Lavinia Ramsar Site
Ecological Character Description

March 2012

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Lavinia Ramsar Site
Ecological Character Description

by

Final

March 2012

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LIST OF ABBREVIATIONS

CAMBA	China-Australia Migratory Birds Agreement
CEPA	Community Education and Public Awareness
CPS	Components, Processes and Services
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth) (former name for DSEWPaC)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth) (former name for DoE)
DPIW	Department of Primary Industries and Water (former name for DPIPWE)
DPIWE	Department of Primary Industries, Water and Environment (former name for DPIPWE)
DoE	Department of the Environment (Commonwealth)
ECD	Ecological Character Description
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* (a Commonwealth Act)
JAMBA	Japan-Australia Migratory Birds Agreement
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea-Australia Migratory Birds Agreement

INTRODUCTORY NOTES

This Ecological Character Description (ECD) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the EPBC Act, nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

The *Water Act 2007* requires that in preparing the Murray-Darling Basin Plan, the Murray-Darling Basin Authority (MDBA) must take into account Ecological Character Descriptions of declared Ramsar wetlands prepared in accordance with the National Framework.

This ECD is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

DISCLAIMER

While reasonable efforts have been made to ensure the contents of this ECD are correct, the Commonwealth of Australia as represented by the Department of the Environment does not guarantee and accepts no legal liability whatsoever arising from or connected to the currency, accuracy, completeness, reliability or suitability of the information in this ECD.

Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

EXECUTIVE SUMMARY

This Ecological Character Description (ECD) has been developed following the National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (DEWHA 2008) and contains information on the Lavinia Ramsar Site (hereinafter referred to as 'the site'). This information includes: geographic and administrative details; the site's ecological character (including components, processes, benefits and services) at the time of Ramsar listing (1982) and currently; gaps in knowledge of the site and issues for management; actual or potential threats; changes that have occurred since listing; site monitoring needs and limits of acceptable change; and communication, education and public messages to facilitate management and planning.

The Site

Lavinia Ramsar Site is situated on the northeast coast of King Island in Bass Strait, approximately equidistant between Cape Otway on mainland Australia and the north-west tip of the main island of Tasmania (Figure E1). Its location within Bass Strait gives it a maritime climate and places it within the 'roaring forties', the latitudes at which strong westerly winds prevail, often bringing heavy precipitation. King Island is the largest island in western Bass Strait, being approximately 65 kilometres long, 25 kilometres wide and 110,160 hectares in area (Finzel 2004a). The Island has subdued topography and low relief (Environment Australia 2000) with its highest point being 168 metres above sea level (ASL) (Barnes et al. 2002).

Lavinia Ramsar Site is a State Reserve situated between Boulder Point at its northern end and Cowper Point, approximately 12 kilometres north of Naracoopa, at its southern end. The northern section of the Site extends approximately 8 kilometres inland (Figure E1). Its boundary to the east is Bass Strait and boundaries to the north, south and west contain a mixture of freehold land and unallocated Crown land (PWS 2000). The site is mostly below 20 metres ASL and is 7034 hectares in size.

Lavinia Ramsar Site contains a highly significant and diverse set of ecosystems, including a significant lagoon and wetland system, coastal and bush landscapes, and, a rich cultural heritage. Major wetlands within the site include a large estuary with saltmarsh, coastal lagoons, perched lakes, swamp forests, and numerous smaller, seasonally inundated, wetland areas. The site is one of the few largely unaltered areas of King Island and contains much of the remaining native vegetation on King Island. The closed canopy of the swamp forest exceeds 30 metres in places. The reserve contains about 200 hectares of quality feeding habitat for the nationally endangered orange-bellied parrot (*Neophema chrysogaster*- Endangered, TSPA 1995, EPBC 1999).

The site is currently listed under the following criteria:

> Criterion One - A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate bioregion.
>
> Criterion Two - it supports vulnerable, endangered, or critically endangered species or threatened ecological communities;
>
> Criterion Three - it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region; and,
>
> Criterion Four - it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Figure E1: Lavinia Ramsar Site and Boundary (DEH, 2006).

The site's estuary and associated samphire mud flats, coastal swamps, and lagoons are important habitat for a range of state and nationally threatened species. This is a significant component of the reserve and adds significantly to its biodiversity. This biodiversity includes the orange-bellied parrot (noted above) and the JAMBA listed short-tailed shearwater (*Puffinus tenuirostris*). The site can be separated into 4 ecosystem units (Figure E2):

1. The Sea Elephant Estuary
2. The Coastal Strip
3. The Dunes
4. The Northern Sandsheet

These ecosystem units are not independent of each other, having elements that overlap in time and space. A brief paragraph-description of each ecosystem is presented below. Detailed descriptions of their components and processes are provided in Section 3 of this document.

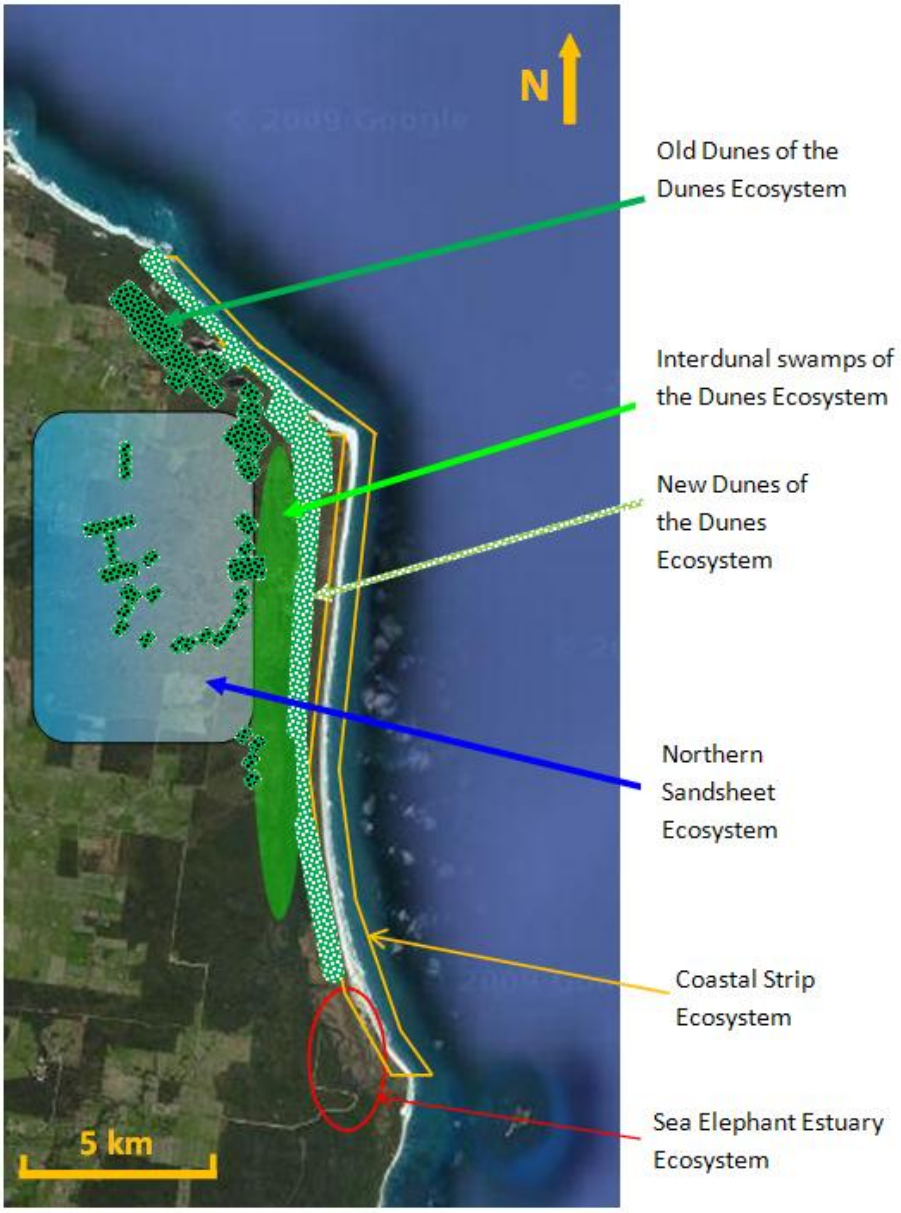


Figure E2: Ecosystem units of the Lavinia Ramsar Site (green dots in Northern Sandsheet Ecosystem indicate remnant dunes)**.**

Conceptual Models

A conceptual model was produced for each of the ecosystems (Figures E3 – E6).

The Sea Elephant Estuary Ecosystem

The Sea Elephant Estuary receives its freshwater from the largest river on King Island (the Sea Elephant River) and drains into Bass Strait midway along the east coast. As well as containing significant saltmarsh areas that provide feeding and roosting habitat for the orange-bellied parrot (*Neophema chrysogaster*) the estuary contains a coastal lagoon and an actively developing sand spit. Socio-economic values of the estuary include recreational fishing and a commercial aquaculture facility (an oyster farm).

The Coastal Strip Ecosystem

The Coastal Strip Ecosystem covers the entire coast of the site, from Boulder Point in the north to Cowper Point in the south. This ecosystem includes the coastal calcareous sand beaches of the site as well as the fore-dunes. The Coastal strip contains important sea-bird rookeries and overlaps with the Sea Elephant Estuary Ecosystem, described above.

The Dunes Ecosystem

This ecosystem consists of three main sub-components – the New Dunes, the Old Dunes and the Interdunal Swamps. The Old Dunes formed approximately 120,000 years ago during considerably higher sea levels and are situated inland of the New dunes (Pemberton 2004), which commenced forming within the last 10,000 years and form a rim around King Island. Between the Old and New Dune systems, there is a series of lagoons, lakes wetlands and peatlands, forming in the Interdunal depressions.

The Northern Sandsheet

The Northern Sandsheet Ecosystem is a Quaternary sand plain which forms flat to undulating country inland of the Dunes Ecosystem. The plains are thought to have originated during periods of relatively high Quaternary sea levels, in which marine-estuarine sedimentation occurred and formed the plain onto which terrestrial sediments were subsequently deposited. Vegetation of the ecosystem includes an extensive successional mosaic of sedgeland, heath and scrub (Duncan 1986) and also heathy woodlands (D'Costa et al. 1993).

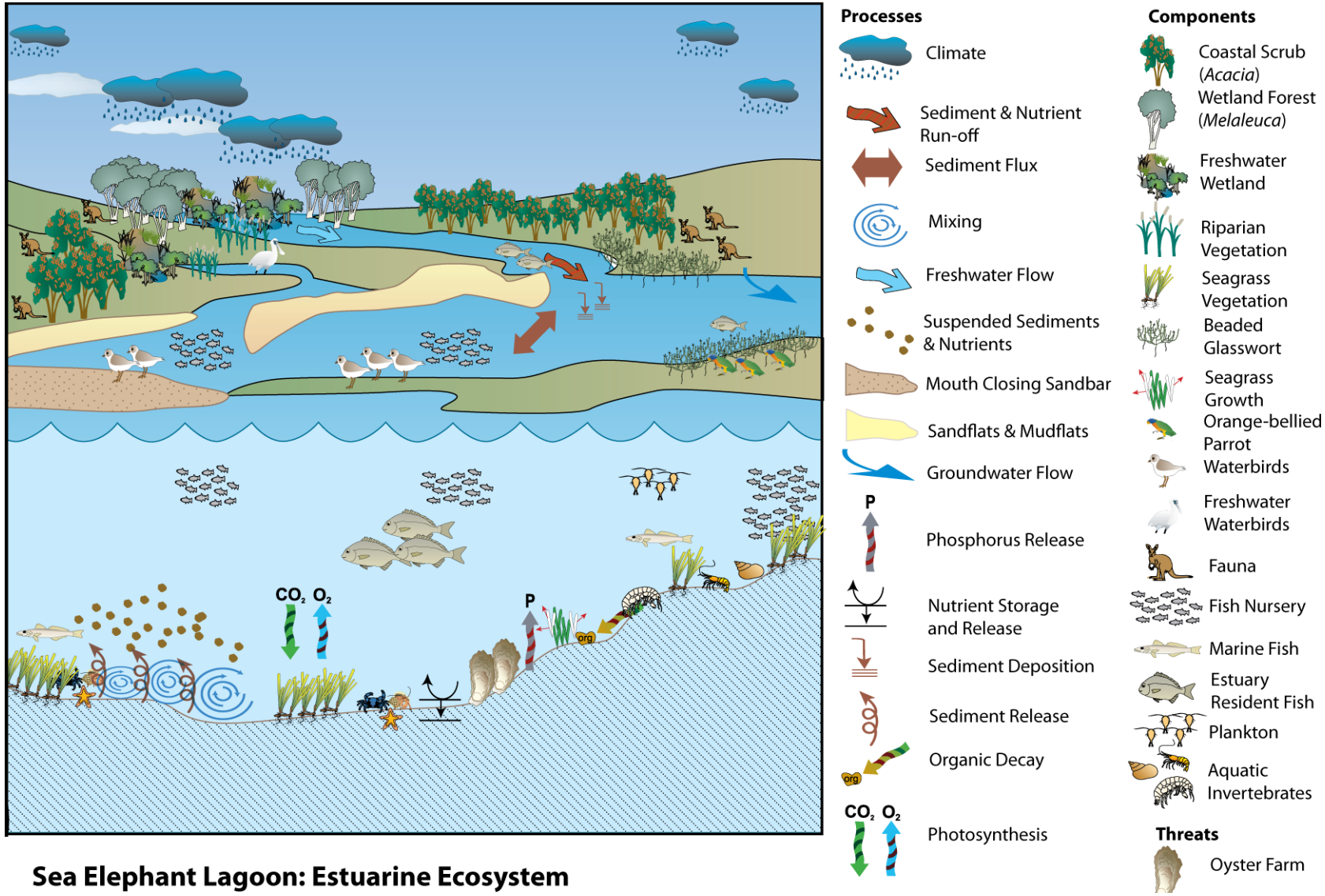


Figure E3: Landscape conceptual model of the Sea Elephant Estuary Ecosystem

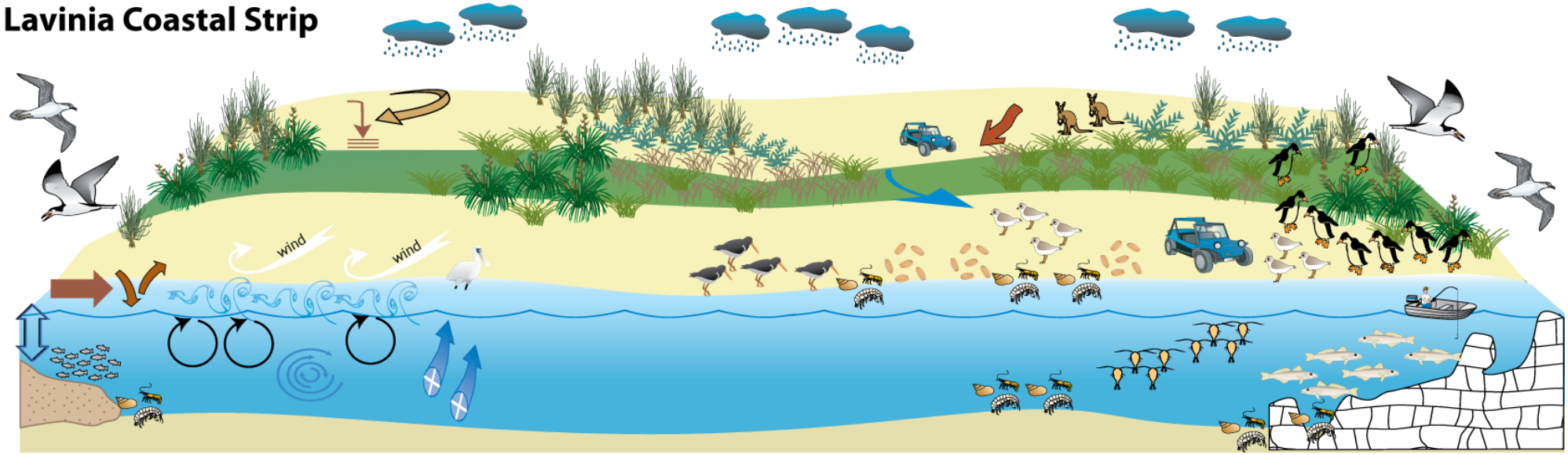


Figure E4: Landscape conceptual model of the Coastal Strip Ecosystem.

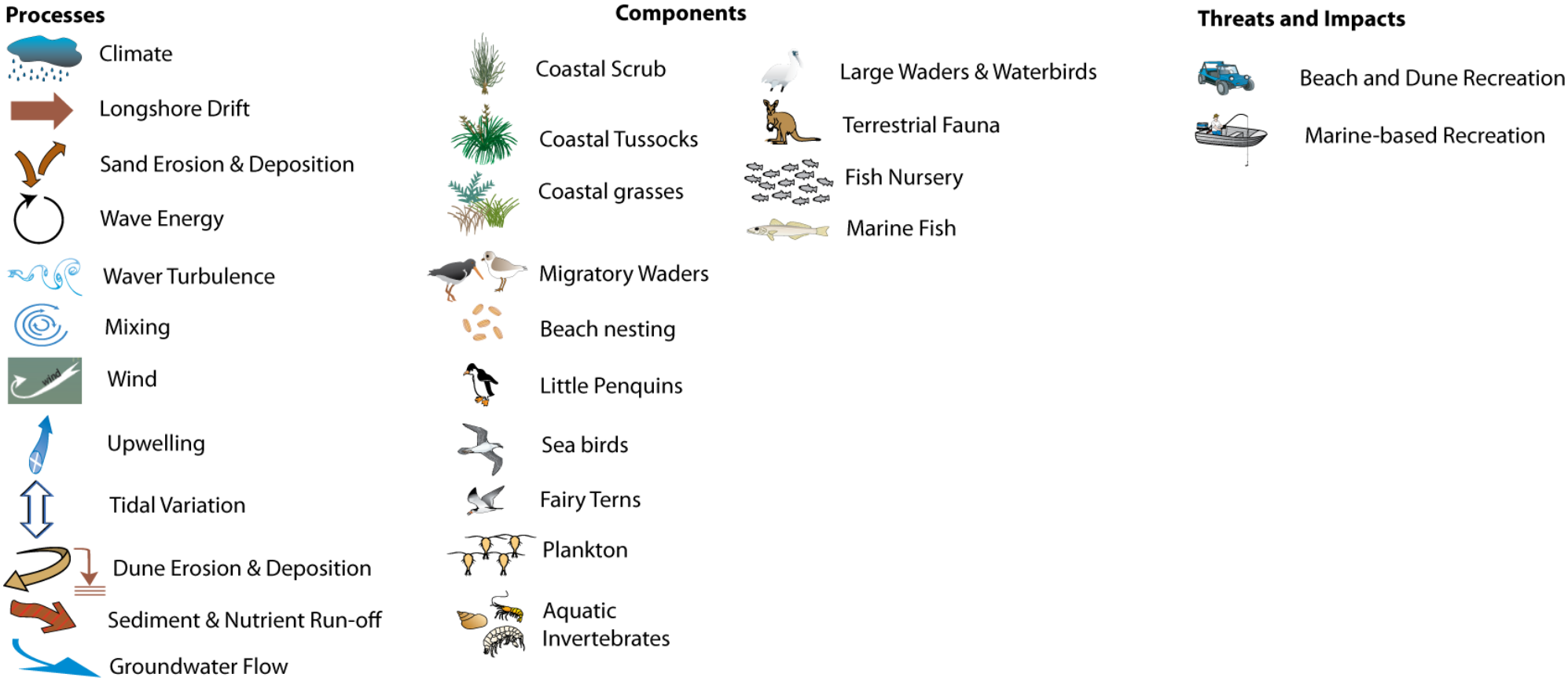


Figure E4: Landscape conceptual model of the Coastal Strip Ecosystem (Legend).

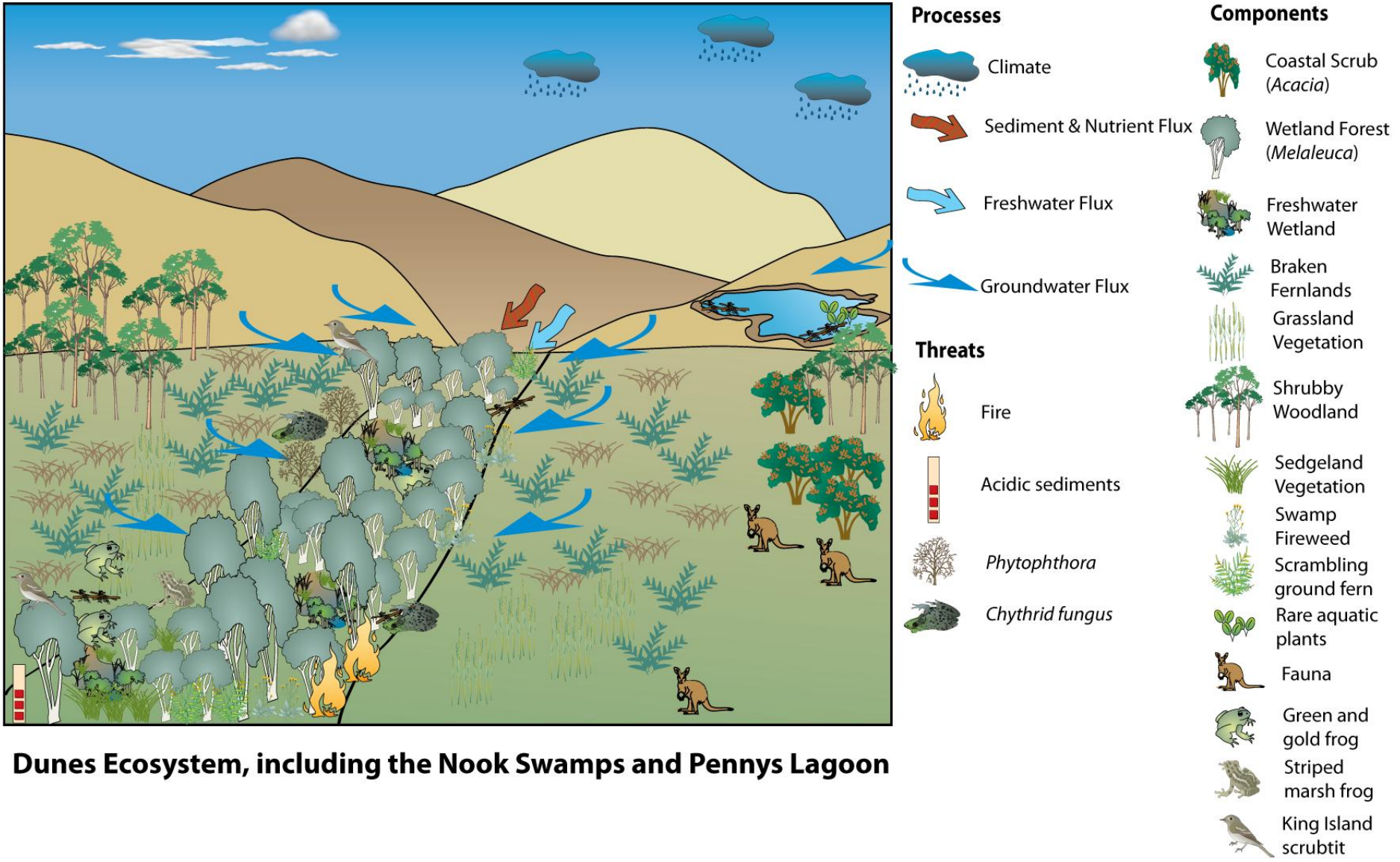


Figure E5: Conceptual model of the Dunes Ecosystem.

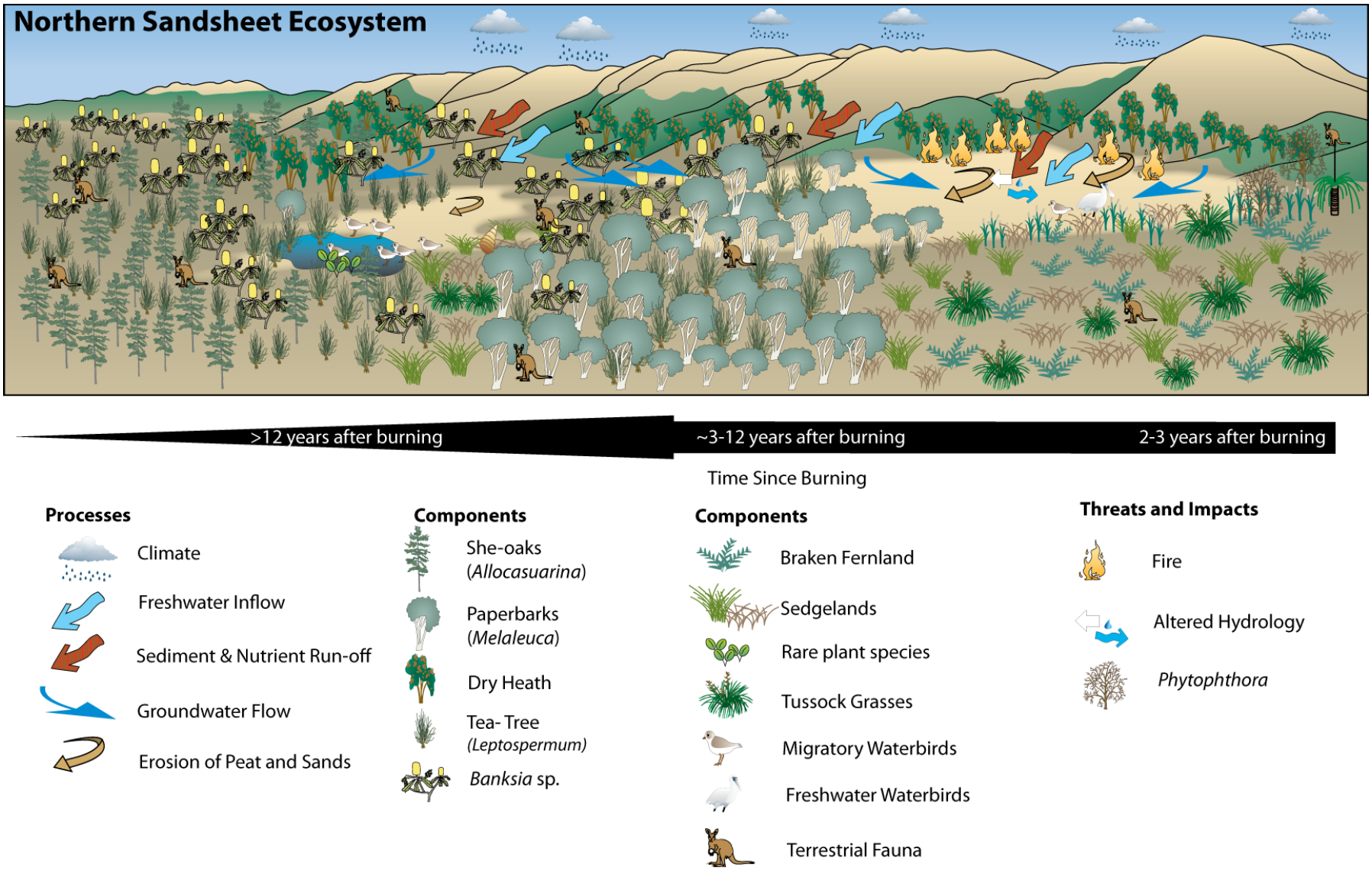


Figure E6: Conceptual model of the Northern Sandsheet Ecosystem.

Key Actual or Potential Threats to the Site

The drivers of the major actual and likely threats to the ecosystems of the site were identified through discussions with local land holders and the project Steering Committee and through review of relevant documents. These are:

Sea Elephant Estuary

- Fire
- Recreation (primarily vehicle use)
- Up-catchment impacts on water quality
- Feral Cats
- Potential acid sulphate soils
- Aquaculture
- Climate Change

Coastal Strip

- Weeds
- Fire
- Recreation (via vehicle use)
- Feral cats
- Climate change

The Dunes and Northern Sandsheet

- Fire
- Drainage in the upper catchment
- *Phytophthora cinnamomi* (dieback fungus)
- Weeds (e.g. *Typha*)
- Past land clearance
- *Batrachochytrium dendrobatidis* (chytrid fungus)
- Climate change
- Potential acid sulphate soils

Limits of Acceptable Change

Several of the Limits of Acceptable Change (LAC) for the individual ecosystems are applicable across the Lavinia Ramsar site. The LAC presented in the summary table below (Table E1) are applicable for the entire site unless specifically indicated.

Table E1: Summary Table of the Limits of Acceptable Change for the Lavinia Ramsar Site

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Wetland vegetation communities (supporting regional biodiversity, rare & representative wetland types, and regionally threatened species).	The baseline information used in this assessment is the wetland type map produced as part of this ECD (Figure 3). The rare and representative vegetation for the site includes Ramsar wetland types Xf, Xp, H, Tp, Ts and H. There are quantitative data available on the areal extent on the first four of these, whereas Ts was not able to be distinguished from a suite of wetland types occupying the King Island sedge/heath/scrub complex. There is also quantitative data available on the areal extent on the fifth wetland type (H).	Based on the information available, the limits of acceptable change for component are: • No more than ten percent (24 hectares) reduction in the combined area of wetland types **Xf** and **Xf/Xp** (freshwater tree-dominated wetlands and forested peatlands). These wetland types overlap and together have a combined area of 242 hectares; and • No more than ten percent (6 hectares) loss of wetland type **Tp** (Permanent freshwater marshes/pools) (currently 61.2 hectares); and • No more than ten percent (6 hectares) loss of wetland type **H** (Tidal marshes) (currently 63.1 hectares).	These limits have been set as a common sense approach to defining a significant loss in wetland types. There are no data on the variability of the Ramsar wetland types at the site and until this ECD, there was no mapping of the Ramsar wetland types. The majority of wetland area within the site is Ts/W/U and is part of a vegetation continuum that will change in response to fire regime and hydrologic variability. Therefore meaningful LAC cannot be set for these wetland types. As the wetland habitat map was made without proper field surveying, it will need verification.	Medium

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Regionally rare plant species (supporting regional biodiversity, through supporting regionally threatened species).	The only baseline information available is that these six rare species were recorded as being within particular habitat types at the site. It is assumed that they were also present at the time of designation.	Presence of: • showy willowherb (*Epilobium pallidiflorum*); • hairy brooklime (*Gratiola pubescens*); • fan triggerplant (*Stylidium beaugleholei*); • small triggerplant (*Stylidium despectum*); • submerged watertuft (*Trithuria submersa*); and • pink bladderwort (*Utricularia tenella*).	There is no quantitative information on any of these species within the site. The species were described in terms of location, recorded as part of a subjective survey. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of these six species is provided.	Low
Nationally rare plant species (scrambling groundfern, swamp fireweed) (provision of habitat for nationally threatened fauna species)	These two species are recorded as being at the site. It is assumed that they were also present at the time of designation.	Presence of: • scrambling groundfern (*Hypolepis distans*); and • swamp fireweed (*Senecio psilocarpus*).	The semi-quantitative information available for these species is insufficient to set quantitative LAC. Therefore a qualitative LAC based on presence / absence of these two species is provided.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Regionally rare bird species (support for regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna).	The only baseline information available is that these two species are recorded as being at the site. It is assumed that they were also present at the time of designation.	Presence of: • white-bellied sea eagle (*Haliaeetus leucogaster*); and • eastern curlew (*Numenius madagascariensis*).	There is no quantitative information on either of these species within the site. The most likely locations of each species within the site have been predicted on the basis of habitat needs and preferences. However, numbers are not available. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of these two species is provided.	Low
Striped marsh frog (support for regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna).	The only baseline information available is that this species is recorded as being at the site. It is assumed that it was also present at the time of designation.	Presence of the striped marsh frog (*Limnodynastes peroni*).	There is no quantitative information on *Limnodynastes peroni* at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Orange-bellied parrot (provision of habitat for nationally threatened fauna species).	It is estimated that there are currently less than 150 individuals of this species left in the wild. The number appears to be declining. Although it is likely that all or most of the migrating population uses King Island, during the annual migration to mainland Australia, no data were available for numbers using the Lavinia Ramsar Site.	Two LAC are provided for the orange-bellied parrot, one of which is the same as an LAC for wetland vegetation: • Presence of orange-bellied parrots during the annual migration period; and • No more than ten percent loss of wetland type **H** (Tidal marshes) (currently 61.2 hectares) (same as third LAC for wetland vegetation communities).	The orange-bellied parrot is endangered and is a major reason for the site's Ramsar status. Further reductions in population numbers may be beyond site management control, but it is a critical component of the site's ecological character. It is therefore vital that the site still offers the quality and quantity of habitat required by the migrating parrots, particularly the salt marsh habitat. It is not currently possible to determine numbers of this species that use the site during migration.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
King Island scrubtit (provision of habitat for nationally threatened fauna species).	A low reliability estimate of the population size of the King Island scrubtit was estimated to be 150 or less breeding birds and it is suspected to be decreasing. The Nook Swamp – in particular the stands of swamp paperbark - has been confirmed as the critical location for the King Island scrubtit.	Two LAC are provided for the King Island scrubtit, one of which is the same as an LAC for wetland vegetation: • Presence of the King Island scrubtit; and • No more than ten percent (24 hectares) reduction in the combined area of wetland types **Xf** and **Xf/Xp** (freshwater tree-dominated wetlands and forested peatlands). These wetland types overlap and together have a combined area of 242 hectares.	There is uncertainty about the current population size of the King Island scrubtit and no information was found on the population size at the time of listing. With the reported diminishing size of the population, it is probable that the population is now outside the limits of natural variability. However, this cannot be assessed. It remains vital that the site continues to offer the quality and quantity of habitat required by the scrubtit, particularly the swamp paperbark habitat.	Low
Green and gold frog (provision of habitat for nationally threatened fauna species).	The only baseline information available is that this species is recorded as being at the site. It is assumed that it was also present at the time of designation.	Presence of the green and gold frog (*Litoria raniformis*).	Similar to the other rare / threatened species, there is no quantitative information on *Litoria raniformis* at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Waterbirds and seabirds [provision of nesting habitat for waterbirds and seabirds; and provision of habitat for nationally threatened fauna species (fairy tern)].	The only baseline information available is that six species of waterbirds & seabirds nest at the site, one of which (fairy tern) is listed on the IUCN redlist.	The presence of nesting populations in 2 out of 3 years for: • fairy tern (*Sterna nereis*); • little tern (*Sterna albifrons*); • hooded plover (*Thinornis rubricollis*); • Australian pied oystercatcher (*Haematopus longirostris*); • short-tailed shearwater (*Puffinus tenuirostris*); and • little *penguin (Eudyptula minor).*	No quantitative information on these species at the site means that no quantitative limits of acceptable change can be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Migratory birds.	The only baseline information available is that these eleven species were recorded as using the site at the time of designation.	Presence in 2 out of 3 years of: ○ short-tailed shearwater (*Puffinus tenuirostris*); ○ cattle egret (*Ardea ibis*); ○ great egret (*Ardea modesta*); ○ ruddy turnstone (*Arenaria interpres*); ○ sharp-tailed sandpiper (*Calidris acuminata*); ○ red-necked stint (*Calidris ruficollis*); ○ white-throated needletail (*Hirundapus caudacutus*); ○ Caspian tern (*Hydroprogne caspia*); ○ little tern (*Sterna albifrons*); and ○ greenshank (*Tringa nebularia*).	There is no quantitative information on these species at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

LAC explanatory notes:

1. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.
2. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.
3. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.
4. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.
5. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

Changes in Ecological Character since Listing

Due to deliberately lit fires, there has been a loss of wetland (swamp paperbark forest) and peatland components of the site, constituting a change in ecological character. This change is for the at least the short to medium term (years to several decades). A determination will require time (possibly many decades) to assess whether regrowth in the Nook Swamps results in new wetland communities and a return to its former ecological character.

Knowledge Gaps

The following knowledge gaps are those which will help define/refine quantitative LACs for the site and provide further data to monitor the Site's status into the future (Table E.2).

Table E2: Knowledge gaps for the Lavinia Ramsar site

Component	Identified knowledge gaps	Recommended data collection or other action to address the gap.	Priority
Wetland Vegetation Community	No accurate mapping of all wetland types.	A vegetation, wetland type and topographical survey across the whole site to produce an accurate picture of vegetation communities, wetland types and the landscape.	High
Orange-bellied parrot	Specific numbers using the site and their percentage of migrating population.	Survey of site during migration.	Very high

Component	Identified knowledge gaps	Recommended data collection or other action to address the gap.	Priority
King Island scrubtit	Specific population numbers	Annual survey, due to suspected diminishing population size	Very high
Species important for regional biodiversity (flora and fauna; all ecosystems) but especially: ○ white-bellied sea eagle ○ eastern curlew. ○ waterbirds and seabirds (including migratory species) ○ fairy tern ○ green and gold frog ○ six regionally threatened plant species	Little baseline information or understanding of natural variability. A lack of quantitative surveys of nests and breeding or migrating populations at the site. This is particularly important for the IUCN-listed fairy tern.	Surveys during season of maximum growth (flora) or migrating/breeding season (fauna). This would include a comprehensive survey of vegetation and fauna such as birds, fish, and frogs.	High
Fire regime	Historical and pre-historical frequency and extent; and trajectory of any changes.	Documentation of complete fire history of the site since settlement; analysis (e.g. coring) of swamp sediments for analysis of pollen and charcoal bands.	High
Coastal geomorphology	Baseline information on rates and trends of landforming processes, particularly in relation to dune stability and natural variation. Natural variation in estuary opening – recurrence interval and causes. Also any influences on water quality indicators	Slope stability; erosion assessments. Studies on the importance of root-binding in maintaining dune stability. Review of any historical records, aerial photographs, anecdotal data.	Medium

Component	Identified knowledge gaps	Recommended data collection or other action to address the gap.	Priority
Hydrology	Flow into and through the Nook Swamps. Water levels in major wetlands (Penny's Lagoon and Martha-Lavinia Swamp). Discharge data from Sea Elephant River into the estuary, including variability. Groundwater dynamics of the system.	Gauge installation/augmentation, flow measurements, and flow modelling.	Medium

Key Site Monitoring Needs

The monitoring needs of the site focus on the knowledge gaps, Limits of Acceptable Change for the maintenance of the site's ecological character and also major threats to the site (Table E.3). Priorities for monitoring were based on importance of the component, process or threatening process, to the site's ecological character.

