categories are based upon the following:

- The weed's degree of invasiveness or ability to expand into intact scrub
- The weed's capability to disrupt natural processes in bushland
- The degree of difficulty involved in preventing or controlling an infestation.

Table 8. NCS Bushland Condition Monitoring Manual Weed Threat Categories

Category	Description
5	Highly invasive in either disturbed or intact remnant bushland; spreads rapidly producing dense stands and a blanket cover. Potential to eliminate almost all understorey species. Very difficult to control without outside help.
4	Highly invasive in either disturbed or intact bushland, with the potential to spread rapidly and produce very dense stands given favourable habitat and / or vectors. High potential to reduce native species diversity and abundance. Can be controlled with sustained effort.
3	Invasive in intact bushland with moderate potential to reduce native species diversity. Rate of spread is slower than Category 4 and 5 weeds but once present will persist and threaten biodiversity. May produce dense stands over a wide area but can be controlled with sustained effort.
2	Generally only invade disturbed bushland, but may spread rapidly. However, generally only a slight potential to reduce native species diversity, unless present in high densities.
1	Generally only invade disturbed bushland. Often widespread and abundant but not considered a significant threat to biodiversity, unless present at very high densities.

The Bushland Condition weed threat categories provided the basis for assessment in this study; however some adaptation was necessary to incorporate the present and potential distribution of species (i.e. widespread versus limited). Potential for distribution incorporates the number of vectors a species has (greater numbers of vectors enable the species to spread more readily) and the potential area(s) a weed species may inhabit (i.e. preference for specific habitats). Table 9 summarises the weed value allocation system used to assign threat levels to weed species in the Southern Fleurieu coastal region.

Table 9. Weed Value Allocation System

Value	BCM Weed Threat ategory	BCM Weed Threat Category Description	Distribution
9	5	Highly invasive in either disturbed or intact remnant bushland, spreads rapidly producing dense stands and a blanket cover. Potential to eliminate almost all understorey species. Very difficult to control without outside help.	Widespread OR Currently limited with numerous vectors
8			Limited distribution with few vectors
7	4	Highly invasive in either disturbed or intact bushland, with the potential to spread rapidly and produce very dense stands given favourable habitat and / or vectors. High potential to reduce native species diversity and abundance. Can be controlled with sustained effort.	Widespread OR Currently limited with numerous vectors
6			Limited distribution with few vectors
5	3	Invasive in intact bushland with moderate potential to reduce native species diversity. Rate of spread is slower than Category 4 and 5 weeds but once present will persist and threaten biodiversity. May produce dense stands over a wide area but can be controlled with sustained effort.	Widespread OR Currently limited with numerous vectors
4			Limited distribution with few vectors
3	2	Generally only invade disturbed bushland, but may spread rapidly. However, generally only a slight potential to reduce native species diversity, unless present in high densities.	Widespread OR Currently limited with numerous vectors
2			Limited distribution with few vectors
1	1	Generally only invade disturbed bushland. Often widespread and abundant but not considered a significant threat to biodiversity, unless present at very high densities.	N/A

An internal DEH assessment using the value allocation system identified 101 priority environmental weed species. The results were analysed by Southern Fleurieu coastal flora expert Ron Taylor and DEH staff, incorporating local experience and knowledge of weed management.

It should be noted that the surveys undertaken for the original weed lists occurred several years before this Action Plan was developed, thus distributions have changed for some species, with some being much more widespread or effective control implemented. This has been taken into account in the assessment process through the incorporation of local knowledge.

4.4.4 Results

The threat value allocation process identified a total of 85 priority environmental weeds for the Southern Fleurieu coastal region, each featuring a weed threat value between 1 and 9. The results and distribution of species (by cell) are displayed in Table 10.

Table 10. Southern Fleurieu Coastal Region Priority Environmental Weeds and Associated Threat Values

# of Records	Species Name	Common Name	Threat Value	Cell Number
17	*Asparagus asparagoides*	Bridal Creeper	9	2, 4, 8, 9, 10, 11, 13, 14, 15, 19, 20, 23, 24, 26
2	*Asparagus declinatus*	Bridal Veil	8	14, 15
6	*Ehrharta villosa* var. *maxima*	Pyp Grass	8	1, 2, 3, 10, 15
16	*Gazania linearis*	Gazania	8	1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 19, 20, 24, 25, 26
13	*Acacia cyclops*	Western Coastal Wattle	7	1, 4, 5, 6, 9, 10, 11, 12, 19, 20, 21, 22, 23, 24,
27	*Lycium ferocissimum*	African Boxthorn	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
1	*Ulex europaeus*	Gorse	7	23, 24
10	*Chrysanthemoides monilifera* ssp. *monilifera*	Boneseed	6	1, 3, 6, 8, 9, 10, 11, 14, 15, 22
3	*Dipogon lignosus*	Lavatory Creeper	6	9, 10, 11
14	*Leptospermum laevigatum*	Coast Tea-tree	6	1, 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 17, 25
3	*Polygala myrtifolia*	Myrtle-leaf Milkwort	6	10, 11, 20
5	*Rhamnus alaternus*	Blowfly Bush	6	8, 10, 11, 14, 23, 24
1	*Acacia longifolia* var. *longifolia*	Sallow Wattle	5	14, 15, 24
15	*Acacia saligna*	Golden Wreath Wattle	5	1, 4, 5, 6, 8, 9, 10, 11, 12, 20, 23, 24, 26
2	*Disa bracteata*	African Orchid	5	14, 15
27	*Euphorbia paralias*	Sea Spurge	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 26, 27
19	*Euphorbia terracina*	False Caper	5	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 22, 23, 24
5	*Melianthus comosus*	Tufted Honey-flower	5	18, 19, 20, 22, 24, 25
24	*Olea europaea* ssp. *europaea*	Olive	5	2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
21	*Oxalis pes-caprae*	Soursob	5	1, 2, 3, 5, 6, 7, 8, 10, 11, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
7	*Arctotis stoechadifolia*	White Arctotis	4	5, 9, 11, 12, 23, 24, 25
5	*Argyranthemum frutescens*	Marguerite Daisy	4	8, 9, 10, 11, 12, 24
7	*Carpobrotus edulis*	Hottentot Fig	4	2, 4, 5, 6, 9, 13, 15, 25
12	*Coprosma repens*	New Zealand Mirror-bush	4	2, 5, 6, 8, 9, 10, 11, 12, 13, 14
17	*Ehrharta calycina*	Perennial Veldt Grass	4	7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25
1	*Juncus acutus*	Sharp Rush	4	2, 14
10	*Marrubium vulgare*	Horehound	4	1, 4, 6, 10, 11, 13, 19, 20, 21, 22, 23
11	*Pinus* spp.	Pine spp.	4	2, 4, 6, 8, 9, 10, 11, 12, 15, 23
14	*Solanum linnaeanum*	Apple Of Sodom	4	4, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26
6	*Agave Americana*	Century Plant	3	5, 9, 10, 11, 12, 15
14	*Brassica tournefortii*	Wild Turnip	3	1, 2, 6, 9, 10, 11, 14, 15, 18, 19, 20, 21, 23, 24, 25
15	*Cynodon dactylon*	Couch	3	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 20, 23, 25
10	*Diplotaxis* sp.	Wall Rocket	3	
2	*Ferraria crispa* ssp. *crispa*	Black Flag	3	15, 24
9	*Galenia pubescens* var. *pubescens*	Coastal Galenia	3	1, 5, 6, 9, 10, 13, 14, 20, 25
2	*Lupinus cosentinii*	Sand Lupin	3	19, 20
20	*Malva* spp.	Marshmallow spp.	3	1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 24
8	*Mesembryanthemum crystallinum*	Common Iceplant	3	4, 5, 6, 8, 9, 14, 20, 24
44	*Plantago* spp.	Plantain spp.	3	1, 2, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27
21	*Reichardia tingitana*	False Sowthistle	3	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 18, 19, 20, 21, 22, 25, 27

