Department for Environment and Heritage

DRAFT RECOVERY PLAN FOR 23 THREATENED FLORA TAXA ON EYRE PENINSULA, SOUTH AUSTRALIA

2007-2012

Government of South Australia

Acknowledgements

Thank you to the following people for the information, comments and assistance provided in the preparation of this recovery plan:

- Anthony Freebairn (Department for Environment and Heritage, South Australia) for the preparation of an earlier draft of this recovery plan and significant contribution to early recovery actions in his former role as Threatened Flora Project Officer
- Snow Burton, Sally Deslandes, Chris Deslandes, Pam Hewstone and Jane Hutchinson (community contributors and volunteers)
- Phil Ainsley, David Armstrong, Geoff Axford, Doug Bickerton, Peter Copley, Nigel Cotsell, Toula Ellis, Tom Gerschwitz, Louisa Halliday, Bill Haddrill, Mary-Anne Healy, Amy Ide, Manfred Jusaitis, Paula Peeters, Joe Quarmby, Joe Tilley, Birgitte Sorensen, Karan Smith, Renate Velzeboer, Helen Vonow, Sarah Way and Mike Wouters (Department for Environment and Heritage, South Australia)
- Anthelia Bond (previously Department for Environment and Heritage, South Australia)
- Geraldine Turner and Nicole Reichelt (Landcare, Eyre Peninsula)
- Robert Coventry, Andrew Freeman, Iggy Honan, Rachael Kannussaar, Peter Sheridan and Tony Zwar (Eyre Peninsula Natural Resources Management Board)
- Tim Reynolds (Department for Transport, Energy and Infrastructure)
- Tim Jury and Yvonne Steed (Threatened Plant Action Group)
- Simon Bey (Greening Australia) and Melissa Horgan (previously Greening Australia)
- Daphne Bates, Helen and Trevor Cox, Hazel O'Connor and Janet Smyth (Australian Plant Society)
- Larry Bebbington (Habitat and Land Management Consultant)
- Ben White (Seeds ExtraordinEYRE)
- Marion and Merrick Savage (Eyre Native Seeds)
- Tumby Bay Area School and Cummins Area School staff for supporting threatened flora recovery
- Sallyann Hill (previously Eyre Peninsula Natural Resources Management Group, Cleve)
- Eric Britten, David Hall and Ian Fitzsimmons (District Council of Lower Eyre Peninsula)
- David Dupree (District Council of Tumby Bay)
- Alf Brinkmann (District Council of Cleve)
- David Jones (Centre for Plant Biology Research, Canberra) and Bob Bates (Plant Biodiversity Centre, Adelaide)
- Di Delaine (Rural Solutions SA, South Australia).

Citation

Pobke, K 2007, *Draft recovery plan for 23 threatened flora taxa on Eyre Peninsula, South Australia 2007-2012,* Department for Environment and Heritage, South Australia.

Executive summary

Introduction

This is a regionally based multi-species recovery plan for twenty-one nationally listed and two state listed threatened plant species found on Eyre Peninsula, South Australia. Table 1 lists the species addressed in this plan. The recovery plan is prepared within the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and guidelines produced by Environment Australia (2002).

The plan's strategic, regional approach to threatened flora recovery will provide direction to managers who are planning for and funding the sustainable management of Eyre Peninsula's natural resources (see Sections 4 and 29-31 in particular). Individual species sections in the plan (Sections 6-28) will be useful for plant enthusiasts wishing to pursue recovery of individual species or groups of species (e.g. orchids or wattles) that are specific to their region or area of interest. The individual species sections present information such as biology and ecology, known threats, and recovery actions for each of the 23 species addressed in the plan.

Goals and objectives

Two recovery goals form the basis of this plan:

Goal 1 Recover threatened plant species critical habitat on Eyre Peninsula.

Goal 2 Recover threatened plant species populations on Eyre Peninsula.

These are 30 year goals, as they are realistically achievable only over a long-term time frame (i.e. by 2037).

The threatened flora species addressed within this plan (Table 1) are prioritised based on the literature, field observations, formal studies, previous actions and known threats. The recovery of these species, and their critical habitat, will be achieved through the completion of Objectives, Actions and Performance Criteria (Section 4 and Appendix D). Priority Focus Work Areas are identified in Figure 30.1.

Recovery of threatened flora species is defined by five objectives:

Objective 1 Obtain baseline information, including critical and potential habitat, for each threatened flora species.

Objective 2 Increase understanding, appreciation and involvement in threatened flora recovery efforts.

Objective 3 Manage immediate threats and improve threatened flora critical habitat.

Objective 4 Conduct research critical to management by addressing knowledge deficiencies in threatened flora biology and ecology (including threat identification).

Objective 5 Monitor threatened flora populations and evaluate the success of recovery actions.

Actions within the recovery plan are relevant for 5 years, at which point the plan will require review. During review, progress towards the goals should be assessed and actions may subsequently need to be modified. Success will be determined by whether species are either down-listed or stabilised, according to IUCN criteria (IUCN 2001). It is likely that within 5 years some threatened flora species will be successfully down-listed (see targets in Table 1); however, the ability to down-list species is influenced by the species' priority category (Table 29.1) and the corresponding level of allocated resources.

Table 1. Eyre Peninsula threatened flora species addressed within this recovery plan: level of endemism, conservation status, priority category and target conservation status within 5 years

	Endangered *EPBC Act*			**Vulnerable** *EPBC Act*		
Threatened wattles	**Chalky Wattle (*Acacia cretacea*)**	◉	P1	Resin Wattle (*Acacia rhetinocarpa*)	◉	P2
	Whibley Wattle (*Acacia whibleyana*)	◉	P1			
	Fat-leaved Wattle (*Acacia pinguifolia*)	↓	P1			
	Jumping-jack Wattle (*Acacia enterocarpa*)	↓	P1			
Threatened orchids	^ **Mt Olinthus Greenhood (*Pterostylis 'Mt Olinthus'*)**	◉	P3	**Nodding Rufous-hood (*Pterostylis* aff. *despectans*)**	◉	P2
	Metallic Sun-orchid (*Thelymitra epipactoides*)	◉	P1	Winter Spider-orchid (*Caladenia brumalis*)	◉	P1
				Desert Greenhood (*Pterostylis xerophila*)	◉	P2
Threatened annuals	-			Annual Candles (*Stackhousia annua*)	◉	P2
				Silver Candles (*Pleuropappus phyllocalymmeus*)	↓	P3
Other threatened flora species (perennials)	**Prickly Raspwort (*Haloragis eyreana*)**	◉	P2	**West Coast Mintbush (*Prostanthera calycina*)**	↓	P2
				Tufted Bush-pea (*Pultenaea trichophylla*)	↓	P2
				Ironstone Mulla Mulla (*Ptilotus beckerianus*)	◉	P1
				Silver Daisy-bush (*Olearia pannosa* ssp. *pannosa*)	↓	P1
				Bead Samphire (*Halosarcia flabelliformis*)	◉	P2
				^ Sandalwood (*Santalum spicatum*)	◉	P2
				Club Spear-grass (*Austrostipa nullanulla*)	◉	P3
				Granite Mudwort (*Limosella granitica*)	◉	P3
				Microlepidium alatum	◉	P3
				Yellow Swainson-pea (*Swainsona pyrophila*)	◉	P3

Key

Bold and black text = Endemic to Eyre Peninsula
Black text = Endemic to South Australia
Grey text = Known populations in other Australian states
^ = Only listed under the *National Parks and Wildlife Act 1972*
◉ = Aim to maintain and stabilise species population over 5 years
↓ = Aim to down-list species threatened status within 5 years
P1 = Priority 1 species P2 = Priority 2 species P3 = Priority 3 species

Costs

A minimum financial investment of approximately $ 154 000 on average per year for 5 years is required to implement the plan's Core performance criteria, which focus primarily on Priority 1 threatened flora species. To fund the entire recovery plan, a financial investment of approximately $ 300 000 per year for 5 years will start meeting the conservation needs of all threatened flora taxa and cricital habitat identified within this plan.

Wider benefits

Implementation of this plan contributes to holistic natural resource management goals, including habitat protection and management, linking fragmented habitats, strategic threat abatement, and community engagement in regional biodiversity and conservation issues. Anticipated broader ecological benefits of the plan include:

- maintenance of habitat integrity that facilitates ecosystem adaptation to climate change
- protection of water dependent ecosystems, such as wetlands and riparian areas, within threatened flora species critical habitat
- an improved understanding of threatened flora and insect/pollination processes
- an improved understanding of soil biota function in threatened plant habitats.

Contents

Figures

Tables

1 Species information and general requirements

This plan outlines recovery actions for 21 nationally threatened plant taxa and two state threatened plant taxa (Table 1.1).

Table 1.1. Status of threatened plant species covered within this plan

Species Name	Common Name(s)	Conservation Status		
		State NPW Act	National EPBC Act	International IUCN 2001
Acacia cretacea	**Chalky Wattle**	**E**	**E**	**CR**
Acacia enterocarpa	Jumping-jack Wattle	E	E	EN
Acacia pinguifolia	Fat-leaved Wattle	E	E	EN
Acacia rhetinocarpa	Resin Wattle	V	V	VU
Acacia whibleyana	**Whibley Wattle**	**E**	**E**	**CR**
Austrostipa nullanulla	Club Spear-grass	V	V	VU
Caladenia brumalis	Winter Spider-orchid	V	V	EN
Haloragis eyreana	**Prickly Raspwort**	**E**	**E**	**EN**
Halosarcia flabelliformis	Bead Samphire	V	V	VU
Limosella granitica	Granite Mudwort	V	V	VU
Microlepidium alatum	*no common name*	V	V	VU
Olearia pannosa ssp. *pannosa*	Silver Daisy-bush	V	V	EN
Pleuropappus phyllocalymmeus	Silver Candles	V	V	VU
Prostanthera calycina	**West Coast Mintbush**	**V**	**V**	**VU**
Pterostylis* aff. *despectans	**Nodding Rufous-hood**	**V**	**V**	**CR**
Pterostylis 'Mt Olinthus'^	**Mt Olinthus Greenhood**	**E ^**	**-**	**CR**
Pterostylis xerophila	Desert Greenhood	V	V	CR
Ptilotus beckerianus	Ironstone Mulla Mulla	V	V	EN
Pultenaea trichophylla	**Tufted Bush-pea**	**R**	**V**	**VU**
*Santalum spicatum^*	Sandalwood	V ^	-	EN
Stackhousia annua	Annual Candles	V	V	CR
Swainsona pyrophila	Yellow Swainson-pea	R	V	VU
Thelymitra epipactoides	Metallic Sun-orchid	E	E	CR

Key:

Bold and black text = Endemic to Eyre Peninsula
Black text = Endemic to South Australia
Grey text = Known populations in other Australian states
^ = Only listed under the *National Parks and Wildlife Act 1972*

State and National conservation status classifications: E = Endangered, V = Vulnerable, R = Rare
ICUN classifications (vers. 3.0): CR = Critically Endangered, EN = Endangered, VU = Vulnerable

1.1 Other threatened flora of Eyre Peninsula

In total, thirty-one nationally threatened flora species grow on Eyre Peninsula. These species are listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). The nine nationally listed threatened flora species excluded from this plan include five species that grow within the Eyre Peninsula Natural Resources Management (NRM) Board region:

- Feathery Wattle (*Acacia imbricata*), Vulnerable
- Lehmann's Apple-berry (*Billardiera* sp. 'Yorke Peninsula'), Endangered
- Slender Bell-fruit (*Codonocarpus pyramdalis*), Vulnerable
- Small-flower Daisy-bush (*Olearia microdisca*), Endangered
- Trailing Hop-bush (*Dodonaea procumbens*), Vulnerable.

Another threatened flora species found within the Eyre Peninsula NRM Board region is the state Vulnerable Senna Wattle (*Acacia praemorsa*), which is currently under consideration for listing under the *EPBC Act 1999* as nationally Endangered.

The other four species grow on northern Eyre Peninsula, within the Department for Environment and Heritage's (DEH) West Region, and within the South Australian Arid Lands NRM Board and/or Alinytjara Wilurara NRM Board regions:

- Black-fruit Bluebush (*Maireana melanocarpa*), Vulnerable
- Corunna Daisy (*Brachycome muelleri*), Endangered
- Ooldea Guinea-flower (*Hibbertia crispula*), Vulnerable
- Scarlet Grevillea (*Grevillea treueriana*), Vulnerable.

Species included within this plan were finalised by the Ark on Eyre Threatened Flora Recovery Team and originally 25 species were included (unpublished meeting minutes 27 March 2001). Since 2001, information from local botanical experts and a review of State Herbarium records has meant that Feathery Wattle (*Acacia imbricata*) is awaiting down-listing from the *EPBC Act 1999* and is therefore omitted from this plan. Immediate risks to Corunna Daisy (*Brachycome muelleri*) have meant that DEH's Seed Conservation Centre in Adelaide is undertaking recovery actions for this species, with a focus on germination requirements and translocation (D Bickerton [DEH] 2007, pers. comm.). All other species are currently beyond the scope of this plan and will be included in future recovery plans as necessary.

1.2 Region

The Eyre Peninsula NRM Board region spans 55 000 km^2, geographically defined as the landmass south of Ceduna and Whyalla (
Figure 1.1). The Australian environment is categorised into bio-geographic areas using a system known as Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell 1995). In this system, Eyre Peninsula is part of the Eyre Yorke IBRA region, which is a large region separated into subregions, based on landforms, climate and vegetation associations (Laut et al. 1977). By far the majority of threatened flora species on Eyre Peninsula grow within the Eyre Hills IBRA subregion. The subregion consists of the Southern and Eastern Uplands, which are two distinct and geographically separate hilly areas, bisected by the Eyre Mallee IBRA subregion (
Figure 1.1) (DEH-EGIS 2007).

The Eyre Hills IBRA subregion spans 1 168 241 hectares and reaches elevations of 447 metres AHD (Australian Height Datum). Nineteen of the threatened flora species listed in this plan are restricted in their distribution to the Eyre Hills IBRA subregion (Table 1.2).

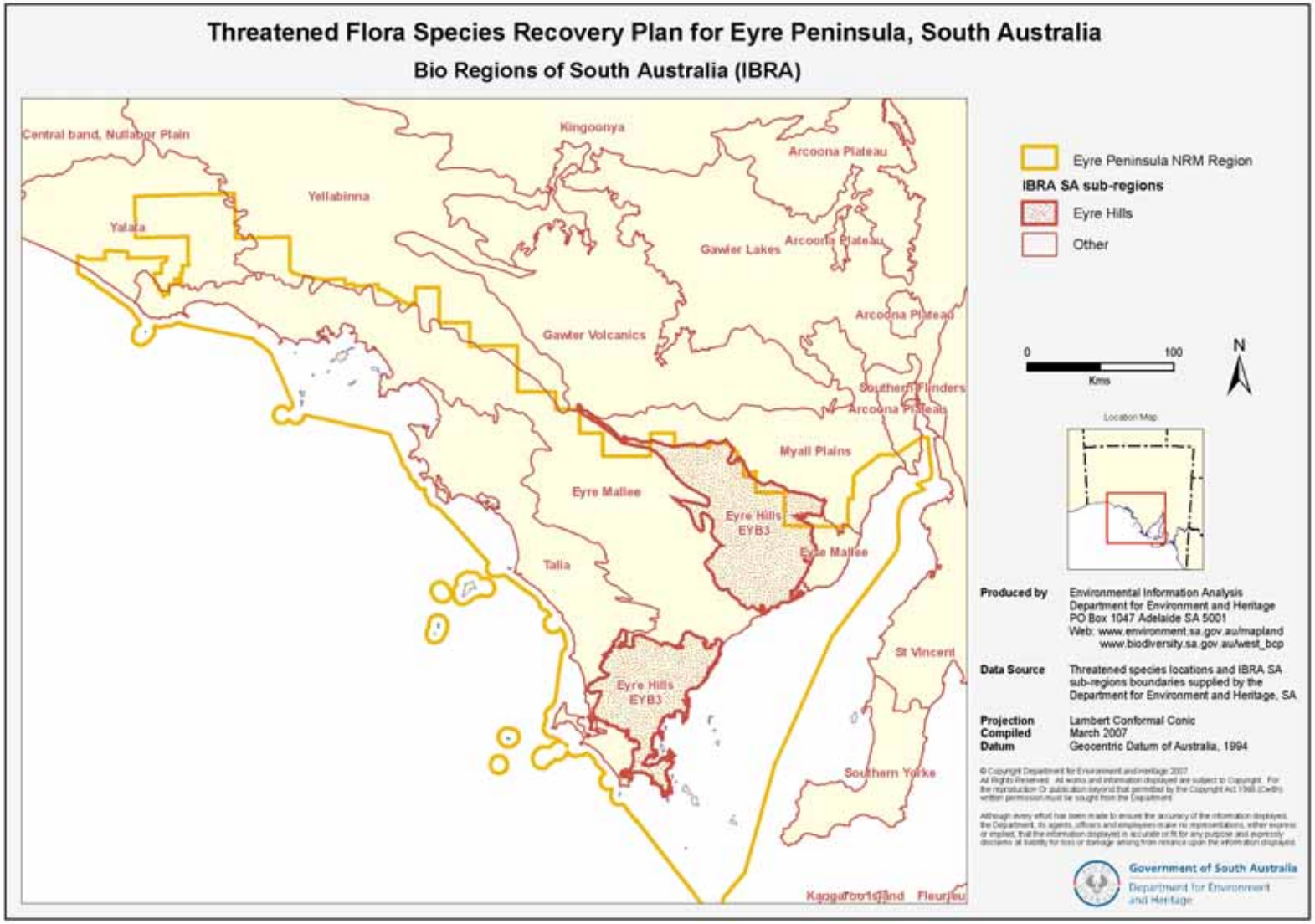


Figure 1.1. Eyre Peninsula Interim Biogeographic Regionalisation of Australia (IBRA) Sub-regions

Table 1.2. Species and percentage of their population within Eyre Hills IBRA Subregion

Species	% population in Eyre Hills IBRA Sub Region SA	Species	% population in Eyre Hills IBRA Sub Region SA
Silver Daisy-bush	100	Jumping-jack Wattle	95
Nodding Rufous-hood	100	Whibley Wattle	86
Desert Greenhood	100	Metallic Sun-orchid	83
Tufted Bush-pea	100	Winter Spider-orchid	65
Annual Candles	100	Resin Wattle	50
Mt Olinthus Greenhood	100	Silver Candles	34
Fat-leaf Wattle	99	Bead Samphire	11
Prickly Raspwort	99	Yellow Swainson-pea	11
Chalky Wattle	97	West Coast Mintbush	10
Ironstone Mulla Mulla	96		

1.3 Conservation status and legislation

In Australia, species can be listed as threatened at a national level, under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). All species listed under this Act are recognised as Matters of National Environmental Significance (Commonwealth of Australia 2006). Species can also be listed as threatened at a state level. In South Australia, state level threatened flora are protected under the *National Parks and Wildlife Act 1972* (*NPW Act*) and listed in Schedules 7, 8 and 9.

Species conservation status is periodically reviewed. For example, at the time of publication, Senna Wattle (*Acacia praemorsa*) is being considered for listing under the *EPBC Act 1999* as nationally endangered. Similarly, Feathery Wattle (*Acacia imbricata*) is being considered for down-listing, as a result of recommendations from local experts and extensive surveys completed under the interim recovery plan.

Threatened plant species in this plan are assessed and reviewed against the World Conservation Union criteria (IUCN) (Table 1.1). This is an important review process because it ensures international conservation status classification standards are applied. Australian legislation bases its criteria for conservation status on IUCN criteria. All actions and performance criteria in this plan are structured to link back to IUCN criteria.

Objectives of the *Environment Protection and Biodiversity Conservation Act 1999*

This plan has been developed in line with *Environment Protection and Biodiversity Conservation Act 1999* objectives 1.2.1, 1.2.2, 1.2.3 and 1.2.4.

EPBC Act Objective 1.2.1: Promoting a cooperative approach to the protection and management of the environment involving governments, the community, land holders and indigenous people.

To be successful, this plan requires the community and stakeholders to adopt and implement recovery actions, and complete a critical review to progress future work. Therefore, expected outcomes include involvement of stakeholders and promotion of cooperative natural resource management (Actions 2a – 2c).

EPBC Act Objective 1.2.2: Assisting in the co-operative implementation of Australia's environmental responsibilities.

This plan contains performance criteria that directly deliver and/or support environmental legislation and policy at national, state and regional levels. This legislation and policy includes:

- United Nations Convention on Biological Diversity (International)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (International)
- National Strategy for the Conservation of Australia's Biological Diversity (National)
- National Biodiversity and Climate Change Action Plan (National)
- South Australia's Strategic Plan (State)
- *No Species Loss* – A Nature Conservation Strategy for SA 2007-2017 (State)
- State Natural Resources Management Plan 2006 (State)
- NatureLinks: East Meets West Corridor Plan Draft (Regional)
- Initial Natural Resources Management Plan for the Eyre Peninsula Natural Resources Management Region 2006-07 (Regional).

EPBC Act Objectives 1.2.3 and 1.2.4: Recognising the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity and promoting the use of indigenous peoples' knowledge with the involvement of, and in co-operation with, the owners of the knowledge.

1.4 International obligations

The goals in this plan are consistent with Australia's obligations under the Convention on Biological Diversity, ratified by Australia in 1993, and the National Strategy for the Conservation of Australia's Biological Diversity (1996).

Although some species covered by this plan are known to occur within wetlands, the recovery actions for these species will not impact on obligations made under the Convention on Wetlands of International Importance (Ramsar Convention 1971).

The Winter Spider-orchid (*Caladenia brumalis* syn. *Arachnorchis brumalis),* Desert Greenhood (*Pterostylis xerophila*), Nodding Rufous-hood (*Pterostylis* aff. *despectans*) and Metallic Sun-orchid (*Thelymitra epipactoides*) are listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975) (CITES). All corresponding recovery actions in this plan are considered within Australia's obligations under CITES.

1.5 Affected interests

The successful implementation of this plan will require that all stakeholders are identified and engaged in the implementation of this plan. This plan is designed to link with community groups, land managers and statutory organisations connected with threatened plant species on Eyre Peninsula (Table 1.3).

Private land holders, land developers, mining lease holders, SA Water, ETSA Utilities, Local Government, the Department for Environment and Heritage (DEH), and the Department for Transport Energy and Infrastructure (DTEI) are all major stakeholders that directly own or manage sites where these threatened flora species are known to occur. When new sub-populations or populations are discovered, the relevant land managers will be consulted regarding recovery actions on land for which they are responsible.

Table 1.3. Current and potential regional, state and national stakeholders involved in the management of threatened plant species on Eyre Peninsula

Regional stakeholders	Code
Australian Plant Society Groups (Eastern Eyre Peninsula, Kimba & Districts, Southern Eyre)	APSG
Consultants and Contractors	C&C
*Cummins Landcare Group	CL
*District Council of Ceduna	DCC
*District Council of Elliston	DCE
*District Council of Franklin Harbour	DCFH
*District Council of Le Hunte	DCLH
*District Council of Lower Eyre Peninsula	DCLEP
*District Council of Streaky Bay	DCSB
*District Council of Tumby Bay	DCTB
*District Council of Whyalla	DCW
Eyre Peninsula Natural Resources Management Board	EPNRMB
*Friends of Parks Groups	FOP
Garden Clubs	G.Clubs
General Public	GP
Local Government Association	LGA
*Local Indigenous Community	LIC
Local Sandalwood Society	LSS
*Private Land Holders	PL
Project Officer	PO
Recovery Team	RT
Schools (e.g. Cummins Area School, Tumby Bay Area School)	S
Tourism Eyre Peninsula	TEP
Tour Operators (e.g. Great Australian Bight Safaris)	TO
State stakeholders	**Code**
*Australian Railroad Group Pty Ltd (ARG)	ARG
*Department for Environment and Heritage (including Botanic Gardens, Plant Biodiversity Centre and State Herbarium)	DEH
*Department for Transport, Energy and Infrastructure	DTEI
Department for Land, Water and Biodiversity (including Native Vegetation Council)	DLWB
*ETSA Utilities	ETSA
General Public	GP
*Indigenous Community	IC
Nature Foundation SA	NFSA
Primary Industries and Resources SA	PIRSA
*SA Water	SAW
South Australian Country Fire Service	SACFS
South Australian Museum	SAM
Threatened Plant Action Group	TPAG
National (and interstate) stakeholders	**Code**
Australian Network for Plant Conservation	ANPC
CSIRO	CSIRO
* Department of Environment and Conservation (Western Australia, formerly CALM)	DEC
* Department of Sustainability and Environment (Victoria)	DSE
Department of the Environment and Water Resources	DEWR
General Public	GP
Green Corps	GC
Greening Australia	GA
Research Institutions including Universities	RI
Threatened Species Network	TSN
WWF–Australia	WWF
* = Stakeholders that directly manage land with threatened plants	

1.6 Existing recovery documents

Past recovery plans or documents with management recommendations exist for several species covered by this plan (Appendix C).

1.7 Roles and interests of Indigenous people

The requirements of the *Native Title Act 1993* only apply to land where Native Title rights and interests may exist. When implementing any recovery actions in this threatened species plan where there has been no Native Title determination, or where there has been no clear extinguishment of Native Title, consideration must be made as to the possibility that Native Title may continue to exist.

Generally, the *Native Title Act 1993* requires certain procedures to be followed prior to undertaking activities that may affect Native Title rights and interests. Such activities are known as future acts, and these may include certain recovery actions in this plan. The adoption of this plan will be subject to any Native Title rights and interests that may continue in relation to the land and/or waters.

Nothing in the plan is intended to affect Native Title. The relevant provisions of the *Native Title Act 1993* should be considered before undertaking any future acts that might affect Native Title. Procedures under the *Native Title Act 1993* are additional to those required under the *Aboriginal Heritage Act 1998*.

A draft of this recovery plan has been referred to the Aboriginal Partnership Unit of the Department for Environment and Heritage, who will undertake consultation with relevant Indigenous communities. This consultation will determine the role and interests of Indigenous communities with regard to the implementation of this plan.

1.8 Benefits to other species/ecological communities

Threatened flora recovery work has anticipated benefits for many fauna species and plant communities on Eyre Peninsula. Objectives within the plan strive towards holistic habitat protection and management, strategic threat abatement, and increasing community awareness of, and engagement in, conservation and sustainability issues.

Benefits to vegetation communities

Important vegetation communities (DEH 2002) are expected to benefit from threatened flora recovery actions, for example:

- Sugar Gum (*Eucalyptus cladocalyx*) Woodlands (regionally Threatened on Eyre Peninsula) – Part of Ironstone Mulla Mulla, Metallic Sun-orchid, Silver Daisy-bush and Winter Spider-orchid critical habitat. Also support the Eyre Peninsula Yellow-tailed Black-Cockatoo (*Calyptorhynchus funereus*; state Vulnerable, regionally Endangered) and Common Brushtail Possum (*Trichosurus vulpecular*; state Vulnerable, regionally Rare)
- Purple-flowered Mallee Box (*Eucalyptus lansdowneana* ssp. *albopupurea*), Drooping Sheoak *(Allocasuarina verticillata*) +/- Coastal White Mallee *(E. diversifolia*) Mallee and Woodland (regionally Rare on Eyre Peninsula) – Part of Metallic Sun-orchid critical habitat
- Broad-leaf Box (*Eucalyptus behriana*) Woodland communities (regionally Vulnerable) – Part of Jumping-jack Wattle critical habitat
- Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*) Woodlands (state Endangered) – Part of Fat-leaved Wattle critical habitat.

Plant species that are similar to the species included in this plan are expected to benefit from baseline data, monitoring and research that addresses knowledge deficiencies and future trends in flora populations. Gaining knowledge and addressing common threats related to these similar plant species will improve our understanding of aspects such as limited niches and the impact of climate change, failed and successful flowering

responses, potential pests and diseases, pollinator needs, and fire sensitivity and necessity. Eighty-eight regionally threatened flora species grow within the Eyre Hills IBRA subregion (DEH-EGIS 2007) and 20 state threatened flora species occur within Priority 1 Focus Work Areas (Table 30.3). These species are expected to benefit from the implementation of recovery actions within these areas.

Benefits to fauna

Thirteen state threatened fauna species are known to occur within Priority 1 Focus Work Areas identified within this plan for threatened flora recovery. These and other fauna species are expected to benefit indirectly from actions that deliver broad-scale improvement to the landscape (e.g. environmental weed control, more appropriate fire regimes, and habitat restoration activities). Fauna are likely to directly benefit from recovery actions that focus on plants that provide them with shelter and food (e.g. prostrate or spiky plants that provide safe refuge for species such as reptiles, small wrens and spiders). As an example, threatened Sandalwood plants provide shelter sites for native spotted Jezebel butterflies to breed and grow, and the butterflies' larvae have actually been observed growing better on Sandalwood than on any other plant species (DEC 2007).

Wattle species provide direct food resources (mainly seeds) to native ants and birds (e.g. cockatoos, Emus, Malleefowl), and indirect food resources to beetles and wasps, which eat mites and thrips feeding on wattle flowers (Tame 1992). Honeyeaters and bird species of conservation significance within the Koppio woodlands include the Western Gerygone (*Gerygone fusca*; state Rare) and Diamond Firetail (*Stagonopleura guttata*; state Vulnerable) (DEH-EGIS 2007; DEH 2002; S Way [DEH] 2007, pers. comm.). Each of these threatened bird species has been recorded within Priority 1 Focus Work Areas identified within this plan (Table 30.3). Other species include the White-striped Freetail-bat (*Tadarida australis*), the Inland Freetail-bat (*Mormopterus planiceps*) and Greater Long-eared Bat (*Nyctophilus timoriensis*; state Vulnerable), which flies above the vegetation canopy searching for insects within dry woodlands across Eyre Peninsula (DEH-EGIS 2007; DEH 2002; S Way [DEH] 2007, pers. comm.).

Benefits to ecosystem services

Ecosystem services are the natural processes that are responsible for clean air and water, and numerous other environmental goods such as pollination of crops and native vegetation, shade and shelter, maintenance of fertile soil, and climate regulation (CSIRO Australia 2007; Lindenmayer & Burgman 2005).

Recovery of threatened flora critical habitat is expected to benefit symbiotic fungi (*mycorrhiza*) in the soil. Mycorrhiza assist with plant uptake of water, nutrients and trace elements, helping to produce terrestrial ecosystems that are more resilient to stresses, i.e. attack from pathogens and insects (Grey & Grey 2005).

Threatened wattle (*Acacia*) and pea (*Pultenaea*) species, and other species in the Leguminoseae family, use symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen. 'Nitrogen-fixing' plays an essential role in ecosystem function by producing nitrate and/or ammonium, which benefits the whole system of plants and provides flow-on nitrogen to animals (CILR 2007).

Recovery actions seeking to address threatened orchid reproduction and recruitment issues are expected to increase our understanding of invertebrates and pollinator species. Healthy invertebrate populations are an important foundation to trophic systems that support larger animals such as birds, bats and reptiles. In turn, these animals offer insect 'cleaning and pest control services', which are fundamental ecosystem services.

1.9 Social and economic impacts

Implementation of this recovery plan is not intended to cause significant adverse social and economic impacts. Beneficial social and environmental impacts are likely to result from the implementation of a significant number of the planned recovery actions. Such benefits include provision of funding and professional human resources to Eyre Peninsula, promoting and fostering cooperative community teamwork, and the development of community interest and skills in natural resource management. The recovery of vegetation communities associated with Eyre Peninsula's threatened plant species is expected to enhance ecosystem services, which may in turn benefit agricultural production and produce positive social and economic impacts.

1.10 Evaluation of plan performance

The South Australian Department for Environment and Heritage, in conjunction with the recovery team, will evaluate the performance of this recovery plan. The plan is to be reviewed within 5 years of its commencement (Table 31.2). Any changes to management or recovery actions will be documented accordingly.

2 Definitions

Words and terms uncommon to everyday language are used within this plan, with many also having very specific legal meanings (e.g. critical and potential habitat). For further definitions please refer to the glossary in Appendix B.

2.1 Critical and potential habitat

This document is a regionally based recovery plan for nationally threatened flora occurring on Eyre Peninsula. Critical and potential habitat occurring outside of the Eyre Peninsula Natural Resources Management region is therefore not addressed in this plan.

Under regulation 7.09 of the *Environment Protection and Biodiversity Conservation (EPBC) Regulations 2000,* habitat critical to survival is defined as:

- sites needed to meet essential life cycle requirements,
- sites of food sources, water, shelter, fire and flood refuges or those used at other times of environmental stress,
- essential travel routes between sites,
- sites necessary for seed dispersal mechanisms to operate or to maintain populations of species essential to the threatened species or ecological community,
- habitat used by important populations,
- habitat that is required to maintain genetic diversity, and/or
- areas that may not be occupied by the species and/or ecological community, but that are essential for the maintenance of those areas where they do occur.

Critical habitat

Current knowledge of the ecology and biology of nationally threatened flora on Eyre Peninsula is considered insufficient to precisely determine the spatial boundaries of critical habitat required under the EPBC criteria outlined above. For the purpose of this recovery plan, known and historic distribution mapping has been substituted as the interim critical habitat mapping for threatened flora on Eyre Peninsula. Known distribution meets the majority of EPBC criteria and will be used until critical habitat can be determined (Recovery Action 1c).

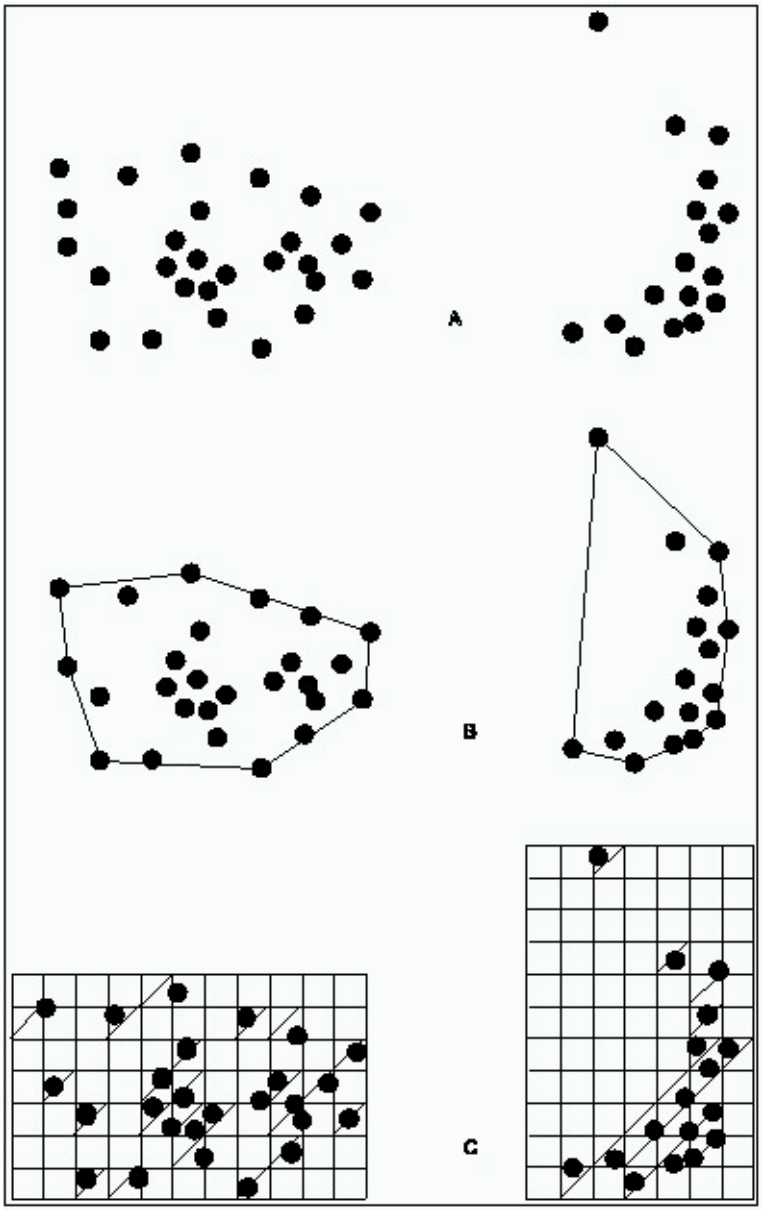
Potential habitat

Potential habitat is defined as habitat that is not critical to the current survival of threatened flora species, but that may be important to the long term recovery of a particular species as that species is encouraged to expand in distribution. Two performance criteria in this plan (1c.2 and 1c.3) address mapping of potential habitat.

2.2 Extent of occurrence and area of occupancy

IUCN (2001) defines extent of occurrence as the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known (inferred or projected) sites of present occurrence of a taxon (Figure 2.1, Pictures A and B).

The measurement of extent of occurrence may exclude discontinuities or disjunctions within the overall distributions of taxa (e.g. large areas of obviously unsuitable habitat), but see 'Area of occupancy'. Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence) (IUCN 2001).



Key: (A) Is the spatial distribution of known, inferred or projected sites of present occurrence. (B) Shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (C) Shows one measure of area of occupancy, which can be achieved by the sum of the occupied grid squares (IUCN 2001).

Figure 2.1. Diagrams explaining extent of occurrence and area of occupancy

Area of occupancy

Area of occupancy is defined as the area within a species' extent of occurrence that is occupied by that taxon (Figure 2.1, Picture C). The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitat. In some cases, the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data.

2.3 Populations and sub-populations

Population

The legal definition of a population is an occurrence of the species or community in a particular area (*EPBC Act 1999*). A population is a group of conspecific individuals (i.e. belonging to the same species), commonly forming a breeding unit within which the exchange of genetic material is more or less unrestricted, and/or a group sharing a particular habitat at a particular time (Lindenmayer & Burgman 1998). However, in the IUCN Red List criteria the term 'population' is used differently to its common biological usage, and population is defined as the total number of individuals of the taxon (IUCN 2001).

This plan uses the term 'population' in two slightly different ways. It refers to the whole Eyre Peninsula population of a species, and it refers to populations where there is an obvious and large geographical separation in locations of the same species.

Sub-population

Sub-population(s) are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (IUCN 2001).

At the time of publication the genetic relationship between threatened flora 'populations' or 'sub-populations' on Eyre Peninsula is unknown, so the use of the terms 'population' and 'sub-population' are based on presumed genetic exchange only.

3 Overview of threats

Threats to plant species on Eyre Peninsula have been separated into two categories, 'direct threats' or 'impediments to recovery'. All identified direct threats and impediments to recovery are listed in no particular order in Tables 3.1 and 3.2 respectively. The majority of threats to the species in this plan have been identified; however, it is likely that some threats remain unknown and are therefore not listed. Details of direct threats and impediments to recovery are outlined for each plant species within the species description sections (Sections 6–28).

Direct threats

Direct threats are defined as processes which directly impact on the short-term survival of threatened plant populations, e.g. weed invasion. Some of the direct threats listed in the plan are recognised as Key Threatening Processes under federal legislation (*EPBC Act 1999*). Examples of Key Threatening Processes relevant to threatened flora include:

- land clearance (corresponds with vegetation clearance in this plan)
- competition and land degradation by feral goats and feral rabbits (corresponds with high grazing pressure)
- dieback caused by the water mould *Phytophthora cinnamomi* (corresponds with pest and disease).

Impediments to recovery

Impediments to recovery are defined as processes that will significantly influence the long-term survival of threatened plant species, but will not necessarily impact on the current day-to-day species survival. Impediments to recovery also include processes that restrict the ability of managers to stop or prevent threatening processes.

Phytophthora

Symptoms of the plant pathogen *Phytophthora cinnamomi*, a water mould, have been discovered in the Koppio Hills and Wanilla areas of Lower Eyre Peninsula. *Phytophthora* is considered a significant threat to flora within this area. Six of the species addressed within this plan, *Acacia whibleyana*, *Caladenia brumalis*, *Olearia pannosa* ssp. *pannosa*, *Ptilotus beckerianus*, *Pultenaea trichophylla* and *Thelymitra epipactoides* are listed as occurring within habitat susceptible to *Phytophthora* in the national *Threat Abatement Plan for Dieback caused by the root-rot fungus* Phytophthora cinnamomi (Environment Australia 2001). Velzeboer et al. (2005) ranked all South Australian threatened flora based on the proportion of each species' population in proximity to *Phytophthora* and each plant species' conservation status. Based on these parameters, the following species were ranked, starting with the species most at threat from *Phytophthora*:

1. *Acacia pinguifolia*
2. *Haloragis eyreana*
3. *Acacia enterocarpa*
4. *Thelymitra epipactoides*
5. *Acacia whibleyana*
6. *Pultenaea trichophylla*
7. *Ptilotus beckerianus*.

Illegal collection of firewood from roadside and railway vegetation, and use of off-trail motorbikes during wet conditions, are potential vectors that could easily spread *Phytophthora.*

Table 3.1. Summary of direct threats to threatened flora recovery on Eyre Peninsula and a summary of recommended actions

Direct threats	Brief summary of actions
High grazing pressure	Determine and minimise impact of native, domestic and feral herbivore grazing on threatened plants, Determine seasonal timing of grazing that causes most damage to plant species.
Illegal collection or harvest	Work with DEH Investigation and Compliance Unit, Encourage seed and plant material collection through DEH permit system.
Mineral exploration/extraction	Twice yearly updates of BDBSA central database that mining companies use, Provide regular updates and information on threatened plant species.
Off-road vehicles and rubbish dumping	Actively deter off-road vehicle traffic and rubbish dumping in critical habitat, Communicate risk of *Phytophthora* spread by off-road vehicles.
Pest and disease (*Phytophthora*)	Conduct suspected *Phytophthora* site testing, Communicate known *Phytophthora* sites, Ensure DEH *Phytophthora* hygiene practices and national biosecurity guidelines are used in delivery of on-ground actions.
Roadside management (including railway and essential services easements)	Establish a Roadside Marker System for significant flora and fauna along council roads, Twice yearly updates of BDBSA central database that councils use, Provide regular updates and information on threatened plant species.
Salinity/changes in hydrology	Determine impact and encourage/support activities to mitigate soil salinity and significant changes in hydrology.
Spray drift	Research the effect of spray drift on threatened plant critical habitat and break down in plant life cycle, Provide up-to-date and easily accessible threatened plant information to all land holders with threatened plants.
Urban development/subdivision	Twice yearly updates of BDBSA central database that councils use, Provide regular updates and information on threatened plant species.
Vegetation clearance	Encourage minimal clearing of native vegetation in or adjacent to critical and/or potential habitat.
Weed invasion	Determine and minimise impact of environmental weeds on threatened plant species using the most efficient and effective methods. Support eradication of Bridal Veil and control of Bridal Creeper on Eyre Peninsula.

Table 3.2. Summary of impediments to threatened flora recovery on Eyre Peninsula and a summary of recommended actions

Impediments to recovery	Brief summary of actions
Availability of resources	Obtain resources from funding bodies/private companies, Support Recovery Project Officer, Develop stakeholder skills in native plant management, Encourage in-kind support for threatened plant recovery.
Lack of coordination of recovery actions	Establish and support a threatened plant recovery team, Appoint Recovery Project Officer, Conduct periodic evaluations of recovery project, Integrate recovery actions into other natural resource management on Eyre Peninsula, Monitor effectiveness of on-ground actions.
Habitat fragmentation	Target on-ground actions to minimise the impact of declining genetic diversity, edge effects and the distance effects associated with small isolated populations in fragmented landscapes.
Inappropriate disturbance regimes	Monitoring and research to determine appropriate disturbance regimes for threatened plants and critical habitat. Identify break downs in threatened plant life cycles that are attributed to inappropriate disturbance.
Inappropriate fire regimes	Conduct monitoring and research to determine appropriate fire regimes for threatened plants and critical habitat. Inappropriateness of the fire regime refers to the frequency, interval, intensity, extent and seasonality with respect to how it can be a threatening process.
Lack of involvement of stakeholders	Establish threatened plant recovery team and volunteer group, Provide up-to-date and easily accessible threatened plant information to all land holders with threatened plants, Facilitate community involvement in recovery of species and habitat.
Lack of knowledge (ecology and biology) and baseline information (understanding of threats)	Survey threatened plant records and potential habitat, Develop model to identify potential habitat and climatic change requirements, Encourage adaptive threat management, Safely store threat survey/monitoring data in a central database.
Lack of recruitment/small population size	Survey potential habitat, Involve community to identify new sub-populations and report, Research break downs in plant life cycle, Monitor population numbers, Plant/translocate if feasible.
Restricted distribution/isolated sub-populations	Identify threats causing distribution restriction, Use corridors to connect isolated sub-populations, Model population viability.

4 Overview of recovery

4.1 Recovery process

The recovery process begins with clearly defined goals and ends with an assessment of how well these goals have been achieved (Figure 4.1). Beneath the goals are objectives, of which this plan has five (Section 4.3), followed by actions and performance criteria. This layering of goals through to performance criteria channels big picture/policy level direction into on-ground work. The recovery process is tied together with monitoring to ensure continuous improvement.

Targets and recommendations from international, national, state and regional policies and plans feed into the recovery process, and outcomes from the recovery plan help deliver threatened species targets listed in these higher level policies and plans.

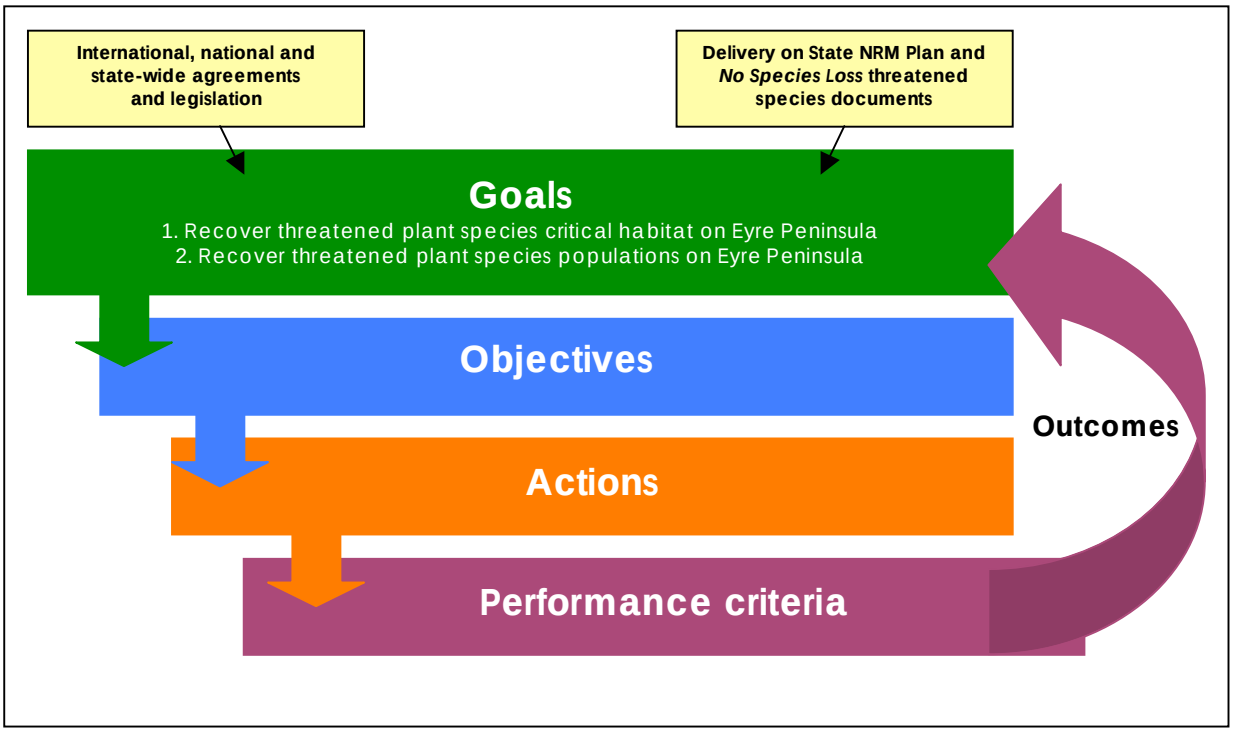


Figure 4.1. Relationship between recovery goals, objectives, actions, performance criteria and outcomes

4.2 Goals

Because we are dealing with ecological improvement, a long-term time frame is applicable for program goals (DEH 2004a; DWLBC 2006). The recovery plan has two goals to be achieved over the next 30 years (by 2037). Thirty years is considered the timeframe needed to succeed in the following goals:

Goal 1 Recover threatened plant species critical habitat on Eyre Peninsula.
Goal 2 Recover threatened plant species populations on Eyre Peninsula.

This plan has a lifespan of 5 years, at which point it will require review. The plan will need to be reviewed and modified every 5 years, dependant upon progress. Subsequent plans will ensure continual progress against the long-term goals. Success will be determined by whether species are either down-listed or stabilised. Improvement of species critical habitat, ecosystem function, and areas containing state or regionally Rare species and threatened plant communities, are implied in the delivery of Goal One.

4.3 Objectives

The plan has five objectives used to define areas of work required to achieve the goals. These objectives include:

Objective 1 Obtain baseline information, including critical and potential habitat, for each threatened flora species.

Objective 2 Increase understanding, appreciation and involvement in threatened flora recovery efforts.

Objective 3 Manage immediate threats and improve threatened flora critical habitat.

Objective 4 Conduct research critical to management by addressing knowledge deficiencies in threatened flora biology and ecology (including threat identification).

Objective 5 Monitor threatened flora populations and evaluate the success of recovery actions.

4.4 Actions

Actions define the recovery tasks. Public involvement at this level is crucial to the success of the recovery progress. This plan has five sets of actions that correspond directly to the five objectives:

Actions 1a – 1d (Box 1)
Actions 2a – 2c (Box 2)
Actions 3a – 3f (Box 3)
Actions 4a – 4h (Box 4)
Actions 5a – 5c (Box 5)

Actions 1a – 1d: Obtain baseline information

It is important to have a good baseline understanding of the region's threatened flora, so that we know what we are starting with. For the species covered by this plan, over 900 records span Eyre Peninsula, so there are many sites that require verification or minimum dataset information. Inaccuracies and limitations in the current threatened flora baseline information exist, for example, variances in location details, population size and structure information, area of occupancy and extent of occurrence. Actions 1a – 1d aim to rectify baseline information inaccuracies, help formally define critical habitat, and enable review against IUCN criteria.

Box 1. Actions linked with Objective 1: Obtain baseline information

1a	Re-survey known threatened flora sites recording minimum dataset information collection/records.
1b	Determine landscape attributes (including slope, aspect, soils, geology, altitude, vegetation, fire history, and surrounding land use) associated with priority species using Geographic Information Systems (GIS).
1c	Map critical and potential threatened plant habitat and ground truth this information.
1d	Conduct targeted surveys for new populations.

Actions 2a – 2c: Increase understanding, appreciation and involvement

Successful threatened species recovery relies on the involvement of the local community. Actions 2a – 2c outline how the community might be involved. The ability to coordinate community involvement through activities such as organising and supporting volunteers, fostering in-kind support, and managing monetary investment is a key action for the recovery program.

Box 2. Actions linked with Objective 2: Increase understanding, appreciation and involvement

2a	Maintain ability to coordinate and implement recovery program and support community involvement (including the ability to apply for and manage external funds).
2b	Implement a Communication Strategy to support and encourage the management of threatened plant species.
2c	Support volunteer involvement in implementation of recovery actions.

Actions 3a – 3f: Manage threats and improve habitat

To decrease the risk of extinction, the recovery team will focus on prevention, reduction and management of foreseeable threats. Salinity, changes in hydrology, weed invasion, grazing pressure, *Phytophthora* and land clearance are examples of threats that affect the short-term survival of threatened flora. Habitat improvement may include actions such as buffer plantings, ecological burning, reinstatement of associated vegetation communities, and plant translocations. Actions 3a – 3f aim to manage immediate threats to threatened flora and improve quality of habitat. These actions are not comprehensive; however, they provide a good starting point to address some of the most obvious issues.

Box 3. Actions linked with Objective 3: Manage threats and improve habitat

3a	Determine direct and potential threats to each sub-population.
3b	Reduce weed competition within threatened plant species critical habitat.
3c	Reduce grazing damage to threatened plants and critical habitat.
3d	Contain and prevent *Phytophthora* sp. infestations.
3e	Increase off reserve protection.
3f	Increase probability for species to adapt to change.

Actions 4a – 4h: Conduct research critical to management

Research that is critical to the management of a species should not be isolated from the recovery program. There are substantial knowledge gaps in our understanding of the biology and ecology of threatened species. There are many unanswered questions about pollination processes, viable population size, plant genetics, germination triggers, disturbance requirements and plant life cycle bottlenecks. Such critical research is clearly identified within actions 4a – 4h.

Box 4. Actions linking with Objective 4: Conduct research critical to management

4a	Secure funding for students (Honours and/or Post Graduate level) or local community members to conduct research into Eyre Peninsula threatened plant species.
4b	Address basic deficiencies in knowledge of plant biology.
4c	Investigate the role of fire and disturbance on threatened plant life cycles.
4d	Investigate competition and grazing impact on threatened plants.
4e	Investigate genetic relationships within and/or between populations.
4f	Determine the extent to which neighbouring land-uses indirectly affect threatened plant populations.
4g	Research the implications of changing climatic conditions on threatened plant populations.
4h	Conduct Population Viability Assessments for priority 1 threatened plant species recovery (closely linked to action 5c).

Actions 5a – 5c: Monitor populations and evaluate success of recovery actions

Actions 5a – 5c outline the checking mechanisms that will be used to ensure that work is effective, and that recovery objectives and goals have been achieved.

Box 5. Actions linking with Objective 5: Monitor populations and evaluate success of recovery actions

5a	Establish monitoring protocol and schedules for each threatened plant species.
5b	Evaluate recovery actions against performance criteria and schedule.
5c	Review and update Recovery Plan every five years.