Table E3: Key monitoring needs for the Lavinia Ramsar site

Component, process, or threat	Key indicator	Monitoring needs (type and frequency)	Priority
Wetland vegetation community	Area of wetland types.	Establishment of baseline flora species and community data using permanent transects across hydrological gradients and recording of: ○ Species presence/absence ○ Ecological community identification and composition ○ Ecological community mapping and extent ○ Threatened species population sizes and health Survey extent of each wetland type every second or third year to assess changes over time. ID presence of rare plants during surveys and also note weed presence and extent. Low level aerial photography taken in November / December every second or third year in conjunction with resurveying of transects.	High
Fire regime	Intensity and frequency of burns.	Keep records of each burn and monitor for changes in intensity and frequency (especially within sensitive vegetation types).	High
Extent of *Melaleuca ericifolia* swamp forest	Regeneration of areas where the swamp forest has been severely burnt.	Permanent quadrats in burnt areas, assessing plant community development (and whether plant community is developing as expected for *Melaleuca ericifolia* swamp forest).	High

Component, process, or threat	Key indicator	Monitoring needs (type and frequency)	Priority
Saltmarsh	Extent of tracks impacting the salt marsh vegetation of the Sea Elephant Estuary.	Number and total area (m^2) of walking and vehicle tracks in the saltmarsh. Quantitative evidence of impacts from tracks, including loss of total area, weed invasion, species composition changes.	High
Use of site by orange-bellied parrot (OBP) and other bird species	OBP - Numbers of individuals using site versus number using other sites on King Island and number within whole population. Other birds - record population size and number of nesting pairs each year.	Annual monitoring during migration (focus on peak of migration?). Develop monitoring program in consultation with Birds Tasmania. Annually during nesting season.	High
Fish, Frogs and other aquatic fauna	Presence and abundance of fish and frog species within the estuary and wetlands.	Regular sampling of fish and frogs – initially every year (for three to five years) and then reduce to every three years to establish extent of natural viability.	Medium-high
Disturbance to nesting shorebirds	Disturbance indicators such as tyre tracks, other signs of disturbance during nesting.	Annually during nesting season.	Medium-high
Water Quality of Sea Elephant Estuary	Nutrients (total phosphorus, total nitrogen, dissolved nitrogen); dissolved oxygen; electrical conductivity; pH; temperature; algal biomass.	Water Samples (nutrients, algal biomass); probes/meters (dissolved oxygen, electrical conductivity, pH, temperature). Monthly over summer, otherwise quarterly.	Medium (medium-high in summer)
Surface Water	Flow into and through the Nook Swamps. Water levels in major wetlands (Penny's Lagoon and Martha-Lavinia Swamp). Discharge from Sea Elephant River into the estuary.	Monthly gauge measurements and annual (spring or high flow period) flow/velocity monitoring.	Medium-high
Depth to groundwater	Changes in depth to groundwater, particularly in Northern Sandsheet area.	Quarterly or monthly monitoring of bores to determine whether there is a trend of lowering of water table. If a trend is found, determine cause(s).	Medium-high

Component, process, or threat	Key indicator	Monitoring needs (type and frequency)	Priority
Ground surface saturation	Extent of land area that is saturated.	In conjunction with monitoring of swamp forest regeneration, determine whether saturated surface area is decreasing. Analyse data in conjunction with results from 'Depth to Groundwater' monitoring.	Medium-high
Phytophthora cinnamomi	Spread of fungus.	Regular soil sampling (yearly – more frequently if rapid spread is occurring), testing for presence of the fungus.	Medium

Communication, education and public awareness (CEPA) messages

Communication, Education and Public Awareness messages are designed to help raise awareness of wetland values and functions. Key messages for the Lavinia Ramsar site should include:

- the Lavinia Ramsar site, at 7034 hectares, contains the majority of the remaining native vegetation of King Island;
- the site contains three species that are threatened globally: orange-bellied parrot (Critically Endangered); fairy tern (vulnerable) and green and gold frog (Vulnerable) and one that is threatened nationally - scrambling ground fern (Endangered);
- the site contains important habitat for nesting shorebirds, which are vulnerable to vehicles and predators (including pets and feral animals) during the nesting season;
- there are several rare and/or poorly reserved Tasmanian vegetation communities within the site, including *Melaleuca ericifolia* swamp forest, saltmarsh, and three wetland types (freshwater aquatic wetlands, herbfields and grasslands marginal to wetlands, and sedge/rush wetland);
- The saltmarsh of the Sea Elephant Estuary is a key habitat for the migration of orange-bellied parrots. This habitat is particularly susceptible to the impacts of vehicles being driven through the saltmarsh; and,
- Fire is an important component of the site, with different vegetation communities requiring different burning regimes, ranging from 200 years of more between burns for some communities, to less than 30 years for others. Misuse of burning can have major consequences on the vegetation diversity of the site. Appropriate burning regimes need to be designed by vegetation ecologists, local landowners, and other stakeholders working together.

1. INTRODUCTION

This document is the Ecological Character Description (ECD) for the Lavinia Ramsar Site (hereinafter referred to as 'the site'). It contains:

- geographic and administrative details of the site
- a description of the site's ecological character, including:
  - key ecological **components** of the site
  - critical dynamic aspects, or **processes**, that occur within and between the components
  - important values of the site (at the time of Ramsar listing and currently), described as **benefits** and **services** and
  - **conceptual models** of the site, displaying the key components and processes
- actual or potential **threats** to the site
- **gaps** in knowledge that is required for the description, management and protection of the site
- **changes** that have occurred since listing or are currently occurring to the site
- **acceptable limits** to changes in the site's ecological character
- site **monitoring** needs, and
- communication, education and public **awareness messages** that will facilitate management and planning for the site.

1.1 Purpose of an Ecological Character Description

Ecological Character Descriptions are critical in understanding the ecological character of a Ramsar site through the description of ecosystem components, processes, benefits and services. They form the benchmark for management action, including site monitoring to detect negative impacts, thus ensuring the site maintains its ecological character. It is imperative that the limits of acceptable change are documented as managers need to know how extensively ecosystem components, processes, benefits and services can vary without the ecological character changing. Information on the benchmarks or limits of acceptable change indicates when the ecological character has changed or is likely to change. The Environment Protection and Biodiversity Conservation Act, 1999 (the EPBC Act) provides the legal framework for ensuring the ecological character of all Australian Ramsar sites is preserved (DEWHA 2008).

The objectives of this ECD are (McGrath, 2006):

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations* 2000 (Commonwealth of Australia):
   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
   b) to formulate and implement planning that promotes:
      i) conservation of the wetland; and
      ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.
2. To assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its

territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.

3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.
4. To assist the administration of the EPBC Act, particularly:
   a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or
   b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.
5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

The preparation of an ECD also forms the basis of understanding and management of the listed wetland site, including the information required for:

- providing a baseline description of the site as a benchmark for assessing any changes in ecological character
- identifying potential threats and impacts, and evaluating risks to the site
- identifying critical gaps in knowledge and approaches/methods for addressing these gaps
- determining methods and approaches for assessing changes to its condition
- designing programs for monitoring its condition
- devising efficient and appropriate management plans for the ongoing protection of the wetland

The process for preparing an ECD should also engage the relevant stakeholders, thereby laying the foundations for alignment of goals and agreed management outcomes.

1.2 Site details

The Ramsar site initially consisted of the southern 1,730 hectares of the current site. It was listed as the Sea Elephant Conservation Area Ramsar site in 1982 and its boundary corresponded with the (then) Sea Elephant River Wildlife Sanctuary. In 1988, the Sea Elephant River Wildlife Sanctuary was incorporated into the adjoining Lavinia Nature Reserve and underwent some boundary realignment. In 1994, the Ramsar site boundary was redefined to incorporate the whole of the Lavinia Nature Reserve and the name of the Ramsar site was changed to become the Lavinia Ramsar Site.

The Sea Elephant Conservation Area Ramsar Site was nominated in the 1982 RIS against the (then) criterion 2(a), for supporting an appreciable number of individuals of a rare, vulnerable or endangered species or subspecies. Following listing, the criteria were increased between 1982 and 1991 to include 2(c) (providing a habitat for plants or animals at a critical stage of their biological cycle) and 2(d); (a site of special value for one or more endemic plant or animal species) (RIS 1991).

Following revision of the listing criteria in 1999, original criteria 2(a), 2(b) and 2(c) translate to the revised criteria 2, 4 and 3, respectively. The list of criteria met by the site was subsequently proposed (Draft RIS 2005) to include criterion 1 of the revised criteria - for

containing representative, rare or unique wetland types. Further details of the listing criteria are provided in Section 2.5.

The eastern boundary of the reserve follows the low water mark from approximately 2 kilometres south of Boulder Point south to Cowper Point (PWS 2000). The land boundary to the west and south is adjoined primarily by private land (see Section 2.3 and Figure 2). Three blocks of unallocated crown land adjoin the reserve west of the reserve's southern section adjacent to the Nook Swamps and the Sea Elephant River. All unallocated Crown land is covered with native vegetation, as is the majority of adjacent private land (Rando 1987).

Site details are presented in Table 1.

Table 1: Site Details for the Lavinia Ramsar Site.

Ramsar Site	Lavinia Ramsar Site
General Location	Lavinia Ramsar Site is situated on the north east coast of King Island between Boulder Point to the north and Cowper Point to the south, approximately 12 kilometres north of the town of Naracoopa. The northern section of the site extends approximately 8 kilometres inland. The majority of the site is below 20 metres ASL.
Geographical Coordinates	Boulder Point: (northern end of site): 39° 38.415'S; 144° 03.700'E Cowper Point: (southern end of site): 39°49.308'S; 144°07.511'E Approximate middle of site: 39° 45.0'S; 144°05.0'E
Area	7034 hectares.
Date of Listing	The Ramsar site was initially listed in 1982 as the Sea Elephant Conservation Area and its boundary corresponded with the Sea Elephant River Wildlife Sanctuary. In 1988, the Sanctuary was incorporated into the adjoining Lavinia Nature Reserve. The Ramsar site boundary was redefined in 1994 to correspond with the Lavinia Nature Reserve boundary. The status of the reserve was again changed in 2001 to a State Reserve.
Baseline Year Used for Description	November 1982 (while the rest of the site was incorporated into the Ramsar boundary in 1994, it was effectively part of the site.
Original Description Date	2012 (this document is the first description).
Status of Description	First description, following site visit and consultation with stakeholders and land owners.
Compiler's Name	Peter Newall (Independent Ecological Consultant) and Lance Lloyd (Lloyd Environmental Pty Ltd) on behalf of NRM North. Enquiries to: Emma Williams, NRM North, PO Box 1224, Launceston, Tas 7250.
Ramsar Information Sheet	Ramsar Information Sheet: Lavinia. Updated 1998; 2010 update completed as part of the ECD completion. Ramsar sites information service, Ramsar sites database: http://www.wetlands.org/rsis/ Ramsar Site No.: 253. Wetlands International Site Reference No.: 5AU005.
Management Plan	Management plan currently being revised.
Responsible Management Authority	Director, Parks and Wildlife Service, GPO Box 1751, HOBART, Tasmania 7001.

1.3 Date of description

This ecological character description has been undertaken in June 2010, some 28 years after the Sea Elephant Conservation Area Ramsar site was listed in November 1982. It is a Ramsar Convention requirement that the ecological character description reflects the conditions at the time of listing. Consequently, this document is focused on the 1982 condition of the site. The situation is complicated by the fact that the site has been listed in two stages: (1982 and 1994, as described in Section 1.2). To avoid confusion, the focus of this ECD is the 1982 ecological character of the area covered by the current site.

Due to a paucity of pre-listing information, this ECD utilises various studies and reports on the wetland system undertaken since listing, interpreted to infer the conditions at the time of listing as accurately as possible. Changes to the site's ecological character have occurred between listing and present day. These changes are identified and described in Section 7 of this report.

1.4 Relevant Treaties, Legislation and Regulations

Most of the treaties, legislation and regulations relevant to the protection of the site have been enacted subsequent to its 1982 listing date. However, this section discusses relevant legislation and regulations up to present day.

1.4.1 International

Ramsar Convention

The *Convention on Wetlands of International Importance* (Ramsar, Iran, 1971), otherwise known as the Ramsar Convention, is an international treaty dedicated to the conservation and sustainable use of wetlands (Environment Australia 2001). Australia was one of the first 18 countries to become a signatory to the Convention in 1971. The Ramsar Convention Bureau provides the framework for local, regional and national actions, and international cooperation. It also maintains a List of Wetlands of International Importance. Within Australia there are 65 Ramsar-listed sites, totalling 7.5 million hectares (DEWHA 2008a).

Migratory bird bilateral agreements and conventions

Australia is a signatory to four international conventions on migratory species. The conventions are:

- The Japan-Australia Migratory Birds Agreement (JAMBA);
- The China-Australia Migratory Birds Agreement (CAMBA);
- The Republic of Korea-Australia Migratory Birds Agreement (ROKAMBA); and,
- The Bonn Convention on Migratory Species (CMS).

JAMBA, CAMBA and ROKAMBA are bilateral agreements between the governments of Japan and Australia, China and Australia, as well as Australia and the Republic of Korea which seek to protect migratory birds in their major habitats in each country. The three agreements list species that migrate between Australia and the respective countries. The majority of listed species are shorebirds and the agreements require the parties to protect migratory birds, including the protection and conservation of their habitats. The JAMBA agreement also includes specific provisions for cooperation on conservation of threatened birds (DEH 2005).

The Bonn CMS adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the migratory species are birds.

1.4.2 National

Commonwealth - Environment Protection and Biodiversity Conservation Act 1999.

Australia's obligation to protect and maintain the ecological character of its Ramsar sites is recognised in Commonwealth legislation through the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Under the EPBC Act any actions that have, or are likely to have, a significant impact on a matter of national environmental significance require approval from the Commonwealth Environment Minister. There are seven matters of national environmental significance identified in the Act, of which only three are relevant to Lavinia. These are:

- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities; and,
- Migratory species.

Under the EPBC Act, any action or proposed action that is likely to have a significant impact on the ecological character of a declared Ramsar wetland is considered a matter of National Environmental Significance and should be referred to the Commonwealth Minister for Environment for Assessment. Actions that are considered to have an effect or potential effect on wetland ecological character involve:

- areas of the wetland being destroyed or substantially modified, or
- a substantial and measurable change in the hydrological regime of the wetland - for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland, or
- the habitat or lifecycle of native species dependent upon the wetland being seriously affected, or
- a substantial and measurable change in the physico-chemical status of the wetland - for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or
- an invasive species that is harmful to the ecological character of the wetland being established in the wetland.

The EPBC Act also dictates standards for managing Ramsar wetlands through the Australian Ramsar Management Principles that have been established as regulations under the Act (Environment Australia 2001).

1.4.3 State

The Tasmanian legislation of most relevance to the site includes the

- *Threatened Species Protection Act 1995;*
- *Nature Conservation Act 2002;*
- *Forest Practices Act 1985;*
- *Fire Services Act 1979;*
- *Crown Lands Act 1976; and*
- *National Parks and Reserve Management Act 2002.*

The *Threatened Species Protection Act* establishes a Scientific Advisory Committee and enables the development of threatened species lists, strategies, threat abatement and recovery plans. The *Act* also enables the imposition of interim protection orders and facilitates the development of land-management plans.

Threatened vegetation communities at the Site and elsewhere in Tasmania are protected through recent amendments to the *Nature Conservation Act 2002* and the *Forest Practices Act 1985*:

- *Nature Conservation Amendment (Threatened Native Vegetation Communities) Act 2006*; and
- *Forest Practices Amendment (Threatened Native Vegetation Communities) Act 2006*.

The new legislation establishes a list of threatened communities under the *Nature Conservation Act 2002*, and provides measures to protect these communities from clearance and conversion under the *Forest Practices Act 1985*.

The *Fire Services Act 1995* was passed to amalgamate fire services in the State, and to consolidate and amend the law relating to preventing and extinguishing fires and the protection of life and property from fire. Within the Lavinia Ramsar site, the Parks and Wildlife Service is responsible under the *Fire Services Act 1995* for all aspects of fire management within the site (PWS 2000).

The *Crown Lands Act 1976* controls use of crown land within or adjacent to the site. Similarly, the *National Parks and Reserves Management Act* is relevant to the site, as State Reserves are a category of reserve under the Tasmanian reserve system and include areas of land containing significant natural landscapes; natural features; and/or sites, objects or places of significance to Aboriginal people. State reserves are to be managed for the following objectives:

- to conserve natural biological diversity;
- to conserve geological diversity;
- to preserve the quality of water and protect catchments;
- to conserve sites or areas of cultural significance;
- to encourage cooperative management programs with Aboriginal people in areas of significance to them in a manner consistent with the purposes of reservation and the other management objectives;
- to encourage education based on the purposes of reservation and the natural or cultural values of the State reserve, or both;
- to encourage research, particularly that which furthers the purposes of reservation;
- to protect the nature reserve against, and rehabilitate the nature reserve following, adverse impacts such as those of fire, introduced species, diseases and soil erosion on the nature reserve's natural and cultural values and on assets within and adjacent to the nature reserve;
- to encourage tourism, recreational use and enjoyment consistent with the conservation of the State reserve's natural and cultural values.

2. GENERAL DESCRIPTION OF THE SITE

This description of the site is based upon its condition at the time of listing (25 years ago) as far as can be ascertained from the published and other information for the site. Changes to the ecological character of the site since listing are presented in Section 7 of this report.

2.1 Setting

Lavinia Ramsar Site is on the northeast coast of King Island in Bass Strait, approximately equidistant between Cape Otway on mainland Australia and the north-west tip of the main island of Tasmania (Figure 1). Its location within Bass Strait gives it a maritime climate and places it within the 'roaring forties', the latitudes at which strong westerly winds prevail, often bringing heavy precipitation.

King Island is the largest island in western Bass Strait, being approximately 65 kilometres long, 25 kilometres wide and 110,160 hectares in area (Finzel 2004a). The Island has subdued topography and low relief (Environment Australia 2000) with its highest point being Gentle Annie, at 168 metres ASL (Barnes et al. 2002).

King Island is mainly formed on Precambrian rock and Quaternary sediments. Five major landscape types have been identified across King Island (Jerie et al. 2000):

1. Relatively flat landscape surfaces of the southern areas, at elevations of 40–45 metres, 70-75 metres and 120 metres);
2. Steep escarpments linking one flat landscape surface to another (or to sea level);
3. The area covered by dunes along the western coast;
4. The area influenced by dunes along the eastern coast; and,
5. The low surface in the north of the island, including drained lagoons.

The Lavinia Ramsar Site is located within the latter two of these landscape types.

2.2 Overview of the Site

Lavinia Ramsar site is situated between Boulder Point at its northern end and Cowper Point, approximately 12 kilometres north of Naracoopa, at its southern end. The northern section of the site extends approximately 8 kilometres inland. Its boundary to the east is Bass Strait and boundaries to the north, south and west contain a mixture of freehold land and unallocated Crown land (PWS 2000).

Lavinia Ramsar site is mostly below 20 metres ASL and extends over 7034 hectares. The site contains a highly significant and diverse set of ecosystems, including a lagoon and wetland system, coastal and bush landscapes, and a rich cultural heritage. Major wetlands within the site include a large estuary with saltmarsh, coastal lagoons, perched lakes, swamp forests, and numerous smaller, seasonally inundated, wetland areas. The site is one of the few largely unaltered areas of King Island and contains much of the remaining native vegetation on King Island. The closed canopy of the swamp forest exceeds 30 metres in places. The reserve contains about 200 hectares of quality feeding habitat for the nationally endangered orange-bellied parrot (*Neophema chrysogaster*- Endangered TSPA 1995, EPBC 1999).

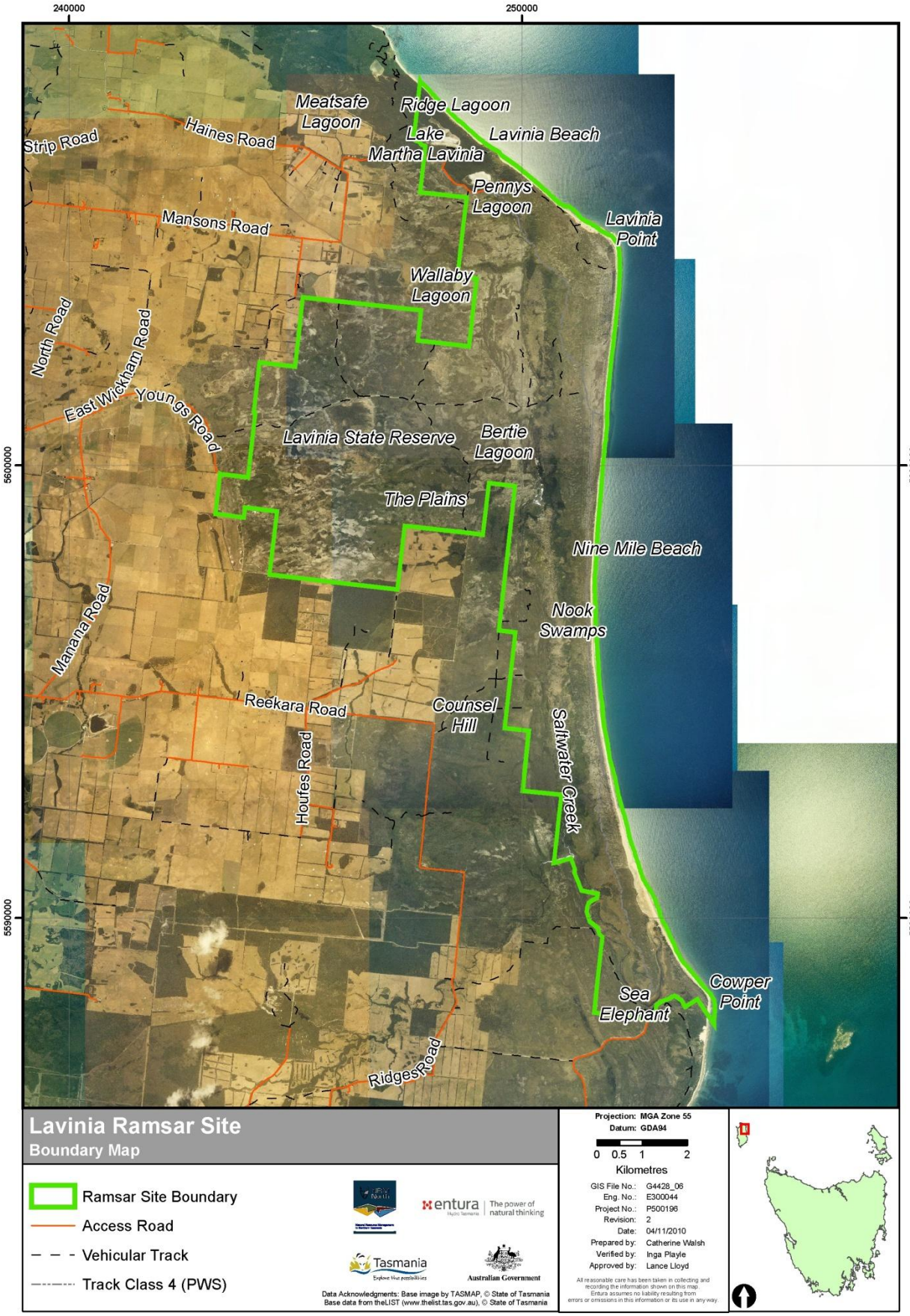


Figure 1: Map of Lavinia Ramsar Site, King Island.

The site's estuary and associated samphire mud flats, coastal swamps, and lagoons are important habitat for a range of state and nationally threatened species. The estuary is a significant component of the reserve and adds significantly to its biodiversity. This biodiversity includes the orange-bellied parrot (noted above) and the JAMBA listed short-tailed shearwater (*Puffinus tenuirostris*), which nests in rookeries along the coast. The estuary habitat has been shaped by the Holocene dune ridges and a migrating outlet, which is deflected north by longshore drift and recent dune development leading to an impressive spit and ribbon lagoon developing (Dixon 1996).

The coastal and bush landscapes support natural flora and fauna and a previously thought extinct terrestrial snail, the southern hairy red snail (*Austrochloritis victoriae*, Vulnerable, TSPA 1995). Lavinia State Reserve is known to support at least thirteen flora species that are listed on Tasmania's TSPA, and two flora species listed on the EPBCA (Table 2; source: DPIPWE's Natural Values Atlas).

Table 2: Threatened flora recorded from Lavinia State Reserve (DPIPWE 2011).

Common	Species	TSP Act	EPBC Act	Habitat	Location (ecosystem)
Tiny fingers	*Caladenia pusilla*	rare		dry heath	Dunes & Sandsheet
Blueberry ash	*Elaeocarpus reticulatus*	rare		damp scrub & forest	Dunes & Sandsheet
Showy willowherb	*Epilobium pallidiflorum*[#]	rare		damp/wet areas	Dunes – Nook Swamp & L. Martha Lavinia
Hairy brooklime	*Gratiola pubescens*[#]	vulnerable		wet herbfields	Dunes – near Nook Swamp
Scrambling groundfern	*Hypolepis distans*[#]	endangered	endangered	tea tree scrub	Dunes – Nook Swamp
Shade pellitory	*Parietaria debilis*	rare		coast teatree scrubs (sand)	Sandsheet
Tiny mitrewort	*Phyllangium distylis*	rare		damp heath	Sandsheet
Banded greenhood	*Pterostylis sanguinea*	rare		dry heath	Sandsheet
Swamp fireweed	*Senecio psilocarpus*[#]		vulnerable	swampy grassland	Dunes – near Nook Swamp
Fan triggerplant	*Stylidium beaugleholei*[#]	rare		damp heath/lagoon margins	Sandsheet & Dunes (L. Martha Lavinia)
Small triggerplant	*Stylidium despectum*[#]	rare		wet heath	Sandsheet
Bluestar sun-orchid	*Thelymitra holmesii*	rare		damp heath	Sandsheet
Submerged watertuft	*Trithuria submersa*[#]	rare		damp heath	Sandsheet
Pink bladderwort	*Utricularia tenella*[#]	rare		damp heath/lagoon margins	Sandsheet & Dunes (L. Martha Lavinia)

[#]wetland dependent (= generally found in areas subjected to at least seasonal waterlogging or inundation)

Flora species that are endemic to Tasmania and occur on the site include western scrub sheoak (*Allocasuarina zephyrea*) and Brooker's gum (*Eucalyptus brookeriana*).

The Lavinia Ramsar site is also known to have significant Aboriginal sites, particularly around the lagoon system and the coastal beaches (PWS 2000). The area is a State Reserve (proclaimed in 2001) and is surrounded by private freehold and some unallocated Crown land. The land use in the reserve is nature conservation and recreation (boating, fishing, camping, and off-road driving). In contrast, the surrounding area supports livestock grazing, mineral exploitation and mining.

A comprehensive fauna survey has yet to be undertaken in the Lavinia State Reserve (PWS 2000). Over 170 bird, 20 mammal and nine reptile species have been recorded in the wild on King Island since European occupation (PWS 2000). However, Donaghey (2003) has synthesized published information on the fauna of King Island and supplemented the information with strategic surveys.

From 35 native mammal species in Tasmania, 13 terrestrial & freshwater species (including two species of bat) and two marine species have been found on King Island and all are found in the Lavinia Ramsar site (PWS 2000). These are:

- platypus (*Ornithorhynchus anatinus)*[#];
- echidna (Tasmanian) (*Tachyglossus aculeatus setosus*);
- swamp antechinus (Tasmanian) (*Antechinus minimus minimus*) [#];
- three possums – common ringtail (Tasmanian) (*Pseudocheirus peregrinus viverrinus*), common brushtail (*Trichosurus vulpecula fuliginosus*) (Tasmanian) and eastern pygmy (Tasmanian) (*Cercartetus nanus nanus*);
- three macropods - bennetts wallaby (*Macropus rufogriseus*), Tasmanian pademelon (*Thylogale billardierii*), and long-nosed potoroo (*Potorous tridactylus*);
- two bats - lesser long-eared bat (*Nyctophilus geoffroyi*) and gould's wattled bat (*Chalinolobus gouldii*);
- water rat (*Hydromys chrysogaster*) [#];
- swamp rat (*Rattus lutreolus*) [#];
- New Zealand fur seal (*Arctocephalus forsteri*) [#]; and
- leopard seal (*Hydrurga leptonyx*) [#].

[#]wetland dependent

Six frogs are found on King Island, including two tree frogs, the nationally vulnerable green and gold frog (*Litoria raniformis*) and brown tree frog (*Litoria ewingi*); two marsh frogs, eastern banjo frog (*Limnodynastes dumerili*) and striped marsh frog (*Lymnodynastes peroni*); and two froglets, the common or brown froglet (*Crinia signifera*) and smooth froglet (*Geocrinia laevis*) (Donaghey 2003). As all are typically found in or around water, particularly permanent water, it is not surprising that all have been found at the Lavinia State Reserve (PWS 2000).

The reptiles of King Island include three snakes and six lizards. All have been recorded in the Lavinia State Reserve (PWS 2000) but none are wetland dependent.

2.3 Land Tenure and Ownership

The area within the present boundary was proclaimed a Nature Reserve in 1988 and changed to a State Reserve in 2001 (Figure 2). This area includes the previous Lavinia Wildlife Sanctuary and the Sea Elephant Nature Reserve, plus additional surrounding areas (National Parks and Reserved Management Act, 2002).

Within the site, there is a mariculture lease, for an oyster farm within the Sea Elephant Estuary.

The majority of surrounding land is private freehold and Conservation Areas with Councillor Island to the east of Cowper Point, recently proclaimed as a Nature Reserve.

Since the mapping in Figure 2 was completed two additional private land titles (one of them abutting the State reserve on the west side of Nook Swamp at Sea Elephant River) now have perpetual conservation covenants in place (Title references are 208063/1 and 121914/1). Furthermore, the crown land at the northern extent of the map is now part of the Lavinia State Reserve.

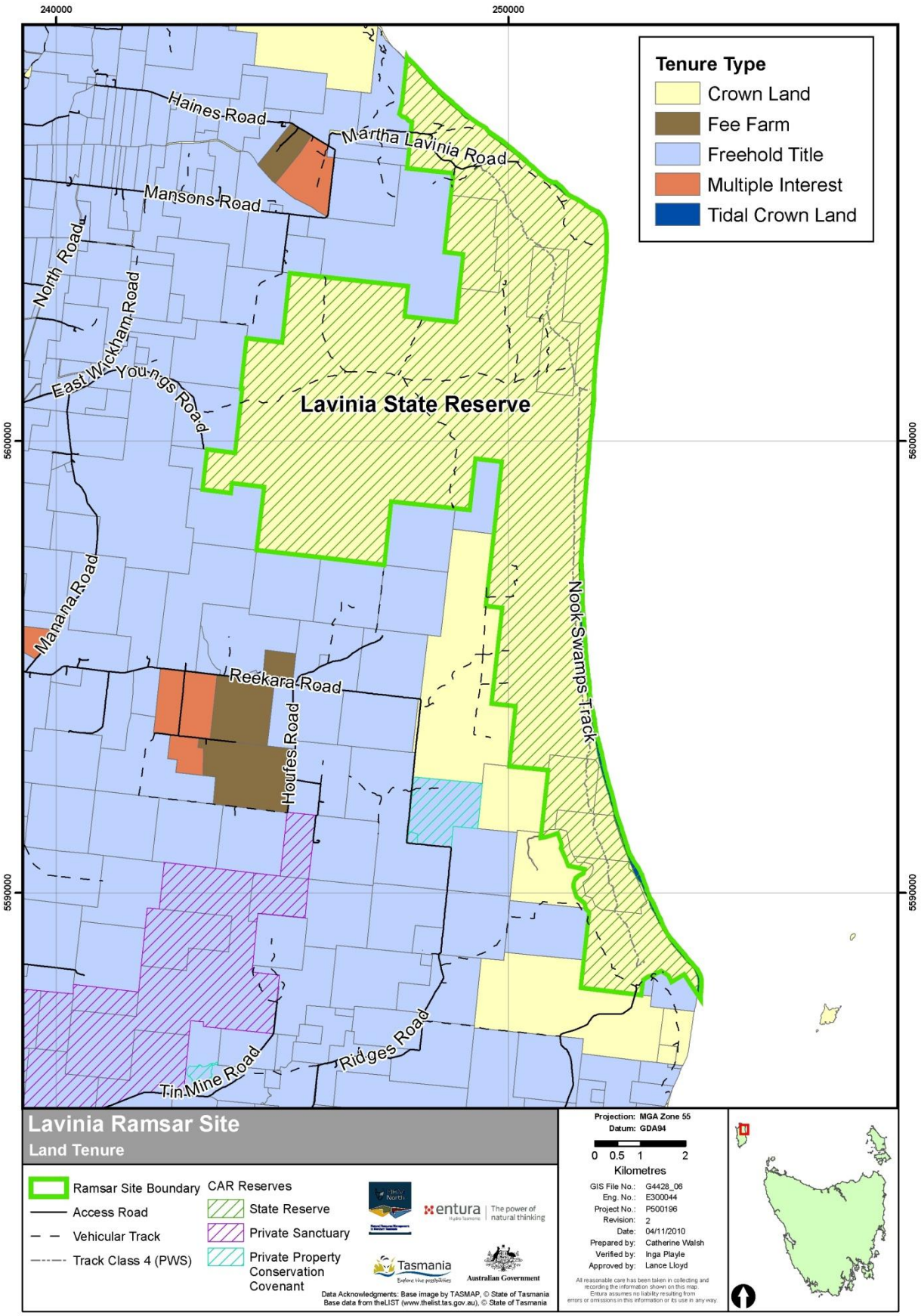


Figure 2: Land tenure within and adjacent to the Lavinia Ramsar site.

2.4 Ramsar Wetland Types at the Site

A draft RIS (2005) for the site listed eleven Ramsar wetland types at the site – six inland (types M, O, Tp, Ts, W and Xf) and five marine/coastal wetland types (E, F, G, H and K). Through site inspections and discussions with the Steering Committee, two inland wetland types and two marine/coastal wetland types were added to this list, resulting in a total of 15 Ramsar wetland types at the site:

Inland

- Type M: Permanent rivers/streams/creeks
- Type O: Permanent freshwater lakes (over 8 hectares)
- Type Tp: Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils
- Type Ts: Seasonal/intermittent freshwater marshes/pools on inorganic soils
- Type W: Shrub-dominated wetlands
- Type Xf: Freshwater, tree-dominated wetlands
- Type U: Non-forested peatlands
- Type Xp: Forested peatlands

Marine/Coastal

- Type E: Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks
- Type F: Estuarine waters; permanent water of estuaries and estuarine systems of deltas.
- Type G: Intertidal mud, sand or salt flats
- Type H: Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes
- Type K: Coastal freshwater lagoons; includes freshwater delta lagoons
- Type D: Rocky marine shores; includes rocky offshore islands, sea cliffs.
- Type J: Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea

These wetland types and their corresponding TASVEG codes are provided in Table 3. TASVEG is a Tasmanian Government classification system used to describe and map vegetation communities across the state. The TASVEG codes are provided as the descriptions of vegetation communities in this ECD are mostly based on documents that use this classification system. Locations of each wetland type across the site are also provided in Table 3.

Table 3: Correspondence between Ramsar Wetland Type and TASVEG Community type for plant communities in Lavinia Ramsar Site.

Ramsar Wetland Type	**Corresponding TASVEG Code**	**Location** (Examples)
Type M: Permanent rivers/streams/creeks	Open water (**OAQ**)	Sea Elephant River
Type O: Permanent freshwater lakes (over 8 hectares)	Open water (**OAQ**)	Pennys Lagoon, Lake Martha Lavinia
Type Tp: Permanent freshwater marshes/pools; ponds, marshes & swamps on inorganic soils	Lacustrine herbland (**AHL**), Freshwater aquatic sedgeland and rushland (**ASF**)	Pools and marshes in the dunes and interdunes, around and north of the Nook Swamp
Type Ts: Seasonal/intermittent freshwater marshes/pools on inorganic soils	Lacustrine herbland (**AHL**), Freshwater aquatic sedgeland and rushland (**ASF**)	Fresh pools and marshes in the dunes and interdunes, around and north of the Nook Swamp
Type W: Shrub-dominated wetlands	King Island sedge/heath/scrub complex (**SSK**), Short Paperbark Swamp (**SMR**)	Wet heath and Wet scrub, Short paperbark swamp on sandsheet and Nook Swamp
Type Xf**:** Freshwater, tree-dominated wetlands	*Melaleuca ericifolia* swamp forest (**NME**)	Nook Swamp
Type U: Non-forested peatlands	King Island sedge/heath/scrub complex (**SSK**)	Wet heath and Wet scrub, on sandsheet and Nook Swamp
Xp: Forested peatlands	*Melaleuca ericifolia* Swamp forest (**NME**)	Nook Swamp
Type E: Sandy shores	Sand & mud (**OSM**)	Sandy beaches of the Coastal Strip
Type F: Estuarine waters	Open water (**OAQ**)	Sea Elephant Estuary
Type G: Intertidal mud or sand flats	Sand & mud (**OSM**)	Sea Elephant Estuary
Type H: Intertidal marshes	Graminoid saltmarsh (**ARS**), Succulent saltmarsh (**ASS**) ,	Sea Elephant Estuary
Type K: Coastal freshwater lagoons	Open water (**OAQ**)	Pennys Lagoon, Lake Martha Lavinia
Type D: Rocky marine shores	-	
Type J: Coastal brackish/saline lagoons	Open water (**OAQ**)	Sea Elephant Estuary

Each Ramsar wetland type and the area that each type occupies within the site are listed in Table 4. Not all wetland types could be allocated individual areas, as some types overlapped and others were too small or too variable to be measured accurately. Where relevant, these are noted in the comments column of Table 4. A map of the distributions of the wetland types across the site is provided in Figure 3.

It should be noted that it is possible that the area of tree-dominated wetlands and forested peatlands (Xf/Xp) has been underestimated at the expense of 'shrub-dominated wetlands' (W) due to the mapping being based on aerial photos taken since the time of listing and after fires in 1992, 1996, 2001 and 2007).

Table 4: Wetland types within the site, their area, and comments relating to measurement of each type's area.