21	*Scabiosa atropurpurea*	Pincushion	3	1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 20, 21, 22, 24, 26, 27
1	*Verbascum thapsus ssp. thapsus*	Great Mullein	3	22
7	*Verbascum virgatum*	Twiggy Mullein	3	10, 11, 13, 15, 18, 23,
3	*Zantedeschia aethiopica*	White Arum Lily	3	18, 20, 24
2	*Chondrilla juncea*	Skeleton Weed	2	14, 15
2	*Cynara cardunculus* ssp. *flavescens*	Artichoke Thistle	2	22, 26
4	*Dimorphotheca pluvialis*	Cape Marigold	2	5, 6, 9, 10, 11
20	*Echium plantagineum*	Salvation Jane	2	4, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
18	*Ehrharta longiflora*	Annual Veldt Grass	2	2, 6, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26
27	*Lagurus ovatus*	Hare's Tail Grass	2	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
14	*Limonium* spp.	Lavender spp.	2	1, 2, 4, 5, 6, 8, 9, 11, 12, 14, 15, 16, 19, 21, 22, 26, 27
3	*Matthiola incana*	Common Stock	2	8, 9, 21
8	*Osteospermum fruticosum*	Seascape Daisy	2	5, 6, 8, 9, 10, 11, 12, 23
19	*Pennisetum clandestinum*	Kikuyu	2	1, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 20, 23, 24, 25, 27
4	*Rosa canina*	Dog Rose	2	15, 22, 23, 24, 27
7	*Senecio pterophorus*	African Daisy	2	4, 7, 10, 11, 14, 15, 18
11	*Stenotaphrum secundatum*	Buffalo Grass	2	1, 2, 5, 8, 9, 10, 11, 12, 14, 15
7	*Tamarix aphylla*	Athel Pine	2	2, 5, 6, 8, 9, 11, 24, 25
4	*Tetragonia decumbens*	Sea Spinach	2	20, 23, 25, 27
3	*Aeonium arboretum*		1	5, 9, 12
7	*Aloe* spp.	Aloe	1	9, 11
17	*Arctotheca calendula*	Cape Weed	1	1, 2, 5, 6, 8, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 26
11	*Asphodelus fistulosus*	Onion Weed	1	1, 2, 3, 4, 6, 8, 13, 15, 18, 19, 20
23	*Atriplex prostrata*	Creeping Saltbush	1	1, 2, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 25, 26, 27
26	*Avena* spp.	Wild Oat spp.	1	1, 2, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
57	*Bromus* spp.	Brome spp.	1	1, 2, 4, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
6	*Carduus tenuiflorus*	Slender Thistle	1	10, 14, 15, 18, 19, 22
2	*Casuarina glauca*	Grey Buloke	1	1, 6
1	*Centaurea calcitrapa*	Star Thistle	1	1
12	*Chenopodium album*	Fat Hen	1	6, 7, 9, 10, 11, 12, 13, 14, 15, 19, 24
12	*Conyza* spp.	Fleabane spp.	1	1, 2, 4, 6, 7, 10, 11, 12, 13, 15, 18
5	*Cotyledon orbiculata* spp.	Cotyledon	1	2, 5, 6, 9, 10, 11
15	*Gomphocarpus cancellatus*	Broad-leaf Cotton-bush	1	2, 4, 10, 13, 15, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
13	*Helminthotheca echioides*	Ox-tongue	1	4, 6, 9, 10, 11, 12, 14, 22, 23, 24, 26, 27
32	*Hypochaeris* spp.	Cat's Ear spp.	1	1, 2, 3, 4, 6, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
20	*Lolium* spp.	Ryegrass spp.	1	1, 6, 10, 11, 12, 13, 14, 15, 18, 19, 20, 22, 27
28	*Medicago* spp.	Medic spp.	1	1, 2, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
14	*Melilotus* spp.	Centaury spp.	1	1, 2, 4, 10, 11, 12, 13, 15, 16, 18, 19, 20, 26
11	*Oenothera stricta* ssp. *stricta*	Common Evening Primrose	1	2, 11, 12, 13, 14, 15, 19, 20, 21, 23, 24, 25
3	*Opuntia* spp.	Cactus spp.	1	
2	*Phalaris minor*	Lesser Canary-grass	1	6, 14
12	*Romulea* spp.	Onion-grass	1	6, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 27
35	*Sonchus* spp.	Sow-thistle spp.	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27
11	*Thinopyrum junceiforme*	Sea Wheat-grass	1	1, 2, 4, 5, 6, 7, 15, 22, 23, 24, 25
63	*Trifolium* spp.	Clover spp.	1	2, 4, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27

4.4.5 Highest Priority Weeds – Red Alert Weeds

Part of the process for assessing weeds as a threat within the Bushland Condition Monitoring Manual is identification of 'Red Alert Weeds'. Red Alert weeds are species that are already presenting a major threat to bushland or have the potential to become major threats (ie. the highest priority weeds).

Weeds with a threat category of 3, 4 or 5 are classified as Red Alert Weeds as they have the capacity to spread quickly, even in intact vegetation, and are difficult to control (Croft et al, 2006). The higher the number of Red Alert species present in bushland, the greater the threat of weed invasion in the future. Any category 4 or 5 species should receive immediate attention.

In the context of the weed value allocation process, Red Alert Weeds are those with values from 4 to 9 (refer to Table 9). A total of 29 Red Alert Weeds have been identified in the Southern Fleurieu coastal region through this methodology. The following provides a brief threat analysis for category 4 and 5 weed species (weeds with values in the GIS analysis from 6 to 9).

***Asparagus asparagoides* (Bridal Creeper)**

Bridal creeper is considered to be one of the greatest weed threats to conservation and biodiversity in southern Australia. Listed as a Weed of National Significance, a specific strategy has been developed to contain and minimise its impact in Australia through coordinated management at National, State and Regional levels. Long-term community commitment to fund and implement strategies is required, in addition to promotion of best-practice for bridal creeper infestations where bio-control agents are established.

***Asparagus declinatus* (Bridal Veil)**

Bridal veil is a highly invasive environmental weed that climbs and smothers native vegetation, forming dense canopies which shade out understorey species. While little research has been conducted on the ecology of Bridal Veil, its impacts appear to be similar to those of Bridal Creeper. Given the adverse impacts Bridal Creeper has had on Australia's environment, there is some urgency for research into Bridal Veil to further understand its ecology and potential for spread. With the release of host-specific biological controls for Bridal Creeper, there is a risk that Bridal Veil may become a more serious weed as Bridal Creeper is controlled.

***Ehrharta villosa var. maxima* (Pyp Grass)**

Pyp grass is an environmental weed of high impact originally introduced as a dune stabiliser. It can be a rampant coloniser of disturbed areas, creating thick suffocating thatches which severely impede native seedling penetration and growth. It will grow through existing vegetation and become suppressive by forming closed areas due to mats of deep creeping rhizomes. It can also form thick suffocating canopies.