4.5 Performance criteria

The above mentioned actions may consist of numerous components. To deal with these complexities, all actions have been broken down into performance criteria. Performance criteria are designed to ensure that the progress of the plan can be effectively benchmarked against timelines, and that planners can see the progress of certain components of an action. For example, the action may be 'Reduce weed competition within threatened plant species critical habitat'; however, there may be three performance criteria such as:

- Reduction in abundance and density of high risk weeds, within 80% of Focus Work Area 1 by 31st December 2008, 2009, 2010 and 30th December 2011.
- Reduction in abundance and density of medium risk weeds, within 50 m of Priority 1 species populations by 31st December 2008, 2009, 2010 and 30th December 2011.
- Reduction in abundance and density of high risk weeds, within 50% of Focus Work Areas 2 and 3 by 31st December 2008, 2009, 2010 and 30th December 2011.

This plan has 92 performance criteria, linked to specific objectives and actions:

Performance criteria 1a.1 – 1d.3 (Box 6)
Performance criteria 2a.1 – 2c.3 (Box 7)
Performance criteria 3a.1 – 3f.8 (Box 8)
Performance criteria 4a.1 – 4h.2 (Box 9)
Performance criteria 5a.1 – 5c.2 (Box 10)

These criteria have been spilt into Core, Tier 1 and Tier 2 categories, which relate to available budget. Associated recovery plan costs and budget are explained in detail in Section 31. Importantly, Core performance criteria are the very minimum criteria to be completed in striving to meet the recovery goals.

Box 6. Performance criteria linked to Objective 1 and Actions 1a–1d: Obtain baseline information

1a.1	Surveys conducted and minimum dataset* information collected for 90% of Priority 1 species sub-populations by 31st December 2012. **[CORE]**
1a.2	Surveys conducted and minimum dataset* information collected for 70% of Priority 2 species sub-populations by 31st December 2012. **[TIER 2]**
1a.3	Surveys conducted and minimum dataset* information collected for 50% of Priority 3 species sub-populations by 31st December 2012. **[TIER 3]**
1b.1	All minimum dataset information analysed via GIS to determine patterns in variables such as landscape, associated vegetation, fire history, and surrounding land use for Priority 1 species by 30th September 2008 (links to 1c.2). **[CORE]**
1c.1	Critical habitat identified and mapped for all threatened plant species within this plan by 31st March 2008. **[CORE]**
1c.2	Refined potential habitat identified and mapped for Priority 1 species by 30th September 2008 (links to 1b.1). **[CORE]**
1c.3	Broad potential habitat identified and mapped for Priority 2 and 3 species by 30th June 2010. **[TIER 2]**
1c.4	Critical habitat mapping ground truthed for Priority 1 species by 31st December 2010 (links with 1a.1). **[CORE]**
1c.5	Existing and potential corridors for Priority 1 species populations identified by 31st March 2011. **[CORE]**
1d.1	Active searches conducted for Priority 1 species in potential habitat completed by 31st December 2010 (links with 1c.2). **[CORE]**
1d.2	Opportunistic searches conducted for suspected fire and disturbance dependant species (Appendix I) in properties within most recently burnt habitat (ongoing-opportunistic). **[TIER 2]**
1d.3	100% of plant samples collected from potential new populations verified by State Herbarium staff and voucher specimens stored in State Herbarium by 29th March 2013 ^. **[CORE]**

* Minimum dataset consists of Biological Database of South Australia (BDBSA) minimum dataset requirements and recovery minimum dataset (Appendix G).

Box 7. Performance criteria linked to Objective 2 and Actions 2a – 2c: Increase understanding, appreciation and involvement

2a.1	At least 1x FTE maintained to co-ordinate the recovery program for the duration of the plan. **[CORE]**
2a.2	Funds sought, and where successful, managed for the delivery of the recovery actions (ongoing). **[CORE]**
2a.3	Adequate resources (i.e. $ 767 250 for Core) secured to conduct recovery actions for the duration of the plan (ongoing). **[CORE]**
2a.4	Recovery Team for threatened flora on Eyre Peninsula established and functioning, as per Terms of Reference (Appendix H), by 31st December 2007 (links to 2c.1). **[CORE]**
2a.5	Log of volunteer hours, land holder in-kind contributions and technical support hours maintained (ongoing) ^. **[CORE]**
2a.6	Support staff engaged to assist with fieldwork, logistics and volunteer training and support where appropriate (ongoing). **[TIER 2]**
2b.1	Communication strategy developed for threatened plant information (based on Russell, Mercer & Watt 2004) by 31st March 2008. **[CORE]**
2b.2	Monitoring techniques, research results and data shared with state, interstate and international nature conservation agencies on an as needs basis and particularly for SA Government planning and *EPBC Act 1999* referral purposes (links to 2b.1). **[CORE]**
2b.3	Timely, accurate and easy to understand updates readily accessible to stakeholders through targeted media outlets, outlined in the threatened plant communication strategy (ongoing) (links to 2b.1). **[CORE]**
2c.1	One threatened flora volunteer group on Eyre Peninsula formalised by 31st Dec 2007 (links to 2b.1). **[CORE]**
2c.2	At least one annual meeting for/with threatened flora volunteers hosted for the duration of the recovery plan (periodically throughout year) (links to 2b.1). **[CORE]**
2c.3	Yearly training provided to threatened flora volunteers on a needs basis (periodically throughout year) (links to 2b.1 and 2c.2). **[CORE]**

Box 8. Performance criteria linked to Objective 3 and Actions 3a – 3f: Manage threats and improve habitat

3a.1	Compile and review current and potential threats affecting Priority 1 and 2 species sub-population in local threat assessment database by 31st March 2011. **[CORE]**
3a.2	Prioritise current and potential threats, based on level of risk, at all Priority 1 species sub-populations by 31st March 2011 under the following headings: Weeds (identify high, medium and low risk weeds), Grazing, Pest and disease, Critical habitat issue (i.e. fire regime, salinity, disturbance, corridors, surrounding land use). **[CORE]**
3a.3	Prioritise current and potential threats, based on level of risk, at 50% Priority 2 sub-populations/population by 31st March 2011 (using the headings as in 3a.2). **[TIER 2]**
3a.4	Prioritise all weed and grazing control required within Focus Work Areas 1, 2 and 3 in consultation with Eyre Peninsula Natural Resources Management Officers by June 2008, June 2009, June 2010 and June 2011 (links to 2c.1). **[CORE]**
3b.1	Reduction in abundance and density of high risk weeds, within 80% of Focus Work Area 1 by 31st December 2008, 2009, 2010 and 30th December 2011. **[CORE]**
3b.2	Reduction in abundance and density of medium risk weeds, within 50 m of Priority 1 species populations by 31st December 2008, 2009, 2010 and 30th December 2011#. **[CORE]**
3b.3	Reduction in abundance and density of high risk weeds, within 50% of Focus Work Area 2 and 3 by 31st December 2008, 2009, 2010 and 30th December 2011. **[TIER 2]**
3c.1	Determine cause of grazing damage (native, livestock, feral animal or combination) to grazing prone or suspected grazing damaged species by 31st December 2008, 2009, 2010 and 30th December 2011. **[CORE]**
3c.2	Implement most appropriate control method to prevent severe grazing to Priority 1 and 2 species (ongoing). **[TIERS 2 & 3]**
3d.1	Complete soil tests at all suspected *Phytophthora* spp. infestations within 5 km of Priority 1 species sub-populations by 30th September 2008, 2009, 2010 and 2011. **[CORE]**
3d.2	In collaboration with DEH and NRM staff, distribute updated *Phytophthora* spp. infestation information to relevant threatened flora stakeholders by 31st December 2008, 2009, 2010, 30th December 2011 and 31st December 2012 (links to 2b.1 and 2c.1). **[CORE]**
3d.3	Use DEH *Phytophthora* spp. hygiene practices in implementing all on-ground recovery actions (ongoing and links with 3c.2). **[CORE]**
3e.1	Establish Significant Roadside Marker System(s) within a minimum of two Eyre Peninsula District Councils by 29th June 2012. **[TIERS 2 & 3]**
3e.2	Railway Marker System maintained and improved (ongoing, links with 2b.1). **[TIER 2]**
3e.3	Actively provide land holders with threatened plant species information, grants/funding and information on all varieties of land conservation agreements (ongoing). **[CORE]**
3e.4	Negotiate Heritage Agreements or conservation covenants based on critical habitat, potential habitat and/or translocation plans (ongoing). **[TIER 2]**
3f.1	Complete soil sampling at threatened flora species sub-populations suspected of being, or becoming, affected by salinity or acidification by 30th September 2011. **[TIER 2]**
3f.2	Determine need and type of strategic vegetation buffers required to maintain Priority 1 species critical habitat and plant/population condition by 31st March 2009 and 2010 (links with 1c.4). **[CORE]** Examples of strategic vegetation buffering activities include: ▪ address severe fragmentation/increase available habitat ▪ control dryland salinity ▪ enhance existing corridors ▪ arrest erosion/prevent top-soil loss/improve condition of soil biota ▪ address lack of pollinator food or shelter source ▪ reinstate vegetation communities (allowing for species succession).
3f.3	Implement salinity abatement specifically for threatened species critical habitat, in consultation with relevant agencies and in context with catchment salinity control projects by 31st December 2012. **[TIERS 2 & 3]**
3f.4	Implement abatement/strategic vegetation buffers for threatened species critical habitat (as determined in 3f.2) in consultation with relevant agencies and in context with regional Natural Resource Management plan (ongoing). **[TIERS 2 & 3]**
3f.5	Enhance connectivity between Priority 3 species sub-populations within the East meets West corridor (ongoing). **[TIER 3]**

3f.6	Determine feasibility of translocation for Priority 1 species, in accordance with the 'Guidelines for the translocation of threatened plants in Australia' by 31st December 2008 (Vallee et al. 2004). **[TIER 2]**
3f.7	Undertake translocation of Priority 1 species, after checks from Vallee et al. (2004) by 30th September 2011. **[TIER 2]** Note: Highly recommended to complete recovery action 1b first at minimum, and with actions 4b, 4c and 4h if resources are available. Some species have known special translocation requirements. These are described in the species sections of this plan.
3f.8	Collect and store seed from priority threatened plant species in collaboration with Millennium Seed Bank & State Herbarium of SA (ongoing). **[CORE]** Note: Includes initiating collection, collection of wider genetic stock, periodic recollection to replenish seed bank after viability testing, seed for planned translocation projects or educational purposes.

Box 9. Performance criteria linked to Objective 4 and Actions 4a – 4h: Conduct research critical to management

4a.1	One honours student per year (minimum) funded to work on critical management research recovery actions (ongoing). **[CORE]**
4a.2	One list of plant knowledge deficiencies and management critical research questions supplied to DEH research hub by March 2008, June 2010 and June 2012. **[CORE]**
4b.1	Break downs in Priority 1 species life cycle identified by 31st December 2012 ^. **[CORE]**
4b.2	Break downs in Priority 2 species life cycle identified by 31st December 2012 ^. **[TIER 2]**
4b.3	Break downs in Priority 3 species life cycle identified by 31st December 2012 ^. **[TIER 3]**
4b.4	Pollinators and pollination vector(s) for Priority 1 species determined by 31st December 2012 ^. **[TIER 2]**
4b.5	Germination trigger(s) and recruitment patterns determined for Priority 1 species by 31st December 2012 ^. **[TIER 2]**
4b.6	Average longevity for Priority 1 species determined (observed or estimated) by 31st December 2012 ^. **[TIER 3]**
4b.7	Sub-population soil classification and pH level identified for Priority 1 and 2 species by 30th December 2011. **[CORE]**
4b.8	Symbiotic mycorrhiza determined for Priority 1 threatened orchid species by 31st December 2012 ^. **[TIER 3]**
4c.1	One literature review of fire ecology and disturbance information for suspected fire and disturbance dependant plant species (Appendix I) completed, in consultation with DEH Fire Management Unit and experts in botanical disturbance requirements, by 31st December 2009. **[TIER 2]**
4c.2	Determine need for prescribed burn and identify which areas or sub-populations require burning by 31st December 2009 (i.e. state of threatened flora sub-population, extent of community senescence and fire sensitive fauna) (done in conjunction with recovery actions 1a.1, 1a.2, 1a.3 and 1c.4). # **[CORE]**
4c.3	Two prescribed burn experiment designs completed (hypotheses, pre and post burn monitoring) in consultation with DEH Fire Management Unit and South Australian Country Fire Service by 31st December 2010. # **[TIER 2]**
4c.4	Two prescribed burns conducted for fire dependent threatened flora species recovery by December 2012 ^. **[TIER 2]**
4c.5	Two disturbance requirement experiments designed (hypotheses, pre and post disturbance monitoring) in consultation with experts in botanical disturbance requirements by 31st December 2010. **[TIER 3]**
4c.6	Two disturbance requirements trials conducted for disturbance dependent threatened flora species by 29th June 2012 ^. **[TIER 3]**
4d.1	Two canopy-cover trials conducted for suspected disturbance dependant threatened plant species by 29th June 2012 (links with 3b and 4c) ^. **[TIER 2]**
4d.2	Two grazing pressure exclosures trials determining herbivore(s) responsible, extent, timing and severity of grazing pressure and the long-term and short-term survival impacts by 29th June 2012. **[CORE]**
4e.1	Genetics relationship within and between sub-populations determined for Whibley Wattle, Resin Wattle and Chalky Wattle by 29th June 2012 (apply findings 3f.6 and 3f.7 criteria). **[TIER 2]**

4e.2	Determine genetic relationship between remaining Priority 1 species sub-populations by 31st December 2012 (apply findings 3f.6 and 3f.7 criteria). **[TIER 3]**
4f.1	Determine if chemical drift is having a detrimental effect on threatened flora populations, critical habitat, pollinators and/or soil biota by 31st December 2011. **[TIER 3]**
4f.2	Investigate if changes in hydrology (e.g. soil moisture, salinity) are influencing critical habitat degradation or threatened flora decline by 31st December 2012. **[TIER 3]**
4g.1	Model impact of climatic change on Priority 1 species critical habitat by 31st December 2010 (apply findings 3f.6 and 3f.7 criteria). **[TIER 3]**
4g.2	Research potential impact of climate variation on Priority 1 species reproduction by 31st December 2012. **[TIER 3]**
4h.1	Minimum viable population calculated for Priority 1 threatened flora by 31st December 2010 (links to IUCN projected decline or increase in species criteria) (links to 4h). **[CORE]**
4h.2	Minimum viable population calculated for Priority 2 threatened flora by 30th March 2012 (links to IUCN projected decline or increase in species criteria) (links to 4h). **[TIER 2]**

Box 10. Performance criteria linked to Objective 5 and Actions 5a – 5c: Monitor populations and evaluate success of recovery actions

5a.1	Establish list of Key Monitoring Sites for all threatened plant species finalised by March 2010. ** **[CORE]**
5a.2	Upgrade electronic local threatened plant monitoring and threat assessment database by 31st March 2008. **[CORE]**
5a.3	Twice yearly (during second and fourth quarters) storing and archiving of raw monitoring data and management critical research reports (e.g. ecological burn monitoring data/final report), including update of data into local monitoring database and DEH Biological Databases of South Australia (linked with 2f.1). **[CORE]**
5a.4	Priority 1 species Key Monitoring Sites monitored annually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 31st December 2008, 2009, 2010 and 30th December 2011. **[CORE]**
5a.5	Priority 2 species Key Monitoring Sites monitored biannually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 31st December 2008, 2009, 2010 and 30th December 2011. **[TIER 2]**
5a.6	Priority 3 species Key Monitoring Sites monitored biannually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 30th December 2011. **[TIER 3]**
5a.7	Life class structure at Priority 1 species Key Monitoring Sites re-surveyed once every five years (^ 1a). **[CORE]**
5a.8	All translocated populations monitored biannually. **[CORE]**
5a.9	Prescribed burn monitoring data analysis and recommendations reported by 31st December 2012 (links to 4c.3). **[TIER 2]**
5a.10	Herbivore exclosures trials monitored annually (linked to 4d.3). **[CORE]**
5a.11	Weed control effectiveness in Focus Work Areas investigated seasonally for the duration of the plan ^ (links with 3b). **[CORE]**
5a.12	Herbivore density monitored, on needs basis, conducted within Chalky Wattle critical habitat. **[TIER 2]**
5a.13	Incorporate recommended actions to manage, prevent or eliminate impacts from surrounding land-use on critical habitat by 31st December 2012. **[TIER 3]**
5b.1	Recovery action progress check against performance criteria/schedule and IUCN criteria completed in the third year of project implementation by 30th June 2010. **[CORE]**
5b.2	Amend recovery actions and performance criteria to incorporate results from management critical research by 30th June 2010 (or before if research determined necessary). **[CORE]**
5b.3	Final recovery action check against performance criteria and IUCN criteria completed in preparation for 5c.1 by 31st December 2012. **[CORE]**
5c.1	Re-evaluation of recovery plan: full re-assessment of the status of nationally threatened plant species on Eyre Peninsula completed by 31st December 2012. **[CORE]**
5c.2	Review second stage of threatened flora recovery program by June 2013. **[CORE]**

Key

* = Performance criteria linked to a list

** = Key Monitoring Sites may be based on, but are not limited to: Largest sub-population population, Most outlying sub-population, Most genetically different sub-population, Oldest or youngest age class structured sub-population(s), Site with overlapping Priority 1, 2 or 3 species.

^ = Performance criteria has direct reporting criteria

= Performance criteria is linked to management critical research

[CORE] = Performance criteria is the bare minimum and must be completed as standard for other performance criteria to follow (Standard project).

[TIER 2] = Performance criteria able to start with Tier 2 level of funding (Table 31.1).

[TIER 3] = Performance criteria able to start with Tier 3 level of funding and the only level that covers all threatened flora species within this plan (Table 31.1).

5 Introduction to species' descriptions

While this recovery plan has a regional focus, it is important that treatments of individual species be included in order to identify recovery priorities at a species level. Prioritised recovery of threatened flora at a regional level is outlined in Section 30 'Prioritisation of Focus Work Areas' and Section 31 'Five year timetable and associated costs'.

The regional conservation status for each species has been reassessed using IUCN criteria, including current estimates of the number of individuals/populations. It is important to note that a global assessment of species status is required to correctly conduct IUCN assessments.

To maximise outcomes for the majority of species, this plan is strategic and species are prioritised. Nevertheless, the plan is flexible and enthusiasts of certain plant species will find ample information on immediate threats and recovery actions required for each individual species. The flexibility of the plan allows proactive individuals and communities to register as volunteers and work on species specific to their region or interest.

Sections 6 to 28 provide a brief summary of each threatened flora species' conservation status, distribution, habitat critical to survival, biology and ecology, previous management actions, threats to the species, recovery actions and references. Within these sections the threats to species have been analysed using a risk matrix (Table 5.1), giving readers an understanding of which threat is most concerning at an individual species level. The number of threats can otherwise seem overwhelming and confusing. Threats to species are complex and some major threats (e.g. habitat loss) are realistically often a combination of a number of lesser threats.

Table 5.1. Risk matrix table used throughout plan to analyse threat severity to individual species

Risk Analysis		Consequences				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	**High**	**High**	**Extreme**	**Extreme**	**Extreme**
	Likely 4	Moderate	**High**	**High**	**Extreme**	**Extreme**
	Possible 3	Low	Moderate	**High**	**Extreme**	**Extreme**
	Unlikely 2	Low	Low	Moderate	**High**	**Extreme**
	Rare 1	Low	Low	Moderate	**High**	**High**

Risk is the exposure to the possibility of events that will have an impact on the survival of threatened flora species. In the traditional sense, risk assessment and management is done to establish what an acceptable risk is. In this plan however, the risk assessment simply gives the reader a perspective of the threats that will result in the worst consequences.

Allocating the appropriate categories for **Likelihood** is relatively straightforward. The following key has been used to assess categories for **Consequences**:

Insignificant: A threat that would result in a consequence that could be considered part of the species' natural cycle and/or affecting less than 10% of the population on Eyre Peninsula.

Minor: A threat affecting less than 50% of sub-populations and expected to stabilise or decrease without intervention of recovery actions.

Moderate: **a.** A threat affecting more than 50% of sub-populations and expected to stabilise or decrease with intervention of recovery actions.
b. A threat that is thought to be likely, but which remains unchecked.

Major: **a.** A threat affecting more than 50% of sub-populations and expected to increase in severity over time, and which is not easily treatable through recovery actions.
b. Localised extinction of a threatened flora species on Eyre Peninsula within 5 years.

Catastrophic: Foreseeable *in situ* extinction of a threatened flora species on Eyre Peninsula within 5 years.

6 Chalky Wattle *Acacia cretacea* Maslin and Whibley

6.1 Status

When assessing Chalky Wattle vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 6.1). This is important given that this species only occurs on Eyre Peninsula. Chalky Wattle is however recognised as Endangered at the Regional, State and National levels (Table 6.1).

Table 6.1. Chalky Wattle vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Endangered
Extent of occurrence (km²)	6	Endemic to Eyre Peninsula	
Area of occupancy (km²)	0.33		
Sub-populations	12		
Estimated # of individuals	1270		

IUCN Criteria	Justification
CR B1	Extent of occurrence estimated to be less than 100 km²
CR B1a	Severely fragmented or known to exist at no more than 10 locations
CR B1a 2	Area of occupancy estimated to be less than 10 km²
CR B1a 2a	Severely fragmented or known to exist at only a single location
CR B1a 2a,b(i)	Continued decline, observed, inferred or projected, in extent of occurrence
CR B1a 2a,b(i)(iii)	Continued decline, observed, inferred or projected, in area, extent or quality of habitat

6.2 Distribution

Chalky Wattle is endemic to north-eastern Eyre Peninsula, South Australia. The species has a very small area of occupancy and highly restricted extent of occurrence (Figure 6.1; Table 6.1). All plants are located in 12 remnant patches of vegetation, scattered along sand ridges in agricultural land and along an unsealed access track in roadside vegetation (Jusaitis et al. 2000). A total population count of 1274 individuals was recorded in the most recent 1999 survey (Jusaitis et al. 2000).

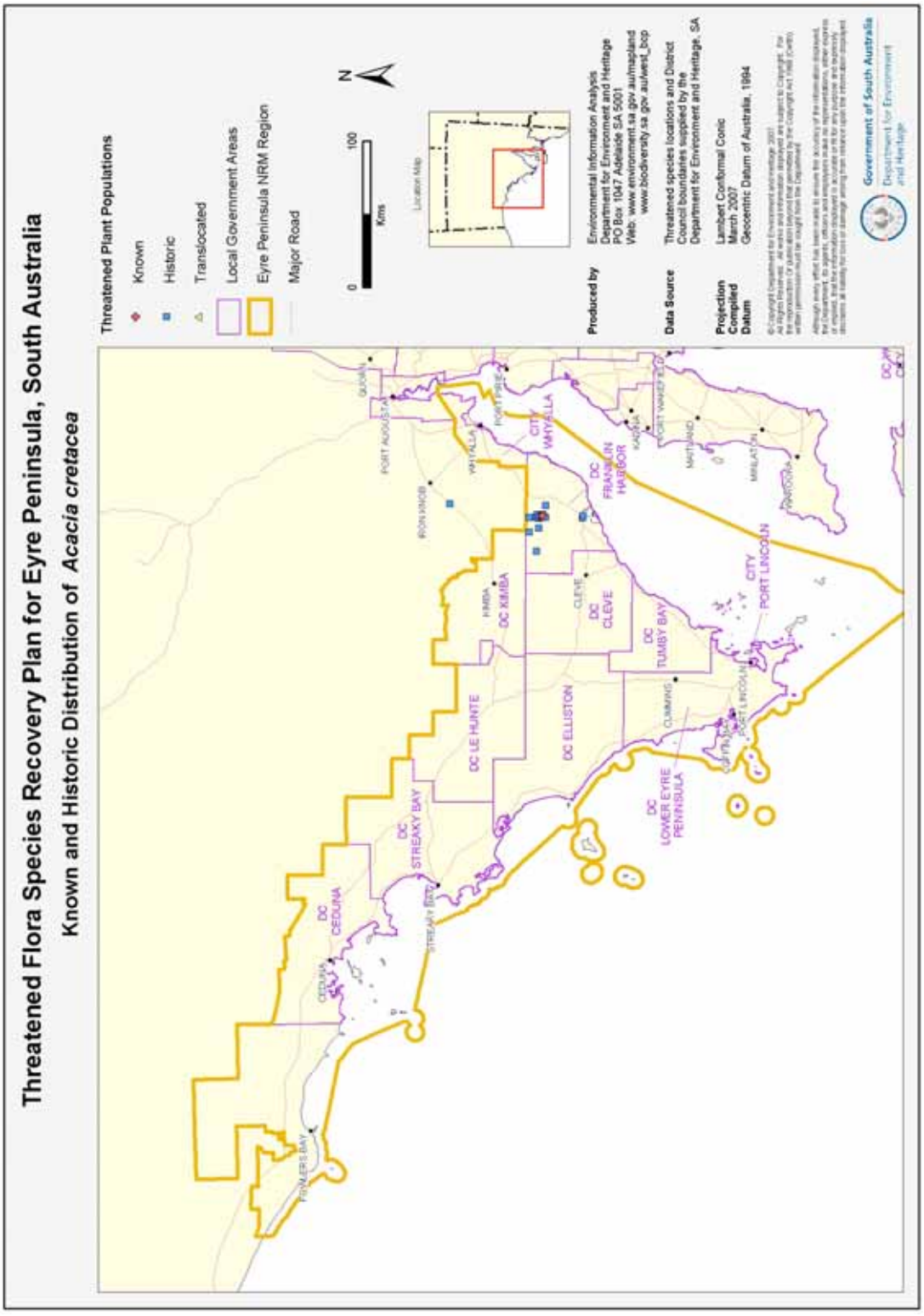
Chalky Wattle grows within the District Council of Franklin Harbour, approximately 30 km north-west of Cowell (Jusaitis et al. 2000; Figure 6.1).

6.3 Habitat critical to survival

All known habitat of Chalky Wattle is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Chalky Wattle grows in deep red sand, through gently undulating country with low sand ridges, in an area approximately 170 m above sea level (DEH-EGIS 2006). It is currently confined to vegetated sand ridges (Jusaitis et al. 2000).



Note: Chalky Wattle details are held on internal DEH files and are available on request.

Figure 6.1. Distribution of Chalky Wattle on Eyre Peninsula

Vegetation associations

Chalky Wattle grows in association with Ridge-fruited Mallee (*Eucalyptus incrassata*), Broombush (*Melaleuca uncinata*), Spinifex (*Triodia irritans*), Gorse Bitter-pea (*Daviesia ulicifolia*) and Silvery Phebalium (*Phebalium bullatum*) (Jusaitis et al. 2000).

The broad description for the vegetation association corresponding with Chalky Wattle is Eucalyptus mallee forest and mallee woodland (DEH-EGIS 2006). Dominant species include Ridge-fruited Mallee (*Eucalyptus incrassata*) mid mallee woodland, over Broombush (*Melaleuca uncinata*) tall shrubland and Ribbed Thryptomene (*Thryptomene micrantha*) (mixed) low open shrubland and low open hummock grassland (DEH-EGIS 2006). The species also survives near saline areas with *Halosarcia* species (samphire) low sparse shrubland over Round-leaf Pigface (*Disphyma crassifolium* ssp. *clavellatum*) and forbs (DEH-EGIS 2006).

Climate

Chalky Wattle inhabits an area that receives an average rainfall of around 300 mm per year (DEH-EGIS 2006). Mean annual rainfall at the nearby township of Cowell is 279.9 mm (BOM 2007). The nearest recorded mean annual maximum and minimum temperatures are 23.7 °C and 10.4 °C respectively, recorded at Kimba (55 km to the north-west of the population).

Known populations within reserves

Chalky Wattle is not currently conserved within the South Australian reserve system. Heritage Agreement 1329 (6.5 hectares) protects one of the Chalky Wattle sub-populations. Heritage Agreements to the north-west and south of the known population have similar habitat and may be investigated in the future.

Benefits to other species

Species surviving in a highly fragmented landscape are expected to benefit from the conservation of Chalky Wattle. Heritage Agreements to the north-west and south of the Chalky Wattle populations would be completely isolated if not for remnant vegetation currently growing on sand ridges and roadsides. These narrow vegetation corridors are thought to benefit and facilitate native fauna movement, and this is currently being researched by Flinders University (Driscoll & Halliday 2007). Malleefowl (*Leipoa ocellata*[1]) inhabit this landscape and are also thought to benefit from the conservation of corridors.

Chalky Wattle plays an important role in soil conservation. As a member of the Leguminoseae family, the species uses symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen (CILR 2007). Nitrate or ammonium produced in this process benefits the whole system, plants and animals through the flow-on of the nitrogen cycle. Retention and enhancement of sandy ridge vegetation is expected to stabilise and minimise sand blows within marginal cropping land.

[1] Malleefowl *(Leipoa ocellata*) is listed as nationally Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*

6.4 Biology and ecology

Chalky Wattle is a perennial, usually single-stemmed tree, growing 3.5 to 4 metres tall. The trees have a straggly appearance, comprising an open crown, slender trunk and distinct chalky-white coloured branchlets (Maslin & Whibley 1987; Jusaitis et al. 2000).

Flowering occurs from July to January (Whibley & Symon 1992). Flowers look typically 'wattle-like', lemon-yellow to golden-yellow in colour, with round flower heads on 4-11 mm long stalks.

Pollination is unconfirmed; however, the plant is likely to be insect pollinated similar to other *Acacia* species (M Jusaitis [DEH] 2006, pers. comm.).

Seed pods develop between July and October (Whibley & Symon 1992); however, seed dispersal has not been studied in-depth. Seeds are 5-7 mm, have a black seed coat and a yellow aril (Whibley & Symon 1992).

Germination is rainfall and fire dependent. Higher than average annual rainfall has corresponded with above average Chalky Wattle growth (Jusaitis et al. 2000). Growth and flowering is spasmodic and seasonal, appearing to be more prolific after a wet spring season (Jusaitis et al. 2000). An example of this was the 2004/2005 season, when Chalky Wattle failed to produce any seed after the drought in winter 2004 (S Bey [Greening Australia] & K Pobke [DEH] 2005, pers. comm.).

Chalky Wattles are also known to sucker from the base and along near-surface roots, particularly after fire (Maslin & Whibley 1987; Jusaitis et al. 2000). Preliminary research results show evidence that Chalky Wattle is highly dependent on fire to trigger germination, and in fact no natural germination has been recorded in the absence of fire (M Jusaitis [DEH] 2006, pers. comm.). Disturbance is also assumed to trigger germination, but this remains to be tested.

Grazing pressure

Grazing exclusion trials were established by M Jusaitis and A Freebairn in 2002 (Section 6, Hundred of Glynn) to study the impact of grazing pressure on Chalky Wattle. These trials continue to be monitored. Grazing of Chalky Wattle outside the fenced trials was severe, particularly during early stages of regeneration. Flowering and fruiting of grazed Chalky Wattles was delayed when compared with wattles in ungrazed areas (M Jusaitis [DEH] 2006, pers. comm.).

Related species

Chalky Wattle is considered to be closely related to seven species (Maslin & Whibley 1987; Whibley & Symon 1992) that also grow on Eyre Peninsula. These species include:

- Angled Wattle (*Acacia anceps*)
- Alcock's Wattle *(A. alcockii*)
- Wallowa (A. calamifolia)
- Gill's Wattle (*A. gillii*)
- Coast Golden Wattle (*A. leiophylla*)
- Coast Wallowa (*A. nematophylla*)
- Notable Wattle (*A. notabilis*).

6.5 Previous management actions

Table 6.2. Previous management actions to conserve Chalky Wattle

	Previous management actions
1990-94	Seed collected by Manfred Jusaitis (Senior Biologist, Science and Conservation, DEH) on ten sampling occasions. Stored at the Seed Conservation Centre, Adelaide.
1991	Recovery plan written by Manfred Jusaitis.
1995	Phenology of Chalky Wattle floral development studied (Jusaitis et al. 2000).
1996	Stock-proof fence erected to enclose the largest natural population in Section 6, Hundred of Glynn. A smaller rabbit-proof enclosure was erected inside this fence (Jusaitis et al. 2000).
1999	Annie Bond (former Threatened Flora Ecologist, DEH) surveyed three private properties within the Hundred of Glynn and recorded 1274 Chalky wattles.
2002	Fuel and vegetation assessments for Chalky Wattle burn trial conducted by Anthony Freebairn (former Threatened Flora Officer, DEH) and Amanda Slipper (Fire Management Section, DEH).
2002	Prescribed ecological burn trial for Chalky Wattle conducted on private property, Section 6, Hundred of Glynn, with the assistance of Mangalo and Salt Creek Country Fire Service. Approximately 2 hectares burnt.
2002	Twenty-three kilometres of fencing erected on Section 14, Hundred of Glynn in preparation for the post-fire grazing and grazing exclusion study.
2003	Kangaroo density surveys undertaken in Chalky Wattle habitat coordinated by A Freebairn, A Bond, and C Arnold (Wildlife Technical Officer, DEH). The results were analysed and compiled by C Arnold and L Farroway (Ecologist Kangaroo Management, DEH) (DEH Recfind file 40/1495). The dataset from the 11 transects (walked) was considered insufficient to generate a reliable model fit. Results were 46 Western Grey Kangaroos and four Euros recorded from 118.6 km of transects (3.94 macropods per km^2).
2003	Chalky Wattle tube stock planted in Heritage Agreement 1329 by Green Corps team (supervisor Ben White).
2004	One hundred Chalky Wattle seedlings planted near Ungarra (on roadside at northern end of Wilkins Lane). Organised by Andrew Freeman (Bush Management Advisor, EPNRMB) and 2004 Green Corps team. Note: Records of previous management actions are kept in DEH Recfind file 40/1495.

6.6 Threats to Chalky Wattle and associated recovery goals

The long-term goals are to down-list Chalky Wattle conservation status from Endangered to Vulnerable, and continue to recover Chalky Wattle critical habitat on Eyre Peninsula. However, the immediate short-term goal is to stabilise Chalky Wattle conservation status at Endangered.

Chalky Wattle has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that may respond well to fire (Appendix I). This species may be at considerable risk from climate change based on its limited extent of occurrence and habitat limitations. The survivorship of translocated Chalky Wattles has already shown links with above average rainfall in 1992, and rapid soil moisture depletion during summer 1996 (Jusaitis 2005).

Table 6.3 details the key threats and summarises performance criteria relevant to Chalky Wattle recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 6.3. Key threats to Chalky Wattle and summary of associated performance criteria

Direct threat: **Habitat fragmentation**	Risk
Risk: Habitat insufficient for long-term viability (Jusaitis et al. 2000) **Likelihood:** Likely habitat degradation **Consequence:** Eventual local extinction = Major Habitat consists of narrow remnant mallee strips, surrounded by agricultural land along sand ridges and roadsides.	Extreme
Direct threat: Restricted distribution/isolated populations	
Risk: Localised extinction (Jusaitis et al. 2000) **Likelihood:** Possible **Consequence:** Extinction of species = Major Small extent of occurrence (approximately 6 km²) and area of occupancy (approximately 0.33 km²). Only one known population.	Extreme
Direct threat: Small population/lack of recruitment	
Risk: Decreased resilience to environmental changes, pests or diseases **Likelihood:** Possible (requires further research) **Consequence:** Loss of genetic diversity which undermines recovery efforts and currently no recruitment without recovery actions of prescribed burning = Major Small population size (approximately 1274 individuals) may result in low genetic variability, e.g. reduced seed viability and plant vigour from interbreeding. Chalky Wattle is known to produce low seed yields, even in good seasons (S Bey [Greening Australia] 2007, pers. comm.).	Extreme
Direct threat: High grazing pressure	
Risk: Loss of plants or plant health from grazing **Likelihood:** Almost certain **Consequences:** Lower plant heights, less flowering/seed set, nil seedlings recruited = Major Kangaroos graze young growth, and grazing wains as plants become less palatable. Sheep continued to graze mature Chalky Wattle foliage (Jusaitis et al. 2000).	Extreme
Knowledge gap: Inappropriate fire regimes	
Risk: Fire frequency/intensity (either not enough or too much) may threaten Chalky Wattle survival **Likelihood:** Almost certain **Consequences:** Minimal to no recruitment = Moderate	Extreme
Direct threat: Salinity/changes in hydrology	
Risk: Dryland salinity potential to affect population **Likelihood:** Likely **Consequences:** 5-10% loss of population = Moderate Recent dead-standing Chalky Wattles suggest a salt scald may be expanding within the road reserve.	High
Direct threat: Roadside management	
Risk: Road maintenance activities which degrade critical habitat/population **Likelihood:** Possible **Consequences:** Moderate Approximately 15% of the remnant Chalky Wattle population is located in roadside reserve.	High
Direct threat: Pest and disease	
Risk: A reduced number of plants due to damage caused by pest and disease **Likelihood:** Possible **Consequences:** Insignificant Collar rot and borers in old Chalky Wattles, Psyllids (*Acizzia* sp.) and caterpillar damage found on young growth (Jusaitis et al. 2000; M Jusaitis [DEH] 2007, pers. comm.).	Low

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.1 1b.1 1c.1 1c.2 1c.4 1c.5 1d.1 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.2 3a.4 3b.1 3b.2 3c.2 3d.1 3d.2 3d.3 3e.1 3e.3 3e.4 3f.1 3f.2 3f.3 3f.4 3f.6 3f.7 3f.8	4b.4 4b.6 4c.2 4c.5 4e.1 4f.2 4g.1 4g.2 4h.1	5a.4 5a.7 5a.8 5a.9 5a.10 5b.2

6.7 Main references

Jusaitis, M 1998, *Recovery plan* Acacia whibleyana*,* South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide.

Jusaitis, M 1991, *Recovery plans* Prostanthera eurybiodes, Pterostylis arenicola, Acacia cretacea, Pultenaea trichophylla, Department for Environment and Heritage, Black Hill Flora Centre, Adelaide.

Jusaitis, M 2005, 'Translocation trials confirm species factors affecting the establishment of three endangered plant species', *Journal of Ecological Management and Restoration*, vol. 6, no. 1.

Jusaitis, M, Bond, A, Smith, K, Sorensen, B & Polomka, L 2000, Acacia cretacea *recovery plan: Annual report*, Plant Biodiversity Centre, Department for Environment and Heritage, South Australia.

Jusaitis, M & Polomka, L in press, *Weeds and founder propagules influence translocation success in endangered Whibley Wattle,* Acacia whibleyana *(Leguminosae)*, unpublished paper, Department for Environment and Heritage, South Australia.

Jusaitis, M & Sorensen, B 1998, *Conservation Biology of* Acacia whibleyana, South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 2007, 'Successful augmentation of an *Acacia whibleyana* (Whibley Wattle) population by translocation', *Australian Plant Conservation, Bulletin of the Australian Network for Plant Conservation*, vol. 16, no. 1.

Vallee, L, Hogbin, T, Monks, L, Makinson, B, Matthes, M & Rossetto, M 2004, Guidelines for *the translocation of threatened plants in Australia,* Australian Network for Plant Conservation, Canberra.

7 Jumping-jack Wattle *Acacia enterocarpa* RV Smith

7.1 Status

When assessing Eyre Peninsula Jumping-jack Wattle vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 7.1). Jumping-jack Wattle is recognised as Endangered at the Regional, State and National levels (Table 7.1).

Table 7.1. Jumping-jack Wattle vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Endangered
Extent of occurrence (km²)	5700		
Area of occupancy (km²)	0.065		
Sub-populations	18		
Estimated # of individuals	786		
IUCN Criteria	**Justification**		
EN C	Population size is estimated to be fewer than 2500 mature individuals on Eyre Peninsula		
EN C1*	Estimated continued decline in Eyre Peninsula population of at least 20% within two generations		

7.2 Distribution

Jumping-jack Wattle occupies disjunct sub-populations on Eyre Peninsula, Yorke Peninsula and in the South East region of South Australia, and Lawloit Range and Little Desert in western Victoria (Whibley & Symon 1992). Extent of occurrence on Eyre Peninsula is approximately 1800 km² occurring within latitude 34°5' to longitude 136°10' (Butler) in the north, and latitude 34°24' to longitude 135°42' (Edillilie) in the south (DEH-EGIS 2006) (Figure 7.1; Table 7.1).

Many sub-populations are located on roadsides managed by the district councils of Lower Eyre Peninsula, Tumby Bay and Franklin Harbour. Jumping-jack Wattle also grows within rail reserves maintained by Australian Railroad Group Pty Ltd (ARG) and amongst vegetation corridors along water pipelines maintained by SA Water.

7.3 Habitat critical to survival

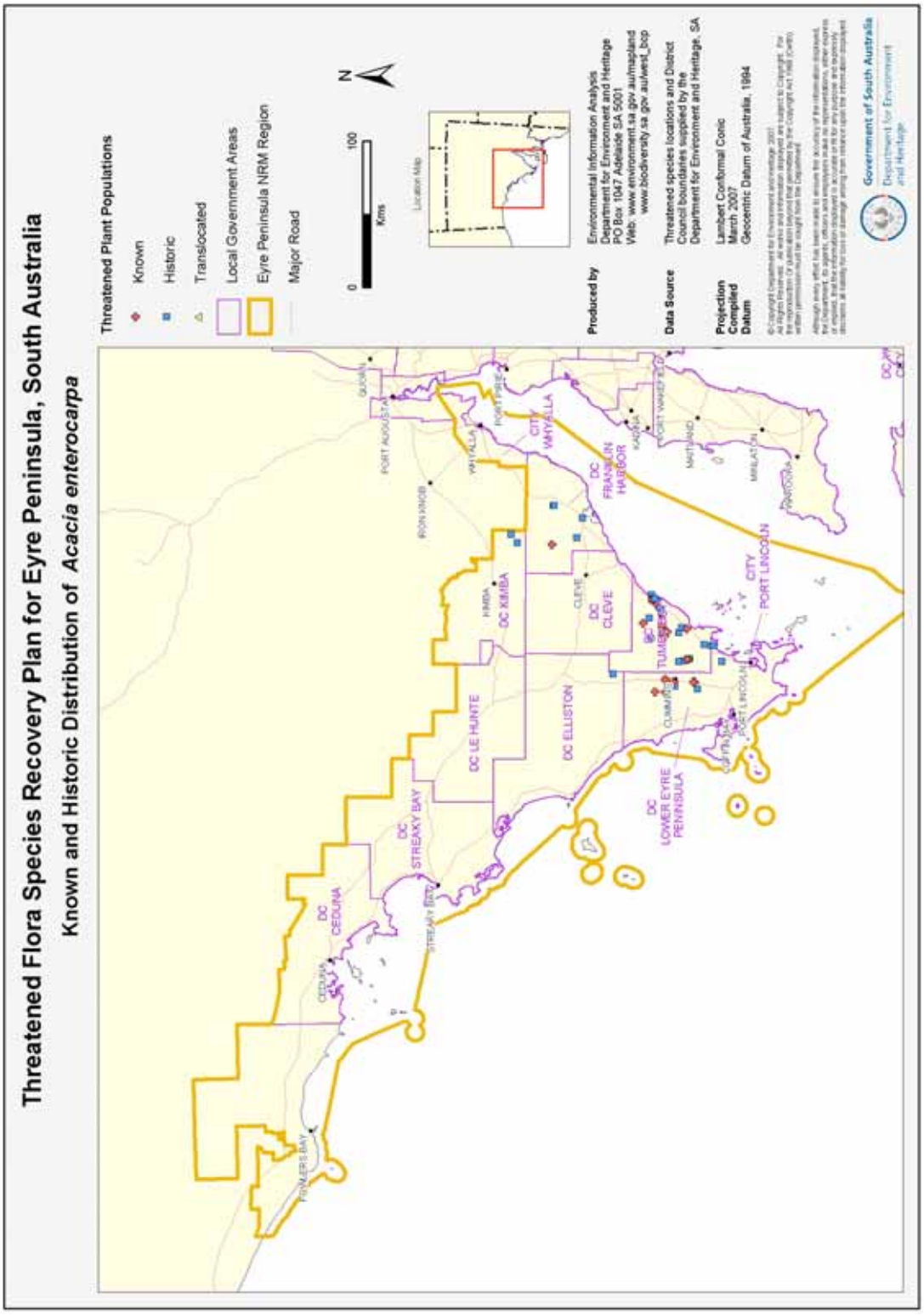
All known habitat of Jumping-jack Wattle is considered to be critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Whibley and Symons (1992) report Jumping-jack Wattle growing in sandy alkaline and hard neutral yellow duplex, red shallow porous loam, and grey cracking and self-mulching clays. Northern sub-populations of Jumping-jack Wattle grow in red calcareous, hard pedal red duplex soils and dense brown loams, whereas southern sub-populations inhabit mottled-yellow duplex soils interspersed with red duplex and red friable loams (Laut et al. 1977).

Vegetation associations

Eyre Peninsula Jumping-jack Wattle grows in association with a wide range of vegetation communities (Tables 7.2 and 7.3) (DEH-EGIS 2006). Similarly in Victoria, Jumping-jack Wattle populations are known to inhabit a wide range of vegetation communities (Overman & Venn 2004).



Note: Jumping-jack Wattle details are held on internal DEH files and are available on request.

Figure 7.1. Distribution of Jumping-jack Wattle on Eyre Peninsula

A ground truthed southern Jumping-jack Wattle sub-population near Edillilie has been recorded growing in association with Broad-leaved Box (*Eucalyptus behriana*), Peppermint Box *(E. odorata*) and Dumosa Mallee (*E. dumosa*).

Table 7.2. Vegetation associations of northern Eyre Peninsula Jumping-jack Wattle sub-populations

Primary species	Secondary species	Understorey species
Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland	Broombush (*Melaleuca uncinata*) tall shrubland	Ribbed Thryptomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland over Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*), Half-beard Spear-grass (*Austrostipa hemipogon*)
Square-fruit Mallee (*Eucalyptus calycogona*), +/- White Mallee (*E. phenax* ssp. *phenax)* mid mallee woodland	Broombush (*M. uncinata*), and Dryland Tea-tree *(Melaleuca lanceolata*) mid shrubs	Small Hop-bush *(Dodonaea bursariifolia*), +/- Ribbed Thryptomene (*Thryptomene micrantha*) low shrubs over Common Eutaxia (*Eutaxia microphylla)*
Yorrell (*Eucalyptus gracilis*), +/- Dumosa Mallee (*E. dumosa*), +/- Gilja (*E. brachycalyx)*, +/- Red Mallee (*E.* oleosa) mid open mallee forest	Sheep Bush (*Geijera linearifolia*), Dryland Tea-tree (*Melaleuca lanceolata*) shrubs	Wards Weed (**Carrichtera annua*), Rusty Spear-grass (*Austrostipa eremophila*), Mealy Saltbush (*Rhagodia parabolica*), Ruby Saltbush (*Enchylaena tomentosa*) and Grey Bindyi (*Sclerolaena diacantha)* shrubs

Climate

Jumping-jack Wattle inhabits the 300-500 mm rainfall zone (Whibley and Symon 1992).

- Northern sub-populations extend to near Butler Tanks where mean annual rainfall is 363.4 mm (from North Parnda weather station) (BOM 2007).
- Southern sub-populations grow in the vicinity of Cummins and receive a higher mean annual rainfall of 425.3 mm (BOM 2007).

Table 7.3. Vegetation associations of southern Jumping-jack Wattle sub-populations

Primary species	Secondary species	Understorey species
Capped mallee (*Eucalyptus pileata*), +/- Beaked Red Mallee (*E. socialis*), +/- Ridge-fruited Mallee (*E. incrassata*), +/- Cummins Mallee (*E. peninsularis*) mid mallee woodland	Broombush (*Melaleuca uncinata*), Dryland Tea-tree (*M. lanceolata*), Mallee Honey-myrtle (*M. acuminata*) mid shrubs	Common Eutaxia (*Eutaxia microphylla*), Silvery Phebalium (*Phebalium bullatum*) low shrubs
Broombush (*Melaleuca uncinata*) tall open shrubland	Silver Broombush (*Babingtonia behrii*), +/- Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs	Spinifex (*Triodia irritans*), +/- *Hibbertia* sp. *Glabriuscula* (DJ Whibley 9012)
Open	Open	Scented Mat-rush (*Lomandra effusa*), Balcarra Spear-grass (*Austrostipa nitida*), Common Wallaby-grass (*Austrodanthonia caespitosa*), Black-head Grass (*Enneapogon nigricans*)open tussock grassland
Cummins Mallee (*Eucalyptus peninsularis*), +/- Ridge-fruited Mallee (*E. incrassata*), +/- White Mallee (*E. phenax)*, +/- Dumosa Mallee (*E. dumosa*), +/- Square-fruit Mallee *(E. calycogona*) mid mallee woodland	Broombush (*Melaleuca uncinata*), Dryland Tea-tree (*M. lanceolata*), Mallee Honey-myrtle (*M. acuminata*) tall shrubs	Limestone Saw-sedge (*Gahnia deusta*) low sedges
Dumosa Mallee (*Eucalyptus dumosa*), +/- Beaked Red Mallee (*E. socialis*), +/- Yalata Mallee (*E. yalatensis*) mid mallee woodland	Broombush (*Melaleuca uncinata*), Dryland Tea-tree (*M. lanceolata*), Mallee Honey-myrtle (*M. acuminata*) tall shrubs	+/- Spinifex (*Triodia irritans*) low hummock grasses
Ridge-fruited Mallee (*Eucalyptus incrassata*), +/- Narrow-leaf Red Mallee (*E. leptophylla*) mid mallee woodland	Dune Tea-tree (*Leptospermum coriaceum*), Broombush (*Melaleuca uncinata*), Scrub Cypress Pine (*Callitris verrucosa*), Silver Broombush (*Babingtonia behrii*) shrubs	*Hibbertia australis*, Golden Pennants (*Glischrocaryon behrii*) shrubs

Known sub-populations within reserves

Jumping–jack Wattle is located within the South Australian reserve system (Table 7.4), but is not known to occur within any Heritage Agreements. Approximately 34 plants grow on roadsides within four Roadside Marker Sites in the District Council of Lower Eyre Peninsula.

Table 7.4. Jumping-jack Wattle sub-populations in reserves on Eyre Peninsula

NPWSA Reserve	Sub-populations	Observers
The Plug Range Conservation Park	1	T Croft & K Lehman 1990
Middlecamp Hills Conservation Reserve	1 (historical record)	D Keane 1985

Benefits to other species

Recovery actions to conserve Jumping-jack Wattle are expected to benefit regionally Vulnerable Broad-leaf Box communities (*Eucalyptus behriana*) (DEH 2002; S Bey [Greening Australia] 2005, pers. comm.; D Ancell [EPNRM] 2005, pers. comm.). *E. behriana* is only known from three disjunct areas in South Australia (Nicolle 1997) and its Eyre Peninsula distribution is also limited.

Jumping-jack Wattle is a member of the Leguminoseae family, which uses symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen (CILR 2007). Nitrate or ammonium produced in this process benefits the whole system, plants and animals through the flow-on of the nitrogen cycle.

The closely related species Spine Bush (*Acacia nyssophylla*) provides habitat to small birds such as fairy-wrens and chats (Hussey 2002). It is likely that Jumping-jack Wattle may have a similar role in the ecosystem, given that it is a prickly, dense shrub.

7.4 Biology and ecology

Jumping-jack Wattle is a perennial shrub. It is dense, spreading and prickly, growing to 1.5 m in height (Whibley & Symon 1992). Phyllodes (leaf-like structures) are linear 2-4.5 cm long and approximately 1 mm in diameter. Phyllodes can be straight or slightly curved, and have a rough texture ending with a rigid, sharp reddish-brown tip.

Flowering occurs from May to October. The wattle flowers (inflorescences) grow from the joint between the phyllode and stem (axillary), and generally grow in pairs. Inflorescences contain about 20 flowers on small flower stems (peduncles), which are approximately 5 mm long (Whibley & Symon 1992). Pollination is unconfirmed; however, the plant is likely to be wind or insect pollinated.

Seed development and dispersal have not been studied. Seeds are known to have a small, creamy-white coloured aril (S Bey [Greening Australia] 2007, pers. comm.). Seeds develop in a seed pod, which visually resembles the shape of a jumping-jack firecracker, hence the origin of the common name (Whibley & Symon 1992). The scientific species name '*enterocarpa*' also refers to the distinct shape of the seedpod – *enteron* meaning intestine, and *karpos* meaning fruit (Greek origin) (Whibley & Symon 1992).

To date, germination has been unobserved and unstudied. The average longevity of Jumping-jack Wattle is also unknown.

Fire dependence triggers are only generally understood based on generalisations of the *Acacia* genus. Fire response of Jumping-jack Wattle requires further study.

Related species

Jumping-jack Wattle is related to three species, which occupy much drier habitats on northern Eyre Peninsula (Whibley & Symon 1992):

- Veined Wait-a-while (*Acacia colletioides*)
- Spine Bush (Acacia nyssophylla)
- Six-nerve Spine-bush (*Acacia hexaneura*) (Cowan & Maslin 2001).

7.5 Previous management actions

Since 2007, 18 Jumping-jack Wattle sub-populations have been revisited and/or verified out of the 26 reported. Previous management actions are included in Table 7.5.