Ramsar Wetland Type	Area (Hectares)	Comments (where delineation was difficult or overlapped between wetland types)
Inland		
M	9.5	—
O	42.2	The two permanent freshwater lakes at the site (Pennys Lagoon and Lake Martha Lavinia) are also coastal freshwater lagoons (Type K). The area allocated to Type O therefore overlaps completely with the area for Type K.
Tp	61.2	—
Ts/W/U	1291.2	Many of the poorly-drained, wetland areas in the Nook Swamp and the sandsheet contained small temporary pools surrounded by the King Island sedge/heath/scrub vegetation complex. Therefore, based upon their vegetation cover, these wetlands included intermittent marshes and pools, shrub-dominated wetlands, and non-forested peatlands that could not be distinguished spatially or temporally.
W	427.1	—
Xf	19.3	—
Xf/Xp	222.8	For most of the *Melaleuca ericifolia* swamp forest at the site, it was difficult to determine which areas were freshwater tree-dominated wetlands (Xf) and which were forested peatlands (Xp). Most of this forest type was placed in a combined Xf/Xp grouping. Any separations are estimates and will need further data for a more confident delineation.
Marine/Coastal		
E	—	This wetland type was the very thin strip of sand that forms the eastern boundary of the site and could not be drawn with sufficient confidence to plot or calculate an area. The area of sandy shore will change with the tides.
F	76.5	The area of this wetland type his was calculated as the whole of the Sea Elephant Estuary, excluding the saltmarshes. During times of low water level in the estuarine lagoon, some of this area would form the intertidal mud or sand flat
G	—	This is the area that is exposed when the estuarine waters are low, and was not able to be calculated separately from available information.
H	63.1	—
K	42.2	See comments for Type O
D	—	Areas of rocky substrate in the coastal strip. Only one was seen and was too small to be shown in Figure 3
J	—	The water of Sea Elephant Estuary is brackish to saline and therefore the areas allocated to wetland type F at the site could also be classed as wetland type J.

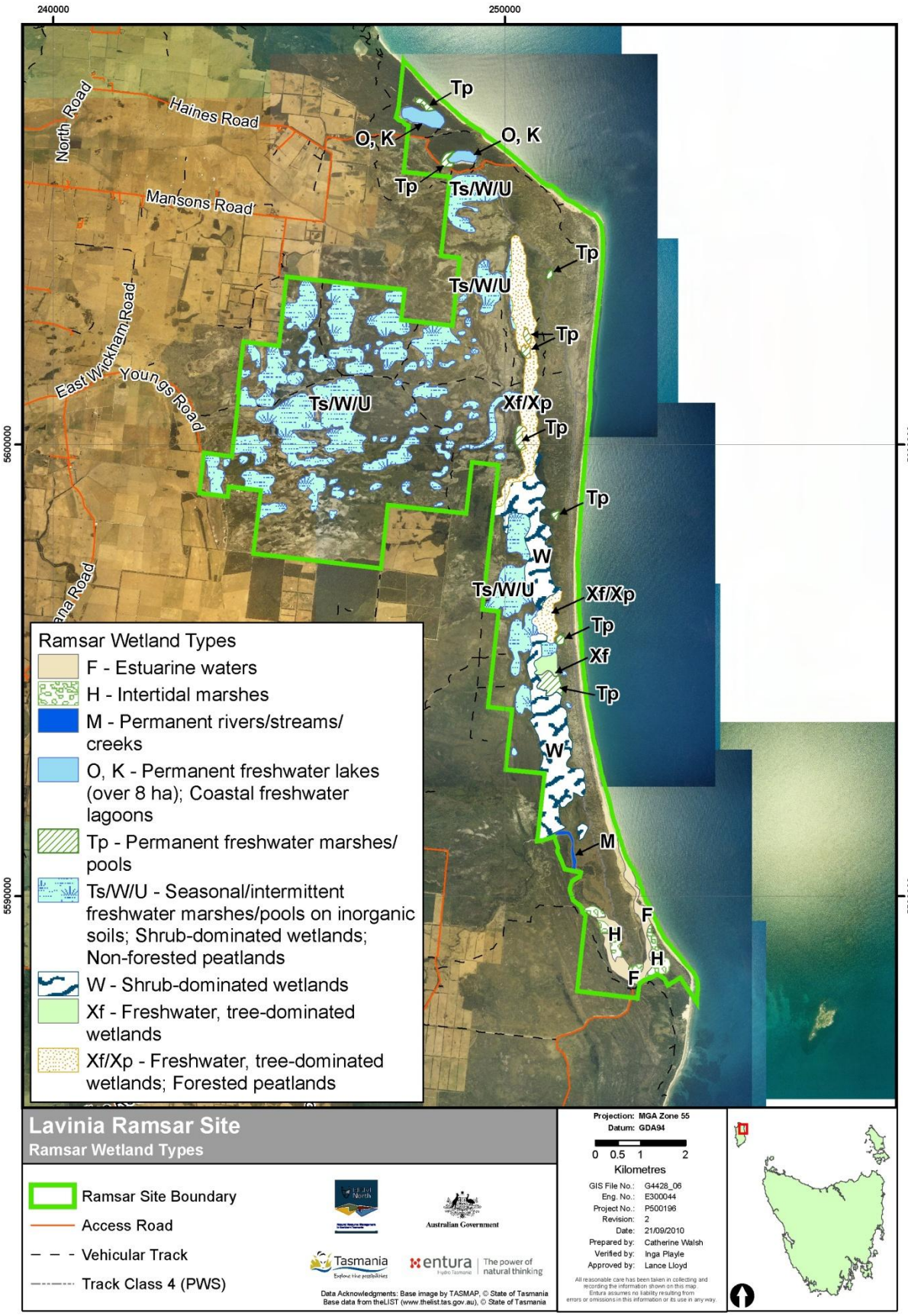


Figure 3: Ramsar Wetland Types at Lavinia Ramsar Site.

2.5 Ramsar Listing Criteria

The Sea Elephant Conservation Area was originally listed in 1982 under criterion 2(a) – "it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species". This was in relation to the site supporting the orange-bellied parrot (*Neophema chrysogaster*) during its migration between southwest Tasmania and mainland Australia.

Between 1982 and 1991 the listing criteria were expanded to include criterion 2(c) - it is of special value as the habitat of plants or animals at a critical stage of their biological cycle; and criterion 2(d) - it is of special value for one or more endemic plant or animal species or communities. These two criteria were also included due to the site's importance to the orange-bellied parrot. In the 2005 (draft) RIS, produced after the updating of Ramsar Criteria and also after the addition of the Lavinia Nature Reserve to the Ramsar Site, an extra criterion was added, criterion 1 of the updated criteria - a wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

2.5.1 Criteria under which the site is designated

The four Ramsar criteria under which the site is listed are described below with justifications that include information and data for relevant ecological and physical features.

Criterion 1 (representative/rare/unique wetland type in appropriate biogeographic region).

Within Australia, Ramsar biogeographic regions are delineated on the basis of major drainage divisions. The site is located in the Tasmanian Drainage Division (Commonwealth of Australia 2009), which consists of the whole of Tasmania. The marine and estuarine parts of the site also fall under the Bass Strait IMCRA Province (Commonwealth of Australia 2006).The site is one of the few largely unaltered areas of native vegetation remaining on King Island, containing wetland types that are representative of, and/or rare to, the bioregion. These include *Melaleuca ericifolia* swamp forest, freshwater aquatic wetlands, herbfields and grasslands, and sedge/rush wetland.

The wetland vegetation associated with wetland types Xf (Freshwater, tree dominated wetlands) and Xp (Forested Peatlands) are listed as rare and endangered in Tasmania under schedule 3A of the Nature Conservation Act 2002. The wetland vegetation associated with wetland types H (Intertidal marshes), Ts (Seasonal/intermittent freshwater marshes & pools) and Tp (Permanent freshwater marshes & pools) are listed as vulnerable in Tasmania under schedule 3A of the Nature Conservation Act 2002 (Duncan 1986, Barnes et al. 2002; DPIW; 2007). These include the wetlands at Pennys Lagoon, Lake Martha Lavinia, large parts of the Nook Swamp (including the *Melaleuca ericifolia* swamp forest) and the Sea Elephant Estuary.

The saltmarsh vegetation of the Sea Elephant Estuary (Wetland Type H) is also a good representative of this vegetation type for the bioregion, containing most saltmarsh formations and species found in Tasmania (Duncan 1986). Within the 'Saltmarsh' category graminoid saltmarsh and succulent saltmarsh have both been recorded within the Sea Elephant Estuary (Barnes et al. 2002).

In addition, the Sea Elephant Estuary lagoon (Wetland type J) is rare example of a lagoon, being formed within a dune swale between parallel dunes that are probably the longest and best-developed in Tasmania extending north from the Sea Elephant River mouth to Lavinia Point (PWS 2000, Harris 1993). The sand dunes in this system have been classed as "outstanding" at a State level from a geoconservation perspective (Dixon 1996). The dunefield peatlands of the site and the Sea Elephant Estuary have been listed as sites of

significance on the Tasmanian Geoconservation Database (TGD), (DPIPWE 2009).

Collectively, these data indicate the site would have met the criterion at the time of listing and currently meets this criterion.

Criterion 2 (vulnerable/endangered/critically endangered species or ecological communities).

This criterion is focused on species and communities listed at the Commonwealth level, principally through the EPBC Act. The Site supports the following taxa, listed under section 179 of the EPBC Act and/or the IUCN Red List:

- orange-bellied parrot (*Neophema chrysogaster*, Critically Endangered, EPBC Act);
- green and gold frog (*Litoria raniformis*, Vulnerable, EPBC Act);
- fairy tern (*Sterna nereis*, Vulnerable, IUCN Redlist);
- King Island scrubtit (*Acanthornis magna greeniana*, Critically Endangered, EPBC Act);
- scrambling groundfern (*Hypolepis distans*, Endangered, EPBC Act); and
- swamp fireweed (*Senecio psilocarpus*, Vulnerable, EPBC Act).

On King Island orange-bellied parrots occur in low, salt marsh of the Sea Elephant Estuary, dominated by beaded glasswort (*Sarcocornia quinqueflora*) and shrubby glasswort (*Tecticornia arbuscula*) with scattered reeds, and flanked by dense swamp paperbark (*Melaleuca ericifolia*) scrub. They are also found in pasture and in other grassy areas, including golf courses and sometimes on beaches (DEWHA 2009b). They have been recorded on King Island roosting and loafing in dense clumps of swamp paperbark (*Melaleuca ericifolia*) and coastal wattle (*Acacia sophorae*) at the edges of estuaries (DEWHA 2009b). Within the site, their primary feeding grounds and roosting areas are within the Sea Elephant Estuary saltmarsh and surrounds, and the Nook Swamp.

The green and gold frog has combined habitat requirements of permanent waters with still to slow-flowing areas (for breeding) and nearby forests and grasslands (for feeding) all of which are provided by the Lavinia Ramsar Site. The Nook Swamp and the other wetland habitats of the Dunes ecosystem provide areas of permanent fresh water, aquatic vegetation, and extensive grasslands and sedgelands adjacent to the wetlands. Pennys Lagoon and Lake Martha Lavinia provide the permanent freshwater habitats required for breeding, and nearby forests and grasslands. Threats to the green and gold frog include Chytrid fungus (DPIPWE unpublished data), and habitat loss through stock grazing and irrigation (DEWHA 2009b). The Site provides some sanctuary from habitat loss, making it a key refuge for this species.

The fairy tern is a marine listed species under the EPBC Act and the IUCN Redlist. In Australia, there are approximately 5000 to 6000 mature birds at around 170 sites, with estimates of 100 to a few hundred pairs in Tasmania (Birdlife International 2009). Disturbance by humans, dogs and vehicles, either causing the direct destruction of eggs or desertion of nests are key threats to the species, and the site offers refuge from these. The fairy tern has been recorded breeding at the site (RIS draft, 2005).

The King Island scrubtit is an accepted subspecies of the scrubtit (*Acanthornis magnus*) and is confined to remnant habitats on King Island. The population size of the King Island scrubtit is estimated, with low reliability, to consist of 150 or less breeding birds and it is suspected to be decreasing (DEWHA 2009b). In recent years it has been recorded in only two locations: the Nook Swamp, and Colliers Swamp. The Nook Swamp - the largest tract of remaining habitat for the subspecies - has been confirmed as the critical location for the King Island scrubtit, with several instances of successful breeding being observed (KINRMG, undated). The population in the Nook Swamp is estimated to consist of at least 50 birds, and possibly as many as 100 birds (DEWHA 2009b).

The King Island scrubtit is rare or scarce in the small areas of suitable habitat that remain on King Island, inhabiting remnant patches of mature Swamp Paperbark *Melaleuca ericifolia* forest that occur in flat, low-lying and poorly-drained swamps that support a dense understorey of young Swamp Paperbark and ground-layer plants (DEWHA 2009b). The scrubtit is reliant on mature *Melaleuca ericifolia* swamp forest and burning of this habitat by wildfires is considered to be the single greatest threat to this species (Donaghey 2011).

The scrambling groundfern is known from poorly drained areas at the scrubby margins of swamp forests in northwest Tasmania and King Island, typically on soils with high organic matter and moderate to poor drainage (Threatened Species Section 2011a). There are seven known populations of scrambling groundfern in Tasmania and the population at the site is the only one listed in a State Reserve (Threatened Species Section 2011a). Threats to the scrampling groundfern are listed as land clearance and inappropriate forestry activities, drainage of habitat, stock damage, weed invasion and peat fires. Despite being burnt in January 2001 and February to March 2007, the scrambling groundfern recovered rhizomatously (Threatened Species Section 2011a).

Swamp fireweed is a semi-aquatic species, known from six sites in Tasmania, all in swampy habitats (Threatened Species Section 2011b). Threats to the species include land clearing, inappropriate disturbance regimes (e.g. cultivation, grazing, fire), weeds, browsing pressures by native and introduced species, and climate change (via drying out of low-lying areas and increased competition from weeds. The population at the site is one of three in Tasmania known in protected areas (Threatened Species Section 2011b).

The site would have met the criterion at the time of listing and currently meets this criterion.

Criterion 3 (supports populations of plant and/or animals important for regional biodiversity).

This site is a hotspot of biodiversity at a regional scale partly due to the mix of habitat and wetland types supported by the site but also because the ecological communities on King Island represent a transitional zone between the Australian mainland and north-west Tasmania, supporting species from both the north and south (Barnes et al. 2002).

There are nine wetland dependent species listed at the State level under the Tasmanian *Threatened Species Protection Act 1995* that are supported by the site:

- white-bellied sea eagle (*Haliaeetus leucogaster*, vulnerable, TSPA);
- eastern curlew (*Numenius madagascariensis*, endangered, TSPA);
- the striped marsh frog (*Limnodynastes peroni*, endangered, TSPA), one of six found within the reserve (there being only 11 Tasmanian frog species);
- showy willowherb (*Epilobium pallidiflorum*, rare, TSPA);
- hairy brooklime (*Gratiola pubescens,* vulnerable, TSPA; found in wet herbfields in the Dunes – near Nook Swamp);
- fan triggerplant (*Stylidium beaugleholei*; rare TSPA; found in damp heath and lagoon margins, e.g. around Lake Martha Lavinia and Sandsheet Ecosystem);
- pink bladderwort (*Utricularia tenella*, rare TSPA; found in damp heath and lagoon margins, e.g. around Lake Martha Lavinia and Sandsheet Ecosystem);
- small triggerplant (*Stylidium despectum,* rare TSPA; wet heath);
- submerged watertuft (*Trithuria submersa* rare TSPA; damp heath, Sandsheet Ecosystem).

The white-bellied sea eagle hunts for prey from a range of terrestrial habitats and water bodies, including estuaries (DEWHA 2009b). Its use of the Lavinia Ramsar site means it may hunt for fish from the Sea Elephant Estuary. The eastern curlew is most commonly

associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats. It mainly forages on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near saltmarsh, and on ocean beaches near the tideline (DEWHA 2009b). The frogs require permanent water, aquatic vegetation and good invertebrate populations found in the swamp habitats in the Dunes and other ecosystem types.

The diversity of the vegetation communities is significant aspect of the site (DPIW 2007). In a bioregional context, this site is significant also because it contains the largest reserved patch of *Melaleuca ericifolia* swamp forest in Tasmania (Barnes et al. 2002; Barrow 2008). There are also significant vegetation communities associated with seabird rookeries within the site as well as the large variety of wetland types at the site including: freshwater aquatic wetlands, herbfields and grasslands marginal to wetland, and sedge/rush wetland all present and protected within the site (Barnes et al. 2002).

The site would have met the criterion at the time of listing and currently meets this criterion.

Criterion 4 (supports species at critical stages or provides refuge in adverse conditions).

The site in general, and the Sea Elephant Estuary in particular, provide a critical feeding and resting site for the endangered orange-bellied parrot (*Neophema chrysogaster*) during its annual migration between south-eastern Australia and Tasmania (OBPRT 1999). This species is recognised as endangered in the Japan - Australia Migratory Bird Agreement (JAMBA).

The extensive beaches of the site support many beach nesting shorebirds including the fairy tern (*Sterna nereis*), Australian pied oystercatcher (*Haematopus longirostris*), and hooded plover (*Thinornis rubricollis*); and Cowper Point is recognised as a priority site for the little tern (*Sterna albifrons*, rare, TSPA) (Bryant 2002). The site also supports breeding populations of the little penguin (*Eudyptula minor*) (Donaghey 2003).

Three rookeries of the JAMBA listed short-tailed shearwater (*Puffinus tenuirostris*) are located within the reserve, including one at Lavinia Point, one at Cowper Point and a third, reported to be just south of Nook Swamp (PWS 2000). The Short-tailed Shearwater breeds in burrows under the grass tussocks of the Coastal Grasslands in this ecosystem.

Overall, the site supports ten migratory birds listed on the CAMBA and JAMBA, as well as five which are also listed on the ROKAMBA. These species are: short-tailed shearwater (*Puffinus tenuirostris*), cattle egret (*Ardea ibis*), great egret (*Ardea modesta*), ruddy turnstone (*Arenaria interpres*), sharp-tailed sandpiper (*Calidris acuminata*), red-necked stint (*Calidris ruficollis*), white-throated needletail (*Hirundapus caudacutus*), Caspian tern (*Hydroprogne caspia*), little tern (*Sterna albifrons*) and greenshank (*Tringa nebularia*).

The site would have met the criterion at the time of listing and currently meets this criterion.

2.5.2 Assessment against the remaining designation criteria

Criterion five: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

There are no data which would provide the evidence that the site supports 20,000 or more waterbirds (at time of listing or currently).

Criterion six: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

There are no data on waterbird numbers at the site and therefore no data to support the site meeting this criterion currently or at time of listing.

Criterion seven: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

There are no data on the fish fauna of the site. It is unlikely that the site would have a high degree of endemism or biodisparity in its fish communities, but this cannot be assessed. Accordingly, there is no data to support the site meeting this criterion at time of listing or currently.

Criterion eight: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

There are no data on the fish fauna of the site. Given the nature of the site and its diversity of wetland habitat this criterion might be important but there is no data which would provide evidence for this, either currently, or at time of listing.

Criterion nine: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

There are no estimates of the total population of non-avian wetland dependent animal species or sub-species at the site. Accordingly, there is no data to support the site meeting this criterion at time of listing or currently.

3. ECOSYSTEM UNITS OF THE LAVINIA RAMSAR SITE

Focusing on the natural ecosystem as a delineator, the site can be separated into 4 units (Figure 4). These are the:

- Sea Elephant Estuary;
- Coastal Strip;
- Dunes; and,
- Northern Sandsheet.

These ecosystem units are not independent of each other, having elements that overlap in time and space. Descriptions and conceptual models for each ecosystem are presented below.

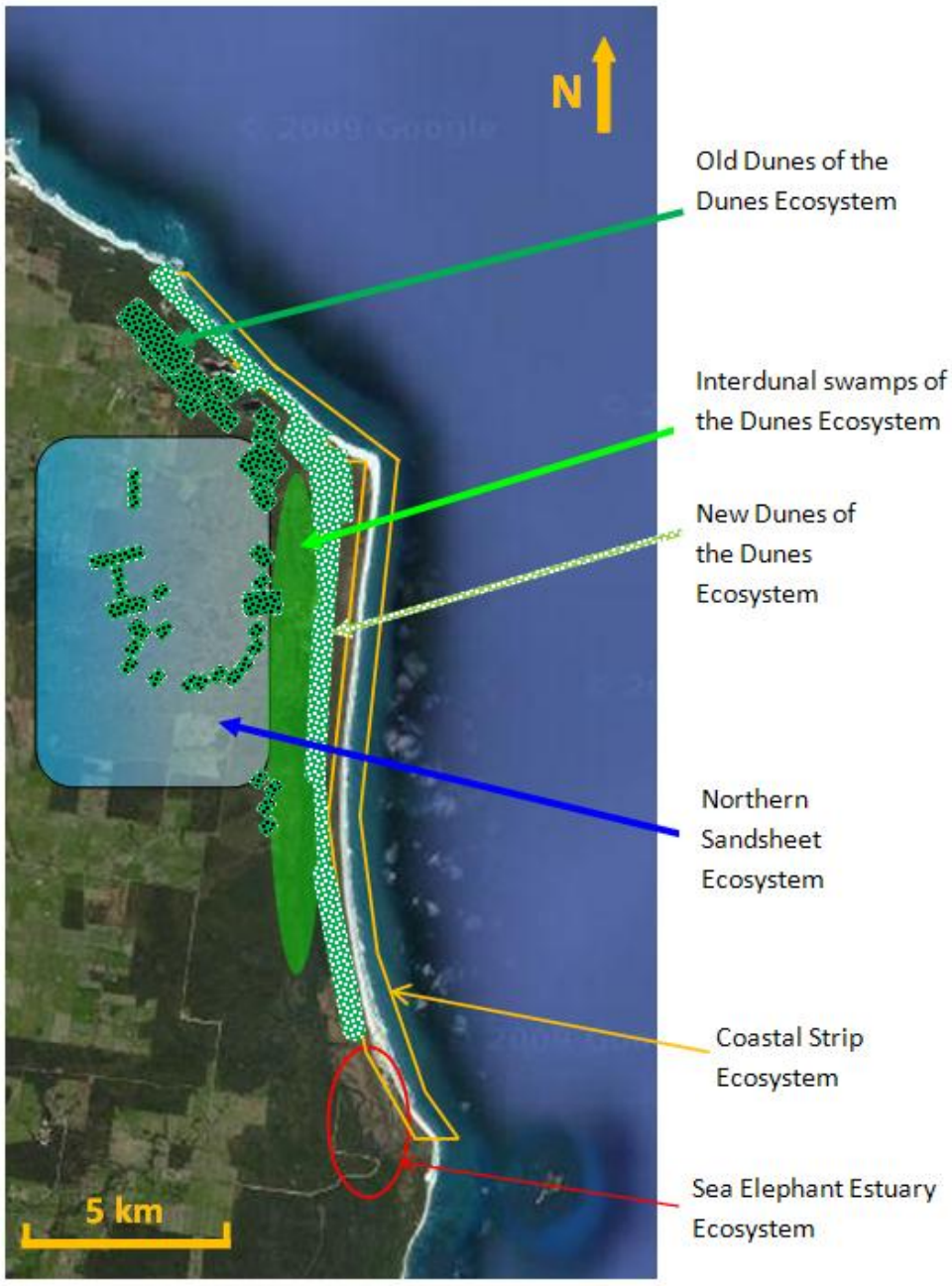


Figure 4: Ecosystem units of the Lavinia Ramsar Site (green dots in Northern Sandsheet Ecosystem indicate remnant Old Dunes). Source: Google Maps.

3.1.1 Sea Elephant Estuary Ecosystem

The **Sea Elephant Estuary Ecosystem** receives its freshwater from the largest river on King Island and drains into Bass Strait midway along the east coast. As well as containing significant saltmarsh areas that provide feeding and roosting habitat for the orange-bellied parrot (*Neophema chrysogaster*) the estuary contains a coastal lagoon and an actively developing sand spit. Socio-economic values of the estuary include recreational fishing and a commercial mariculture facility (an oyster farm).

The Sea Elephant River is the largest river on King Island and drains into Bass Strait midway along the east coast. Its estuary is classified as a "near pristine, wave dominated, strandplain estuary by the OzCoasts classification (OzCoasts 2009). However, the Ozcoasts classification is typically more applicable to outer estuaries (Jason Bradbury, personal communication). In the inner estuary, upstream of the beach, the landforming energetics are, in order of dominance, tidal, fluvial and *lastly* waves (Jason Bradbury, personal communication). The Sea Elephant River estuary is classified by Edgar et al. (1999) as a 'barred, low salinity estuary' and is recognised as a Tasmanian estuary with high conservation significance. 'High' conservation estuaries were those that remain in a relatively pristine condition, based upon human population densities (less than 0.5 people per square kilometre in the catchment and drainage areas). Another criterion for high conservation status was "agricultural and cleared land covering less than 10 per cent of catchment area" (Edgar et al. 1999, p59). However, this would not be the case for the Sea Elephant Estuary, with a large percentage of the Sea Elephant River catchment cleared for agriculture (Baker 2006).

Within the Lavinia Ramsar Site, the Sea Elephant River flows in a southerly direction towards Cowper Point (Figure 5), before turning abruptly north. The river previously discharged into Bass Strait at a point one or more kilometres north of its current mouth location. It has been diverted south by Holocene dune ridge development, leaving a flat corridor with many meandering river channels – some of which still fill during floods (Jennings 1959). Within this corridor, the sheltered, flat landscape provides the low energy conditions suitable for the development of saltmarsh habitat.

At its southernmost point, the river is deflected north by the development of a sandy spit and recent dune development. The shifting sands of the river mouth have caused a substantial back-up of brackish water, creating a large sand spit, a ribbon lagoon and saltmarsh which, combined with the saltmarsh in the Holocene dunes, extends up to five kilometres inland (DEWHA 2009a) (Figure 6). The spit development has been identified as a good example of an active on-going process and is recognised as a site of geoconservation significance for Tasmania (Dixon 1996).

The saltmarsh created by these past and present land forming processes is very significant as a stopover site for the nationally endangered migratory orange-bellied parrot (*Neophema chrysogaster*), with most or all of the population of this species passing through the Sea Elephant River Estuary. The plants of the saltmarsh provide a critical feeding ground and also roosting sites for the orange-bellied parrot (DEWHA 2009a).

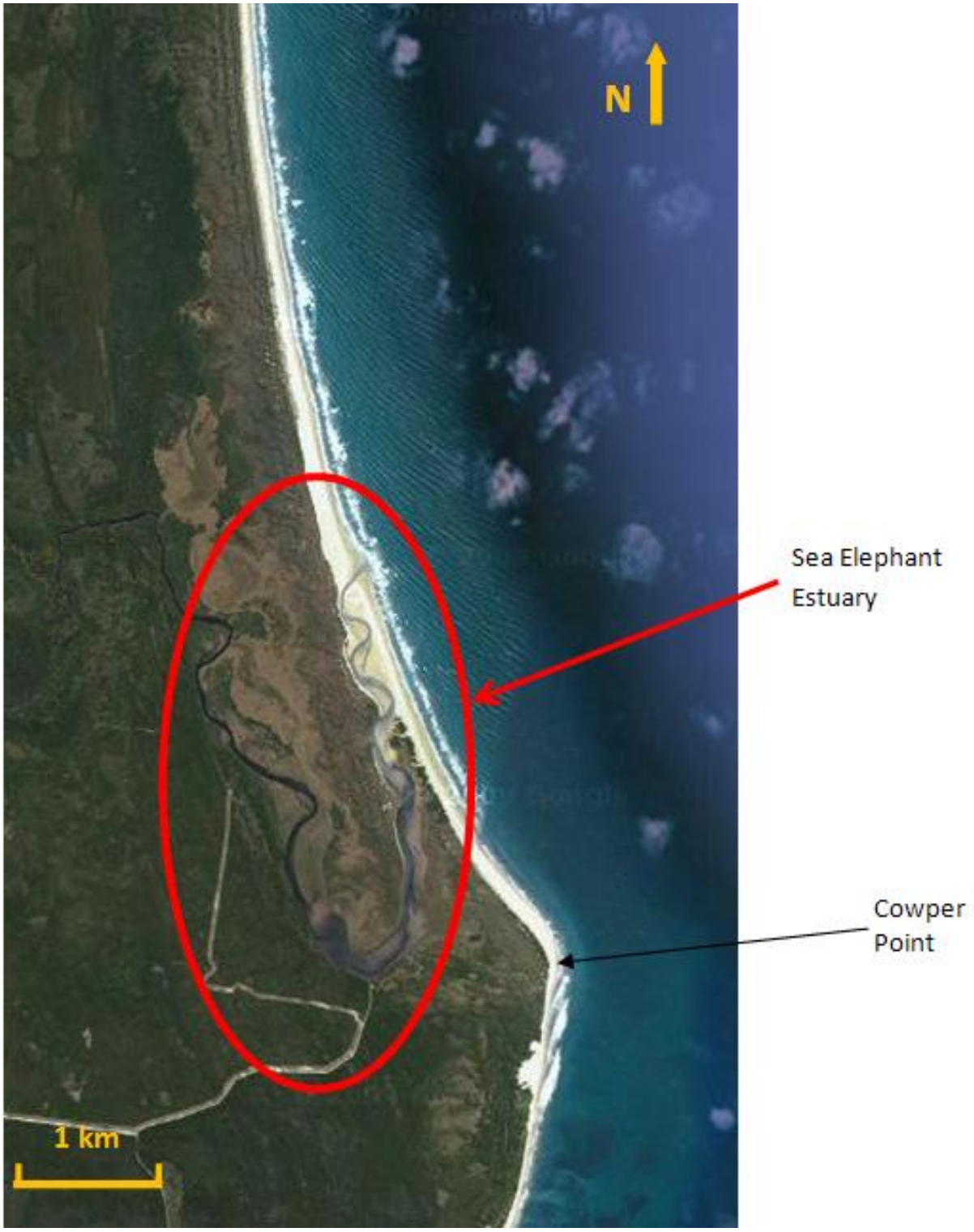


Figure 5: General location of the Sea Elephant Estuary Ecosystem. Source: Google Maps.

Figure 6: View of the southern end of the lagoon at Sea Elephant Estuary.

Water quality of the estuary is unknown, although there has been sampling undertaken of the Sea Elephant River at Bicentennial Rd, approximately five kilometres upstream of where the river enters the Lavinia Ramsar site (Graham 2005; Baker 2006). At this site, the river shows the impacts of draining extensive areas of agricultural land, with elevated nutrients and low dissolved oxygen concentrations.

Conceptual Model of the Sea Elephant Estuary

The central focus of the conceptual model for the Sea Elephant Estuary is the saltmarsh habitat provided by the ecosystem (Figure 7). The vegetation of the ecosystem (primarily saltmarsh) and habitat (saltmarsh, mudflats, sandflats, open water) provide the support required by the identified biota (orange-bellied parrot, white-bellied sea eagle, eastern curlew, migratory species, and the saltmarsh itself) that are the focus of the ecosystem services (Figure 8). Similarly, it is the open water habitat and saltmarsh that provide the basis of the recreation/tourism, oyster-farming, water supply for fire-fighting and educational/scientific benefits of the ecosystem.

The ecosystem is built on a physical habitat base which is formed by a combination of the geomorphic structure of the site's dunes and the geomorphic processes of the coastal long-shore drift at the river mouth (Figure 7). The dune landforms have resulted in the Sea Elephant River forming a long, north-south, ribbon-like channel near its mouth. The spit barrier dams the river for most of the time, with occasional breaches occurring either naturally, or by workers of the oyster farm to allow tidal flushing of the estuary for water quality purposes.

The low river gradient between the dunes and the protection afforded by the spit barrier combine to produce a low energy environment, which is required for the development of saltmarsh (Kirkpatrick and Glasby 1981). The hydrology and water quality of the estuary play an important role in the type and distribution of the saltmarsh plant species. The two most widespread saltmarsh species associations in the Sea Elephant Estuary – graminoid saltmarsh and succulent saltmarsh – are both typically found in poorly drained sites, with succulent saltmarsh typically found in more saline areas (Kirkpatrick and Glasby 1981). Quality feeding habitat for orange-bellied parrots within the estuary is found in the graminoid saltmarsh dominated by sea rush (*Juncus kraussii*) which gives way in a patchwork formation to open areas densely carpeted with beaded glasswort (*Sarcocornia quinqueflora*). This species, combined with creeping brookweed (*Samolus repens*), also forms an understorey within the sea rush saltmarsh. A narrow strip of succulent saltmarsh dominated by shrubby glasswort (*Tecticornia arbuscula*), fringing the lower reaches of the eastern shore, is regularly used for perching (Brown and Wilson, 1984).

The low energy environment conducive to the development of saltmarsh also enables the formation of mudflats and sandflats within the estuary (Figure 8). These provide important foraging habitat for the eastern curlew, red-necked stint and greenshank, and to a lesser extent the great egret, cattle egret and short-tailed sandpiper (Table 5). The low energy open water surface of the estuary also provides potentially valuable fishing waters for the white-bellied sea eagle.

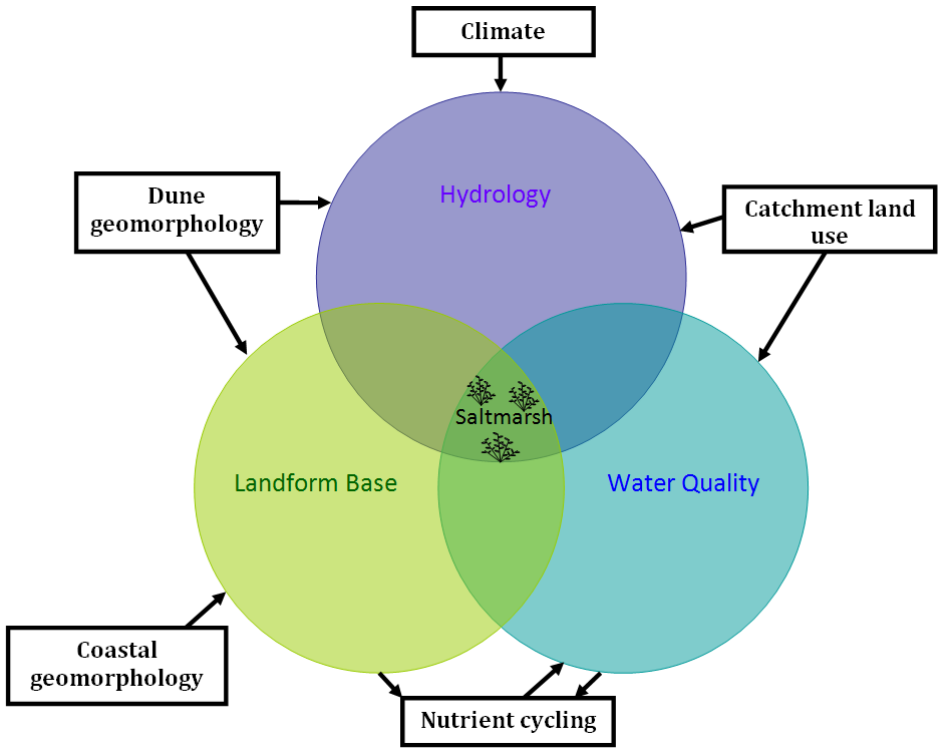


Figure 7: Simple conceptual model of the Sea Elephant Estuary Ecosystem.

The importance of feeding upon fish and macroinvertebrate populations at the site by the bird species listed above has not been assessed, however some general information on habitat and diet for each species is provided in Table 5, below.

Table 5: Important waterbird species of the Sea Elephant Estuary, with their common habitat and diet. Source: Birdlife International (2009), DEWHA (2009b), PWS (2009) and Pizzey (1980).

Species	**Habitat(s)**	**Diet**
White-bellied sea eagle *(Haliaeetus leucogaster*	Generally found in coastal habitats, characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea). Breeding territories are located close to water, and mainly in tall open forest or woodland The white-bellied sea-eagle generally forages over large expanses of open water; particularly individuals that occur in coastal environments close to the sea-shore, where they forage over in-shore waters	The white-bellied sea-eagle feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion.
Eastern curlew	The eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets.	The eastern curlew is carnivorous, mainly eating crustaceans (including crabs, shrimps and prawns), small molluscs, as well as some insects.

Species	Habitat(s)	Diet
	The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes use the mangroves. It mainly forages on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on saltflats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline. It roosts on sandy spits and islets, especially on dry beach sand near the high-water mark, and among coastal vegetation including low saltmarsh or mangroves.	
Cattle egret	The cattle egret inhabits a range of habitats, including open grassy areas such as meadows, livestock pastures, semi-arid steppe and open savanna grassland subject to seasonal inundation, dry arable fields, artificial grassland sites (e.g. lawns, parks, road margins and sports fields), flood-plains, freshwater swamps, rice-fields, wet pastures, shallow marshes, mangroves and irrigated grasslands (with ponds, small impoundments, wells, canals, small rivers and streams). It rarely occupies marine habitats or forested areas although in Australia it may enter woodlands and forests, and it shows a preference for fresh water although it may also use brackish or saline habitats. It occurs from sea-level up to c.1,500 metres.	Its diet consists primarily of insects such as locusts, grasshoppers, beetles, adult and larval butterflies and moths, dragonflies and centipedes. However, worms, spiders, crustaceans, frogs, tadpoles, molluscs, fish, lizards, small birds, rodents and vegetable matter may also be taken.
Great egret	The great egret inhabits many kinds of inland and coastal wetlands although it is mainly found along the coast in the winter or during droughts (e.g. in Australia). It frequents river margins, lakes shores, marshes, flood-plains, oxbow lakes, streams, damp meadows, aquaculture ponds, reservoirs, and the shallows of, mudflats, coastal swamps, saltmarshes, seagrass flats, offshore coral reefs, lagoons and estuaries when in coastal locations.	In aquatic habitats its diet consists of fish, amphibians, snakes, aquatic insects and crustaceans although in drier habitats terrestrial insects, lizards, small birds and mammals are more commonly taken.
Red-necked stint (*Calidris ruficollis*)	The red-necked stint is found on the coast, in sheltered inlets, bays, lagoons, estuaries, intertidal mudflats and protected sandy or coralline shores.	Red-necked stints are omnivorous, taking seeds, insects, small vertebrates, plants in saltmarshes, molluscs, gastropods and crustaceans.