***Gazania spp.* (Gazania)**

Gazania species are problematic plants which spread readily by water, wind and in dumped refuse. Gazania infestations are found around almost all coastal townships due to their popularity as garden plants. Gazania species readily establish in dunes and severely alter plant communities by suppressing native plants with their high demand for moisture. The sale of these plants by the local nursery industry needs to include a warning of the risks for its use in coastal areas and should not be used in council landscaping projects.

***Acacia cyclops* (Western Coastal Wattle)**

Western coastal wattle is an Australian native species indigenous to the west coast of the state which is considered a serious environmental weed outside of its natural range. It will compete with native pioneer species and when left un-checked may form monocultures which shade out indigenous understorey species. Western coastal wattle needs to be controlled to the stage where it no longer impacts significantly on the natural function of the coastal environment.

***Lycium ferocissimum* (African Boxthorn)**

A declared plant in South Australia, African boxthorn is an aggressive weed that shades and crowds out native vegetation. It often occurs under trees and shrubs where birds roost and when left unchecked, will form dense, impenetrable thickets which often provide habitat for introduced fauna such as rabbits and foxes. African boxthorn's significant presence on the coast gives it the unique status of the only weed species that

rates as a floristic group in the Coastal Dune and Clifftop vegetation study of South Australia. It is present in all but two cells in the Southern Fleurieu coastal zone.

***Ulex europaeus* (Gorse)**

A Weed of National Significance, Gorse is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and its economic and environmental impacts. It is a major agricultural weed in Tasmania and parts of Victoria, and is increasingly becoming a threat as an environmental weed in many national parks and other bushland areas. Gorse commonly grows where rainfall is evenly distributed throughout the year and in the range 650-900 mm. It prefers fertile soils as well as on light sands, heavy clays and disturbed soils. According to the CRC for Weed Management, gorse could potentially infest most of coastal southern Australia based on climate suitability.

***Chrysanthemoides monilifera ssp. monilifera* (Boneseed)**

Boneseed is a Weed of National Significance and declared in South Australia with invasive characteristics including high seed production, a long-lived seed bank and an ability to spread rapidly. It is a serious environmental weed of headlands and dunes.

***Dipogon lignosus* (Lavatory Creeper)**

Lavatory creeper is a vigorous climber which invades disturbed, sandy sites near or on the coast, forming dense canopies which shade and smother native vegetation. It also fixes nitrogen which results in increased soil fertility and subsequently supports other weed species. Lavatory creeper is considered a high weed risk "sleeper" due to its prolonged seed dormancy and the species ability to grow rapidly.

***Leptospermum laevigatum* (Coast Tea-tree)**

Coastal tea-tree is an Australian native indigenous to the east coast of Australia. It invades disturbed dune areas within close proximity to the shoreline, significantly altering natural systems by forming dense thickets and changing fauna habitat.

***Polygala myrtifolia* (Myrtle-leaf Milkwort)**

Myrtle-leaf Milkwort competes with indigenous wattle species and can become very dominant in higher rainfall areas. The species does not need disturbance to colonise and can germinate in heavy shade. It readily regenerates by seed and spreads into coastal dune and cliff top environments via birds, water and ants.

***Rhamnus alaternus* (Blowfly Bush)**

Blowfly bush invades dry coastal vegetation but also lower light conditions in closed shrub and woodlands. Plants are long-lived, with a preference for disturbed soils; however they are also able to germinate in established vegetation. Seed spreads via birds and can therefore be widely dispersed.

4.4.6 Weeds as a Threatening Process – Cell Value Analysis

Assigning values to environmental weeds not only enables identification of the highest priority species, but also allows levels of threat to different coastal areas (cells) to be determined and compared.

Section 4.4.4 features cell-specific priority environmental weed lists and their correlating values. When the values of all priority environmental weeds within each cell are averaged, it provides a nominal value that subsequently enables comparison of this threat layer between cells. These nominal weed threat values have been mapped as a GIS layer and are illustrated in Figure 23.

It is important to note that the presence of higher value weeds in a cell will increase the average; however the collective presence of many lower value weeds will also have a similar influence. Some discussion occurred amongst DEH GIS and scientific staff regarding the possibility of simply presenting the threat value for red alert weeds (those with a value of 4 or greater) per cell so as not to dilute the threat value of higher priority weeds. It was decided that lower priority weeds should still be featured in Figure 1 due to their collective impact and contribution towards the overall threat to an area of coastal vegetation.

Refer to Section 5.1 for detailed discussion concerning weeds as a threatening process in individual cells.

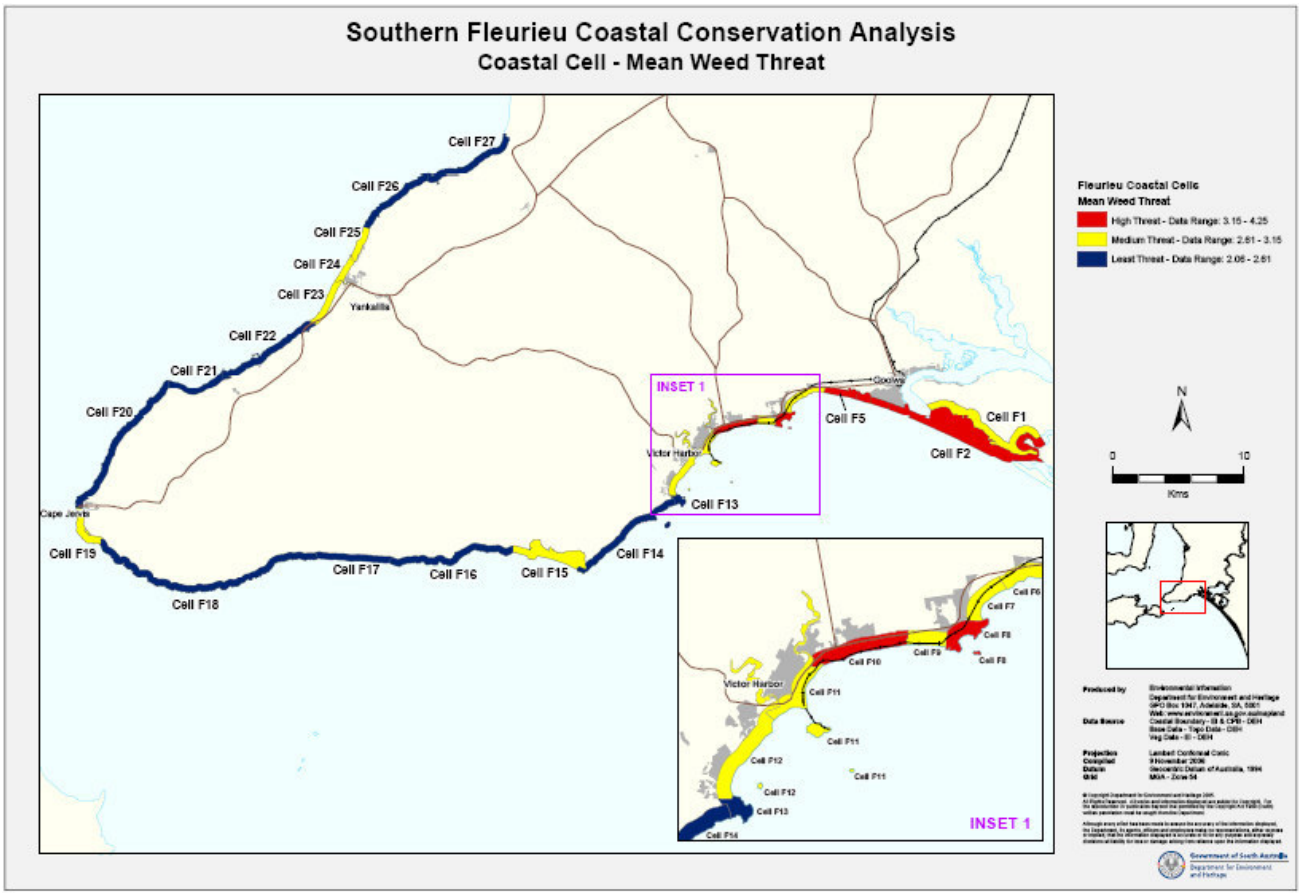


Figure 23. Priority Weed Distribution in the Southern Fleurieu Coastal Zone (detailed, all priorities included)

4.4.7 Other considerations

Non-rated weeds of importance

Several weed species were not rated as high priority environmental weeds during the threat evaluation process, although were still noted as being of importance due to either their usefulness or increasing popularity as garden plants.