Table 7.5. Previous management actions to conserve Jumping-jack Wattle

	Previous management actions and points of interest
2001-03	Revisits to historical Jumping-jack Wattle populations by L Bligh, A Freebairn, D Ancell and A Bond. Brief site assessments recorded on datasheets (DEH Recfind file 40/A248477).
2001	Jumping-jack Wattle community awareness raising article, as part of 'Unusual Suspects' series printed in autumn edition of local newsletter *The Long Run* (author A Freebairn).
2001	Illegal clearance of previously surveyed Jumping-jack Wattle sub-populations along the Railway Reserve between Port Lincoln and Buckleboo (DEH Recfind file 40/1176).
2002	Forty Jumping-jack Wattle tube stock planted by Cummins Area School students into a roadside site on the Bratten Way (north-west of Cummins). Threatened Species Network and World Wildlife Fund funded Community Grant '*Habitat restoration for three endangered species on Lower Eyre Peninsula'* (Project ID SA03/103). Aim: to reinstate population. Year 10 students hand weeded the site (DEH Recfind file 40/1496).
2002	Workshop held by Threatened Plant Action Group (TPAG) at Port Neil to encourage community involvement in recovery actions.
2003	Thirty Jumping-jack Wattle grown and translocated to the Bratten Way roadside site. Planted with Fat-leaved Wattle (*A. pinguifolia*) (nationally Vulnerable), Merrit (*Eucalyptus flocktoniae*), Native Pine (*Callitris gracilis*) and Cockies Tongue (*Templetonia retusa*) (DEH Recfind file 40/1496).
2003	Seed collected by Green Corps team from Dog Fence Road population, for local *ex situ* seed bank and future revegetation (DEH Recfind file 40/1496).
2006	Jumping-jack Wattle Threatened Flora of Eyre Peninsula Information Sheet produced as a milestone for the Ark on Eyre project (DEH Recfind file 40/A142070).

7.6 Threats to Jumping-jack Wattle and associated recovery goals

The long-term goals are to down-list Jumping-jack Wattle conservation status from Endangered to Vulnerable and continue to recover Jumping-jack Wattle critical habitat on Eyre Peninsula. We are aiming to achieve this down-listing within the duration of this plan (by 2012).

Jumping-jack Wattle has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 7.6 details the key threats and summarises performance criteria relevant to Jumping-jack Wattle recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 7.6. Key threats to Jumping-jack Wattle and summary of associated performance criteria

Direct threat: **Habitat fragmentation**	Risk
Risk: Long-term viability decrease as species ability to colonise suitable area declines **Likelihood:** Decrease in suitable habitat = Likely **Consequences:** Lower recruitment = Major Small sub-populations in highly fragmented road and rail reserve vegetation may have low genetic variability and genetic flow because of their small size and isolation. Resilience to environmental changes, pests or diseases may therefore be reduced.	Extreme
Direct threat and knowledge gap: **Inappropriate fire regime(s)**	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Almost certain **Consequence:** Moderate Acacia species, in general, are known require fire to trigger certain responses, e.g. seedling recruitment (Bradstock et al. 2002). The majority of Jumping-jack Wattle sub-populations on Eyre Peninsula are long unburnt (DEH-EGIS 2007 fire scar mapping). An historic Jumping-jack Wattle sub-population in Middlecamp Hills Conservation Park needs re-surveying after a bushfire in 2005 to observe species response to fire.	Extreme
Direct threat: **Weed invasion**	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Almost certain **Consequences:** Moderate Roadside reserves are subjected to weed competition. It is highly likely that germinating Jumping-jack Wattle will be out-competed by Bridal Creeper (*Asparagus asparagoides*) in some sites. African Boxthorn (*Lycium ferocissimum*) is also found at many Jumping-jack Wattle sites. The impact of weed species on the different stages of Jumping-jack wattle has not been investigated.	Extreme
Direct threat: **Lack of recruitment/small population size**	
Risk: Depleted soil seedbank and population decline from consecutive years of low to no viable seed yield **Likelihood:** Likely **Consequence:** Moderate All surveyed sub-populations on Eyre Peninsula display poor seed set and no recruitment is evident (A Freebairn [DEH] 2004, pers. comm.). Some sub-populations are comprised only of mature to senescent individuals. There is thought to be a strong relationship between rainfall and seed set, with the species observed regularly aborting seed in dry conditions (A Freebairn [DEH] 2004, pers. comm.).	High
Direct threat: **Roadside management**	
Risk: Localised species extinction of sub-populations from failing to apply, or lack of applying, environmental best practise to roadside and easement work **Likelihood:** Possible **Consequences:** Moderate The majority of known sub-populations are located on roadsides (district councils of Tumby Bay, Kimba and Franklin Harbour), rail reserves and water pipeline reserves. These are at risk of clearance from maintenance and earthwork activities. Excluding railway reserves, Significant Vegetation Marker Systems are yet to be establised to clearly identify these sites to workers.	High
Direct threat: **Salinity/changes in hydrology**	
Risk: Localised extinction of sub-populations from increased salinity or changes in hydrology **Likelihood:** Possible **Consequences:** Moderate Some Jumping-jack Wattle sub-populations are found in drainage areas. Therefore, alteration to drainage and riparian zones is expected to impact significantly on this species' survival.	High

Direct threat and knowledge gap: **High grazing pressure**						
Risk: Loss of germinated juveniles which unstabilises life class structure and increases risk of population decline **Likelihood:** Possible (unknown, requires survey) **Consequences:** Moderate Grazing pressure on Jumping-jack Wattles is currently unstudied and un-observed. Domestic livestock, rabbits and kangaroos may find unprotected juvenile plants palatable.						**High**
	Objective 1 **Baseline information**	**Objective 2** **Community involvement**	**Objective 3** **Manage threats and improve habitat**		**Objective 4** **Research critical to management**	**Objective 5** **Monitoring and evaluation**
Performance criteria	1a.1 1b.1 1c.1 1c.2 1c.4 1c.5 1d.1 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.2 3a.4 3b.1 3b.2 3c.1 3c.2 3d.1 3d.2 3e.1 3e.2	3e.3 3e.4 3f.1 3f.2 3f.3 3f.4 3f.5 3f.6 3f.7 3f.8	4b.1 4b.4 4b.5 4c.2 4h.1	5a.4 5a.7 5a.8 5a.9 5b.2

7.7 Main references

Cowan, RS & Maslin, BR 2001, in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

Hussey, BMJ 2002, 'Wattle I plant for wildlife?', *Conservation Science Western Australia*, vol. 4, no. 3, pp. 62-71.

Moritz, KN & Bickerton, DC 2007, *Draft Recovery Plan for the Nationally Endangered Jumping-jack Wattle* Acacia enterocarpa *(R.V. Smith)*, report to the Species Listing, Recovery and Policy Section, Australian Government Department of the Environment and Water Resources, Canberra.

Overman, T & Venn, D 1999, *Action Statement No. 85 Jumping-jack Wattle*, Department of Sustainability and Environment, Victoria.

Stuwe, J 1980, 'Rare and endangered Victorian plants 1. *Acacia enterocarpa*', *Victorian Naturalist*, vol. 97, pp. 157-8.

Whibley, DJE & Symon, DE 1992, *Acacias of South Australia*, South Australian Government Printer, Adelaide.

8 Fat-leaved Wattle *Acacia pinguifolia* JM Black

8.1 Status

When assessing Eyre Peninsula Fat-leaved Wattle vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 8.1). Fat-leaved Wattle is recognised as Endangered at the Regional, State and National levels (Table 8.1).

Table 8.1. Fat-leaved Wattle vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Endangered
Extent of occurrence (km²)	4545		
Area of occupancy (km²)	0.7	Endemic to South Australia	
Sub-populations	61		
Estimated # of individuals	2770		
IUCN Criteria	**Justification**		
EN A2	It is estimated that population size on Eyre Peninsula will reduce by 50% over three generations		
EN A2c*	Expected decline in the area of occupancy, extent of occurrence and quality of habitat on Eyre Peninsula		

8.2 Distribution

Fat-leaved Wattle is known from disjunct sub-populations on Eyre Peninsula, and a small sub-population near Finniss in the Southern Lofty Herbarium Region. Sub-populations on Eyre Peninsula have an extent of occurrence over 4500 km², occurring within latitude 34º5'16" to longitude 136º7'16" (northern extent) and latitude 34º32'15" to longitude 135º40'20" (southern extent) (DEH-EGIS 2006). Eyre Peninsula Fat-leaved Wattle sub-populations occur in three district regions (Figure 8.1):

- northern sub-populations occur near Cockaleechie, Ungarra and Bulter Tanks
- south-western sub-populations extend to Cummins, Coulta and Wanilla in the south
- south-eastern sub-populations span hills in the Hundreds of Koppio and Hutchison.

Fat-leaved Wattle records from Kulliparu and nearby Yeldulknie conservation parks appear to be significantly outside the species' range and require verification.

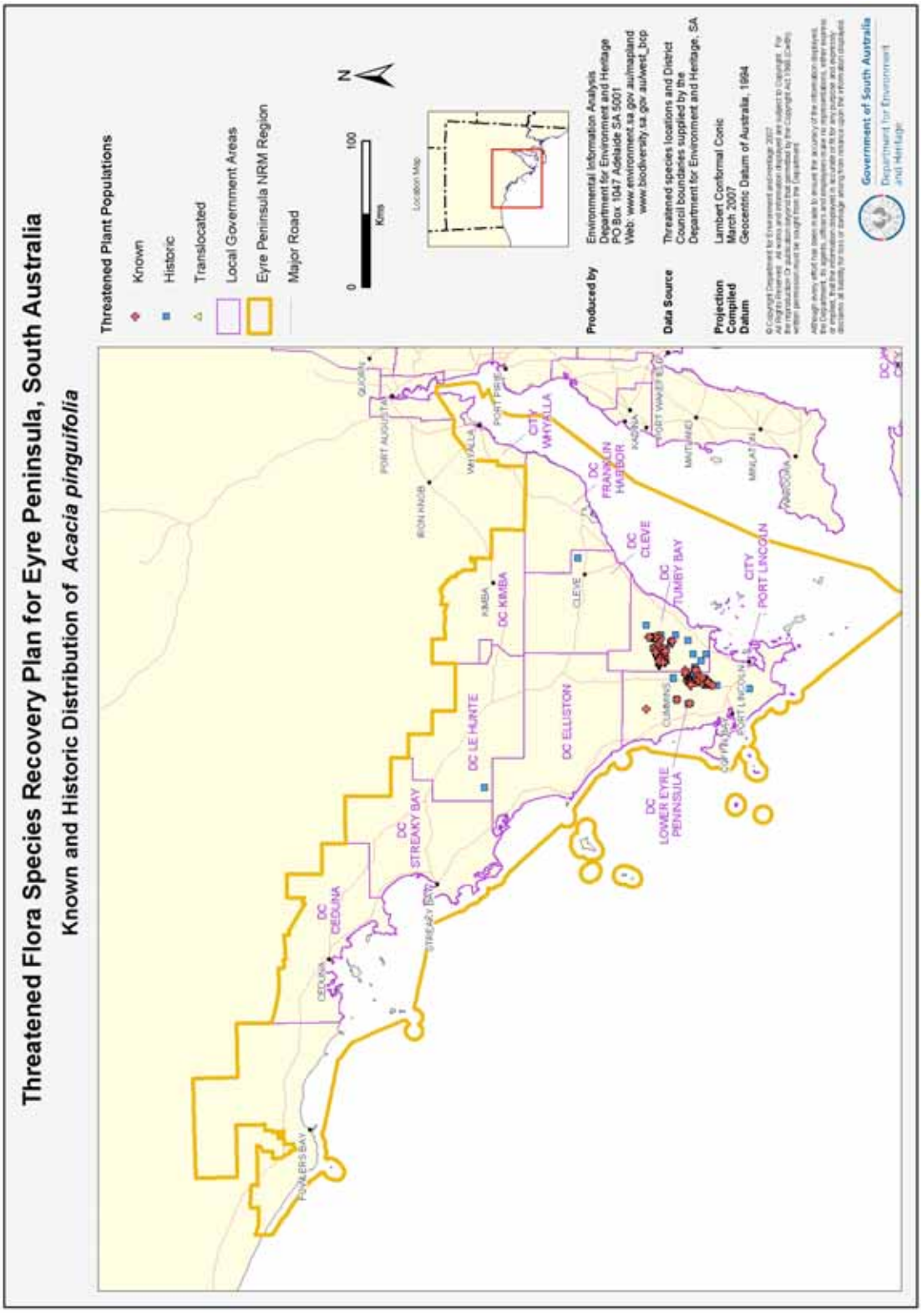
Many sub-populations are located on roadsides managed by the district councils of Lower Eyre Peninsula and Tumby Bay. The species also grows within rail reserves maintained by Australian Railroad Group Pty Ltd (ARG).

8.3 Habitat critical to survival

All known habitat of Fat-leaved Wattle is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Fat-leaved Wattle occupies topography ranging from 60 m above sea level (north of Edillilie) to 180 m above sea level (Koppio Hills, and between Ungarra and Cockaleechie). Populations at Finniss grow in sands, sandy clay loams, and clay loams with a pH of between 7.5 and 9.5 (DEH 2007).



Note: Fat-leaved Wattle details are held on internal DEH files and are available on request.

Figure 8.1. Distribution of Fat-leaved Wattle on Eyre Peninsula

Sub-populations on southern Eyre Peninsula have been collected from cream loam with clay subsoil and an undulating west-facing aspect (DEH 2007). The species has also been recorded growing on calcareous red loam, brown clay loam on schist, brown clay loam on broken limestone, and pale grey soil over ironstone gravel (DEH 2007). Laut et al. (1977) records Fat-leaved Wattle growing primarily in mottled-yellow duplex or hard pedal mottled-yellow duplex.

The south-eastern Fat-leaved Wattle sub-populations, found throughout the Koppio Hills, grow in heavy soils and in low-lying areas. These observations correspond with records in DEH (2007) that state the species is more commonly found on poorly drained sites. Fat-leaved Wattle has also been found growing on white clay soil on a north-facing slope.

Vegetations associations

Fat-leaved Wattle sub-populations at Finniss grow in association with similar primary overstorey species as Eyre Peninsula sub-populations (Table 8.2) (DEH-EGIS 2006). Finniss populations grow with Dumosa Mallee (*Eucalyptus dumosa*) and/or White Mallee (*E. phenax*), +/- Narrow-leaved Red Mallee *(E. foecunda*), +/- Square-fruited Mallee *(E. calycogna*) (DEH 2007).

Table 8.2. Vegetation associations of northern Fat-leaved Wattle sub-populations

Primary species	Secondary species	Understorey species
Square-fruit Mallee (*Eucalyptus calycogona*), +/- Dumosa Mallee (*E. dumosa*) mid mallee woodland	Broombush (*Melaleuca uncinata*), +/- Hard-leaf Wattle (*Acacia sclerophylla* var. *sclerophylla*), +/- Dryland Tea-tree (*M. lanceolata*) tall shrubs	+/- Spinifex (*Triodia scariosa*) mid hummock grasses
Capped Mallee (*E. pileata*), +/- Beaked Red Mallee (*E. socialis*), +/- Ridge-fruited Mallee (*E. incrassata*), +/- Cummins Mallee (*E. peninsularis*) mid mallee woodland	Broombush (*Melaleuca uncinata*), Dryland Tea-tree (*M. lanceolata*), Mallee Honey-myrtle (*M. acuminata*) mid shrubs	Common Eutaxia (*Eutaxia microphylla),* Silvery Phebalium (*Phebalium bullatum*) low shrubs
Broombush (*Melaleuca uncinata*) tall open shrubland	Silver Broombush *(Babingtonia behrii*), +/- Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs	Spinifex (*Triodia irritans*), +/- *Hibbertia* sp. *glabriuscula* (DJ Whibley 9012)
Coastal White Mallee (*E. diversifolia* ssp. *diversifolia*) mid mallee woodland	+/- Dryland Tea-tree (*Melaleuca lanceolata*), +/- Broombush *(M. uncinata*) tall shrubs	Prickly Ground-berry (*Acrotriche patula*), +/- Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs

South-western and south-eastern Fat-leaved Wattle sub-populations also grow in association with Coastal White Mallee, Ridge-fruited Mallee and Broombush vegetation associations similar to the northern sub-populations. However, due to the slightly higher rainfall and different soils, the southern sub-populations are also found in Sugar Gum (*Eucalyptus cladocalyx*) mid woodlands and Box woodlands (Table 8.3) (DEH-EGIS 2006).

Climate

Fat-leaved Wattle inhabits the 400-500 mm rainfall zone, apart from two outlying recorded sub-populations that require verification. Mean annual rainfall at Tod Reservoir, the most central Bureau of Meteorology weather station site within the species' distribution range, is 485.3 mm. Mean annual maximum and minimum temperatures are 20.9 °C and 9.6 °C respectively (BOM 2007). Fat-leaved Wattle's western distribution spans out towards Wanilla where mean annual rainfall is 509.4 mm (BOM 2007).

Known populations within reserves

Fat-leaved Wattle is not currently conserved within the South Australian reserve system. Potential habitat mapping actions will help to identify similar floristic habitats within and outside of the reserve system.

Table 8.3. Vegetation associations of southern Fat-leaved Wattle sub-populations

Primary species	Secondary species	Understorey species
Drooping Sheoak (*Allocasuarina verticillata)* low woodland	+/- Yacca (*Xanthorrhoea semiplana*) shrubs	Kangaroo Grass (*Themeda triandra*), Hill Raspwort (*Gonocarpus elatus*), Hard Mat-rush (*Lomandra multiflora* ssp. *dura*), Crested Spear-grass (*Austrostipa blackii*) tussock grasses
Sugar Gum (*Eucalyptus cladocalyx*) mid woodland	+/- Golden Wattle (*Acacia pycnantha*), Rock Wattle (*Acacia rupicola*), +/- Yacca (*Xanthorrhoea semiplana*), +/- Broombush (*Melaleuca uncinata*) mid shrubs	Peach heath (*Lissanthe strigosa* ssp. *subulata*), Small-flower Wallaby-grass (*Austrodanthonia setacea*) low shrubs, Broad-leaf Raspwort (*Gonocarpus mezianus*), Coarse Lagenophora (*Lagenophora huegelii*)
Broad-leaf Box (*Eucalyptus behriana*), +/- Peppermint Box (*E. odorata*) low open woodland	Open	Grass Family *(Gramineae* sp.) tussock grasses
Peppermint Box (*Eucalyptus odorata*), +/- *E. phenax* mid mallee woodland	Broombush (*Melaleuca uncinata*) mid shrubs	Bearded oat (**Avena barbata*), +/- Slender Velvet-bush (*Lasiopetalum baueri*) mid tussock grasses over +/- Broad-leaf Raspwort (*Gonocarpus mezianus*)
Narrow-leaf Red Mallee (*Eucalyptus leptophylla*), +/- Dumosa Mallee (*E. dumosa*) mid mallee woodland	Dryland Tea-tree (*Melaleuca lanceolata*), +/- Mallee Honey-myrtle (*M. acuminata*) tall shrubs	+/- Spinifex (*Triodia irritans*) low hummock grasses

Benefits to other species

Recovery actions to conserve Fat-leaved Wattle are expected to benefit species surviving in highly fragmented landscapes. Fat-leaved Wattle grows in association with Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*) woodland, which is a State Endangered vegetation association (DEH 2001).

Species in the Leguminoseae family, including Fat-leaved Wattle, use symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen, which plays an important role in ecosystem function (CILR 2007). The nitrate or ammonium produced in this process benefits a whole system of plants and provides flow-on nitrogen to animals.

Fat-leaved Wattle shares overlapping habitat with Feathery Wattle (*Acacia imbricata*) (nationally Vulnerable), Broad-leaf Box (*Eucalyptus behriana*) (state Rare), and Peppermint Box (*E. odorata*) (currently under nomination as nationally Endangered). It also grows in association with regionally threatened Sugar Gum (*E. cladocalyx*) woodlands (DEH 2002). These woodlands are habitat for woodland bird species, such as the Eyre Peninsula Yellow-tailed Black-Cockatoo (*Calyptorhynchus funereus*) (state Vulnerable, regionally Endangered on Eyre Peninsula), and the Common Brushtail Possum (*Trichosurus vulpecula*) (state Vulnerable, regionally Rare on Eyre Peninsula).

8.4 Biology and ecology

Fat-leaved Wattle is a perennial, dense, 1-2 m tall to 2-3 m broad spreading light-green shrub (Whibley 1986). The species derives its common name from its 1-3.5 cm long phyllodes (leaf-like structures), which are thick (2-3 mm in diameter) and fleshy, giving them a fat appearance.

Flowering usually occurs between July and October. The wattle flowers (inflorescences) are simple, and grow from the joint between phyllode and stem (axillary). Fat-leaved Wattle flowers can grow in twos or in clusters of up to four flower heads (Whibley & Symon 1992). Pollination is unconfirmed, but the plant is likely to be wind or insect pollinated.

Seed development and dispersal has not been adequately studied. Seeds have whitish, fleshy arils and develop within seed pods that are 5-7 cm long and 5 mm broad (Whibley 1986). The majority of surveyed sub-populations produce large amounts of viable seed and recruitment is evident within many sub-populations (A Freebairn [DEH] 2004, pers. comm.).

Fire dependences triggers

Generally *Acacia* species are early post-fire colonisers, producing seed early in their life cycle. Recruitment gradually decreases in line with a decrease in disturbance (Luke & McArthur 1978). Mass germination of Fat-leaved Wattle seedlings was observed within the fire scar following the 2005 Wangary Bushfire. Preliminary results from post-fire studies showed short-term die off of the seedlings (thought to be attributed to drought conditions); however, the number of juvenile plants remained relatively high (Ecological Associates 2007). Ecological Associates also undertook comparison monitoring between burnt and unburnt sites from 2006-2007 (DEH Recfind file 40/1185).

Related species

Fat-leaved Wattle is related to the following two species, which also grow on Eyre Peninsula but have distributions further north of the known range for Fat-leaved Wattle (Whibley and Symon 1992):

- Menzel's Wattle (*Acacia menzelii*)
- Dwarf Nealie (Acacia wilhelmiana).

8.5 Previous management actions

Table 8.4. Previous management actions to conserve Fat-leaved Wattle

	Previous management actions and points of interest
1990-93	Three year research project on Fat-leaved Wattle funded by World Wide Fund for Nature (Jusaitis & Sorensen 1994).
1992-93	Trial translocations of Fat-leaved Wattle to several photo-point sites on Eyre Peninsula (Jusaitis & Sorensen 1994).
2003	Fat-leaved Wattle translocated to the Bratten Way roadside site (near Cummins). Planted with Jumping-jack Wattle (*A. enterocarpa*) (nationally Vulnerable), Merrit (*Eucalyptus flocktoniae*), Native Pine (*Callitris gracilis*) and Cockies Tongue (*Templetonia retusa*) (DEH Recfind file 40/1498).
2005	Wangary 'Black Tuesday' bushfire on 11th January 2005 burnt through populations of Fat-leaved Wattle on Lower Eyre Peninsula.
2005	Ecological Associates Pty Ltd contracted to DEH on 14th Dec 2005 to undertake monitoring of vegetation response following the Lower Eyre Peninsula bushfire. One of the species assessed was Fat-leaved Wattle (DEH Recfind file 40/1185). Monitoring and assessments finished June 2007.
2006	Fat-leaved Wattle community awareness raising media on ABC local radio and flyers through PIRSA bushfire re-establishment mail-outs, K Pobke (DEH Recfind file 40/A142128).
2006	Three Fat-leaved Wattle translocations established with the support of the Cummins Area School and facilitated by K Pobke, N Reichelt and I Foster. All translocations established on private land, with the goal of establishing the species away from roadsides and railway edges, and monitoring progress (DEH Recfind file 40/1498).
2006	Fat-leaved Wattle Threatened Flora of Eyre Peninsula Information Sheet produced as a milestone for the Ark on Eyre project (DEH Recfind file 40/A142070).

8.6 Threats to Fat-leaved Wattle and associated recovery goals

The long-term goals are to down-list Fat-leaved Wattle conservation status from Endangered to Vulnerable, and continue to recover Fat-leaved Wattle critical habitat on Eyre Peninsula. However, the immediate short-term goal is to stabilise Fat-leaved Wattle conservation status at Endangered.

Fat-leaved Wattle has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 8.5 details the key threats and summarises performance criteria relevant to Fat-leaved Wattle recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 8.5. Key threats to Fat-leaved Wattle and summary of associated performance criteria

Direct threat and knowledge gap: **Habitat fragmentation**	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Possible **Consequence:** Major The majority of populations grow in highly fragmented vegetation on road and rail reserves. They may have low genetic variability and genetic flow because of their size, isolation and environmental stress.	Extreme
Direct threat and knowledge gap: Inappropriate fire and disturbance regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire/disturbance from critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires/disturbances are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Almost certain **Consequence:** Moderate Inappropriate disturbance regimes have the potential to threaten Fat-leaved Wattle sub-populations. Different types of disturbance (e.g. burning, soil disturbance), the intensity, frequency, and season of the events are expected to influence Fat-leaved Wattle population structure. Long periods between disturbance events are expected to result in successional decline in Fat-leaved Wattle. Disturbance too soon after Fat-leaved Wattle germination could result in population failure and localised extinction.	Extreme
Direct threat: Weed invasion	
Risk: Species out competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate *Acacia* species often require disturbance events to trigger germination and to develop suitable niches within otherwise 'closed' ecosystems. However, fragmented ecosystems are quickly invaded by weed species after disturbance events, and weeds compete directly with germinating Fat-leaved Wattle. Monitoring after the 2005 Wangary bushfire recorded mass germination of seedlings (Ecological Associates 2007). Bridal Creeper (*Asparagus asparagoides*), Perennial Veldt Grass (*Ehrharta calycina*), Rye Grass (*Lolium* rigidum), Wild Oats (*Avena fatua*), Boneseed (*Crysanthemoides monilifera* ssp. *monilifera*) and Aleppo Pines (*Pinus halepensis*) all currently compete with and invade Fat-leaved Wattle habitat (Ecological Associates 2006).	High
Direct threat and knowledge gap: High grazing pressure	
Risk: Loss of germinated juveniles which unstabilises life class structure and increases risk of population decline. **Likelihood:** Likely **Consequences:** Moderate Sheep grazing of adult and juvenile Fat-leaved Wattles was observed in 2006 (drought year) within the fire zone (Prider 2006). Grazing pressure on Fat-leaved Wattle sub-populations requires further study; however, it is currently suspected that grazing is a threat to plant growth, flowering and recruitment.	High

Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply environmental best practise. **Likelihood:** Possible **Consequences:** Moderate Fat-leaved Wattle sub-populations have suffered significant losses from illegal vegetation clearance. Clearance of previously surveyed Fat-leaved Wattle sub-populations along the Railway Reserve between Port Lincoln and Buckleboo in 2003 is an example of the most extensive damage to Fat-leaved Wattle sub-populations (DEH Recfind file 40/1176). After the 2005 Wangary Bushfire, sub-populations of adult Fat-leaved Wattles suffered partial and total sub-population clearance through vegetation clearance in post-bushfire 'clean up' (Prider 2006a). Maintenance by other service providers managing services and easements along roadsides could also pose a threat to Fat-leaved Wattle.	**High**
Direct threat: Pest and disease (*Phytophthora*)	
Risk: Localised species extinction and loss of critical habitat **Likelihood:** Possible **Consequences:** Moderate Velzeboer et al. (2005) considers Fat-leaved Wattle sub-populations on Lower Eyre Peninsula to currently be within Moderate to Low Risk Management Zones.	**High**
Knowledge gap: Spray drift	
Risk: Plant stress leading to localised species extinction (short or long-term) from spray drift **Likelihood:** Possible **Consequences:** Moderate Herbicide drift is considered a potential threat to the species.	**High**

	Objective 1 Baseline information	Objective 2 Community involvement	Objective 3 Manage threats and improve habitat	Objective 4 Research critical to management	Objective 5 Monitoring and evaluation
Performance criteria	1a.1 1d.1 1b.1 1d.3 1c.1 1c.2 1c.4 1c.5	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3e.2 3a.2 3e.3 3a.4 3e.4 3b.1 3f.1 3b.2 3f.2 3c.2 3f.3 3d.1 3f.4 3d.2 3f.6 3d.3 3f.7 3e.1 3f.8	4b.4 4b.6 4b.7 4c.2 4e.1 4f.1 4g.1 4h.1	5a.4 5a.7 5a.8 5a.9 5b.2

8.7 Main references

Jusaitis, M & Sorensen, B 1994, Conservation studies on endangered plant species from South Australia's agricultural regions, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Pound, L, Obst, C & How, T 2004, *Draft recovery plan for* Acacia pinguifolia *(Fat-leaved Wattle)*, report to the Threatened Species and Communities Section, Australian Government Department of the Environment and Heritage, Canberra.

Whibley, DJE & Symon, DE 1992, *Acacias of South Australia*, South Australian Government Printer, Adelaide.

9 Resin Wattle *Acacia rhetinocarpa* JM Black

9.1 Status

When assessing Eyre Peninsula Resin Wattle vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 9.1). Resin Wattle is recognised as Vulnerable at the Regional, State and National levels (Table 9.1).

Table 9.1. Resin Wattle vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	1669		
Area of occupancy (km²)	0.95		
Sub-populations	7		
Individuals	1000		
IUCN Criteria	**Justification**		
VU B2	Area of occupancy estimated to be less than 2000 km² on Eyre Peninsula		
VU B2a	Severely fragmented and known to exist in no more than 10 locations on Eyre Peninsula		
VU B2a,b(iii)*	Continued decline in area, extent and quality of habitat on Eyre Peninsula		

9.2 Distribution

Resin Wattle, also known as Neat Wattle, grows in disjunct sub-populations on the Yorke and Eyre Peninsula, Southern Lofty, and Murray Herbarium Regions (Whibley & Symon 1992). On Eyre Peninsula, Resin Wattle has an extent of occurrence over 1600 km², which encompasses an area from Kimba to just north of Arno Bay, Cleve and Lock (Figure 9.1).

Resin Wattle sub-populations survive within roadside vegetation managed by the Department for Transport, Energy and Infrastructure, and the district councils of Cleve, Franklin Harbour and Kimba. Resin Wattle sub-populations also grow on a water reserve (H531600, Section 22) south of Heggaton Conservation Reserve.

9.3 Habitat critical to survival

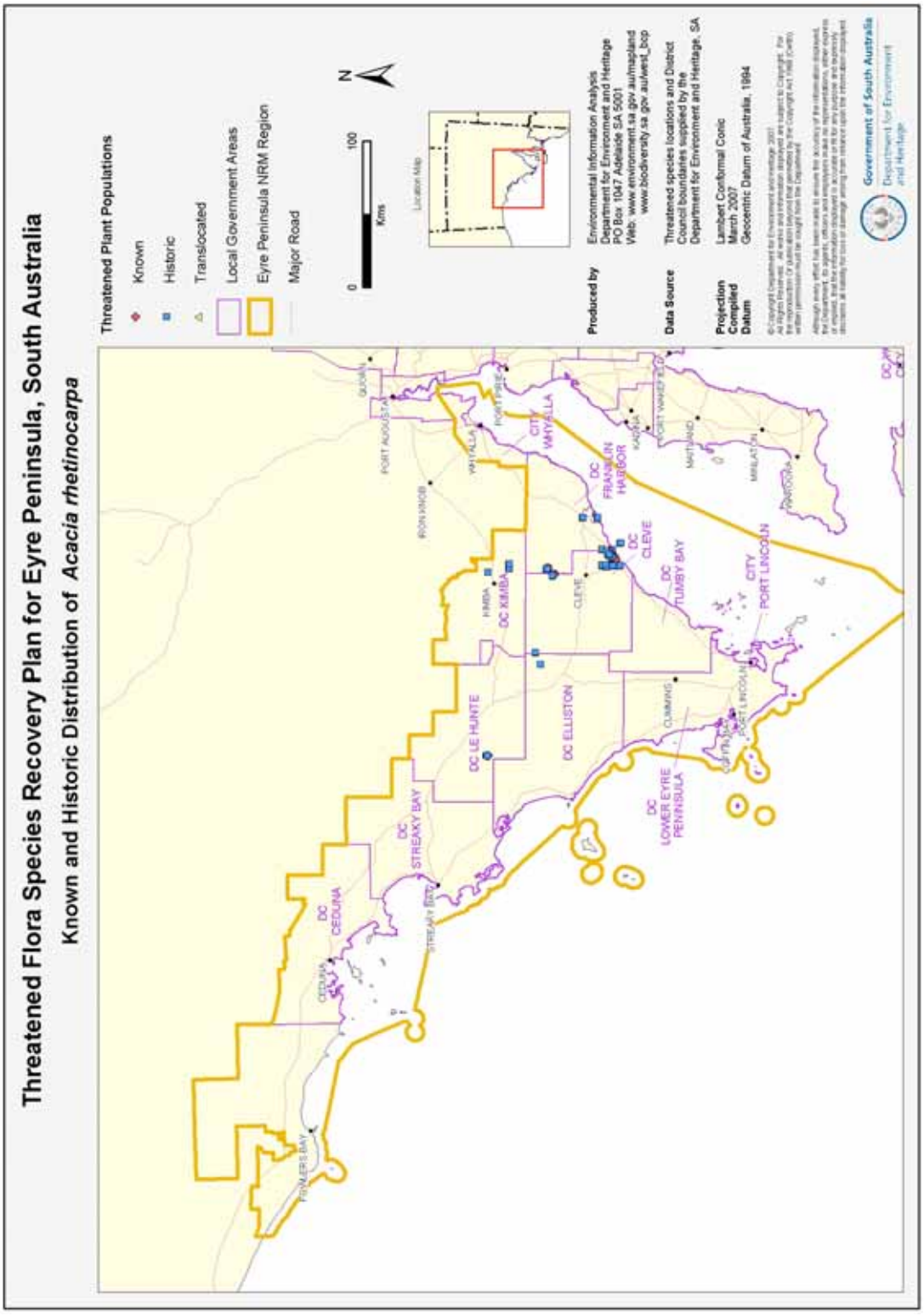
All known habitat of Resin Wattle is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Resin Wattle is recorded growing in a range of soils, although more commonly on brownish sands or sandy apedal mottled-yellow duplex soils (Laut et al. 1977). Whibley and Symon (1992) record Resin Wattle growing in calcareous sands, red shallow porous loam or grey-brown calcareous loamy earths. Resin Wattle grows in topography as low as 10 m above sea level (in the south-east of Eyre Peninsula, near Cowell and Arno Bay) to 70 m above sea level (in the north-west, near Mount Damper).

Vegetation associations

Resin Wattle has been recorded growing in open scrub, associated with Yorrell (*Eucalyptus gracilis*), Beaked Red Mallee (*E. socialis*) and Ridge-fruited Mallee *(E. incrassata*) (Whibley & Symon 1992). Resin Wattle grows in association with vegetation broadly described as *Eucalyptus* mallee forest and mallee woodland (DEH-EGIS 2006).



Note: Resin Wattle details are held on internal DEH files and are available on request.

Figure 9.1. Distribution of Resin wattle on Eyre Peninsula

Near Arno Bay, Resin Wattle survives in degraded sites largely devoid of remnant vegetation, where DEH floristic mapping does not detect a floristic vegetation layer (DEH-EGIS 2006). This is also the case with some sub-populations on Yorke Peninsula, where the associated vegetation has been heavily modified (Green 1993). The small areas on Eyre Peninsula where Resin Wattle does grow in association with vegetation are classified as dune crest and dunes/hills, plains and swales; sand to clay loam; and sandy soils.

These sub-populations grow in association with Ridge-fruited Mallee (*Eucalyptus incrassata),* +/- Narrow-leaf Red Mallee *(Eucalyptus leptophylla)* mid mallee woodland over Green Tea-tree (*Leptospermum coriaceum),* Broombush *(Melaleuca uncinata),* Scrub Cypress Pine *(Callitris verrucosa),* Broom Baecka *(Babingtonia behrii)* shrubs over *(Hibbertia australis),* and Golden Pennants (*Glischrocaryon behrii)* (DEH-EGIS 2006).

Resin Wattle sub-populations to the north-east of Mangalo grow with mallee overstorey similar to the southern sub-populations, where Ridge-fruited Mallee over Broombush and Green Tea-tree dominate. Understorey associations comprise of Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs over Sandhill Bog-rush (*Schoenus racemosus*) and Woolly Spinifex (*Triodia lanata*).

Climate

Sub-populations of Resin Wattle on Eyre Peninsula grow within the 400-300 mm per year rainfall zone (DEH-EGIS 2006).

- The northern extent of Resin Wattle sub-populations could be expected to experience similar climatic conditions to Minnipa, with mean annual maximum and minimum temperatures of 24 ºC and 10.9 ºC respectively, and a mean annual rainfall of 327.3 mm (BOM 2007).
- Northern-eastern Resin Wattle sub-populations are close to Mangalo and could be expected to receive slightly more rainfall than 346.2 mm (mean annual) (BOM 2007).
- The southern Resin Wattle sub-populations (near Arno Bay) receive the lowest mean annual rainfall of 317.5 mm (BOM 2007).

Known populations within reserves

Resin Wattle is located within the South Australian reserve system (Table 9.2), but is not known to occur within any Heritage Agreements.

Table 9.2. Resin Wattle sub-populations in reserves on Eyre Peninsula

NPWSA Reserve	Sub-population	Observer
Hambidge Conservation Park	1	NRT Lothian 1967

Benefits to other species

The conservation of Resin Wattle is expected to benefit species surviving in a highly fragmented landscape. Resin Wattle's extent of occurrence covers 244 880 hectares. Of this area, only 5% (12 607 hectares) of remnant vegetation remains (NVMB 1987). Recovery actions will include identifying corridors and other methods that can be used to extend Resin Wattle from its currently restricted range.

Species in the Leguminoseae family, including Resin Wattle, uses symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen, which plays an important role in ecosystem function (CILR 2007). Nitrate or ammonium produced in this process benefits a whole system of plants and provides flow-on nitrogen to animals.

9.4 Biology and ecology

Resin Wattle is a perennial, compact, rounded shrub that grows 0.5-1.5 m tall (Whibley & Symon 1992). The species has small (2-5 mm long, 2-3 mm wide) leaf-like structures (phyllodes) that are oblique and obovate in shape, and yellowish-green. Resinous coating over the foliage renders the plant sticky to touch and this is the reason for the common name, Resin Wattle.

Flowering usually occurs between August and October (Whibley & Symon 1992). The wattle flowers (inflorescences) are simple, and grow from the joint between phyllode and stem (axillary) on hairless (glabrous) 4-7 mm flower stems (peduncles). They generally grow singly. Inflorescences usually contain 12-15 flowers.

Pollination remains unconfirmed; however, it is likely to occur via wind.

Seed development and dispersal has not been studied; however, it is suspected that ants play a role in seed dispersal. Seed pods develop between November and January (Green 1993). Seeds have fleshy arils and grow broad seed pods averaging 1-3.5 cm long and 2-2.5 mm (Whibley & Symon 1992).

Germination has not been widely studied, but is suspected to be influenced by fire or disturbance. Data on Resin Wattle sub-populations in the Monarto region suggest plants tend to senesce after approximately thirty years of age (Green 1993). It is suspected that the establishment of the Monarto sub-population corresponds with vegetation rolling disturbance (Davies 1995).

Fire dependence triggers

Resin Wattle is suspected of having fire dependence triggers. Resin Wattle is thought to be an early post-fire successional species.

Related species

Resin Wattle is closely related to four species, of which only Merrall's Wattle grows on Eyre Peninsula. The related species include:

- Gold Dust Wattle (*Acacia acinacea*)
- Merrall's Wattle (*Acacia merrallii*)
- Hairy-pod Wattle (*Acacia glandulicarpa*).

Resin Wattle is noted to also having affinities with *Acacia brachyclada*, an endemic Western Australian species (Whibley & Symon 1992).

9.5 Previous management actions

Table 9.3. Previous management actions to conserve Resin Wattle

	Previous management actions
1967	Resin Wattle collected from Hambidge Conservation Park (TRN Lothian 4162 in AD; Davies 1995). Location notes state the sample was taken from within 100 m of the southern boundary of the park, towards the western boundary.
~1995	Search conducted to re-locate Resin Wattle in Hambidge Conservation Park, but unable to find the species (Davies1995).
2000	Annie Bond (DEH, State Threatened Flora Officer) and Anthony Freebairn made site visits to three Resin Wattle roadside sub-populations near Arno Bay (DEH Recfind file 40/A248477, Part 1). Threats to these sites were identified and part counts of plants made.
2001	A community awareness raising article on Resin Wattle was printed in the summer edition of local newsletter *The Long Run* (author A Freebairn). Repeated again in summer 2002 as part of the 'Unusual Suspects' series.
2001	Anthony Freebairn made a site visit to a Resin Wattle roadside sub-population near Cowell (11/10/2001) (DEH Recfind file 40/A248477, Part 1). Threats to these sites were identified and total count of plants made.
2002	Wesley Crisp and Corey Yeates found a single Resin Wattle on private property, approximately 20 km south-west of Yaninee (DEH Recfind file 40/A248477, Part 1).
2002-03	Successfully established tubestock planted and direct seeded along roadside (set further back within a paddock) on the Kimba to Cleve Road (S Bey [Greening Australia] 2007, pers. comm.).

9.6 Threats to Resin Wattle and associated recovery goals

The long-term goals are to down-list Resin Wattle conservation status from Vulnerable to Near Threatened and continue to recover Resin Wattle critical habitat. However, the immediate short-term goal is to stabilise Resin Wattle conservation status at Endangered.

Resin Wattle has been ranked as a Priority 2 species based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 9.4 details the key threats and summarises performance criteria relevant to Resin Wattle recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 9.4. Key threats to Resin Wattle and summary of associated performance criteria

Direct threat and knowledge gap: **Habitat fragmentation**	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Almost certain **Consequence:** Moderate Majority of sub-populations are on road reserve (A Freebairn [DEH] 2004, pers. comm.), and may have low genetic variability and genetic flow because of their size, isolation and environmental stress.	Extreme
Direct threat and knowledge gap: Small population/lack of recruitment	
Risk: Species sub-populations become smaller than that minimum viable population limit **Likelihood:** Almost certain **Consequence:** Moderate Minimal natural recruitment has been observed (A Freebairn [DEH] 2004, pers. comm.) and, where recruitment is found, it's along roadsides and corresponds with mechanical soil disturbance. Sub-populations in mature mallee communities appear to be senescing, suggesting long-unburnt fire regimes maybe unsuitable for Resin Wattle. Seed set is generally poor although plants located in wetter habitats set significantly more seed than the population average (seed viability to be determined) and attempts to propagate this species on Eyre Peninsula have not been successful (A Freebairn [DEH] 2004, pers. comm.).	Extreme
Direct threat and knowledge gap: Inappropriate fire and disturbance regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Almost certain **Consequence:** Moderate Different types of disturbance (e.g. burning, soil disturbance) and the intensity, frequency and season of the disturbance events are expected to influence Resin Wattle population structure. Infrequent disturbance events are thought to cause successional decline in Resin Wattle and too frequent disturbance, too soon after Resin Wattle germination, could result in localised extinction.	Extreme
Direct threat and knowledge gap: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Possible **Consequence:** Moderate Weed invasion may limit Resin Wattle germination; however, this requires further study.	High
Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply environmental best practise **Likelihood:** Possible **Consequences:** Moderate Inappropriate roadside management (actions not within best practise guidelines) threaten roadside sub-populations (e.g. roadsides near Arno Bay and Cowell, DEH Recfind file 40/A248477, Part 1). Maintenance of other essential services, such as water pipelines, overhead powerlines and underground cables, has the potential to threaten Resin Wattle if not managed appropriately.	High

Direct threat and knowledge gap: Salinity/changes in hydrology	
Risk: Localised species extinction and degradation of critical habitat from increased salinity and changes in hydrology **Likelihood:** Possible **Consequences:** Moderate Resin Wattle sub-populations currently survive along creeks which are likely to be affected by rising dryland salinity and changes in hydrology. Preliminary assessments of sub-populations have already identified signs of salinity (DEH Recfind file 40/A248477, Part 1).	**High**
Direct threat and knowledge gap: High-grazing pressure	
Risk: Loss of germinated juveniles, which unstabilises life class structure and increases risk of population decline **Likelihood:** Possible **Consequences:** Moderate In 2000, grazing by domestic livestock was identified as a likely threat to some sub-populations near Arno Bay (DEH Recfind file 40/A248477, Part 1). Grazing pressure on Resin Wattle is unknown and unstudied.	**High**
Direct threat and knowledge gap: Pest and disease	
Risk: Localised species extinction and degradation of critical habitat from pest and disease **Likelihood:** Possible **Consequences:** Moderate To date, no assessment has been undertaken of pest or disease affecting Resin Wattle on Eyre Peninsula. Resin Wattle has been listed in the *Phytophthora* Low Risk Management Zone (Velzeboer et al. 2005).	**High**

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**		Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.2 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.3 3a.4 3b.3 3c.1 3c.2 3d.2	3d.3 3e.1 3e.3 3e.4 3f.1 3f.4 3f.8	4b.2 4b.7 4c.2 4e.1 4h.2	5a.5 5a.9 5b.2

9.7 Main references

Davies, R 1995, *Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia*, Botanic Gardens of Adelaide and State Herbarium, South Australia.

Green, P 1993, *Threatened plants of Yorke Peninsula*, Conservation Council of South Australia, Adelaide.

Obst, C 2005, *South Australian Murray Darling Basin threatened flora recovery plan,* report to the Threatened Species and Communities Section, Australian Government Department of the Environment and Heritage, Canberra.

Velzeboer, R, Stubbs, W, West, A & Bond, A 2005, *Threatened plant species at risk from Phytophthora in South Australia*, Department for Environment and Heritage, South Australia.

10 Whibley Wattle *Acacia whibleyana* RS Cowan & Maslin

10.1 Status

When assessing Whibley Wattle vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 10.1). This is important given that this species only occurs on Eyre Peninsula. Whibley Wattle is however recognised as Endangered at the Regional, State and National levels (Table 10.1).

Table 10.1. Whibley Wattle vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Endangered
Extent of occurrence (km²)	38.0		
Area of occupancy (km²)	0.35	Endemic to Eyre Peninsula	
Sub-populations	4		
Estimated # of individuals	450		
IUCN Criteria	**Justification**		
CR B1	Extent of occurrence estimated to be less than 100 km²		
CR B1a	Severely fragmented habitat		
CR B1a,b(iii)	Continuing decline observed in area, extent and quality of habitat		
CR B1a,b(iii)(v)	Continuing decline in number of mature individuals		

10.2 Distribution

Whibley Wattle is endemic to southern Eyre Peninsula, and is found solely within the District Council of Tumby Bay (Figure 10.1) (Jusaitis & Sorensen 1998). The species is known from four isolated sub-populations, surviving in remnant and roadside vegetation near the township of Tumby Bay. All sub-populations are surrounded by agricultural land.

The extent of occurrence of Whibley Wattle is approximately 38 km², occurring within latitude 34°16'39" to longitude 136°0'36" (Lincoln Uplands) in the north-west, and latitude 34°29'26" to longitude 136°6'1" (Tumby Plains) in the south-east (DEH-EGIS 2006). Concentrated around a salt lake and consisting of predominately adult plants, the south-eastern sub-populations are the most isolated in terms of distribution.

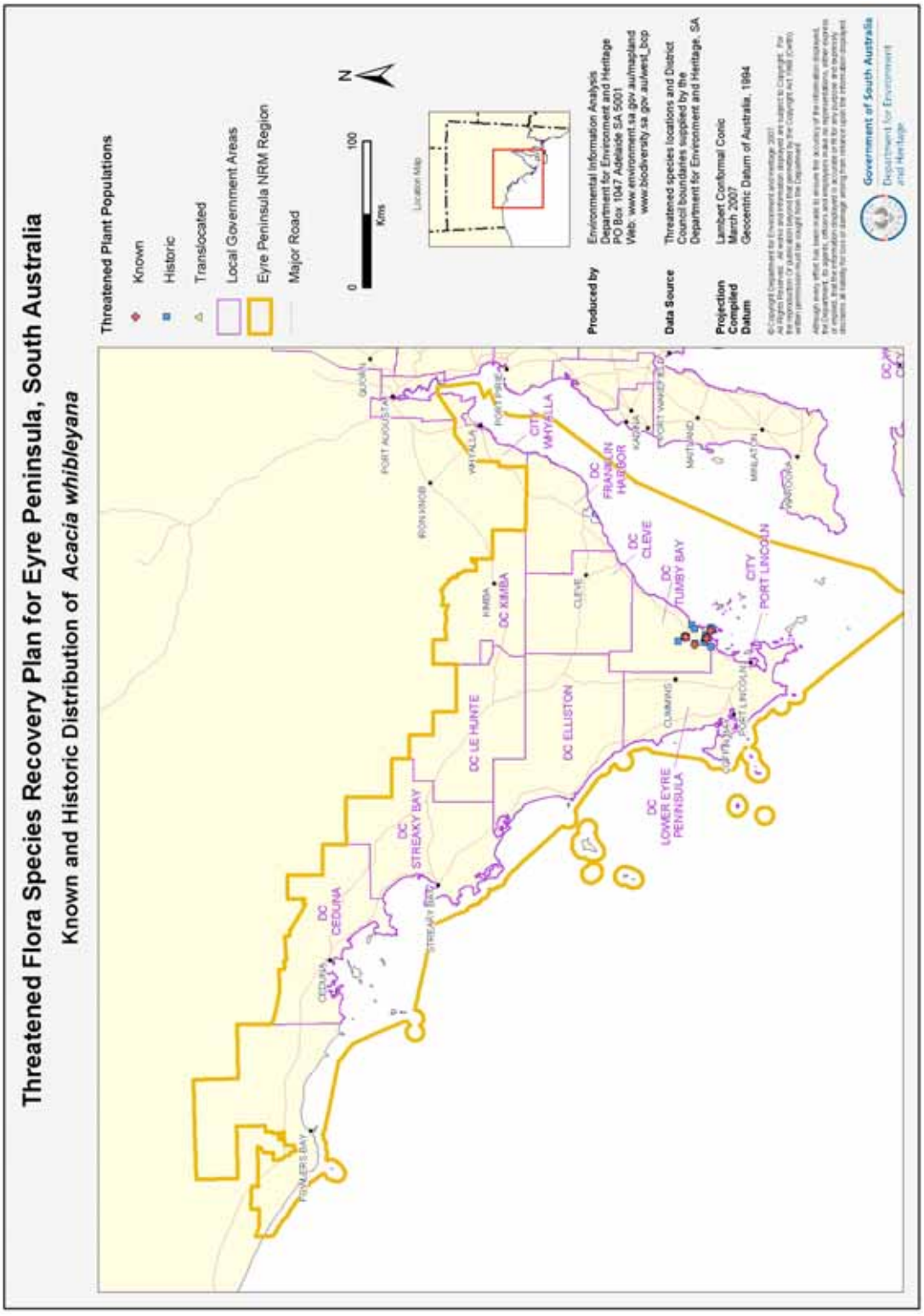
10.3 Habitat critical to survival

All known habitat of Whibley Wattle is considered to be critical to its survival. It is likely that additional critical habitat is yet to be identified. While the genetic relationship within and between the sub-populations still needs to be determined, the sub-populations have been named, for identification purposes only (
Figure 10.2):

- Quarry sub-population (north-western), which includes Mount Liverpool sub-population
- Salt lake sub-population (south-eastern), which includes the Tumby plains roadside isolated plants.

Topography and soil type

The Quarry and Mount Liverpool sub-populations occur within the Lincoln Uplands, growing in the Laube land system, which comprises of loam over red clay and shallow stony soils (Jusaitis & Sorensen 1998). Both the Quarry and Mt Liverpool sub-populations grow at approximately 150 m above sea level.



Note: Whibley Wattle details are held on internal DEH files and are available on request.

Figure 10.1. Distribution of Whibley Wattle on Eyre Peninsula

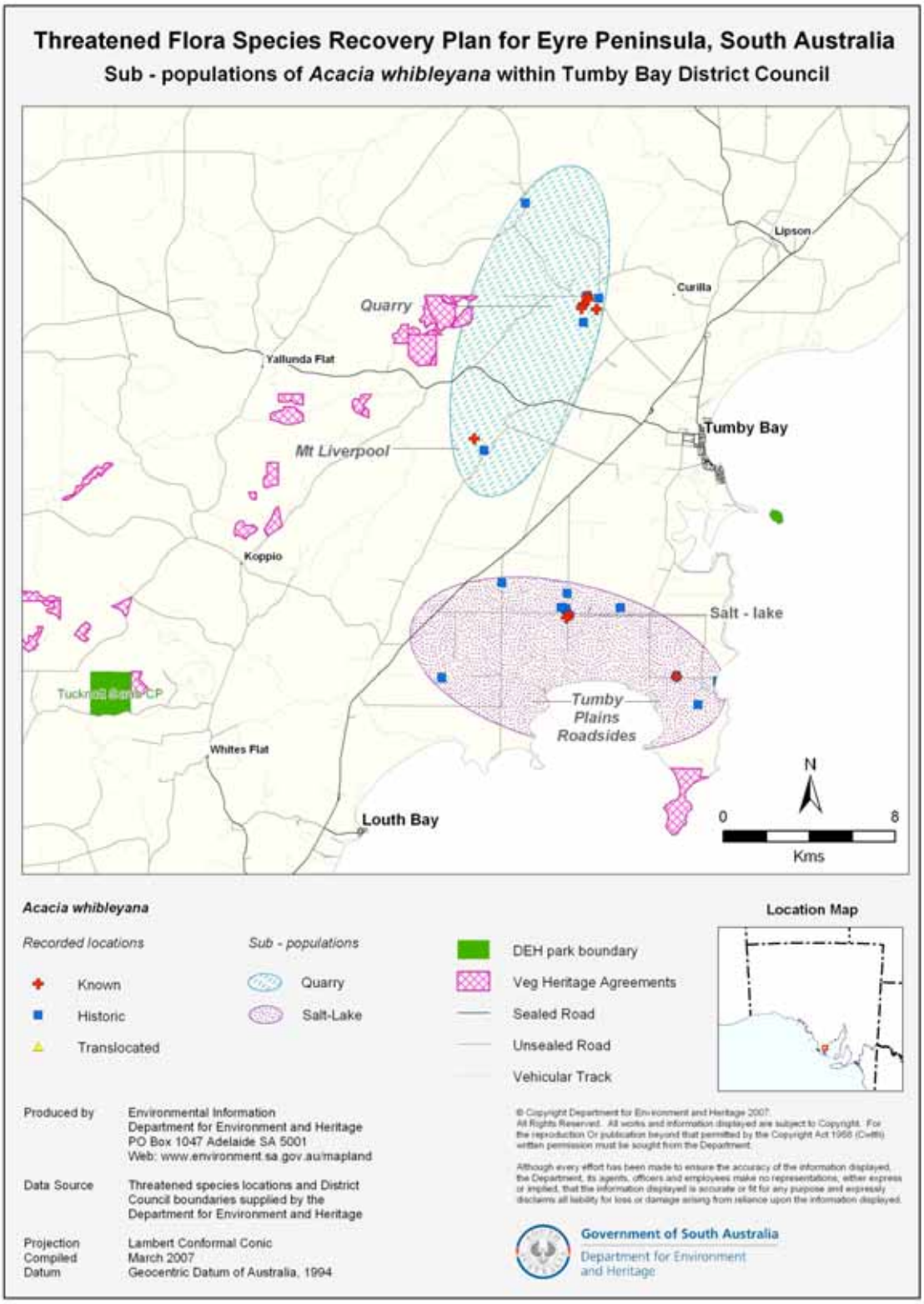


Figure 10.2. Whibley Wattle sub-population names (not based on genetic populations, descriptors only)

The Salt lake sub-populations occur on the Tumby plains, growing in the Yaranyacka land system. This system is made up of calcareous sandy loam and sandy loam over red clay in undulating rises and fans (Laut et al. 1977). Both sub-populations grow on saline soils 10 m above sea level. Whibley Wattle seems to tolerate moderately saline soils. However, Jusaitis and Sorensen (1998) have shown that plants grown in soils with electrical conductivity (EC) greater than 3.5 mS/cm display a significant reduction in growth.