Species	Habitat(s)	Diet
Caspian tern	The breeding, passage and wintering habitats of the Caspian tern are similar, although during the winter it is largely confined to the coast. It frequents sheltered sea coasts, estuaries, inlets, bays, harbours, coastal lagoons, and saltmarshes. When breeding the species shows a preference for nesting on sandy, shell-strewn or shingle beaches, sand-dunes, flat rock-surfaces, sheltered reefs or islands with sparse vegetation and flat or gently sloping margins surrounded by clear, shallow, undisturbed waters. It also forms winter roosts on sandbars, mudflats and banks of shell	The Caspian tern's diet consists predominantly of fish 5-25 cm in length as well as the eggs and young of other birds, carrion, aquatic invertebrates (e.g. crayfish), flying insects and earthworms.
Sharp-tailed sandpiper (*Calidris acuminata*)	The sharp-tailed sandpiper prefers the grassy edges of shallow inland freshwater wetlands. It is also found around flooded fields, mudflats, mangroves, rocky shores and beaches	The sharp-tailed sandpiper feeds on aquatic insects and their larvae, as well as worms, molluscs, crustaceans and sometimes, seeds.
Greenshank	In its wintering grounds the Greenshank frequents a variety of freshwater, marine and artificial wetlands, including swamps, open muddy or rocky shores of lakes and large rivers, sewage farms, saltworks, inundated rice-fields, ponds, reservoirs, flooded grasslands, saltmarshes, sandy or muddy coastal flats, mangroves, estuaries, lagoons and pools on tidal reefs or exposed coral, although it generally avoids open coastline. On migration this species occurs on inland flooded meadows, dried-up lakes, sandbars and marshes	This species is chiefly carnivorous, its diet consisting of insects and their larvae (especially beetles), crustaceans, annelids, molluscs, amphibians, small fish (mullet *Liza* spp., clinids *Clinus* spp.) and occasionally rodents.

Twenty-four macroinvertebrate species were collected at Sea Elephant Estuary during surveys in the late 1990s (Edgar et al. 1999). This was a mid-range measure within a program that sampled 111 moderate to large estuaries around Tasmania. Some estuaries in the survey had as low as two species, whereas others had over 100 species. Within the 24 species collected at the Sea Elephant Estuary, eight were crustaceans, four were gastropods, four were bivalves, three were polychaetes and five were classed as 'other' (Edgar et al. 1999). The mean estimated biomass of macrofauna from the samples at the estuary was 84.6 grams per square metre and the estimated productivity was 457.7 micrograms per square metre per day (Edgar et al. 1999). These figures were also in the mid-range of values obtained across the Tasmanian estuaries.

There is no information on the total number and abundance of fish species within the Sea Elephant Estuary. However, eight freshwater species are listed as occurring within the Lavinia Ramsar Site (PWS 2000):

- short-finned eel (*Anguila australis*)
- spotted galaxias (*Galaxias truttaceous*)
- common jollytail (*Galaxias maculatus*)
- climbing galaxias (*Galaxias brevipinnis*)
- Tasmanian smelt (*Retropinna tasmanica*)
- pygmy perch (*Nannoperca australis*)
- freshwater flathead (Sandy) (*Pseudophritis urvillii*)
- rainbow trout (*Oncorhynchus mykiss*)

Australian grayling have previously been recorded at the site as a single specimen prior to listing but have not been recorded since that initial record. It is not known whether this was a vagrant or resident species which has been lost.

The hydrology and water quality of the ecosystem are critical to its provision of benefits and services. The continued provision of sufficient water from the Sea Elephant River is a key process for the estuary. Similarly, the water quality of the estuary must be maintained in order to continue the provision of many of the current benefits and services, including the provision of fish and macroinvertebrates as food for the bird species listed above.

Although there do not appear to be any studies on nutrient cycling of the estuary, it is likely that this process occurs, providing carbon, nitrogen and phosphorus for the biota of the system. Contributions of nutrients to the estuary from further up the catchment have the potential to overload the system and turn it eutrophic (refer 'threats' section, Section 3.2.4). Nitrogen cycling (including denitrification) is an important process in many estuarine environments, reducing the concentrations of available nitrogen for planktonic algae, thereby reducing the likelihood of harmful algal blooms.

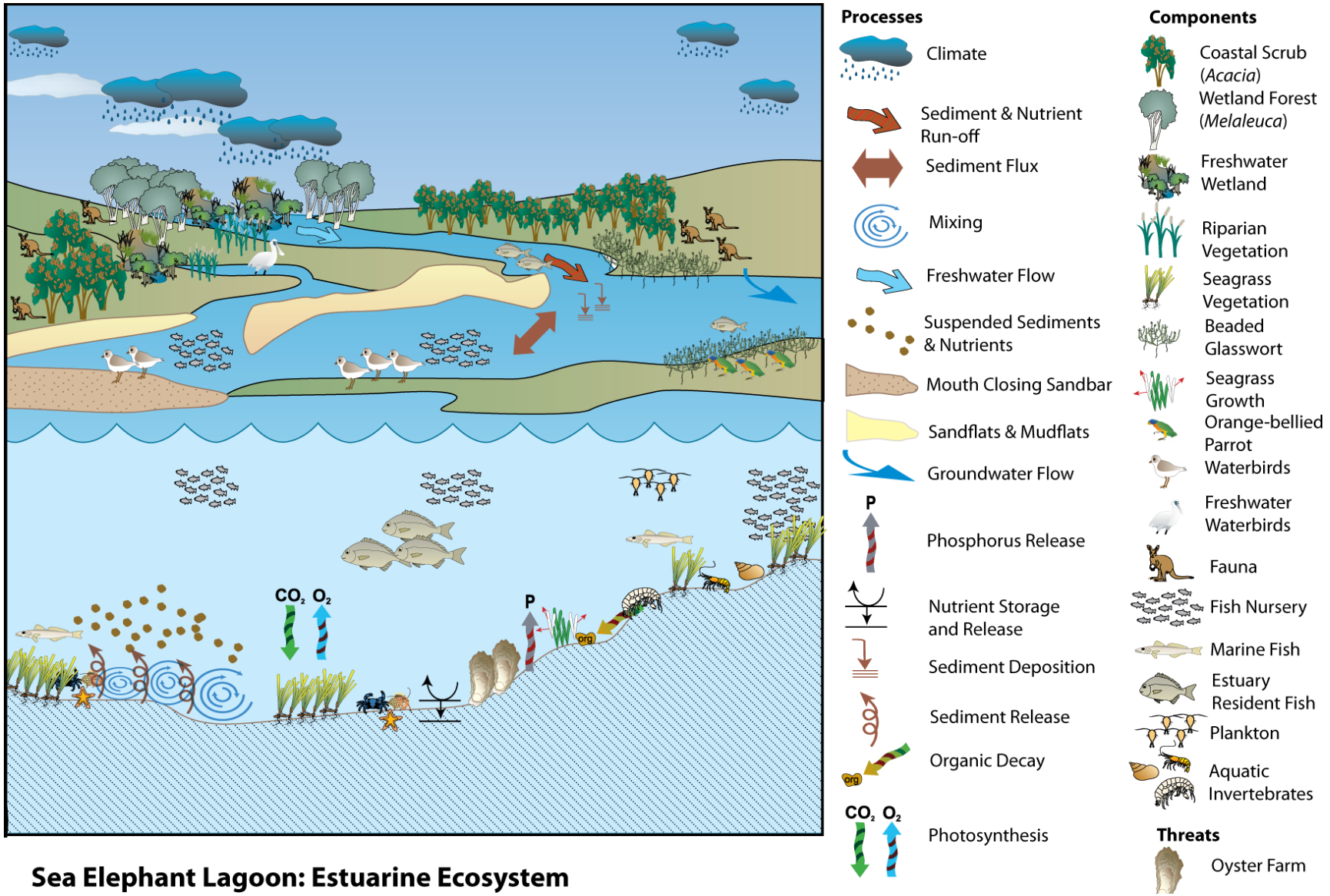


Figure 8: Landscape conceptual model of the Sea Elephant Estuary Ecosystem.

3.1.2 Coastal Strip Ecosystem

The **Coastal Strip Ecosystem** covers the entire coast of the site, from Boulder Point in the north to Cowper Point in the south (Figure 9) and includes sand dunes and beaches consisting of Quaternary coastal calcareous sands. There are also some areas of rocky shoreline that extend out to form reefs. This ecosystem contains important sea-bird rookeries and overlaps with the Sea Elephant Estuary Ecosystem, described above.

Figure 9: General location of the Coastal Strip Ecosystem. Source: Google Maps.

Behind the sandy beaches of the Coastal Strip, coastal grassland communities increase in ground cover from coastal grasses up to foredunes that typically contain heath and scrub communities (e.g. Figure 10), or bracken fields in the more frequently burnt areas (Barnes et al. 2002).

Figure 10: View of the Coastal Strip at Cowper Point.

The Coastal Strip provides habitat for feeding and nesting for many species of shorebirds (See Table 6). Cowper Point is recognised as a priority site for resident shorebirds, with a high diversity of beach nesting and migratory shorebirds. Eight resident species and four migratory species of shorebirds have been recorded at Cowper Point (Bryant 2002). Similarly, the shoreline at the mouth of the Sea Elephant River was one of four sections of coastline identified by Lovibond (2007) as having highest suitability for shorebird management, based on high ecological (shorebird) significance and low likelihood of human disturbance.

The Coastal Strip Ecosystem also supports short-tailed shearwater (*Puffinus tenuirostris)* rookeries in the grass tussocks immediately behind the beach at Cowper Point. Similarly, there are breeding colonies of little penguin (*Eudyptula minor*) that build or have built burrows in the dunes and tussocks immediately behind the sandy beach (Bryant 2002).

Table 6: Important waterbird species of the Coastal Strip, with their common habitat and diet. Source: Birdlife International (2009), DEWHA (2009b), PWS (2009), RIS draft (2005) and Pizzey (1980).

Species	**Habitat(s)**	**Diet**
White-bellied Sea Eagle *(Haliaeetus leucogaster*	See Table 5.	See Table 5.
Eastern curlew	See Table 5.	See Table 5.
Ruddy turnstone	Outside of the breeding season the Ruddy turnstone is mainly coastal. It forages in flocks of 10-100 or more individuals, especially in tidal areas. During the winter it frequents productive rocky and shingle shores, breakwaters, sandy beaches with storm-wracked seaweed, short-grass saltmarshes, sheltered inlets, estuaries, mangroves swamps, exposed reefs and mudflats with beds of molluscs.	Outside of the breeding season its diet consists of insects, crustaceans, molluscs (especially mussels or cockles), annelids, echinoderms, small fish, carrion and birds eggs.
Short-tailed shearwater (*Puffinus tenuirostris*)	The Short-tailed Shearwater is found on headlands and islands covered with tussocks and succulent vegetation such as Pigface (*Carpobrotus rossii*). Headlands allow for easy take off and landing.	Shearwaters feed on krill, squid and fish.
Red-necked stint (*Calidris ruficollis*)	See Table 5.	See Table 5.
Caspian tern	See Table 5.	See Table 5.
Sharp-tailed sandpiper (*Calidris acuminata*)	See Table 5.	See Table 5.
Greenshank	See Table 5.	See Table 5.
Fairy tern (*Sterna nereis*)	The Fairy Tern breeds on sheltered mainland coastlines and close islands, usually on sandy beaches. **This species breeds at the site.**	The Fairy Tern feeds almost entirely on fish.
Hooded plover (*Thinornis rubricollis*)	The species primarily inhabits sandy, ocean beaches, with the highest densities on beaches with large amounts of beach-washed seaweed, that are backed by extensive open dunes. The species shows a preference for nesting on flat beaches and stony terraces and primary sand dunes. **This species breeds**	In eastern Australia, it is an opportunistic feeder and takes a range of invertebrates.

Species	Habitat(s)	Diet
	at the site.	
Little tern (*Sterna albifrons*)	The species breeds on barren or sparsely vegetated beaches, islands and spits of sand, shingle, shell fragments, pebbles, rocks or coral fragments[1] on seashores or in estuaries, saltmarshes, and rivers. It shows a preference for islets surrounded by saline or fresh water where small fish can be caught without the need for extensive foraging flights. Outside of the breeding season the species frequents tidal creeks, coastal lagoons and saltpans and may foraging at sea up to 15 kilometres offshore. **This species breeds at the site.**	Its diet consists predominantly of small fish and crustaceans 3-6 cm long as well as insects, annelid worms and molluscs.
Australian pied oystercatcher (*Haematopus longirostris*)	The Australian pied oystercatcher mostly inhabits mudflats, sandbanks and sandy ocean beaches. This species breeds in pairs, typically in sand just above the high water mark on beaches, sandbars and lagoon margins. **This species breeds at the site.**	It feeds on bivalve molluscs, found by sight or by probing with their long bills into mud and wet sand. Oystercatchers also eat worms, crustaceans and insects.

Conceptual Model of the Coastal Strip

The most important ecological processes of the Coastal Strip are its provision of feeding, breeding and resting habitat for the bird species listed in Table 6, including the IUCN redlisted fairy tern. Coastal geomorphic processes along the strip include: wave wash depositing greater volumes of sand than it removes as backwash thereby providing the sandy beach; longshore drift of sand creating the sandy spit barrier at the mouth of the Sea Elephant River; and the combination of wind and wave action that encourages dune formation behind the beach front (Figure 11).

Recognised vegetation communities within this ecosystem includes Sand Dune Vegetation (TASVEG Code SAC), Coastal Grasslands and Herbfields (TASVEG Code GHC), Bracken (TASVEG Code FPF) and Muttonbird Rookery (TASVEG Code SRC). The Sand Dune and the Coastal Grasslands vegetation associations on the foredunes of the site provide important stability for the sand dunes, with root binding and wind protection reducing the potential impacts of wind erosion and blowouts in the dunes. The strand and foredunes front directly onto the littoral beach and therefore experience the full exposure to wind and salt spray. Along the seaward edge of the foredunes, the primary colonisers are rhizomatous grasses such as the introduced Marram grass (*Ammophila arenaria*), coastal fescue (*Austrofestuca littoralis*) and blue tussock grass (*Poa poiformis*). Associated with these species are halophytic succulents such as sea rocket (*Cakile maritima*) and saltbushes (Atriplex spp.), and/or shrubs such as cushion bush (*Leucophyta brownii*) and coast everlasting (*Ozothamnus turbinatus*), or succulents of the Coastal Herbfields, including pigface (*Carpobrotus rossii*) and bower spinach (*Tetragonia implexicoma*). (Duncan 1986).

This vegetation provides vital habitat for fauna of the Coastal Strip. In particular, the succulent herbfield, fernland, open shrubland and tussock grassland are recognised as important plant associations for the short-tailed shearwater rookeries. Similarly, the little penguin (*Eudyptula minor*) often nests in vegetated areas of the foredunes. Intense burning or frequent cool burning can lead to the loss of woody species in the association, as these species regenerate by rootstock or seed which is destroyed by hot or frequent fires. The woody species are replaced by vegetative reproducers such as bracken (*Pteridium esculentum*) and tussock grasses, leading to the establishment of floristically-poor Bracken-field or tussock grassland on parts of the foredunes.

Other forms of habitat provided by the Coastal Strip include the sandy beaches and the exposed rocky reefs. The areas of sandy beach above the highest water line are used by beach nesting fairy tern (*Sterna nereis*), hooded plover (*Thinornis rubricollis*) and little tern (*Sterna albifrons*) (Bryant 2002). Below the high water mark, the wetted beach, shallows, and any rocky reefs would be used for foraging by several species, including ruddy turnstone, red-necked stint, hooded plover, sharp-tailed sandpiper and possibly greenshank, and eastern curlew. These species all prey on invertebrates and their larvae, including insects, annelids, crustaceans, molluscs and gastropods. Although the little tern, hooded tern and Caspian tern feed mostly on fish, they would also use the sandy beach for foraging and/or resting.

No known data has been collected on the marine fish fauna of the Lavinia Ramsar Site. However, the fish supply for the piscivorous species listed above is clearly a vital component of the site. Similarly, no known data were found for the marine water quality of the site, although it is clearly an important component of the site as well. Water quality is unlikely to change dramatically (beyond natural variability) unless through climate change. Although much of the marine water near the site is beyond the site's boundaries, it is clearly a component of the ecosystem and therefore pertinent to its ecological character.

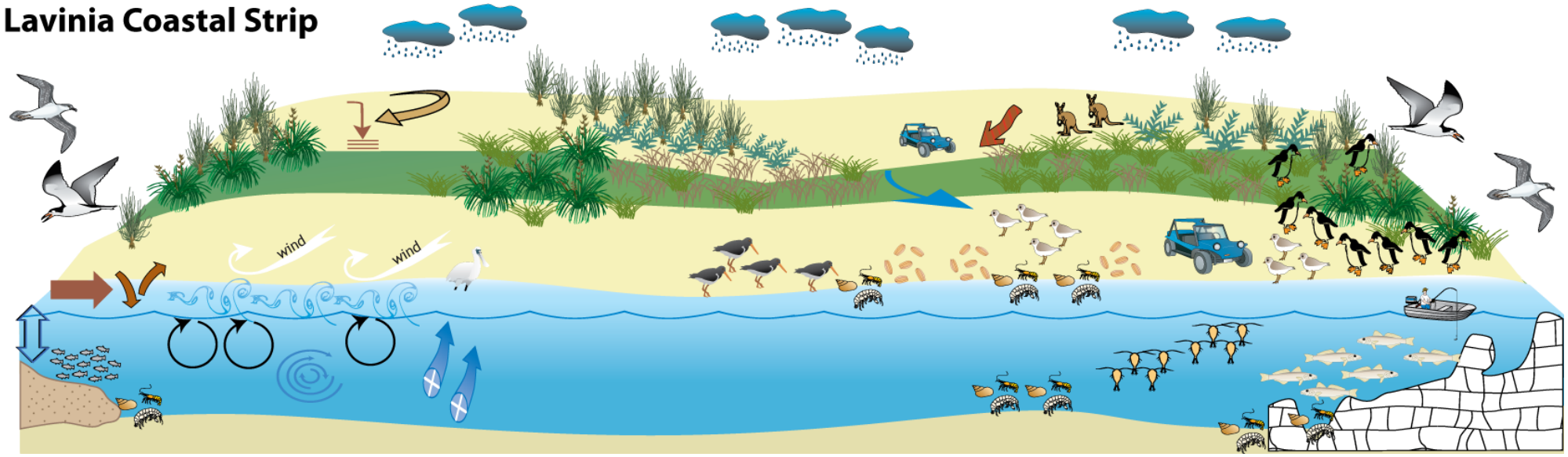
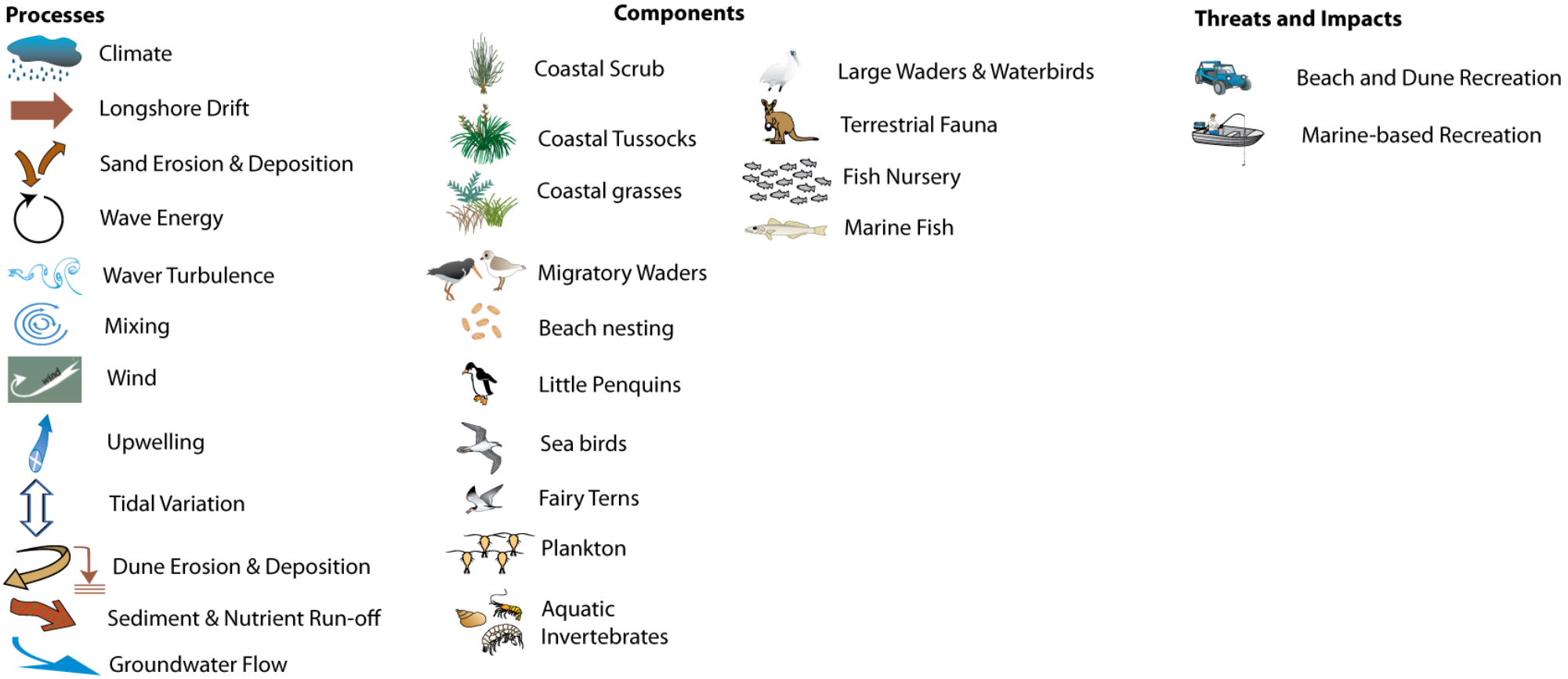


Figure 11: Conceptual Model of the Coastal Strip Ecosystem.



Legend for Figure 11: Conceptual Model of the Coastal Strip Ecosystem

3.1.3 The Dunes Ecosystem

The **Dunes Ecosystem** consists of three main sub-components – the New Dunes, the Old Dunes and the Interdunal Swamps, which as shown in Figure 12, is not a contiguous patch of land. The Dunes contains vegetation communities ranging from sand dune heaths to peat swamps. However, the common element underlying all these units is the series of sand dunes that run parallel to the coast. These sand dunes are the result of several distinct episodes of dune formation which have been grouped into two major dune forming periods.

The first dune forming period created the Old Dunes and occurred within the upper Pleistocene approximately 120,000 years ago during considerably higher sea levels. These are situated inland of the New Dunes (Pemberton 2004). The second dune forming period commenced in the Holocene within the last 10,000 years, during which the New Dunes originated and now form a rim around King Island (Jennings 1959; D'Costa et al. 1993) adjacent to the sea (Jerie et al. 2000). The New Dunes themselves consist of two distinct fields (of similar area): revegetated blownout terrain; and younger beach ridges. Although largely stabilized by vegetation, they have steep dune faces indicative of their more recent/ongoing formation (D'Costa et al. 1993). Both sets of dunes are remnants of former shorelines. The Old Dunes have a discontinuous distribution around the island's rim (Jennings 1959) (Figure 12).

Between the Old and New Dune systems, there is a series of lagoons, lakes wetlands and peatlands, forming in the interdunal depressions. In the north, these depressions contain Pennys Lagoon and Lake Martha Lavinia. These lakes are partially dammed by the New Dunes. However, their morphology is mostly controlled by the form of the stable ridges of the Old Dunes (Jerie et al. 2000). South of the lakes, the interdunal depression contains the Nook Swamp, a ribbon-like series of wetlands that run roughly parallel to the coast along much of the reserve's length. The freshwater areas of the Nook Swamp are dominated by closed forest (refer Section 4.3.1), dominated by swamp paperbark (*Melaleuca ericifolia*) (Duncan 1986) (Figure 13).

The vegetation of the Dunes Ecosystem reflects the system's geomorphology and the distance from the coast. On the New Dunes, the vegetation grades from the grass tussocks found in the Coastal Strip, becoming increasingly woody with distance from the coast and elevation. Heath and scrub are extensive on the back-dunes, with heath grading into scrub on the more sheltered slopes and with dense scrub being found in the hollows and swales (Duncan 1986). Vegetation height is inversely proportional to the strength of onshore winds, with lee slopes and swales supporting the tallest shrubs and trees (Barnes et al. 2002).

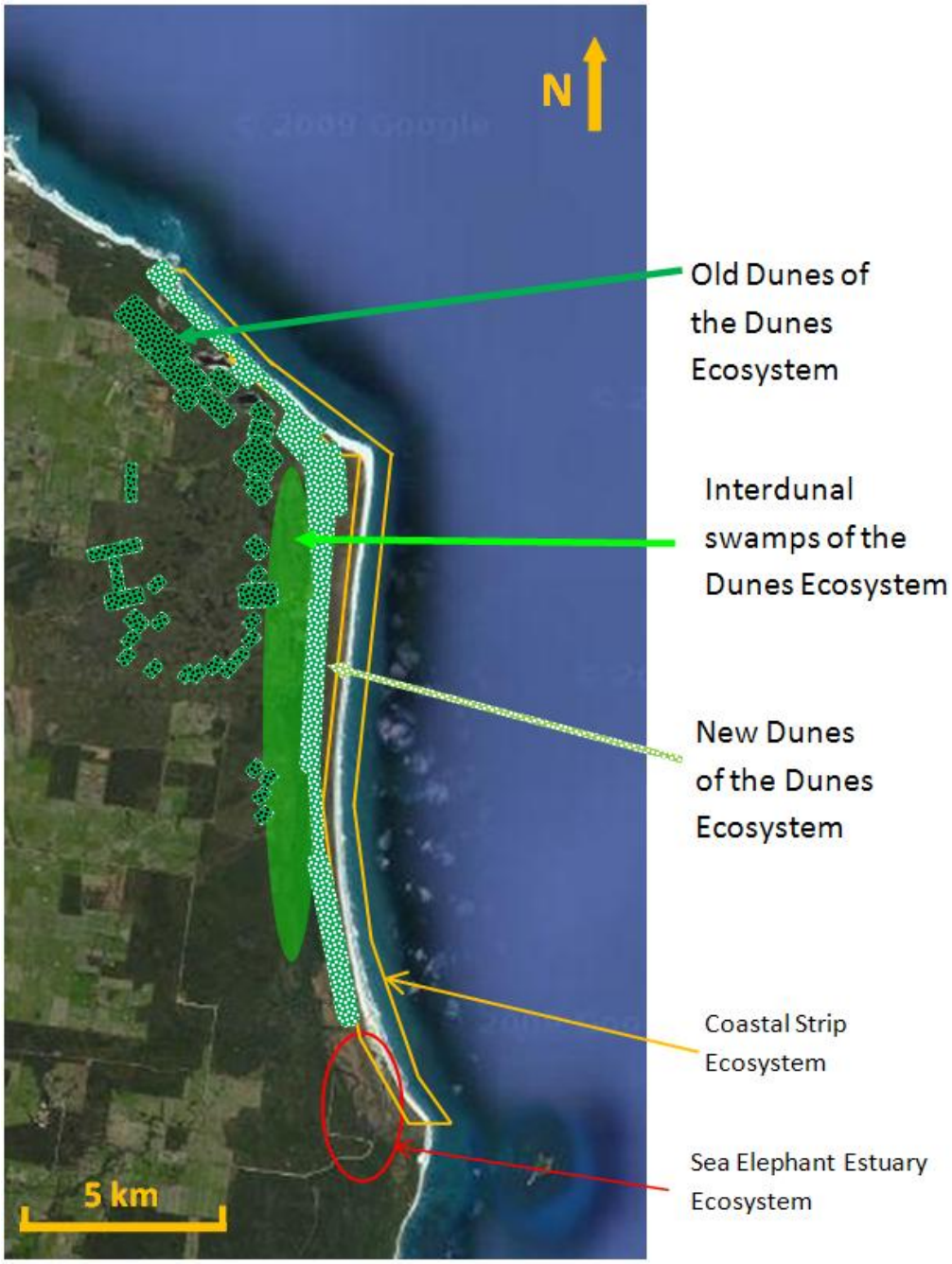


Figure 12: General location of the Old and New Dunes in the Dunes Ecosystem.

At the time of listing, the Nook Swamp contained the tallest swamp paperbark forest on King Island, with a canopy exceeding 30m in height (Duncan 1986).

The Nook Swamp and the surrounding wetlands contain extensive peatlands developed in two contexts. Firstly, fibrous peats up to one metre in depth are found associated with Melaleuca Swamp Forests. These soils are likely to be many thousands of years old. Secondly, shallower humic peats have developed in surrounding wetlands in depressions on the plains, extending from the Dunes into the Northern Sandsheet Ecosystem (refer Section 3.1.4). The fibrous peats under the Melaleuca forests are particularly sensitive to fire, and significant effects on surface and groundwater hydrology may be expected following major peat fires (Houshold personal communication). The sand dunes in this system have been classed as "outstanding" at a State level from a geoconservation perspective (Dixon 1996).

Figure 13: The canopy of the swamp forest in the Nook Swamp.

Water quality of the Nook Swamp is unknown. However, water samples have been collected from a drainage line that drains Egg Lagoon (to the west of the site) into the Nook Swamp (Bobbi et al. 1999). This drainage line is likely to be a major contributor to the surface water of the Nook Swamp. Egg Lagoon lies outside the site boundary and has had artificial drains constructed within, to expedite the drainage of waters and thereby 'reclaim' the Lagoon for agricultural use. This has altered the flow regime and quality of the water drained from Egg Lagoon to the Nook Swamp. During rainfall events, drainage lines deliver water more efficiently and rapidly to receiving stream channels, leading to faster and deeper floods with associated erosion and accompanied by lower base flows during dryer periods. This process would be expected to lead to the Egg Lagoon drains delivering artificially high pulses of nutrients and sediments to the wetlands in the Nook Swamp during storm events. In contrast, periods of lower flow may be expected to contain higher salt and nitrate concentrations, reflecting the artificial increase of groundwater in the stream.

The results from Bobbi et al. (1999) showed the Egg Lagoon drainage as having the highest electrical conductivity (a measure of salt concentrations) of all east flowing waterways on King Island, with an EC of 4400 µS cm-1. The same site also had the highest nitrate reading of the King Island sites in the study, measuring 1.4 mg L-1. Samples taken from the site for total phosphorus and total nitrogen yielded relatively low concentrations of these nutrients in comparison with the rest of King Island (Bobbi et al. 1999). These data support the suggestion that the samples were collected from a waterway that is impacted by artificial drainage and that the samples were gathered during relatively low flows (i.e. during a period in which ground water was a high proportion of the flow). If samples had been collected during, or immediately after a high rainfall event, they would most likely show lower electrical conductivities and nitrate concentrations, accompanied by high pulses of total nitrogen and total phosphorus.

Conceptual Model of the Dunes

The geomorphology (landforms) of this ecosystem and its surrounding landscape play a major influence on the hydrology of the system and therefore on the highly diverse array of wetlands and vegetation types within the system (Figure 14). Most of the groundwater of the dunes ecosystem is fed by rainfall on impermeable granite outcrops to the west of the site and by rain that falls directly onto the sandy, permeable catchment. This rain sinks into these permeable sands and runs through the unconsolidated sands of the basin.

In addition to the regional groundwater there are also local, perched groundwater systems, forming many smaller lagoons with hydrologic systems independent of the regional system (Figure 14). The perching occurs as a result of impermeable organic horizons forming in the sand. Inflows are provided from the local catchments, with slow seepage and evaporation resulting in a surplus of water, forming wetlands perched over these impermeable beds. Pennys Lagoon is an example of this type of perched lake.

Other surface waters of the system include Lake Martha Lavinia, dammed between the Old and New Dunes, and the waterways of the Nook Swamp, which ultimately drain into the Sea Elephant River. Much of the water in the Nook Swamp is locally derived or delivered as surface water from catchments to the west of the Lavinia Ramsar Site, most notably the Egg Lagoon and Saltwater Creek catchments. The artificial drains from Egg Lagoon have been discussed earlier, in relation to altered flow regime and water quality, and are represented in Figure 14.

The vegetation of the ecosystem ranges from dry heath and scrub of the King Island scrub complex on the Dunes, to the *Melaleuca ericifolia* swamp forest in the low-lying land between the New Dunes and the Old Dunes. The location of the individual units of the King Island scrub complex across the ecosystem is a function of fire history and drainage (see 3.1.4), with the wet heath and wet scrub occurring on poorly-drained sites (e.g. areas of impeded drainage on flat plains), whereas the dry heath and dry scrub are situated on better-drained sites, such as the rises and crests of Old Dunes (Figure 14).

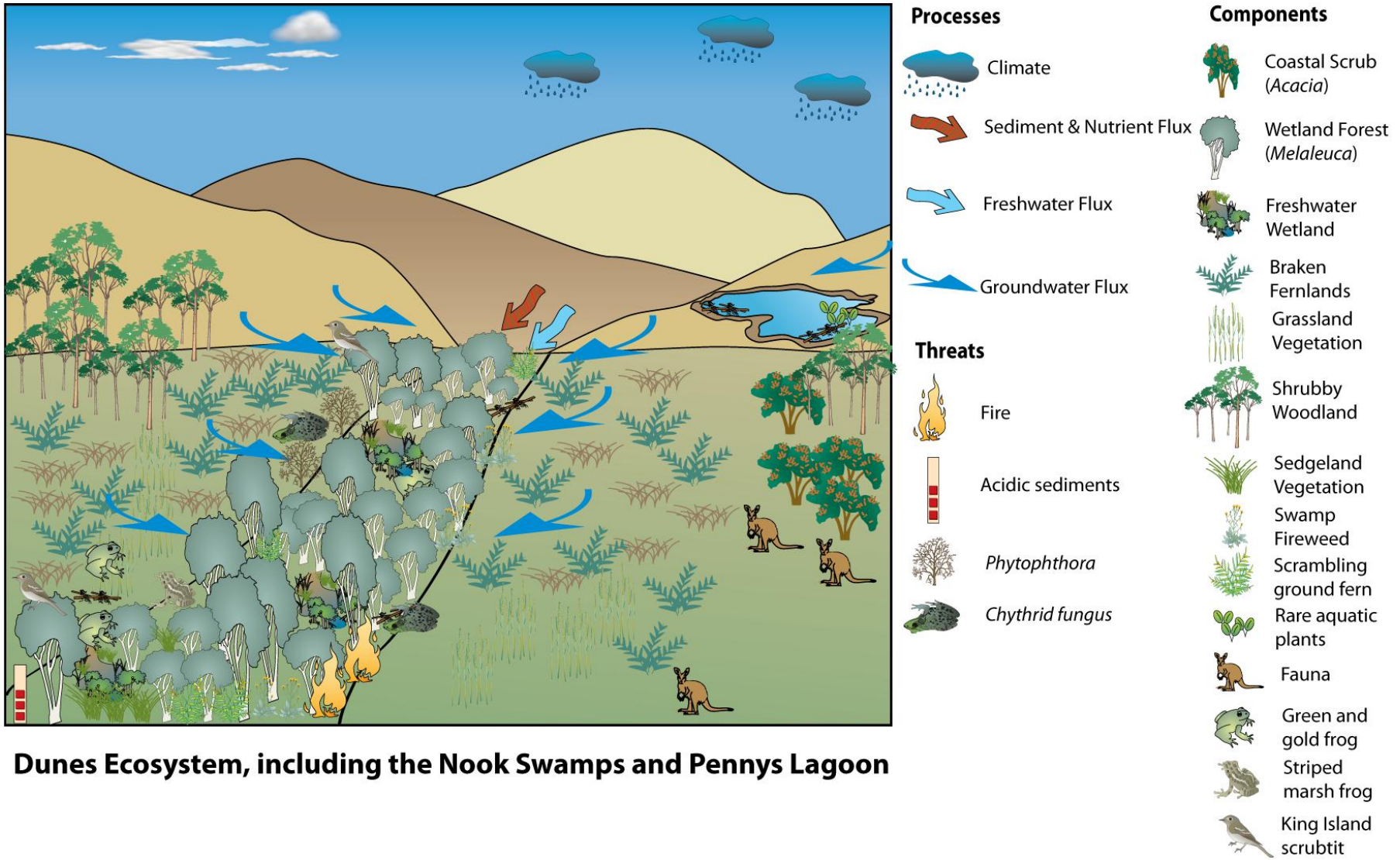
The Dunes Ecosystem also contains bracken fernland in the driest and/or most frequently burnt areas and coastal grass and herbfields in the sand dunes behind the Coastal Strip, as well as some areas of *Eucalyptus viminalis* shrubby/heathy woodland within the swales of the Old Dune system near Lake Martha Lavinia. Areas of coastal scrub community are also found in the sand dunes behind the Coastal Strip, with a sizeable stand in the New Dunes behind Lavinia Point. The vegetation cover across the New and Old Dunes is important for protecting the sandy soils from wind erosion.

Melaleuca ericifolia swamp forest and short paperbark swamp occupy the poorly drained and seasonally inundated areas in the lowest parts of the landscape (Figure 14), including areas around lakes and along creek lines, with the *Melaleuca ericifolia* swamp forest typically found on the heavier of the poorly drained soils. It is under the *Melaleuca* swamps that the site's fibrous peats develop, whereas the shallow humic peats develop under the wet heath and wet scrub occurring in areas of impeded drainage on the flat plains. It is also the *M. ericifolia* swamp forest that provides vital habitat for the King Island scrubtit. Scrub bordering the *Melaleuca ericifolia* swamp forests provides the moderately to poorly drained habitat used by the scrambling ground fern (Figure 14).

The 'herbfields marginal to wetlands' vegetation community around Pennys Lagoon and on the western edge of Lake Martha Lavinia provide ideal habitat for the green and gold frog and the striped marsh frog (Figure 14), as does the sedge/rush wetland vegetation on the western edge of Pennys Lagoon. Both of these vegetation units provide sedge/grasslands necessary for hunting, in close proximity to permanent still-to-slow flowing water required for breeding. These vegetation units are also support the fan triggerplant and pink

bladderwort, recorded at the margins of Lake Martha Lavinia (Richard Schahinger, personal communication) and also the swamp fireweed.

The fire regime of the site plays a vital role in the biodiversity, vegetation floristics and structure, peat formation and maintenance, and the dune stability of the ecosystem. The fire regime will be influenced by fire history (through the development of fire promoting vegetation) and the climate; both of which are discussed in section 5 (Threats).