Useful Weeds

Ammophila arenaria (Marram Grass)

Marram Grass was historically introduced to the coast to aid in dune stabilisation projects. While not considered overly invasive, the grass can alter foredune shape, creating steeper dunes that are more prone to erosion by waves. Marram Grass is no longer recommended for revegetation projects due to a preference for utilising local provenance species and advances in propagation techniques for the indigenous species *Spinifex hirsutus* (Rolling Spinifex).

Marram Grass is not usually targeted for control due to the stabilisation benefits it provides and presence of other higher priority environmental weeds. Taylor (N/D) comments that revegetation with native species is deemed to be the only means of control required. Indigenous seedlings can be planted in Marram Grass as the plants provide native seedlings with some protection without impacting on their survival. This method has the advantage of ensuring removal of the plant does not occur without replacement.

Cakile maritima ssp. maritima (Two-horned Sea Rocket)

Sea Rocket is a plant of metropolitan distribution, meaning it is found in coastal zones throughout the world. It is a pioneer species and tends to occupy the incipient dune where conditions are harsh and few species can survive. For this reason, Sea Rocket provides benefit through its ability to trap sand and assist with dune formation processes. Furthermore the species provides habitat and food for indigenous fauna including lizards

and insects. Whilst not indigenous, the plant should not be targeted for removal in the absence of alternative species filling these useful functions.

Garden Plants

Aptenia cordifolia (Heart-leafed Iceplant)

Heart-leafed Iceplant is a succulent creeper gaining popularity as a garden plant. It is likely to be an issue around urban centres where it either spreads from household gardens or is deliberately planted into coastal habitats abutting residential properties. While not currently a major issue, planting of this species should be discouraged and deliberate plantings in the coastal environment removed.

Correa sp.

It has been noted that a nursery-supplied Correa is being utilised in Council landscaping projects. The species is likely to be an Australian native rather than a locally indigenous species and has the potential to become weedy in the Southern Fleurieu coastal zone. It is recommended that Councils discontinue planting this species and look at alternative drought tolerant indigenous species as alternatives.

4.4.8 Declared Weeds of the Southern Fleurieu Coastal Region

It was noted during the weed threat evaluation process, that not all declared species recorded in the Southern Fleurieu coastal region are considered priority environmental weeds. Nevertheless, land managers have responsibilities relating to management of these species, ranging from control to prevention of the sale and movement of particular species, which must be taken into account. Table 11 identifies declared weeds of the Southern Fleurieu coastline, associated management responsibilities, and recorded location (by cell).

Table 11. Location of Declared Weeds of the Southern Fleurieu Coastal Region and Associated Management Responsibilities

Scientific Name	Common Name	Management Responsibilities
Allium vineale	Field Garlic	MSCR
Asparagus asparagoides	Bridal Creeper	MSCR
Asparagus declinatus	Bridal Veil	MSCR
Carduus tenuiflorus	Slender Thistle	*R
Chondrilla juncea	Skeleton Weed	NMSCR
Chrysanthemoides monilifera ssp. *Monilifera*	Boneseed	MSCR
Cirsium vulgare	Spear Thistle	*
Convolvulus arvensis	Field Bindweed	*MSCR(1)
Cuscuta campestris	Chilean dodder	NMSCR
Cynara cardunculus	Wild Artichoke	*MSR
Diplotaxis tenuifolia	Lincoln Weed	*MSR
Echium plantagineum	Salvation Jane	*NMSR
Emex australis	Three-corner Jack	MSCR
Eragrostis curvula	African Love-grass	MSCR (2)
Euphorbia terracina	False Caper	MSCR
Hirschfeldia incana	Buchan Weed	*
Lycium ferocissimum	African Boxthorn	MSCR
Marrubium vulgare	Horehound	NMSCR
Moraea flaccida	One-leaf Cape Tulip	NMSCR
Olea europaea ssp. *europaea*	Olive	CR(3)
Oxalis pes-caprae	Soursob	*MSR(1)
Rosa canina	Dog Rose	NMSCR
Silybum marianum	Variegated Thistle	*MSR
Tamarix aphylla	Athel Pine	S
Urex europaeus	Gorse	MSCR
TOTAL Southern Fleurieu Coastal Zone	**25**	

* Control required in part of state
N Notifiable throughout the state
N notifiable in part of state
M Movement
S Sale
C Control
R Roadsides

(1) Excludes cultivar 'Consul'.
(2) Includes only Olives not planted & maintained for domestic or commercial use.
(3) Control & roadsides only apply to land used for the extraction or removal of soil, loam, sand and gravel.

4.4.9 Potential high priority weeds in the Southern Fleurieu coastal zone

While assessing weeds as a key threat to the Southern Fleurieu coast, it was noted that a number of high priority environmental weeds are not currently present in the region however are highly likely to become established in the future. It is imperative that land managers and communities are aware of these potential high priority weeds and are readily able to identify any new arrivals or outbreaks. Particular species of concern are detailed below. Images of these species are featured in 4.4.11 and are marked as 'early warning' species.

Trachyandra divaricata (Dune Onion Weed)

One of the highest priority weeds on the Adelaide metropolitan coast, Dune Onion Weed can travel via ocean currents and will certainly soon appear in the Southern Fleurieu region. The species would be allocated a weed threat value between 7 and 9 as it rapidly establishes in either intact or disturbed vegetation and is extremely persistent. Control in the Adelaide region is proving to be highly expensive with a persistent, long-term approach to containment and control required.

Oenothera drummondii (Beach Primrose)

Beach Primrose is a new arrival to the Adelaide metropolitan coast. The species has become naturalised along the Queensland and New South Wales coastline and whilst climatic conditions are different in southern Australia, it has displayed properties that indicate the species may become significantly more widespread.

Chrysanthemum monilifera var. rotundata (Bitou Bush)

A weed of national significance (WONS), Bitou Bush was originally introduced to the eastern states as a dune stabiliser for revegetation projects. Having spread prolifically and displaced coastal dune vegetation communities, major funds and community effort are being invested into controlling this species. Recent studies have noted that this species appears to be moving southwards into more temperate climates.

Arctotheca populifolia (Beach Daisy)

Beach daisy is able to withstand the harsh conditions of the beach environment and is a highly invasive weed of foredunes and coastal grasslands. It possesses the ability to cover large areas of accumulating sand, with seed spread occurring via wind and tidal currents. It has become a serious threat to biodiversity in Western Australia and needs to be recognised early to prevent establishment in the Southern Fleurieu coastal zone.