Vegetation associations

Quarry and Mt Liverpool sub-populations: Adult Whibley Wattles remain scattered through remnant native vegetation, forming the largest known sub-population. Mount Liverpool sub-populations grow in association with remnant Merrit (*Eucalyptus flocktoniae*), Capped mallee *(E. pileata*) and Dumosa mallee *(E. dumosa*) (Jusaitis & Sorensen 1998).

Salt lake and roadside sub-populations: The salt lake Whibley Wattle sub-population grows in association with Mallee Honey-myrtle (*Melaleuca acuminata*), Native Apricot (*Pittosporum phylliraeoides*), Ruby Saltbush (*Enchylaena tomentosa*), Slender Velvet-bush (*Lasiopetalum baueri*), Bower Spinach (*Tetragonia implexicoma*), Spiny Wattle (*Acacia spinescens*) and samphire species (Jusaitis & Sorensen 1998).

Whibley Wattles in outlying roadside areas on the Tumby plains are extremely isolated and persist in weed infested roadside verges that are mostly devoid of remnant vegetation.

Climate

The mean annual rainfall for Tumby Bay is 337.8 mm (BOM 2007). Localised variation in rainfall is noticeable, for example, Whibley Wattle Lincoln Uplands sub-populations receive higher localised rainfall than the south-eastern Tumby Plains sub-population, which survive in the rain shadow of the hills.

Known populations within reserves

Whibley Wattle is not found within the South Australian reserve system.

Isolated individual plants are located within roadside vegetation reserves under the control of the District Council of Tumby Bay, and within private property.

Benefits to other species

Whibley Wattle grows within the Hundred of Hutchison, which has no *NP&W Act* reserves and has only 4428 ha of remnant vegetation (NVM 2002). Pest control is essential to maintain and improve the ecological integrity of this area's highly fragmented habitat. Removal of introduced species is expected to have net benefits to other species relying on these habitats.

Buffering of associated vegetation communities to form or improve vegetated corridors is expected to aid movement of species and benefit flora, fauna, fungi and invertebrates.

Whibley Wattle plays an important role in soil conservation. Being a member of the Leguminoseae family, it uses symbiotic soil bacteria (*Rhizobia* spp.) to fix nitrogen (CILR 2007). Nitrate or ammonium produced in this process benefits the whole system, plants and animals, through the flow-on of the nitrogen cycle.

Table 10.2. Important Whibley Wattle sub-populations

Area and sub-population	Estimated # of plants	Extent (ha)	Sub-population descriptions
North-western extent of species range Sub-populations at the quarry site contain younger plants that appear healthier, produce more seed and are growing more vigorously than those in the salt lake sub-population.			
Quarry, Mine Hill Road and adjacent private property sub-population	55	3.3 ha	Whibley Wattle tubestock planting has been undertaken adjacent to the Quarry sub-population on private land (refer to Table 10.3)
Mount Liverpool sub-population	9	16 ha	Subdivided property being developed for rural living, Section 114, Hundred of Hutchinson (DEH Recfind file 40/1500)
South-eastern extent of species range Salt-scalded landscape surrounded by cleared agricultural land. Second priority, until genetic studies are completed. The significance of this site is the ability of the species to survive in a highly saline environment.			
Salt lake sub-population	164 (planted and naturally occuring)	3.2 ha	A further 41 Whibley Wattle tubestock (not included in count adjacent) and other associated flora species were planted in 2006 with the intention of expanding the Salt lake sub-population and as part of a long-term aim to increase sub-population connectivity.
Isolated roadside sub-populations	34 (planted and naturally occuring)	Minimal roadside verge	Road reserves, surrounded by cleared agricultural land (i.e. road near salt lake, Thuruna Road, Moonlight Bay Road, White River Road, Schramms Road, Massena Bay Road).

10.4 Biology and ecology

Whibley Wattle is a dense, perennial shrub that can grow to 2.5 m tall and 4 m wide (Whibley & Symon 1992).

Flowering occurs between August and October. The species' pollination process, flowering and seed production has been studied by Jusaitis and Sorensen (1998). In 1996-97, plants in the Quarry sub-population were shown to yield more pods per infructescence, indicating a higher rate of successful pollination in the Quarry area; however, no specific pollinators have been observed to date (Jusaitis & Sorensen 1998).

Fruits (four to six seeds per pod) mature from December through to January. The onset of flowering and final quantity of seed produced varies between the north-eastern Quarry sub-population and south-western Salt lake sub-population (Jusaitis & Sorensen 1998). Six percent of pods at the Quarry sub-population contained no seed (1996-97 study); however, the Salt lake sub-population showed no such deficiency (Jusaitis & Sorenson 1998).

Seed dispersal is assisted by ants, which are attracted to the off-white coloured arils on the seeds (Jusaitis & Sorensen 1998).

Fire dependence triggers

Like other wattle species, the seeds of Whibley Wattle have a hard seed-coat dormancy mechanism and seed requires scarification before propagation (Jusaitis & Sorensen 1998). To date, no research has been conducted into *in situ* germination triggers.

Related species

Whibley Wattle is closely related to two species (Whibley & Symon 1992):

- Umbrella Bush (*Acacia lineolata* complex), which occurs mainly in Western Australia
- Hook-leaf Wattle (*Acacia ancistrophylla* var. *lissophylla*), which occurs on Eyre Peninsula, the Murray region, and southern Yorke Peninsula.

10.5 Previous management actions

Table 10.3. Previous management actions to conserve Whibley Wattle

	Previous management actions
1994	Jusaitis and Sorensen (1998) began studying the conservation biology of Whibley Wattle. Only 41 plants were known from the Salt lake sub-population in 1995.
1995	Rabbit-proof fencing was erected at the salt lake site by the Landcare Environment Action Program (LEAP) through Barry Stirling (local land holder) and Rachel May (Landcare Officer). They also organised for the closure of a vehicle track that had until then passed through the sub-population.
1995	Approximately 130 Whibley Wattle plants were discovered growing in a disused roadside quarry between Sections 293 and 294, Hundred of Hutchison. Bollards were erected by the District Council of Tumby Bay to prevent vehicle access to the site.
1995	Whibley Wattle seed was collected by DEH staff from the Salt lake site. This seed was germinated and seedlings grown at the Black Hill Flora Centre nursery to use for *in situ* translocation trials in 1996 (Jusaitis & Sorensen 1998).
1996	Searches for new Whibley Wattle sub-populations were conducted along Mine Hill Road, Marshalls Road, Wadella Falls and Draypole Road. No further sub-populations found.
1996-98	An *in situ* experiment, examining the impact of herbivores on seedling growth and establishment, was conducted at the Salt lake sub-population (Jusaitis & Sorensen 1998).
1996-97	Jusaitis and Sorensen (1998) conducted a flowering and seed production study at the Salt lake and Quarry sub-populations. The Quarry sub-population produced a higher seeds per pod average than the Salt lake sub-population.
1996-97	A study of the effects of weed competition on Whibley Wattle germination was undertaken at the Salt lake sub-population (Jusaitis & Sorensen 1998).
1997	Jusaitis and Sorensen (1998) established three permanent photo points.
1997	Bridal Creeper and African Boxthorn weed control was undertaken at the Salt lake sub-population habitat. An *in situ* trial examined the tolerance of the species to salt. Soil samples were collected from the Salt lake site and Quarry site to examine the soil seed bank (Jusaitis & Sorensen 1998).
2000	A community awareness-raising article on Whibley Wattle community awareness was printed in local newsletter *The Long Run*, 7th September (author A Freebairn).
2003	Whibley Wattle seed was collected from Salt lake and Quarry sub-populations by the Seed Conservation Centre, Adelaide Botanic Gardens. Seeds will be used for germination tests and long-term, low temperature (-20 °C and 4 °C) storage as part of the Millennium Seed Bank Project.

	Previous management actions
2003	Whibley Wattle tubestock (grown by Greening Australia) were planted into four quadrats on Section 293, Hundred of Hutchison, by Tumby Bay Area School (TBAS) students and staff, and the 2003 Green Corps Team. Two quadrats were established on hill slopes (east-facing), and the remaining two quadrats on the lower slopes/start of a tributary (shaded valley with midday sun only). Kangaroos caused considerable grazing damage to the tubestock planted in the valley.
2004	200 Whibley Wattle tubestock planted by Tumby Bay Area School (TBAS) and Geraldine Turner (Landcare Officer, EPNRM) in Hundred of Hutchison, Plan 56991 A1 (directly north of the quarry site). Plants were propagated by TBAS staff and students, and all plants were individually tagged and guarded with kangaroo/rabbit-proof tree guards. TBAS students will continue to monitor growth rates. A count in 2005 recorded 114 plants surviving (G Turner [EPNRM] 2005, pers. comm.). Tree guards were removed in 2007.
2004	TBAS students planted 50 tubestock in a gully on Section 293, Hundred of Hutchison, organised by G Turner.
2004	Green Corps team members, G Turner and A Freeman (Bush Management Advisor, EPNRMB) planting Whibley Wattle tubestock in two roadside locations (Marshall's Road and Baillie's Road) within the District Council of Tumby Bay. Site checks in 2005 recorded 67 plants alive on Marshall's Road (without tree guards, 62% death rate in first year) and 46 plants on Baillie's Road (more successful with tree guards, 64% of tubestock planted still suviving at end of first year).
2005	47 Whibley Wattle tubestock planted by TBAS students and staff, G Turner and K Pobke along creekline, Sections 176 and 177, Hundred of Hutchison. Plants were propagated by TBAS staff and students and all plants were individual tagged.
2006	41 Whibley Wattle tubestock and approximately 200 tubestock of associated species (re-creation of associated vegetation community) were planted by TBAS students and staff, G Turner and K Pobke along creekline, Section 293, Hundred of Hutchison. 2006 was a drought year, although tubestock were planted with water crystals, shade cloth and supplementary watering.
2006-07	TBAS students, G Turner and K Pobke conducted a small soil trial, which compared the growth of Whibley Wattle tubestock in standard potting soil (for Australian natives) and soil from Hundred of Hutchison, Plan 56991 A1 (translocation site). On average, tubestock grown in soil from the site grew 20 cm taller than those grown in potting soil. Appropriate soil hygiene was practised throughout this trial.

10.6 Threats to Whibley Wattle and associated recovery goals

The long-term goal is to down-list Whibley Wattle conservation status from Endangered to Vulnerable and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Whibley Wattle conservation status at Endangered.

Whibley Wattle has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 10.4 details the key threats and summarises performance criteria relevant to Whibley Wattle recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 10.4. Key threats to Whibley Wattle and summary of associated performance criteria

Direct threats: Habitat fragmentation, Restricted distribution/isolated populations	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Almost certain **Consequence:** Major Sub-populations grow in highly fragmented and geographically isolated areas (approximately 14 km between sub-populations), and may have low genetic variability and genetic flow because of their size, isolation and associated environmental stress. Whibley Wattle habitat is generally in poor ecological health. This is being exacerbated by additional environmental and anthropogenic stresses such as rising dryland salinity, grazing pressure, sparsely located individuals and land subdivisions. Extent of occurrence is estimated at 38 km. The species is at threat of becoming extinct as a result of a localised catastrophic event. It is more foreseeable that a series of catastrophic events could cause the extinction of this species. For example, frequent and high intensity bushfires, which are expected to increase due to climate change (Lucus et al. 2007), could result in exhaustion of the already limited soil seed bank, death of young germinants and death of already stressed semi-senescent adult plants.	Extreme
Direct threat and knowledge gap: Salinity/changes in hydrology	
Risk: Localised species extinction and degradation of critical habitat from increased salinity and changes in hydrology **Likelihood:** Almost certain **Consequences:** Major Dryland salinity is currently estimated to affect one-third of the Whibley Wattle population (Jusaitis & Sorensen 1998). If salinity levels rise, salinity is expected to further stress plants and cause Whibley Wattle deaths in the Salt lake and isolated roadside sub-populations (Jusaitis & Sorensen 1998). Salinity in this area is caused by removal of perennial native vegetation. Loss of these deep rooted plants means more water infiltrates beyond the root zone and moves salts up the soil layers, commonly called 'secondary salinity' (EPNRMB 2007).	Extreme
Direct threat: High grazing pressure	
Risk: Loss of germinated juveniles which unstabilises life class structure and increases risk of population decline **Likelihood:** Almost certain **Consequences:** Major Livestock have been observed grazing Whibley Wattle and in turn preventing natural recruitment on private property (A Freebairn [DEH] 2004, pers. comm.). Grazing by native herbivores, particularly kangaroos, may have reduced the success of the 2004 translocation trial (G Turner [EPNRM] 2005, pers. comm.). Subsequently in the second translocation, adjacent to the Quarry sub-population, all plants were caged in kangaroo and rabbit proof tree guards. Seasonal increases in rabbit populations are also expected to affect grazing pressure on newly germinated wattles.	Extreme
Direct threat and knowledge gap: Inappropriate fire and disturbance regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Almost certain **Consequence:** Moderate This threat relates to 'Restricted distribution/isolated populations'. Too frequent fire would be detrimental to Whibley Wattle. The main risk may really be that Whibley Wattle sites are long unburnt and this may be contributing to the lack of seedling germination and recruitment.	Extreme

Direct threat: **Weed invasion**	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Almost certain **Consequences:** Moderate Whibley Wattle transplanted into weedy and non-weedy sites in 1996 resulted in the death of all seedlings planted within the weedy site and 48% survival (after 2 years) of plants within the non-weedy site (Jusaitis 2005). Bridal Creeper (**Asparagus asparagoides*), African Boxthorn (**Lycium ferocissimum*) and exotic grasses (agricultural pasture grasses predominantly) have been identified as high priority weeds to control within Whibley Wattle habitat (Jusaitis & Sorensen 1998). Roadside Whibley Wattle habitat is largely denuded of native vegetation and contains Wild Oats (**Avena* sp.), Rye Grass (*Lolium* sp.) Barley Grass (**Critesion murinum*) and Threat Iris (**Gynandriris setifolia*) (Jusaitis 2005).	**Extreme**
Direct threat and knowledge gap: **Lack of recruitment/small population size**	
Risk: Species population becomes smaller than the minimum viable population limit **Likelihood:** Likely **Consequence:** Moderate Salt lake sub-population plants are close to senescence (Jusaitis & Sorensen 1998) and there are no more than a couple of natural recruitments at any of the sub-populations (opportunistic searches 2004-06). Such a limited area of occupancy may result in deleterious genetic evolution, e.g. decreased production or viability of seed, and decreased plant vigour.	**High**
Direct threat: **Vegetation clearance/Roadside management**	
Risk: Localised species extinction, and loss of genetic material caused by roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Likely **Consequences:** Moderate Many plants are located on road reserves and are at risk of clearance by road maintenance activities.	**High**
Direct threat: **Pest and disease**	
Risk: Loss of a couple of plants through to localised extinction due to plant stress (possible degradation of critical habitat from *Phytophora* if spread to that area) **Likelihood:** Likely **Consequences:** Moderate Insect galls, white scale and caterpillars found on some plants, particularly on plants at the salt lake site, could cause additional plant stress, but are not likely to cause a significant long-term threat (Jusaitis & Sorensen 1998). Whibley Wattle critical habitat is currently within a Low Risk Management Zone for *Phytophthora* (Velzeboer et al. 2005).	**High**
Direct threat: **Urban development/Sub-division**	
Risk: Loss of species sub-population as a result of illegal clearance, e.g. progression of development without vegetation assessment **Likelihood:** Possible **Consequences:** Moderate Land sub-division within Whibley Wattle critical habitat in 2004 at Mount Liverpool highlights the threat building development poses on Whibley Wattle critical habitat if not planned for and managed appropriately.	**High**
Direct threat: **Mineral exploration/extraction**	
Risk: Localised species extinction and degradation of critical habitat from mineral extraction **Likelihood:** Unlikely **Consequences:** Moderate The Quarry sub-population and adjacent translocated plants are located within a council roadside verge (old mine quarry site). Whibley Wattle plants would be at considerable risk if mineral extraction were to recommence.	Moderate

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.1 1b.1 1c.1 1c.2 1c.4 1c.5 1d.1 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.2 3a.4 3b.1 3b.2 3c.2 3d.1 3d.2 3d.3 3e.1 3e.3 3e.4 3f.1 3f.2 3f.3 3f.4 3f.6 3f.7 3f.8	4b.4 4b.6 4b.8 4c.2 4d.3 4e.1 4f.1 4f.2 4g.1 4g.2 4h.1	5a.4 5a.7 5a.8 5a.9 5a.10 5b.2

10.7 Main references

Jusaitis, M 2005, 'Translocation trials confirm species factors affecting the establishment of three endangered plant species', *Journal of Ecological Management and Restoration*, vol. 6, no. 1, pp. 61-67.

Jusaitis, M & Polomka, L in press, *Weeds and founder propagules influence translocation success in endangered Whibley Wattle,* Acacia whibleyana *(Leguminosae)*, unpublished paper, Department for Environment and Heritage, South Australia.

Jusaitis, M & Sorensen, B 1997, *Research Plan Annual Report January 1997,* Acacia whibleyana, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 1997a, *Progress Report August 1997* Acacia whibleyana, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 1998, *Conservation Biology of* Acacia whibleyana, South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 2007, 'Successful augmentation of an *Acacia whibleyana* (Whibley Wattle) population by translocation', *Australian Plant Conservation, Bulletin of the Australian Network for Plant Conservation*, vol. 16, no. 1.

Whibley, DJE & Symon, DE 1992, *Acacias of South Australia*, South Australian Government Printer, Adelaide.

11 Winter Spider-orchid *Caladenia brumalis* syn. *Arachnorchis brumalis* DL Jones

11.1 Status

When assessing Eyre Peninsula Winter Spider-orchid vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 11.1). Winter Spider-orchid is however recognised as Vulnerable at the Regional, State and National levels (Table 11.1).

Table 11.1. Winter Spider-orchid vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	4012	Endemic to South Australia	
Area of occupancy (km²)	0.0125		
Sub-populations	4		
Estimated # of individuals	168		

IUCN Criteria	Justification
EN C	Population size estimated to number fewer than 2500 mature individuals on Eyre Peninsula
EN C2	A continuing decline, observed, projected or inferred, in numbers of mature individuals on Eyre Peninsula
EN C2a(i)	No sub-population on Eyre Peninsula estimated to contain more than 250 mature individuals
EN C2a(i),b*	Extreme fluctuations in number of mature individuals on Eyre Peninsula

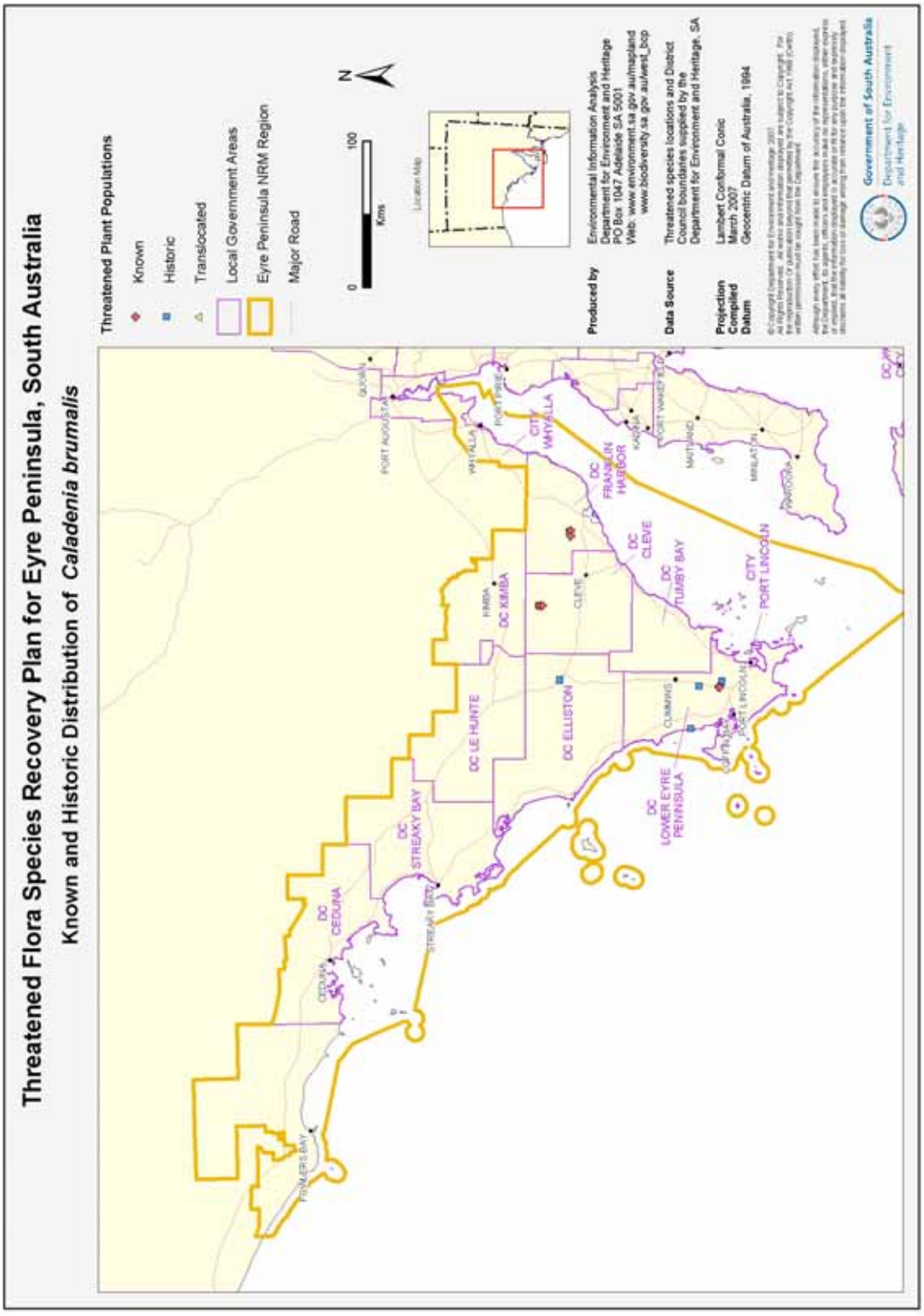
11.2 Distribution

Winter Spider-orchid (*Caladenia brumalis*, also known as *Arachnorchis brumalis*) is endemic to South Australia. Populations grow near Adelaide, on Eyre Peninsula and on Yorke Peninsula (Bates 2006). The actual distribution of the species is relatively uncertain due to mistaken identity (Bates 2006). Bates (2006) emphasises that Winter Spider-orchids grow in coastal areas, and not in ranges. Therefore, sub-population records for places such as Carapee Hill and Coolanie Ranges require closer attention and genetic testing (R Bates 2007, pers. comm.). With this in mind, the extent of occurrence for Winter Spider-orchid on Eyre Peninsula may range between 4012 km² (i.e. within latitude 33°24'50.87"S to longitude 136°15'56.28" (Carapee Hill) in the north, and latitude 34°32'51.10"S to longitude 135°43'6.93" (Wanilla) in the south (DEH-EGIS 2006)), and a more conservative estimate of 230 km², which encompasses only the more coastal and inland Wanilla southern sub-populations (DEH-EGIS 2007) (Figure 2.1).

Winter Spider-orchid sub-populations occur within reserves, private property and roadside vegetation within the district councils of Elliston, Franklin Harbour and Lower Eyre Peninsula.

11.3 Habitat critical to survival

All known habitat of Winter Spider-orchid is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.



Note: Winter Spider-orchid details are held on internal DEH files and are available on request.

Figure 11.1. Distribution of Winter Spider-orchid on Eyre Peninsula

Topography and soil type

Winter Spider-orchids on Southern Eyre Peninsula grow in hard mottled-yellow duplex soils within low open-forest. Northern sub-populations at Carapee Hill are recorded on sandy pedal mottled-yellow duplex soils within open-scrub (Laut et al. 1977).

Vegetation associations

Winter Spider-orchid has been recorded growing in association with vegetation communities listed in Table 11.2 (DEH-EGIS 2006). However, in many cases individual orchids frequently grow in more open niches, within and on the edges of these vegetation associations.

Table 11.2. Vegetation associations of selected Winter Spider-orchid sub-populations

Sub-populations	Associated vegetation
Northern (Carapee Hill)	Broombush (*Melaleuca uncinata*) shrubland >1m over low shrubs Cup Wattle (*Acacia cupularis*) (mixed) shrubland >1m over shrubs
Roadside	Drooping Sheoak (*Allocasuarina verticillata*) woodland over tall shrubs and low shrubs
Heritage Agreement at Coles Point	Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*) mallee woodland over shrubs and forbs

Associated vegetation

The largest Winter Spider-orchid population grows in association with Sugar Gum (*Eucalyptus cladocalyx)* woodland with an understorey of Yacca (*Xanthorrhoea semiplana* ssp. *semiplana*), Guinea-flower (*Hibbertia riparia*), Peach Heath (*Lissanthe strigosa*), Port Lincoln Ground-myrtle (*Homoranthus homoranthoides*) and Milkmaids (*Burchardia umbellata*). This habitat was burnt during the Wangary Bushfire on January 11th 2005.

Climate

The extent of occurrence of Winter Spider-orchid spans 4012 km^2, and covers average yearly rainfall zones of 300-500 mm (DEH-EGIS 2006). Northern Winter Spider-orchid sub-populations in the vicinity of Darke Peak could be expected to receive mean annual rainfall of 380.8 mm. Winter Spider-orchid sub-populations in the southern extent of the species range near Wanilla could be expected to receive mean annual rainfall of 509.4 mm (BOM 2007).

Known populations within reserves

Some Winter Spider-orchids are found within the Eyre Peninsula reserve system (Table 11.3). Other sub-populations grow within Heritage Agreements in the Coolanie Ranges and near Coles Point.

Table 11.3. Winter Spider-orchid sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Carapee Hill Conservation Park	1? (requires genetic testing)	D Symon 1974 AD Freebairn 2001
Wanilla Land Settlement Conservation Reserve	1	AD Freebairn, P Hewstone and J Hutchinson 2001
Wanilla Conservation Park	1	JZ Weber 1989

Benefits to other species

The conservation of Winter Spider-orchid habitat is expected to produce broader biodiversity benefits to associated vegetation communities and the animals that depend on these areas. Recovery actions, particularly those focusing on weed and pest control, will improve habitat for understorey plant species. Research and monitoring of native pollinators will expand current knowledge on local invertebrate diversity, and is expected to benefit a multitude of flora and fauna species. Increasing our understanding of pollinator service and the influence this has on the health of fragmented ecosystems is expected to have flow-on benefits to the primary industry sector.

Other threatened flora species growing within Winter Spider-orchid habitat include Ironstone Mulla Mulla (*Ptilotus beckerianus*) (nationally Vulnerable), Silver Daisy-bush (*Olearia pannosa* ssp. *pannosa*) (nationally Vulnerable), Metallic Sun-orchid (*Thelymitra epipactoides*) (nationally Endangered) and Twisted Sun-orchid (*Thelymitra flexousa*) (state Rare). Conservation of these threatened species is expected to benefit their associated Sugar Gum woodland habitat. Sugar Gum woodland is recognised as regionally threatened (DEH 2002) and is also habitat for woodland bird species, which are in decline.

11.4 Biology and ecology

The Winter Spider-orchid is a slender, robust orchid that grows 20-50 cm tall (Bates & Weber 1990). The orchid is deciduous, dying back to below-ground tubers in summer and producing a new leaf in autumn or winter. Leaves are oblong-lanceolate in shape and grow 4-15 cm long. Leaves are covered in short, dense hairs and have a red colouration towards the base, extending into light green over the majority of the leaf surface.

Flowering occurs in June though until September under favourable weather conditions. Orchids usually have one flower, rarely two, which are up to 70 mm across (Bates 2006). Flowers are cream coloured, often with dark markings, but can appear in yellow, pink and other colour variations (Bates & Weber 1990).

Pollination remains unconfirmed for Eyre Peninsula populations. Bee and fly species are known pollinators of spider-orchids, particularly those with white coloured flowers. Male thynnid wasps are known pollinators of spider-orchids (Jones 2006), pollinating via pseudocopulation[2]. This type of pollination is common throughout the *Caladenia* (syn. *Arachnorchis*) genus (Stoutamire 1983). Winter Spider-orchids form hybrids with Pink Caladenia (*Caladenia latifolia)* and *Caladenia conferta* (Bates 2006).

Following pollination, seeds develop in the ovary, which eventually encloses to form a seed pod. The basic seed dispersal process observed involves the seed pod maturing, drying out and dehiscing (bursting open). At this point, slits appear in the seed capsule and seeds either fall to the ground or are dispersed by wind (D Bickerton [DEH] 2007, pers. comm.). Seed set and viability requires further study, as does germination.

Germination triggers are unstudied; however, orchid germination generally depends upon the presence of mycorrhiza fungi (Sweedan & Merritt 2006) and appropriate fire regimes for long-term survival and flowering success (ANBG 2007).

Winter Spider-orchid is affected by grazing (known only from a study of the southern population). During 2006, 29% of Winter Spider-orchids were recorded as affected by grazing in an orchid caging study as part of the Lower Eyre Peninsula Bushfire Re-establishment Program (Ecological Associates 2007). Invertebrate species (potentially slugs, snails, etc.) were the most frequent herbivores at this time (Ecological Associates 2007).

[2] Pseudocopulation is a process by which an insect transfers pollen while attempting to mate with the flower.

Fire dependence triggers

Winter Spider-orchid plant numbers tripled in the southern sub-population following the 2005 Wangary Bushfire, but long-term monitoring is needed to identify trends (Ecological Associates 2007; DEH Recfind file 40/1185 contains post fire data).

Similar species

Winter Spider-orchid is similar in appearance to a number of white-coloured spider-orchids including the White Beauty Spider-orchid (*Caladenia argocalla*), Pink-lipped Spider-orchid (*C. behrii*), Sand Spider-orchid (*C.* aff. *arenaria*), Pretty Spider-orchid (*C. colorata*), Scented Spider-orchid (*C. fragrantissima*) and Ghost Spider-orchid (*C.* sp. Brentwood syn. *Arachnorchis intuta*) (Bates 2006).

11.5 Previous management actions

Table 11.4. Previous management actions to conserve Winter Spider-orchid

	Previous management actions
2001	Winter Spider-orchid article in local *Port Lincoln Times* newspaper as part of community awareness-raising series 'Threatened Flora Census' (author A Freebairn).
2005	Post-fire response studies conducted by Dr Jane Prider (Ecological Associates, Adelaide, as a contractor to DEH) focusing on the southern Eyre Peninsula Winter Spider-orchid population (Prider 2006). Funded through the Commonwealth and State Government Lower Eyre Peninsula Bushfire Re-establishment Program (Peeters and Way 2005).
2006	In March the monitoring technique and process was reviewed for the southern Eyre Peninsula Winter Spider-orchid population. This was conducted by K Pobke in consultation with orchid recovery volunteers. New field location markers and monitoring quadrat system trialled in 2006.
2006	In June the first anti-grazing orchid cages and pollination monitoring trial on the southern Eyre Peninsula Winter Spider-orchid population was begun by Dr Jane Prider (Prider 2006) (DEH Recfind file 40/1185, Ecological Associates 2007). Grazing was recorded on 29% of all orchids within open control sites and the most frequent herbivores were potentially invertebrates (Ecological Associates 2007).
2006	*Phytophthora* control station and signage erected within Winter Spider-orchid habitat for public education to prevent the spread of *Phytophthora* (DEH Recfind file A142127). Winter Spider-orchid habitat is within the *Phytophthora* High Risk Management Zone (Velzeboer et al. 2005).
2005-07	Extensive post-fire weed control within southern Eyre Peninsula Winter Spider-orchid habitat was conducted by Ben White (SEEDS ExtraordinEYRE, Port Lincoln, as a contractor to DEH). Main weeds controlled included Perennial Veldt Grass, South African Daisy and Freesias.
Ongoing	Annual monitoring of southern Eyre Peninsula Winter Spider-orchid population by orchid recovery volunteers Jane Hutchison, Pam Hewstone and Sally Deslandes (DEH Recfind file 248478).

11.6 Threats to Winter Spider-orchid and associated recovery goals

The long-term goals are to down-list Winter Spider-orchid conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Winter Spider-orchid conservation status at Vulnerable.

Winter Spider-orchid has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and Focus Work Areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 11.5 details the key threats and summarises performance criteria relevant to Winter Spider-orchid recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 11.5. Key threats to Winter Spider-orchid and summary of associated performance criteria

Direct threat: **Habitat fragmentation**	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Almost certain **Consequences:** Major Winter Spider-orchid occurs in habitat that is highly fragmented and subjected to significant weed invasion (see Pest and Disease section in this table). The species has extremely limited opportunity for dispersal/colonisation due to the fragmented nature of the surrounding landscape. A combination of habitat fragmentation and introduced predators (feral cats and foxes) have caused the loss of small native mammals in the orchid's ecosystem. It is thought that these small mammals once facilitated seed dispersal and colonisation, for example echidna's (Feuerherdt & Petit 2004) may be one reason behind declining orchid numbers.	Extreme
Direct threat: **Pest and disease (*Phytophthora*)**	
Risk: Localised species extinction and degradation of critical habitat caused by pest and disease **Likelihood:** Likely **Consequence:** Major Southern Eyre Peninsula Winter Spider-orchid populations occur within a High Risk Management Zone for *Phytophthora* (Velzeboer et al. 2005). Although there are preventive actions to prevent spread into critical habitat, this threat is considered to cause major consequence should those preventive measures fail.	Extreme
Direct threat: **High grazing pressure**	
Risk: Loss of orchids and high potential of long-term plant stress resulting in population decline **Likelihood:** Almost certain **Consequence:** Moderate Continued grazing to plants each season will limit the production of viable seed capsules. 37% of all flowering orchids within the Wanilla sub-population were grazed (in 2005 pre-bushfire). In 2005 after the Black Tuesday Bushfire, up to around 75% of the Wanilla sub-population was grazed, presumably by kangaroos. Anti-grazing cage trials in 2006 showed that herbivory (potentially by snails, slugs and other invertebrates) is a threat to the species and molluscicides or similar should be trialled (Ecological Associates 2007). Browse pressure and soil disturbance from sheep grazing and rabbits may represent the largest threat to northern sub-populations (A Freebairn [DEH] 2001, pers. comm.).	Extreme
Direct threat and knowledge gap: **Inappropriate fire and disturbance regimes, Small population/lack of recruitment**	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire/disturbance from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires/inappropriate disturbance are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Southern Eyre Peninsula Winter Spider-orchids near Wanilla were pollinated in 2006-07 (two years after Wangary Bushfire 2005) (Ecological Associates 2007). Before this event, southern Eyre Peninsula Winter Spider-orchids were not producing viable seed capsules (A Freebairn [DEH] 2004, pers. comm.). Since the 2005 bushfire, there have been anecdotal reports from property owners in the Koppio Hills and Wanilla area reporting new Winter Spider-orchid sub-populations (no samples have been taken for the State Herbarium).	High

Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate Weeds that infest or threaten southern Eyre Peninsula Winter Spider-orchid habitat include Bridal Creeper (*Asparagus asparagoides*), Perennial Veldt Grass (*Ehartia* sp.), Freesia, Wild Gladiolus *(Gladiolus* undulates), Soursob (*Oxalis pes-caprae*) and Tree Lucerne (*Chamaecytisus proliferus*). These weed species readily out-compete orchids. Winter Spider-orchid habitat in the north is less fragmented and Bridal Creeper (*Asparagus asparagoides*) and Cape Weed (*Arctothea Calendula*) impact on these sub-populations (A Freebairn [DEH] 2004, pers. comm.).	**High**
Direct threat: Lack of knowledge/baseline data	
Risk: Loss sub-population and genetic material due to lack of information **Likelihood:** Unlikely **Consequences:** Moderate The northern sub-populations appear to be viable, with plants producing seed (A Freebairn [DEH] 2004, pers. comm.). However, this requires further investigation as only a minimum of population data has been collected from these populations to date and long-term viability is unknown.	Moderate
Direct threat: Illegal collection or harvest	
Risk: Loss of individual plants, risk of disease spread into critical habitat **Likelihood:** Possible **Consequences:** Minor Illegal collection of this species has the ability to further endanger and undermine recovery actions, particularly on Lower Eyre Peninsula where park visitation is higher and parks are smaller. Winter Spider-orchid is listed under the protection of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) (UNEP-WCMC 2007).	Moderate

	Objective 1 Baseline information	Objective 2 Community involvement	Objective 3 Manage threats and improve habitat	Objective 4 Research critical to management	Objective 5 Monitoring and evaluation
Performance criteria	1a.1 1d.2 1b.1 1d.3 1c.1 1c.2 1c.4 1c.5 1d.1	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3d.2 3a.2 3d.3 3a.4 3f.1 3b.1 3f.2 3b.2 3f.4 3c.1 3f.6 3c.2 3f.7 3d.1 3f.8	4b.4 4g.2 4b.5 4h.1 4b.8 4h.2 4c.2 4d.2 4e.2 4f.1 4g.1	5a.4 5a.8 5a.9 5a.10 5b.2

11.7 Main references

Bates, R 2006, CD-ROM, *South Australian native orchids*, unpublished, Adelaide.

Jones, D 2006, *A complete guide to native orchids of Australia including the island territories*, Reed New Holland, Australia.

Quarmby, J 2006, *Recovery plan for twelve threatened orchids in the Lofty Block region of South Australia 2007-2012*, Department for Environment and Heritage, South Australia.

Stoutamire, WP 1983, 'Wasp-pollinated species of *Caladenia* (Orchidaceae) in South-Western Australia', *Australian Journal of Botany*, vol. 31, no. 4, pp. 383-394.

12 Club Spear-grass *Austrostipa nullanulla* J Everett and SWL Jacobs

12.1 Status

When assessing Eyre Peninsula Club Spear-grass vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 12.1). Club Spear-grass is recognised as Vulnerable at the Regional, State and National levels (Table 12.1).

Table 12.1. Club Spear-grass vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	8813		
Area of occupancy (km²)	0.1		
Sub-populations	5		
Estimated # of individuals	10 000		
IUCN Criteria	**Justification**		
VU A3	A suspected population size reduction on Eyre Peninsula of greater or equal to 50% over the last 10 years or three generations		
VU A3c	A decline in area of occupancy, extent of occurrence and quality of habitat on Eyre Peninsula		
VU A3c,e*	The effects of introduced taxa and hybridisation on Eyre Peninsula		

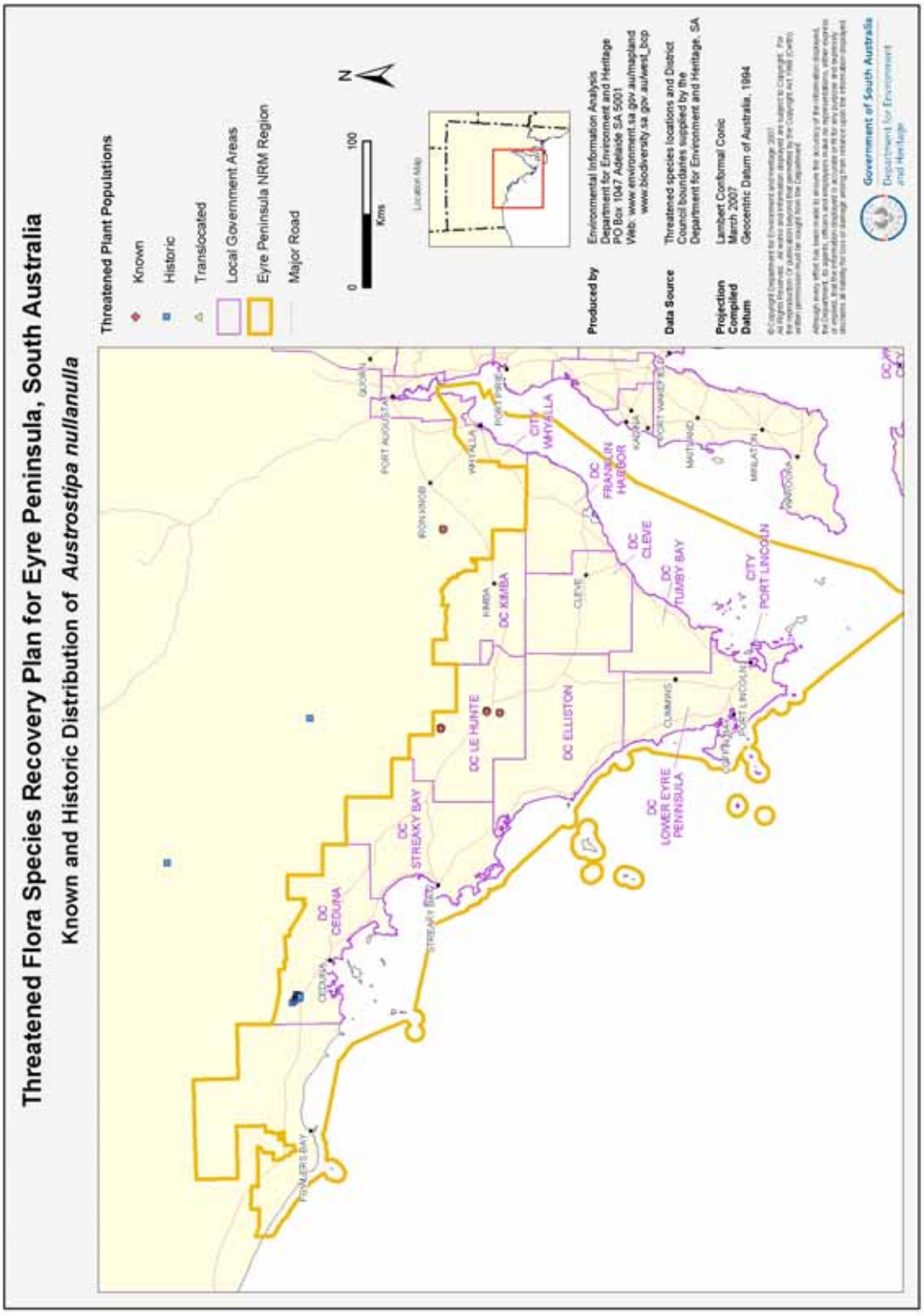
12.2 Distribution

Club Spear-grass (*Austrostipa nullanulla,* syn. *Stipa nullanulla*) grows in three states, i.e. New South Wales (Everett 1986), Victoria (Briggs & Leigh 1996) and South Australia. In South Australia, Club Spear-grass is found in the Murray, Yorke Peninsula, Gairdner-Torrens, North-Western and Eyre Peninsula regions (Barker et al. 2005). Generally, Club Spear-grass is thought to occupy gypseous soils on the outskirts of salt lakes across the north of South Australia (L Bebbington 2005, pers. comm.). Specifically, on Eyre Peninsula the extent of occurrence of Club Spear-grass is approximately 8800 km². The species occurs within latitude 32°0'36"S to longitude 135°25'49"E southwest of Coolia (near Lake Gairdner, the northern most recorded distribution), and latitude 33°10'48"S to longitude 135°28'24"E at the southern-most record just south of Wudinna (DEH-EGIS 2006) (Figure 12.1).

Club Spear-grass grows within the district councils of Le Hunte and Kimba, and the unincorporated areas, including outer hundreds of Port Augusta, Gairdner and Yardea.

12.3 Habitat critical to survival

All known habitat of Club Spear-grass is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.



Note: Club Spear-grass details are held on internal DEH files and are available on request.

Figure 12.1. Distribution of Club Spear-grass on Eyre Peninsula

Topography and soil type

Club Spear-grass is restricted to gypsum soils, often called 'flour gypsum', surrounding saline lakes in the northern part of Eyre Peninsula. It is known to grow within topography of 60-200 m above sea level (DEH-EGIS 2006). Near Lake Wannamanna, the species has been recorded growing in the low dunes and swales surrounding salt scalds (surveyed by C Yates and W Crisp in 2002). New South Wales Club Spear-grass sub-populations are described as restricted to gypseous lunettes and copi rises, on the margins of relict lakes and on crests and sides of lunettes above old lake floors (DEC 2005).

Vegetation associations

The habitat of Club Spear-grass varies from chenopod shrubland, and mixed-species grassland, through to grassland dominated by Club Spear-grass. On Eyre Peninsula, Club Spear-grass has been recorded growing in association with Nealie (*Acacia rigens*), Helm's Oak-bush (*Allocasuarina helmsii*) and an understorey of *Zygophyllum aurantiacum, Enneapogon* sp. and small *Compositae* sp. (surveyed by Yeates and Crisp in 2002).

The following associated vegetation communities have been sourced from floristic mapping (DEH-EGIS 2006). They still require ground truthing because, for example, in many cases spear-grass may grow on the edges of these associations (Table 12.2).

Table 12.2. Vegetation associations of Club Spear-grass sub-populations

Primary species	Secondary species	Understorey species
Red Mallee (*Eucalyptus oleosa*) mid mallee woodland	Boree (*Melaleuca pauperiflora* ssp. *mutica),* +/- Dryland Tea-tree (*M. lanceolata*), +/- Sheep Bush (*Geijera linearifolia*) tall shrubs	Ruby Saltbush (*Enchylaena tomentosa* var. *tomentosa*), +/- Bladder Saltbush (*Atriplex vesicaria*) low shrubs over Grey Bindyi (*Sclerolaena diacantha*)
Southern Cypress Pine (*Callitris gracilis*), +/- Bullock Bush (*Alectryon oleifolius* ssp. *canescens*) low open woodland	+/- Umbrella Bush (*Acacia ligulata*) tall sparse shrubland	Black Bluebush (*Maireana pyramidata*) low sparse shrubland

Climate

Club Spear-grass inhabits the 300-400 mm rainfall zones; however, the majority of sub-populations grow in arid regions, which receive average yearly rainfalls of 200 mm or less (DEH-EGIS 2006). Sub-populations could be expected to experience a climate similar to Minnipa, which receives mean annual maximum and minimum temperatures of 24 °C and 10.9 °C respectively, and mean annual rainfall of 327.3 mm (BOM 2007).

Known sub-populations within reserves

Club Spear-grass grows within Lake Gilles Conservation Reserve (first recorded by S Carruthers and S Kenny in 1998) (DEH-EGIS 2006).

Benefits to other species

The conservation of Club Spear-grass is expected to benefit multiple species through protection and management of habitat. Control of feral goats and understanding of fire dependence are examples of two broad-scale management techniques expected to benefit other plant species growing in association with Club Spear-grass. Collecting baseline data is expected to have broader conservation benefits, particularly in our understanding of grass species, flowering response to environmental conditions and reproductive biology.

12.4 Biology and ecology

Club Spear-grass is a small, perennial grass that has stems to 0.5 m high. This species is characterised by ear-like outgrowths coming from the auricles[3]. The plant's woolly hairs are 9 mm long, lower glume[4] 9-11 mm long, and upper glume 8-10 mm long. It has an awn[5] 5-7 cm long that is bent twice (Everett 1986).

Flowering occurs in response to rain in summer months, mainly during December to January (DEC 2005), and the species most likely follows a C_4 pathway (Jessop, Dashorst & James 2006). Pollination is assumed to be via wind, but is unknown. Frequent hybridisation is thought to occur amongst similar grass species (L Bebbington 2004, pers. comm.). Seeds are dispersed via wind, rain and flood events, with the awn and sharp point of the floret[6] assumed to aid in seed burial (DEC 2005). In general, grass seed is thought to have a short viability span of 3-5 years (DEC 2005).

Club Spear-grass is very similar to Vickery's Spear-grass (*Austrostipa vickeryana*). Differences between the two are distinguished almost entirely by measurements (Jessop et al. 2006).

Fire dependence triggers

Soil disturbance is thought to stimulate Club Spear-grass germination (L Bebbington 2004, pers. comm.); however, this is yet to be tested. The New South Wales Rural Fire Service recommends that Club Spear-grass is not burnt more frequently than once every ten years (NSW 2004).

12.5 Previous management actions

Table 12.3. Previous management actions to conserve Club Spear-grass

	Previous management actions
2001	A Freebairn and M Horgan collected 15 grams of Club Spear-grass seed from the Lake Gilles population.
2003	Plant survey in Club Spear-grass habitat conducted by A Freebairn with the Friends of Kimba District Parks (DEH volunteers). 15 volunteers, 105 hours.
2004	Club Spear-grass seed collected from Eyre Peninsula sub-populations by Seed Conservation Centre, Adelaide, for germination tests and long-term low temperature storage, as part of the Millennium Seed Bank Project.

12.6 Threats to Club Spear-grass and associated recovery goals

The long-term goals are to down-list Club Spear-grass conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Club Spear-grass conservation status at Vulnerable.

Club Spear-grass is a Priority 3 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that may respond well to fire (Appendix I).

Table 12.4 details the key threats and summarises performance criteria relevant to Club Spear-grass recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

---

3 Auricles are an ear-shaped appendage at base of a leaf

4 Glume is one of a pair of empty bracts at the base of a spikelet

5 Awn is a long appendage at the apex of a glume, lemma or palea

6 Floret is a grass flower consisting of lemma, palea, lodicules, stamens, pistil

Table 12.4. Key threats to Club Spear-grass and summary of associated performance criteria

Direct threat and knowledge gap: **Inappropriate fire regimes**	Risk
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Club Spear-grass fire regime requirements are largely unknown. However, too frequent or intense fires would be expected to impact on the recruitment success of this grassland. The NSW Rural Fire Service recommends that Club Spear-grass is not burnt more frequently than once every 10 years (NSW 2004).	High
Direct threat and knowledge gap: Salinity/changes in hydrology	
Risk: Localised species extinction and degradation of critical habitat from increased salinity/changes in hydrology **Likelihood:** Likely **Consequences:** Moderate Increases in salinity scald patches within Club Spear-grass habitat may limit available habitat.	High
Direct threat and knowledge gap: High grazing pressure	
Risk: Loss of plants resulting in loss of available seed leading to increased risk of population decline **Likelihood:** Likely **Consequence:** Moderate Goats and sheep graze Club Spear-grass heavily (A Freebairn [DEH] 2004, pers. comm.). Rabbits and kangaroos often dig the entire plant out and feed on the base and root system of many *Austrostipa* species, including Club Spear-grass (L Bebbington 2005, pers. comm.). Reports of rabbits extensively grazing and burrowing in the soft gypsum soils of NSW Club Spear-grass sub-populations identifies that this would also be a threat to SA sub-populations.	High
Direct threat: Habitat fragmentation	
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Possible **Consequence:** Moderate IUCN criteria B1, 2c defines Club Spear-grass as threatened due to a limited extent of occurrence or area of occupancy and severe fragmentation. Further threats to Club Spear-grass sub-populations are the inferred, observed or projected continual decline, in area, extent and/or quality of habitat.	High
Direct threat and knowledge gap: Mineral exploration/extraction	
Risk: Localised species extinction and degradation of critical habitat from mineral exploration and/or extraction **Likelihood:** Possible **Consequence:** Moderate Club Spear-grass is restricted to growing in gypsum soils. Gypsum mining on Eyre Peninsula has the potential to threaten Club Spear-grass sub-populations if not managed appropriately. This requires further investigation.	High
Knowledge gap: Lack of knowledge and baseline information	
Risk: Loss of sub-population(s) and genetic material due to lack of information **Likelihood:** Unlikely **Consequences:** Moderate Insufficient baseline information (such as size of populations, age structure and reproduction success) and lack of biological knowledge (e.g. break downs in life cycle stages, pollination, cause and/or percentage of population dying/reaching senescence) needs to be addressed. Prior to 2004, the surveyed Eyre Peninsula sub-populations were reported to display good seed set with recruitment (A Freebairn [DEH] 2004, pers. comm.); however, no recent site visits have been undertaken to confirm if this is still the case.	Moderate

Direct threat: **Damage from off-road vehicles**						
Risk: Degradation of critical habitat and loss of individual plants **Likelihood:** Unlikely **Consequences:** Minor Club Spear-grass sub-populations have the potential to be damaged from off-road vehicle use and/or heavy machinery traffic (e.g. storage of road maintenance machinery temporarily along side roadways). Maintenance of other utilities with services and easements along roadsides, such as electricity and telephones, could also threaten Club Spear-grass sub-populations.						Low
	Objective 1 **Baseline information**	**Objective 2** **Community involvement**	**Objective 3** **Manage threats and improve habitat**		**Objective 4** **Research critical to management**	**Objective 5** **Monitoring and evaluation**
Performance criteria	1a.3 1c.1 1c.3 1d.2 1b.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.4 3c.1 3d.2 3d.3 3f.1 3f.3	3f.4 3f.5 3f.8	4b.3 4c.2	5a.6 5b.2

12.7 Main references

DEC 2005, *A spear-grass – profile*, Department of Environment and Climate Change NSW, Sydney, viewed 8 November 2007, <http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10081>.