Dunes Ecosystem, including the Nook Swamps and Pennys Lagoon

Figure 14: Conceptual model of the Dunes Ecosystem.

3.1.4 Northern Sandsheet Ecosystem

The **Northern Sandsheet Ecosystem** is a Quaternary sand plain which forms flat to undulating country inland of the Dunes Ecosystem. The plains are thought to have originated during periods of relatively high Quaternary sea levels, in which marine-estuarine sedimentation occurred and formed the plain onto which terrestrial sediments were subsequently deposited. The Quaternary sediments which form the substrate of the Northern Sandsheet ecosystem have buried Precambrian bedrock (Orr 2003). Due to the low relief, surface water has little capacity to erode or even form channels in this area (Jerie et al. 2000) resulting in the development of large areas of freshwater marshes, shrub-dominated wetlands and unforested peatlands. Part of the Dunes Ecosystem is situated within the Northern Sandsheet Ecosystem (Figure 15).

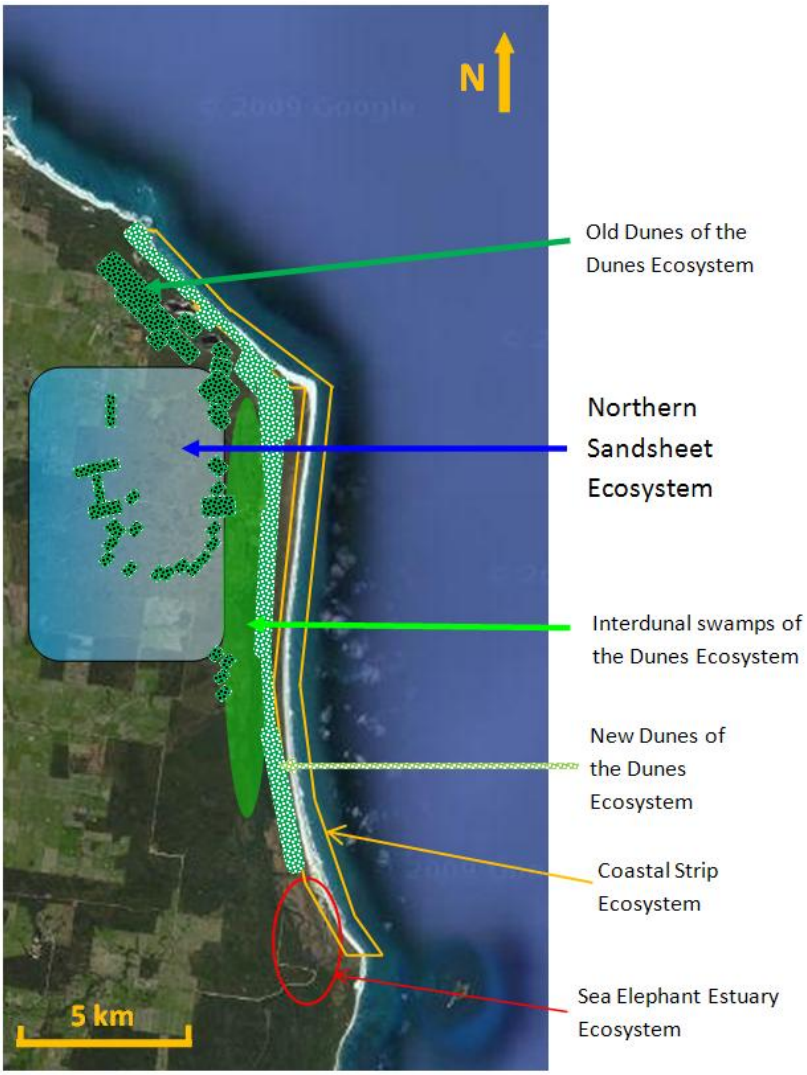


Figure 15: General location of the Northern Sandsheet Ecosystem (green dots in Northern Sandsheet Ecosystem indicate remnant dunes).

The vegetation of this ecosystem is mostly an extensive successional mosaic of sedgeland, heath and scrub (Duncan 1986) and also heath woodlands, characterised by stunted trees with dense shrubby understoreys (D'Costa et al. 1993). The peatlands that have developed in the numerous poorly drained depressions within the area support shallow humic peats,

and are covered by sedgeland, wet heath or wet scrub, depending on the stage of vegetation succession.

Sedgeland is the most ephemeral and least extensive component of the vegetation, constituting the earliest stage of post-fire succession (Figure 16) (Duncan 1986). Although sedges typically dominate this vegetation type, bracken (*Pteridium esculentum*) may dominate sedgeland on drier sites and sites that are species-poor due to frequent burning, turning them into a bracken fernland.

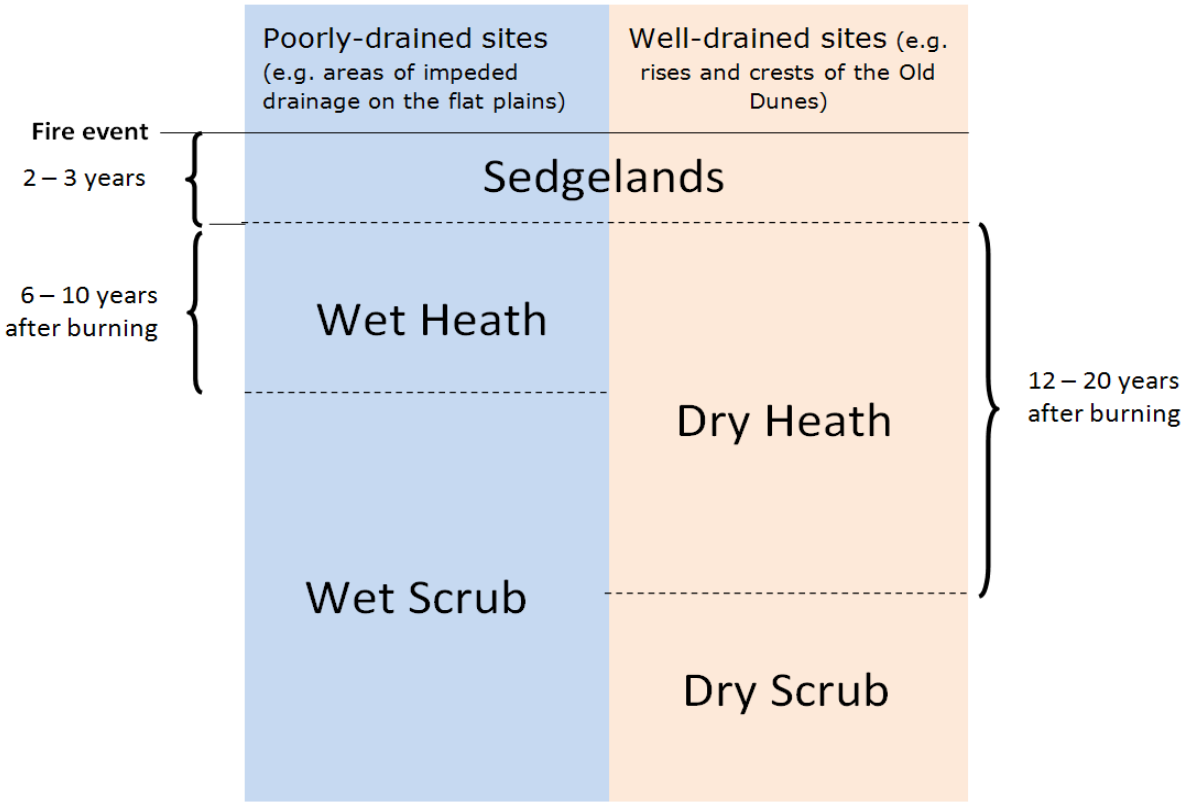


Figure 16: Successional path of the King Island Sedge/Heath/Scrub Complex.

The next stage of the succession – heath – is dominated by woody shrubs to a height of 2 metres and is a transition between sedgeland and scrub (woody shrubs higher than 2 metres). Heath has two main associations: wet heath and dry heath, with the wet heath being more extensive in the Ramsar site, reflecting the impeded drainage of the flat plain (Duncan 1986) and is typically dominated by tea trees (*Leptospermum* spp), paperbarks (*Melaleuca* spp) and banksias (*Banksia* spp). Scrub vegetation is the soil-limited climax of the succession in these often infertile soils, and is usually dominated by tea trees, banksias and she-oaks (*Allocasuarina* spp.) (Duncan 1986).

Other vegetation communities with some (minor) representation in the Northern Sandsheet are the *Eucalyptus viminalis* shrubby/heathy woodland, some *Melaleuca squarrosa* scrub near a waterway and some *Eucalyptus brookeriana* wet forest on a floodplain near Salt Creek. The *Eucalyptus viminalis* shrubby/heathy woodland typically occurs in dry situations, such as ridgelines, in coastal areas or on sandy soils, whereas the *Melaleuca squarrosa* dominated swamps occur on deep, poorly drained peaty soils (Barnes et al. 2002). The *Eucalyptus brookeriana* Wet Forest is noted as often being associated with drainage lines, creeks and slight topographic depressions in the landscape (Barnes et al. 2002).

Conceptual Model of the Northern Sandsheet

The predominance of the King Island Sedge/Heath/Scrub Complex within the Northern Sandsheet Ecosystem (Figure 17) reflects the combined influences of fire regime, hydrology, geomorphology, soil fertility and climate. The mosaic is strongly influenced by the intervals between fires (Figure 16) and location on the landscape, with the wetter depressions tending to wet heath and scrub and the drier rises and ridges tending to dry heath and scrub. The wetter depressions are caused the poor drainage described above and also by groundwater fed by rainfall on impermeable granite outcrops to the west of the site, that sinks into the adjacent permeable sands and runs eastwards below the sandsheet.

The sedgeland plants and tussock grasses in Figure 17 represent the vegetation in areas that have been recently burnt, with bracken representing areas that are drier or have been frequently burnt. The scrub and heathlands are represented by the spread of she-oaks, paperbarks, tea-trees and banksias, as these shrubs are typically dominant in two or more or the scrub/heath community types.

The two orchids (tiny caladenia and banded greenhood) tend to occur within heathland and woodland communities, on moderately to well drained soils close to peaty or wet soils, but would tend to become shaded out once heathland becomes too dense or progresses to scrubland. In contrast, several other TSPA-listed plant species found at the site are more likely to be found in the depressions and soaks, often with a peat soil, and/or associated with wetland margins or drying wetlands. These include the fan triggerplant (*Stylidium beaugleholei*), small triggerplant (*Stylidium despectum*), submerged watertuft (*Trithuria submersa*) and pink bladderwort (*Utricularia tenella*).

Although no data were available, it is highly likely that several of the wetlands within the sandsheet are used by migratory and other waterbirds.

The major threats identified for the sandsheet ecosystem were:

- fire (increase in frequency);
- dieback fungus (*Phytophthora cinnamomi*); and
- climate change, with the major influence of climate change being an increased risk of fire frequency and/or intensity.

These are discussed further in the Threats section (Section 5).

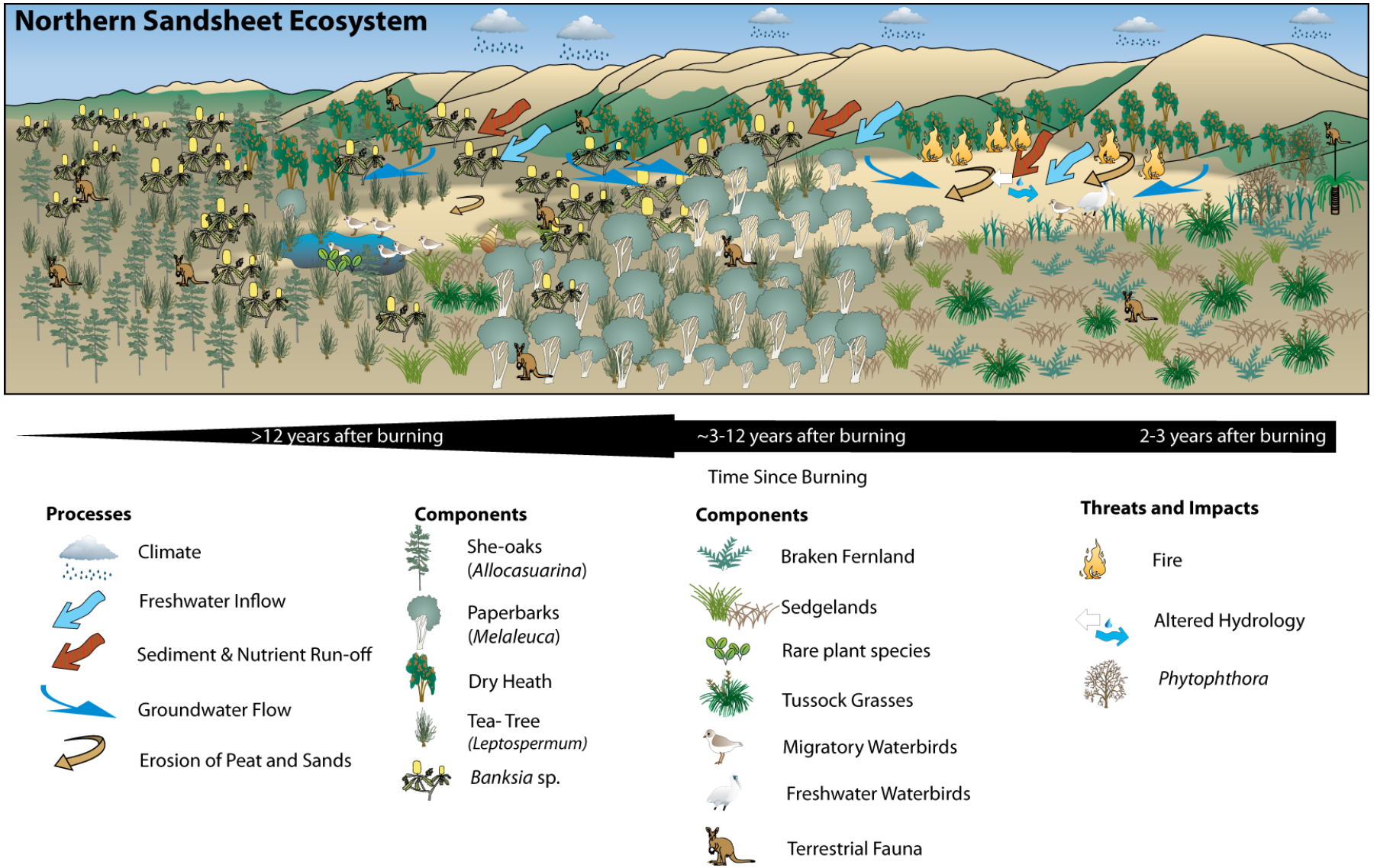


Figure 17: Conceptual model of the Northern Sandsheet Ecosystem.

4. COMPONENTS, PROCESSES AND SERVICES OF THE LAVINIA RAMSAR SITE

The approach adopted for the presentation and discussion of the components, processes and services of the Lavinia Ramsar Site involves:

- Presenting the process used to identify the critical components, processes and services of the site and the linkages between them. This is important as the critical components, processes and services are used to identify major threats and limits of acceptable change to the site.
- A summary and description of the essential elements of the site (components and processes that are important in supporting the ecological character of the site but not critical).
- A description of the critical components, processes and services that influence the ecological character of the Lavinia Ramsar Site.

Ecosystem components include the physical, chemical and biological parts of a wetland (Millennium Ecosystem Assessment 2005). Ecosystem processes are dynamic forces and include all those processes that occur between organisms and within and between populations and communities. This includes interactions with the non-living environment that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological.

In practice, many components can also be processes. For example, climate, hydrology and geomorphology can each be viewed as static parts (components) of the sites as well as dynamic forces (processes) that bring about change to the wetland. In this ECD they are considered together.

4.1 Identifying Critical Components, Processes and Services of the Site

The production of an ECD requires the identification, description and where possible, quantification of the critical components, processes, benefits and services that characterise the site. As a minimum, DEWHA (2008) recommends the selection of critical components, processes, benefits and services as those:

1. that are important determinants of the site's unique character;
2. that are important for supporting the Ramsar criteria under which the site was listed;
3. for which change is reasonably likely to occur over short to medium time scales (<100 years); and
4. that will cause significant negative consequences if change occurs.

Identification of the critical components and processes also assists identification of components and processes that may not be critical to the site, but are important in supporting the critical components, processes, and services. These have been termed 'essential elements' and may act as early warning indicators of a potential change in character and therefore should be considered in management planning for the site (Hale 2010). Using the approach of Hale (2010), a simple conceptual model has been developed that displays the essential elements for the site, the critical components and processes, the benefits and services (CPS) and the listing criteria as well as showing the links between these features (Figure 18).

Ten critical components and processes were identified for the Lavinia Ramsar site:

- wetland vegetation communities;
- regionally rare plant species;
- nationally rare plant species (scrambling groundfern, swamp fireweed);
- regionally rare bird species;
- striped marsh frog;
- orange-bellied parrot
- King Island scrubtit;
- green and gold frog;
- waterbirds and seabirds; and,
- migratory birds.

All of these meet the four criteria provided by DEWHA (2008): they are central to the character of the site; they are directly linked to the Ramsar criteria for which the site was listed; they could potentially change in the next 100 years; and their change would result in a negative change in the ecological character of the site. The identified essential elements for the site are:

- climate;
- geomorphology;
- hydrology;
- terrestrial vegetation;
- fire regime;
- water quality; and,
- fish and macroinvertebrates (as food).

All seven of these elements support the critical components and processes of the site, without being directly linked to the listing criteria for the site.

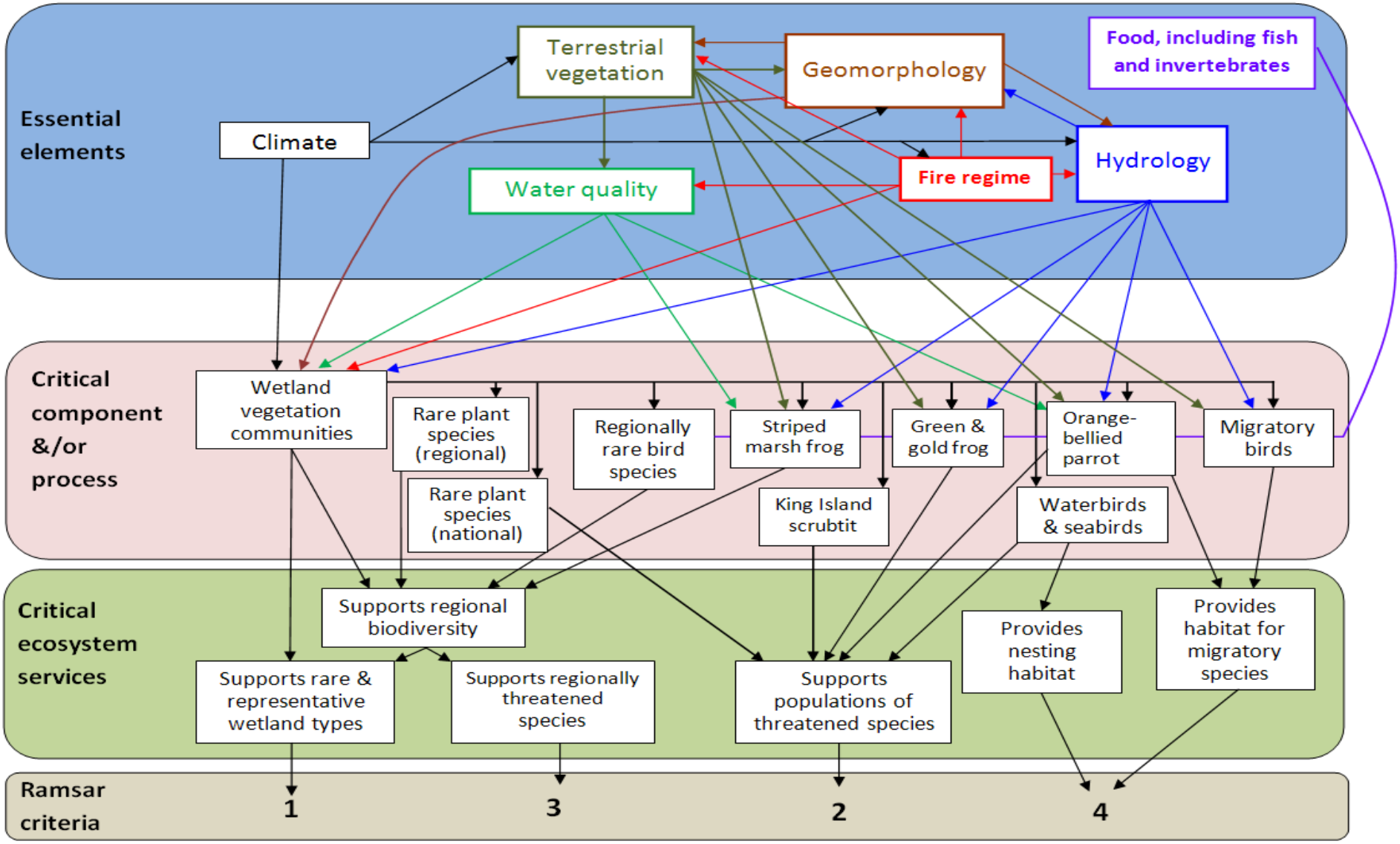


Figure 18: Conceptual model linking components, processes and services of the site with the Ramsar listing criteria.

4.2 Essential Elements of the Site

4.2.1 Climate

King Island experiences a temperate maritime climate (also known as a marine west coast climate), which is typified by mild, moist conditions with warm summers and cool winters. These climates do not typically have a dry season, although there is often a clear winter peak in rainfall (Strahler and Strahler 1992). Data from the Currie Post Office (the closest Bureau of Meteorology site to the Lavinia Ramsar Site) support this general description (Figure 19).

The Currie Post Office has an 88-year data record for rainfall (1909-1997) and an 82-year data record for maximum and minimum temperatures. Data for the site indicate that rainfall is consistent, with annual rainfall having a 10th percentile of 698.4mm, a median of 876.9mm and a ninetieth percentile of 1100.9mm. At Currie, the warmest month is typically February with a mean daily maximum temperature of 20.6 °C and a mean daily minimum of 13.1 °C. The coolest month is July, with a mean daily maximum temperature of 12.9 °C and a mean daily minimum of 7.8 °C. The data from the King Island Airport (rainfall data from 1974-2009; temperature data 1995-2009) is almost identical to that of the Currie Post Office.

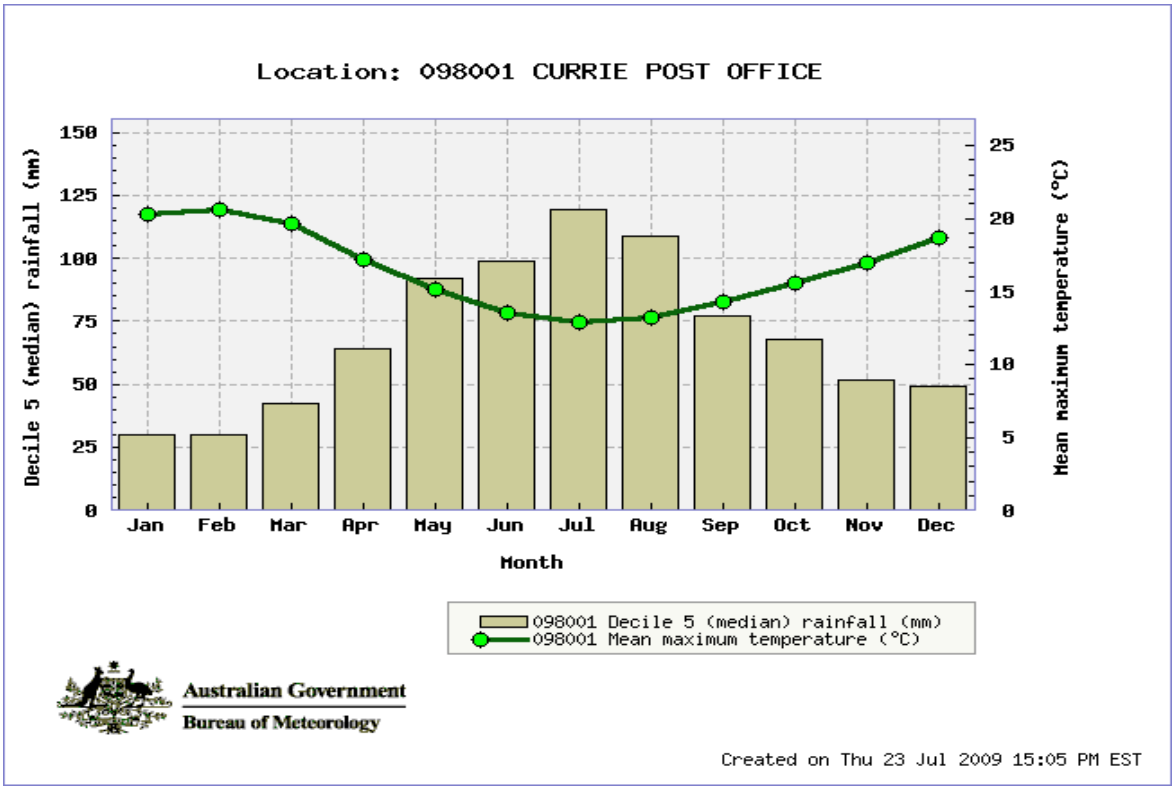


Figure 19: Climographs for Currie Post Office (source: http://www.bom.gov.au/climate/averages/tables/cw_098001.shtml).

In the context of this ECD, key features of the climate experienced by the site are mild temperatures (warm rather than hot summers and cool rather than cold winters), relatively high rainfall, and consistency of rainfall.

Another key feature of the site relevant to its ecological character is the wind direction and speed. The winds across King Island have a strong southwesterly component with average wind speeds typically between 20 and 25 kilometres per hour for all months (Commonwealth of Australia 2009). High wind speeds are common, with speeds above 40 kilometres/h regularly recorded.

4.2.2 Geomorphology

Sandy deposits dominate the site (PWS 2000). These deposits primarily consist of Quaternary sediments, and emerged marine surfaces that have subsequently formed dune systems, dune barrage lagoons and inland sand sheets (Orr 2003). Inland sand sheets cover much of the western area of the site. The sandsheets consist largely of aeolian sediments that may reach up to 10 metres in depth (Lloyd 2003), overlying marine and estuarine surfaces (Calver 1998, Pemberton 2004). These sand sheets form gently undulating surfaces of low dunes, peatlands and swamps, with a sandy duplex soil that is highly susceptible to waterlogging (Rando 1987).

Between these sandsheets and the eastern coast of the site are the series of sand dunes described in Section 3.1.4 (The Dunes Ecosystem). Despite being at higher elevations – up to 80 metres ASL - the Old Dunes (Lloyd 2003) have less relief than the New Dunes, due to the longer period of weathering, and are often described as low relief dunes and rolling sand sheets (e.g. Orr 2003, D'Costa 1993). The Old Dunes are discontinuous and occur sporadically around King Island and also within the site (Figure 20).

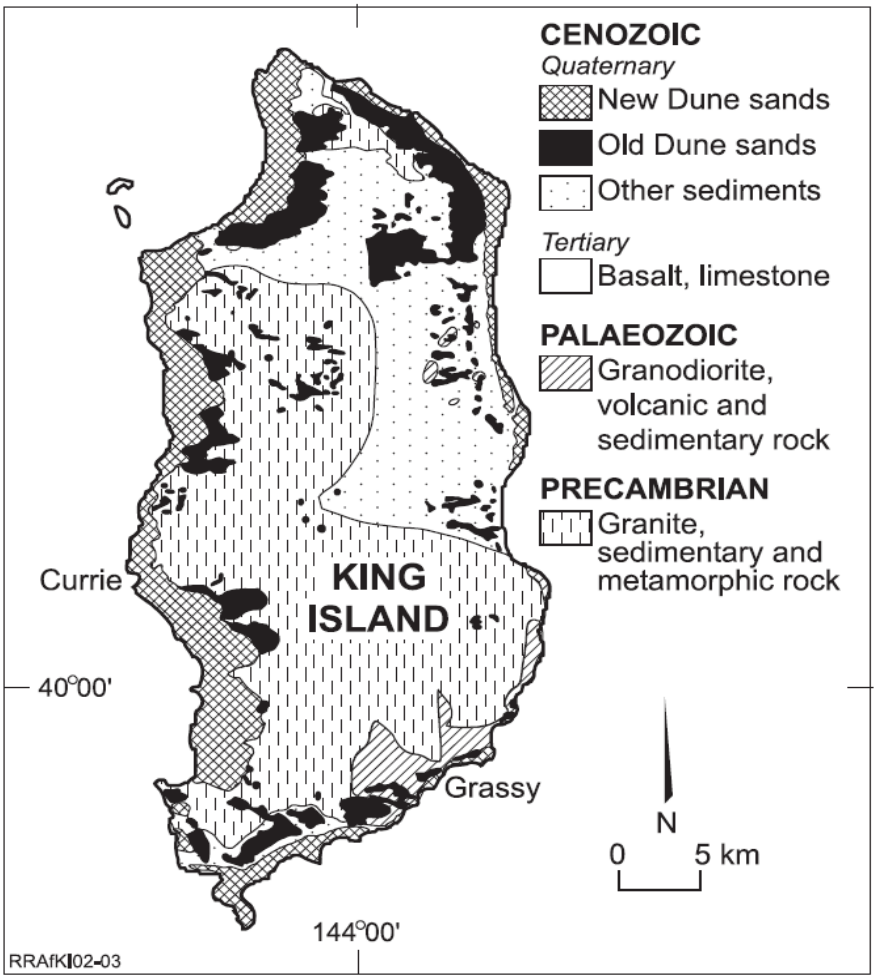


Figure 20: Generalised geology of King Island (Source: Orr 2003).

An important geoconservation feature of the site is that a complete suite of dunes exists, from recently formed parallel dunes close to the beach to the older dunes at a slightly higher elevation southwest of the swamp land (Harris 1993). These parallel dunes are probably the longest and best-developed in Tasmania extending north from the Sea Elephant River mouth to Lavinia Point (PWS 2000, Harris 1993) (Figure 21). Intensive grazing and burning of vegetation on the dunes has led to extensive blowouts in places (Lloyd 2003), highlighting the importance of appropriate land use.

At many locations within and between the Old and New Dunes, drainage systems have been impeded by dune formation and are ill-defined, with numerous lakes and swamps occupying enclosed depressions. The extensive Nook Swamp, which runs roughly parallel to the coast along much of the reserve's length, occupies a flat depression which separates the new system of parallel dunes from the old parabolic dunes further inland.

Figure 21: Lavinia Point to Cowper Point dunes (Source: RMCD 2007). Fires in 2007 clearly exposed the parallel nature of the dunes.

Seaward of the New Dunes lies the Coastal Strip, made of Quaternary coastal calcareous sands forming sand dunes and beaches. The two major beaches of the site are the Nine Mile Beach and Lavinia Beach which are highly susceptible to wind and wave erosion (PWS 2000). The coast has been growing out to sea at a rapid rate in comparison to anywhere in mainland Tasmania (Pemberton 2004).

At the southern end of Lavinia Beach is the mouth of the Sea Elephant River. The location of the river mouth has varied considerably in the past and is continuing to do so. During the Pleistocene, the mouth was probably very close to the present confluence of Saltwater Creek with the Sea Elephant River (approximately 10 kilometres north of the current estuary). With the development of the Holocene dunes the Sea Elephant River has been forced south and over the last ninety years its mouth has moved up and down the coast (PWS 2000), contributing substantially to the current character of the Sea Elephant Estuary, including its long ribbon-like shape, its low gradient (and hence low energy environment) and its general closure to the sea.

4.2.3 Hydrology

The northern part of King Island has been described as a depressed interior surrounded by a rim of coastal dunes (the Old and New Dunes, described above). These dunes impede drainage from inland, leading to extensive swamps, lakes and river deflections – including the Sea Elephant Estuary, as described above (Jennings 1959).

The major groundwater systems influencing the Lavinia site fall into two general types:

1. local groundwater systems within unconsolidated sands, present in the sedimentary basin (the 'depressed interior' described by Jennings 1959); and
2. local perched groundwater systems occurring within the coastal dunes (Dyson undated).

The first type of groundwater system controls the hydrology of much of the Lavinia Ramsar Site. The main source of this groundwater is rain falling on impermeable granite outcrops to the west of the site and running through the unconsolidated sands of the basin (Houshold personal communication, in Draft RIS 2005). Wetlands, soaks, peatlands and some streams are formed where the land surface intersects with these groundwater systems. Within the site, the main surface flows dependent on this type of groundwater system are the lower end of the Sea Elephant River and its northern tributaries through Saltwater Creek and the Nook Swamp.

Upstream of the Nook Swamp (and the site), artificial drains have been constructed to 'reclaim' wetland areas of Egg Lagoon. The drains from Egg Lagoon have been directed towards the Nook Swamp (Jordan 1975). The intended effect of draining Egg Lagoon was to turn the lagoon into land available for agriculture. However, there are unintended ecological effects of draining lagoons (Jerie et al. 2000). These include the delivery of high pulses of nutrients and sediments to the Nook Swamp wetlands during storm events, described in section 3.1.3.

The second major type of groundwater system found within the site - local perched groundwater systems – has been discussed in section 3.1.3 in relation to the conceptual model for the Dunes Ecosystem. Perched water tables have led to many smaller lagoons with independent hydrological systems. Being independent of regional groundwater systems these small wetlands are vulnerable to mechanical activity which may disrupt the organic 'plugs', allowing increased seepage rates (Houshold personal communication, in Draft RIS 2005).

4.2.4 Terrestrial Vegetation

Terrestrial vegetation communities are important in providing the overall structural vegetation fabric for the Lavinia Ramsar Site providing buffer and supporting habitat for the wetland communities (Duncan 1986; Barnes et al. 2002; PWS 2000). Terrestrial vegetation of the site reflects a suite of influences, including soil type and fertility, landform, distance from the coast, climate and hydrology. Superimposed upon the mosaic is the powerful influence of fire (Duncan 1986) (see section 5).

Barnes et al. (2002) identified 25 native plant communities on King Island, thirteen of which are recorded within the site and seven of which are terrestrial. The vegetation classification system used by Barnes et al. (2002) was TASVEG (see Harris and Kitchener 2005 and DPIW 2009b, for information).

The terrestrial communities include the following:

- sand dune vegetation – TASVEG Code SAC;
- sea bird rookery complex – TASVEG Code SRC;

- King Island sedge/heath/scrub complex – TASVEG Code SSK;
- bracken – TASVEG Code FPF;
- coastal grasslands and herbfields – TASVEG Code GHC;
- tall or dense and windpruned coastal scrub– TASVEG Code SSC; and
- King Island *Eucalyptus globulus* subsp. *globulus* heathy woodland – TASVEG Code DKW.

Two of these communities – sea bird rookery complex and King Island sedge/heath/scrub complex – require further comment. Although listed in this ECD as terrestrial, the King Island sedge/heath/scrub complex within the site contains a number of marshes/pools, non-forested peatlands, sedgelands, and shrub-dominated wetlands. This is particularly the case in the Northern Sandsheet Ecosystem, which is largely covered by the King Island sedge/heath/scrub complex (Figure 22), yet also contains large areas of wetland and peatland (Figure 3).

Sea bird rookery complex is identified by DPIPWE Tasmania as a separate vegetation community, that is variable in structure and floristic composition, and distinguished by a combination of general features. These general features include (Harris and Kitchener 2005):

1. coastal heathland vegetation associated with seabird rookeries;
2. grassy, scrubby or comprised of herbfields or succulent prostrate or scrambling shrubs;
3. seabird burrows are common; and
4. succulent and ruderal species are prominent.

From the perspective of this ECD, the most important aspect of the sea bird rookery complex is that it provides support for the short-tailed shearwater and the little penguin.

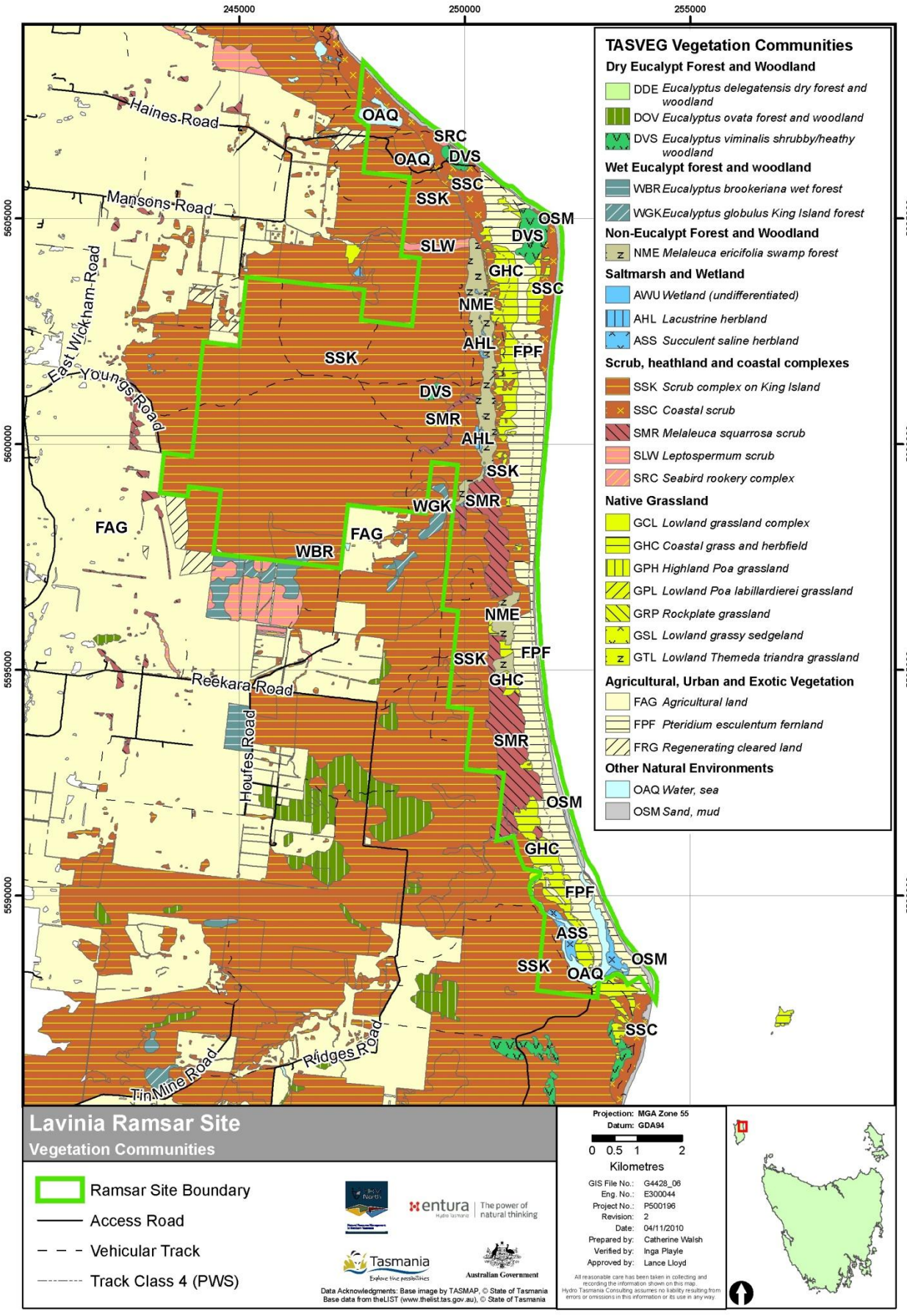


Figure 22: TASVEG Vegetation Communities within Lavinia Ramsar Site.