4.4.10 Managing Weeds

Despite longstanding control measures administered by a wide range of natural resource managers, there is evidence of an increasing rate of weed encroachment towards every ecosystem of immediate conservation value within Australia (Agriculture and Resource Management Council of Australia and New Zealand Environment and Conservation Council, 1999). The public ownership and linearity of the coast make the recognition of the weed disturbance problematic. More needs to be done as weeds are having an impact on the coast and no adequate baseline data or monitoring is in place.

While it would be desirable to consider the control of weeds on the coast as a high priority, funds will be a limiting factor and weed management strategies should subsequently aim to reduce or eliminate physical disturbance to native vegetation. In addition, targeting the control of weeds and preventing new incursions in areas of high biodiversity value and in large areas currently relatively free of weeds is vital.

Actions

A number of land management practices can be enacted which could decrease weed ingress, including: rationalising access tracks, restricting fire breaks to only where required, controlling introduced grazing animals, maintaining both weed-free and fertiliser-free buffer zones around native vegetation.

It is imperative that potential introductions of plants for productive or amenity purposes are thoroughly vetted in terms of invasive characteristics. At a local level, many coastal weeds are readily available for purchase from commercial plant nurseries and local produce markets. Information on the risk of garden plants that are known coastal weeds needs to be made available to those who are likely to use these species in near-coastal situations.

Early Warning

The Cooperative Research Centre for Australian Weeds Management is resourcing a project for an early weed warning system. It is a collaborative effort utilising the on-line facilities of the Australian Virtual Herbarium and cooperation between the National and State Weed authorities. As weed flora is constantly changing with new introductions, the collection of specimens and mapping can be vitally important. More resources and development of a centralised weed database with GIS capability could reverse the lack of environmental weed mapping. Pest 2000 is a current database that has been developed for weeds by PIRSA.

A serious weed often appears after it has naturalised and the earlier the awareness of a widening distribution, the greater chance of timely control measure being implemented. With efficient weed risk assessment and rapid response to weed outbreaks, future environmental damage can be minimised.

Acknowledgments

Particular thanks is extended to Southern Fleurieu coastal ecologist Ron Taylor, who provided extensive and highly valuable input in identification of weeds present in the region, their distribution and impacts on the local coastal environment.

4.4.11 Weeds of Concern in the Southern Fleurieu Coastal Region

Priority Rating

Asparagus asparagoides (Bridal Creeper)

9

Asparagus declinatus (Bridal Veil)

Ehrharta villosa var. maxima (Pyp Grass)

8

Gazania linearis (Gazania)

Lycium ferocissimum (African Boxthorn)

7

Acacia Cyclops (Western Coastal Wattle)

Priority Rating

Ulex europaeus (Gorse)

7

Leptospermum laevigatum (Coast Tea-tree)

6

Chrysanthemoides monilifera ssp. monilifera (Boneseed)

Dipogon lignosus (Lavatory Creeper)

6

Polygala myrtifolia (Myrtle-leaf Milkwort)

Priority Rating

Rhamnus alaternus (Buckthorn)

6

Euphorbia paralias (Sea Spurge)

5

Euphorbia terracina (False Caper)

Olea europaea (Olive)

5

Melianthus comosus (Tufted Honey-flower)

Priority Rating

Acacia longifolia ssp. longifolia (Sallow wattle)
Solly Reserve, Victor Harbor
Photograph: Ron Taylor

5

Acacia saligna (Golden Wreath Wattle)

Oxalis pes-caprae (Soursob)

5

Carpobrotus edulis (Hottentot Fig)

4

Solanum linnaeanum (Apple of Soddom)

Priority Rating

Ehrharta calycina (Perennial Veldt Grass)

4

Marrubium vulgare (Horehound)

Juncus acutus (Sharp Rush)

4

Arctotis stoechadifolia (White Arctotis)

Pinus halepensis (Aleppo Pine)

4

Priority Rating

Brassica tournefortii (Wild Turnip)

3

Scabiosa atropurpurea (Pincushion)

Ferraria crispa ssp. crispa (Black Flag)
Photograph: Ron Taylor

3

Malva spp. (Mallow)

Mesemryanthemum cristallinum (Common Iceplant)

3

Galenia pubescens (Coastal Galenia)

Priority Rating

Lupinus cosentinii (Sand Lupin)

3

Cynodon dactylon (Couch)

Agave americana (Century Plant)

3

Reichardia tingitana (False Sow Thistle)

Plantago spp. (Plantain)

3

Verbascum thapsus ssp. thapsus (Great Mullein)
Lady Bay

Priority Rating

Zantedeschia aethiopica (White Arum Lily)
Fishery Creek

3

Chondrilla juncea (Skeleton Weed)

2

Tamarix aphylla (Athel Pine)

Tetragonia decumbens (Sea Spinach)

2

Stenotaphrum secundatum (Buffalo Grass)

Priority Rating

Echium plantagineum (Salvation Jane / Paterson's Curse)
Photograph: Jeff Reid (APS)

2

Ehrharta longiflora (Annual Veldt Grass)
Encounter Bay
Photograph: Ron Taylor

Osteospermum fruticosum (Seascape Daisy)

2

Limonium companyonis (Sea-lavender)

Lagurus ovatus (Hare's Tail Grass)

2

Dimorphotheca pluvialis (Cape Marigold)

Priority Rating

Cynara cardunculus ssp. Flavescens
(Atrichoke Thistle)

2

Pennisetum clandestinum (Kikuyu)
The Bluff

Rosa canina (Dog Rose)
Inman Valley
Photograph: Ron Taylor

2

Asphodelus fistulosus (Onion Weed)

1

Avena barbata (Wild Oat)
Encounter Bay
Photograph: Ron Taylor

Priority Rating

Chrysanthemoides monilifera ssp. Rotundata
(Bitou Bush)
EARLY WARNING

No Rating

Diplotaxis tenuifolia (Lincoln Weed)

Matthiola incana (Common Stock)
Fishery Creek

No Rating

Oenothera drummondii (Sandhill Evening-primrose)
EARLY WARNING

Senecio pterophorus (African Daisy)
Photograph: Ron Taylor
Fishery Beach

No Rating

Trachyandra divaricata (Dune Onion-weed)
EARLY WARNING

All photographs other than individually noted taken by Ron Sandercock
Coastal Protection Branch
Department for Environment and Heritage

4.5 Dune Areas

Blowouts, deflation and transgressive dunes are common around the sand dune coast of the Southern Fleurieu coastal region. The causes of dune instability are both natural and human induced. They include storm damage, fire, drought, and plant disease, off road vehicle impact, grazing and clearance. These causes, with regard to any one area, may be multiple and often interlinked. Also the de-vegetation of a dune may be linked to a single event, such as a fire or a storm; but the impact of such an event may be exacerbated by previous circumstances, such as years of drought, or the establishment of a carpark within the dunes.

On high-energy sandy coasts storm damage to the foredune is common, and through natural causes this damage may develop to a large blowout. Primary colonising dune plants may, over time, reclaim this area resulting in a diversity of dune plant species, and habitat, within the dune complex. Diversity of dune plant species is a consideration in decisions to act or not act over dune stabilisation and also in decisions over how to act. Extensive planting of one species of dune plant, Marram, has in the damper parts of the Australian coast in Tasmania and Victoria, resulted in areas where there is a very low number of plant species. In these circumstances Marram has created an apparently stable situation where other plants have found it hard to invade.

However, if there is widespread de-stabilisation, creating an extensive transgressive dunefield, natural revegetation may be slower, and over time large quantities of sand may be transported by the wind. Where large quantities of sand are transported landwards, damage to native vegetation or farmland may occur through burial. In addition, in extreme cases, coastal recession may result from transport of sediment inland from the beach.