Jessop, J, Dashorst, G & James, F 2006, *Grasses of South Australia: An illustrated guide to the native and naturalised species*, The Board of Botanic Gardens of Adelaide and State Herbarium, South Australia.

NSW RFS 2004, *Threatened species hazard reduction list: Part 1 - Plants*, NSW Rural Fire Service, viewed 8 November 2007, <http://www.rfs.nsw.gov.au/file_system/attachments/State/Attachment_20050304_5C7BDF1C.pdf>.

13 Prickly Raspwort *Haloragis eyreana* Orchard

13.1 Status

When assessing Prickly Raspwort vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 13.1). This is important given that this species only occurs on Eyre Peninsula. Prickly Raspwort is recognised as Endangered at the Regional, State and National levels (Table 13.1).

Table 13.1. Prickly Raspwort vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Endangered
Extent of occurrence (km²)	2047		
Area of occupancy (km²)	0.74	Endemic to Eyre Peninsula	
Sub-populations	69		
Estimated # of individuals	16 000		
IUCN Criteria	**Justification**		
EN B2	Area of occupancy estimated to be less than 500 km²		
EN B2b(iv)	Continuing decline inferred in area, extent and quality of habitat		
EN B2b(iv)c(iv)	Extreme fluctuations in number of mature individuals		

13.2 Distribution

Prickly Raspwort (*Haloragis eyreana)* is endemic to Lower Eyre Peninsula, where it grows in lower lying areas, along roadsides and near stormwater drains adjacent to road intersections (Jusaitis & Smith 1998) (Figure 13.1). The species' extent of occurrence on Eyre Peninsula is approximately 2000 km², occurring within latitude 33°38'40"S to longitude 136°45'57"E (Middlecamp Hills) in the north, and latitude 34°24'5"S to longitude 135°42'32"E (Edillilie) in the south (DEH-EGIS 2006).

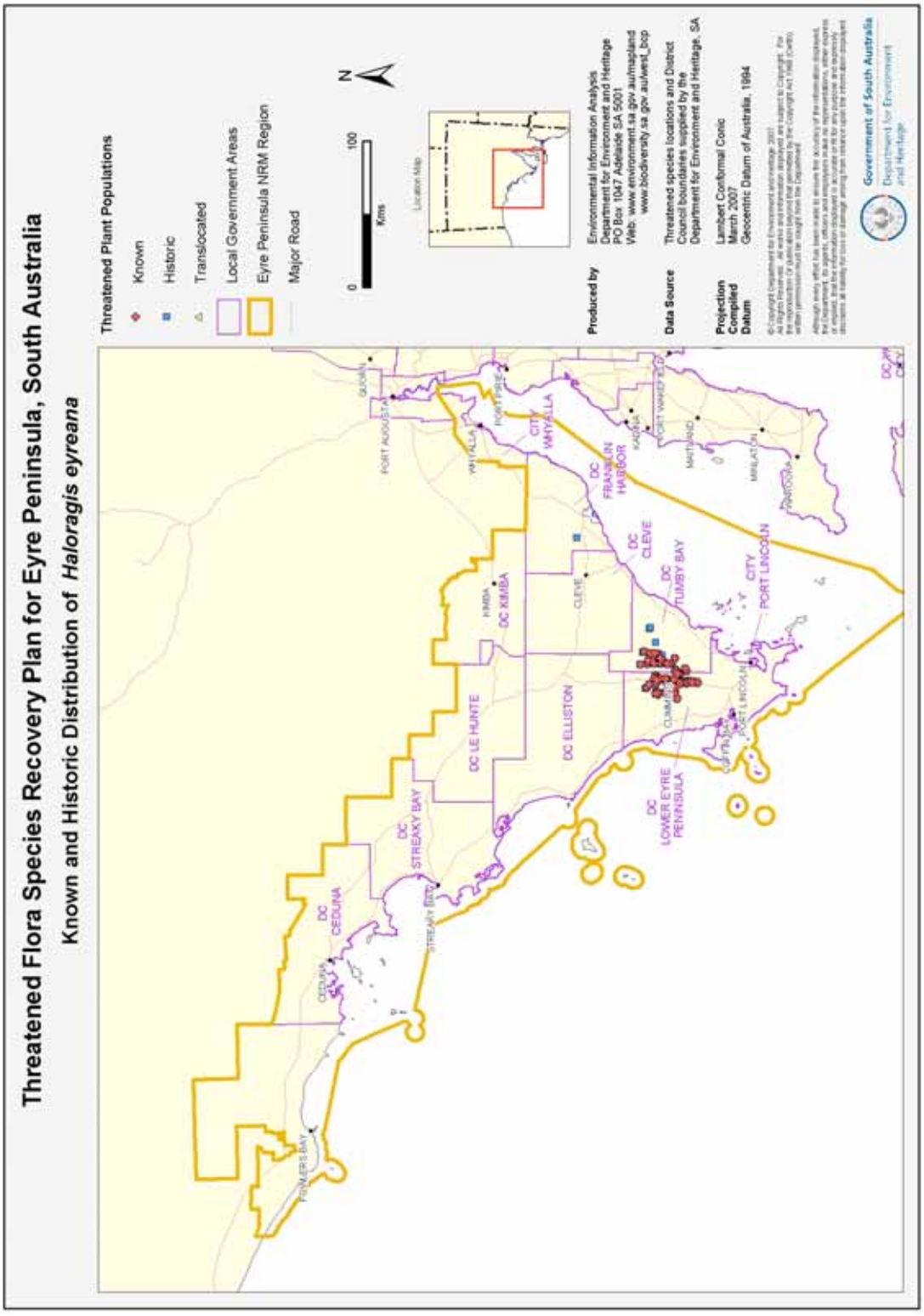
Prickly Raspwort grows within the district councils of Lower Eyre Peninsula, Tumby Bay and Franklin Harbour. Prickly Raspwort also grows within rail reserves maintained by Australian Railroad Group Pty Ltd (ARG) and along corridors with water pipelines maintained by SA Water.

13.3 Habitat critical to survival

All known habitat of Prickly Raspwort is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Prickly Raspwort grows predominantly on poorly drained mottled-yellow duplex soils and hard pedal red-duplex soils in historically grassland areas that have been cleared for agriculture (Laut et al. 1977). Jusaitis et al. (2000a) record Prickly Raspwort growing in grey, brown or reddish clays soil with an average pH of 7.8. The species grows in soils that set hard in summer yet become waterlogged in winter.



Note: Prickly Raspwort details are held on internal DEH files and are available on request.

Figure 13.1. Distribution of Prickly Raspwort on Eyre Peninsula

Vegetation associations

Prickly Raspwort inhabits areas that are considerably modified from their pre-settlement state. Areas near Prickly Raspwort sub-populations have been extensively cleared for crop production. Agricultural land in the area would have once been dominated by Yorrell (*Eucalyptus gracilis*), Capped Mallee (*E. pileata*), Ridge-fruited Mallee (*E. incrassata*) and Broombush (*Melaleuca uncinata*) (Leigh, Boden & Briggs 1984). Frequently, Prickly Raspwort is found growing in disturbed open grassland areas. It is only occasionally found growing in more intact habitat, where it is associated with Ridge-fruited Mallee (*Eucalyptus incrassata*), Dumosa Mallee (*E. dumosa*) or Totem-poles (*Melaleuca decussata*) (Jusaitis et al. 2000a).

Climate

Prickly Raspwort inhabits the 300-500 mm rainfall zone (DEH-EGIS 2006). The climate experienced by the Middlecamp Hills northern sub-population is best estimated from Cowell's climate, where the mean annual rainfall is 279.9 mm (BOM 2007). In Prickly Raspwort's southern-most range, sub-populations could be expected to experience climate similar to Wanilla, where mean annual rainfall is much higher at 509.4 mm (BOM 2007).

Known sub-populations within reserves

There is one record of Prickly Raspwort within Middlecamp Hills Conservation Park, first observed by R Davies in 1982 (DEH-EGIS 2006). This record is considered to be outside of the species' currently known range and requires further verification.

Benefits to other species

The conservation of Prickly Raspwort is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data is expected to benefit other plant species growing in association with the herb. In particular, these activities will benefit those plant species within similar limited niches, and with similar life forms, flowering response and/or pollinator needs.

13.4 Biology and ecology

Prickly Raspwort is a perennial, herb growing to 10-30 cm tall. A full taxonomic description of Prickly Raspwort is given in Black (1986a, p. 970).

Flowering occurs between October and November, with fruit developing in December. Flowers develop starting from the base and extend to the tip of flowering stems (Jusaitis & Smith 1998; Jusaitis et al. 2000a). According to Orchard (1980), inflorescences are composed of up to five hermaphroditic flowers; however Jusaitis et al. (2000a) found that Prickly Raspwort plants average three to five flowers per node. Plants from two sub-populations have even been recorded with up to 12 and 15 flowers per node (from plants in sub-populations J3 and J1 respectively (Jusaitis et al. 2000a).

Studies show varied differences in seed production both between and within provenances. For example, sub-population E had consistently higher yield that other sub-populations (35-50 seeds per 100 fruits) (Jusaitis et al. 2000a). Fruit and seed morphology, seed production, and the species breeding system have been studied quite extensively (see Jusaitis et al. (2000a)).

Prickly Raspwort reproduces from seed and vegetatively (Jusaitis & Smith 1998; Jusaitis et al. 2000a). The fruit contains an inhibitor or inhibitors that give a dormancy period. The seed itself is surrounded by hard, woody fruit, but it is unlikely that this seed coat would be a barrier to germination (Jusaitis et al. 2000a).

Pollen is readily dispersed by wind gusts, with the optimal weather conditions for cross-pollination believed to be hot, dry summer days with a light to moderate breeze (Jusaitis et al. 2000a). Bagging experiments on nursery-grown plants in Adelaide indicated that insect pollination did not affect seed yield, which further supports that the species probably relies on wind for pollination (Jusaitis et al. 2000a).

The response of Prickly Raspwort to fire is unknown.

13.5 Previous management actions

Prickly Raspwort research work has been led by Manfred Jusaitis (Senior Biologist, DEH). A summary of research trials and results is listed in Table 13.2.

Table 13.2. Previous management actions to conserve Prickly Raspwort

	Previous management actions and points of interest
1990	Seed of Prickly Raspwort thought to be male sterile. Thought that the species reproduced entirely vegetatively (Orchard 1980 in Jusaitis et al. 2000a).
1997	Survey of Prickly Raspwort sub-populations (Jusaitis et al. 2000a, p. 6). Site names include A, B, C, D, E, F, G, H, I1, I2, J, K, L and M, reaching a total of 2933 plants from these sites near Cummins, Yeelanna, Koppio and Cockaleechie. Prickly Raspwort sub-populations are defined based on the assumption that a 500 m gap of no Prickly Raspwort plants (e.g. along a roadside) constitutes a separate sub-population, as it is unlikely that genetic exchange would take place over that distance (Jusaitis et al. 2000a).
1998	Survey of Prickly Raspwort sub-populations (Jusaitis & Smith 1998; Jusaitis et al. 2000a, p. 6). From a further 37 newly recorded sub-populations a total of 11 748 plants were surveyed.
1998	In May, two field trials were established to investigate the potential impact of road maintenance activities, weeds and herbivores on growth and regeneration of Prickly Raspwort. <u>Soil disturbance, slashing and herbicide effects</u> Trials at sites named Three Brothers, Pearson's Road and Moreenia investigated effects of: • soil grading: early (May) compared with late (October) • vegetation slashing: early (August/September) compared with late (September/October) • annual grass control with herbicide: 0.5 or 1 L/ha of Fusillade® in August. <u>Weed and grazing effects</u> Three enclosures (5 m^2 constructed of chicken-wire) were established on roadside near Cockaleechie. Pairs of 1 m^2 quadrats were set up inside and outside the enclosures. Enclosures included one hand weeded site and one control (left as is). Five photo-points were set up with a 10 m^2 quadrat for vegetation assessment in varying representative Prickly Raspwort habitat.
1998	Propagation and ex situ collection including micro-propagation, cuttings and germination. Gibberellin and smoked water trialled (Jusaitis et al. 2000a).
1998	Fertile (plump white seed) collected from nursery-grown and in situ plants. This proved that the species could produce viable seed. It had previously been assumed to reproduce vegetatively only (Jusaitis et al. 2000a).
1999	Survey of Prickly Raspwort sub-populations (Jusaitis et al. 2000a, p. 6). Eleven new Prickly Raspwort sub-populations recorded, comprised of 1047 plants.
1999	*Haloragis eyreana* Recovery team meeting held in Adelaide in April.

	Previous management actions and points of interest
2000	First year results of field trials: • density of Prickly Raspwort increased as result of early slashing (result from single replicate only) (Jusaitis et al. 2000a) • weed control using Fusillade® conducted at Sites L; 22(a and b); 6a; I; M; 15, 9b. Annual grasses were controlled and there was no observed impact on Prickly Raspwort or Wallaby-grass (*Danthonia* sp.) (M Jusaitis [DEH] 2001, pers. comm.) • results so far do not show significant reduction in Prickly Raspwort density as a result of grading or slashing (Jusaitis et al. 2000a) • weed free plots had higher density and cover of Prickly Raspwort and higher numbers of seedlings • no significant herbivore damage was recorded between the fenced and unfenced trials.
2000	*Haloragis eyreana* Research Plan with allocated Project Officer (Karan Smith to June 1999 and Anthelia Bond from August 1999; staff transition period) was coordinated by Manfred Jusaitis (Project Number 574, Project ID ESU06082) (DEH Recfind file 40/1492).
2002	Habitat trials established along Bratten Way to test Prickly Raspwort growth and reproduction in different waterlogged soil micro-niches.
2003	Seed collected from two sub-populations for the Seed Conservation Centre, Adelaide. Seed has been tested and has been entered into the seedbank for long-term, low temperature storage (P Ainsley [DEH] 2004, pers. comm.).
2004-06	M Jusaitis and K Pobke completed Prickly Raspwort monitoring. Small bushfire (2006) had burnt through Bratten Way soil moisture trial.
2005	Prickly Raspwort Threatened Flora of South Australia Information Sheet produced (DEH Recfind file 40/1492).

13.6 Threats to Prickly Raspwort and associated recovery goals

The long-term goals are to down-list Prickly Raspwort conservation status from Endangered to Vulnerable, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Prickly Raspwort conservation status at Endangered.

Prickly Raspwort has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 13.3 details the key threats and summarises performance criteria relevant to Prickly Raspwort recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 13.3. Key threats to Prickly Raspwort and summary of associated performance criteria

Direct threat: Habitat fragmentation	**Risk**
Risk: Complex to determine because Prickly Raspwort grows within fragmented systems, but this could also threaten species' resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Major The majority of known populations are small and occur in highly fragmented vegetation on road and rail reserves. These fragmented populations of Prickly Raspwort may have low genetic variability and genetic flow because of their small size and isolation. Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases. Differences in seed production have already been observed at different sub-populations and the factor(s) contributing to such differences are unknown. Prickly Raspwort distribution spans six different Hundreds, all of which are extensively cleared, with less than 8% of native remnant vegetation remaining (NVMB 1987).	Extreme
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Almost certain **Consequence:** Moderate Weed invasion, particularly grass weed species, suppresses Prickly Raspwort seedling regeneration, density and cover (Jusaitis et al. 2000a). Low-lying areas in road and rail reserves are all easily colonised by introduced grasses such as Couch (*Cynodon dactylon*) and Oat (*Avena* sp.). These sites already sustain relatively small numbers of plants that could quickly become locally extinct from weed encroachment. Weeds recorded within Prickly Raspwort critical habitat include False Brome (*Brachypodium distachyon*), Pimpernel (*Anagallis arvensis*), Common Sow-thistle (*Sonchus oleraceus*), Cape Weed (*Arctotheca calendula*), Thread Iris (*Gynandriris setifolia*), Couch (*Cynodon dactylon*) and Common Onion-grass (*Romulea rosea*) (Jusaitis et al. 2000a).	Extreme
Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Likely **Consequences:** Moderate Roadside management activities such as grading and slashing may impact on Prickly Raspwort sub-populations; however, preliminarily results show Prickly Raspwort density and cover has not been significantly affected by slashing and grading. Maintenance of other essential services, such as water pipelines, overhead powerlines and underground cables, is an identified threat to Prickly Raspwort.	High
Direct threat: Salinity/changes to hydrology, Inappropriate disturbance regimes	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Possible **Consequences:** Moderate Low-level disturbance has been demonstrated to invigorate Prickly Raspwort; however, high-level disturbance with any weed invasion will result in the extinction of this species at a site (M Jusaitis [DEH] 2006, pers. comm.).	High

	Objective 1 Baseline information	**Objective 2 Community involvement**	**Objective 3 Manage threats and improve habitat**	**Objective 4 Research critical to management**	**Objective 5 Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3f.1 3a.3 3f.4 3a.4 3f.8 3b.3 3d.3 3d.3	4e.1	5a.5 5a.9 5b.2

13.7 Main references

Jusaitis, M, Bond, A, Smith, K & Polomka, L 2000, Haloragis eyreana *Research Plan*, Department for Environment and Heritage, South Australia.

Jusaitis, M, Bond, A, Smith, K & Polomka, L 2000a, *Annual Report for* Haloragis eyreana *Research Plan*, Department for Environment and Heritage, South Australia.

Jusaitis, M & Smith, K 1997, Progress report Haloragis eyreana, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Jusaitis, M & Smith, K 1998, Haloragis eyreana *Research Plan: Annual report*, Department for Environment, Heritage and Aboriginal Affairs, South Australia.

Leigh, J, Boden, R & Briggs, J 1984, *Extinct and endangered plants of Australia*, MacMillan, Australia.

Orchard, AE 1986, 'Haloragaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, PartIII: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

14 Bead Samphire *Halosarcia flabelliformis* PG Wilson

14.1 Status

When assessing Eyre Peninsula Bead Samphire vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 14.1). Bead Samphire is recognised as Vulnerable at the Regional, State and National levels (Table 14.1).

Table 14.1. Bead Samphire vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	22 160		
Area of occupancy (km²)	0.5		
Sub-populations	10		
Estimated # of individuals	10 000		
IUCN Criteria	**Justification**		
VU D2*	Population with very restricted area of occupancy and number of locations on Eyre Peninsula such that it is prone to the effects of human activities or stochastic events within a very short period of time in an uncertain future and is thus capable of becoming Critically Endangered or even Extinct in a short time period		

14.2 Distribution

Bead Samphire, also known as Bead Glasswort, grows in Western Australia, South Australia and Victoria. The majority of known sub-populations grow in South Australia (Carter 2005). Isolated Bead Samphire sub-populations grow in the South-East, Northern Lofty and Eyre Peninsula regions in South Australia (DEH-EGIS 2007). On Eyre Peninsula, Bead Samphire has an extent of occurrence in excess of 22 000 km² (Figure 14.1) and grows within latitude 31°58'1"S to longitude 132°25'5"E (Fowlers Bay) in the north, and latitude 34°28'40"S to longitude 135°50'52"E (Koppio Tod Reservoir) in the south (DEH-EGIS 2006). There is also one offshore sub-population on Flinders Island.

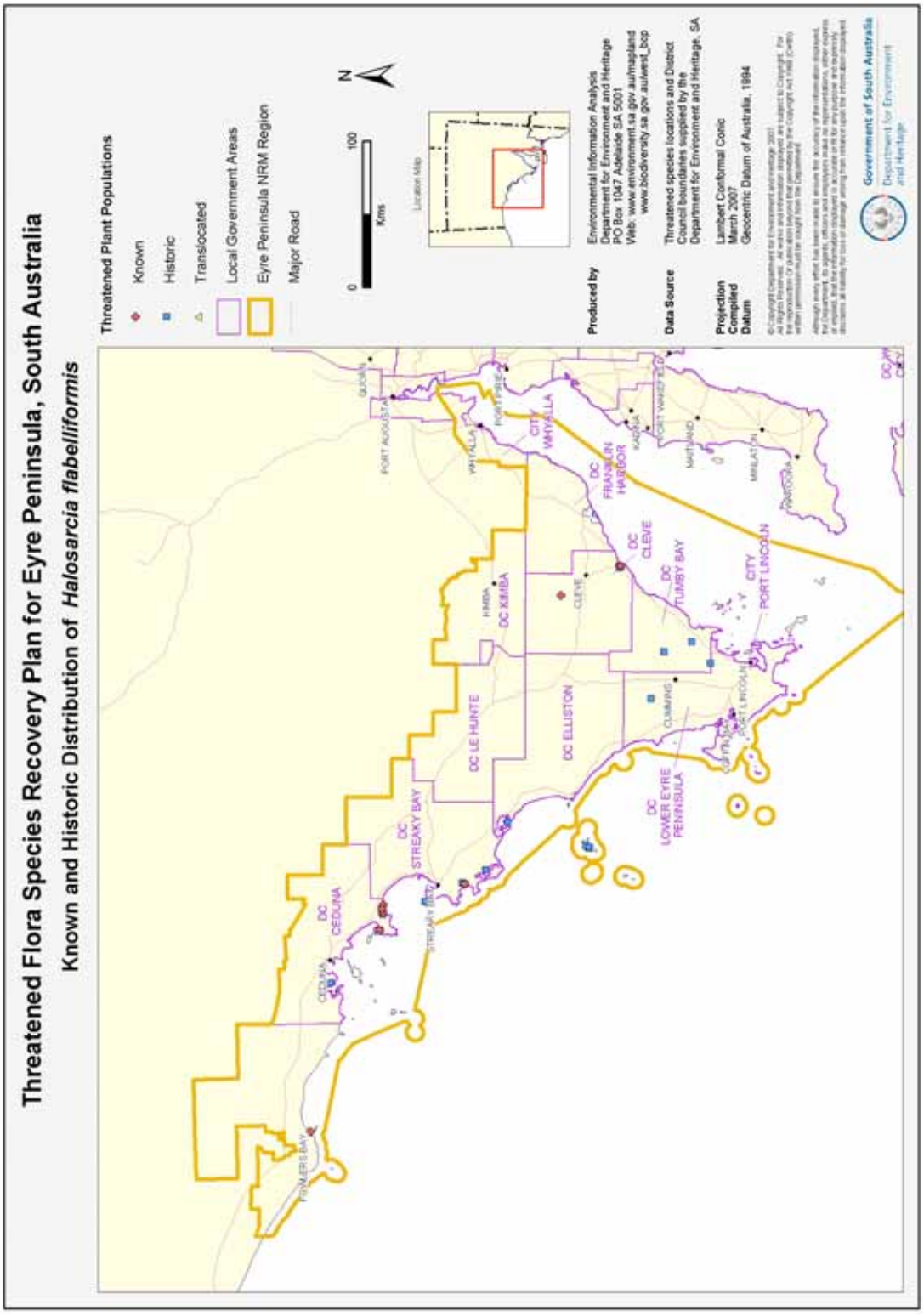
Bead Samphire grows within the district councils of Cleve, Streaky Bay, Elliston, Ceduna, Tumby Bay and Lower Eyre Peninsula, and on land managed by the Outback Areas Community Development Trust.

14.3 Habitat critical to survival

All known habitat of Bead Samphire is considered to be habitat critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Bead Samphire grows on the margins of salt lakes and coastal salt marshes over gypsum deposits, and is often associated with other *Halosarcia* species (Scarlett & Parson 1993). Habitat preference of Bead Samphire sub-populations close to St Kilda and Adelaide have been studied by Coleman and Cook (2005), who found that Bead Samphire grows in soils that can tolerate a wider soil moisture content than associated edge vegetation. Bead Samphire grows on playa surfaces within mineral soils with a pH of 7.9-8.1, and high chlorinate levels (Coleman & Cook 2005). Bead Samphire habitat preference corresponds with the hard pans, which have been recorded at depths of 25-50 cm (Coleman & Cook 2005). General soil descriptions are given in Table 14.2.



Note: Details of Bead Samphire locations are held on internal DEH files and are available on request.

Figure 14.1. Distribution of Bead Samphire on Eyre Peninsula

Vegetation associations

Bead Samphire usually occupies different niche habitat than other *Halosarcia* species. The species grows almost specifically in monoculture stands within low-lying habitat niches. Associated salt tolerant vegetation communities grow on these low-lying areas (see Table 14.2) (DEH-EGIS 2006).

Table 14.2. Examples of niche sharing species, soil description and associated edge vegetation for Bead Samphire

Soil description	Niche-sharing species	Edge associated vegetation
Acraman Creek Conservation Park Tidal flat – Silty clay loam (top 5 cm)	Grey Samphire (*Halosarcia halocnemoides*) and Bead Samphire *(H. flabelliformis*)	Brown-head Samphire (*Halosarcia indica* ssp*. leiostachya*) low shrubland over Salt Bluebush (*Maireana oppositifolia*), Grey Samphire (*Halosarcia halocnemoides*) and Thorny Lawrencia (*Lawrencia squamata*)
Arno Bay Calcareous loam, less than 10 m above sea level	Bead Samphire *(Halosarcia flabelliformis*)	Grey Mangrove (*Avicennia marina* ssp. *marina*) low open forest over +/- samphire (*Halosarcia* sp.), +/- Beaded Samphire (*Sarcocornia quinqueflora*) shrubs

Climate

Bead Samphire inhabits a wide-ranging rainfall zone of 300-500 mm (DEH-EGIS 2006). Fowler's Bay is near the northern extent of the Bead Samphires' Eyre Peninsula range and has mean annual maximum and minimum temperatures of 21.5 °C and 12.3 °C respectively, and a mean annual rainfall of 299.3 mm (BOM 2007). Arno Bay, near the species' southern sub-populations, has a mean annual rainfall of 315 mm (BOM 2007).

Known sub-populations within reserves

Bead Samphire is located within the South Australian reserve system (Table 14.3).

Table 14.3. Bead Samphire sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Sceale Bay Conservation Park	1	L Bebbington 2005
Acraman Creek Conservation Park	1	D Fotheringham & G Pearce 1991 D Fotheringham 1996
Fowlers Bay Conservation Park	1	T Schultz 2005

Benefits to other species

The conservation of Bead Samphire habitat is expected to benefit a wide range of species associated with salt marsh, salt lake and tidal samphire habitats on Eyre Peninsula, particularly those species that will be under threat from sea level rises associated with climate change. For example, hover flies are known to use Bead Samphire as larvae raising habitat and fly larvae have been observed feeding on the plants seeds (B Saunders 2006, pers. comm.).

14.4 Biology and ecology

Bead Samphire is a small woody perennial, belonging to the Chenopod family. Bead Samphires grow to approximately 20 cm high and have upward curving branches. These branches comprise of succulent segments, often described as barrel-shaped or narrow-obovoid (egg-shaped). The size of each segment is approximately 5 mm long and 2.5 mm

wide (Wilson 1986). The feature that distinguishes Bead Samphire from other *Halosarcia* species is its free opposite bracts on the spike.

The flowering and fruiting phases of the Bead Samphire life cycle take place from January to May (Wilson 1986). Flowers, or more precisely the plant's stamens and stigmas, develop as yellow/white, barely visible dots along the flowering spikes, at the top of branches. Flowers of *Halosarcia* species are bisexual, producing both male and female parts (Datson 2002). The pollination process and seed dispersal mechanisms are currently unknown.

Bead Samphire germination triggers and requirements are unknown. In general, reproduction of samphire species is known to require soil salinity and temperature triggers (Datson 2002). Bead Samphire seeds have a tough, bumpy, brown testa (outer coating) and are less than 1 cm long.

14.5 Previous management actions

Table 14.4. Previous management actions to conserve Bead Samphire

	Previous management actions
1959-2005	Opportunistic surveys/observations locating Bead Samphire populations on Eyre Peninsula (recorded by 17 observers). These records are kept on internal DEH databases.
1996	Tidal and salt marsh community survey by DEH. 30 x 30 m quadrats used to record plant species lists, cover/abundance data and general soil information. Surveys relevant to understanding Bead Samphire habitat requirements include: ACR00203 Acraman Creek CP, and ARN00102 Arno Bay.
2004-ongoing	Arno Bay Progress Association and members of the Arno Bay Estuaries Group met to discuss samphire and salt marsh conservation and ecosystem function. EPNRMB Coastal Management Officer, EPNRMB Wetlands Officer and DEH Threatened Flora Project Officer attended.
2005	Bead Samphire article published in *West Coast Babbler: The Ark on Eyre Newsletter* (spring edition) to raise community awareness of Arno Bay estuary system and highlight Bead Samphire (DEH Recfind file 40/1491).
2006	Bead Samphire information sheet produced (DEH Recfind file 40/1491)
2006	Staff field trip and community workshop held at Arno Bay as part of EPNRMB project officers' community capacity building milestones (DEH Recfind file 40/A142128).
2006	Site visits to Bead Samphire sub-populations in Sceale Bay, Fowlers Bay and Acraman Creek conservation parks, and at Arno Bay. Juvenile, adult and damaged plants tagged and recorded for future monitoring. One line intercept transect established at Fowlers Bay to monitor impact from off-road vehicles on this population (DEH Recfind File 40/A248477).
2006	Bead Samphire Threatened Flora of Eyre Peninsula Information Sheet produced as a milestone for the Ark on Eyre project (DEH Recfind file 40/A142070).

14.6 Threats to Bead Samphire and associated recovery goals

The long-term goals are to down-list Bead Samphire conservation status from Vulnerable to Near Threatened and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Bead Samphire conservation status at Vulnerable

Bead Samphire has been ranked as a Priority 2 species based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 14.5 details the key threats and summarises performance criteria relevant to Bead Samphire recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 14.5. Key threats to Bead Samphire and summary of associated performance criteria

Direct threat: **Restricted distribution/isolated and disjunct sub-populations**	Risk
Risk: Widespread loss of species across multiple sites if species cannot colonise new sites **Likelihood:** Likely **Consequence:** Major Bead Samphire's restricted niche habitat and disjunct sub-populations are expected to affect the species ability to survive climate change (e.g. sea-level rise).	Extreme
Direct threat: Salinity/changes in hydrology, Urban development/subdivision	
Risk 1: Localised species extinction and degradation of critical habitat most likely from changes in hydrology **Risk 2:** Loss of species sub-population as a result of illegal clearance, e.g. progression of development without vegetation assessment **Likelihood:** Likely **Consequence:** Major Rising regional saline groundwater tables are considered a potential long-term threat to populations in Victoria (Scarlett & Parson 1993). Bead Samphire is tolerant of seasonal inundation, but would be threatened by rising water tables, which lead to excessive and/or prolonged flooding (Venn 2005). In general, samphire species cannot tolerant long periods of drought (Datson 2002). Similar threats to Eyre Peninsula Bead Samphire populations are probable and need to be investigated, for example: • water harvesting (e.g. nearby harvest of ground water behind sand dunes) may affect the amount/quality of water the samphire ecosystem needs to survive • rising sea-level as a result of climate change and the ability of samphire species to migrate • the impact of variables such as drainage, nutrient loading, sedimentation and pollution on critical habitat. The predominantly coastal habitat of Bead Samphire makes the species highly susceptible to direct and indirect impacts from coastal development, as described above in changes to hydrology. Examples of direct impacts include clearance of habitat and populations, and indirect impacts include changes in hydrology, drainage, pollination, and nutrient and sediment run-off.	Extreme
Direct threat: Off-road vehicles and rubbish dumping	
Risk: Localised species extinction and degradation of critical habitat from off-road vehicles and rubbish dumping **Likelihood:** Likely **Consequences:** Moderate Off-road vehicles frequently cause disturbance to Bead Samphire habitat, increase the risk of weed species introduction, and change water-flow through soil compaction and depression. Rubbish dumping is also a concern due to environmental pollutants and the message that dumping gives to the community about the intrinsic value of salt marsh environments.	High
Direct threat and knowledge gap: Mineral exploration/extraction	
Risk: Localised species extinction and degradation of critical habitat from mineral exploration/extraction **Likelihood:** Possible **Consequences:** Moderate Bead Samphire populations in Victoria are under threat from gypsum mining (Scarlett & Parson 1993). Gypsum mining and salt extraction on Eyre Peninsula has the potential to threaten Bead Samphire populations if not managed appropriately.	High
Knowledge gap: Lack of knowledge and baseline information	
Risk: Localised species extinction and degradation of critical habitat from lack of information **Likelihood:** Possible **Consequences:** Moderate Baseline information about Bead Samphires on Eyre Peninsula lacks information about the size of populations, age structure, reproduction success and knowledge of break-downs in life cycle stages, pollination, and cause and percentage of population dying/reaching senescence.	High

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3b.3 3a.3 3f.1 3a.4 3f.3 3b.3 3f.4 3c.2 3f.8 3d.2	4b.2 4b.6 4h.2	5a.5 5a.7 5b.2

14.7 Main references

Carter, O 2005, *DRAFT Recovery Plan for* Halosarcia flabelliformis *(Bead Glasswort) in South Australia, Western Australia and Victoria 2006 - 2010*, Arthur Rylah Institute for Environmental Research & Department of Sustainability and Environment, Heidelberg, Victoria.

Scarlett, NH & Parson, RF 1993, 'Rare and threatened plants in Victoria', in DB Foreman & NG Walsh (eds), *Flora of Victoria, Volume 1: Introduction*, Inkata Press, Melbourne.

Venn, DR 2005, *Action Statement No. 95 Bead Glasswort* Halosarcia flabelliformis, Department of Sustainability and Environment, Victoria.

15 Granite Mudwort *Limosella granitica* WR Barker

15.1 Status

When assessing Eyre Peninsula Granite Mudwort vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 15.1). Granite Mudwort is recognised as Vulnerable at the Regional, State and National levels (Table 15.1).

Table 15.1. Granite Mudwort vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	6090		
Area of occupancy (km²)	0.01		
Sub-populations	5		
Estimated # of individuals	500		
IUCN Criteria	**Justification**		
VU D	Population very small or restricted on Eyre Peninsula		
VU D2*	Population with very restricted area of occupancy (typically less than 20 km²) or number of locations (five or fewer) on Eyre Peninsula such that is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or Extinct in a very short time period		

15.2 Distribution

Granite Mudwort distribution is confined to seasonally wet rock-pools (gnamma holes) on top of granite inselbergs and outcrops, across northern Eyre Peninsula. Sub-populations survive in disjunct sub-populations within an estimated 6000 km² extent of occurrence, occurring within latitude 31°29'23"S to longitude 136°53'18"E (south-west of Mount Gunson) in the north, and latitude 33°25'59"S to longitude 136°15'37"E (Carappee Hill) in the south (DEH-EGIS 2006) (Figure 15.1).

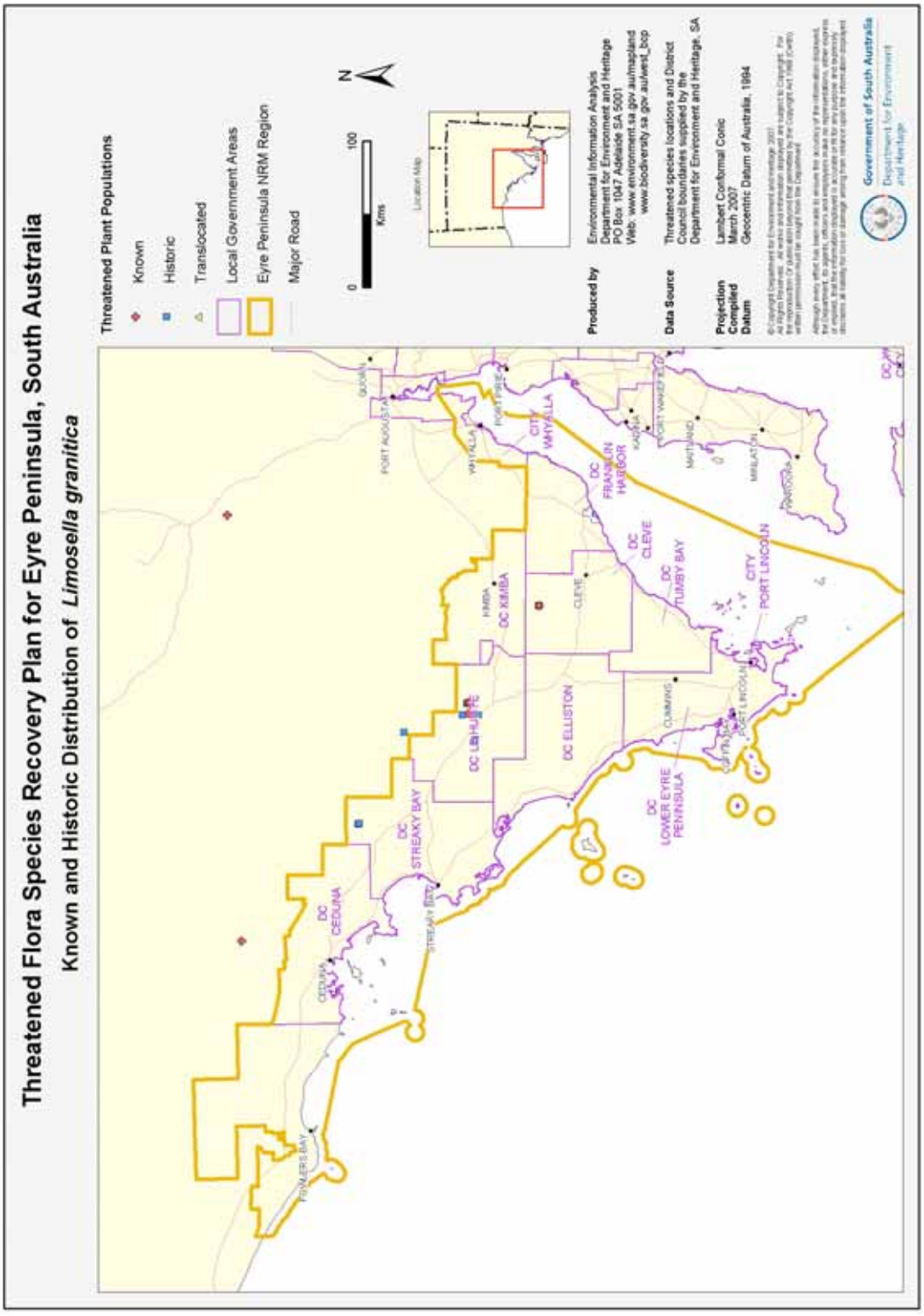
Granite Mudwort grows within the district councils of Le Hunte, Cleve and Streaky Bay, and the Counties of Bosanquet (Gawler Ranges National Park). Granite Mudwort has also been recorded within the South Australian Arid Lands NRM region, in the DEH West region (near Lake Gairdner) and the DEH Outback region (near Lake Torrens) (DEH-EGIS 2007).

15.3 Habitat critical to survival

All known habitat of Granite Mudwort is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography, soil, vegetation associations and other features

Granite Mudwort habitat comprises seasonally wet gnamma holes on granite outcrops (Barker 1984), with a range of 150 m high (in the District Council of Streaky Bay) to 370 m high (in Carappee Hill Conservation Park). The species grows in fine silt and, while it is assumed that depth and water quality of the gnamma may influence available habitat, these parameters are unknown.



Note: Details of Granite Mudwort locations are held on internal DEH files and are available on request.

Figure 15.1. Distribution of Granite Mudwort on Eyre Peninsula

Climate

Granite Mudwort sub-populations experience different climates, for example:

- the western sub-population could be expected to experience a climate similar to Ceduna, with mean annual maximum and minimum temperatures of 22.6 °C and 10.6 °C respectively, and mean annual rainfall of 292.8 mm.
- north-east sub-populations could be expected to experience a climate similar to Woomera, with mean annual maximum and minimum temperatures of 25.7 °C and 12.6 °C respectively, and a mean annual rainfall of 185.5 mm
- the southern most sub-populations could be expected to experience a climate similar to Darke Peak, with a mean annual rainfall of 380.8 mm.

Known sub-populations within reserves

Granite Mudwort occurs within the South Australian reserve system (Table 15.2). Sub-populations are known from Mount Wudinna, Carappee Hill Conservation Park, Wallala Hill, Yumbarra Conservation Rerserve and Pygery Rocks. Granite Mudwort is suspected to grow on granite outcrops in the western Gawler Ranges and Moody Tanks Conservation Park; however, these records require verification.

Table 15.2. Granite Mudwort sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Carappee Hill Conservation Park	1	D Symon 1979 D Murfet and R Taplin 1998
Yumbarra Conservation Reserve	1	A Freebairn, B Waining and M Horgan 2001

15.4 Biology and ecology

Granite Mudwort is a small perennial, aquatic plant, which grows submerged in water with leaves that float on the water surface. Leaf blades are 3-8 cm long, obovate, attenuate at the base, and obtuse to rounded at the apex.

Flowering occurs between August and October; however, it is unknown if flowering takes place underwater or between rainfall events that replenish gnamma holes (Barker 1984). Flowers are white and have black anthers, which carry white coloured pollen (Barker 1984). Each flower has an outer whorl (calyx), which is red-purple and 2-3 mm long. A full taxonomic description is given in Black (1977).

The plant produces a tiny 2.5-3.5 mm dark brown capsule, which down-turns into the silt. Seeds from the capsules are dark brown, narrow to oblong, and only 0.9-1.1 mm long (Black 1977).

Granite Mudwort is closely allied to *Limosella australis* and both species can easily be confused. *Limosella australis* has undifferentiated or elliptic leaf blades; however, leaf structure is highly variable in the field and either species can only be positively identified when flowering (Black 1977).

Granite Mudwort pollination and germination requirements are unknown. It is also unknown how much disturbance this species can tolerate.

15.5 Previous management actions

To date, the initial surveys locating Granite Mudwort sub-populations on Eyre Peninsula are the only known steps towards conservation. The earliest recorded survey of Granite Mudwort was in 1935 by Ising, when the species was recorded from Wudinna Hill. Crisp completed the most recent extensive surveys in 2002 from Wudinna and Pygery Rocks.

15.6 Threats to Granite Mudwort and associated recovery goals

The long-term goals are to down-list Granite Mudwort conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Granite Mudwort conservation status at Vulnerable.

Granite Mudwort has been identified as a Priority 3 species based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). It is a species thought to be at high risk from climatic variation. The niche habitat of Granite Mudwort makes the species highly susceptible to localised extinction. The impact of extended or extreme weather patterns could be expected to affect the survival of this perennial aquatic species.

Table 15.3 details the key threats and summarises performance criteria relevant to Granite Mudwort recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 15.3. Key threats to Granite Mudwort and summary of associated performance criteria

Direct threat: Weed invasion	**Risk**
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate Weed species can already be seen out-competing Granite Mudwort within gnamma holes near Wudinna (K Pobke [DEH] 2005, pers. comm.).	**High**
Direct threat: Inappropriate disturbance regimes	
Risk: Localised species extinction and degradation of critical habitat from inappropriate disturbance **Likelihood:** Likely **Consequence:** Moderate Mining, silting-up of gnamma holes, off-track motorbikes and visitor use (i.e. trampling) threaten Granite Mudwort. Herds of feral goats are also known to muddy and trample through rock pools (A Freebairn [DEH] 2004, pers. comm.). Damara Sheep around the Gawler Ranges could also threaten populations (L Bebbington 2005, pers. comm.).	**High**
Direct threat: Pest and disease	
Risk: Localised species extinction and degradation of critical habitat from pest and disease **Likelihood:** Possible **Consequence:** Moderate Granite Mudwort may be highly susceptible to water borne pests and diseases, e.g. increases in water nutrient levels could increase the risk of algal blooms.	**High**
Direct threat and knowledge gap: Spray drift	
Risk: Localised species extinction and degradation of critical habitat from spray drift **Likelihood:** Rare **Consequences:** Minor	Low

	Objective 1 Baseline information	**Objective 2 Community involvement**	**Objective 3 Manage threats and improve habitat**	**Objective 4 Research critical to management**	**Objective 5 Monitoring and evaluation**
Performance criteria	1a.3 1c.1 1c.3 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.4 3b.1 3d.2 3d.3 3f.1 3f.4 3f.5 3f.8	4b.3 4f.1	5a.6 5b.2

15.7 Main reference

Barker, WR 1984, 'Scrophulariaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

16 *Microlepidium alatum* JM Black; EA Shaw

16.1 Status

When assessing Eyre Peninsula *Microlepidium alatum* vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 16.1). *Microlepidium alatum* is recognised as Vulnerable at the Regional, State and National levels (Table 16.1).

Table 16.1. *Microlepidium alatum* vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	7325		
Area of occupancy (km²)	0.07		
Sub-populations	7		
Estimated # of individuals	1000		
IUCN Criteria	**Justification**		
VU B1	Extent of occurrence estimated to be less than 20 000 km² on Eyre Peninsula		
VU B1a	Not known from more than 10 locations on Eyre Peninsula		
VU B1a,c(iv)*	Extreme fluctuations in the number of mature individuals on Eyre Peninsula		

16.2 Distribution

Microlepidium alatum does not have a common name. Until relatively recently the species was thought to be endemic to Eyre Peninsula. In 2005 however, a national check of herbarium records found *M. alatum* was collected from Western Australia and recorded in the Victorian Herbarium (Sheet No. Mel74365, DEH Recfind file 40/1489). At the time of publication, the Western Australian *M. alatum* record still requires verification. On Eyre Peninsula the species' extent of occurrence is approximately 7300 km², growing within latitude 31°16'52"S to longitude 131°29'59"E (near Nullarbor Regional Reserve) and latitude 33°3'27"S to longitude 135°28'13"E (near Wudinna) (DEH-EGIS 2006) (Figure 16.1).

Microlepidium alatum is known from road reserves within the district councils of Ceduna and Le Hunte, and the County of Hopetoun (Hundreds of Sturdee and Caldwell).

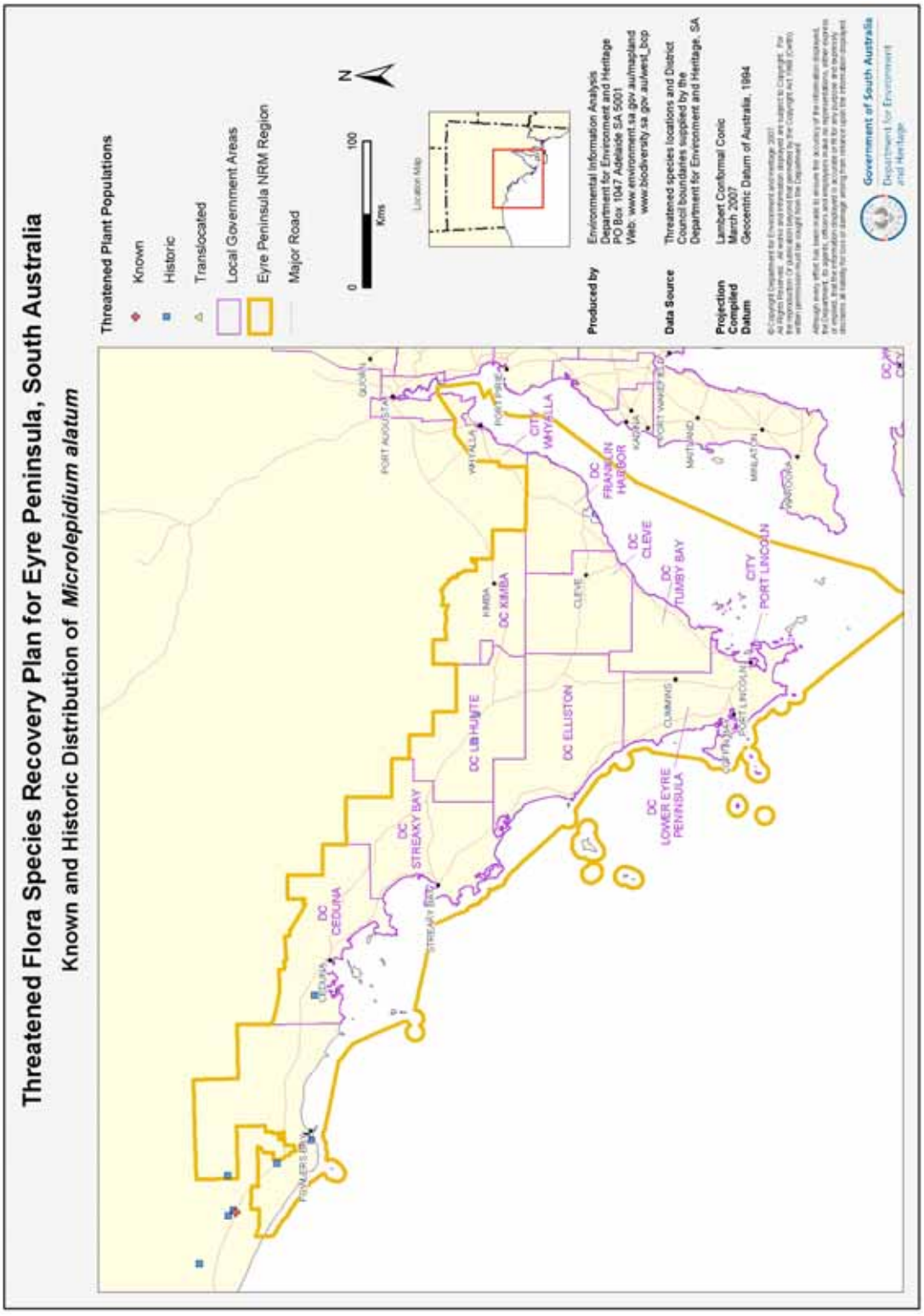
16.3 Habitat critical to survival

All known habitat of *Microlepidium alatum* is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Microlepidium alatum occupies topography ranging from elevations of 60 m above sea level near Wudinna at the southern extent of the species range to 110 m above sea level in the north. Microlepidium alatum grows in protected areas, often moss beds, predominantly located on the southern, shaded side of vegetation.

The only known soil description for M. alatum is light brown/white sandy loam soils over sheet limestone. This was recorded from one sub-population on Eyre Peninsula (DEH Recfind file 40/A24477).



Note: *Microlepidium alatum* details are held on internal DEH files and are available on request.

Figure 16.1. Distribution of *Microlepidium alatum* on Eyre Peninsula

Vegetations associations

Apart from growing in association with moss beds, *M. alatum* grows in semi-arid habitats (Black 1986) in *Melaleuca lanceolata* open-woodland with mixed *Chenopod* and *Eremophila* shrubland (A Freebairn [DEH] 2004, pers. comm.). DEH-EGIS (2006) still requires detailed vegetation descriptions for the majority of areas associated with *Microlepidium alatum* (Table 16.2).

Table 16.2. Vegetation associated with *Microlepidium alatum*

Primary species	Secondary species	Understorey species
Roadside near Fowlers Bay Conservation Park *Acacia* sp. Winged (CR Alcock 4936)	+/- Coast Daisy-bush (*Olearia axillaris*), +/- Sheep Bush (*Geijera linearifolia*) mid open shrubland	+/- Spinifex (*Triodia compacta*), +/- Southern Sea-heath (*Frankenia pauciflora* var. *fruticulosa*) low shrubs
Near Wudinna Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*), Dumosa Mallee (*E. dumosa*), +/- Nundroo Mallee (*E. calcareana*), +/- Beaked Red Mallee (*E. socialis*) mid mallee woodland	Dryland Tea-tree (*Melaleuca lanceolata*), Broombush (*M. uncinata*) tall shrubs	Black Grass Saw-sedge (*Gahnia lanigera*), +/- Spinifex (*Triodia irritans*) low sedges

Climate

Microlepidium alatum inhabits the 400-500 mm rainfall zone. Mean annual rainfall in the vicinity of the northern range of *M. alatum* is 292.1 mm at Fowlers Bay. Mean annual maximum and minimum temperatures are 22.6 °C and 10.5 °C respectively. Mean annual rainfall for Minnipa, at the southern most extent of *M. alatum* range, is 327.3 mm and mean annual maximum and minimum temperatures are 24 °C and 10.9 °C respectively.

Known populations within reserves

Microlepidium alatum has been recorded within the South Australian reserve system (Table 16.3).

Table 16.3. *Microlepidium alatum* sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Fowlers Bay Conservation Park	1	A Freebairn and M Horgan 2001
Yellabinna Regional Reserve	Unknown	AG Spooner 1972

Benefits to other species

The conservation of *Microlepidium alatum* is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data is expected to benefit other plant species growing in association with *M. alatum*, particularly those species within such limited niches, and with similar life forms, flowering response and/or pollinator needs.

16.4 Biology and ecology

Microlepidium alatum is a small, annual herb that grows to 20 cm tall (Hewson 1986). Growth form is variable and related to rainfall. Plants vary from spreading to erect, stout and rigid, and are rarely branched (Hewson 1986). Herbarium records show that plants can reach 20 cm in height; however, during the 2001 field season plants averaged 3-5 cm

in height (A Freebairn [DEH] 2001, pers. comm.). Plants are glabrous with basal leaves that are obovate to 20 mm long and upper leaves to 150 mm long.

Flowering varies with seasonal rainfall, but generally occurs during August and September (Hewson 1986). *Microlepidium alatum* has small flowers, which develop into winged fruit 4-5.5 mm long, containing seeds 0.8-1 mm long (Hewson 1986).

Pollination, germination and fire response of *M. alatum* is unknown and requires further study.