4.2.5 Fire Regime

Fire as a component and process across King Island has changed since European settlement. There is some evidence of pre-European aboriginal burning on King Island, with a rise in charcoal in the fossil record from about 39,000 years ago (D'Costa et al. 1993). However, since then glacial retreats and consequent sea level rises have resulted in King Island being separated from mainland Tasmania for several thousand years and there is no evidence for aboriginal influence or permanent occupation on King Island until the 1800s, when aboriginal women were taken there by European sealers and hunters (Rando 1978; Finzel 2004b).

Despite being inhabited for less than 100 years, by 1880 there were already huge stands of fire-killed timber on King Island (Rando 1978). In 1887 an expedition of the Field Naturalists Club of Victoria "were struck by the extent of destruction of native vegetation by fire, particularly of forest vegetation which was replaced by scrub or dense growth of bracken fern" (Duncan 1986).

Fire regime is a major determinant of vegetation communities at the site and across King Island:

> *The mosaic of sedgeland, heath and scrub which covers much of Lavinia N.R. is a function of past fire history. These vegetation types form a pyrrhic succession, similar to that occurring on infertile soils in Southwest Tasmania. Fire is also partly responsible for variation in the coastal complex and local dominance of vegetative producers such as bracken. The situation is much more stable in the swamp forest, which is the oldest and tallest community in the reserves* (Duncan 1986).

Fire regime elements include the frequency of recurrence, the (heat) intensity of fires, and the time since the last fire. The fire regime also has a spatial element, in the form of 'patchiness', whereby some parts of the landscape have been more recently burnt than others, contributing to a patchwork, or mosaic of vegetation communities and structure across the landscape.

At the time of listing, there were extensive mosaics of sedge/heath/scrub communities across the Northern Sandsheet within the site, indicating that fires had been recent and at least occasional across that ecosystem. This is because (depending on hydrology and soil type) sedgeland might transform into heathland only two-to-three years post-burning and heath may transform into scrub within 6 to 20 years after a fire (Duncan 1986). An inappropriate fire regime, such as frequent cool burning across the entire community, would have the potential to reset this vegetation complex to be uniform in age and hence largely uniform in structure (within the constraints of soil and hydrology). If the cool burning were too frequent, the community could even be lost and replaced by bracken fernland. Similarly, an intentional or accidental very hot fire across the whole community would also reset the vegetation to a uniform age. A particularly damaging aspect of this is that a lack of variety in vegetation (floristics and structure) contributes to a loss of habitat diversity for the fauna of the area.

The vegetation of the Nook Swamp records a contrasting fire regime to the occasional, patchy fires indicated by the sedge/heath/scrub mosaic. At the time of listing the Nook Swamp contained swamp forest with stands of swamp paperbark (*Melaleuca ericifolia*) that were over 30 metres tall and likely to be 200 years in age (Duncan 1986), indicative of a very low fire recurrence interval. Despite the high water table and low fuel loads inhibiting the spread of ground fires, the Nook Swamp remains vulnerable to wildfires fanned by westerly and north-westerly winds, particularly in high fire danger periods. This vulnerability was demonstrated in the years before listing, with a wildfire coming close to burning the swamp in 1972 (the fire burnt much of the rest of the Lavinia State Reserve), and wildfire in 1978 actually burning part of the Nook Swamp, including some of the stand of the tallest trees (Barnes et al. 2002).

Short paperbark swamp has a similar vulnerability to fire as *Melaleuca ericifolia* Swamp Forest, and fire management recommendations for these two communities are the same (Barnes et al. 2002). Both follow the same post-fire regeneration and succession path structurally, from wet heath, through wet scrub, to closed forest.

The 'time of listing' sets the temporal boundary for description of the ecological character of the site. However, many of the components and processes have a natural variability that must be included within the description, and this variability is discussed in subsequent sections of this document, in relation to Limits of Acceptable Change. Components and processes may also be on a trajectory, or trend, which may lead to conditions beyond the experience of the historical and natural variability of the site. It is possible that fire regime is one component/process that is on a trajectory of more frequent burning. This may be a function of:

- positive feedback whereby previous burning has favoured vegetation types that, in turn, promote fire (e.g. bracken fernland);
- the effects of artificial drainage making organic soils and peatlands dryer and hence more susceptible to fire; and,
- increased "fire weather" associated with drought (and perhaps climate change), resulting in less rain, higher temperatures, more evaporation and/or lower humidity.

4.2.6 Water quality

Water quality of the site is unknown, although there has been sampling undertaken of the Sea Elephant River at Bicentennial Rd, approximately five kilometres upstream of where the river enters the Lavinia Ramsar site (Graham 2005; Baker 2006).

The river shows the influences of draining extensive areas of agricultural land, with elevated nutrients and low dissolved oxygen concentrations (Table 7). It is reasonable to assume that these results are representative of the water quality at the time of listing, as most or all of the land clearance for agriculture within the catchment would have already taken place by 1982.

Water quality may improve as water flows through the site, as the site is well vegetated and there is minimal risk of further impacts. Also there is some possibility that water quality may have been improving slightly in 2005/06 (and may be continuing to improve), as actions have commenced to reduce stock access to the river, including efforts to fence out stock and rehabilitate riparian areas, including in the monitoring site (Baker 2006) upstream of the Lavinia Ramsar Site. Unlimited access by stock to King Island's waterways was noted by Bobbi (1999) to facilitate sediment and nutrient loss from paddocks to streams, having serious implications for nutrient enrichment of the coastline and coastal lagoons on the eastern side of the island.

Table 7: Summary of Water Quality Results from the Sea Elephant River at Bicentennial Road Bridge (November 2004 to September 2006) (Source: Baker 2006).

Parameters	Minimum Value	Median Value	Maximum Value	Number of Samples
Dissolved Oxygen (mg/litre)	0.1	5.4	8.3	22
Water Temperature (°C)	7.6	12.9	19.6	22
pH (Units)	5.3	6.2	7.2	22
Conductivity (µS/cm)	420	564	900	21
Turbidity (NTUs)	3.0	42.0	98.0	22
Total Phosphorus (mg/litre)	0.036	0.083	0.328	6
Total Nitrogen (mg/litre)	0.790	0.914	2.200	4

4.2.7 Fish and macroinvertebrates

Fish

Seven native and one introduced freshwater fish species occur at the site, none of which are considered threatened. All of the native species occur in the Sea Elephant River (PWS 2000). These are:

- short-finned eel (*Anguila australis*)
- spotted galaxias (*Galaxias truttaceous*)
- jollytail (*Galaxias maculatus*)
- climbing galaxias (*Galaxias brevipinnis*)
- Tasmanian smelt (*Retropinna tasmanica*)
- freshwater flathead (*Pseudophritis urvillii*)
- southern pygmy perch (*Nannoperca australis*)

The first six species listed above spawn in marine or estuarine zones, and the juveniles of these species disperse widely in estuaries and/or local coastal waters prior to re-entering freshwater (Donaghey 2003). Although the southern pygmy perch is regarded as a freshwater species, it has a high tolerance to salt. All of the species could occur in each???

According to Donaghey (2003), the Australian grayling (*Prototroctes maraena*), listed as vulnerable under the EPBC Act, has only been recorded once on the island but not during recent surveys, and is therefore either a vagrant or is locally extinct. However, Backhouse et al. (2008) list it as being recorded in three rivers on King Island (Ettrick, Duck and Detention Rivers), although none of these are in the Lavinia Ramsar site.

Rainbow trout (*Oncorhynchus mykiss*), an introduced fish, are also known from the site (PWS 2000).

Macroinvertebrates

One hundred and seventy invertebrates have been recorded for King Island or in the waters surrounding King Island (PWS 2000), over one hundred and forty of which are freshwater

species (Donaghey 2003). Although the macroinvertebrate faunas of the streams generally reflect stream condition (that is, the more degraded streams are dominated by macroinvertebrates that tolerate poor water quality and degraded habitat), it is not the same for the wetlands of King Island. Donaghey (2003) commented that "in contrast to the streams, each wetland on King Island has its own distinctive faunal community, which seems to bear little or no relationship with the condition of the wetlands. The faunal community in these wetlands is strongly dependent on the aquatic vegetation, which are in turn dependent on water regime and quality, and light conditions." Although only seven wetlands were sampled for the study, differences in the macroinvertebrate fauna were marked.

The data presented by Donaghey (2003) lists 17 species of aquatic macroinvertebrates found from a survey of the Sea Elephant River and 22 species found from a survey of Nook Swamp. The sampling sites were not provided and so the data from the Sea Elephant River may or may not be from within the Lavinia Ramsar Site. However, as the site encompasses the Nook Swamp, the data from Nook Swamp must be from within the site. The list of invertebrates is not complete and research into the species and their ecological requirements is needed (Donaghey 2003). The paucity of data on animal abundance highlights the need for faunal surveys and research in the reserve. Baseline data is vital to formulate management decisions.

Twenty-four macroinvertebrate species were collected at Sea Elephant Estuary during surveys in the late 1990s (Edgar et al. 1999). This was a mid range measure within a program that sampled 111 moderate to large estuaries around Tasmania. Some estuaries in the survey had as few as two species, whereas others had over 100 species. Within the 24 species collected at the Sea Elephant Estuary, eight were crustaceans, four were gastropods, four were bivalves, three were polychaetes and five were classed as 'other' (Edgar et al. 1999). The mean estimated biomass from the samples at the estuary was 84.6 grams per square metre and the productivity was 457.7 micrograms per square metre per day (Edgar et al. 1999). These figures were similarly in the mid-range of values obtained across the Tasmanian estuaries.

4.3 Critical Components and Processes of the Site

4.3.1 Wetland vegetation communities

The wetland vegetation of the site includes *Melaleuca ericifolia* swamp forest and forested peatlands, both of which are rare and vulnerable in the region and are therefore directly related to the listing criteria. Similarly, the wetland vegetation associated with wetland types H (Intertidal marshes), Ts (Seasonal/intermittent freshwater marshes & pools) and Tp (Permanent freshwater marshes & pools) are listed as vulnerable in Tasmania under schedule 3A of the Nature Conservation Act 2002 (Duncan 1986, Barnes et al. 2002; DPIW 2007) and therefore also form part of the listing criteria. These and other types of wetland vegetation at the site provide support for rare floral species and also provide habitat that supports rare, threatened and migratory faunal species, thereby highlighting the importance of wetland vegetation to the site's unique character. These communities could easily change through human disturbance, changes to the fire regime, or climate change. Such a loss would clearly be detrimental to the site's ecological character. These facts support its designation as a critical component to the site.

A description of the wetland vegetation communities, their floristic make-up, environmental influences and their locations within the landscape of the site is provided below.

***Melaleuca ericifolia* Swamp Forest – TASVEG Code NME**

The swamp forest community is dominated by swamp paperbark (*Melaleuca ericifolia*), with stands up to 30 metres tall forming a closed forest canopy. This swamp forest is seasonally inundated and dominates freshwater areas of the Nook Swamp. It also occurs locally in long,

unburnt swamps and along stream courses elsewhere within the Ramsar site. Scented paperbark (*Melaleuca squarrosa*) is associated with this community in the wetter areas, whereas manuka (*Leptospermum scoparium*) is associated with the community on the drier areas of the site. In general, the species diversity of swamp forest is very low, due to the dense nature of the canopy, with very few tall shrubs present and ground cover establishing at the edges and in gaps on the forest floor.

The high water table and low fuel loads on the forest floor where this community establishes inhibit the spread of ground fires, except in extremely dry seasons. However, the location of the swamp forest within the Lavinia State Reserve (predominantly the Nook Swamp), makes it vulnerable to wildfire fanned by westerly and north-westerly winds. If intense, wildfires could cause long term effects to the swamp forest.

In 1978, 4 years before Ramsar listing of the site, some of the swamp forest in the Nook Swamp was burnt by wildfire. The burnt area began regeneration through wet heath to wet scrub, but the remaining (unburnt) trees in the Nook Swamp are the oldest within the site, and are estimated to have been approximately 200 years old. Loss of any part of this rare and endangered (DPIW 2007) community type represents a real concern particularly as the remaining stand is one of the largest and best remaining in Tasmania.

Subsequent to listing, wildfires have again occurred within the site. These are discussed in 'Changes to ecological character since listing' (Section 7 of this document).

Graminoid Saltmarsh (Saline Sedgeland/Rushland) – TASVEG Code ARS

Salt marshes are restricted to areas that are periodically inundated by the sea, where the landforms protect the area from wave action, providing a low energy zone that enables fine sediments to accumulate. On King Island saltmarsh is restricted to the estuaries of the Sea Elephant River and the Yellow Rock River, the former being within the Lavinia Ramsar Site.

Graminoid saltmarsh is the more widespread of the two saltmarsh types defined for the site and occupies the less saline and slightly less waterlogged areas of the estuary (i.e. typically just inland of the succulent saltmarsh). This community is dominated by sea rush (*Juncus kraussii*) with an intertussock flora of beaded glasswort (*Sarcocornia quinqueflora*), and halophytic herbs/sedges, such as creeping brookweed (*Samolus repens*), swampweed (*Selliera radicans*) and Shiny bog-sedge (*Schoenus nitens*).

Succulent Saltmarsh – TASVEG Code ASS

Succulent saltmarsh is found near the mouths of estuaries and inlets, where the inundation occurs more frequently and the water is more saline. The most common succulent herb is beaded glasswort (*Sarcocornia quinqueflora*), which occupies the most saline and moist frequently inundated areas. shrubby glasswort (*Tecticornia arbuscula*) heath occurs in slightly less saline and less waterlogged areas and in Sea Elephant Estuary it forms a narrow strip which fringes the lower reaches of the eastern shoreline. There is a transition zone between the two succulent communities, and beaded glasswort is common as an understorey of the shrubby glasswort heath community.

Lacustrine Herbland – TASVEG Code AHL

Herbfields marginal to wetlands occur as a thin fringe around wetlands where the water level fluctuates. They usually have high diversity and are characterised by species that are usually less than 50 cm high. Common species include mossy pennywort (*Hydrocotyle mucosa*), angled lobelia (*Lobelia alata*), swamp weed (*Selliera radicans*) and creeping brookweed (*Samolus repens*).

Within Lavinia State Reserve, marginal herbfields are found around the edges of Pennys Lagoon and on the southern and western sides of Lake Martha Lavinia.

Freshwater aquatic sedgeland and rushland – TASVEG Code ASF

These wetlands often occur around large lagoons and are often localised, small and patchy. They develop on soils that are frequently (or permanently) inundated with water ranging from fresh to saline and have a deep peat soil. They are typically dominated by sedges and rushes of the genera *Juncus*, *Baumea*, *Carex*, *Eleocharis*, and *Lepidosperma*, with very few shrubs or herbs. Within Lavinia State Reserve, sedge/rushland is found along the edges of Pennys Lagoon and Lake Martha Lavinia.

Short Paperbark Swamp – TASVEG Code SMR

This community type is dominated by a dense layer of scented paperbark (*Melaleuca squarrosa*) and manuka (*Leptospermum scoparium*), to a height range of 2 to 8 metres. They occur through the Lavinia Nature State Reserve on deep, poorly drained peaty soils. Similar to the swamp forest communities, the dense canopy of short paperbark swamp communities usually inhibits the growth of low shrubs or ground cover species. Typically only spreading rope rush (*Empodisma minus*), saw sedge (*Gahnia grandis*) and, occasionally, tassel cordrush (*Baloskion tetraphyllum*) can form thickets within this community, and often these become light deprived as the canopy thickens after the last fire. Short paperbark swamps have high conservation value as they are relatively rare on King Island and have high biodiversity value, especially when they are part of a continuous vegetation mosaic, as is the case in the Lavinia State Reserve.

4.3.2 Regional rare plant species

The plant species listed as rare within the bioregion are clearly directly related to the listing criteria, and part of the site's unique character. Their reliance upon wetland habitat makes them vulnerable to change through the same threats to the wetlands of the site, and their loss would be detrimental to the site's character. These facts support their designation as a critical component to the site. Six wetland associated species considered rare within the bioregion have been recorded at the site:

- showy willowherb (*Epilobium pallidiflorum*);
- hairy brooklime (*Gratiola pubescens*);
- fan triggerplant (*Stylidium beaugleholei*);
- small triggerplant (*Stylidium despectum*);
- submerged watertuft (*Trithuria submersa*); and
- pink bladderwort (*Utricularia tenella*)

Showy willowherb is a perennial plant, described as growing along riverbanks or in swamps (Botanic Gardens Trust 2010), and inhabiting wet places (DPIW 2009). In 2003, the Mount Faulkner Conservation Area was the only known Tasmanian reserve with this species, indicating the importance of the population at the Lavinia Ramsar Site.

Hairy brooklime is a perennial herb that grows in damp or swampy ground, and lake margins (Botanic Gardens Trust 2010). In Tasmania the species is most commonly located in permanently or seasonally damp or swampy ground (DPIW 2009). Gap-forming disturbance, such as fire, may be required by Hairy brooklime to enhance seedling recruitment (DPIW 2009). However, there is insufficient information regarding the ecology of this species and DPIW (2009) recommended that management actions should not use fire as a tool until further studies have been conducted.

Fan triggerplant is recorded as occupying hollows, wet areas and soaks, often with a peat soil (DPIW 2009). Similar to hairy brooklime, fan triggerplant may benefit from suitable fire frequencies that reduce competition for light from the surrounding taller shrubs (DPIW 2009).

Small triggerplant is an annual herb described as growing in drying swamp flats and watercourses (Botanic Gardens Trust 2010) and in Tasmania, grows in moist habitat such as

wet-soaks (often with a peat soil), muddy flats and saline swamps along the coast in the north of the State (DPIW 2009). The Lavinia Ramsar Site is one of the key areas for this species and also one of four reserves in which the species occurs (DPIW 2009). Similar to fan triggerplant, this species may benefit from suitable fire frequencies that reduce competition for light from the surrounding taller shrubs.

Submerged watertuft is an annual herb, found growing in areas subjected to flooding, and shallow temporary depressions and small watercourses (Botanic Gardens Trust 2010) and in Tasmania is typically found submerged in marshy, freshwater habitat (DPIW 2009). In 2003 it was listed as occurring in three reserves, none of which were the Lavinia Ramsar Site.

Pink bladderwort is a small herb found in wet heaths on the islands of Bass Strait (DPIW 2009). In 2003 it was not known to occur in any reserves, although it was known to occur on King Island (DPIW 2009).

4.3.3 Scrambling ground fern

The nationally-listed scrambling groundfern is also directly related to the listing criteria, and part of the site's unique character. Scrambling groundfern was considered to be endemic to New Zealand until its discovery in 1973 at the margins of the Nook Swamps (Threatened Species Unit 2011a). It is found in poorly drained areas at the scrubby margins of swamp forests. There are less than 1000 known individuals of the species across Tasmania and its total areal extent is less than 3 hectares. Within the Nook Swamp, there are an estimated 200 individuals, occupying an area of approximately 0.4 hectares.

4.3.4 Swamp fireweed

Swamp fireweed is similarly directly related to listing and the site's unique character, and hence a critical component. The total population of swamp fireweed in Tasmania is likely to be less than 250 plants, occupying less than one hectare in total. The species has been found in six widely scattered sites in Tasmania, exacerbating the risk of population losses from chance events (Threatened Species Unit 2011b). Within the site there are estimated to be less than 50 individuals, occupying an area of approximately 25 square metres (Threatened Species Unit 2011b).

4.3.5 Regionally rare bird species

Similar to the plant species listed as rare within the bioregion, the regionally rare bird species are directly related to the listing criteria, part of the site's unique character, vulnerable to change through the same threats to the wetlands of the site, and their loss would be detrimental to the site's character. These facts support their designation as a critical component to the site.

Two bird species recorded at the site are rare in the bioregion and dependent of the wetland habitat provided by the site. These are the white bellied sea eagle and the eastern curlew. The diets and preferred habitats of these two species are presented in section 3 of this document (Ecosystem Units). Both species use habitats found in the Sea Elephant Estuary and also within the Coastal Strip, with the white bellied sea eagle using the open waters of these ecosystems for hunting and the eastern curlew using the sheltered shallows (and occasionally open beaches) for hunting prey. The white bellied sea eagle is likely to roost and breed in the taller trees found in the Nook Swamp whereas the eastern curlew typically roosts in the vegetation types found around the Sea Elephant Estuary, such as sheltered beaches and salt marshes (see Table 5).

4.3.6 Striped marsh frog

The striped marsh frog is another regionally rare species. Although it is widespread and common along the eastern seaboard of mainland Australia, it is uncommon in Tasmania, confined to the north east and far northwest (including King Island (PWS 2010)).

This species is predominantly a pond-dweller but is reported to be able to adapt to a range of water habitats (Australian Museum 2010). Within the site there are a range of water habitats, although the permanent ones would mostly be restricted to the Nook Swamp and the perched lakes within the Dunes Ecosystem.

4.3.7 Orange-bellied parrot

The orange-bellied parrot is one of three faunal species at the site that is dependent on the wetland habitat of the site and also listed as significant at the national level (Critically Endangered, EPBC). The orange-bellied parrot is endemic to south-eastern Australia, migrating yearly from the breeding site in south-western Tasmania, in a northward direction, along the western and north-western coast of Tasmania and through western Bass Strait, to spend the non-breeding period on the mainland. They return via the same route (DEWHA 2009b). The breeding area of the orange-bellied parrot is restricted to south-western Tasmania, and during the northward migration birds have regularly been recorded on King Island and most, if not all, of the population is believed to pass through this location (Brown & Wilson 1984).

The primary feeding and roosting sites for the parrot within the site are the salt marshes within and surrounding the Sea Elephant Estuary. They also occur in dense clumps of swamp paperbark, such as those found in the Nook Swamp.

The entire known wild orange-bellied parrot population exists as one population and is unlikely to exceed 150 individuals (Commonwealth of Australia 2005; DEWHA 2009b, Birdlife International 2010). Recent modelling has suggested that this species could become extinct within 3 to 5 years and has prompted an increase in capture of wild birds to boost the captive breeding program for the species (DSEWP & C 2010).

4.3.8 King Island scrubtit

The King Island scrubtit (critically endangered EPBC) is the second of three nationally listed faunal species that is dependent on wetland vegetation habitat at the site. It is confined to remnant habitat patches on King Island and its core critical habitat is the tall mature swamp paperbark forest in the Nook Swamps (Donaghey 2011). The number of individuals and the area inhabited by the species appears to be decreasing (DEWHA 2009b; Donaghey 2011). The diet of the King Island scrubtit is unknown but expected to consist of insects, spiders and snails (DEWHA 2009b). it has been observed foraging low to the ground in dense undersotrey floiage, and at elevations in the canopy of swamp paperbark forest (Donaghey 2011).

4.3.9 Green and gold frog

The green and gold frog (also known as the growling grass frog and the southern bell frog) is the third faunal species at the site that is dependent on the wetland habitat of the site and also listed as significant at the national level (Vulnerable, EPBC). The species has declined dramatically across its range. Population studies have shown that green and gold frog populations are positively influenced by permanent water, the extent of aquatic vegetation, extensive riparian or floodplain grasslands and the presence of other nearby green and gold frog populations (Heard et. al. 2004). The species is dependent upon permanent freshwater lagoons for breeding. The ideal breeding habitat is the shallow part of still or slow-flowing lagoons, generally with a complex vegetation structure (DEWHA 2009b). Despite their requirement for permanent water for breeding, they also require terrestrial habitat (such as

grasslands and forests), feeding mainly on terrestrial invertebrates such as beetles, termites, cockroaches, moths, butterflies and various insect larvae (DEWHA 2009b).

4.3.10 Waterbirds and seabirds

The avifauna is perhaps the most conspicuous and most studied component of King Island's fauna. In 1971, a report describing the results of faunal surveys on the Island (Green and McGarvie 1971) estimated 164 bird species (156 confirmed) recorded from the Island and its adjacent waters, including one species introduced from the Australian mainland and nine non-Australian species. Those authors noted that a number of species would 'undoubtedly be added by further observations', and this has been the case with subsequent tallies of 'over 170' (PWS 2000) and 182 (Donaghey 2003). This compares with 212 species recorded for Tasmania (Donaghey 2003). King Island has 86 species of land and freshwater birds recorded breeding on the island or as regular visitors and 12 species of resident or breeding marine birds or waders (Donaghey 2003).

The three reports noted above provide species numbers of birds across the whole of King Island. One report (PWS 2000) also provides a list of 144 species that have been recorded within the Lavinia Ramsar Site. Of these 144 species, more than half (74 species) are waterbirds or seabirds. The list in PWS (2000) does not include the little tern noted by Bryant (2002) to occur and breed at the site. Therefore, at least 75 species of waterbirds and seabirds have been recorded at the site, including the IUCN redlisted fairy tern.

The identification of the component 'waterbirds and seabirds' as critical, lies in the fact that the site provides breeding habitat for several of these species. Six of these have been recorded breeding at the site. These are: the hooded plover, little tern, fairy tern, Australian pied oystercatcher, short-tailed shearwater and the little penguin.

4.3.11 Migratory birds

The site supports ten migratory birds listed on the CAMBA/JAMBA/ROKAMBA agreements. These are:

- ruddy turnstone (*Arenaria interpres)*, which have a habitat preference of rocky reefs and shores washed by surf;
- sharp-tailed sandpiper (*Calidris acuminata*), which are typically found around the grassy edges of shallow inland freshwater wetlands but are also found around mudflats, estuaries, rocky shores and beaches;
- red-necked stint *(Calidris ruficollis)*, which use a range of habitats, including sandy or shellgrit beaches, tidal mudflats, lake/lagoon shores, and saltmarsh;
- white-throated needletail (*Hirundapus caudacutus*), which are non-breeding migrants in Australia;
- caspian tern (*Hydroprogne caspia)*, which are found near the coast, in extensive wetlands, on coastal and interior beaches and sheltered estuaries;
- greenshank (*Tringa nebularia)* which may prefer swamps and saltmarshes but are also found on beaches.
- short-tailed shearwater (*Puffinus tenuirostris*), which nest in rookeries within the coastal strip;
- little tern (*Sterna albifrons*), which breed in parts of the Coastal Strip of the site;
- cattle egret (*Ardea ibis*), which use a wide range of wetland habitats, including peatlands, estuaries and lagoons; and

- great egret (*Ardea modesta*) which, similar to the cattle egret, use a wide range of wetland habitats, including peatlands, estuaries and lagoons;

Therefore, as well as being critical to the site's ecological character, these species are also protected under international agreements.

4.4 Benefits and Services of the site

DEWHA (2008), states that benefits and services should be described in accordance with the Millennium Ecosystem Assessment (2005) definition of ecosystem services. This definition is: 'the benefits that people receive from ecosystems'. This definition focuses on the benefits that people receive from ecosystems (economic, social and cultural) although they may not benefit humans directly.

The Millennium Ecosystem Assessment (2005) identifies four main categories of ecosystem benefits and services:

- **Provisioning services —** the products obtained from the ecosystem such as food, fuel and fresh water.
- **Regulating services —** the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation.
- **Cultural services —** the benefits people obtain through spiritual enrichment, recreation, education and aesthetics.
- **Supporting services —** the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

The majority of the Lavinia Ramsar Site is not operated for any extraction of products such as food, fuel or water, nor is it used for any regulatory services. A notable exception to this is the use of the Sea Elephant Estuary for aquaculture (oyster farming). A more minor exception is the use of water from the lagoon at Sea Elephant Estuary for fire-fighting emergencies. Both these are discussed within the benefits section below.

Any climatic regulation within the site is unmeasured and is likely to only occur at a very local scale. The site is popular for passive recreation, surfing and four-wheel driving.

Benefits and services for Ramsar sites (DEWHA 2008) include:

- direct benefits to humans derived from the site (provisioning, regulating and cultural services); and,
- non-anthropocentric ecosystem supporting services derived from the site.

Benefits to humans derived from the site include:

- provision of water for aquaculture;
- provision of water supply for fire fighting;
- Tourism/recreation (land-based and water-based);
- educational and scientific values including studies on orange-bellied parrots, saltmarsh ecology, shorebirds, dune geomorphology, dune vegetation ecology; and
- cultural heritage (Indigenous and European).

The ecosystem supporting services provided by the site include a site which:

- supports rare wetland types and types representative of the bioregion;
- supports regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna;
- support for regionally threatened species, including six plant, two bird and one frog species;
- provision of habitat for three nationally threatened fauna species (green and gold

frog, orange-bellied parrot and King Island scrubtit) and two flora species (scrambling groundfern and swamp fireweed);

- provision of nesting habitat for waterbirds and seabirds (including the IUCN isted fairy tern); and
- provision of habitat for ten migratory bird species listed under international agreements.

The benefits and services provided by the site are shown in Table 8.

Table 8: Ecosystem benefits and services provided by the Lavinia Ramsar Site.

Category of Ecosystem Benefit/service	**Ecosystem Benefit/service**	**Description**
Provisioning services	Aquaculture.	The Sea Elephant Estuary ecosystem within the site is used for oyster farming.
	Water supply (fire fighting).	Water from the Sea Elephant Estuary can be taken for use in fire fighting, specifically for use if the saltmarsh of the estuary is burning.
Cultural services	Tourism/recreation.	The site is used for land a water based tourism/recreation, including surfing, four-wheel driving, picnicking, and bird-watching.
	Scientific/educational.	The site has been the subject of several biological, ecological and geomorphic studies and is likely to be again.
	Heritage.	There is a possible archaeological site connected with colonial whaling and sealing operations at the southern end of the site.
Supporting services	Supports rare and representative wetland types.	The site supports wetland vegetation communities listed as rare in the bioregion; and with substantial parts of the site in near natural condition several wetland types at the site are representative condition for the bioregion.
	Supports regional biodiversity.	Through its range of habitat types, geomorphic settings and hydrological systems, the Site supports a range of species dependent upon lake, swamp, peatland and coastal freshwater lagoon habitat.
	Supports regionally threatened species.	The site supports six plant, two bird and one frog species listed within the bioregion.
	Supports nationally listed species.	The site supports populations of three nationally listed fauna and two flora species.
	Nesting habitat for waterbirds and seabirds.	At least four species of resident shorebirds and two species of seabirds are known to breed at the site, including the fairy tern.
	Habitat for migratory	Ten migratory bird species listed in

Category of Ecosystem Benefit/service	Ecosystem Benefit/service	Description
	species.	international agreements use the habitats provided by the site.

4.4.1 Critical Benefits and Services

The critical services supporting the ecosystem(s) of the site can be identified using the same determinants as those used for selecting the critical components and processes (DEWHA 2008). These are the services:

- that are important determinants of the site's unique character;
- that are important for supporting the Ramsar criteria under which the site was listed;
- for which change is reasonably likely to occur over short to medium time scales (<100 years); and
- that will cause significant negative consequences if change occurs.

None of the provisioning services or cultural services presented in Table 8 meets the first two of these determinants and most don't meet the third or fourth determinants. In contrast, each of the supporting services meets all four of the determinants: they are central to the character of the site; they are directly linked to the Ramsar criteria for which the site was listed; they could potentially change in the next 100 years; and their change would result in a negative change in the ecological character of the site.

4.4.2 Linking services to processes and components of the site

Each critical ecosystem service identified in section 4.4.1 supports one or more criteria for which the site is designated, and links in with specific components of the site through ecological processes. These are presented in Table 9. The linkages between the components, process and services are provided in Figure 18.

Table 9: Ecosystem services provided by the Lavinia Ramsar Site with relevant processes and components.

Ecosystem Services	Ecological Processes Creating/Supporting the Service	Specific Components & Processes
Supports rare and representative wetland types (criterion one)	Maintenance of landforms (and land forming dynamics) that provide the base for the estuary ecosystem and saltmarshes.	Geomorphology, hydrology, climate, terrestrial vegetation (via geomorphology), fire regime (via terrestrial vegetation).
	Provision of fresh water volumes and quality for estuary ecosystem requirements (including saltmarshes).	Hydrology, water quality.
	Provision of occasional influx of marine waters for saltmarsh.	Geomorphology.
	Maintenance of physical features that provide the base for the Nook Swamp and surrounding wetland mosaic (including extensive peatlands, coastal lagoons and perched lakes) within the Dunes	Geomorphology, hydrology, climate, terrestrial vegetation (via geomorphology), fire regime.

Ecosystem Services	Ecological Processes Creating/Supporting the Service	Specific Components & Processes
	ecosystem.	
	Provision of fresh water regime for maintenance of wetland mosaic in Dunes and Sandsheet ecosystems.	Hydrology, geomorphology.
Supports regional biodiversity (criteria one and three)	Supports rare and representative wetland types (criterion 1).	
	Provision of a habitat for rare plant species (criterion 3).	
	Provision of a habitat for rare animal species (criterion 3).	
Supports regionally rare/threatened species (criterion three)	Provision of a habitat for six regionally rare plant species.	Wetland vegetation habitat*.
	Provision of a habitat for regionally rare bird species (white-bellied sea eagle, eastern curlew).	Wetland vegetation habitat*, (including fish and invertebrates).
	Provision of a habitat for regionally rare frog species (striped marsh frog).	Wetland vegetation habitat*, water quality, terrestrial vegetation, hydrology, food (including invertebrates).
Supports populations of threatened species (criterion two)	Provision of water regime and habitat to meet the ecological needs and the maintenance of nationally listed bird (orange-bellied parrot, King Island scrubtit), frog (green and gold frog) and plant (scrambling groundfern, swamp fireweed) species, and an IUCN redlisted bird (fairy tern).	Wetland vegetation habitat*, hydrology, terrestrial vegetation, climate, water quality, food (including fish and invertebrates).
Provides nesting habitat for waterbirds and seabirds (criterion four)	Provision of habitat for species that breed on-site.	Wetland vegetation habitat*, food (including fish and invertebrates).
Provides habitat for migratory species (criterion four)	Provision of habitat for wetland-dependent, listed migratory species.	Wetland vegetation habitat*, (including fish and invertebrates).

*includes all components and processes that support wetland habitat

5. KEY ACTUAL OR POTENTIAL THREATS TO THE SITE

Following a thorough review of the relevant documentation, inputs from local land holders and the project Steering Committee, the drivers of the major actual and likely threats to the Lavinia Ramsar Site were identified as:

- Community attitudes;
- Fire;
- Recreation (primarily vehicle use);
- Catchment impacts on water quality;
- Drainage in the upper catchment;
- Past land clearance;
- Weeds;
- Acid sulphate soils;
- *Phytophthora cinnamomi* (dieback fungus);
- *Batrachochytrium dendrobatidis* (chytrid fungus);
- Feral cats;
- Aquaculture;
- Climate change; and
- Mining.

Community Attitudes

Driver/stressor models of these threats are presented in Figure 23, Figure 24 and Figure 25. These models have been modified from a structure presented in Davis and Brock (2008) to include a social component (local community attitudes) above the primary 'driver' level. Attitudes of local communities are likely to be an influential force upon threatening processes for many wetlands. In a geographically isolated location such as King Island, issues of 'local community rights' versus 'government-imposed regulations' have high potential to govern the extent and severity of threat drivers. As Lovibond (2007) states, "King Islanders consider coastal access, privacy, freedom, and tradition to be valuable social assets, *and that management actions perceived to compromise these values will engender little cooperation from the community*" (emphasis ours).

The most readily identifiable influence of community attitudes on the Lavinia Ramsar Site ecosystem occurs through recreational driving within the reserve, particularly in the Sea Elephant Estuary and the Coastal Strip Ecosystems. This is also likely to be one of the most difficult issues to resolve, with unregulated coastal driving considered by many to be a long-held right of the community. Physical impacts of this activity are discussed below, but it is important to emphasize that programs fostering community ownership and pride in the site need to be maintained and may provide important benefits if used in conjunction with barriers to site access.

Threats from fire and from land management upstream of the site are also affected by local community attitudes. Discussions with members of the local community suggest that at least one recent major fire was deliberately lit. The use of fire in land and vegetation management must be regulated following detailed discussions with all stakeholders, including Government, local community, landowners and local fire volunteers.

Attitudes of the local community also impact through past drainage and land clearance of the upper catchment. The impacts of past land clearance on salinisation of the soils and on

the receiving surface waters of the catchment are difficult to reduce (Dyson undated), as the process has already resulted in the liberation of salts from the groundwater. Similarly, threats from drainage of the upper catchment will be difficult to manage, as the alteration of flow regimes leads to alteration of channel shapes and sediment transport in stream systems. The drainage of Egg Lagoon began nearly a century ago (in 1911), with subsequent extensions in 1920 and 1924 (Jordan 1975). Therefore the influence of community attitudes lies in ameliorating the effects of actions taken by previous generations, rather than determining whether or not drainage occurs.

Management of the riparian zones of streams that drain into the site also contains an element of attitude, although this may be difficult to separate from economic capacity. An examination of socio-economic drivers is beyond the scope of an ECD, but should be included within a management plan for the site.

Fire

Fire threatens many components of the Lavinia Ramsar Site. The most serious threat posed by fire to the ecosystem is that of burning the Nook Swamp. Although the high water table and low fuel loads on the forest floor of the Nook Swamp tend to inhibit the spread of fires, its loss would be of major consequence to the Ramsar site. The Nook Swamp and the surrounding peatlands could be severely impacted or even lost with a sufficiently hot fire. Hydrological changes caused by drainage and climate change increase the site's vulnerability to burning during periods of high fire danger. Many of the State and Commonwealth listed species within the site are dependent on the Nook Swamp and loss of this habitat could lead to a substantial change in ecological character.