Data on unstable dunes was obtained from the existing layer ‘coastal hazards’, based on recent aerial photography. Values (0 – 9) for coastal cells were obtained from this layer. High values were given where dunes were de-vegetated, ‘actual drift hazard’. Medium threat values were given to other dunes, ‘potential drift hazard’.

Generally dune instability is not a problem in this region. Actual instability is identified at the frontal dunes of the Sir Richard Peninsula, Goolwa, and irregularly distributed within Newland Head Conservation Park. Potential instability is recorded at these localities as well as the Normanville Dunes.

4.6 Cliff Stability

High risk is found along the W coast of the peninsula, with the exception of the Normanville embayment. From Cape Jervis to Newland risk is low to medium. Newland Head to the Bluff shows high values, then the coast east of the Bluff values are low, with the exception of medium risks from Middleton to Surfers and at the Port Elliot headlands.

4.7 Coastal Acid Sulfate Soil

Acid sulfate soils are naturally occurring soils with significant percentages of iron sulphide. These soils commonly occur in low-lying coastal areas where the water table is at or close to the surface. They were formed during or after marine inundation, when seawater containing dissolved sulfate covered organic rich environments, such as coastal wetlands, mangroves, salt marshes or Tea-tree thickets. While these soils are below the water table they remain relatively stable, simply being slowly processed by anaerobic bacteria; iron present within the soil combines with sulphur from the sulfate to form iron sulfides.

However, when these soils are exposed to the air, oxidation occurs and sulfuric acid is formed. The acid may simply react with carbonates and clay within the soil, but if a build up of acidic soil water occurs or is flushed to a waterway, damage to life forms may occur. In NSW for example, fish kills have been reported following disturbance to swampy areas near estuaries and coastal lakes.

Coastal acid sulfate soils have been mapped by the CSIRO in South Australia, (Fitzpatrick et al, 2003) and the results included as digital layer within the threats analysis.

CSIRO Acid Sulfate Soil Map Classes for South Australia

Map Legend	Class Description
(a) Actual CASS (disturbed). (b) Potential CASS (disturbed)	**Actual Coastal Acid Sulfate Soils**. Very high risk. (Not in Southern Fleurieu) **Potential Coastal Acid Sulfate Soils in subsoil below 20 cm (up to 1 metre thick) with surface monosulfidic black ooze (MBO)**, intertidal (mainly in samphire). Moderate risk because carbonate layers usually occur above and below.
Potential CASS (mangrove)	**Thick PCASS – mangrove soil**. Mainly in mangroves, with high risk
Potential CASS (tidal stream)	**PCASS of tidal streams** (CPASS underlying, not extensive laterally). Moderate risk.
Potential CASS (intertidal tidal)	**PCASS in subsoil below 20 cm (up to 1 m thick) with surface monosulfidic black ooze (MBO)**, intertidal (mainly in samphire). Moderate risk because carbonate layers usually occur above and below.
Potential CASS (supratidal)	**PCASS in subsoil below 50 cm (up to 1 m thick) with some surface MBO – supratidal**. (Mainly in samphire, salt bush, blue bush or saltpan associated with hypersaline soils where there is less frequent tidal inundation). Moderate to low risk.
Sand	**Soils of sand dunes and ridges**. (No PCASS or CASS within I metre of the surface). Low risk of PCASS below watertable.
Calcarenite/ Aeolianite	**Calcareous soils and hardpans**. (No PCASS, highly neutralising). No or very low risk.
Marine soils	**Marine soils – subtidal and intertidal marine**. (PCASS may be present, CASS neutralised by tides and carbonates). No or very low risk.
Other soils	**Soils associated with other land uses within coastal landforms**. Risk requires individual investigation; guided by adjacent mapped units.

CASS above: Coastal Acid Sulfate Soils

PCASS above: Potential Coastal Acid Sulfate Soils

Mapping of acid sulfate soils in South Australia has been carried out by the CSIRO by a sampling procedure. Within the Southern Fleurieu coastal boundary, sampling points were located near the Murray Mouth.

The Coast Protection Board Policy on Coastal Acid Sulfate Soils (see Coastline 33, January 2003) relates to avoiding or minimising the risk of development in high and moderate risk areas. The Board advises on development applications within coastal zone (as defined on the Development Plan), including advice over PCASS. However, farm drainage schemes and mining activity that have the potential to activate PCASS, have not usually been referred to the Board for assessment. It should be noted that the Development Regulations 1993 (schedule 2, paragraph 5) defines any excavation or filling exceeding 9 cu.m. within the coastal zone as development which requires approval.

Risk of acid sulfate soil development has been assessed as negligible throughout the region, with the exception of the estuarine shores of the Murray Mouth area, where high to medium risk is seen. However, there appears to be potential at the Myponga estuary, Watsons Gap and the Lower Inman, which are under investigation.

4.8 Climate Change

Coastal environments are adapted to climatic variability, for example dry years and wet years, associated with the ENSO (El Nino – Southern Oscillation) changes on a global scale. Climatologists are able to document change and trends over decades and sometimes centuries. Recently, human induced changes in the composition of the atmosphere, through the addition of greenhouse gases, have begun to influence climate.

4.8.1 The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) of the World Meteorological Organisation has co-coordinated the work of scientists on climate change since 1989. Three major reviews of global changes and modelled predictions of future changes ('Assessment Reports') have been produced, in 1991, 1996 and 2001. The next assessment report is due in September 2007.

The Third Assessment Report of the IPCC (2001) concluded that:

- Collectively, observations show the world is warming;
- Most of the warming of the last 50 years is attributable to human activities;
- Emissions of greenhouse gases have altered the composition of the atmosphere and will continue to do so throughout the present century;

- Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that affect the climate system;
- Confidence in the ability of models to project future climates has increased;
- Global average temperature and sea level are projected to rise.

New evidence (Steffen 2006, quoted in Suppiah 2006, p.vii) since the Third Assessment Report of the IPCC (2001) shows:

- Most of the IPCC conclusions have been confirmed or strengthened in recent years.
- The global average surface temperature has increased by 0.7^{o}C during the last century.
- Heatwaves and heavy rainfall have increased in many regions, while glaciers, ice sheets and frosts have decreased.
- Oceans are becoming more acidic.
- The global average sea level has risen 1.7mm per year since 1900.
- There have been shifts in plant and animal locations and seasonal behaviour consistent with global warming.
- The unusual nature of the warming of the past 50 years, relative to the past 1,000 – 2,000 years, has been supported by many other independent studies.
- The influence of human activities has been detected in land-ocean temperature contrasts, the annual cycle of surface temperature over land, the hemispheric temperature contrast, regional (not just global) warming, the height of the tropopause (between the troposphere and stratosphere) and the heating of the oceans.
- New information about climate feedbacks indicates a greater likelihood of warming at the higher end of the uncertainty range.

There now appears little doubt about the direction of change in the model projections: the present doubt is over the amount and the speed of change.

4.8.2 The CSIRO review of climate change in South Australia

The CSIRO has reviewed climate change in South Australia, documenting recent past trends and examining the results of modelling future changes over time spans of decades, (McInnes et.al, 2003, revised in Suppiah et. al., 2006). The work is based on regionally specific modelling as well as the latest findings of the Intergovernmental Panel on Climate Change (IPCC)

4.8.3 Observed climate trends in South Australia

Over the period spanning 1950 to 2005, South Australia's average temperature has increased by 1.2°C, slightly faster than the national trend. 2005 was the warmest year on record in SA. Sea surface temperatures in the region have risen at about half the rate of the land-based temperatures.