16.5 Previous management actions

Table 16.4. Previous management actions to conserve *Microlepidium alatum*

	Previous management actions
2001	Surveys undertaken by A Freebairn to check historic locations of *Microlepidium alatum* in Eyre Peninsula's Far West. Populations were successfully located at only two of the historical locations (Fowlers Bay Conservation Park and on the Yalata Aboriginal Lands, east of the Yalata community). The record for a site at Yalata named Bright Well was not re-located, even following consultation with the Land Management Supervisor for the Yalata Aboriginal community.

16.6 Threats to *Microlepidium alatum* and associated recovery goals

The long-term goals are to down-list *Microlepidium alatum* conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise *M. alatum* conservation status at Vulnerable.

Microlepidium alatum has been identified as a Priority 3 species based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that may be sensitive to fire and disturbance (Appendix I).

Table 16.5 details the key threats and summarises performance criteria relevant to *M. alatum* recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 16.5. Key threats to *Microlepidium alatum* and summary of associated performance criteria

Direct threat: **Habitat fragmentation**	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate *Microlepidium alatum* sub-populations may have low genetic variability and gene flow because of their small population size, isolation and environmental stresses.	High
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate Competition and out-placement by weeds is a threat to *M. alatum* surviving in highly fragmented habitat. Highly invasive weed species pose the biggest threat to space and nutrients of small annual herbs like *M. alatum*. Wards Weed (*Carrichtera annua*) is invading *M. alatum* habitat (A Freebairn [DEH] 2004, pers. comm.) and other weeds, such as Bridal Creeper (*Asparagus asparagoides*), African Boxthorn (*Lycium ferocissimum*) and weedy grasses, are all suspected as being highly probable invaders of *M. alatum* habitat.	High
Direct threat and knowledge gap: Inappropriate disturbance regimes	
Risk: Localised species extinction and degradation of critical habitat from inappropriate disturbance regimes **Likelihood:** Likely **Consequence:** Moderate Inappropriate disturbance regimes have the potential to threaten *M. alatum* and undermine recovery actions. Disturbance of moss beds through vehicle access and stock trampling are identified threats to *M. alatum* (A Freebairn [DEH] 2004, pers. comm.). Although *M. alatum* germination and recruitment requirements are unknown, it is assumed that disturbance of the moss bed habitat would be deleterious to *M. alatum* reproductive success and modify micro-habitat making it unsuitable for *M. alatum* colonisation.	High
Direct threat: High grazing pressure	
Risk: Loss of plants and seed source with a high potential to cause population decline **Likelihood:** Likely **Consequences:** Moderate Being an annual herb species, *M. alatum* is assumed to be highly palatable to stock, feral and native herbivores alike.	High
Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Possible **Consequences:** Minor Roadside management and maintenance is a threat to *M. alatum* if not carried out appropriately. Roadside Vegetation Management Plans need ensure roadside *M. alatum* sub-populations are known to all operational staff so that no species of national environmental significance is put in jeopardy. *Microlepidium alatum* was recorded in a parking bay approximately 6 km south east of the Yalata roadhouse and, although this site was highly disturbed, the moss beds were generally undisturbed (A Freebairn [DEH] 2004, pers. comm.).	Moderate

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.3 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.4 3f.5 3b.1 3f.8 3d.2 3d.3 3f.1 3f.4	4b.3	5a.6 5b.2

16.7 Main reference

Hewson, H 1986, 'Cruiferae (Brassicaceae)', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part I: Lycopodiaceae-Rosaceae,* South Australian Government Printer, Adelaide.

17 Silver Daisy-bush *Olearia pannosa* ssp. *pannosa* | Hook

17.1 Status

When assessing Eyre Peninsula Silver Daisy-bush vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 17.1). Silver Daisy-bush is however recognised as Vulnerable at the Regional, State and National levels (Table 17.1).

Table 17.1. Silver Daisy-bush vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	2208		
Area of occupancy (km²)	0.1175		
Sub-populations	18		
Estimated # of individuals	1150		
IUCN Criteria	**Justification**		
EN B1	Extent of occurrence estimated to be less than 5000 km² on Eyre Peninsula		
EN B1a	Severely fragmented populations on Eyre Peninsula		
EN B1a,b(iii)*	Continuing decline inferred in area, extent and quality of habitat on Eyre Peninsula		

17.2 Distribution

Silver Daisy-bush (also known as Silver Leaf Daisy-bush) occurs in the Flinders Ranges, Northern Lofty, Murray (Obst 2005), Yorke Peninsula (Steed 2002), Southern Lofty and South-East regions of South Australia, and also occurs in Victoria and New South Wales.

Sub-populations on Eyre Peninsula have an extent of occurrence of over 2200 km², occurring within latitude 33°24'35" to longitude 136°42'40" (northern extent), and latitude 36°36'20" to longitude 135°43'35" (southern extent) (DEH-EGIS 2006). The sub-populations can be described as occurring in two geographically separate areas (Figure 17.1); however, this is not yet based on any genetic information:

- northern sub-populations: Cleve Hills to Coolanie Range area, north-west of Cowell
- southern sub-populations: Koppio Hills and Greenpatch area, Lower Eyre Peninsula.

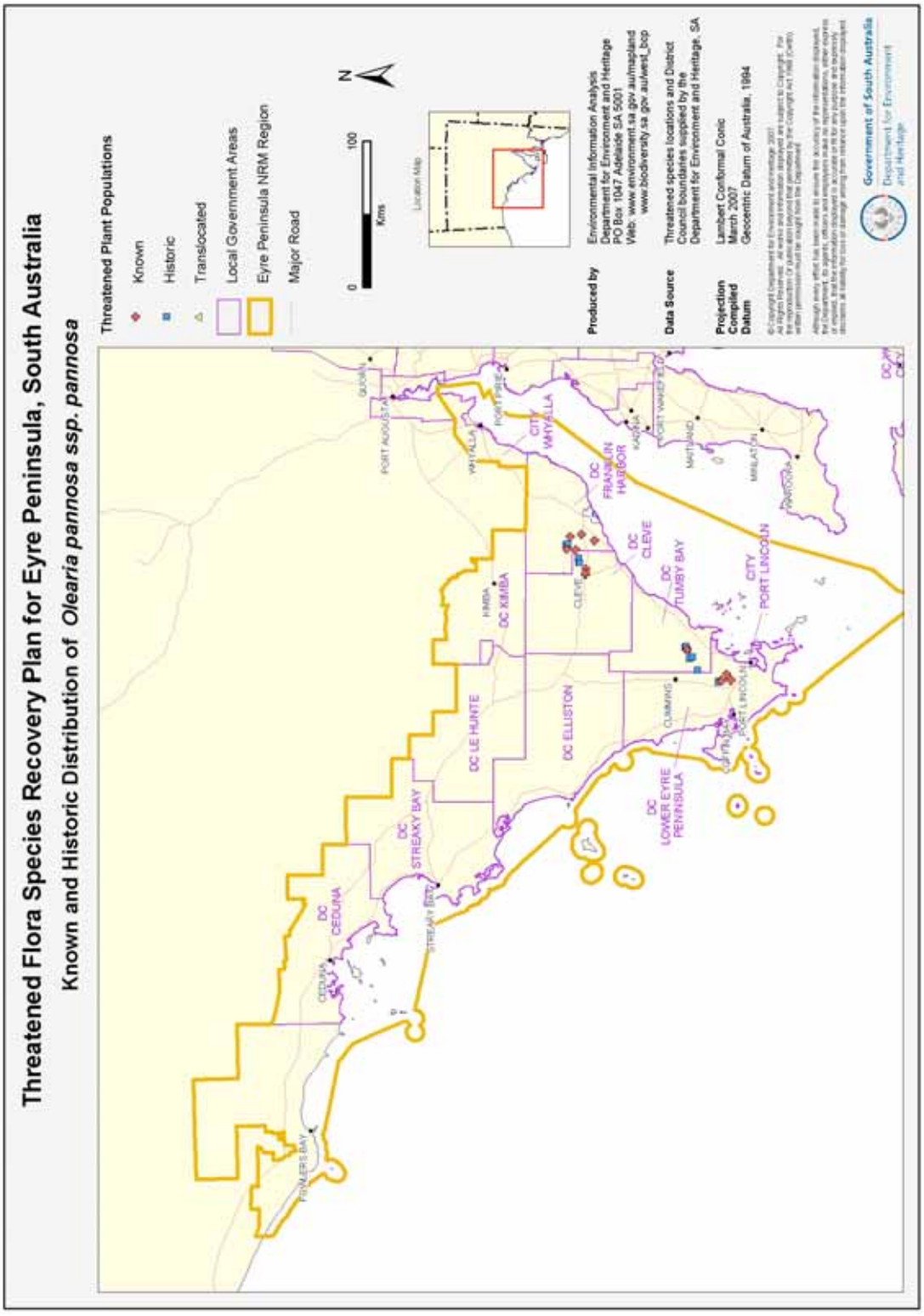
Silver Daisy-bush sub-populations are known to occur within roadside reserves managed by SA Water (south of Yeldulknie Conservation Park), and the district councils of Franklin Harbour and Tumby Bay. It is highly likely that this species may exist within roadsides in the District Council of Cleve.

17.3 Habitat critical to survival

All known habitat of Silver Daisy-bush is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Silver Daisy-bush grows on hill slopes in association with hard pedal mottled-yellow duplex soils and hard pedal red duplex soils (Laut et al. 1977). Northern sub-populations occupy topography ranging from 140-300 m, whereas southern sub-populations occupy a broader and higher topographic range of 30-510 m above sea level.



Note: Silver Daisy-bush details are held on internal DEH files and are available on request.

Figure 17.1. Distribution of Silver Daisy-bush on Eyre Peninsula

Vegetation associations

Silver Daisy-bush is found in mallee, woodlands and forest communities (Black 1977; Obst 2005). Surveys within the Hundreds of Wanilla, Cleve and Hawker recorded Silver Daisy-bush growing in association with Sugar Gum (*Eucalyptus cladocalyx*), Drooping Sheoak *(Allocasuarina verticillata*), Broombush *(Melaleuca uncinata*), Rock wattle (*Acacia rupicola*) and *Xanthorrhoea* sp., with native grasses and litter, and at one site with native pine (*Callitris* sp.) (DEH Recfind file 40/ A248477). Associated vegetation communities listed in Table 17.2 and 17.3 have been sourced from DEH-EGIS (2006).

Table 17.2. Vegetation associations of northern Silver Daisy-bush sub-populations

Primary species	Secondary species	Understorey species
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	Coastal Daisy-bush (*Olearia axillaris*), Coastal Beard-heath (*Leucopogon parviflorus*), Dryland Tea-tree (*Melaleuca lanceolata*) tall shrubs	+/- Coastal Velvet-bush (*Lasiopetalum discolor*) low shrubs
Peppermint Box (*Eucalyptus odorata*), +/- *E. phenax* mid mallee woodland	Broombush (*Melaleuca uncinata*) mid shrubs	Bearded Oat (**Avena barbata*), +/-Slender Velvet-bush (*Lasiopetalum bauerii*) mid tussock grasses over +/-Broad-leaf Raspwort (*Gonocarpus mezianus*)
Mallee Box (*Eucalyptus porosa*) mid open mallee woodland	Open	*Austrostipa* sp., Scented Mat-rush (*Lomandra effusa*), Satin Everlasting (*Helichrysum leucopsideum*), Fireweed Groundsel *(Senecio pinnatifolius)* and tussock grasses
Open	Broombush (*Melaleuca uncinata*) tall open shrubland	Silver Broombush (*Babingtonia behrii*), +/- Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs over +/- Spinifex (*Triodia irritans*), +/- Guinea-flower (*Hibbertia* sp.) (DJ Whibley 9012)
Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland	Broombush (*Melaleuca uncinata*) tall shrubland and Ribbed Thryptomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland	Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*), Half-beard Spear-grass (*Austrostipa hemipogon*)

Climate

Silver Daisy-bush inhabits the 400-500 mm rainfall zone (DEH-EGIS 2006). Mean annual rainfall for the Tod Reservoir, central to the southern Silver Daisy-bush sub-populations, is 485.3 mm, with a mean annual temperature of 20.9 °C maximum and 9.6 °C minimum (BOM 2007). The northern-most Silver Daisy-bush sub-populations, close to and north of Cleve, could be expected to experience a climate similar to Cleve, with mean annual maximum and minimum temperatures of 22 °C and 11.3 °C respectively, and a mean annual rainfall of 400.8 mm.

Table 17.3. Vegetation associations of southern Silver Daisy-bush sub-populations

Primary species	Secondary species	Understorey species
Sugar Gum (*Eucalyptus cladocalyx)* mid woodland	+/- Golden Wattle (*Acacia pycnantha* over Rock Wattle (*Acacia rupicola*), +/- Yacca (*Xanthorrhoea semiplana*), +/- Broombush (*Melaleuca uncinata*) mid shrubs	Peach Heath (*Lissanthe strigosa* ssp. *subulata)*, Small-flower Wallaby-grass (*Austrodanthonia setacea*) low shrubs over Broad-leaf Raspwort (*Gonocarpus mezianus*), and Coarse Lagenophora (*Lagenophora huegelii*)
Coast Ridge-fruited Mallee (*Eucalyptus angulosa),* Narrow-leaf Red Mallee (*E. leptophylla*), +/- White Mallee (*E. dumosa* complex), +/- Yorrell (*E. gracilis*) mid mallee woodland	Open	Open
Slender Honey-myrtle (*Melaleuca gibbosa*), Short-leaf Honey-myrtle (*M. brevifolia*), +/- Scarlet Bottlebrush (*Callistemon rugulosus*), +/- Dwarf Hakea (*Hakea rugosa*) mid shrubland	Broombush (*Melaleuca uncinata*), *Hakea mitchellii,* Heath tea-tree *(Leptospermum myrsinoides)*	Open
Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*), +/- Peppermint Box (*E. odorata*) low open forest	Open	Open

Known populations within reserves

Silver Daisy-bush is located within the South Australian reserve system (Table 17.4). The species also grows within Crown land at Ticklebelly Hill in Cleve, and within four Heritage Agreements on Eyre Peninsula.

Table 17.4. Silver Daisy-bush sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Wanilla Conservation Park	1	A Freebairn 2001; J Prider 2006
Wanilla Land Settlement Reserve	1	Not recorded
Middlecamp Hills Conservation Park	1	Pobke 2005

Benefits to other species

The conservation of Silver Daisy-bush habitat is expected to produce broader biodiversity benefits for the Eyre Peninsula Yellow-tailed Black-cockatoo (*Calyptorhynchus funereus*) (state Vulnerable, regionally Endangered on Eyre Peninsula) and Common Brushtail Possum (*Trichosurus vulpecula*) (state Vulnerable, regionally Rare on Eyre Peninsula). These two state threatened fauna species inhabit the same Sugar Gum (*Eucalyptus cladocalyx*) woodland habitat as Silver Daisy-bush (Way & Bates 2005). Sugar Gum woodland communities are only known in four sub-populations on Eyre Peninsula and are considered regionally threatened (DEH 2002). The nationally Vulnerable Winter Spider-orchid (*Caladenia brumalis*) also shares overlapping habitat with Silver Daisy-bush (DEH Recfind file 40/A248477).

17.4 Biology and ecology

Silver-Daisy-bush is a perennial, low spreading shrub, which can grow up to 1.5 m tall (Cooke 1986). It is closely related to the Velvet Daisy-bush (*Olearia pannosa*), which is known to be a long-lived species, with some plants suspected of being over 100 years old (Cropper 1993). Silver Daisy-bush gets its common name from the visual appearance of its leaves. Mature leaves are shiny green on the top and have a distinct white/cream/pale rusty-brown coloured, soft, velvet texture (tomentose) on the underside of leaves (Cooke 1986).

Flowering occurs from August to October. Flowers have a typical daisy appearance with distinctive ray florets. Flowers are usually white, but can be found in pale mauve, although this is rare (Cooke 1986). Ray florets are 12-24 mm wide and 20-30 mm long. The flowering head (capitula) grows on a solitary terminal and on the upper leaf axils on 15-22 mm long flower stalks (peduncles).

Olearia species are generally known to be self-infertile and must be cross-pollinated by insects (Schaumann, Barker & Greig 1987). Pollination of Silver Daisy-bush on Eyre Peninsula is unconfirmed and requires further study.

Seeds have pappus (fine, feathery hairs), which are thought to aid seed dispersal by acting as a parachute carried on the wind. The closely related Velvet Daisy-bush also has a heavy achene (one-seeded fruit) in relation to the pappus (Bartley 1990). This results in most fruits being dispersed within a 3 m radius of the parent plant, giving the species limited ability to disperse. Natural populations of Silver Daisy-bush are known to have poor seed set rates (A Freebairn [DEH] 2005, pers. comm.; Obst 2005).

Germination of Eyre Peninsula sub-populations to date is unobserved and unstudied. Silver Daisy-bush has however been successfully propagated by the nursery industry in South Australia and used in an unknown number of revegetation programs within the Murray region (Obst 2005) and anecdotally on properties on the Eyre Peninsula (K Pobke [DEH] 2006, pers. comm.). Studies of Victorian Velvet Daisy-bushes found that only 0.6-7.7% of fruits contained germinal seed, and fruits were often damaged by insect predation (Bartley 1990). *Asteraceae* (daisy) species are known to form associations with mycorrhiza, especially in nutrient poor soils (Schaumann, Barker & Greig 1987). Bartley (1990) found that newly germinated Velvet Daisy-bushes could produce tuberous roots at two months old, but were slow with initial shoot growth. It is unknown if Silver Daisy-bush can also produce tubers at such a young age.

La Trobe University researchers discovered Silver Daisy-bush reproduces by suckers along a thick stem (Cropper 1993). Suckering plants are genetic clones of their parent plants. Soil, litter and vegetation often cover the underground or near-ground stem. Numbers of individuals, in particular seedlings, are therefore frequently overestimated in population counts. It is difficult to determine how many actual individuals are present without disturbing plants or conducting genetic analyses.

Silver Daisy-bush has been observed re-sprouting vegetatively from rootstock of burnt adult plants (K Pobke [DEH] 2005, pers. observation). The same plants flowered in the first season post-fire, something that was not expected until the second or third season (M Jusaitis [DEH] 2005, pers. comm.). These observations strengthen Bartley's (1990) assumptions of how dormant axillary vegetative buds in mature plants would respond to damage from fire or grazing. Silver Daisy-bush was found to resprout from basal mersistems at sub-populations burnt in the 2005 Wangary bushfire (Ecological Associates 2007). The short, 2 year preliminary monitoring results show no clear indication that fire increases recruitment (i.e. new seedlings); however, there was anecdotal evidence that more sub-populations were found post-fire (Ecological Associates 2007; DEH Recfind file 40/1488). In a similar example, the Velvet Daisy-bush (*Olearia pannosa*) has seedlings that grow substantial underground storage structures very early in their life cycle (Bartley 1990).

Related species

Silver Daisy-bush is closely related to the following two species (Black 1977):

- Silver-leaved Daisy or Velvet Daisy-bush (*Olearia pannosa*), which has a distribution in South Australia, New South Wales and Victoria
- Velvet Daisy-bush (*Olearia pannosa* subsp. *carophylla*), which only occurs in the Mount Remarkable area of South Australia.

17.5 Previous management actions

Table 17.5. Previous management actions to conserve Silver Daisy-bush

	Previous management actions
2001	Formal confirmation of Silver Daisy-bush on Section 404 in the township of Cleve, now known as the Ticklebelly Hill site. In 2001, it was estimated that 200 individuals existed on the Ticklebelly Hill site (DEH Recfind file 40/1488).
2001	Conservation biology student Annabelle Bushell worked with Anthony Freebairn on Silver Daisy-bush recovery project.
2001	Silver Daisy-bush community awareness raising article was printed in the winter edition of the local newsletter *The Long Run*, as part of the 'Unusual Suspects' series (author A Freebairn) (DEH Recfind file 40/1488).
2002	Silver Daisy-bush Ticklebelly Hill site fenced by 13 Cleve Area School students and two Cleve District Council employees. The protection of the Ticklebelly Hill site involved the Australian Plant Society, Landcare, Department for Environment and Heritage, Future Directions, Animal Plant and Weed Control Board, the Cleve District Council and agriculture students from Cleve Area School (associated media in the Eyre Peninsula Tribune during 2002).
2002	Monitoring sites established at the Ticklebelly Hill site in conjunction with year 10 students from Cleve Area School.
2005-07	Ecological Associates Pty Ltd contracted to DEH on 14th Dec 2005 to undertake Monitoring of vegetation response following the Lower Eyre Peninsula bushfire. One of the species assessed was Silver Daisy-bush (DEH Recfind file 40/1185). Monitoring and assessments concluding June 2007.
2006	Signage installed at Ticklebelly Hill site to increase awareness of plant species on the site, in particular the Silver Daisy-bush. Signs were funded by the Australian Government's Natural Heritage Trust through the Eyre Peninsula Natural Resources Management Group as part of the Ark on Eyre project (DEH Recfind file 40/A142070).
2006	During the 2006 drought, Silver Daisy-bushes on private property were observed dropping leaves, dying back, and appearing stressed from lack of soil moisture, even more so than seen in previous years (D DeLaine [PIRSA] 2006, pers. comm.).

17.6 Threats to Silver Daisy-bush and associated recovery goals

The long-term goals are to down-list Silver Daisy-bush conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Silver Daisy-bush conservation status at Vulnerable.

Silver Daisy-bush has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 17.6 details the key threats and summarises performance criteria relevant to Silver Daisy-bush recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 17.6. Key threats to Silver Daisy-bush and summary of associated performance criteria

Direct threat: High grazing pressure, Pest and Disease *(Phytophthora*)	
Risk: Loss of juveniles, developing seed heads and adult plants. Impact on population life class structure, decreases in viable seed yield, and increases in plant stress resulting in long-term population decline **Likelihood:** Almost certain **Consequence:** Moderate Grazing by domestic livestock is thought to have restricted Silver Daisy-bush growth and recruitment on private property (A Freebairn [DEH] 2004, pers. comm.; S Bey [Greening Australia] 2005, pers. comm.). Plants are often found growing in areas where grazing has been restricted or paddocks spelled from livestock grazing for extended periods. Silver Daisy-bush populations on Eyre Peninsula produce viable seed, although most recruitment is thought to be from suckering of mature plants (A Freebairn [DEH] 2004, pers. comm.). However, insects have been observed to predate up to 90% of seed from populations in both the southern and northern Eyre Hills IBRA subregion over two seasons (A Freebairn [DEH] 2004, pers. comm.). *Corticaria japonica* beetles have been identified at Silver Daisy-bush sites and are known to eat surface moulds on seeds (E Matthews [South Australian Museum], 2001 pers. comm.). *Corticaria* sp. beetles have also been recorded on Victorian Velvet Daisy-bushes (Bartley 1990). Bartley (1990) reports the beetles appear to eat rotting infertile ovules or shrivelled seed tissue from undeveloped Velvet Daisy-bush fruits, rather than the healthy tissue. *Phytophthora* has the potential to threaten Silver Daisy-bush sub-populations, critical habitat and affect species survival (Velzeboer et al. 2005). The species currently falls within the Moderate Risk Management Zone.	Extreme
Direct threat and knowledge gap: Small population/lack of recruitment	
Risk: Species sub-populations become smaller than the minimum viable population limit **Likelihood:** Likely **Consequence:** Major Silver Daisy-bush is a clonal species and therefore it is difficult to gauge population size and genetic fitness. Seemingly healthy populations may be threatened by limited gene pool. This concern is reiterated by Schaumann, Barker and Greig (1987) who state that small populations of *Olearia* probably rely on cross-pollination and are at risk of slow decline because of a small gene-pool. Recovery effort requires information on population genetics and population modelling to assist in reducing this threat.	Extreme
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Almost certain **Consequences:** Moderate Roadside sub-populations in particular are threatened by weed encroachment. This is also the case with Yorke Peninsula Silver Daisy-bush sub-populations (Steed 2002). Bridal Creeper is a major threat (A Freebairn [DEH] 2004, pers. comm.). In the Koppio Hills, Aleppo Pines have the potential to out-compete Silver Daisy-bush (Way 2006). Weeds controlled at the Ticklebelly Hill site included Aleppo Pines, Bridal Creeper, Gazanias, African Box Thorn and Sour Sobs.	Extreme
Direct threat: Habitat fragmentation	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate Land clearance and grazing has caused fragmentation of Silver Daisy-bush populations. These remaining populations may have low genetic variability because of their small size and isolation from each other, e.g. inbreeding can lead to decreased seed production and viability.	High

Direct threat and knowledge gap: **Inappropriate fire and disturbance regimes**	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire and disturbance from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires and inappropriate disturbance severity is experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Silver Daisy-bush relies on some disturbance. In Victoria, the species has colonised previously logged sites (Cropper 1993). Increased light availability following fire appears to encourage germination. A similar response to fire has been observed among many *Olearia* species (Cropper 1993). 2005 Wangary fire results.	**High**
Direct threat: Roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Possible **Consequences:** Moderate Silver Daisy-bush sub-populations are known to occur within roadside reserves managed by SA Water (south of Yeldulknie Conservation Park), and the district councils of Franklin Harbour and Tumby Bay. It is highly likely that this species may occur within roadsides in the District Council of Cleve.	**High**

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**		Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.1 1b.1 1c.1 1c.2 1c.4 1c.5 1d.1 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.2 3a.4 3b.1 3b.2 3c.2 3d.1 3d.2 3d.3	3f.1 3f.2 3f.4 3f.6 3f.7 3f.8	4b.1 4b.3 4b.4 4b.5 4b.6 4c.2 4e.1 4h.1	5a.4 5a.7 5a.8 5a.9 5a.10 5b.2

17.7 Main references

Bartley, MJ 1990, 'Notes on fruit condition, germinability and seedling morphology of *Olearia pannosa* Hook (Velvet Daisy-bush)', *The Victorian Naturalist*, vol. 107.

Cooke, DA 1986, 'Compositae (Asteraceae)', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

Cropper, S 1993, *Management of endangered plants*, CSIRO Publications, Australia.

Steed, Y 2002, *Threatened Plant Action Group site action plan* Olearia pannosa *ssp.* pannosa *Silver-leaved daisy bush, Roadside populations near Pt. Vincent*, Threatened Plant Action Group, Adelaide.

18 Nodding Rufous-hood P*terostylis* aff. *despectans* syn. *Oligochaetochilus mirabilis* DL Jones

18.1 Status

When assessing Nodding Rufous-hood vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 18.1). This is important given that this species only occurs on Eyre Peninsula. Nodding Rufous-hood is however recognised as Vulnerable at the Regional, State and National levels (Table 18.1).

Table 18.1. Nodding Rufous-hood vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	197.7		
Area of occupancy (km²)	0.08	Endemic to Eyre Peninsula	
Sub-populations	4		
Estimated # of individuals	220		
IUCN Criteria	**Justification**		
CR C2	Population size estimated to number fewer than 250 mature individuals		
CR C2b	Continuing decline and extreme fluctuations in number of mature individuals		

18.2 Distribution

Nodding Rufous-hood (*Pterostylis* aff. *despectans* syn. *Oligochaetochilus mirabilis*) only grows on Eyre Peninsula. It has an extent of occurrence of approximately 190 km² (Figure 18.1) and grows within latitude 33°9'94"S to longitude 136°31'55"E (Kelly) in the north, and latitude 33°36'53"S to longitude 136°48'34"E (Coolanie Valley) in the south (DEH-EGIS 2006). This distribution area spans the district councils of Kimba and Franklin Harbour.

Nodding Rufous-hood was recently described as *Oligochaetochilus mirabilis*; however, the State Herbarium of South Australia currently recognises it as *Pterostylis* aff. *despectans* (Jones 2007).

18.3 Habitat critical to survival

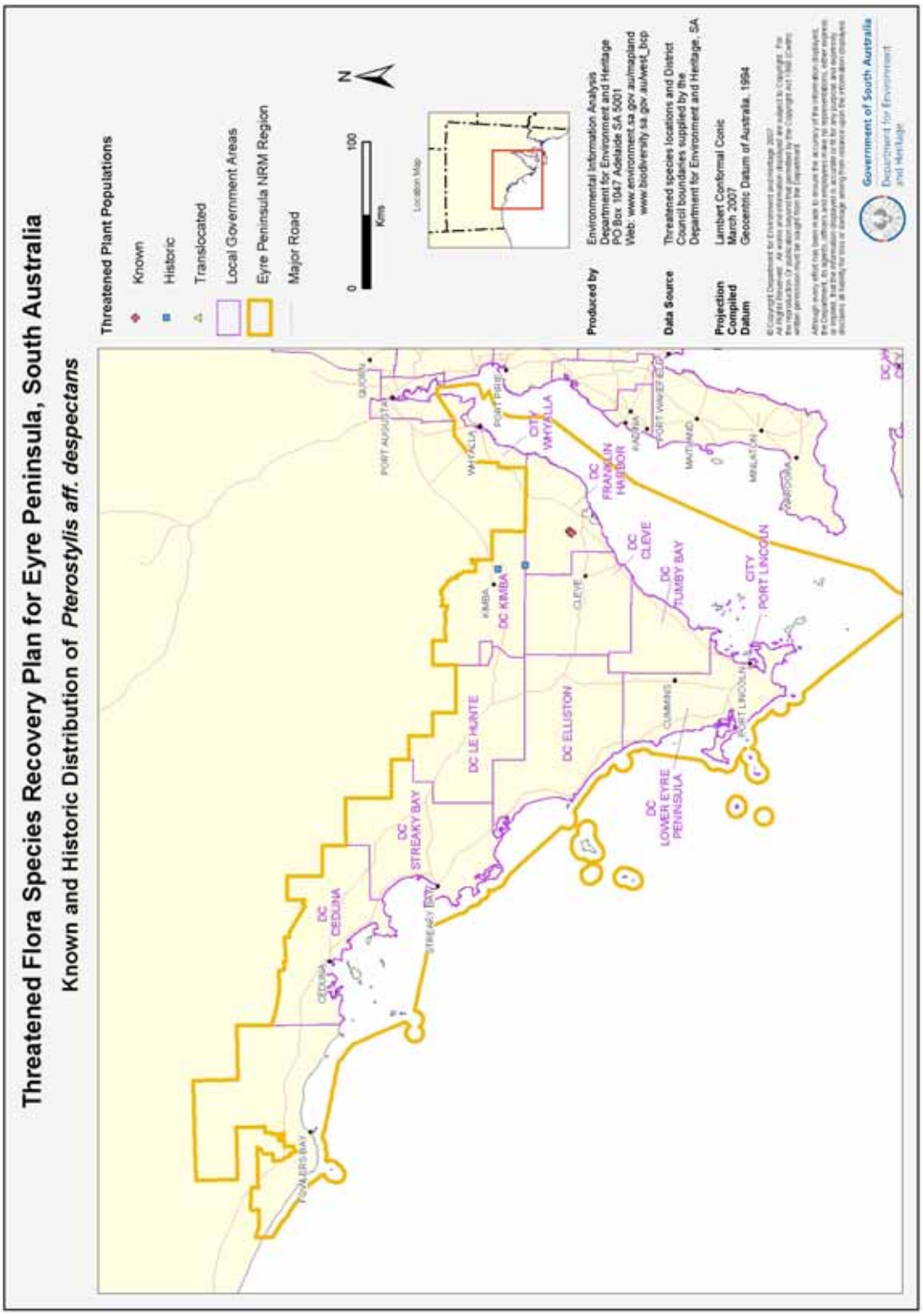
All known habitat of Nodding Rufous-hood is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Nodding Rufous-hood grows within the Messenger Land System, on quartzite strike ridges with dense brown loams (Laut et al. 1977). The orchid species has also been recorded growing in rocky soil of mallee heathland (Bates & Weber 1990) and stony brown loams (Bates 2006).

Vegetation associations

Nodding Rufous-hood grows in association with Broombush (*Melaleuca uncinata*), native pine *(Callitris* sp.) and Eucalypt Woodlands (Bates 2006). No ground truthed information detailing species assemblage has been recorded. The following vegetation associations (Table 18.2) are therefore sourced from DEH-EGIS (2006).



Note: *Pterostylis* aff. *despectans* 'Eyre Peninsula' details are held on internal DEH files and are available on request.

Figure 18.1. Distribution of Nodding Rufous-hood on Eyre Peninsula

Table 18.2. Vegetation associated with Nodding Rufous-hood sub-populations on Eyre Peninsula

Primary species	Secondary species	Understorey species
Broombush (*Melaleuca uncinata*) tall open shrubland. Occasionally with *Eucalyptus* sp. overstorey (A Freebairn [DEH] 2004, pers. comm.).	Silver Broombush (*Babingtonia behrii*),+/- Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs	+/- Spinifex (*Triodia irritans*), +/- *Hibbertia* sp. *glabriuscula*
Eucalyptus sp. including Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland over Broombush (*Melaleuca uncinata*) tall shrubland	Ribbed Thryptomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland	Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*), Half-beard Spear-grass (*Austrostipa hemipogon*)

Climate

Nodding Rufous-hood inhabits the 300 mm rainfall zone (DEH-EGIS 2006). The mean annual rainfall at nearby Mangalo is 346.2 mm.

Known populations within reserves

Nodding Rufous-hood is not known within the Eyre Peninsula reserve system.

Benefit to other species

The conservation of Nodding Rufous-hood is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data is expected to benefit other plant species growing in association with the orchid, particularly those species within similar dryland habitats, and with similar life forms, flowering response and/or pollinator needs.

18.4 Biology and ecology

Nodding Rufous-hood is a dwarf orchid species growing to 10 cm high. Its leaves form a basal rosette that withers prior to flowering (Bates & Weber 1990). There are one to several flowers (Bates 2006), which open in sequence on long decurved pedicels.

Flowering occurs between October and early January. It is this late flowering period that makes Nodding Rufous-hood distinguishable from other orchids, because most co-occurring greenhoods/rufous-hoods flower much earlier in the season. Pollination is unconfirmed; however, it is likely to be aided by flies (Bates 2006). It is not known if the orchid provides any nectar or rewards to pollinators.

Seed development, dispersal, germination, and post-fire and soil disturbance response are unknown and require further study.

18.5 Previous management actions

Table 18.3. Previous management actions to conserve Nodding Rufous-hood

	Previous management actions
2001-03	Original surveys by R Bates in 1985 and 1987 (near Kimba) and by P Bell in 1985 (Carpee Puntha Hill).
2000	Revisit surveys to all historical locations conducted by A Freebairn. Survey data located in DEH Recfind File 40/1485. Twenty-three individuals noted.

18.6 Threats to Nodding Rufous-hood and associated recovery actions

The long-term goals are to down-list Nodding Rufous-hood conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Nodding Rufous-hood conservation status at Vulnerable.

Nodding Rufous-hood has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 18.4 details the key threats and summarises performance criteria relevant to Nodding Rufous-hood recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 18.4. Key threats to Nodding Rufous-hood and summary of associated performance criteria

Direct threat: Habitat fragmentation	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate	**Extreme**
Direct threat and knowledge gap: Small population/lack of recruitment	
Risk: Species sub-populations become smaller than the minimum viable population limit **Likelihood:** Possible **Consequence:** Moderate Nodding Rufous-hood populations may have low genetic variability because of their small population size. Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases. Inbreeding may also reduce the production or viability of seed, and the vigour of plants. However, seed set is generally good and recruitment is evident within known populations (A Freebairn [DEH] 2004, pers. comm.).	**High**
Direct threat: High grazing pressure	
Risk: Loss of orchid seeds from grazing of flowers and/or long-term accumulative reduction in plant health caused by grazing, resulting in population decline **Likelihood:** Likely **Consequence:** Moderate All known populations are located on private property and may be grazed by sheep perodically. The impact of sheep grazing on Nodding Rufous-hood is undetermined. These locations are also susceptible to rabbit grazing.	**High**
Direct threat: Inappropriate disturbance and fire regimes	
Risk 1: Localised species extinction and degradation of critical habitat from inappropriate disturbance and fire regimes **Risk 2:** Species (including soil seedbank) will become extinct due to exclusion of disturbance/fire from its critical habitat **Risk 3:** Species (including soil seedbank) will become locally extinct if too disturbance/frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Excessive trampling has the potential to directly damage the plants, e.g. plants fail to reach seed production stage or fail to set seed. Trampling will indirectly affect the survival of the species via soil surface disturbance, soil compaction and introduction of weeds. High densities of Nodding Rufous-hood were recorded growing in rolled vegetation, 2 years after rolling. However, where soil was most disturbed, Dandelion weeds had taken over (A Freebairn [DEH] 2000, pers. comm.). It is unknown what fire requirements this species may have.	**High**

Direct threat and knowledge gap: **Weed invasion**	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequences:** Moderate Cape Weed (*Arctotheca calendula*) invasion is extensive in populations occurring in Sections 11-14, Hundred of Miltalie. The extent of weed invasion at other sites has not been assessed since 2000.	**High**
Direct threat and knowledge gap: Spray drift	
Risk: Localised species extinction and degradation of critical habitat from herbicide drift **Likelihood:** Rare **Consequences:** Moderate The proximity of Nodding Rufous-hood sites to agricultural land suggests that agricultural spray drift may affect not only this species, but the insect pollinator/s of this species as well. Surveys in 2000 by Freebairn identified the potential threat of locust pesticide drifting into the orchid species' sites.	Moderate

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.3 3a.4 3b.1 3b.3 3c.1 3c.2 3d.2 3d.3 3f.1 3f.4 3f.8	4b.2 4b.4 4b.7 4c.2 4g.1	5a.5 5a.9 5b.2

18.7 Main references

Bates, R 2006, CD-ROM, South Australian native orchids, unpublished, Adelaide.

Bates, RJ & Weber, JZ 1990, *Orchids of South Australia*, South Australian Government Printer, Adelaide.

Bickerton, D & Robertson, M 2000, *Lowly Greenhood (*Pterostylis despectans*) 'Mt. Bryan' Recovery Plan*, Threatened Species Network, Threatened Plant Action Group, Adelaide, viewed 8 November 2007, <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/p-despectans/index.html>.

Jones, DL 2007, 'Two new species of *Oligochaetochilus* (Orchidaceae) from South Australia', *The Orchadian*, vol. 15, no. 9.

Quarmby, J 2006, *Recovery plan for twelve threatened orchids in the Lofty Block region of South Australia 2007-2012*, Department for Environment and Heritage, South Australia.

19 Mount Olinthus Greenhood *Pterostylis* 'Mt Olinthus' syn. *Oligochaetochilus* sp. 'Mt Olinthus' R Bates

19.1 Status

When assessing Mount Olinthus Greenhood vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 19.1). This is important given that this species only occurs on Eyre Peninsula. Mount Olinthus Greenhood is however recognised as Endangered at the Regional and State levels (Table 19.1). The species is not listed at the National level.

Table 19.1. Mount Olinthus Greenhood vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Endangered	Endangered	Nil
Extent of occurrence (km²)	58		
Area of occupancy (km²)	0.0025		
Sub-populations	2	Endemic to Eyre Peninsula	
Estimated # of individuals	approximately 100 (Bates 2006)		
IUCN Criteria	**Justification**		
CR B1	Extent of occurrence estimated to be less than 100 km²		
CR B1a	Known from a single location		
CR B1a,c(iv)	Extreme fluctuations in the number of mature individuals		

19.2 Distribution

Mount Olinthus Greenhood, also known as Mount Olinthus Rufous-hood, is endemic to Eyre Peninsula and is known from only two sub-populations (Figure 19.1) (Bates 2006; Jones 2006). The species has a very small extent of occurrence estimated to be just 58 km². It grows within latitude 136°47'51"S to longitude 33°34'37.26"E (Mount Olinthus) in the north-east (DEH-EGIS 2007), and latitude 136°10'42"S to longitude 33°29'5.50"E (near Darke Range Conservation Park) in the south-west (Bates 2006). All sub-populations are surrounded by agricultural land dominated by cropping and sheep grazing (A Freebairn [DEH] 2004, pers. comm.).

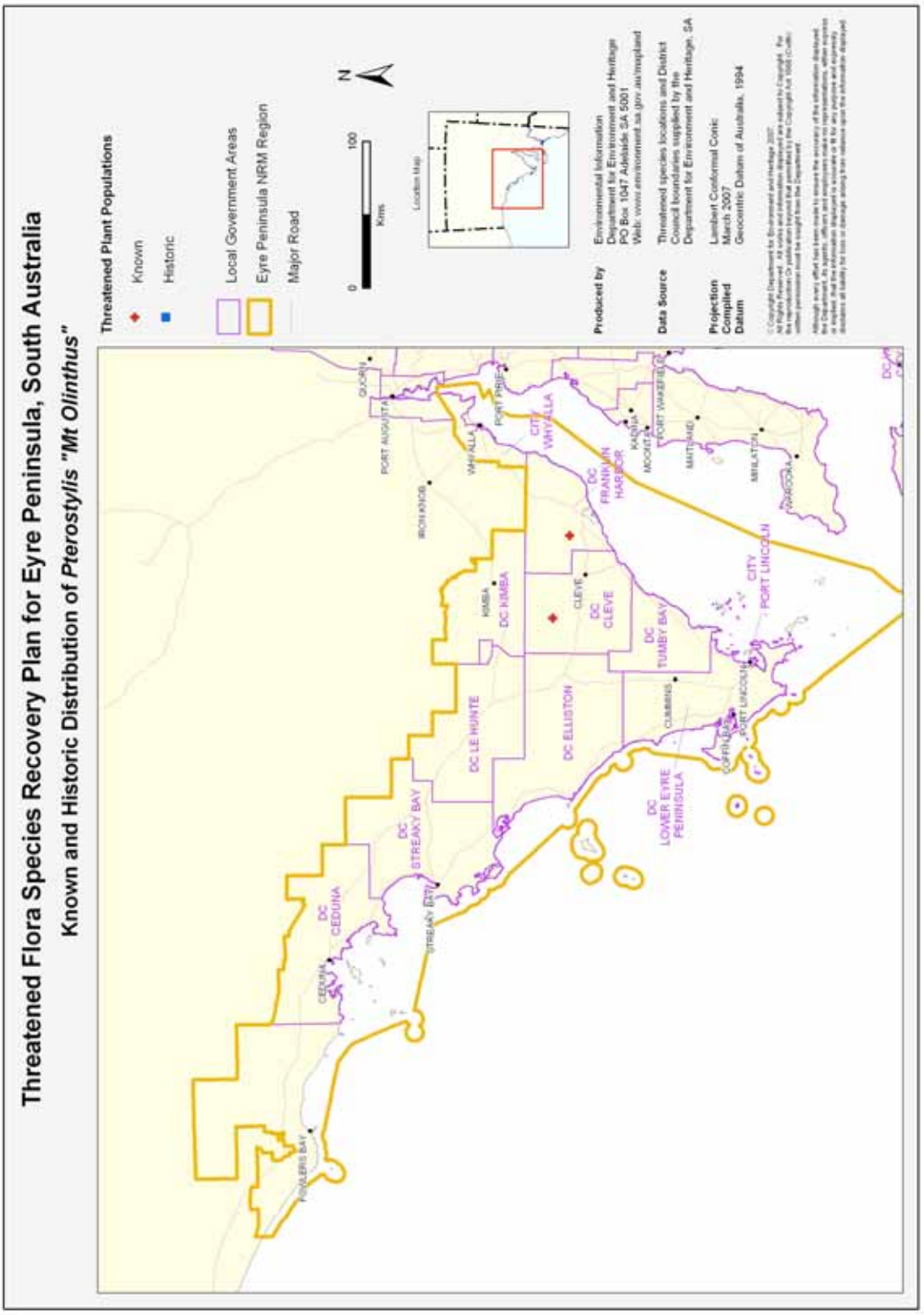
Both sub-populations grow on private property within the District Council of Franklin Harbour.

19.3 Habitat critical to survival

All known habitat of Mount Olinthus Greenhood is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Mount Olinthus Greenhood is known to occur on exposed ridge tops in shallow hard soils overlying quartz (Bates 2006). The Mount Olinthus sub-population grows on the summit ridge at 360 m above sea level (DEH-EGIS 2007).



Note: Mount Olinthus Greenhood details are held on internal DEH files.

Figure 19.1. Distribution of Mount Olinthus Greenhood on Eyre Peninsula

Vegetation associations

Vegetation associated with Mount Olinthus Greenhood is relatively undescribed, with Bates (2006) referring to a low shrubland association. The vegetation associations in Table 19.2 have been sourced from DEH-EGIS (2006).

Table 19.2. Vegetation associated with Mount Olinthus Greenhood sub-populations on Eyre Peninsula

Primary species	Secondary species	Understorey species
Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland	Broombush (*Melaleuca uncinata*) tall shrubland; Ribbed Thryptomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland	Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*) and Half-beard Spear-grass (*Austrostipa hemipogon*).

Climate

Mount Olinthus Greenhood inhabits the 300-350 mm rainfall zone (DEH-EGIS 2006). The Coolanie Ranges and Mount Olinthus would experience site differences in climate compared to the coastal town of Cowell (influenced by aspect and topography); however, Cowell has the nearest weather station. Therefore, as a guide, the Mount Olinthus Greenhood population could be expected to receive 279.9 mm mean annual rainfall (i.e. similar to Cowell).

Known populations within reserves

No known population of Mount Olinthus Greenhood is conserved within the South Australian reserve system.

Benefits to other species

The conservation of Mount Olinthus Greenhood is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data is expected to benefit other plant species growing in association with the orchid, particularly those species within such limited niches, and with similar life forms, flowering response and/or pollinator needs.

19.4 Biology and ecology

Mount Olinthus Greenhood is a tiny deciduous, perennial, terrestrial orchid. When in full flower it only grows to 15 mm tall. The orchid dies back to below ground tubers in summer and produces a leaf in late winter to early spring. Orchids have four to eight blue-green, ovate shaped leaves (40 mm long) arranged in a basal rosette. These basal leaves generally wither before the orchid flowers (Bates 2006).

Flowering usually occurs in late September until November. Each orchid has two to six flowers, which range from greenish-grey, or brown and white in colour. Flowers open one or two at a time (Bates 2006). The hood of the flower (galea) is curved and swollen at the base, with a free point to approximately 6 mm long. Each flower has two tonsils inside.

Pollination is unknown. Seed development and dispersal has not been studied. To date, germination is unobserved and unstudied, and the average longevity of a dormant Mount Olinthus Greenhood tuber is unknown.

Fire dependence triggers for this species are unknown and can only be assumed from the response of others in the genus.

Mount Olinthus Greenhood is similar to *Pterostylis* 'Griselda' (Flinders Ranges), *Pterostylis excelsa* syn. *Oligochaetochilus excelsa* and *Pterostylis* sp. 'Arkaroola' syn. *Oligochaetochilus* sp. 'Arkaroola' (Bates 2006). However, Mount Olinthus Greenhood can be distinguished from these species by its small stature, rigid flowers and anvil shaped labellum (Bates 2006).

19.5 Previous management actions

Table 19.3. Previous management actions to conserve Mount Olinthus Greenhood

	Previous managements actions
	Original surveys by R Bates and A Freebairn. Orchids individually tagged.
2000	Revisit surveys conducted by A Freebairn. Survey data located in internal DEH Recfind file 40/1481.
2003	Site visit to Mount Olinthus by P Hewstone and J Hutchinson on 9th November 2003. Other orchids seen at the site included *Pterosylis aff exelsa*, *P. xerophila*, *P. aff pusila and P. biseta*. In total, approximately 50 Mount Olinthus Greenhoods were recorded (P Hewstone 2005, pers. comm.).
2004	Mount Olinthus Greenhood site visited by K Pobke and A Freeman in a familarisation/project handover tour.

19.6 Threats to Mount Olinthus Greenhood and associated recovery goals

The long-term goals are to down-list Mount Olinthus Greenhood conservation status from State Endangered to State Vulnerable, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Mount Olinthus Greenhood conservation status at State Endangered.

Mount Olinthus Greenhood has been ranked as a Priority 3 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). It is suspected that the species may respond well to fire and disturbance (Appendix I).

Table 19.4 details the key threats and summarises performance criteria relevant to recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 19.4. Key threats to Mount Olinthus Greenhood and summary of associated performance criteria

Direct threat and knowledge gap: Small population/lack of recruitment, Restricted distribution/isolated population, Lack of knowledge and baseline information	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Almost certain **Consequence:** Moderate The Mount Olinthus Greenhood population may have low genetic variability because of its small size, e.g. inbreeding decreases seed viability and plant vigour. Localised catastrophic events could threaten Mount Olinthus Greenhood because of small sub-population size and the plants' isolated ridge-top nature. Climate change is also a probable threat to critical habitat.	**Extreme**
Direct threat: High grazing pressure	
Risk: Loss of orchid seeds from grazing of flowers and/or long-term accumulative reduction in plant health caused by grazing, resulting in population decline **Likelihood:** Likely **Consequence:** Moderate Rabbits, feral goats, and kangaroos may infrequently graze Mount Olinthus Greenhoods and associated orchid habitat (J Hutchison & P Hewstone 2007, pers. comm.). The Mt Olinthus site has been fenced from sheep and the current property owner visits the site during flowering season.	**High**
Direct threat: Illegal collection or harvest	
Risk: Loss of individual plants and genetic material, undermining recovery efforts **Likelihood:** Unlikely **Consequences:** Minor While there is no record of illegal collection of this species, it is still a perceived threat, capable of undermining recovery actions.	Low

	Objective 1 Baseline information	**Objective 2 Community involvement**	**Objective 3 Manage threats and improve habitat**	**Objective 4 Research critical to management**	**Objective 5 Monitoring and evaluation**
Performance criteria	1a.1 1b.1 1c.1 1c.2 1c.4 1c.5 1d.1 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.2 3a.4 3b.1 3b.2 3c.1 3c.2 3d.1 3d.2 3d.3 3e.3 3e.4 3f.1 3f.2 3f.4 3f.6 3f.7 3f.8	4b.2 4b.4 4b.7 4c.2 4h.2	5a.4 5a.7 5a.8 5b.2

19.7 Main reference

Bates, R 2006, CD-ROM, *South Australian native orchids*, unpublished, Adelaide.

20 Silver Candles *Pleuropappus phyllocalymmeus* F Muell

20.1 Status

When assessing Eyre Peninsula Silver Candles vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 20.1). Silver Candles is recognised as Vulnerable at the Regional, State and National levels (Table 20.1).

Table 20.1. Silver Candles vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	2910		
Area of occupancy (km²)	1.0	Endemic to South Australia	
Sub-populations	9		
Estimated # of individuals	100 000		
IUCN Criteria	**Justification**		
VU B1	Extent of occurrence is estimated to be less than 20 000 km² on Eyre Peninsula		
VU B1a	Exists in no more than 10 locations on Eyre Peninsula		
VU B1a,b(iii)	Continuing decline inferred for quality of habitat on Eyre Peninsula		
VU B1a,b(iii),c(iv)*	Extreme fluctuations in the number of mature individuals on Eyre Peninsula		

20.2 Distribution

Silver Candles is endemic to South Australia and is found in disjunct sub-populations across Eyre Peninsula and Yorke Peninsula (Green 1993) (Figure 20.1). The species' extent of occurrence on Eyre Peninsula is approximately 2900 km², within latitude 33°0'29"S to longitude 134°19'17"E (Calpatanna Waterhole Conservation Park) in the north, and latitude 34°40'39"S to longitude 135° 31'32"E (Coomunga) in the south (DEH-EGIS 2006).

Silver Candles grows within the district councils of Streaky Bay and Lower Eyre Peninsula.

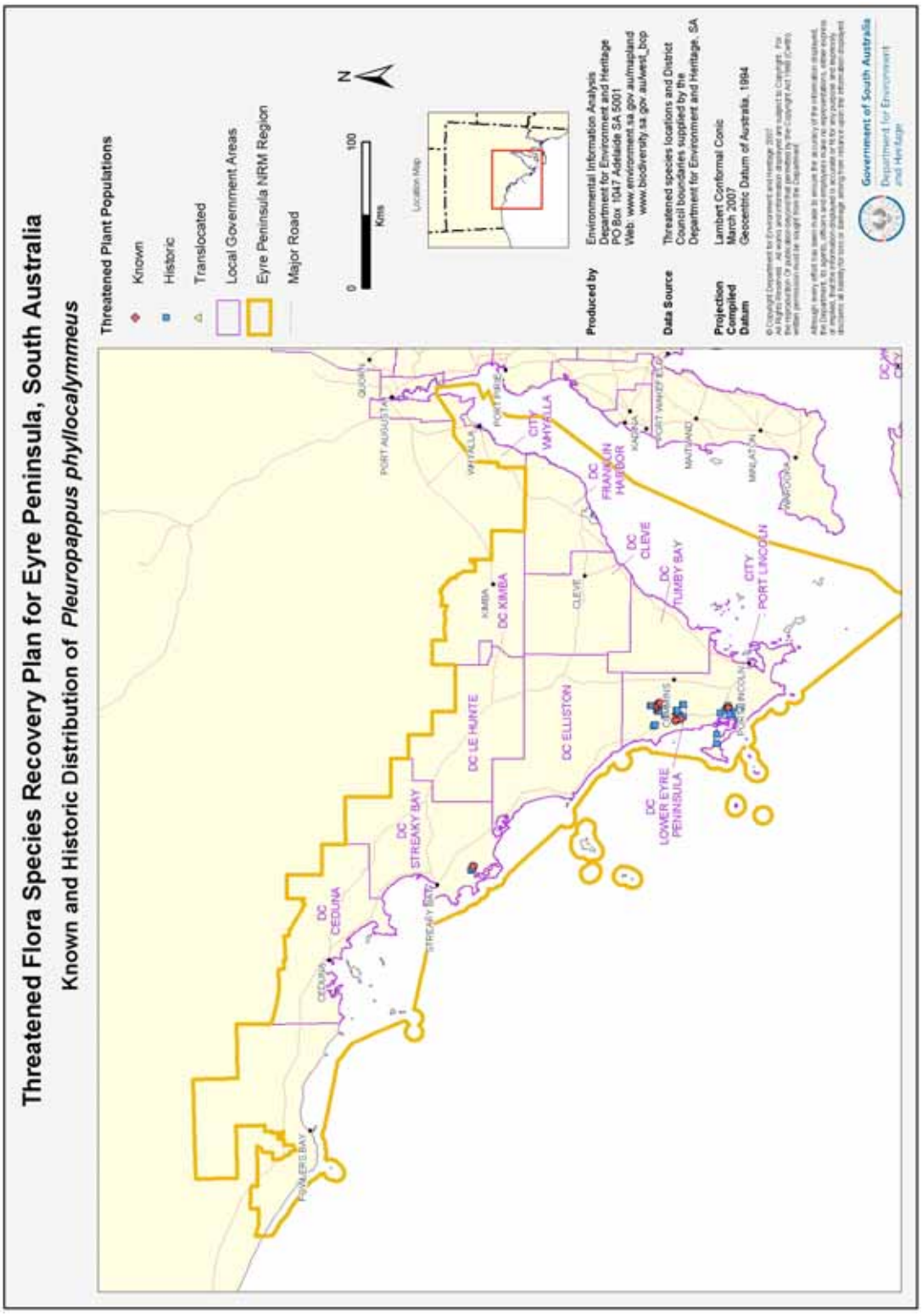
20.3 Habitat critical to survival

All known habitat of this species is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

The Kellidie Bay Silver Candles sub-population is confined to treeless mud flats and grassy flats subject to waterlogging and overlain by sheet limestone (Davies 1995). Soil is fine, sandy loam with a pH of 9. Soils are dark brown in colour when dry, and greyish brown when wet. By comparison, Yorke Peninsula sub-populations grow in clay loam or light clay soils with a similar pH range of 8.5 to 9.5 (Green 1993).