The scrub and woodland communities surrounding the Nook Swamps can accommodate some burning – or even require an occasional burn. However, their greater propensity to burn results in them also being at high risk from fire.

Fire is not generally considered a threat to saltmarsh vegetation (Kirkpatrick and Glasby 1981; Barnes et al. 2002), although Duncan (1986) notes that no conclusive studies have been done on this. Saltmarsh vegetation is considered to be able to recover after fire unless the burning is followed by grazing (Kirkpatrick and Glasby 1981). However, unlike other vegetation communities within the site, saltmarsh does not need burning for its regeneration or maintenance, and even if regeneration was relatively rapid, burning of the saltmarsh vegetation around the Sea Elephant Estuary would have a major impact on the ecological character of the site through the loss of feeding and roosting areas for the orange-bellied parrot. The habitat needs of the parrot occur every year and it is not reasonable to expect a regeneration phase of the salt marsh to be sufficient for the needs of the orange-bellied parrot. Hence fire should be excluded from the saltmarsh whenever possible, with the best fire management regime for this ecosystem being 'no fire' (Barnes et al. 2002).

Beyond the saltmarsh, other areas used for roosting by the orange-bellied parrots, such as dense clumps of swamp paperbark (*Melaleuca ericifolia*) and coastal wattle (*Acacia sophorae*) near the estuary, are considered particularly susceptible to fire under northerly to south-westerly conditions (Brown and Wilson 1984).

Another major risk from fire is the potential for blowouts (sandy depressions in a sand dune system caused by the removal of sediments by wind). The immediate reduction in vegetation cover after fires also increases the vulnerability of the fore dunes to blowouts. This has the potential to lead to a complete loss of vegetation cover until pioneer species can establish and begin revegetation of the blowout. Changes to dune vegetation cover and stability have the potential to impact on the nesting of shearwaters and little penguins at the site.

A fire that was too hot or a fire regime that included too frequent burning could result in replacement of the existing vegetation mosaic with a floristically poorer cover of bracken-

field, leading to reduced shrub cover and hence less structural complexity of the habitat. Bracken-field can be a self-maintaining vegetation cover, as its rapid build-up of light fuel tends to make it more fire prone than other vegetation associations within the site, resulting in frequent cool burns which suit its mode of vegetative propagation. This has the potential to impact the Dunes and Northern Sandsheet Ecosystems in particular. An inappropriate fire regime could also help the establishment of weed species, leading to changes in the floristic structure and habitat provision of the site.

Recreation (vehicles and tracks)

The impact of vehicles on the vegetation of the site has been documented in several reports (e.g. Donaghey 2003; PWS 2000). Within the site, the two major areas currently threatened by vehicle are the Sea Elephant Estuary and the coastal strip. Within the Sea Elephant Estuary, vehicles and motorbikes have caused considerable damage to the saltmarsh community (PWS 2000). The saltmarsh species are extremely fragile, easily destroyed, and take many years to regenerate. Surface hydrology and drainage patterns may also be changed by vehicle use, leading to loss of species diversity and changes to distribution patterns (Barnes et al. 2000). As well as providing habitat for orange-bellied parrots, saltmarsh communities also stabilise the coastal landforms and contribute significant amounts of organic matter to receiving estuaries – providing nutrients for fish and other fauna (Barnes et al. 2000). Although not depicted within Figure 23, loss of the saltmarsh vegetation through vehicle use also contributes to soil erosion (PWS 2000).

The impact of vehicles within the coastal strip is primarily related to the risk they pose to nesting shorebirds. Although there are other threats to the nest sites, such as dogs and walkers, there is a lot of use of the beach for driving, and from a moving vehicle it can be very difficult to see the nests. As the birds nest above the high tide line of the beach, restricting driving to below the tide line may be a reasonable approach. However, management decisions should be assisted by targeted research into the stress created for the nesting birds from having vehicles close to the nests. Use of recreational vehicles within Lavinia also has the potential to further spread weeds and diseases to flora and fauna species that are at risk to these threats.

As discussed earlier, a key to reducing this threat lies in working with the local community to achieve attitudes and outcomes that are acceptable for conservation and recreation.

Catchment impacts on water quality

Land use in the upper catchment of the Sea Elephant River has been described as an ongoing threat to the saltmarsh communities (Barnes et al. 2002). As described in Section 3.1.1, the water quality of the Sea Elephant Estuary is unknown, although data from the Sea Elephant River upstream of the site suggest elevated nutrients and low dissolved oxygen concentrations. The causes of these have been identified as poor riparian vegetation and unlimited stock access to the stream channel (Bobbi 1999) and works have commenced to ameliorate these impacts (Baker 2006). However, there is insufficient information to determine whether the works are reducing the land use impacts and if so, whether the Estuary is showing effects of the initial impacts.

Drainage of the Upper Catchment

The two major effects of draining the wetlands of the upper catchment are the impacts on stream condition (water quality and channel stability) and the lowering of the wetlands' water table leading to desiccation of the wetlands/peatlands and increased probability of fire. As discussed for the conceptual model of the Dunes Ecosystem (Figure 14, p77), the artificial drains from Egg Lagoon deliver rainfall more quickly to the stream channel, leading to faster and deeper floods with associated erosion and accompanied by lower base flows during dryer periods. During these high flow events high pulses of nutrients and sediments are delivered to the wetlands of the Nook Swamp. The elevated nutrients can lead to

eutrophication of the waters, creating excessive algal growth and associated stresses to the aquatic biota. Land use in areas of cleared private land in the catchment upstream of the site can exacerbate the eutrophication, through the application of fertiliser to pastures. Any runoff from these areas flows into the Lavinia Nature Reserve (PWS 2000).

In contrast, during dryer conditions and lower inputs, the wetlands and peatlands may dry out at the surface, losing the wet organic soil layer and/or becoming more susceptible to burning. During low flows the waters in contributing waterways are likely to have increased salinity due to greater groundwater influences, also stressing the biota of the system.

Past Land Clearance

Clearance of vegetation within parts of the catchment upstream of the Lavinia Ramsar Site has contributed to an altered water balance for the catchments. This new water balance results from less evapotranspiration of rainfall and a consequent build-up of groundwater. The increased height of the water table mobilises salts that have built up in the soils and leads to discharges due to local, 'sluggish' groundwater systems (Dyson, undated). The extent to which this issue has impacted plant communities of the Dunes Ecosystem in the past, or will in the future is a knowledge gap. However, increased salinity through past land clearance does pose a likely threat to the vegetation communities of this ecosystem.

Weeds

There are six weeds of national significance on King Island and 21 weeds recorded on the Island are listed as declared weeds in the Tasmanian Weed Management Act 1999 (KINRMG 2010a). Weeds that pose a threat to the wetlands of the site include:

- bulrush (*Typha* spp.);
- thistles (*Carduus* sp. and *Cirsium vulgare*);
- horehound (*Marrubium vulgare*);
- ragwort (*Senecio jacobaea*);
- sea spurge (*Euphorbia paralias*);
- asparagus fern (*Asparagus scandens*); and
- several pasture species.

There are also currently infestations of thistles (*Carduus* sp. and *Cirsium vulgare*) in the Nook Swamp area and horehound (*Marrubium vulgare*) and ragwort (*Senecio jacobaea*) have been found at the northern end of the reserve on the Nook track, although it is not known if they were present at the time of listing. Sea spurge populations have established along all beaches within the reserve. Areas of high conservation value, including the Lavinia reserve have been identified in the top priorities for sea spurge management and control activities (KINRMG 2010b). *Typha* has invaded the Nook Swamp following the 2007 fires (Corbett 2010a and b).

Acid Sulphate Soils

There is a high likelihood of potential acid sulphate soils (PASS) at the site, particularly at Nook Swamp, the interdunal peats, and the Sea Elephant Estuary. Acid sulphate soils have the potential to have a major impact on wetlands and disturbance of potential acid sulfate soils (PASS) may significantly impact on the critical components and services of the site.

Phytophthora cinnamomi (Dieback Fungus)

Phytophthora cinnamomi (Pc) is a destructive and widespread exotic species of water mould carried in soil and water that causes root-rot disease symptoms (dieback) and eventual death to a wide variety of native and introduced plant species (DEH 2009). Species impacted by *Pc* include a large number Tasmanian native plant species in moorland, sedgeland, heath, open forest and disturbed rainforest (PWS 2000, DPIW 2009c). Pc has the potential to significantly alter the ecology of these vegetation types. The disease is present on King

Island and is widespread in Lavinia State Reserve along roadsides and fire-trails. It is also likely to be present along fence lines between the reserve and adjacent private land. Spread of the pathogen from these points of infection is facilitated by the sandy texture of the substrate, the mild climate, frequently moist conditions, off-road use of vehicles and transport of spores by wildlife (PWS 2000).

Although the disease can spread by natural means, it is spread more rapidly and over greater areas by human activity. It can be spread in infected soil carried on boots, wheels and tracks of vehicles and machinery and by animals, which scratch or dig in the soil (PWS 2000). It can also spread by water percolating through the soil or in creeks. Some threatened plant species in Tasmania are known to be declining as a result of *Pc* and more threatened species could also be affected should the fungus be introduced to their populations (DPIW 2009c).

Batrachochytrium dendrobatidis (chytrid fungus)

Chytrid fungus is a fungus that infects the skin of frogs, destroying its structure and function, and can ultimately cause death (DPIWE 2010). The site was tested and found to be positive for chytrid by DPIPWE (tested 24/11/2009) (DPIPWE unpublished information). Although several frog species were found to be present at the site, the long term impacts of chytrid fungus on the frog fauna of the site are currently unknown. Accordingly, this pathogen should also be considered a threat to the ecological character of the site, through its amphibian fauna.

Feral Cats

Feral cats have been mentioned in discussions with local land managers and are noted in several reports as posing a threat to the native wildlife, including the orange-bellied parrot, other bird species and small reptiles and mammals (e.g. Donaghey 2003; OBPRT 1999; PWS 2000;). However, no data was found in relation to feral cat impacts. PWS (2000) notes that feral cats have been observed throughout the Lavinia Nature Reserve and that they are considered a major threat to the orange-bellied parrot because the birds' habit of feeding on low saltmarsh makes them susceptible to predation.

Feral cats were trapped around a feeding site for the orange-bellied parrot during autumn and winter from 1992 to 1995 (OBPRT 1999). After the closure of the Naracoopa rubbish tip in 1995, cat numbers were reported to drop dramatically in the area. There appears to be an awareness of the feral cat threat to the parrots, with OBPRT (1999) noting that a mining proposal included a 'no cats on site' policy, securing all refuse and conducting cat trapping throughout the course of the proposed mining operations.

Aquaculture (Oyster Farm)

The two main threats posed by the oyster farm in the Sea Elephant Estuary are the potential inputs of nutrients from feeding and the occasional opening of the barred estuary for tidal flushing. The estuary opens naturally at irregular intervals. Discussions with resource managers suggest that the estuary is artificially opened on rare occasions (possibly three or four times in the last fifteen years). However, no data for artificial openings nor for water quality impacts of the oyster farm were found.

Other potential impacts of the oyster farm include the impacts of farm vehicles driving within the estuary. The aquaculture lease permits the holders to drive within the estuary once per day, which impacts on the saltmarsh. However, if the river level is too high the lease holders drive along the beach and gain access from the coast, which also impacts on the reserve. Vehicular access within the estuary may also disturb orange-bellied parrots.

Climate Change

Major impacts of predicted climate changes include those associated with rising sea levels, decreased precipitation and increased temperatures. Although climate change projections

contain a high level of uncertainty in terms of magnitude, changes in temperature and rainfall statistics at King Island over the last half century are in accord with climate modelling that predicts lower rainfall and higher temperatures across south-eastern Australia (Timbal and Jones 2008). Similarly, sea level rises over the last half century have been documented and are projected to continue to rise (Rahmstorf 2007). This would lead to potential inundation of the site and beach translation.

Although there is little that can be done at the site or regional scale in terms of stopping rising sea levels, there are management options that can be taken to reduce the *impacts* of rising sea level, including vegetation protection, fire regime management and revegetation.

Another issue associated with climate change is the potential influence of local prevailing wind currents on the coastal landforms of the site. If local wind currents change in magnitude or direction, it is conceivable that the barrier may be diminished or removed by new land-forming processes, potentially opening up the estuary.

Although changes to rainfall, evaporation and temperature may have some impact on water yield of the catchment, the greatest threat to the ecosystem from dryer conditions due to climate change is likely to be through increased fire risks. Higher temperatures and evaporation will increase the likelihood of wildfires across the island. This will need to be factored into management planning.

Mining

Mining leases have been granted to Tasmanian Titanium Pty Ltd. to mine mineral sand south of the Lavinia State Reserve and near the township of Naracoopa. (PWS 2000). Until it is determined whether a mine is to be established, and what its size and environmental management systems will be, this remains a potential threat to the geomorphology of the site and hence the landform base on which the ecosystem is built. Mining Lease 1673P/M within the site does not expire until 25/5/2018 (Jason Bradbury, personal communication).

Summary

The above listed threats have been summarised in Table 10. The likelihood ratings provided in Table 10, are allocated as follows:

- Certain = known to occur at the site or has occurred in the past
- Medium = not known from the site but occurs at similar sites; and
- Low = theoretically possible, but not recorded at this or similar sites

The driver-stressor models of the type presented in Figure 23, Figure 24 and Figure 25 can help with the determination of limits of acceptable change (Davis and Brock 2008). These display the major threats and their pathways of impact upon the critical components, processes and services. Due to the number of potential effects from each threat, not all pathways can be displayed.

Table 10: Summary of actual or potential threats to the Lavinia Ramsar site.

Threat	Potential impacts to wetland component or service	Critical CPS Impacted	Likelihood	Time frame
Fire	• changes to vegetation communities and the species they support. • changes to geomorphology via erosion. • changes to hydrology via infiltration and landform.	- wetland habitat. - rare & regionally rare species. - nesting seabirds & shorebirds.	Medium (saltmarsh); Certain (remaining wetlands).	Current
Recreational vehicle use	• wetland vegetation loss and damage. • reduced habitat for birds and estuarine fish.	- wetland habitat - migratory bird spp. - nesting seabirds & shorebirds.	Certain	Current
Catchment land use	• increased nutrient concentrations (& increased algal growth). • increased turbidity. • impacts on estuarine fish (as food).	- migratory bird spp.	Medium	5 – 20 years
Drainage of upper catchment	• lowering of water table, resulting in less habitat diversity (spatial and temporal), less water to support ecosystem.	- wetland habitat. - green & gold frog. - striped marsh frog. - regionally rare plants.	Low	Current
Vegetation clearance (surrounding land)	• salinity.		Certain	<10 years (commencement)
Weeds	• changes to vegetation communities and habitats (wetland and terrestrial) e.g. invasion of Typha since 2007 fires (Corbett 2010a and b).	- wetland habitat. - rare & regionally rare species.	Certain	Near Future (1-10 years)
Acid sulphate soils	• reduction in diversity and abundance of aquatic flora and fauna.	- biodiversity	Medium	Unknown
Dieback fungus	• loss/reduction of wetland plant species.	- wetland habitat	Certain	Current

Threat	Potential impacts to wetland component or service	Critical CPS Impacted	Likelihood	Time frame
***Chytrid* fungus**	• loss of amphibian fauna.	- green & gold frog. - striped marsh frog.	Certain	Current (recently found at the site)
Feral cats	• predation on orange-bellied parrots, other birds, amphibian.	- orange-bellied parrots. - nesting shorebirds. - other bird spp. - green & gold frog. - striped marsh frog.	Medium	Current
Aquaculture	• increased nutrient concentrations (& increased algal growth). • impacts on estuarine fish (as food).	- migratory bird spp.	Certain	Current
Climate change	• reduced inflows and rainfall; increased evaporation rates; changes to all water dependent ecosystems, increased fire threat.	- all	Medium	20-50 years
Mining	• unknown until proposal produced.	Unknown.	Unknown	Unknown

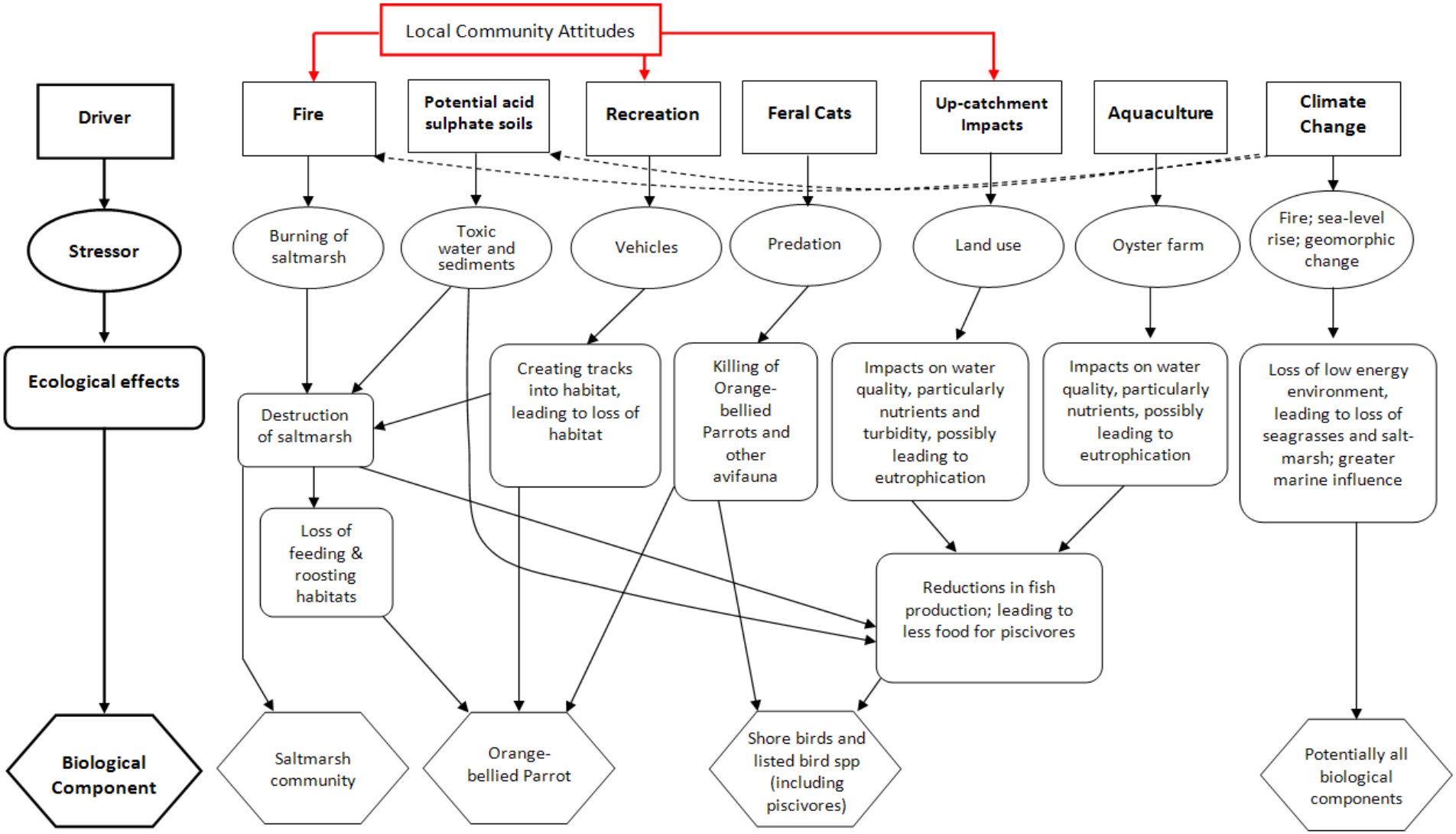


Figure 23: Driver/Stressor Model for the Lavinia Ramsar Site: Part A - Sea Elephant Estuary (after Davis and Brock 2008).

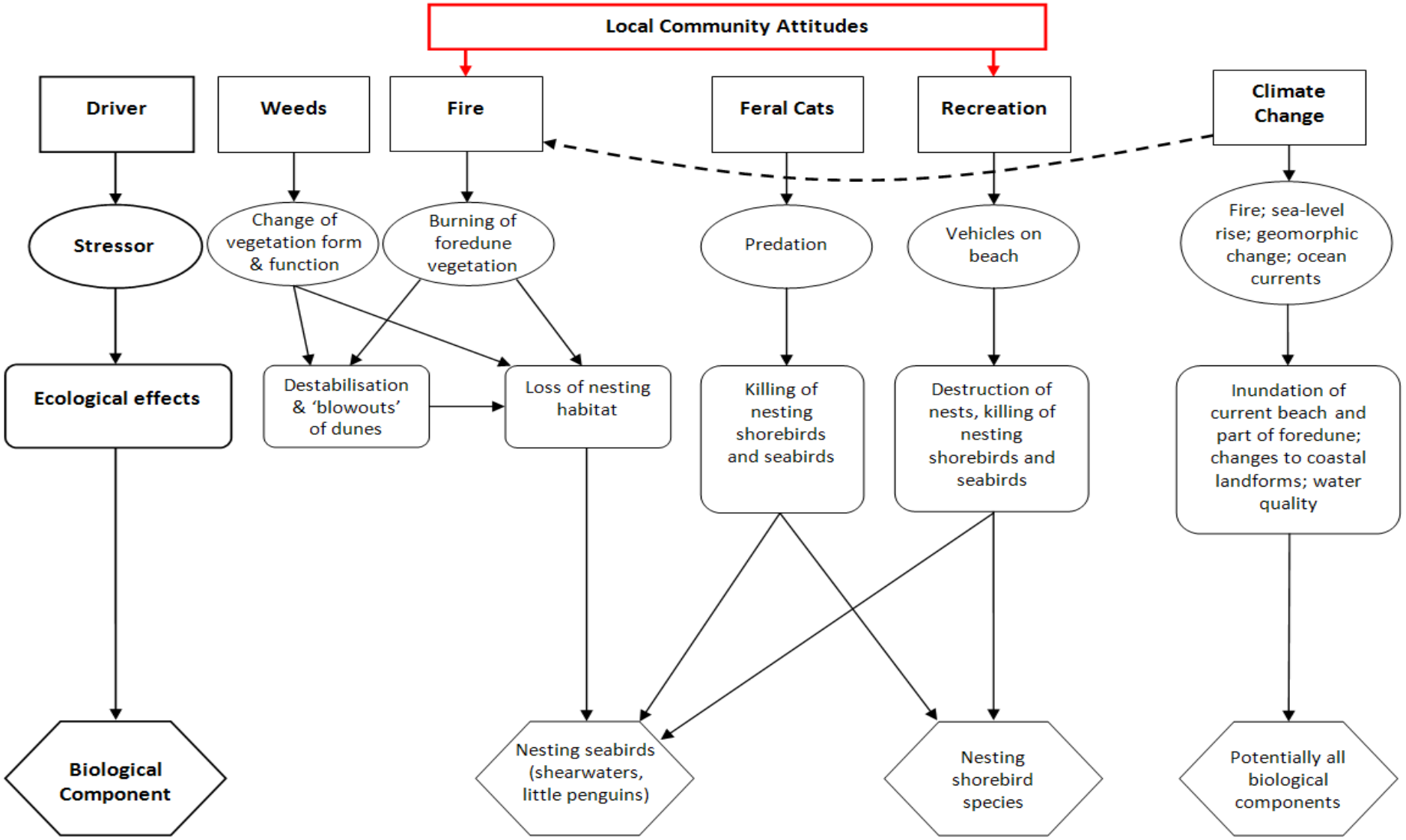


Figure 24: Driver/Stressor Model for the Lavinia Ramsar Site: Part B – Coastal strip (after Davis and Brock 2008).

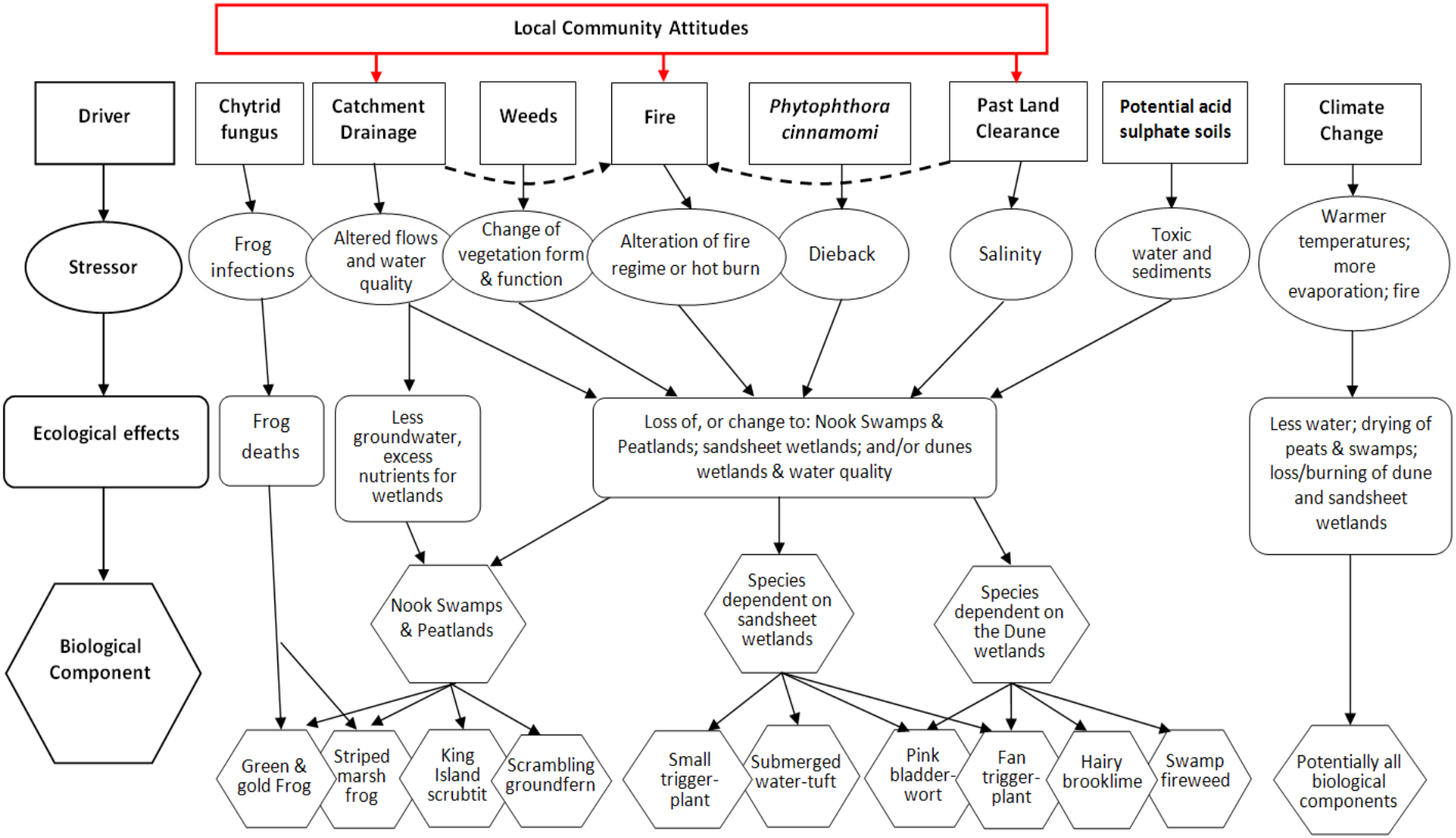


Figure 25: Driver/Stressor Model for the Lavinia Ramsar Site: Part C – Dunes & Sandsheet (after Davis and Brock 2008).

6. LIMITS OF ACCEPTABLE CHANGE

LAC explanatory notes:

1. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.

2. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.

3. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

4. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.

5. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

The aim of deriving LAC is to make it easier to determine when the ecological character of a wetland is likely to change or when it has changed due to pollution or other human interference (DEWHA 2008). Limits of acceptable change are defined by Phillips (2006) as:

"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed."

Hale and Butcher (2008) noted problems associated with using extreme measures of a selected parameter and then setting the limits outside those extremes. These include the possibility of missing shifts in character that stay within the extremes, including more frequent events, changes in seasonal patterns, and changes in central tendency (mean/median). In the Lavinia Ramsar site there were no quantitative data available for any of the critical components prior to this ECD, creating difficulty in defining medians, natural variability and extreme conditions. However, a vegetation map produced as part of this ECD can be used in setting LAC, allowing some quantification.

It is important to recognise the difference between LAC and management triggers. Limits of acceptable change incorporate natural variability (where appropriate) into a quantitative assessment (where possible) of the components that define the Ramsar site's unique character. Using data, expert judgment and the precautionary principle, LAC set a quantitative limit which, if breached, will lead to a genuine change in the site's unique ecological character.

In contrast, management triggers represent smaller changes towards exceeding LAC (or other resource management goals of the site). This is an important distinction, as management triggers should be set at a level that allows appropriate management responses *well in advance* of the LAC being breached. It is not appropriate to provide

management triggers in an ECD, as these must be derived as part of a detailed management plan. However, the information provided in an ECD should be used as part of the management planning process for a Ramsar site.

The following components and processes were identified (Section 4.1) as critical to the ecological character of the Lavinia Ramsar Site:

- wetland vegetation communities;
- regionally rare plant species;
- nationally rare plant species (scrambling groundfern, swamp fireweed);
- regionally rare bird species;
- striped marsh frog;
- orange-bellied parrot;
- King Island scrubtit;
- green and gold frog;
- waterbirds and seabirds; and
- migratory birds.

The following services were identified (Section 4) as critical to the ecological character of the Lavinia Ramsar Site:

- supports rare wetland types and types representative of the bioregion;
- supports regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna;
- support for regionally threatened species, including six plant, two bird and one frog species;
- provision of habitat for three nationally threatened fauna species (fairy tern, green and gold frog and orange-bellied parrot);
- provision of nesting habitat for waterbirds and seabirds; and
- provision of habitat for ten migratory bird species listed under international agreements.

The LAC for critical components and processes overlap with those for the critical services, (**Table 11**). Baseline information, justification, LAC confidence levels and comments are also provided in **Table 11**.

The confidence levels for the LAC represent the degree to which the authors are confident that the LAC represents the point at which a change in character has occurred and follow the approach of Hale (2010):

> **High** – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measureable.
>
> **Medium** – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific literature; or informed expert opinion; LAC is objectively measureable.
>
> **Low** – no site specific data or reliable evidence from the scientific literature or expert opinion, LAC may not be objectively measurable and / or the importance of the indicator to the ecological character of the site is unknown.

Table 11: Limits of Acceptable Change for Lavinia Ramsar Site.

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Wetland vegetation communities (supporting regional biodiversity, rare & representative wetland types, and regionally threatened species).	The baseline information used in this assessment is the wetland type map produced as part of this ECD (Figure 3). The rare and representative vegetation for the site includes Ramsar wetland types Xf, Xp, H, Tp, Ts and H. There are quantitative data available on the areal extent on the first four of these, whereas Ts was not able to be distinguished from a suite of wetland types occupying the King Island sedge/heath/scrub complex. There is also quantitative data available on the areal extent on the fifth wetland type (H).	Based on the information available, the limits of acceptable change for component are: • No more than ten percent (24 hectares) reduction in the combined area of wetland types **Xf** and **Xf/Xp** (freshwater tree-dominated wetlands and forested peatlands). These wetland types overlap and together have a combined area of 242 hectares; and • No more than ten percent (6 hectares) loss of wetland type **Tp** (Permanent freshwater marshes/pools) (currently 61.2 hectares); and • No more than ten percent (6 hectares) loss of wetland type **H** (Tidal marshes) (currently 63.1 hectares).	These limits have been set as a common sense approach to defining a significant loss in wetland types. There are no data on the variability of the Ramsar wetland types at the site and until this ECD, there was no mapping of the Ramsar wetland types. The majority of wetland area within the site is Ts/W/U and is part of a vegetation continuum that will change in response to fire regime and hydrologic variability. Therefore meaningful LAC cannot be set for these wetland types. As the wetland habitat map was made without proper field surveying, it will need verification.	Medium

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Regionally rare plant species (supporting regional biodiversity, through supporting regionally threatened species).	The only baseline information available is that these six rare species were recorded as being within particular habitat types at the site. It is assumed that they were also present at the time of designation.	Presence of: • showy willowherb (*Epilobium pallidiflorum*); • hairy brooklime (*Gratiola pubescens*); • fan triggerplant (*Stylidium beaugleholei*); • small triggerplant (*Stylidium despectum*); • submerged watertuft (*Trithuria submersa*); and • pink bladderwort (*Utricularia tenella*).	There is no quantitative information on any of these species within the site. The species were described in terms of location, recorded as part of a subjective survey. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of these six species is provided.	Low
Nationally rare plant species (scrambling groundfern, swamp fireweed) (provision of habitat for nationally threatened fauna species)	These two species are recorded as being at the site. It is assumed that they were also present at the time of designation.	Presence of: • scrambling groundfern (*Hypolepis distans*); and • swamp fireweed (*Senecio psilocarpus*).	The semi-quantitative information available for these species is insufficient to set quantitative LAC. Therefore a qualitative LAC based on presence / absence of these two species is provided.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Regionally rare bird species (support for regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna).	The only baseline information available is that these two species are recorded as being at the site. It is assumed that they were also present at the time of designation.	Presence of: • white-bellied sea eagle (*Haliaeetus leucogaster*); and • eastern curlew (*Numenius madagascariensis*).	There is no quantitative information on either of these species within the site. The most likely locations of each species within the site have been predicted on the basis of habitat needs and preferences. However, numbers are not available. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of these two species is provided.	Low
Striped marsh frog (support for regional biodiversity through the provision of wetland habitats and through the support to regionally rare flora and fauna).	The only baseline information available is that this species is recorded as being at the site. It is assumed that it was also present at the time of designation.	Presence of the striped marsh frog (*Limnodynastes peroni*).	There is no quantitative information on *Limnodynastes peroni* at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Orange-bellied parrot (provision of habitat for nationally threatened fauna species).	It is estimated that there are currently less than 150 individuals of this species left in the wild. The number appears to be declining. Although it is likely that all or most of the migrating population uses King Island, during the annual migration to mainland Australia, no data were available for numbers using the Lavinia Ramsar Site.	Two LAC are provided for the orange-bellied parrot, one of which is the same as an LAC for wetland vegetation: • Presence of orange-bellied parrots during the annual migration period; and • No more than ten percent loss of wetland type **H** (Tidal marshes) (currently 61.2 hectares) (same as third LAC for wetland vegetation communities).	The orange-bellied parrot is endangered and is a major reason for the site's Ramsar status. Further reductions in population numbers may be beyond site management control, but it is a critical component of the site's ecological character. It is therefore vital that the site still offers the quality and quantity of habitat required by the migrating parrots, particularly the salt marsh habitat. It is not currently possible to determine numbers of this species that use the site during migration.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
King Island scrubtit (provision of habitat for nationally threatened fauna species).	A low reliability estimate of the population size of the King Island scrubtit was estimated to be 150 or less breeding birds and it is suspected to be decreasing. The Nook Swamp – in particular the stands of swamp paperbark - has been confirmed as the critical location for the King Island scrubtit.	Two LAC are provided for the King Island scrubtit, one of which is the same as an LAC for wetland vegetation: • Presence of the King Island scrubtit; and • No more than ten percent (24 hectares) reduction in the combined area of wetland types **Xf** and **Xf/Xp** (freshwater tree-dominated wetlands and forested peatlands). These wetland types overlap and together have a combined area of 242 hectares.	There is uncertainty about the current population size of the King Island scrubtit and no information was found on the population size at the time of listing. With the reported diminishing size of the population, it is probable that the population is now outside the limits of natural variability. However, this cannot be assessed. It remains vital that the site continues to offer the quality and quantity of habitat required by the scrubtit, particularly the swamp paperbark habitat.	Low
Green and gold frog (provision of habitat for nationally threatened fauna species).	The only baseline information available is that this species is recorded as being at the site. It is assumed that it was also present at the time of designation.	Presence of the green and gold frog (*Litoria raniformis*).	Similar to the other rare / threatened species, there is no quantitative information on *Litoria raniformis* at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Waterbirds and seabirds [provision of nesting habitat for waterbirds and seabirds; and provision of habitat for nationally threatened fauna species (fairy tern)].	The only baseline information available is that six species of waterbirds & seabirds nest at the site, one of which (fairy tern) is listed on the IUCN redlist.	The presence of nesting populations in 2 out of 3 years for: • fairy tern (*Sterna nereis*); • little tern (*Sterna albifrons*); • hooded plover (*Thinornis rubricollis*); • Australian pied oystercatcher (*Haematopus longirostris*); • short-tailed shearwater (*Puffinus tenuirostris*); and • little *penguin (Eudyptula minor).*	No quantitative information on these species at the site means that no quantitative limits of acceptable change can be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

Critical component/process (& service)	Baseline information	Limit of acceptable change	Justification and Comments	Confidence
Migratory birds.	The only baseline information available is that these eleven species were recorded as using the site at the time of designation.	Presence in 2 out of 3 years of: ○ short-tailed shearwater (*Puffinus tenuirostris*); ○ cattle egret (*Ardea ibis*); ○ great egret (*Ardea modesta*); ○ ruddy turnstone (*Arenaria interpres*); ○ sharp-tailed sandpiper (*Calidris acuminata*); ○ red-necked stint (*Calidris ruficollis*); ○ white-throated needletail (*Hirundapus caudacutus*); ○ Caspian tern (*Hydroprogne caspia*); ○ little tern (*Sterna albifrons*); and ○ greenshank (*Tringa nebularia*).	There is no quantitative information on these species at the site. Therefore quantitative limits of acceptable change cannot be set and a qualitative LAC based on presence / absence of the species is provided. Based on lack of data for the site, confidence in the LAC representing good indicator of change in ecological character is low.	Low

There is a difficulty in the derivation of LAC for diminishing species, epitomized by the situation of the orange-bellied parrot. The reason for providing LAC is to make it easier to determine change in a wetland, "as a result of technological development, pollution or other human interference" (DEWHA 2008). The global numbers of the orange-bellied parrot are declining and may no longer be viable for sustaining the species in the wild, with the latest data showing the wild population could become extinct within three to five years (DSEWP &C 2010). As a critical component of the Lavinia Ramsar Site, substantial reductions in species number or total loss of the species would be considered a change in the ecological character of the site. This is likely to occur regardless of the environmental condition of the site.