Trends in South Australian annual rainfall since 1910 are generally weaker than other parts of the continent. Most of the north-western part of the state has experienced an increasing rainfall trend while southern coastal regions have experienced slight drying trends since 1950.

4.8.4 CSIRO projections for South Australia's climate

Average regional temperature, rainfall, rainfall intensity and potential evaporation projections for the Mount Lofty Ranges region

Projections are made based on standardised scenarios representing the main demographic, economic and technological driving forces of greenhouse gas emissions, 'SRES scenarios', (Suppiah, p.18).

Annual average temperatures are projected to increase to between 0.4 to 1.2°C by 2030 and 0.8 to 3.5°C by 2070 and these changes are almost uniform throughout the year. Over the ocean, surface air temperature changes reflect those of sea surface temperature: these show a similar trend with a moderating effect in terms of seasonal variation.

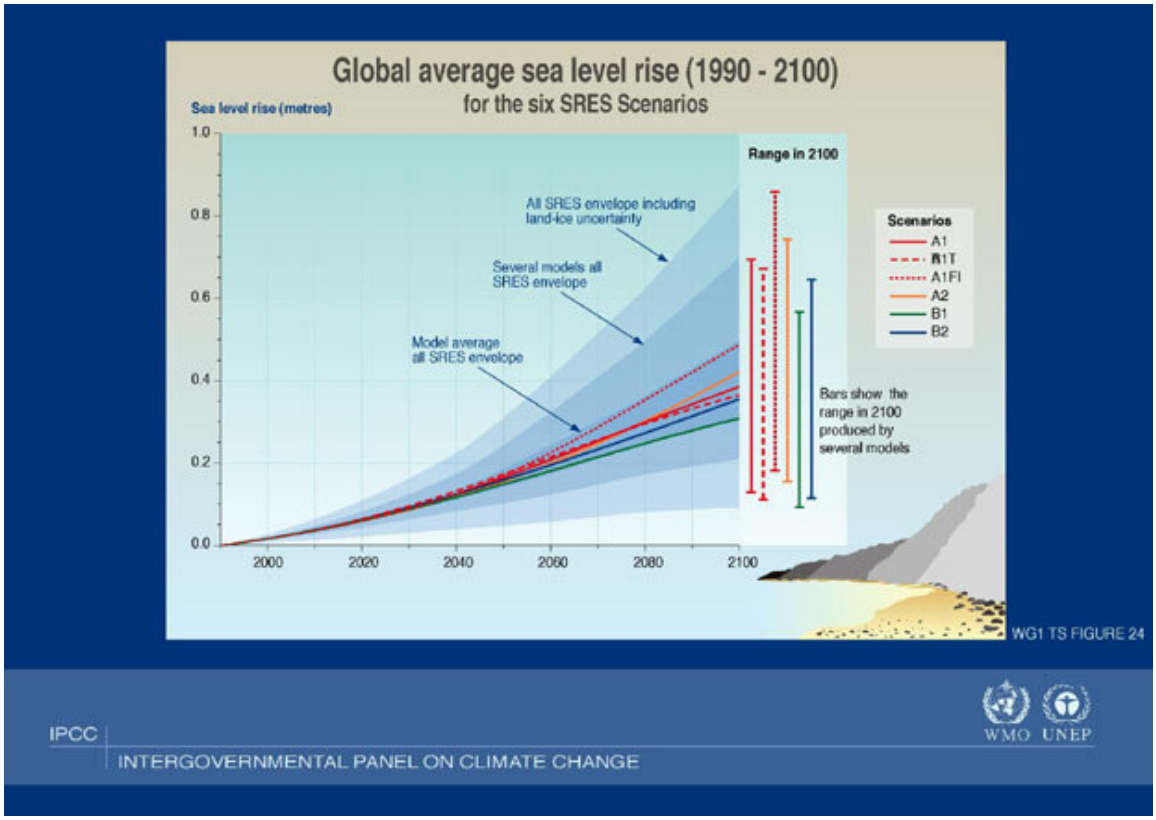
With regard to annual rainfall, decreases of 10% to 1% by 2030, and 30% to 3% by 2070 are projected for areas within 200km of the sea, (Suppiah et.al. p.25); greatest decrease is indicated in spring. However, McInnes et al (p.35) show extreme rainfall events (i.e. periods of intense rainfall) becoming more frequent at all seasons but spring.

Projections of annual potential evaporation indicate increases across the region; average annual water balance shows clear deficits. [Work by Hutson in the Mount Lofty Ranges shows that as a result of changes in water balance there will be a marked fall in normal stream flow. However, intense rainfall events may result in flash floods].

Projections of coastal storms and changing wave conditions

Currently, storm surges of at least half to one metre occur along the South Australian coast; they are caused by W. to S. Westerlies following the passage of fronts and their associated low pressure systems further south. The frequency of winter lows and therefore the frequency of surges decreases by about 20% in the vicinity of SA under enhanced Greenhouse conditions, however, the largest storms show a slight increase in intensity. It should be remembered though that when storm frequency is combined with sea level rise, the probability of a surge at heights within the present range, would increase.

The above represent the best available current scenarios for climate changes within southern South Australia over coming decades. In addition to the above changes, the IPCC predicts a global sea level rise over the next century (and continuing).



As the graph above illustrates, there are a range of sea level scenarios, depending on future levels of emissions and warming. A median value shows a rise of 0.3m by the end of the present century.

Detailed examination of tide gauge records from around the world shows that currently global sea level is rising at an average rate of 1 – 2mm per year, and that sea level has been rising for several decades. The indications are that this rate is increasing: a further acceleration would be needed to equal IPCC projections. Oceanographers indicate that sea level will continue to rise for over 200 years even if carbon dioxide emissions were stabilised now.

Tide gauges also record varying rates of change because of local movements of the land. Sea level rise close to global means is projected for the southern parts of the Gulfs. This appears to apply to the coast from Sellicks Beach to Port Eliott. Bourman et al (2,000) note that geological evidence suggests that in the area from Middleton to the Murray Mouth the land is slowly sinking. Here relative sea level rise rates will be faster that the global average.

McInnes et al (2003) do not discuss changing wave conditions in coastal waters. It is reasonable to assume, however, that under enhanced Greenhouse conditions, changes in wave climate would be expected. Models indicate poleward displacement of climatic zones resulting in a greater frequency of anticyclonic conditions in South Australia's coastal waters. This movement would see the mid-latitude Southern Ocean wind belt, the "Roaring Forties", also displaced south. However, if the changes also result in greater pressure gradients, and hence stronger winds, in the Southern Ocean even in latitudes 50 to 60 South, then South Australian waters will receive a greater percentage of low, long period, swell. At present this is speculative until tested, through year-by-year analysis of wave period frequencies, as recorded by wave rider buoys off Southern Australia.

4.8.5 Impacts of Climate Change within the Fleurieu Region

Changing climatic trends shown by the current records constitute a stress factor for natural and semi-natural habitats within coastal Fleurieu region. Forecast Greenhouse climate scenarios represent a potential risk for coastal habitats: these risks are discussed below.