Sub-populations on Eyre Peninsula grow predominantly in low-lying topography described as stream channels with low gradation slopes and clay provinces, and clay loam alluvial watercourses, or depressions and salt lakes with loamy sand to light clay (DEH-EGIS 2006). Silver Candles grows at elevations of up to 80 m above sea level, but is more commonly found at 10-40 m above sea level.



Note: Silver Candles details are held on internal DEH files and are available on request.

Figure 20.1. Distribution of Silver Candles on Eyre Peninsula

Vegetation associations

Silver Candles grows in association with salt-tolerant vegetation. The species often grows in association with *Melaleuca lanceolata*, particularly around Coffin Bay and Kellidie Bay. Yorke Peninsula sub-populations are known to grow in vegetation dominated by samphire (*Halosarcia* sp.), Sea-heath (*Frankenia* sp.), Thorny Lawrencia (*Lawrencia squamata*), Heathy Bluebush (*Maireana oppositifolia*) and Silky Wilsonia (*Wilsonia humilis*) (Green 1993). On Eyre Peninsula, Silver Candles sub-populations are known to grow in herblands consisting of Salt Angianthus (*Angianthus preissianus*), Common Brown-grass (*Agrostis avenacea*), Common Wallaby-grass (*Danthonia caespitosa*) and Toad Rush (*Juncus bufonius*) (Davies 1995). Associated vegetation communities listed in Table 20.2 have been sourced from DEH-EGIS (2006).

Table 20.2. Vegetation associated with Silver Candles

Primary species	Secondary species	Understorey species
Calpatanna Waterhole Conservation Park Swamp Paper-bark (*Melaleuca halmaturorum*) tall shrubland	Thatching Grass (*Gahnia filum*) sedges	Love Creeper (*Comesperma volubile*), Creeping Brookweed (*Samolus repens*)
Sub-populations near Marble Range Short-leaf Honey-myrtle (*Melaleuca brevifolia*), +/- Totem-poles (*M. decussata*), +/- Swamp Paper-bark (*M. halmaturorum*) tall shrubland	+/- Cutting Grass (*Gahnia trifida*), Thatching Grass (*G. filum*) tall sedges	+/- Bare Twig-rush (*Baumea juncea*)
Mallee Box (*Eucalyptus porosa*) mid mallee woodland	Black Grass Saw-sedge (*Gahnia lanigera*)	Bearded Oat (*Avena barbata*), Common Wallaby-grass (*Austrodanthonia caespitosa*), Prickly Ground-berry (*Acrotriche patula*), Wirewort (*Asteridea athrixioides* forma *athrixioides*) low sedges
Wanilla to Kellidie Bay areas Open	Open	Black-seed Samphire (*Halosarcia pergranulata* ssp. *pergranulata*), Curly Ryegrass (*Parapholis incurva*), +/- Barrel Medic (*Medicago truncatula*) low open shrubland
Kellidie Bay area Slender Honey-myrtle (*Melaleuca gibbosa*), Short-leaf Honey-myrtle (*M. brevifolia*), +/- Scarlet Bottlebrush (*Callistemon rugulosus*), +/- Dwarf Hakea (*Hakea rugosa*) mid shrubland	Broombush (*Melaleuca uncinata*) (NC), *Hakea mitchellii* and Heath tea-tree (*Leptospermum myrsinoides*)	-
Dryland Tea-tree (*Melaleuca lanceolata*), +/- Coast Daisy-bush (*Olearia axillaris*), +/- Coast Beard-heath (*Leucopogon parviflorus*) tall open shrubland	Sea-berry Saltbush (*Rhagodia candolleana* ssp. *candolleana*), +/-Coast Bonefruit (*Threlkeldia diffusa*) low shrubs	-

Climate

Silver Candles inhabits the 300-500 mm rainfall zone (DEH-EGIS 2006). Climate for the species' northern-most sub-population is best estimated from Streaky Bay where mean annual maximum and minimum temperatures are 23 °C and 12.1 °C respectively, with a mean annual rainfall of 378.4 mm. The southern extent of the species' range would be similar to Wanilla's climate, which receives a mean annual rainfall of 509.4 mm.

Known sub-populations within reserves

Silver Candles are recorded within the South Australian reserve system (Table 20.3), and adjacent to the Kellidie Conservation Park boundary. The species also grows within one Heritage Agreement and along the Bratten Way roadside reserve.

Table 20.3. Silver Candles sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Coffin Bay National Park	Unknown, assumed 1	J Cleland 1960 Reserves Committee 1960
Calpatanna Waterhole Conservation Park	2	P Canty and A Wright 2001 T Fuhlbohm 1989
Kellidie Bay Conservation Park	1 (numerous sites)	J Briggs 1983 NPWSA 1989

Benefits to other species

The conservation of Silver Candles habitat is expected to have broader biodiversity benefits, particularly to co-habiting flora and fauna species which inhabitat and/or depend on saline swamps and lakes. Silver Candles habitat includes ecosystems considered to be threatened at a state level, such as state Vulnerable Thatching Grass (*Gahnia filum*) sedgeland in drainage lines and depressions, and state Endangered Cutting Grass (*Gahnia trifida*) sedgeland (DEH 2001).

20.4 Biology and ecology

Silver Candles is an annual herb that grows less than 15 cm tall. Each plant has many stems that arise from the base, and each stem ends in a cluster of shiny, golden daisy flowers (capitula). A full taxonomic description is given in Green (1993).

Flowers open between September and December, after which the seeds set and the adult plant dies completely (Green 1993). The plant's life cycle is usually complete by December and the next generation germinates late in the following winter.

Pollination and species response to fire/disturbance is unstudied and unknown. The Silver Candles sub-population at Lake Malata mining site has been observed coming back in denser coverage in rehabilitated areas than prior to mining (L Bebbington 2005, pers. comm.). Seed longevity and size of viable soil seed bank is also unknown.

20.5 Previous management actions

Table 20.4. Previous management actions to conserve Silver Candles

	Previous management actions
1989	Green (1995) reports Silver Candles was cultivated at the Australian National Botanic Gardens.
1993	An attempt to grow and maintain an *ex situ* sub-population at the Adelaide Botanical Gardens was trialled, but was unsuccessful (K Holliday 1993, pers. comm., cited in Green 1995).
2001	Surveys conducted by A Freebairn and D Hall along roadside verge on Bratten Way.
2001	Permanent monitoring quadrat BH 92-18 established in Kellidie Bay Conservation Park after site had been partially compacted by off-road vehicles (Davies 1995). This monitoring program has the following aims: a. to determine trends in sub-population size over time in a population of Silver Candles b. to determine the long-term impact of compaction by off-road vehicles on a sub-population of Silver Candles c. to determine the extent of weed invasion over time at the site of the same sub-population d. to determine changes in associated native vegetation over time.

20.6 Threats to Silver Candles and associated recovery goals

The long-term goals are to down-list Silver Candles conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Silver Candles conservation status at Vulnerable.

Silver Candles is ranked as a Priority 3 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 20.5 details the key threats and summarises performance criteria relevant to Silver Candles recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 20.5. Key threats to Silver Candles and summary of associated performance criteria

Direct threat: Salinity/changes in hydrology	**Risk**
Risk: Localised species extinction and degradation of critical habitat from increased salinity and changes in hydrology **Likelihood:** Possible **Consequences:** Major Drainage of wetlands, reclaimation of land and degradation of associated vegetation through stock grazing are threats to Silver Candles sub-populations on Yorke Peninsula (Green 1993). These major threats are also applicable to Eyre Peninsula sub-populations.	Extreme
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate This annual ground cover species is highly susceptible to invasive, salt tolerant weeds. Soil disturbance from off-road vehicles facilities weed invasion. Red Brome (**Bromus ruben*), Annual Cats Tail (**Lophochloa cristata*) and Coast Beard-grass (**Polypogon maritimus*) invade available habitat at Kellidie Bay Conservation Park (Davies 1995). Curly Rye Grass (**Parapholis incurva*) invasion threatens the sub-population at Lake Malata (L Bebbington 2005, pers. comm.).	High
Direct threat and knowledge gap: High grazing pressure	
Risk: Loss of seeds from grazing of flowers, resulting in long-term population decline **Likelihood:** Possible **Consequence:** Moderate Grazing by sheep and rabbits has been determined as the most threatening process to sub-populations at Lake Malata (L Bebbington 2005, pers. comm.). Grazing prior to seed release is of particular concern because of loss of viable seed.	High
Direct threat: Inappropriate disturbance regimes, Off-road vehicles	
Risk: Degradation of critical habitat leading to localised species extinction **Likelihood:** Possible **Consequence:** Moderate Due to the species' limited available habitat and low potential to compete with larger species, inappropriate disturbance is a significant threat to the species (A Freebairn [DEH] 2004, pers. comm.). For example, disturbance caused by off-road vehicles (especially at Kellidie Bay) and soil compaction are major threats (Davies 1995).	High

Knowledge gap: Lack of knowledge and baseline information	
Risk: Localised species extinction and degradation of critical habitat from lack of information **Likelihood:** Possible **Consequences:** Moderate Sub-populations produce viable seed and recruitment is evident (A Freebairn [DEH] 2004, pers. comm.); however, little is known about the species' reproductive biology. The percentage of viable seed produced, size of soil seed bank and seed predation have been identified as areas requiring further research (Green 1993). The hypothesis that sub-population size is significantly smaller during dry years remains to be tested, as does the influence of plant size on reproductive success.	**High**
Direct threat: Pest and disease	
Risk: Localised species extinction and degradation of critical habitat from pest and disease (*Phytophthora*) **Likelihood:** Possible **Consequences:** Moderate	**High**

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.3 1c.1 1c.3 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.4 3d.2 3d.3 3e.1 3e.3 3e.4 3f.1 3f.3 3f.4 3f.5 3f.8	4b.3	5a.6 5b.2

20.7 Main references

Davies, R 1995, *Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia*, Botanic Gardens of Adelaide and State Herbarium, South Australia.

Green, P 1993, *Threatened plants of Yorke Peninsula*, Conservation Council of South Australia, Adelaide.

21 West Coast Mintbush *Prostanthera calycina* F Muell ex Benth

21.1 Status

When assessing West Coast Mintbush vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 21.1). This is important given that this species only occurs on Eyre Peninsula. West Coast Mintbush is recognised as Vulnerable at the Regional, State and National levels (Table 21.1).

Table 21.1. West Coast Mintbush vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	50 910		
Area of occupancy (km²)	1.0	Endemic to Eyre Peninsula	
Sub-populations	62		
Estimated # of individuals	1000		
IUCN Criteria	**Justification**		
VU B2	Area of occupancy estimated to be less than 2000 km²		
VU B2a	Severely fragmented populations		
VU B2a,b(v)	Continuing decline inferred in number of mature individuals		

21.2 Distribution

The West Coast Mintbush, also known as Limestone Mintbush, is endemic to Eyre Peninsula. Sub-populations are distributed from Buckleboo to Coorabie over an extent of occurrence exceeding 50 000 km². The species occurs within latitude 32°23'7" to longitude 135°32'55" (northern extent), and latitude 36°49'26" to longitude 135°43'40" (southern extent) (DEH-EGIS 2006). The densest concentration of sub-populations is found between Lock, Venus Bay and Streaky Bay (Figure 21.1).

West Coast Mintbush sub-populations grow within the district councils of Streaky Bay, Elliston, Kimba and Lower Eyre Peninsula. It is highly likely that the species occurs within SA Water reserves; however, there are no records to date. The current known distribution is thought to be heavily influenced by grazing pressure.

21.3 Habitat critical to survival

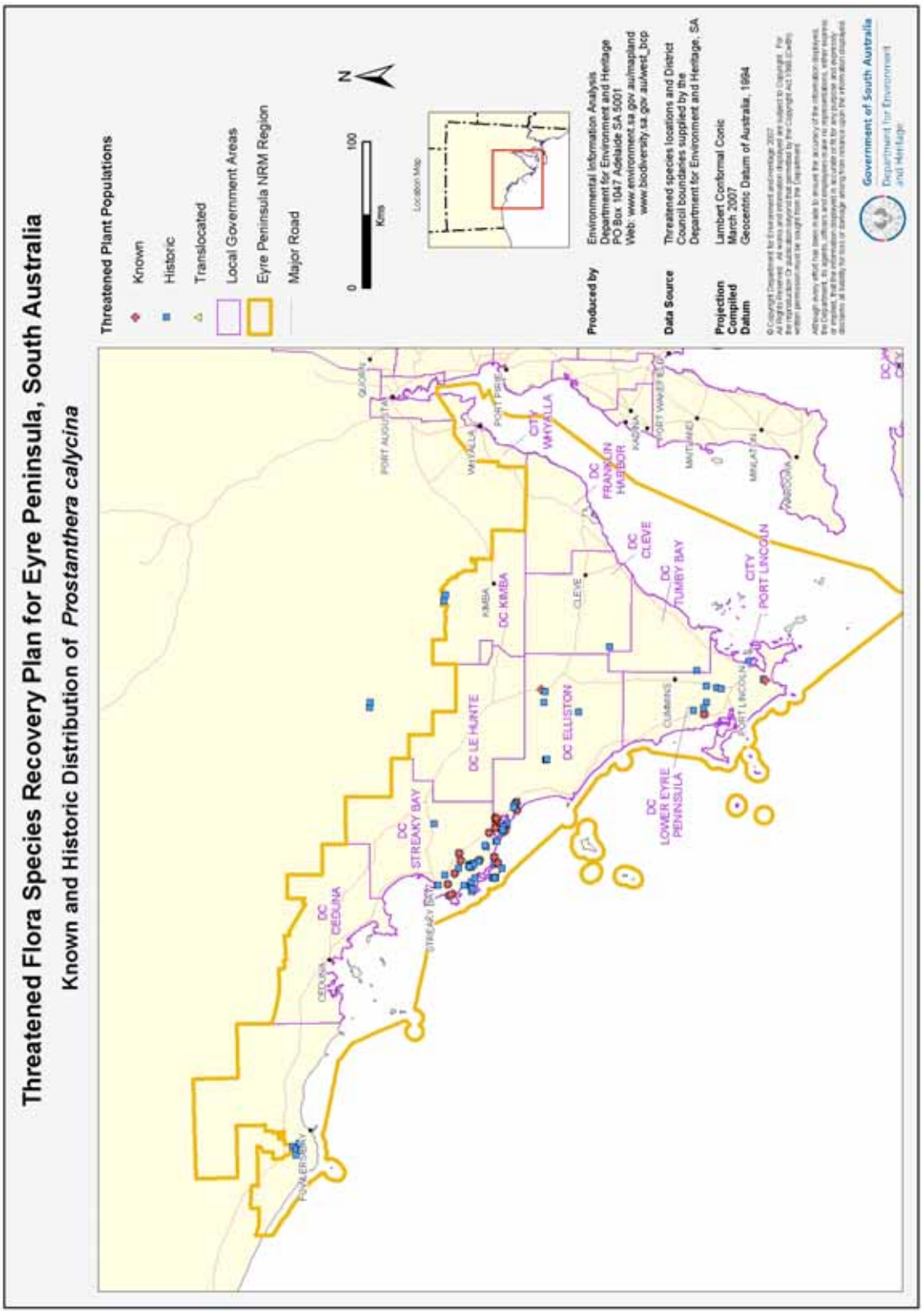
All known habitat of West Coast Mintbush is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

West Coast Mintbush occurs on calcarenite ridges and in mallee communities on sandy loams (Black 1977). In Calpatanna Waterhole Conservation Park, West Coast Mintbush has been recorded growing in pockets of light sandy clay (pH of 9) in sheet limestone on low, broad calcareous ridges (Davies 1995). Sub-populations near Baird Bay are found growing in shallow alkaline clays over limestone (L Bebbington 2005, pers. comm.). Northern sub-populations occupy topography ranging from elevations of 10-120 m, and southern sub-populations occupy a similar range of 60-140 m above sea level.

Vegetation associations

The species is commonly associated with Ridge-fruited Mallee (*Eucalyptus incrassata*), Red Mallee (*E. oleosa*), Beaked Red Mallee (*E. socialis*) and Quandong (*Santalum acuminatum*), along with *Melaleuca*, *Pittosporum*, *Grevillea*, *Hakea* and *Spyridium* species (Black 1977). Northern sub-populations grow within a wide range of vegetation associations (Table 21.2) (DEH-EGIS 2006). Outlying sub-populations on Lower Eyre Peninsula are surrounded by cleared and modified vegetation.



Note: West Coast Mintbush details are held on internal DEH files and are available on request.

Figure 21.1. Distribution of West Coast Mintbush on Eyre Peninsula

Southern West Coast Mintbush sub-populations grow in association with:

- Ridge-fruited Mallee (*Eucalyptus incrassata*) mid mallee woodland over Broombush (*Melaleuca uncinata*), Dune Tea-tree (*Leptospermum coriaceum*) mid shrubs over Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs over +/- Sandhill Bog-rush (*Schoenus racemosus*), +/- Woolly Spinifex (*Triodia lanata*)
- Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*), +/- Drooping Sheoak (*Allocasuarina verticillata*) mid mallee woodland over Dryland Tea-tree (*Melaleuca lanceolata*), +/- Kangaroo Thorn (*Acacia paradoxa*) tall shrubs over Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs.

Table 21.2. Vegetation associations of West Coast Mintbush sub-populations in the vicinity of Streaky Bay and Venus Bay

Primary species	Secondary species	Understorey species
Open	Nitre-bush (*Nitraria billardierei*), +/-Coast Daisy-bush (*Olearia axillaris*) mid open shrubland	Coast Bonefruit (*Threlkeldia diffusa*), Bower Spinach (*Tetragonia implexicoma*), Sea-berry Saltbush (*Rhagodia candolleana* ssp. *candolleana*), Bladder Saltbush (*Atriplex vesicaria*) shrubs
Yorrell *(Eucalyptus gracilis*), +/- White Mallee (*E. dumosa*), +/- Gilja (E. *brachycalyx*), +/- *E. oleosa* ssp. *ampliata* mid open mallee forest	Sheep Bush (*Geijera linearifolia*), Dryland Tea-tree (*Melaleuca lanceolata*) shrubs	Ward's Weed (*Carrichtera annua*), Rusty Spear-grass (*Austrostipa eremophila*), Mealy Saltbush (*Rhagodia parabolic*), Ruby Saltbush (*Enchylaena tomentosa* var.), Grey Bindyi (*Sclerolaena diacantha*) shrubs
Dumosa Mallee (*Eucalyptus dumosa*), +/- Beaked Red Mallee (*E. socialis*), +/- Yalata Mallee (*E. yalatensis*) mid mallee woodland	Dryland Tea-tree (*Melaleuca lanceolata*), Broombush (*M. uncinata*), +/- Mallee Honey-myrtle (*M. acuminata* ssp. *acuminata*) tall shrubs	+/- Spinifex (*Triodia irritans*) low hummock grasses
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	*Coast Daisy-bush* (*Olearia axillaris*), Coast Beard-heath (*Leucopogon parviflorus*), Dryland Tea-tree (*Melaleuca lanceolata*) tall shrubs	+/- Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs
Dryland Tea-tree (*Melaleuca lanceolata*), +/- Coast Daisy-bush (*Olearia axillaris*), +/-Coast Beard-heath (*Leucopogon parviflorus*) tall open shrubland	+/- Sea-berry Saltbush (*Rhagodia candolleana* ssp. *candolleana*), +/-Coast Bonefruit (*Threlkeldia diffusa*) low shrubs	-
Mallee Box (*Eucalyptus porosa*), +/- Drooping Sheoak (*Allocasuarina verticillata*), +/- Golden Wattle (*Acacia pycnantha*) mid mallee woodland	Sweet Bursaria (*Bursaria spinosa* ssp. *spinosa*) shrubs	Black anther flax-lily (*Dianella revoluta*), Spinifex (*Triodia scariosa*) (NC), Ringed Wallaby Grass (*Austrodanthonia caespitosa*), Balcarra Spear-grass (*Austrostipa nitida*), Hard Mat-rush (*Lomandra multiflora* ssp. *dura*), Sticky Sword-sedge (*Lepidosperma viscidum*), Wingless Fissure-plant (*Maireana enchylaenoides*) tussock grasses
Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*) mid mallee woodland	+/- Dryland Tea-tree (*Melaleuca lanceolata*), +/- Broombush (*M. uncinata*) tall shrubs	Prickly Ground-berry (*Acrotriche patula*), +/-Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs
Swamp Paper-bark (*Melaleuca halmaturorum*) tall shrubland	*Thatching Grass* (*Gahnia filum*) sedges	Love Creeper (*Comesperma volubile*), Creeping Brookweed (*Samolus repens*)

Climate

Most of the West Coast Mintbush sub-populations inhabit the 250-500 mm rainfall zone (DEH-EGIS 2006). The densest concentration of West Coast Mintbush plants is near Streaky Bay, which has a mean annual rainfall of 378.4 mm, and mean annual maximum and minimum temperatures of 23 °C and 12.1 °C respectively.

Known populations within reserves

West Coast Mintbush has been recorded within six reserves on Eyre Peninsula (Table 21.3).

Table 21.3. West Coast Mintbush sub-populations in reserves on Eyre Peninsula

NPWSA Reserve	Sub-populations	Observers
Bascombe Well Conservation Park	1	E Jackson; N Donner; R Alcock; H Eichler; J Wheeler and N Lothian 1967
Calpatanna Waterhole Conservation Park	5	1. T Dennis 1978 2. T Fuhlbohm 1988 3. D Murfet and R Taplin1989 4. F Davies1989 5. R Davies and J Briggs 1992
Hincks Conservation Park	1	D Symon; R Alcock & J Wheeler 1968
Point Labatt Conservation Park	1	T Fuhlbohm 1988; G Carpenter 1993
Venus Bay Conservation Park	Many (not yet determined)	1. R Taplin 1987 2. T Fuhlbohm 1989 3. P Copley and P Canty 1992 4. G Carpenter 1993
Venus Bay Conservation Reserve	3	L Huebner 1999

Benefits to other species

The conservation of West Coast Mintbush habitat is expected to benefit a wide range of associated flora and fauna species. Regional pest management and threatened flora recovery are complementary projects that, in part, focus on decreasing the grazing pressure of pest species. Collaborative work between these two groups is anticipated to have successful ecological outcomes.

21.4 Biology and ecology

West Coast Mintbush is a perennial shrub that grows to half a metre tall and spreads across the ground[7]. The species' most distinguishing features are leaves that smell like mint when crushed, and microscopic hairs that grow on the leaf surface. These hairs are 0.3-0.4 mm long, stiff, straight and closely flattened to the leaf.

Flowering occurs from September to December. Flowers are red and tube shaped, with petals opening out. Variations in flower colour, such as yellow and pink, have been observed (D Armstrong [DEH] 2005, pers. comm.).

The plant's pollinator(s) are unknown. Yellow-throated Miners (*Manorina flavigula*) have been observed moving from flower to flower on West Coast Mintbush plants in the Sceale Bay area (K Pobke [DEH] 2006, pers. comm.).

Seeding, fruiting and seed dispersal also require further study. Germination triggers, such as response to fire, are also unknown. West Coast Mintbush produces viable seed (P Ainsley [DEH], 2006 pers. comm.) and recruits *in situ* (L Bebbington 2005, pers. comm.; K Pobke [DEH] 2006, pers. observation), even though the seed was originally thought to be unviable.

[7] A detailed botanical description for *Prostanthera calycina* is found in Jessop and Toelken (1986c).

21.5 Previous management actions

Table 21.4. Previous management actions to conserve West Coast Mintbush

	Previous management actions
1999?	Numerous sites in the Venus Bay to Streaky Bay area were surveyed by Annie Bond (former Threatened Flora Ecologist, DEH). Many West Coast Mintbush sites recorded in this survey were thought to be revisits of historical sites, the majority of which are along road reserves (DEH Recfind file 40/1486).
2001	West Coast Mintbush article in spring edition of local newsletter *The Long Run*, as part of the 'Unusual Suspects' series, to increase community awareness (author A Freebairn).
2005	Seed collected from Calpatanna Waterhole Conservation Park by Seed Conservation Centre staff, Adelaide Botanic Gardens, for germination tests and long-term, low temperature storage, as part of the Millennium Seed Bank Project.
2005	Dr P Ainsley (Germplasm Research Coordinator, DEH) in the process of writing paper on germination method for West Coast Mintbush (DEH Recfind file 40/1486).
2006	D Armstrong and K Pobke began a community awareness raising program focused on identification, recording new locations and amount of grazing on West Coast Mintbush. A workshop was held at Streaky Bay on 13 August with Friends of Parks members.
2006	Article 'Flora facts: West Coast Mintbush' published in Autumn 2006 edition of *West Coast Babbler: the Ark on Eyre Newsletter* (DEH Recfind file 40/A248481).
2006	West Coast Mintbush Threatened Flora of Eyre Peninsula Information Sheet produced as a milestone for the Ark on Eyre project (DEH Recfind file 40/A142070).

21.6 Threats to West Coast Mintbush and associated recovery goals

The long-term goals are to down-list West Coast Mintbush conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise West Coast Mintbush conservation status at Vulnerable.

West Coast Mintbush has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 21.5 details the key threats and summarises performance criteria relevant to West Coast Mintbush recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 21.5. Key threats to West Coast Mintbush and summary of associated performance criteria

Direct threat: High grazing pressure, Lack of recruitment	**Risk**
Risk: Loss of germinated juveniles, and grazing-back of adult plants (including flowers), which unstabilises life class structure and increases risk of population decline **Likelihood:** Almost certain **Consequence:** Moderate Grazing pressure is thought to be the greatest immediate threat to this species (Davies 1995). All surveyed sub-populations show signs of heavy grazing pressure by sheep, kangaroos and rabbits (A Freebairn [DEH] 2004, pers. comm.). Seed viability and level of recruitment in West Coast Mintbush populations is currently unknown.	Extreme
Direct threat: Urban development/subdivision	
Risk: Loss of species sub-populations as a result of illegal clearance, e.g. progression of development without vegetation assessment **Likelihood:** Possible **Consequence:** Moderate Urban development and land subdivision, especially along coastal properties, is anticipated to threaten critical habitat. Subdivision for building development may place West Coast Mintbush populations at risk of becoming degraded or isolated as landscape fragmentation or clearance increases.	High
Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Possible **Consequences:** Moderate The majority of known West Coast Mintbush populations are located on road reserves without Roadside Markers.	High
Knowledge gap: Lack of knowledge and baseline information	
Risk: Localised species extinction and degradation of critical habitat from lack of information **Likelihood:** Possible **Consequences:** Moderate Insufficient baseline information (e.g. size of populations, age structure and reproduction success) and lack of biological knowledge (e.g. break downs in life cycle stages, pollination, and cause or percentage of population dying/reaching senescence) need to be addressed to further recovery actions.	High
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Possible **Consequence:** Minor Weed invasion, particularly Bridal Creeper (*Asparagus asparagoides*), may directly compete with West Coast Mintbush (Davies 1995). However, other prickly weeds, for example African Boxthorn (*Lycium ferocissimum*), seem to offer juvenile mintbush plants protection from grazing.	Moderate

	Objective 1 Baseline information	**Objective 2 Community involvement**	**Objective 3 Manage threats and improve habitat**	**Objective 4 Research critical to management**	**Objective 5 Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.3 3a.4 3b.1 3b.3 3c.1 3c.2 3d.2 3d.3 3e.1 3e.3 3e.4 3f.1 3f.4 3f.8	4b.2 4c.2 4d.3 4h.3	5a.5 5a.10 5b.2

21.7 Main references

Davies, R 1995, Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia, Botanic Gardens of Adelaide and State Herbarium, South Australia.

Jessop, JP & Toelken, HR (eds) 1986c, *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

22 Desert Greenhood *Pterostylis xerophila* syn. *Oligochaetochilus xerophilus* MA Clements

22.1 Status

When assessing Eyre Peninsula Desert Greenhood vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 22.1). Desert Greenhood is however recognised as Vulnerable at the Regional, State and National levels (Table 22.1).

Table 22.1. Desert Greenhood vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	890		
Area of occupancy (km²)	0.0075		
Sub-populations	3		
Estimated # of individuals	50		
IUCN Criteria	**Justification**		
CR C	Population size estimated to be fewer than 250 mature individuals on Eyre Peninsula		
CR C2b*	Continued decline inferred in numbers of individuals because of extreme fluctuations in number of mature individuals on Eyre Peninsula		

22.2 Distribution

Desert Greenhood (*Pterostylis xerophila* syn. *Oligochaetochilus xerophilus* Desert Rustyhood (Jones 2006)) grows in disjunct populations on Eyre Peninsula, in the Gairdner-Torrens and Murray regions of South Australia, and on the edge of the Great Victoria Desert (Jessop & Toelken 1986a; Bates & Weber 1990). On Eyre Peninsula, Desert Greenhood has an extent of occurrence of 890 km², growing within latitude 32°18'6"S to longitude 135°17'50"E (north of Gawler Ranges National Park) in the north, and latitude 33°19'18"S to longitude 137°9'23"E (Hundred of Batchelor) in the south (DEH-EGIS 2006) (Figure 22.1). The species was probably widespread across Eyre Peninsula before settlement (Bates & Weber 1990). Desert Greenhood is probably still more widespread than records show, with the species observed as far south as the Coolanie Range, north of Cowell.

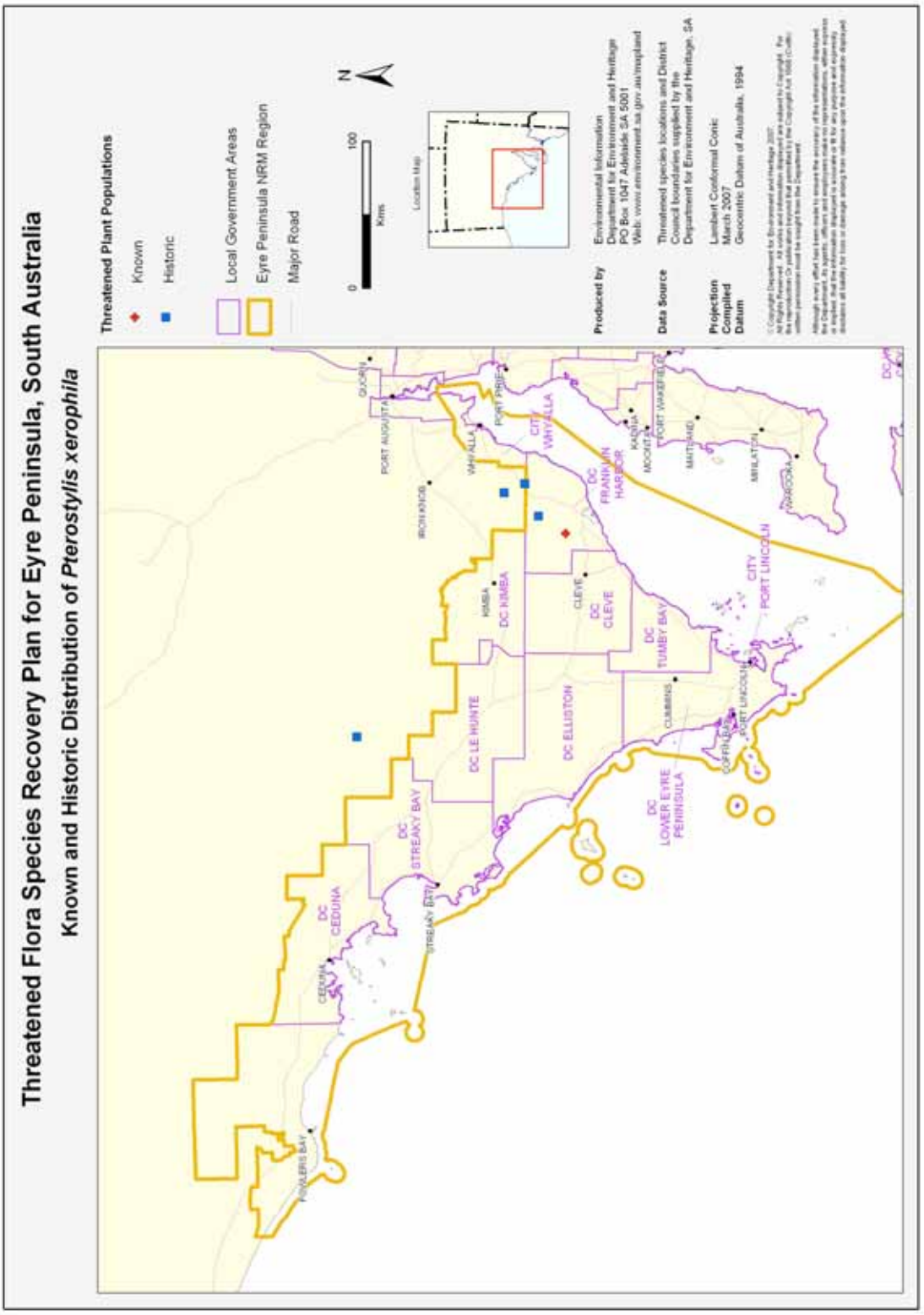
The distribution area of Desert Greenhood spreads into the County of Bosanquet, the Corporation of the City of Whyalla, and most probably the District Council of Franklin Harbour (yet to be confirmed).

22.3 Habitat critical to survival

All known habitat of Desert Greenhood is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Desert Greenhood grows in fertile red loamy soils and can be found mainly on rocky outcrops, where it now inhabitats a much more restricted range than it did prior to agriculture (Bates & Weber 1990). This is reinforced by Jessop and Toelken (1986a) who also record Desert Greenhood growing on or around granite or quartzite rock outcrops and less commonly on fertile alluvial plains. Disjunct sub-populations on Eyre Peninsula occupy topography 250-300 m above sea level near or in the Gawler Ranges, to 140-160 m above sea level near Moonabie Ranges.



Note: Desert Greenhood details are held on internal DEH files and are available on request.

Figure 22.1. Distribution of Desert Greenhood on Eyre Peninsula

Vegetation associations

Desert Greenhood grows in association with dry woodland; however, no ground truthed information detailing species assemblage has been recorded. Vegetation associations in Table 22.2 have been sourced from DEH-EGIS (2006).

Table 22.2. Vegetation associated with Desert Greenhood

Primary species	Secondary species	Understorey species
Broombush (*Melaleuca uncinata*) (NC) tall sparse shrubland	Narrow-leaf Hop-bush (*Dodonaea viscosa* ssp. *angustissima*), Beckler's Rock Wattle (*Acacia beckleri*), +/- Cup Fringe-myrtle (*Calytrix involucrata*)	Spinifex (*Triodia irritans*) low open hummock grassland
Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland, Broombush (*Melaleuca uncinata*) tall shrubland	Ribbed Thrytomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland	Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*), Half-beard Spear-grass (*Austrostipa hemipogon*)
Ridge-fruited Mallee (*Eucalyptus incrassata)*, +/- Narrow-leaf Red Mallee (*E. leptophylla*) mid mallee woodland	Green Tea-tree (*Leptospermum coriaceum*), Broombush (*Melaleuca uncinata*), Scrub Cypress Pine (*Callitris verrucosa*), and Silver Broombush (*Babingtonia behrii*) shrubs	*Hibbertia australis*, Golden Pennants (*Glischrocaryon behrii*) shrubs

Climate

Desert Greenhood inhabits the 200-300 mm rainfall zone (DEH-EGIS 2006). As a generalisation, the mean annual rainfall in the Gawler Ranges is approximately 227.3 mm (BOM 2007, Siam weather station). The mean annual rainfall in Munyeroo, in the vicinity of Desert Greenhood sub-populations, is 286.4 mm (BOM 2007).

Known sub-populations within reserves

There is one suspected Desert Greenhood sub-population in Gawler Ranges National Park, which was last observed on 6 October 2002 (W Crisp 2002, pers.comm.). Plant vouchers were collected for verification.

Benefits to other species

The conservation of Desert Greenhood is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data are expected to benefit other plant species growing in association with the orchid, particularly those species with similar life forms and/or flowering response.

22.4 Biology and ecology

The common name 'Desert Greenhood', and the species name *xerophila* meaning 'loving dry places', reveal the habitat of this species – it grows in the arid regions of Eyre Peninsula. Desert Greenhood is a perennial, terrestrial orchid, which is slender and grows 6-20 cm (Bates & Weber 1990). The orchid has 3-10 variable sized basal leaves, which often wither before flowering (Bates & Weber 1990). It is deciduous in nature, dying back to below ground tubers in summer and producing a leaf in spring. Full taxonomic descriptions of Desert Greenhood are given in Bates (2006) and Jessop and Toelken (1986a).

Flowering occurs between late August and early November (Bates & Weber 1990). Flowers vary in number from 1-8 and are reddish or brown on short pedicels, often nodding (Bates & Weber 1990).

Desert Greenhood pollinator(s) are unknown. Other *Pterostylis* species are known to be pollinated by small gnats and/or flies that are attracted to the flowers by visual stimulation (Duncan 2005). The labellum, column and galea form a 'trap' for the insect, and the insect then has to struggle past the pollinia to escape (Duncan 2005). Pollination is possibly achieved by pseudocopulation[8] (Jones & Clements 2002). Flowering occurs for approximately four weeks and, if pollination has taken place, the seed capsule begins ripening.

Germination to date is unobserved and unstudied. Orchids are known to form symbiotic relationships with mycorrhizal fungus, which help to initiate seed germination and provide essential nutrients to the plant (Duncan 2005). It is unknown which, if any, mycorrhizal species assist Desert Greenhood growth. The longevity of the tuber to endure extended dormancy is also unknown.

Fire dependence triggers are unknown; however, plants have been observed flowering well in the absence of fire (Duncan 2005). Occasional, intense summer fires, particularly after the flowering period, are assumed to promote flowering of dormant plants, seed germination and seedling establishment (Duncan 2005). Fire may also indirectly affect orchids by influencing the fungal symbiont (Duncan 2005).

22.5 Previous management actions

Table 22.3. Previous management actions to conserve Desert Greenhood

	Previous management actions
2001	Desert Greenhood article printed in local newspaper West Coast Sentinel, as part of 'Threatened Flora Census' series, community awareness raising focus, author A. Freebairn.
2002	Survey and *Pterostylis* species plant voucher collection made by Wesley Crisp (5-6th October 2002). (DEH Recfind file 40/A248478).
2007	*Pterostylis* species plant vouchers collected by W Crisp were found and on 26th February 2007 sent by K Pobke to the State Herbarium of South Australia for verification. *Pterostylis* species collected was not Desert Greenhood.

22.6 Threats to Desert Greenhood and associated recovery goals

The long-term goals are to down-list Desert Greenhood conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Desert Greenhood conservation status at Vulnerable.

Desert Greenhood has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle (Duncan 2005).

Table 22.4 details the key threats and summarises performance criteria relevant to Desert Greenhood recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

[8] Pseudocopulation is a process by which an insect transfers pollen while attempting to mate with the flower.

Table 22.4. Key threats to Desert Greenhood and summary of associated performance criteria

Direct threat: Habitat fragmentation	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Possible **Consequence:** Moderate Desert Greenhood has a limited distribution attributed to changes in land use since settlement (Duncan 2005; Bates & Weber 1990). Limited distribution and further fragmentation of what was possibly once a widespread species may be causing genetic bottleneck problems (e.g. low genetic variability and disruption of genetic flow).	High
Direct threat: High grazing pressure	
Risk: Loss of orchid seeds from grazing of flowers and/or long-term accumulative reduction in plant health caused by grazing, resulting in population decline **Likelihood:** Likely **Consequence:** Moderate Sheep have been removed from the Gawler Ranges Nationaly Park and a goat control program is currently in place across the park (C Nixon [DEH] 2006, pers. comm.). The full extent of total grazing pressure requires further investigation.	High
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Possible **Consequence:** Moderate Weed invasion is expected to reduce Desert Greenhood flowering and compete directly with the species for space, light and nutrients. Weeds such as Salvation Jane (*Echium plantagineum*) need to be maintained to a low level of infestation within immediate critical habitat (Duncan 2005).	High
Direct Threat: Inappropriate fire regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Whilst occasional late summer fires are expected to stimulate Desert Greenhood flowering and encourage orchids out of dormancy, timing of fire is a threat to the species. Climate change models predict fires becoming more frequent and more intense (Lucus et al. 2007). Spring and early summer fires would interfere with the flowering process because, for example, tuber energy resources are invested in the flower during this period. Therefore, orchids burnt before seed set could result in reduced population size or localised extinction. Sub-populations assumed burnt in 1990 on private property near Munyaroo and in 2003 in the Gawler Ranges National Park, south of the Conical Hill track, still need to be checked.	High
Direct threat: Illegal collection or harvest	
Risk: Loss of individual plants and genetic material that may undermine recovery actions **Likelihood:** Unlikely **Consequences:** Moderate In a similar approach to Duncan (2005), while there is no record of illegal collection of this species, such activity is still a perceived threat that is capable of undermining recovery actions. Desert Greenhood is listed for protection under CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) (UNEP-WCMC 2007).	Moderate

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3d.3 3a.3 3e.3 3a.4 3e.4 3b.3 3f.1 3c.1 3f.4 3c.3 3f.8 3d.2	4b.2 4b.4 4b.7 4c.2 4h.2	5a.5 5a.9 5b.2

22.7 Main references

Duncan, M 2005, *Draft Recovery Plan for* Pterostylis xerophila *(Desert Greenhood) In Victoria and South Australia 2006-2010*, Department of Sustainability and Environment, Heidelberg, Victoria.

Jessop, JP & Toelken, HR (eds) 1986a, *Flora of South Australia, Part IV: Alismataceae-Orchidaceae*, South Australian Government Printer, Adelaide.

Jones, D 2006, A complete guide to native orchids of Australia, including the island territories, Reed New Holland, Australia.

Jones, DL & Clements, MA 2002, 'A reassessment of *Pterostylis* R.Br (Orchidaceae)', *Australian Orchid Research*, vol. 4, pp. 6-63.

23 Ironstone Mulla Mulla *Ptilotus beckerianus* F Muell ex J Black

23.1 Status

When assessing Eyre Peninsula Ironstone Mulla Mulla vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 23.1). Ironstone Mulla Mulla is however recognised as Vulnerable at the Regional, State and National levels (Table 23.1).

Table 23.1. Ironstone Mulla Mulla vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	185	Endemic to South Australia	
Area of occupancy (km²)	0.03		
Sub-populations	10		
Estimated # of individuals	2500		
IUCN Criteria	**Justification**		
EN B2	Area of occupancy estimated to be less than 500 km² on Eyre Peninsula		
EN B2b(iii)	Continuing decline inferred in area, extent and quality of habitat on Eyre Peninsula		
EN B2b(iii),c(iv)*	Extreme fluctuations in the number of mature individuals on Eyre Peninsula		

23.2 Distribution

Ironstone Mulla Mulla, also known as Becker's Pussy-tail, is endemic to South Australia and grows in disjunct populations on Kangaroo Island and southern Eyre Peninsula (Jessop & Tolken 1986). On Eyre Peninsula, Ironstone Mulla Mulla has an extent of occurrence of approximately 185 km² (Figure 23.1). The species grows within latitude 34°26'17"S to longitude 135°29'30"E (Marble Range) in the north, and latitude 34°39'24"S to longitude 135°43'41"E (railway line near Hyde Road and Lincoln Highway intersection) in the south (DEH-EGIS 2006).

Ironstone Mulla Mulla grows on roadside verges and private property within the District Council of Lower Eyre Peninsula. There is an historical reference of the species growing as far east as Pooninide on Eyre Peninsula (Davies 1986).

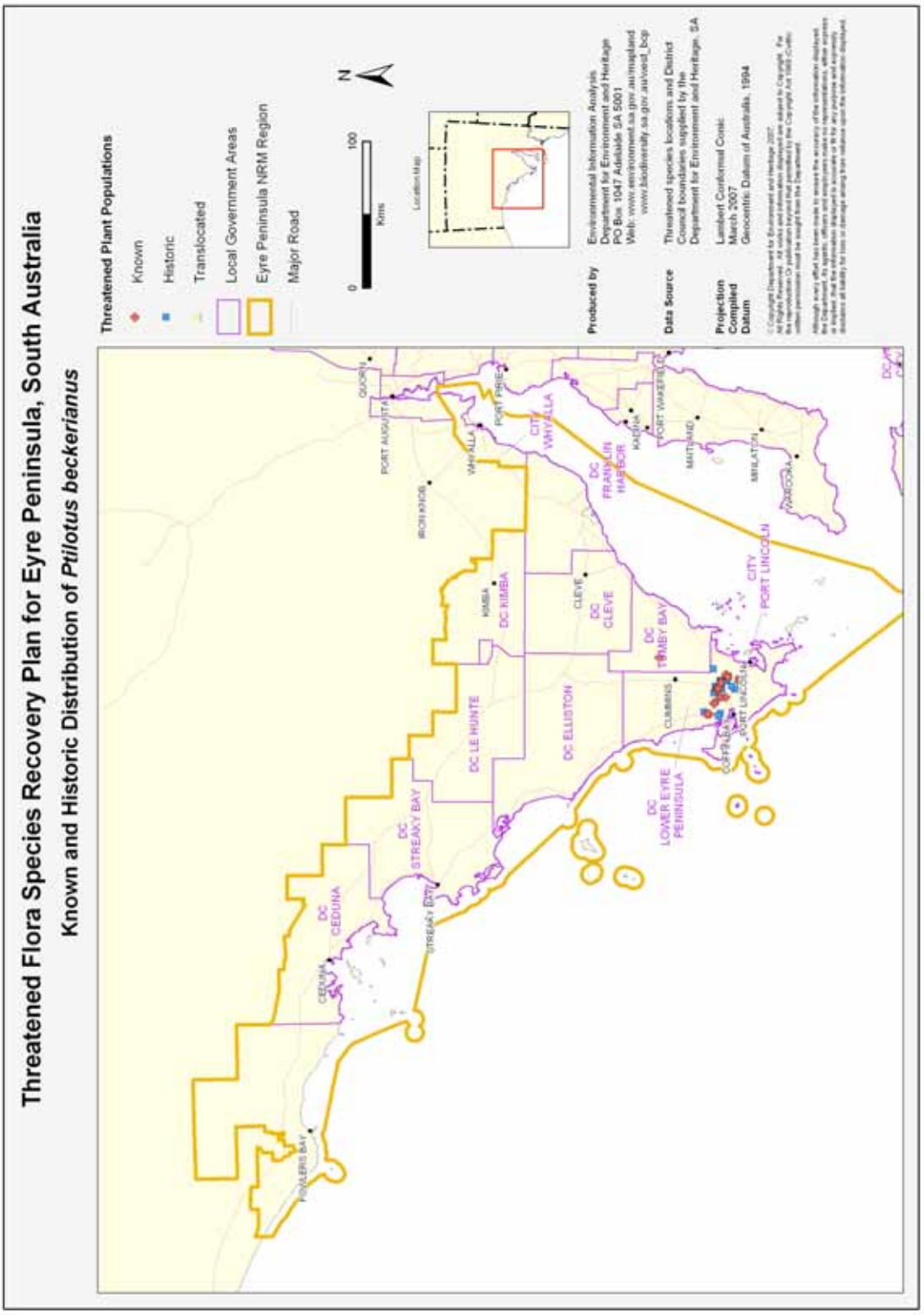
23.3 Habitat critical to survival

All known habitat of Ironstone Mulla Mulla is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Ironstone Mulla Mulla occupies topography ranging from 30 m above sea level to the highest sub-populations on the slopes of Marble Range (160 m above sea level) and in the Koppio hills (up to 230 m above sea level) (DEH-EGIS 2006).

Ironstone Mulla Mulla, as the common name implies, grows on ironstone gravel soils. The species is also known to grow on light yellow brown sandy loams with a relatively neutral pH level (Davies 1995).



Note: Ironstone Mulla Mulla details are held on internal DEH files and are available on request.

Figure 23.1. Distribution of Ironstone Mulla Mulla on Eyre Peninsula

Vegetation associations

Ironstone Mulla Mulla often grows in association with Sugar Gum (*Eucalyptus cladocalyx*) and *Xanthorrhoea* sp. in low open forest or low open woodland along roadsides. Associated vegetation communities are listed in Table 23.2 and have been sourced from DEH-EGIS (2006). Where Ironstone Mulla Mulla sub-populations persist is assumed to be strongly associated with disturbance, hence a significant number of populations exist along regularly graded roadside verges. Although many Ironstone Mulla Mulla plants grow along edges of disturbed roadsides, it should not be assumed that this is ideal habitat for the species.

Roadside sub-populations have not been tested for seed viability and these plants may consist of vegetative regrowth, stimulated by grading, rather than germinated seedlings (K Pobke [DEH] 2006, pers. comm.; Ecological Associates 2007).

Table 23.2. Vegetation associated with Ironstone Mulla Mulla sub-populations

Primary species	Secondary species	Understorey species
Sugar Gum (*Eucalyptus cladocalyx*) mid woodland	+/- Golden Wattle (*Acacia pycnantha*) over Rock Wattle (*A. rupicola*), +/- Yacca (*Xanthorrhoea semiplana*), +/- Broombush (*Melaleuca uncinata*) mid shrubs	Peach Heath (*Lissanthe strigosa* ssp. *subulata*), Small-flower Wallaby-grass (*Austrodanthonia setacea*) low shrubs over Broad-leaf Raspwort (*Gonocarpus mezianus*), Coarse Lagenifera (*Lagenophora huegelii*)
Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*), +/- Ridge-fruited Mallee (*E. incrassata*), +/- Narrow-leaf Red Mallee (*E. leptophylla*), +/- White Mallee (*Eucalyptus peninsularis*) mid mallee woodland	Broombush (*Melaleuca uncinata*) tall shrubs	Rosemary Dampiera (*Dampiera rosmarinifolia*) and *Hibbertia* sp. *glabriuscula* (DJ Whibley 9012) low shrubs
Dropping Sheoak (*Allocasuarina verticillata*) low woodland	+/- Sticky Hop-bush (*Dodonaea viscosa* ssp. *spatulata*) tall shrubs	Bearded Oat (*Avena barbata*), Annual Rock-fern (*Cheilanthes austrotenuifolia*), +/- Sticky Sword-sedge (*Lepidosperma viscidum*), +/-Broad-leaf Raspwort (*Gonocarpus mezianus*) low forbs
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	+/- Yacca (*Xanthorrhoea semiplana*) shrubs	Kangaroo Grass (*Themeda triandra*), Hill Raspwort (*Gonocarpus elatus*), Hard Mat-rush (*Lomandra multiflora* ssp. *dura*), Crested Spear-grass (*Austrostipa blackii*) tussock grasses

Climate

Ironstone Mulla Mulla inhabits the 450-500 mm rainfall zone. The mean annual rainfall is 509.4 mm at Wanilla and 485.3 mm at Koppio. The mean annual maximum and minimum temperatures at the Tod Reservoir weather station are 20.9 °C and 9.6 °C respectively (BOM 2007).

Known sub-populations within reserves

Apart from sub-populations within reserves (Table 23.3), large Ironstone Mulla Mulla sub-populations also grow adjacent to Murrunatta Conservation Park and Conservation Reserve on roadside managed by the District Council of Lower Eyre Peninsula. The council has erected roadside markers for this species.

Table 23.3. Ironstone Mulla Mulla sub-populations within reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Wanilla Conservation Park	1	R Davies 1992
Wanilla Land Settlement Conservation Reserve	1	P Canty 2004 S Deslandes (Annual monitoring)
Tucknott's Scrub Conservation Park	1	P Canty 2004

Benefits to other species

The conservation of Ironstone Mulla Mulla is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data are expected to benefit other plant species growing in association, particularly those surviving within the highly fragmented landscape of Lower Eyre Peninsula, and those that have similar life forms, flowering response and/or pollination needs.

23.4 Biology and ecology

Ironstone Mulla Mulla is a small, perennial herb growing to 10-25 cm tall. Plants are first seen emerging from the ground in a rosette of ground-level (radical) leaves. There can be up to 20 of these radical leaves per base, and leaves range in shape from lanceolate[9] to obovate[10] and spatulate[11]. Eyre Peninsula Ironstone Mulla Mulla plants also show variation in leaf colour from dark purple to dark green (S Deslandes 1999-2007, pers. observation). Multiple stems with upright, bottlebrush-shaped flowers grow from the rosette base.