Quantitative information for the orange-bellied parrot is from its breeding area on mainland Tasmania and its over-wintering sites on mainland Australia, rather than the Lavinia Ramsar Site. Therefore, quantitative limits for the number of individuals visiting the site during migration are unable to be provided despite the fact that there is substantial information on the species' population size in the wild. Further, it will be difficult to assess natural variability of a declining population.

In contrast to the orange-bellied parrot, the King Island scrubtit is likely to have diminished in number due to loss of habitat on King Island, including loss of swamp paperbark habitat at the site. At the site, this can be largely ascribed to fire impacts.

7. CHANGES IN ECOLOGICAL CHARACTER SINCE LISTING

The most readily identifiable impact on the ecology of the Lavinia Ramsar site since listing has been the effect of fire regime (frequency and intensity). Since its listing in 1982, several fires have burnt large sections of the site. These include:

- a fuel reduction fire in 1985, which burnt approximately 50 hectares in the northern end of the site (Rando 1987);
- a wildfire in 1992, which burnt much of the southern section of the site, including a large part of the Nook Swamps (PWS 2000);
- a wildfire in December 1996, which burnt approximately 400 hectares of the northern section of the site (PWS 2000);
- a fire ignited by lightning in January 2001, which burnt almost 6000 hectares of the northern section of the site (and smouldered in peat until June of that year) (RMCD 2007); and
- a deliberately lit fire in February 2007, which over a period of 3 weeks burnt approximately 8,300 hectares of the northern section of the site and surrounds (Figure 26), covering much of the same area as burnt in the 2001 fire. In total, approximately 12,500 hectares of native vegetation was burnt, representing more than a third of the remaining native vegetation on King Island (RMCD 2007). This included much of the largest reserved patch of *Melaleuca ericifolia* Swamp Forest in Tasmania (Figure 27).

However, assessing whether this has caused a change to ecological character requires an assessment of whether the fire regime has changed the critical components, processes or services of the site.

In the decade prior to listing, four fires occurred at the site. Two occurred in 1972, with the first one burning from Lavinia Point south to the Nook Swamps and covering 400 hectares. The same area had been burnt 9 years earlier (Rando 1987). The second fire was later in the year and burnt for approximately one month, burning most of the site excluding the Nook Swamps.

The third fire, in January 1978, was an escaped land-clearing fire that burnt an area of approximately 5000 hectares including a section of the Nook Swamps. The fourth fire was in mid-winter 1983 and burnt south from Lavinia Point for a distance of approximately 10 kilometres (Rando 1987).

These fires indicate that the fire frequency for the site has not changed significantly since listing in 1982. This is supported by the vegetation of the site, much of which is either indicative of Low to Moderate fire sensitivity and either High flammability (e.g. the wet and dry scrub complexes) or Low flammability (wetlands and swamps) (Pyrke and Marsden-Smedley 2005). However, the 2007 fire was quite atypical in that extensive areas of peat were destroyed, as a consequence of the extended drought, so while the frequency of fires may not have altered significantly, their impact on the Lavinia peatlands has. The effect of the 2007 fires does seem to be quite significant on the ecosystems of the Lavinia, and in particular, of the Melaleuca Swamp Forest in the Dunes Ecosystem (Corbett 2010a and b).

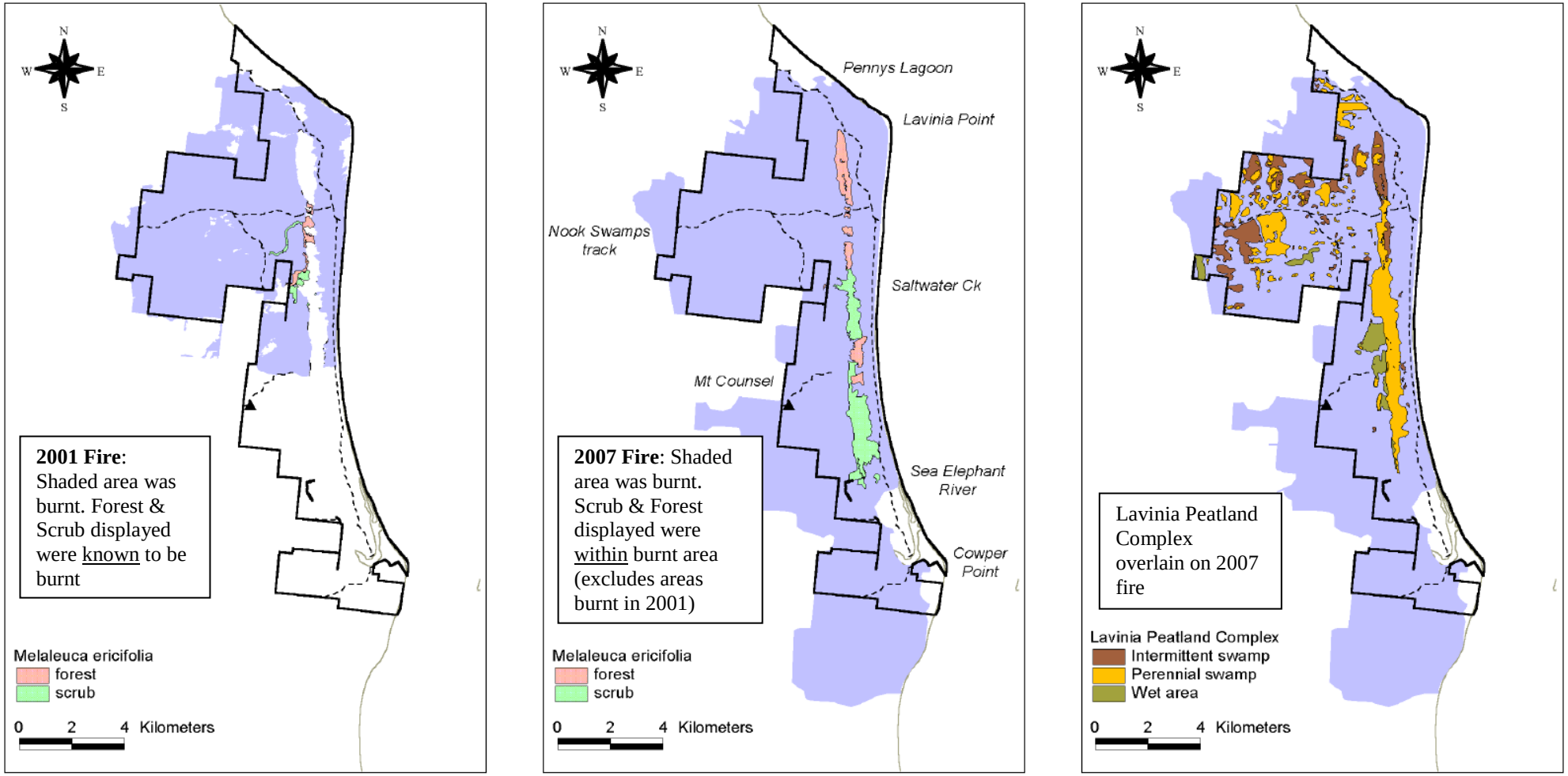


Figure 26: Extent of the 2001 and 2007 fires, and the Lavinia Peatland Complex.

Solid line delineates a 8,947 hectares block, consisting of the Lavinia Ramsar site and adjoining Crown Land (source: RMCD 2007).

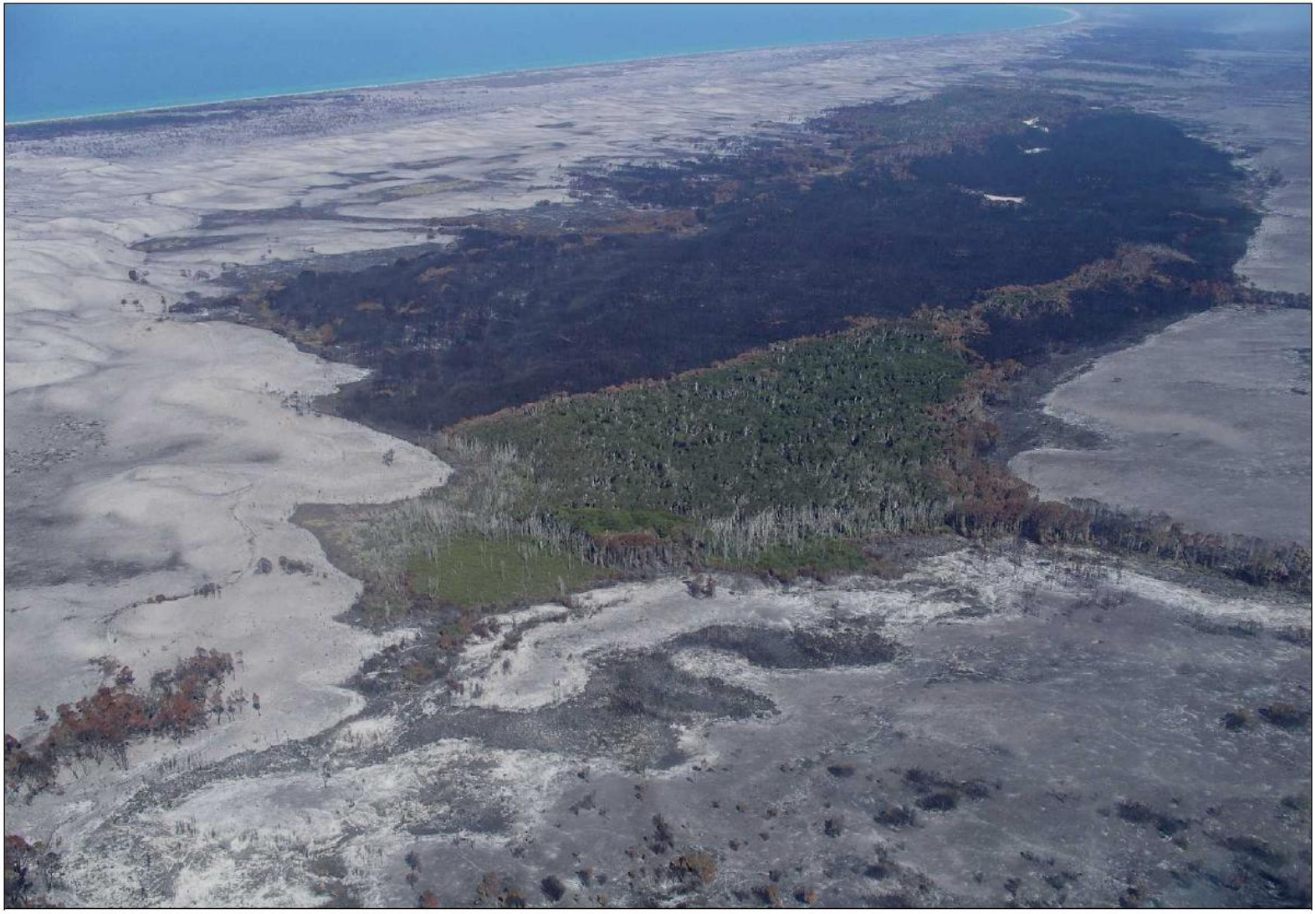


Figure 27: Northern end of Nook Swamps, 22 March 2007, showing the impact of fire on *Melaleuca ericifolia* swamp forests; exposed partially burnt peat along drainage lines in foreground (source: RMCD 2007).

Fires have clearly caused a measurable reduction in *Melaleuca ericifolia* swamp forests since listing (Figure 27; Table 12; Corbett 2010a and b). A particular concern for the *Melaleuca ericifolia* swamp forest is that it requires an infrequent fire recurrence interval for the community to mature. The burning of the *Melaleuca ericifolia* swamp forest may indicate a change in hydrology (lowering of water table) allowing the wetland to burn. It may also indicate a change in fire intensity (possibly aided by a change in hydrology).

The Limits of Acceptable Change that are relevant for assessing whether this may be a change in ecological character are those for the 'Wetlands and peatlands' component; the 'Hydrology (Dunes)' component/process; and the 'Fire regime' component/process. Currently, the hydrology and fire regime limits cannot be assessed as definitely being breached. Data will be required to assess changes in these components.

Critical components were identified using a quartet of determinants, including potential to change in short to medium timeframes (up to 100 years). The 2007 fire resulted in the loss of large areas of peat & swamp forest in Nook Swamps (Corbett 2010a and b). Although time will be required to assess whether regrowth of the swamp forest site forms a wetland community, the estimated age of the stand of swamp forest that was lost (approximately 200 years) and the peatlands that were burnt (measured in thousands of years) indicates that these components will not return in the short to medium term, and therefore their loss constitutes a change in the ecological character of the site (Corbett 2010a and b).

Two other significant changes have occurred as a result of the fires in 2007 (Corbett 2010a and b). One change is the invasion of the weed, *Typha*, along the creek lines within the Nook Swamp. The second is the conversion of some peat swamps to temporary lakes, which oscillate from freshwater marshes to dry salt marsh on an annual basis (Corbett 2010a and b).

In summary, therefore, it cannot be determined whether there has been a change in hydrology and fire regime components of the site. In contrast, there has been a loss of wetland (swamp paperbark forest) and peatland components of the site, constituting a change in ecological character. A determination will require time (possibly many decades) to assess whether regrowth in the Nook Swamps results in new wetland communities and a return to its former ecological character. The reliance of the King Island scrubtit on this habitat type is likely to have caused a substantial decline in the population size of the scrubtit, although this cannot be quantified.

Table 12: Fire damage classes for the *Melaleuca ericifolia* swamp forests within Nook Swamps, from the 2007 fires (Source: RMCD 2007; Corbett 2010a and b).

Level of Fire Damage	**Area (hectares)***	**% of total**
Unburnt	90	15
Trees standing, canopy and most fine fuels burnt: partial loss of peat (5–20 cm).	360	60
Trees prostrate, canopy and all fine fuels burnt: complete loss of peat (up to 40 cm deep).	150	25
Total	**600**	**100**

(*Area figures are approximate only)

The fires left the Saline Sedgelands of the Sea Elephant Estuary relatively unaffected, so impacts upon the orange-bellied parrot (Corbett 2010a and b).

The major issue for the future, is that the remaining, and recovering, areas of Melaleuca Swamp Forest are even more vulnerable to fires and it is critical any future fires are managed and extinguished quickly (Corbett 2010a and b).

8. KNOWLEDGE GAPS AND MONITORING NEEDS

8.1 Knowledge Gaps

The key knowledge gaps for the site include many of the biotic populations, particularly the regionally rare or threatened species. This includes knowledge of abundance and distributions, and also knowledge of natural variability. Knowledge gaps for several other components may be filled using modelling (e.g. stream hydrology), field sampling (e.g. water quality) and historical/palaeo studies (e.g. fire history, groundwater history).

Key knowledge gaps for critical components and processes and three essential elements (one of which – fire - is also a threat), are presented in Table 13, together with recommendations for data collection and a priority ranking. Many of these were taken from the critical components that were unable to have Limits of Acceptable Change due to a lack of baseline information and/or knowledge on natural variability.

Table 13: Knowledge gaps for the Lavinia Ramsar site.

Component	**Identified knowledge gaps**	**Recommended data collection or other action to address the gap.**	**Priority**
Wetland Vegetation Community	No accurate mapping of all wetland types.	A vegetation, wetland type and topographical survey across the whole site to produce an accurate picture of vegetation communities, wetland types and the landscape.	High
Orange-bellied parrot	Specific numbers using the site and their percentage of migrating population.	Survey of site during migration.	Very high
King Island scrubtit	Specific population numbers	Annual survey, due to suspected diminishing population size	Very high

Component	Identified knowledge gaps	Recommended data collection or other action to address the gap.	Priority
Species important for national and regional biodiversity (flora and fauna; all ecosystems) but especially: • white-bellied sea eagle • eastern curlew • waterbirds and seabirds (including migratory species) • fairy tern • green and gold frog • scrambling groundfern • swamp fireweed • six regionally threatened plant species	Little baseline information or understanding of natural variability. A lack of quantitative surveys of nests and breeding or migrating populations at the site.	Surveys during season of maximum growth (flora) or migrating/breeding season (fauna). This would include a comprehensive survey of vegetation and fauna such as birds, fish, and frogs.	High
Fire regime	Historical and pre-historical frequency and extent; and trajectory of any changes.	Documentation of complete fire history of the site since settlement; analysis (e.g. coring) of swamp sediments for analysis of pollen and charcoal bands.	High

Component	Identified knowledge gaps	Recommended data collection or other action to address the gap.	Priority
Coastal geomorphology	Baseline information on rates and trends of landforming processes, particularly in relation to dune stability and natural variation. Natural variation in estuary opening – recurrence interval and causes. Also any influences on water quality indicators	Slope stability; erosion assessments. Studies on the importance of root-binding in maintaining dune stability. Review of any historical records, aerial photographs, and anecdotal data.	Medium
Hydrology	Flow into and through the Nook Swamps. Water levels in major wetlands (Penny's Lagoon and Martha-Lavinia Swamp). Discharge data from Sea Elephant River into the estuary, including variability. Groundwater dynamics of the system.	Gauge installation/augmentation, flow measurements, and flow modelling.	Medium

8.2 Monitoring Needs

The monitoring needs of the site should focus on the knowledge gaps, the Limits of Acceptable Change for the maintenance of the site's ecological character and also the major threats to the site.

Priorities for monitoring were based on importance of the component, process or threatening process, to the site's ecological character (Table 14).

Table 14: Key monitoring needs for the Lavinia Ramsar site.

Component, process, or threat	**Key indicator**	**Monitoring needs (type and frequency)**	**Priority**
Wetland vegetation community	Area of wetland types.	Establishment of baseline flora species and community data using permanent transects across hydrological gradients and recording of: ○ Species presence/absence ○ Ecological community identification and composition ○ Ecological community mapping and extent ○ Threatened species population sizes and health Survey extent of each wetland type every second or third year to assess changes over time. ID presence of rare plants during surveys and also note weed presence and extent. Low level aerial photography taken in November / December every second or third year in conjunction with resurveying of transects.	High
Fire regime	Intensity and frequency of burns.	Keep records of each burn and monitor for changes in intensity and frequency (especially within sensitive vegetation types).	High
Extent of *Melaleuca ericifolia* swamp forest	Regeneration of areas where the swamp forest has been severely burnt.	Permanent quadrats in burnt areas, assessing plant community development (and whether plant community is developing as expected for *Melaleuca ericifolia* swamp forest).	High

Component, process, or threat	Key indicator	Monitoring needs (type and frequency)	Priority
Saltmarsh	Extent of tracks impacting the salt marsh vegetation of the Sea Elephant Estuary.	Number and total area (m^2) of walking and vehicle tracks in the saltmarsh. Quantitative evidence of impacts from tracks, including loss of total area, weed invasion, species composition changes.	High
Use of site by orange-bellied parrot and other bird species	OBP - Numbers of individuals using site versus number using other sites on King Island and number within whole population. Other birds - record population size and number of nesting pairs each year.	Annual monitoring during migration (focus on peak of migration). Develop monitoring program in consultation with Birds Tasmania. Annually during nesting season.	High
Fish, Frogs and other aquatic fauna	Presence and abundance of fish and frog species within the estuary and wetlands.	Regular sampling of fish and frogs – initially every year (for three to five years) and then reduce to every three years to establish extent of natural viability.	Medium-high
Disturbance to nesting shorebirds	Disturbance indicators such as tyre tracks, other signs of disturbance during nesting.	Annually during nesting season.	Medium-high
Water Quality of Sea Elephant Estuary	Nutrients (total phosphorus, total nitrogen, dissolved nitrogen); dissolved oxygen; electrical conductivity; pH; temperature; algal biomass.	Water Samples (nutrients, algal biomass); probes/meters (dissolved oxygen, electrical conductivity, pH, temperature). Monthly over summer, otherwise quarterly.	Medium (medium-high in summer)
Surface Water	Flow into and through the Nook Swamps. Water levels in major wetlands (Penny's Lagoon and Martha-Lavinia Swamp). Discharge from Sea Elephant River into the estuary.	Monthly gauge measurements and annual (spring or high flow period) flow/velocity monitoring.	Medium-high

Component, process, or threat	Key indicator	Monitoring needs (type and frequency)	Priority
Depth to groundwater	Changes in depth to groundwater, particularly in Northern Sandsheet area.	Quarterly or monthly monitoring of bores to determine whether there is a trend of lowering of water table. If a trend is found, determine cause(s).	Medium-high
Ground surface saturation	Extent of land area that is saturated.	In conjunction with monitoring of swamp forest regeneration, determine whether saturated surface area is decreasing. Analyse data in conjunction with results from 'Depth to Groundwater' monitoring.	Medium-high
Phytophthora cinnamomi	Spread of fungus.	Regular soil sampling (yearly – more frequently if rapid spread is occurring), testing for presence of the fungus.	Medium

9. COMMUNICATION, EDUCATION AND PUBLIC AWARENESS (CEPA) MESSAGES

Communication, Education and Public Awareness messages are designed to help raise awareness of wetland values and functions. Key messages for the Lavinia Ramsar site should include:

- the Lavinia Ramsar site, at 7034 hectares, contains the majority of the remaining native vegetation of King Island;
- the site contains four species that are threatened globally: orange-bellied parrot (Critically Endangered); fairy tern (vulnerable); King Island scrubtit (Critically Endangered); green and gold frog (Vulnerable) and swamp fireweed (Vulnerable) and one that is threatened nationally - scrambling ground fern (Endangered);
- the site is contains important habitat for nesting shorebirds, which are vulnerable to vehicles and predators (including pets and feral animals) during the nesting season. In particular, the internationally vulnerable fairy tern, is particularly susceptible to the driving of vehicles along beaches during nesting season;
- there are several rare and/or poorly reserved Tasmanian vegetation communities within the site, including *Melaleuca ericifolia* swamp forest, saltmarsh, and three wetland types (freshwater aquatic wetlands, herbfields and grasslands marginal to wetlands, and sedge/rush wetland);
- The saltmarsh of the Sea Elephant Estuary is a key habitat for the migration of orange-bellied parrots. This habitat is particularly susceptible to the impacts of vehicles being driven through the saltmarsh; and
- Fire is an important component of the site, with different vegetation communities requiring different burning regimes, ranging from 200 years or more between burns for some communities, to less than 30 years for others. Misuse of burning can have major consequences on the vegetation diversity of the site. Appropriate burning regimes need to be designed by vegetation ecologists, local landowners, and other stakeholders working together.

10. GLOSSARY

Definitions of words associated with ecological character descriptions. These are taken from DEWHA 2008 unless otherwise indicated.

Adverse conditions	Ecological conditions unusually hostile to the survival of plant or animal species, such as occur during severe weather like prolonged drought, flooding, cold, etc.
Assessment	The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities
Baseline	Condition at a starting point. For Ramsar wetlands it will usually be the time of listing of a Ramsar site
Benchmark	A standard or point of reference A pre-determined state (based on the values which are sought to be protected) to be achieved or maintained
Benefits	Benefits/services are defined as "the benefits that people receive from ecosystems. See also "Ecosystem Services".
Biogeographic region (also 'bioregion')	A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc.
Biological diversity	The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes.
Catchment	The total area draining into a river, reservoir, or other body of water.
Change in ecological character	Is defined as the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service.
Community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another.
Conceptual model	Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems.
Contracting Parties	Countries that are Member States to the Ramsar Convention on Wetlands. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialized agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice.
Critical stage	Stage of the life cycle of wetland-dependent species. Critical stages being those activities (breeding, migration stopovers, moulting etc.) which if interrupted or prevented from occurring may threaten long-term conservation of the species.

Ecological character	The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (Ecosystem Services). The phrase "at a given point in time" refers to Resolution VI.1 paragraph 2.1, which states that "It is essential that the ecological character of a site be described by the Contracting Party concerned **at the time of designation for the Ramsar List**, by completion of the Information Sheet on Ramsar Wetlands
Ecological communities	Any naturally occurring group of species inhabiting a common environment, interacting with each other especially through food relationships and relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones
Ecosystems	Complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services).
Ecosystem components	The physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes)
Ecosystem processes	The dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment that result in existing ecosystems and bring about changes in ecosystems over time. They may be physical, chemical or biological.
Ecosystem services	The benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food & water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational), and supporting (e.g nutrient cycling, ecological value). See also "Benefits".
Geomorphology	The study of landforms.
Indigenous species	A species that originates and occurs naturally in a particular country.
Introduced (non-native) species	A species that does not originate or occur naturally in a particular country .
Limits of Acceptable Change	The variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed'.
List of Wetlands of International Importance ("the Ramsar List")	The list of wetlands which have been designated by the Ramsar Contracting Party in which they reside as internationally important, according to one or more of the criteria that have been adopted by the Conference of the Parties [http://www.ramsar.org/about/about_glossary.htm].
Monitoring	the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing
Ramsar	City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, "Ramsar Convention on Wetlands" [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Criteria	Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. http://www.ramsar.org/about/about_glossary.htm
Ramsar Convention	*Convention on Wetlands of International Importance especially as Waterfowl Habitat*. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used [http://www.ramsar.org/index_very_key_docs.htm].
Ramsar	The form upon which Contracting Parties record relevant data on proposed

Information Sheet (RIS)	Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed (http://www.ramsar.org/about/about_glossary.htm).
Ramsar List	The List of Wetlands of International Importance [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Sites	Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Sites Database	Repository of ecological, biological, socio-economic, and political data and maps with boundaries on all Ramsar sites, maintained by Wetlands International in Wageningen, the Netherlands, under contract to the Convention [http://www.ramsar.org/about/about_glossary.htm].
Taxa, Taxon	A general name for a taxonomic group whatever level e.g. species or genus of any biota.
Wetlands	Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.
Wetland Assessment	The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.
Wetland Ecological Risk Assessment	A quantitative or qualitative evaluation of the actual or potential adverse effects of stressors on a wetland ecosystem.
Wetland types	As defined by the Ramsar Convention's wetland classification system [http://www.ramsar.org/ris/key_ris.htm#type].
Wise use of wetlands	The maintenance of their ecological character, achieved through the implementation of ecosystem approaches[1], within the context of sustainable development[2]". 1. Including *inter alia* the Convention on Biological Diversity's "Ecosystem Approach" (CBD COP5 Decision V/6) and that applied by HELCOM and OSPAR (Declaration of the First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen, 25-26 June 2003). 2. The phrase "in the context of sustainable development" is intended to recognize that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the Convention, and it is not appropriate to imply that 'development' is an objective for every wetland.

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12. APPENDICES

12.1 Appendix 1: The Consultants

Lance Lloyd, Principal Ecologist, Lloyd Environmental Pty Ltd

Principal Ecologist, Lance Lloyd, BSc, MSc, MAIBiol., provides high level strategic advice and services to industry and Government across Australia. He has over 30 years experience in environmental consulting, research and management. His key expertise developed over this time is in relating the ecology of aquatic systems to the needs of management issues. The majority of his work during his professional life, since 1979, has been in the ecology of aquatic and floodplain ecosystems and water regimes in flowing & lentic waters and their management. His M.Sc. studies, some of his major research projects, and several published papers, focused upon the central role of environmental water management to the ecology and biological requirements of fish, invertebrates and plants. Lance also undertook some ground breaking research on fish and invertebrates as a Research Officer at the University of Adelaide, working on the River Murray.

Lance has extensive experience in studying and understanding the ecology of wetlands (including Ramsar and sites of national significance). During his M.Sc., Lance sampled the Lower Lakes Ramsar Site on a regular basis for fish and invertebrate species and also contributed to University studies and teaching programs on the Coorong. He undertook water management and ecology studies along the mid-Murray wetlands at sites such as Barmah, Gunbower, and Hattah (see below) as well as developing a Strategic Management Plan for the Kerang Lakes Ramsar Site for Parks Victoria. Lance also led a project to develop a wetlands inventory on Commonwealth Lands as a contribution to the "Directory of Important Wetlands in Australia (3rd Edition)". In 2003, Lance led an expert team to review the Environmental Water Requirements for Internationally significant Wetlands Framework where he undertook detailed studies on the Wyndgate Wetlands which are part of Coorong and Lakes Alexandrina and Albert Ramsar Site.

He has contributed significantly to the MDBC Floodplain Wetlands Management Strategy. He was the lead author of the paper entitled "Natural Processes in Floodplain Ecosystems" which synthesised the current knowledge of floodplain wetland ecosystems and was produced as part of the MDBC Floodplain Wetlands Management Strategy. Lance has also assisted the MDBC's Sustainable Rivers Audit team and the Independent SRA Group to develop indicators of floodplain ecosystem health.

In 2004, Lance was a key team member in the "Framework to Assess the Condition of Wetlands of the South Australian River Murray" project. This project identified wetland types, developed conceptual models for each wetland type and used these models to identify measures of floodplain health. Lance has had extensive experience in developing conceptual models of various ecosystems and in developing monitoring and assessment programs.

Further, he became a board member of the Fisheries Co-management Council (FCC) of Victoria (an advisory group to the Victorian Minister of Agriculture) in 2002. He also served on the board of the Victorian Fisheries Research Advisory Board for the Fisheries R&D Corporation. He has been the Translocation Evaluation Panel Chair for the Dept of Primary Industry in Victoria since 2005. Lance was appointed to these Ministerial or high-level positions based upon his expertise in fisheries and fish ecology.

He led the teams which developed the Riverland Ramsar Site and Floodplain Lower Ringarooma Ramsar Site Ecological Character Descriptions. He led the fish and invertebrate ecology team which, in part, developed the Gippsland Lakes and Corner Inlet Ecological Character Description Projects. He is currently completing ECDs for Lavinia, Little Waterhouse Lake, Jocks Lagoon and Bool and Hacks Lagoons Ramsar Sites.

Peter Newall, Independent Consulting Aquatic Ecologist

Peter Newall specialises in aquatic ecology and catchment management. He has a detailed understanding of Government requirements, roles and responsibilities in the water sector and has been involved in drafting policies on the management of aquatic ecosystems and catchments at the regional, State and National level. Peter has 20 years experience as a consultant, ecologist, policy developer and research scientist within the water industry. He holds a BSc Honours degree in Botany/Physical Geography (wetland ecology), a MEnvSci degree in stream ecology and a PhD in aquatic ecoregions and fish distributions.

Peter's training in Physical Geography has provided him with the skills to assimilate and synthesise data and information from a broad range of environmental disciplines, including biology, soil science, soil geomorphology, fluvial geomorphology, climatology and hydrology.

As an aquatic ecologist his work has included: examining the ecological condition of a broad range of streams; developing systems for the use of biological indicators in ecosystem assessment and management; and developing river management policy for the management and protection of rivers. Peter has been involved in developing guidelines and objectives for stream ecosystem health, and deriving biological regions for assessing stream condition. He was a key member of teams that:

- derived nutrient and other water quality objectives for waterways across Victoria (subsequently incorporated into the State Environment Protection Policy);
- developed biological objectives for assessment of ecological condition of waterways across Victoria (also incorporated into the State Environment Protection Policy);
- developed the EPA protocol for the monitoring of licensed discharges to streams in Victoria.

Peter was a member of the CRC for Freshwater Ecology for five years, and has also worked in Environmental Auditing with EPA and URS, focusing on waterway and catchment auditing. During his time at URS, Peter instigated water quality monitoring programs for wetlands and streams for a range of clients, incorporating a risk-based approach to program design and implementation. Since working as an independent consulting aquatic ecologist Peter has worked on a number of ecological assessments, including several Ecological Character Descriptions of Ramsar wetland sites and also several Ecological Risk Assessments of aquatic ecosystems.

12.2 Appendix 2: Methodology to Develop the ECD

This ecological character description was prepared following the general approach presented in National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (DEWHA 2008). This approach is presented in Figure A1.

Figure A1: Summary of steps for the production of an ECD (Source: DEWHA 2008)

Completion of the ECD comprised eight major steps:

1. Project Inception and site visit
2. Literature and Information Review
3. Content of the ECD
4. Preparation of 1st Draft ECD for review by DSEWPAC
5. Preparation of revised RIS, using the ECD
6. Revision of 1st Draft ECD (with DSEWPAC comments)
7. Distribution of 2nd Draft ECD to stakeholders, seeking comments/feedback
8. Finalisation of ECD, incorporating stakeholder comments

Client-consultant partnership was an important component of the process to ensure alignment of goals and common understanding of approaches. This included client-consultant meetings to ensure a high level of communication. The team also conducted interviews and informal discussions with relevant stakeholders and resource managers, to further develop our understanding of the site. The structured workshop (Task 7) assisted with crystallising our understanding of the site and developing the conceptual model for the wetland.

The steps outlined above are described in the following sections;

Step 1: Project Inception and Site Inspection

The project commenced with an inception meeting with the Client Project Manager and the Consultants' project manager. This meeting was to:

- **Confirm** project objectives, and outputs sought;
- **Discuss and finalise** timeframes and key dates for delivery of project outputs**;** and,
- **Confirm** existing information sources and **obtain** relevant reports, information, and data from the client.

This component was vital for ensuring alignment of objectives and discussion of approaches. The inception meeting was also used as a springboard for making contacts, obtaining details of key stakeholders and pursuing reference documents.

Site Inspection: a site inspection was undertaken to view the key areas and habitats of the Lavinia Ramsar Site. The site inspection included members of the Steering Committee and was greatly enhanced by several members of the King Island community contributing their time and knowledge to the inspection.

Step 2: Literature and Information Review

The literature review initially focussed on the condition of the Ramsar site at the time of Ramsar listing. Information on changes to condition since listing was subsequently reviewed and documented. Information reviewed included documents prepared prior to and during the listing process, as well as through perusal of subsequent reports and studies on the condition of the site.

Collate/summarise information from inception meeting and Stakeholders: At the inception meeting relevant available documents held by the client were requested, as well as contact details of stakeholders and their relevant roles in relation to the Ramsar site. Subsequent to the inception meeting contact was made with relevant stakeholders as part of document searching/gathering. The collated and summarised information contributed to an assessment of information gaps and needs.

Information and data search and review: Using the approaches and structures identified at the inception meeting and the collated information, information needs were prioritised and the most likely sources (people and documents) were identified. The data search and summary was a key component of the project and was allocated a substantial amount of time. An "information log" was developed to document the reports and information resources available to the project. The "information log" was used during the course of the

project to inform stakeholders which documents the project team possessed and which ones were missing for the project.

Literature Summary: The information and data obtained was summarised to facilitate review of knowledge status and gaps and used as an important basis for the production of the ECD. The literature summary was structured to enable ready assessment against ECD requirements.

Discussions with NRM North and Government Agencies: Discussion with the client and key Government stakeholders was a regular and vital part of the project, both in the collection of information and also in the compilation of the literature summary. Regular feedback maximised the opportunity to uncover all relevant information.

Step 3: Content of the ECD

A scientific panel was convened and focussed on identifying:

- key ecological components and processes in the site;
- the benefits and services that characterise the site;
- key actual or potential threats to the site;
- knowledge gaps;
- monitoring needs; and,
- an appropriate preliminary conceptual model of the system.

The Panel workshop consisted of the project team, NRM North, DPIPWE, DSEWPAC and stakeholders.

Step 4: Preparation of a Draft ECD for review by DEWHA

A Draft of the ECD was prepared from the information gathered through the literature review, Scientific Panel and through liaison with the client. The draft was provided to the client manager, for distribution to relevant staff within DSEWPAC.

The Draft ECD generally followed the draft national framework, which includes:

- Executive Summary
- Acknowledgements
- Table of Contents
- List of Abbreviations
- **Introduction**, including site details, purpose of the ECD, legislative context
- **Detailed Description of the site**, including overview of the site; ECD context; Ramsar/DIWA criteria; geographic and ecosystem description
- **Description of Ecological Character of the Site**, focusing on components, processes & benefits/services; conceptual model of site & system, quantified limits of change. Consideration will need to include biological, physical and chemical aspects of wetland condition and processes
- **Key Actual or Potential Threats or Risks to the Site**, to aid identification of potential changes and their importance
- **Limits of Acceptable Change**, to be quantitative where possible and place high importance on identified risks/threats
- **Knowledge Gaps** (and suggested approaches for addressing them)
- **Changes in Ecological Character** (if appropriate), including whether changes have occurred since listing
- **Key Site Monitoring Needs**, identified from conceptual model, and covering knowledge gaps, assessing trends/changes and relevant monitoring and management outcomes

- **Communication, Education and Public Awareness (CEPA) Messages**, summarising key ecological messages that will facilitate management planning and action
- Glossary
- References
- Appendices

The 'Executive Summary', 'Acknowledgements', 'List of Abbreviations' 'Glossary' and 'Appendices' were not completed at this draft stage.

Describing the Components, Processes and Benefits/Services: The description of ecological character required identification of the components, processes and benefits/services that are critical to the character of the Ramsar site. An important requirement within this task was the need to document the condition of the site at the time of its designation for the Ramsar list as well as current condition. This included assessments of trends in the condition of relevant components, processes and services and past and current changes in its character.

Development of Conceptual Models: Conceptual models were developed to represent the ecological processes and components of the Ramsar site in a simplified way, to assist in describing the ecological character of the site.

Prepare Draft ECD: The ecological character was described in accordance with the Draft National Framework. This required a description of the ecosystem components, processes and benefits/services that characterise the wetland as well as the conceptual model of the ecological functioning of the wetland system (described above).

Beyond the description of the wetland site, limits of acceptable change to critical components and processes were identified. Knowledge gaps were also identified and recommendations made accordingly, including the development of monitoring recommendations. As well as filling of knowledge gaps, monitoring recommendations considered information required for assessment of trends.

Step 5: Preparation of revised RIS, using the ECD

The preparation of the revised RIS used the existing RIS as a basis and incorporated changes to the site boundaries as well as any relevant changes to the ecology of the site since the preparation of the previous RIS. Much of the work undertaken as part of the Literature Review and also stakeholder discussion and team-member knowledge of the site fed into this task.

Step 6: Revision of 1st Draft ECD

The project team collated the comments provided by NRM North and its stakeholders (Steering Committee) and incorporated those comments into a revision of the draft ECD, producing a 2nd Draft ECD for DEWHA review. The 2nd draft ECD was also circulated to the Steering Committee for further comments.

Step 7: Revision of 2nd Draft ECD

The 2nd Draft was circulated to independent reviewers, DSEWPAC and the Steering Committee and detailed comments received.

Step 8: Finalisation of ECD.

The ECD was finalised, incorporating the stakeholder and DSEWPAC comments following feedback.