Tackling Climate Change: South Australia's Greenhouse Strategy. Natural Resources Issues Paper (2005) brings together expert opinion to assess the greenhouse challenge for the natural resources sector within South Australia. The report by McInnes (2003) mentioned above provides the scenario used by this group to discuss the impacts of change. The excerpts below, Appendix A2 of the McInnes report (Biodiversity pp. 29 – 30), address a number of issues relevant to this project:

> Climate change is likely to exacerbate threatening processes already impacting on biodiversity and other natural resources and lead to the accelerated loss of a range of ecosystem services, ecological function, species and ecological communities." In particular, reduced winter and spring rains and the negative soil water balance will threaten all vegetation communities in the region. This will lead to reductions in geographic range of species and ecological communities and increased risk of extinction for species that are already vulnerable…there will be variable impacts of increasing CO2 concentrations on germination, establishment, growth and regeneration of native species.
>
> Currently, the specifics of these changes are not known at the species or community level. It is evident though that, as climatic envelopes shift, species migration will occur. This process will be more difficult in highly fragmented landscapes. That is, where connectivity between remnant vegetation blocks is maintained or enhanced, vegetation systems are likely to show greater resilience, greater capacity to adapt to the changes.
>
> With rapid climate change, highly invasive exotic species are likely to become more dominant in many landscapes…the ability of native species and ecosystems to remain within bioclimatic envelopes by migrating along climatic and geographical gradients will be a fundamental component of any adaptive response. As exotic weeds and animals are good colonizers after disturbance and within stressed ecosystems they are predicted to respond favorably to climate change as local ecosystems and species are threatened by changing conditions.

The current conservation analysis within this study shows the Southern Fleurieu is a significant area for plant species diversity, numbers of threatened species and the rarity of its vegetation communities. The threat analysis within this study shows that the region has high numbers of aggressive invasive weed species, which are widely distributed. The conservation value of the remnant vegetation areas suggests that continuing investment in weed control should be a high priority throughout this coastal region.

All Greenhouse scenarios show sea level rise, though with a wide variation in the amount of elevation; currently, sea levels are slowly rising globally and projections suggest the rate of rise will increase. For the hard rock headlands and small beaches of the southern part of the Fleurieu Peninsula from Sellicks to the Bluff, sea level rise may be a moderate threat. For example, there will be a species change of life forms at shore platforms and near shore reefs if there is no potential for adjustment to changing tide levels.

Some beach recession and foredune erosion will occur: for these ocean and gulf beaches recessions of the order of 5 to 30 metres over the next 50 years will be expected, depending on beach topography, sand supplies and littoral sediment movement. Medium energy beaches protected by reefs and islands near Victor Harbor will be much more variable in their response, depending again on sand supply, rate of sea level rise in relation to sheltering reefs, but more critically on storm frequency and magnitude under changed climatic regimes. Sand barriers between Middleton and Murray Mouth will recede, and there is a slight threat that the sea will break through the Sir Richard Peninsula on the Goolwa side of the barrage. In these circumstances it is important that the DEH monitoring of the profile line at Beach Road Goolwa is maintained, in order to show recession speeds of the Sir Richard Peninsula relative to sea level rise.

Sand beaches respond markedly to changes of wave climate. Increasing frequency of long period swell would be extremely significant for the Southern Fleurieu coast, since these waves are very powerful. Also, long period swell will respond differently to shoaling compared with short period waves; refraction and hence the angle of wave approach to the shore can change. Thus changes in the spectrum of wave periods are capable of significant impact: capable of changing littoral drift speeds, transporting sediment rapidly along the shore, and changing the patterns of erosion and deposition. The power of the long period waves would impact on foredunes.

Beach plan form is affected by the protection afforded by nearshore reefs: beaches build up behind reefs, often in pointed or salient forms; for example, at Hayborough Point, Victor Harbor. Where this protection is reduced by sea level rise, sharp change in beach plan form may occur, with the salient being cut back.

Increased temperatures and aridity will affect beach and dune vegetation. Dune vegetation on the more arid West Coast of South Australia show similar species to the Fleurieu today; however, recovery from storm damage is slower on west coast dunes.

Cliffs respond in varied ways to changes in sea level and wave climate. Most cliffs of the Southern Fleurieu are composed of ancient sedimentary or metamorphic rocks, or - near Victor Harbor – granite: these are resistant to marine erosion. Many of the cliffs of the peninsula have already been affected by soil erosion, following grazing pressure: it is uncertain whether this will increase under greenhouse scenarios. However, the clay marl cliffs east of Middleton, and the aeolianite (calcarenite) of Surfers, could be sharply eroded in storms following relatively small amounts (c. 30cm) of sea level rise.

Urban storm water systems are challenged by projected changes, since many parts of the systems may need to be adapted to peak flows of larger magnitude.

Saltmarsh complexes are particularly vulnerable to sea level rise if barriers exist to species migration: samphire species flourish between mean sea level and the highest astronomic tides. These communities are adapted to frequency of tidal flooding and soil salinity conditions. Salt marsh, mangrove, swamp paperbark and supra-tidal samphire areas near the Murray Mouth will need to retreat together with the advance of the tides, if they are to survive. Even very small sea level changes will impact on the saltmarsh, because of the very low gradients on these coastal areas. Since these areas are important fish nursery habitat, secondary impacts may be expected.

Tidal flows within the Murray Mouth will alter in complex ways following sea level change, while changes in seasonal run-off have the potential to alter critical salinity values. Conservation analysis within this (section 3.1) shows that 2 vegetation communities near the Murray Mouth are rare within the state and over 80% of their occurrence is in this locality: these are the intertidal Melalleuca habitat and the intertidal / estuarine sedges habitat.

Other estuarine areas within the region are potentially vulnerable to these impacts, such as the stands of Swamp Paperbarks near the mouth of the Hindmarsh and Inman Rivers.

Estuarine fish, and other species, are vulnerable to reduced riverine environmental flows, which are anticipated following rising evaporation rates under greenhouse conditions.

Adaptation to Changed Climatic Conditions

The adaptation to changed climatic conditions by land managers, groups, agencies, and Local and State Government will depend on the climate record and the perception of individuals of the need for adaptation. However, the timelines involved in decisions made now, means that some current actions by the Southern Fleurieu community within the coastal region could reasonably be regarded as a ‘no regrets’ response to current scenarios. It is important that decisions made now, especially those with long-term consequences, do not preclude adaptation in the future. The analysis attempted in this section suggests some priorities for immediate action in order to keep options open.

Plans are necessary in that development now does not compromise adaptation in the future. State policy on coastal flooding and erosion is written in to the Council Development Plans. Continuing action is needed to ensure these policies are adhered to. Setbacks and site levels are tied to advice from the Coast Protection Board (CPB). These standards will be subject to periodic revision following IPCC reports and advice from the CPB Mean Sea Level committee. Ongoing sea level rise underlines the value of many coastal reserves as buffers against coastal erosion and providing space for floodwall protection in some urban areas. Many of Victor Harbor’s reserves fall in this category. It is important that incursions into these reserves for private uses are not allowed to compromise such future needs.

Decisions on floodbanks protecting farmland and towns are development matters, subject to the Development Act, within a context of tenure and ownership. Long time lines are associated with these and it is important that decisions made now, do not critically limit choices in the future. The precautionary principle would appear to apply to these classes of decision at the present time. Floodbanks which prevent the retreat of samphire habitats on Hindmarsh Island should be the subject of review in the light of conservation priorities within this study.

The small estuaries of the region have been identified as significant and distinctive habitat. Here, decisions which allow flexibility and setback adjacent to these areas are relevant. Again, floodbanks and hard protection could lead to unpredictable change in these locations and therefore setback strategies are recommended. Development decisions which preclude such options should be avoided.