Flowering occurs between August and January. The scientific name *Ptilotus* means feathered or winged and refers to the hairy flowers (Greek origin). Generally *Ptilotus flowers* are bisexual, with 20-40 spiky-looking flowers per stem. The flowers are initially hemispherical, becoming ovoid or cylindrically elongated to 9.5 cm (Jessop & Toelken 1986).

Seed structure indicates that seeds are wind dispersed and this is readily seen on Eyre Peninsula (K Pobke [DEH] & S Deslandes 2006, pers. observation). The flowers gradually age, the seed coating hardens and the long hairy plumes on the flower (perianth) disperse on the wind.

Pollination, germination, seed viability and survival, and plant longevity are relatively unknown. Seed abortion levels and triggers require further study. Above the ground, small plants often look like new seedlings; however, below the ground the rosettes suspected of being separate are connected by underground rhizomes and shared root structures (Ecological Associates 2007). Therefore, in monitoring conducted after 2005, all above ground rosettes less than 2 cm apart are assumed to be from the same plant and are therefore counted as 'one' in population counts (Ecological Associates 2007).

Flowering is assumed to be linked to available soil moisture, with less rainfall resulting in fewer plants flowering (S Deslandes 1999-2007, pers. comm.; A Freebairn [DEH] 2004, pers. comm.). Very few flowering Ironstone Mulla Mulla plants were observed during the 2006 drought, even though they had flowered prolifically after fire the previous year. According to monitoring by Sally Deslandes, flowering success is most probably linked to openness of canopy cover (DEH Recfind file 40/1483).

[9] Lanceolate leaves are fattened, two or three times as long as they are broad, and are widest in the middle, tapering to a pointed apex.

[10] Obovate leaves are generally shaped like the longitudinal section of an egg. Their length does not exceed twice their breadth, and the greatest width is slightly above the middle.

[11] Spatulate or spathulate leaves are spoon-shaped, i.e. broader towards the tip, narrower lower down.

Fire dependence triggers for Ironstone Mulla Mulla were studied following the 2005 Wangary Bushfire. As mentioned previously, the species flowered in abundance in the first year after fire; however, the limited data obtained during post-fire monitoring has shown no clear link between Ironstone Mulla Mulla regeneration and fire (Ecological Associates 2007). The occurrence of above average rainfall in the first growing season after fire may have had a positive impact on Ironstone Mulla Mulla (Ecological Associates 2007). The species has fleshy roots (rhizomes), which suggest that physiologically the species could survive after fire (Ecological Associates 2007). This would, however, depend on the timing of the fire. For example, a late summer fire, while the species is in its dormant state, is expected to yield a more positive Ironstone Mulla Mulla response (K Pobke [DEH] 2007, pers. comm.).

23.5 Previous management actions

Table 23.4. Previous management actions to conserve Ironstone Mulla Mulla

	Previous management actions
1998-ongoing	Sally Deslandes conducted quadrat monitoring and photo-points of Ironstone Mulla Mulla sub-population in Wanilla Conservation Park (DEH Recfind file 40/1483).
1999-2004	Three collections of seed were taken by A Freebairn and J Nikkulla from sub-populations on Charlton Gully Road, and the corner of Merintha Creek and Settlers roads (20 g unclean seed in total). Stored at Greening Australia, Port Lincoln. During this time A Freebairn, with the assistance of the Threatened Plant Action Group, began on site management of the sub-population at Wanilla Conservation Park.
2005	Ecological Associates was contracted to monitor post-fire response of Ironstone Mulla Mulla (DEH Recfind file 40/1483), and look to assess plant density and reproductive output.
2006	On 6th January 2006, post-fire seed collection was undertaken by K Pobke and S Deslandes from a total of 292 plants at Settlers Road, Tucknott Scrub Conservation Park, and between Wanilla oval and the railway line (DEH Recfind file 40/1483). On 27th January 2006 this seed (20 g unclean) was sent to the Seed Conservation Centre, Adelaide. Initial examination of the seed found many unviable embryos. Some seed from Koppio sub-populations was collected while still immature; however, seed from sandier sub-populations near Murrunatta was ripe, but still had a hollow epicarp (K Pobke [DEH] 2006, pers. comm.).

23.6 Threats to Ironstone Mulla Mulla and associated recovery goals

The long-term goals are to down-list Ironstone Mulla Mulla conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Ironstone Mulla Mulla conservation status at Vulnerable.

Ironstone Mulla Mulla has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 23.5 details the key threats and summarises performance criteria relevant to Ironstone Mulla Mulla recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 23.5. Key threats to Ironstone Mulla Mulla and summary of associated performance criteria

Direct threat: **Habitat fragmentation**	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate The majority of known populations are small and occur in highly fragmented vegetation, i.e. road and rail reserves. These fragmented sub-populations of Ironstone Mulla Mulla may have low genetic variability and genetic flow because of their small size and isolation. Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases.	High
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequence:** Moderate Competition from annual and perennial grasses is the major threat to Ironstone Mulla Mulla. Bridal Creeper also represents a significant threat across the majority of the habitat, in particular in Sugar Gum (*Eucalyptus cladocalyx*) low open forests.	High
Direct threat: Inappropriate fire regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate	High
Direct threat and knowledge gap: Spray drift	
Risk: Localised species extinction and degradation of critical habitat from spray drift (fertiliser and herbicide) **Likelihood:** Possible **Consequences:** Moderate Herbicide spray drift is an identified threat to Ironstone Mulla Mulla. The agricultural areas surrounding Ironstone Mulla Mulla sub-populations use aerial spraying methods to apply herbicides and insecticides. Council roadside maintenance also involves the periodic use of herbicides.	High
Direct threat: Vegetation clearance/roadside management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Likely **Consequences:** Moderate While Ironstone Mulla Mulla easily colonises disturbed soil at the edge of road formations, its disturbance requirements are poorly understood. It is unknown how seed viability, reproduction and other elements of the species life cycle are affected by roadside management. For example, during the 2005 flowering season, all Ironstone Mulla Mulla plants on the roadside near Murranatta Conservation Reserve were thickly infested with thrips (K Pobke [DEH] 2005, pers. comm.). This was not recorded at any other sub-populations that year.	High
Direct threat: High grazing pressure	
Risk: Loss of plants and seeds leading to population decline **Likelihood:** Likely **Consequences:** Moderate Livestock do not appear to graze Ironstone Mulla Mulla and, even where pasture has been grazed to low levels, this species is often still present (A Freebairn [DEH] 2004, pers. comm.). Grazing by rabbits and kangaroos still requires assessment.	High

Direct threat: **Pest and disease (*Phytophthora*)**					
Risk: Localised species extinction and degradation of critical habitat from pest and disease Likelihood: Likely Consequences: Moderate Ironstone Mulla Mulla occupies high rainfall areas within the High Risk Management zone identified by Velzeboer et al. (2005). It is therefore identified as a nationally threatened species potentially at threat of *Phytophthora* damage.					**High**
	Objective 1 **Baseline information**	**Objective 2** **Community involvement**	**Objective 3** **Manage threats and improve habitat**	**Objective 4** **Research critical to management**	**Objective 5** **Monitoring and evaluation**
Performance criteria	1a.1 1d.2 1b.1 1d.3 1c.1 1c.2 1c.4 1c.5 1d.1	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3d.2 3a.2 3d.3 3a.4 3e.1 3b.1 3e.2 3b.2 3e.3 3c.2 3e.4 3d.1	4b.5 4b.6 4c.2 4d.2 4e.1 4f.1 4h.1	5a.4 5a.7 5a.8 5a.9 5b.2

23.7 Main references

Davies, RJP 1986, Threatened plant species of the Mt Lofty and Kangaroo Island regions of South Australia, Conservation Council of South Australia Inc, Adelaide.

Ecological Associates 2007, *Eyre Peninsula Bushfire Recovery Program: vegetation monitoring,* report to the Department for Environment and Heritage, South Australia.

Davies, R 1995, Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia, Botanic Gardens of Adelaide and State Herbarium, South Australia.

Jessop, JP & Toelken, HR (eds) 1986, *Flora of South Australia, Part I: Lycopodiaceae-Rosaceae*, South Australian Government Printer, Adelaide.

Prider, J 2005, *Ptilotus beckerianus monitoring plan: memorandum*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

Prider, J 2006, *Study design: Fire response monitoring*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

Prider, J 2006a, *Threatened flora threat assessment*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

24 Tufted Bush-pea *Pultenaea trichophylla* HB Will ex JM Black

24.1 Status

When assessing Tufted Bush-pea vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 24.1). This is important given that this species only occurs on Eyre Peninsula. Tufted Bush-pea is however recognised as Rare at the Regional and State levels, and Vulnerable at the National level (Table 24.1).

Table 24.1. Tufted Bush-pea vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Rare	Rare	Vulnerable
Extent of occurrence (km²)	184		
Area of occupancy (km²)	0.295	Endemic to Eyre Peninsula	
Sub-populations	20		
Estimated # of individuals	10 500		
IUCN Criteria	**Justification**		
VU B2	Area of occupancy estimated to be less than 2000 km²		
VU B2a	Severely fragmented populations		
VU B2a,b(iii)	Continuing decline inferred in area, extent and quality of habitat		

24.2 Distribution

Tufted Bush-pea is endemic to southern Eyre Peninsula, where it is confined to the Eyre Hills Sub-region of the Eyre Yorke Block IBRA Region (Figure 1.1). The species' extent of occurrence is approximately 180 km², occurring within latitude 34°9'26" to longitude 136°4'55" (Ungarra) in the north, and latitude 34°29'1" to longitude 135°48'45" (Tucknott Scrub Conservation Park) in the south (DEH-EGIS 2006) (Figure 24.1).

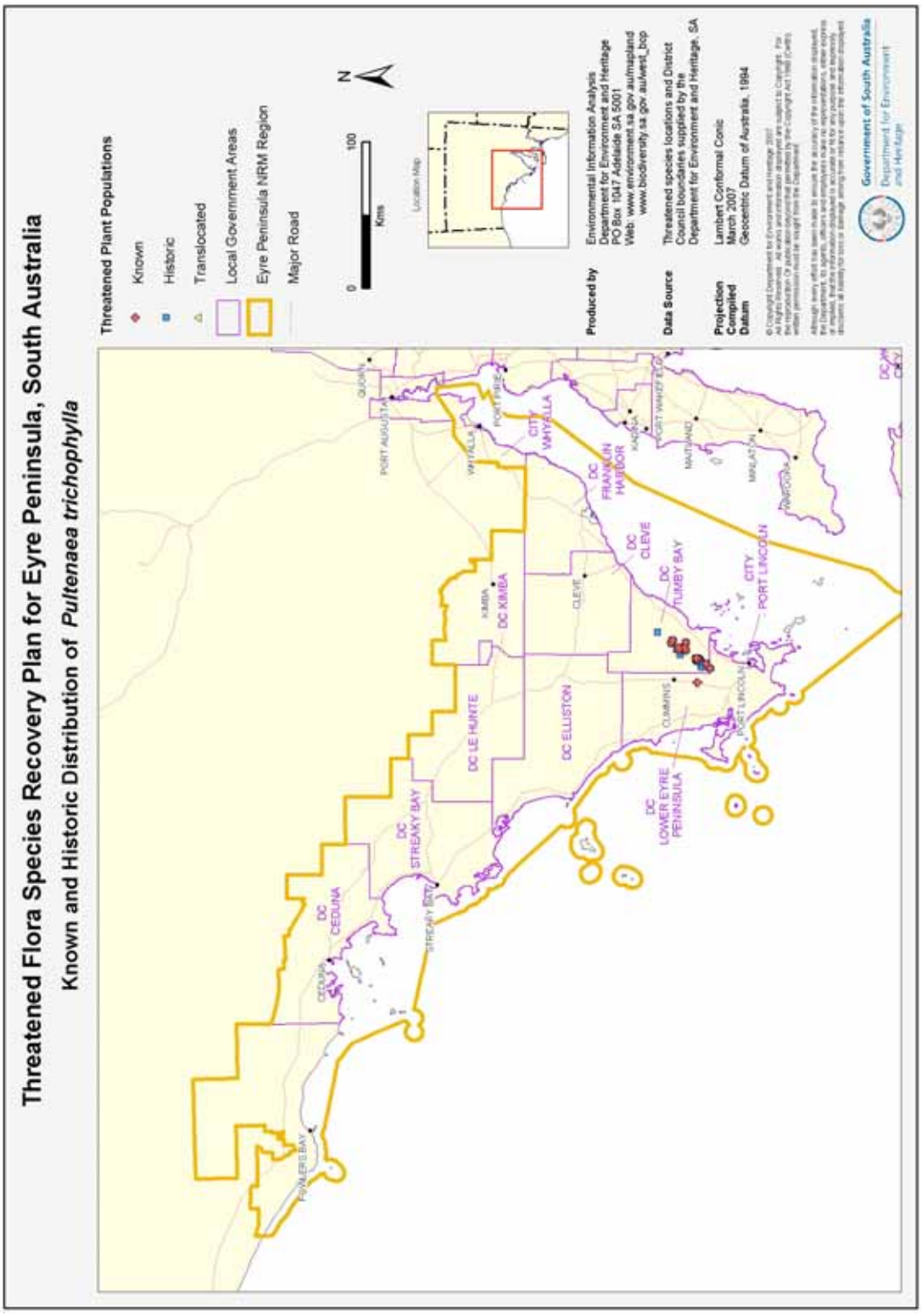
Tufted Bush-pea sub-populations grow within roadside vegetation managed by the District Council of Tumby Bay.

24.3 Habitat critical to survival

All known habitat of Tufted Bush-pea species is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Tufted Bush-pea sub-populations have been recorded within elevations of 110-270 m above sea level. The highest sub-populations grow on Heritage Agreement land near Pillaworta and Dray Pole Hill roads, and the lower sub-populations occur near Ungarra (DEH-EGIS 2006). Tufted Bush-pea has been recorded growing in soil types including pale brown or grey, acidic, sandy or clay loam over ironstone in gullies, hillcrests and undulating plains. The species has also been found in acidic gravelly sandy loam in open depressions, lateritic soils on hill slopes with outcropping quartzite, and hard, red-brown clay loam over laterite on the slopes of hills and gullies.



Note: Tufted Bush-pea details are held on internal DEH files and are available on request.

Figure 24.1. Distribution of Tufted Bush-pea on Eyre Peninsula

Vegetation associations

Vegetation associated with Tufted Bush-pea is referred to as open woodland scrub on loam with ironstone gravel, overlaying yellow clay (Jusaitis 1991). Associated vegetation includes Sugar Gum (*Eucalyptus cladocalyx*), Tate's grass-tree (*Xanthorrhoea semiplana* ssp. *tateana*), Broombush (*Melaleuca uncinata*) and *Darwinia homoranthoides* (Jusaitis 1991). The vegetation associations in Table 24.2 have been sourced from DEH-EGIS (2006).

Table 24.2. Vegetation associated with Tufted Bush-pea sub-populations

Primary species	Secondary species	Understorey species
Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*), +/- Peppermint Box (*E. odorata*) low open forest	Unrecorded	Unrecorded
Coast Ridge-fruited Mallee (*Eucalyptus angulosa*), Narrow-leaf Red Mallee (*E. leptophylla*), +/- Dumosa Mallee (*E. dumosa complex*), +/- Yorrell (*E. gracilis*) mid mallee woodland	Unrecorded	Unrecorded
Sugar Gum (*Eucalyptus cladocalyx*) mid woodland	+/- Golden Wattle (*Acacia pycnantha*), Rock Wattle (*A. rupicola*), +/- Yacca (*Xanthorrhoea semiplana*), +/-Broombush (*Melaleuca uncinata*) mid shrubs	Peach Heath (*Lissanthe strigosa* ssp. *subulata*), Small-flower Wallaby-grass (*Austrodanthonia setacea*) low shrubs over Broad-leaf Raspwort (*Gonocarpus mezianus*), and *Lagenophora huegelii*
Cummins Mallee (*Eucalyptus peninsularis*), +/- Ridge-fruited Mallee (*E. incrassata*), +/- Green-leaf Mallee (*E. phenax*), +/- Dumosa Mallee (*E. dumosa*), +/- Square-fruit Mallee (*E. calycogona*) mid mallee woodland	Broombush (*Melaleuca uncinata*), Dryland Tea-tree (*M. lanceolata*), +/- Mallee Honey-myrtle (*M. acuminata* ssp. *acuminata*) tall shrubs	+/- Limestone Saw-sedge (*Gahnia deusta*) low sedges
Broombush (*Melaleuca uncinata*) tall open shrubland	Silver Broombush (*Babingtonia behrii*), +/-Cup Fringe-mrytle (*Calytrix involucrata*) low shrubs	+/- Spinifex (*Triodia irritans*), +/- and *Hibbertia* sp. *Glabriuscula* (DJ Whibley 9012)

Climate

Tufted Bush-pea inhabits the 400-500 mm rainfall zones (DEH-EGIS 2006). At the Tod Reservoir in the vicinity of the southern extent of sub-populations, the mean annual maximum and minimum temperatures are 20.9 °C and 9.6 °C respectively, and the mean annual rainfall is 485.3 mm (BOM 2007). The mean annual rainfall at Ungarra in the vicinity of the northern-most sub-populations is 411.7 mm (BOM 2007).

Sub-populations within reserves

Tufted Bush-pea is known from Tucknott Scrub Conservation Park where R Bates first observed it in 1994 (DEH-EGIS 2006). The Tucknott Scrub sub-population was presumed burnt during the 2005 Wangary Bushfire, and it is presumed that other sub-populations within Heritage Agreements in the Hundreds of Hutchison, Koppio, Stokes and Louth were also burnt. Three sub-populations (estimated total of 569 plants) survive on roadside reserves within the District Council of Tumby Bay. Table 24.3 shows information about important populations of Tufted Bush-pea.

Table 24.3. Important populations of Tufted Bush-pea

Site	# plants	Extent (m^2)	Reasons
Near Tod River Reservoir	1200-5000	150 000 m^2	Largest known population, regularly monitored by M Jusaitis
Near Uranno	More than 500	Unknown	Large population
Near Nyllow Park and Nyllow Hill	Approximately 500	Unknown	Western facing hill-slope population in which seedling recruitment has been recorded

Benefits to other species

Tufted Bush-pea shares overlapping critical habitat with Eyre Peninsula Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus xanthanotus*) (state Vulnerable, regionally Critically Endangered on Eyre Peninsula) and Common Brushtail Possum (*Trichosurus vulpecula*) (state Rare, regionally Endangered on Eyre Peninsula) (Way & Bates 2005). Broad-scale management techniques used to conserve Tufted Bush-pea habitat is also expected to produce broader biodiversity benefits to woodland bird species such as the Scarlet Robin (*Petroica mulitcolor*) (EP: V) and the Western Grygone (Warbler)(*Gerygone fusca*) and Western Yellow Robin (*Eopsaltria griseogularis*) both of which considered to be in decline on Eyre Peninsula (Way & Bates 2005). Tufted Bush-pea habitat also supports populations of Fat-leaved Wattle (*Acacia pinguifolia*) (nationally Vulnerable) near Nyllow, and Silver Daisy-bush (*Olearia pannosa* ssp. *pannosa*) (nationally Vulnerable).

24.4 Biology and ecology

Tufted Bush-pea is a small, perennial, slender shrub with ascending branches to 30 cm long (Whibley 1986). Branches are reddish and covered with white, curly hairs when young. Leaves occur in false whorls at the ends of small branchlets, on 2-3 mm long petioles (Whibley 1986). A full taxonomic description for this species is found in Whibley (1986).

Small yellow pea flowers blossom between November and February (Jusaitis 1994). The flowers are approximately 7 mm long and grow at the tips of short branchlets. Flowering occurs progressively along the stem (Jusaitis 1991).

Tufted Bush-pea pollinator(s) are unknown. There is very little information on pollination of *Pultenaea* sp.; however, Halictid bees in the *Lasioglossum* genus are recorded as visitors to *Pultenaea* sp. (from one record) on Eyre Peninsula (Victorian Museum 2007).

Tufted Bush-pea seed development and dispersal is unknown. In general, ants are known to store seeds for *Fabaceae* species underground; however, their role in Tufted Bush-pea dispersal is unknown.

Germination en masse has been recorded from one sub-population after fire and good rain (M Jusaitis [DEH] 2007, pers. comm.). Before the 2005 Wangary fire, only two seedling recruits were observed over 10 years of monitoring the same sub-population. *Fabaceae* (pea flowers) in general are known to form symbiotic relationships with soil bacteria (*Rhizobium* sp.), allowing for nutrient fixing. Although average longevity of the species is unknown, M Jusaitis has monitored the same live plants for over 10 years (M Jusaitis [DEH] 2007, pers. comm.).

24.5 Previous management actions

Table 24.4. Previous management actions to conserve Tufted Bush-pea

	Previous management actions and points of interest
1990	Tufted Bush-pea sub-populations surveyed by Black Hill Flora Centre staff. Two photo points were established to monitor roadside populations for long-term study of population dynamics (Jusaitis 1991; Jusaitis 1994).
1990-93	Three year research project on Tufted Bush-pea funded by World Wide Fund for Nature (Jusaitis & Sorensen 1994).
1991-93	Propagation studies (Jusaitis & Sorensen 1994) and trial translocations to study grazing effects (Jusaitis 1997).
2001	One clone of Tufted Bush-pea kept at the Australian National Botanic Gardens.
2003	Seed collected from the Tod River Reservoir sub-population by A Freebairn (DEH, Threatened Flora Project Officer), and stored at the Seed Conservation Centre, Adelaide, for germination tests and long-term low temperature storage as part of the Millennium Seed Bank Project.
2005	Tufted Bush-pea sub-populations burnt in January 2005 during the Wangary Black Tuesday Bushfire. Fire-scar covered 11 sub-populations.
2005	Preliminary assessments of two Tufted Bush-pea sub-populations following the Wangary Bushfire were undertaken by Amber Clarke, Kirsten Knox and Annika Everaadt (DEH Northern and Yorke Region staff).
2006-07	Post-fire follow-up monitoring at Tod River site by Manfred Jusaitis (ongoing).

24.6 Threats to Tufted Bush-pea and associated recovery goals

The long-term goals are to down-list Tufted Bush-pea conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Tufted Bush-pea conservation status at Vulnerable.

Tufted Bush-pea has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle (M Jusaitis [DEH] 2007, pers. comm.).

Table 24.5 details the key threats and summarises performance criteria relevant to Tufted Bush-pea recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 24.5. Key threats to Tufted Bush-pea and summary of associated performance criteria

Direct threat: Habitat fragmentation, Restricted distribution/isolated populations	**Risk**
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate Sub-populations grow in small patches of remnant vegetation interspersed by cleared land. Fewer than 500 individuals occur along roadsides and these populations may be significant in maintaining gene flow between larger populations.	**High**
Direct threat: Pest and disease	
Risk: Localised species extinction and degradation of critical habitat from pest and disease (*Phytophthora*) **Likelihood:** Possible **Consequences:** Moderate *Phytophthora cinnamomi* (water mould) has the potential to threaten Tufted Bush-pea critical habitat and affect the plant species' survival. Velzeboer et al. (2005) regard Tufted Bush-pea as growing in the Moderate to Low Risk Management Zones for *Phytophthora*.	**High**
Direct threat: Inappropriate fire regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Annually monitored Tufted Bush-pea study sites near Tod River Reservoir had prolific seedling germination after the 2005 bushfire and first autumn rains (M Jusaitis [DEH] 2007, pers. comm.). It is highly likely that this very preliminary result of mass seedling germination in response to fire is one of the species' fundamental recruitment methods and a necessary part of the plant's life cycle. Long unburnt sub-populations are assumed to have downward population trends.	**High**
Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequences:** Moderate	**High**
Direct threat: Vegetation clearance/roadside and Railway management	
Risk: Localised species extinction from roadside and easement work failing to apply Environmental Best Practise **Likelihood:** Possible **Consequence:** Minor Road and rail reserve sub-populations are potentially at risk of clearance and/or off-target herbicide damage. These populations are also considered to be at higher risk of weed invasion.	Moderate
Direct threat: High grazing pressure	
Risk: Loss of germinated juveniles and adult plants (including flowers and associated seed), which unstabilises life class structure and increases risk of population decline **Likelihood:** Possible **Consequences:** Minor Tufted Bush-pea grows primarily between agricultural lands and therefore agricultural practices may impact upon this species. Domestic stock appears to utilise this species as a fodder plant, while no evidence has been found of grazing by rabbits and kangaroos (Jusaitis 1991).	Moderate

	Objective 1 Baseline information	Objective 2 Community involvement	Objective 3 Manage threats and improve habitat		Objective 4 Research critical to management	Objective 5 Monitoring and evaluation
Performance criteria	1a.1 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.3 3a.4 3b.1 3b.3 3c.2 3d.2 3d.3	3e.1 3e.3 3f.1 3f.3 3f.4 3f.8	4b.2 4b.6 4c.2 4h.2	5a.5 5a.7 5a.7 5a.9 5b.2

24.7 Main references

Jusaitis, M 1991, *Recovery plans* Prostanthera eurybiodes, Pterostylis arenicola, Acacia cretacea, Pultenaea trichophylla, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Jusaitis, M 1997, 'Experimental translocations: implications for the recovery of endangered plants' in DH Touchell, KW Dixon, AS George & AT Wills (eds), *Conservation into the 21st Century: Proceedings of the 4th International Botanic Gardens Conservation Congress, Perth, Western Australia*, Kings Park and Botanic Garden, Western Australia.

Jusaitis, M & Sorensen, B 1994, *Conservation studies on endangered plant species from South Australia's Agricultural regions*, Black Hill Flora Centre, Botanic Gardens of Adelaide.

National Parks & Wildlife Council 2003, *Review of the status of threatened species in South Australia: Proposed schedules under the South Australian* National Parks and Wildlife Act 1972, discussion paper, Department for Environment and Heritage, South Australia.

25 Sandalwood *Santalum spicatum* R Br. & A. DC

25.1 Status

When assessing Eyre Peninsula Sandalwood vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 25.1). Sandalwood is however recognised as Vulnerable at the Regional and State levels (Table 25.1). The species is not listed at the National level.

Table 25.1. Sandalwood vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Nil
Extent of occurrence (km²)	26 950		
Area of occupancy (km²)	0.4		
Sub-populations	48		
Estimated # of individuals	5000		
IUCN Criteria	**Justification**		
EN A2a	A suspected population size reduction on Eyre Peninsula of at least 50% over the last three generations		
EN A2a,c	A decline in area of occupancy, extent of occurrence and quality of habitat on Eyre Peninsula		
EN A2a,c,d*	Potential levels of exploitation on Eyre Peninsula		

25.2 Distribution

Sandalwood distribution spans from the Western Australian coast, wheat-belt and Nullarbor into South Australia, though to the Gairdner-Torrens region, across the northern part of Eyre Peninsula and into the Flinders Ranges (Jessop & Toelken 1986). Forty-eight Sandalwood populations have been recorded from northern Eyre Peninsula; however, only seven sites have been revisited since 1995 (Figure 25.1). The known Sandalwood populations span four Natural Resource Management regions, namely Eyre Peninsula, Alinytjara Wilurara, South Australian Arid Lands, and Northern and Yorke. The extent of occurrence of Sandalwood across northern Eyre Peninsula is approximately 27 000 km², occurring within latitude 30°14'S to longitude134°47'E (near Andamooka) in the north, and latitude 33°24'S to longitude 136°0'E (near Darke Peak) in the south (DEH-EGIS 2006).

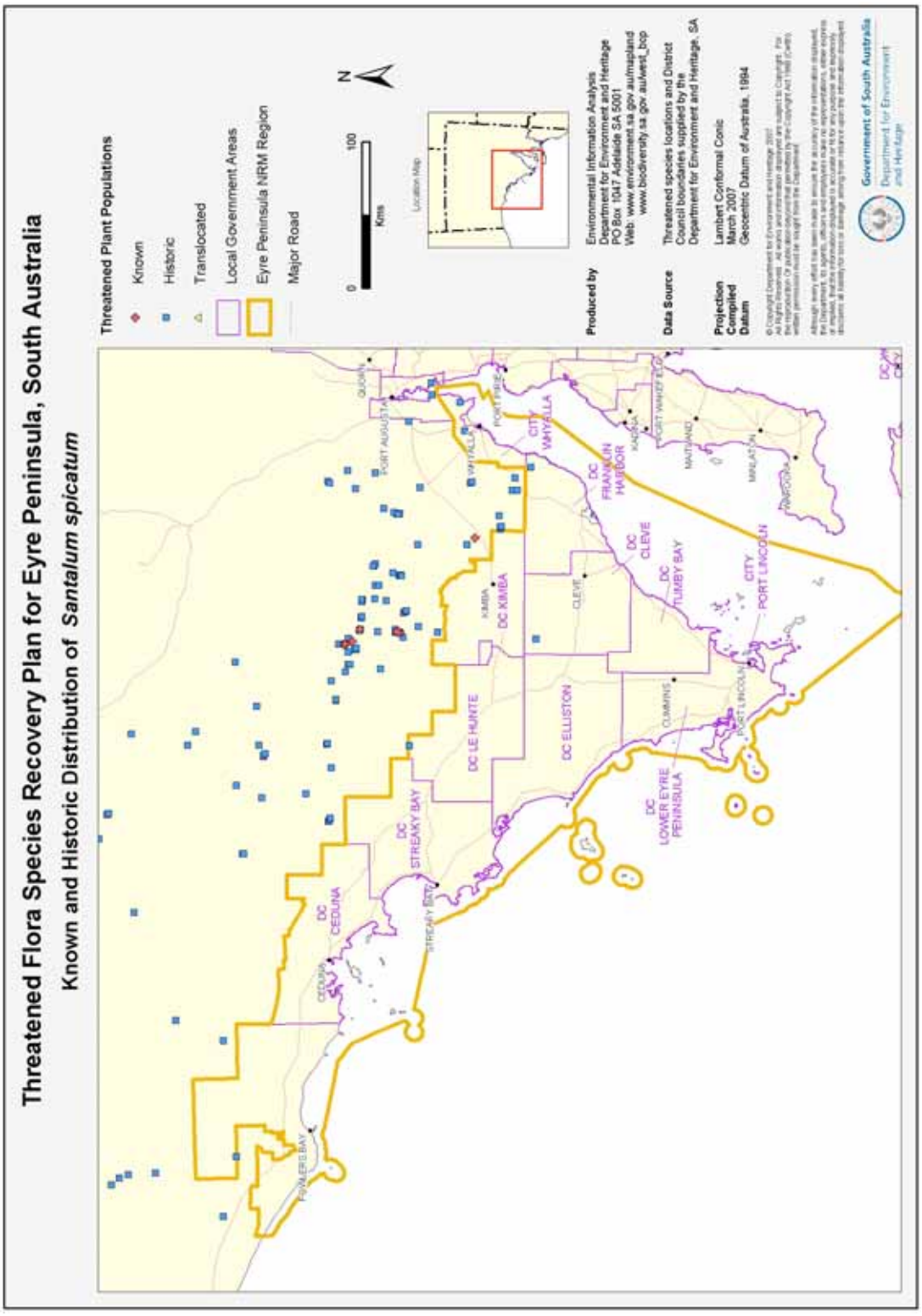
25.3 Habitat critical to survival

All known habitat of Sandalwood is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Sandalwood grows in sandy, gravel and loamy soils, and is also known to grow near granite outcrops (Fox 1997). From DEH-EGIS mapping (2006), Sandalwood locations have been recorded corresponding with the following environmental descriptions:

- dune crests, dune slopes and inter-dunes with sand to loamy sand
- hill foot-slopes with soil derived from up slope erosion, sand, cemented with calcrete
- consolidated dunes with sand to loamy sand
- ridges, hill crests and plains with loam to clay loam.



Note: Details of Sandalwood populations are held on internal DEH files and are available on request.

Figure 25.1. Distribution of Sandalwood on Eyre Peninsula

Vegetation associations

Because Sandalwood is a root hemi-parasite[12] it relies on host species including, but not limited to *Acacia, Allocasuarina*, *Melaleuca* and various herbaceous species (Brand 2000; Brand, Crombie & Mitchell 1999; Fox 1997). Ground truthed vegetation at the Mount Ive Sandalwood sub-population includes overstorey species of Myall (*Acacia papyrocarpa*), *A. aneura* var. *aneura,* Granite Wattle *(A. tarculensis*), Prickly Wattle (*A. tetragonphylla*), *Heterodendrum oleiafolium* and *Allocasuarina* species. Understorey species include Desert Senna (*Senna artemisioides*), Perennial Saltbush (*Atriplex vesicaria*), Ward's Weed (**Carrichtera annua*), Slender Hopbush *(Dodonaea viscosa* ssp. *angustissima*), Lobe-leaf Hopbush (*D. lobulata*), Short-leaf Bluebush (*Maireanna brevifolia*), Black Bluebush (*M. pyramidata*), Porcupine Grass (*Triodia irritans*) and *Ptilotus* species.

Plant species recorded in association with the Lake Gilles Conservation Park Sandalwood sub-population include False Sandalwood (*Myoporum platycarpum*), Sheep Bush (*Geijera linearfolia*), *Senna artemisioides* subspecies, Spiny Fanflower (*Scaevola spinescens*), Bladder Saltbush (*Atriplex vesicaria*) and Notable Wattle (*Acacia notabilis*). Associated vegetation communities are listed in Table 25.2 and have been sourced from DEH-EGIS (2006).

Table 25.2. Vegetation associated with Sandalwood sub-populations, Eyre Peninsula

Primary species	Secondary species	Understorey species
Red Mallee (*Eucalyptus oleosa* ssp. *oleosa*), +/-Boree (*Melaleuca pauperiflora* ssp. *mutica*) mid mallee woodland	Hummock Honey-myrtle (*Melaleuca eleuterostachya*), Broom Emubush (*Eremophila scoparia*), Boree (*Melaleuca pauperiflora* ssp. *mutica*), +/- Merrall's Wattle (*Acacia merrallii*), +/- Sheep Bush (*Geijera linearifolia*) tall open shrubland	Mueller's Daisy-bush (*Olearia muelleri*), Purple Emubush (*Eremophila weldii*), Spinifex (*Triodia scariosa*), +/- Bladder Saltbush (*Atriplex vesicaria*), Stiff Westringia (*Westringia rigida*), Small Hop-bush (*Dodonaea bursariifolia*), +/- Erect Mallee Bluebush (*Maireana pentatropis*), +/- Fleshy Saltbush (*Rhagodia crassifolia*), +/- Bluebush Daisy (*Cratystylis conocephala*) low open shrubland
Three-valve Mallee *(Eucalyptus trivalvis*), Ooldea Mallee (*E. youngiana), Acacia clelandii*, and Mulga (*Acacia aneura* var.) mid mallee woodland	Water Bush (*Grevillea nematophylla* ssp. *nematophylla*), Dead Finish (*Acacia tetragonophylla*), Crimson Emubush (*Eremophila latrobei* ssp. *glabra*), Bluebush (*Maireana sedifolia*) mid sparse shrubland	Australian Boxthorn (*Lycium australe*), Silky Bluebush (*Maireana villosa*) low open hummock grassland
White Mallee (*Eucalyptus dumosa*), +/- Beaked Red Mallee (*E. socialis),* +/-Yalata Mallee (*E. yalatensis*) mid mallee woodland	Dryland Tea-tree (*Melaleuca lanceolata*), Broombush (*M. uncinata*), +/- Mallee Honey-myrtle (*M. acuminata* ssp. *acuminata*) tall shrubs	+/- Spinifex (*Triodia irritans*) low hummock grasses
Yorrell (*Eucalyptus gracilis*), Red Mallee (*Eucalyptus oleosa* ssp. *oleosa*) mid mallee woodland	Bluebush (*Maireana sedifolia*) and *Atriplex* sp. shrubs	Unrecorded
Sheep Bush (*Geijera linearifolia*), +/- *Acacia* sp., +/- Desert Senna (*Senna artemisioides*) mid open shrubland	Nitre-bush (*Nitraria billardierei*)	*Maireana* sp., *Austrostipa* sp. shrubs

[12] Hemi-parasite, where *hemi* is derived from Greek meaning 'half, partial' and *parasite* refers to Sandalwood living on/in other organisms (hosts) though the root system. Sandalwood is able to photosynthesise, but taps into the host plants' roots for water and inorganic nutrients, gradually leading to the demise of the host plants.

Climate

Sandalwood inhabits the arid 150-320 mm rainfall zone (Bonney 1997). From Figure 25.1, it is clear that the northern expanse of Sandalwood populations spans extensively throughout the arid north of South Australia. The southern most Sandalwood sub-populations experience climatic conditions similar to Whyalla (south-eastern extent) and Ceduna (south-western extent). Ceduna's mean annual maximum and minimum temperatures are 22.6 °C and 10.6 °C respectively, with a mean annual rainfall of 292.8 mm. Whyalla has mean annual temperatures of 23.2 °C (maximum) and 13 °C (minimum), and mean annual rainfall of 277.5 mm.

Known sub-populations within reserves

Sandalwood is located within the South Australian reserve system (Table 25.3), and is not known to occur within any Heritage Agreements on Eyre Peninsula.

Table 25.3. Sandalwood sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Yellabina Regional Reserve	1	A Robinson and P Canty 1984
Lake Gairdner National Park	1	C Malley and J Gillen 1985
Lake Gilles Conservation Park	2?	Mason 1973 A Freebairn 2003
Munyaroo Conservation Park	1	A Spooner 1990
Whyalla Conservation Park	1	D Murfet and R Taplin 1998
Winninowie Conservation Park	1	Field Naturalist Society of South Australia (FNS-SA) 1970

Benefits to other species

The conservation of Sandalwood is expected to benefit multiple species through protection and management of habitat. Retaining a tall tree vegetation layer within arid areas is a key conservation objective because grazing pressure on seedlings is resulting in many of these tall, mature trees reaching senescence without recruiting.

Monitoring and control of feral goat grazing for the targeted conservation of Sandalwood will have multiple species benefit. Broad-scale management techniques and collection of baseline data are expected to benefit other plant species growing in association with Sandalwood, particularly those species with similar niches, flowering response and/or pollinator needs. For example, species such as the native Spotted Jezebel butterfly breed and grow on Sandalwood, and the larvae of these butterflies have actually been observed growing better on Sandalwood that any other plant species (DEC 2007). Host species may also benefit.

25.4 Biology and ecology

Sandalwood biology and ecology has undergone substantial research because of the worldwide demand for Sandalwood products, and the subsequent plantation and farm forestry industry. Primary production of Sandalwood, largely Western Australian based, means that Australia still harvests and exports Sandalwood seeds, oil and aromatic heartwood. In the past (1892-1901), harvest of native Sandalwood was big business with an estimated 51 336 tons harvested in that 10 year period alone (Talbot 1983).

As mentioned in Section 25.3, Sandalwood is a root hemi-parasite associated with a range of host species including, but not limited to, various *Acacia* species (Brand 2000; Brand, Crombie & Mitchell 1999). Sandalwood is a perennial shrub or tree that grows to 3-8 m high, with sparse, irregular spreading branches and dull grey-green fleshy leaves (Jessop 1986).

Flowering generally occurs between March and June, but can occur throughout the year (Jessop 1986). Sandalwood flowers change colour, starting with green (day 1), turning pink (day 2) and maturing to dark red (day 3) (Rugkhla, McComb & Jones 1997). Flowers are approximately 5 mm across (Barrett 1987) and grow from the axil (leaf to stem joint) in a cluster arrangement of small flowers (Jessop 1986). Flowers are fragrant and have four petals. The flowering success of individual trees is thought to be influenced by photoperiod[13] response and to a lesser degree influenced by rainfall (Fox 1997). Fruits mature from August to November (Brand & Jones 1999a).

Natural pollinators of Sandalwood are not widely reported in literature, although the species is assumed to be insect pollinated (Byrne et al. 2003), with flies, bees, wasps, ants and native cockroaches regular seen visiting Sandalwood flowers in Western Australia (Barrett 1987). Johnson (1996) observed Flower Wasps (*Scolia* sp., family *Scoliidae*) feeding on flowers of Northern Sandalwood (*Santalum lanceolatum*). Spotted Jezebel Butterflies are known to breed and grow on Sandalwood (DEC 2007), but it is unknown what role, if any, they play in pollination.

Sandalwood produces round, yellowish to red-brown coloured fruits, 2-2.5 cm in diameter, which have a non-succulent exocarp (outermost layer of the fruit wall) (Jessop 1986). Plants can produce fruits as early as 5 years old (Brand 1999b). On average Sandalwood trees start fruiting between 5-10 years old (Brand 1999b). Dry and empty fruits have been observed lying on the ground under mature Sandalwood trees in the Lake Gilles Conservation Park (K Pobke [DEH] & S Bey [Greening Australia] 2005, pers. observation).

Dispersal and germination has been studied in Western Australian Sandalwood sub-populations. Murphy, Garkaklis and Hardy (2005) found that sites that had Brush-tailed Bettongs (*Bettongia penicillata*) had significantly more Sandalwood seedlings and saplings. The seed caching behaviour of Brush-tailed Bettongs meant that seedlings were established significantly further away from parent trees, thereby modifying Sandalwood distribution (Murphy, Garkaklis & Hardy 2005).

Sandalwood is a slow growing species, taking 20-90 years to reach a size that would deem it commercially viable to be harvested (Rugkhla, McComb & Jones 1997) or grow a stem diameter of 127 mm at 15 cm above ground (Brand 1999c). Sandalwood is thought to be fire sensitive, with poor re-sprouting observed post-fire (Brand 1999b).

Two other *Santalum* species occur on Eyre Peninsula, i.e. Quandong (*Santalum acuminatum*) and Bitter Quandong (*S. murrayanum*) (Jessop 1986).

13 Photoperiod is the interval in a 24 hour period during which a plant is exposed to light.

25.5 Previous management actions

Table 25.4. Previous management actions to conserve Sandalwood

	Previous management actions
2001	Sandalwood seeds collected from Lake Gilles CP sub-population by Freebairn.
2002	Site visits and assessments by W. Crisp to Mt. Ive Station Sandalwood populations
2003	Site visit (14/03/03) and assessment by Freebairn of Lake Gilles Conservation Park Sandalwood sub-population. One kilometre transects walked to map/count individual Sandalwood. Results located on internal DEH files, including GPS location, height class, trunk circumference, presence of seed, scats and tracks of kangaroos, goats, and rabbits.

25.6 Threats to Sandalwood and associated recovery goals

The long-term goals are to down-list Sandalwood conservation status from State Vulnerable to State Rare, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Sandalwood conservation status at state Vulnerable.

Sandalwood has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E).

Table 25.5 details the key threats and summarises performance criteria relevant to Sandalwood recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 25.5. Key threats to Sandalwood and summary of associated performance criteria

Direct threat: **High grazing pressure**	Risk
Risk: Loss of germinated juveniles which unstabilises life class structure and severely increases risk of population decline **Likelihood:** Almost certain **Consequence:** Major Goats were identified as being the primary herbivore grazing Sandalwood at the Lake Gilles Conservation park (A Freebairn [DEH] 2003, pers. comm.). These Sandalwood populations all have obvious canopy grazing lines and damage to trunks and branches that can be attributed to goat grazing. The impact of camel grazing on Sandalwood is unknown. Camel grazing of Quandong (*Santalum acuminatum*) in the Great Victoria Desert has been noted (Peeters et al. 2005). Impacts of other herbivore species on Sandalwood are yet to be assessed, with the presence of kangaroos and rabbits at the Lake Gilles site noted (A Freebairn [DEH] 2003, pers. comm.). Future control of grazing at Sandalwood sites will require adequate input into other local programs (e.g. Bounceback) to facilitate strategic expansion to include Sandalwood sites.	Extreme
Direct threat: Inappropriate fire and disturbance regimes	
Risk 1: Species (including soil seedbank) at risk of localised extinction due to large fire in critical habitat **Risk 2:** Identified break down in species reproductive cycle, e.g. seed caching and seed germination nil to minimal across all sub-populations **Likelihood:** Likely **Consequence:** Major Sandalwood is known to be a fire sensitive species (FPC 2007). In particular, a large, intense fire in the species' critical habitat could be expected to kill populations outright. Loss of small mammals as dispersal, distribution and propagation vectors (Murphy, Garkaklis & Hardy 2005) is a significant threat. The long-lived nature of the species means that mature populations will survival up to a point when all plants start senencing at once, and there are no new, younger plants to replace them. Any seed on the ground that has not already been predated or perished, is likely to be damaged by an intense bushfire. Without the seed burial process used by small mammals to cache these seeds into places where they can otherwise germinate, there is likely to be no germination after fire.	Extreme
Direct threat: Habitat fragmentation	
Risk: Reduction in species resilience to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Major The majority of known populations are small and occur in highly fragmented and modified habitat. These fragmented populations of Sandalwood may have low genetic variability and genetic flow, particularly when comparing the species' widespread distribution prior to settlement with their now small, isolated and generally senescing sub-populations. Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases.	Extreme
Direct threat: Lack of recruitment/small population	
Risk: Loss of germinated juveniles which unstabilises life class structure and increases risk of population decline **Likelihood:** Almost certain **Consequences:** Major According to a site visit to Lake Gilles Conservation Park in 2003 by Freebairn, verified populations of Sandalwood demonstrate good seed set, although no recruitment is evident. This lack of recruitment and foreseeable lack of recruitment in the future has also been observed by Bey (S Bey [Greening Australia] 2007, pers. comm.). The lack of recruitment within natural Sandalwood populations requires interventional assistance (S Bey [Greening Australia] 2007, pers. comm.). The current small, but growing interest in Sandalwood forestry on Eyre Peninsula could result in Sandalwood seed from Western Australia coming into areas where Eyre Peninsula Sandalwood is growing. It is assumed that Western Australian Sandalwood is genetically different to that found on Eyre Peninsula. Although it is considered too late to stop this process, policy guidelines should probably be developed to ensure that Western Australian sourced seeds are phased out and local provenance used where possible (P Copley [DEH] 2006, pers. comm.). Such guidelines could include the maintenance of a buffer distance between plantations and wild plants/populations) (P Copley [DEH] 2006, pers. comm.).	Extreme

Direct threat: **Illegal collection and harvest**						
Risk: Loss of individual plants and genetic material, undermining recovery efforts Likelihood: Likely Consequences: Moderate Prices for Sandalwood remain high, therefore, the collection of seed and timber harvesting are potential threats to Sandalwood recruitment and survival.						High
	Objective 1 **Baseline information**	**Objective 2** **Community involvement**	**Objective 3** **Manage threats and improve habitat**		**Objective 4** **Research critical to management**	**Objective 5** **Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3a.3 3a.4 3b.1 3b.3 3c.1 3c.2 3d.3	3e.1 3e.3 3e.4 3f.1 3f.3 3f.4 3f.8	4d.3 4e.1	5a.5 5a.10 5b.2

25.7 Main references

Brand, J & Jones, P 1999a, *Growing Sandalwood (*Santalum spicatum*) on farmland in Western Australia*, information sheet, Department of Conservation and Land Management, Perth.

Brand, J 1999b, *Conserving sandalwood (*Santalum spicatum*) in the rangelands, Western Australia*, information sheet, Department of Conservation and Land Management, Perth.

Brand, J 2002, 'Review of the influence of Acacia species on establishment of Sandalwood *(Santalum spicatum*) in Western Australia', *Conservation Science Western Australia*, vol. 4, no. 1, pp. 125-129.

Barrett, DR 1987, 'Initial observations on flowering and fruiting in *Santalum spicatum* (R.BR.) A.DC. the Western Australian Sandalwood', *Mulga Research Centre Journal*, no. 9.

Fox, F 1997, 'Why is Santalum spicatum common near granite rocks?', *Journal of Royal Society of Western Australia*, vol. 80, pp. 209-220.

Murphy, M, Garkaklis, M & Hardy, G 2005, 'Seed caching by Woylies *Bettongia penicillata* can increase Sandalwood *Santalum spicatum* regeneration in Western Australia', *Austral Ecology*, vol. 30, pp. 747-755.

Rugkhla, A, McComb, J & Jones, M 1997, 'Intra- and inter-specific pollination of *Santalum spicatum and S. album*', *Australian Journal of Botany*, vol. 45, pp. 1083-1095.

Talbot, L 1983, 'Wooden gold: early days of the Sandalwood industry', *Forest Focus*, vol. 30, pp. 21-31.

26 Annual Candles *Stackhousia annua* WR Barker

26.1 Status

When assessing Eyre Peninsula Annual Candles vital attributes against IUCN criteria (IUCN 2001), this species could be considered Critically Endangered (Table 26.1). Annual Candles is however recognised as Vulnerable at the Regional, State and National levels (Table 26.1).

Table 26.1. Annual Candles vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	22.55		
Area of occupancy (km²)	Unknown	Endemic to South Australia	
Sub-populations	3		
Estimated # of individuals	300		
IUCN Criteria	**Justification**		
CR B1	Extent of occurrence estimated to be less than 100 km² on Eyre Peninsula		
CR B1b(iii)	Continued decline inferred in area, extent and quality of habitat on Eyre Peninsula		
CR B1b(iii),c(iv)*	Extreme fluctuations in number of mature individuals on Eyre Peninsula		

26.2 Distribution

Annual Candles is endemic to South Australia and grows in disjunct sub-populations on the southern tips of Eyre Peninsula and Yorke Peninsula, and in the upper South East. On Eyre Peninsula, Annual Candles grows within an estimated extent of occurrence of 22 km², within latitude 34°46'10"S to longitude 135°56'41"E in the north, and latitude 34°54'13"S to longitude 135°55'11"E in the south (DEH-EGIS 2006) (Figure 26.1).

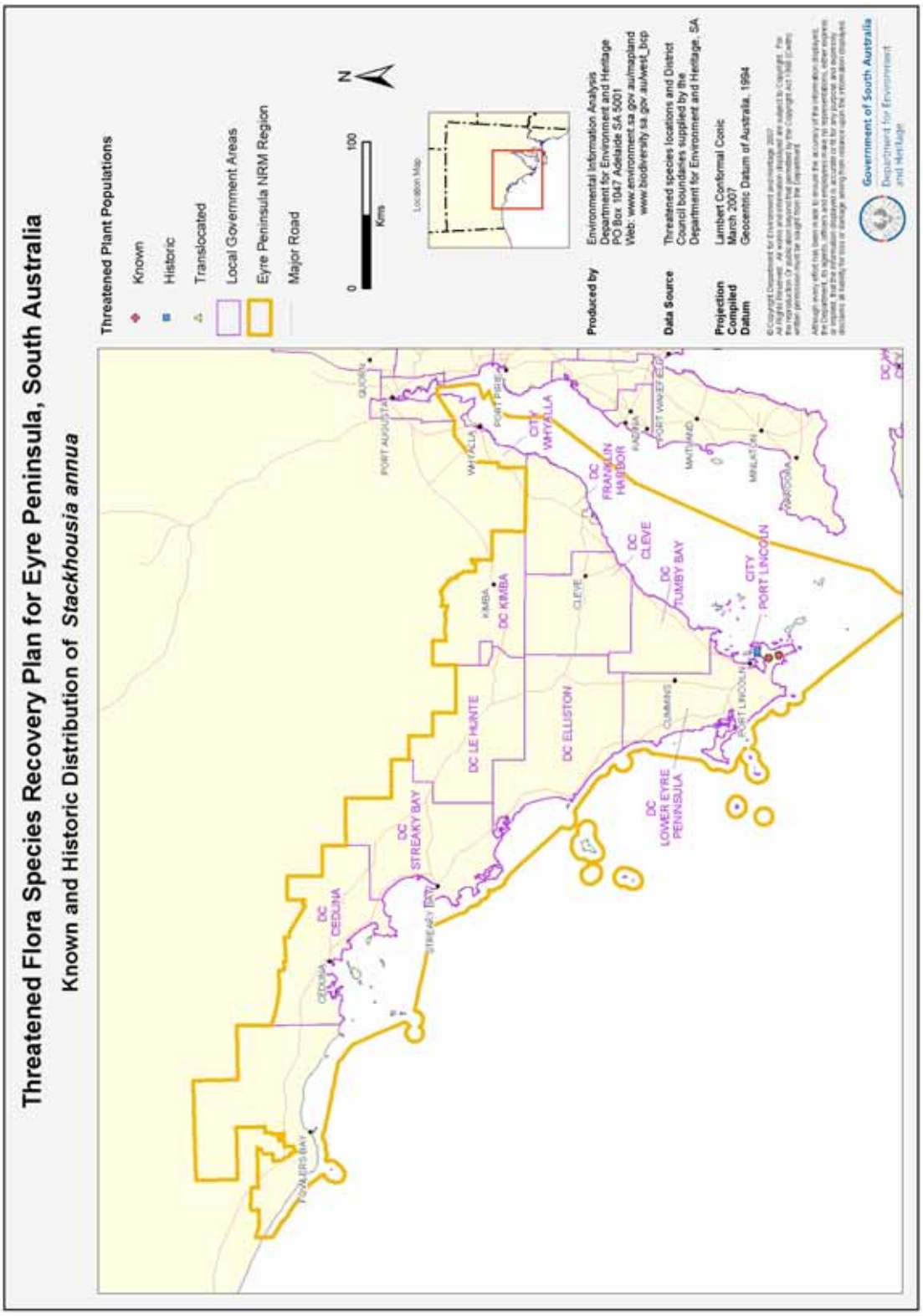
Annual Candles grows in the District Council of Lower Eyre Peninsula.

26.3 Habitat critical to survival

All known habitat of Annual Candles is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Sub-populations of Annual Candles have been found growing on relatively flat terrain on flats and plains that are 10-60 m above sea level (DEH-EGIS 2006). Herbarium records for Eyre Peninsula state that the species grows in grey clay loam over broken limestone and granite. Soils are silty loam, sandy loam and light medium clay, often with calcareous material present (DEH-EGIS 2006). Plants are denser in concentration in damp areas, for example, in graded road gutters in Lincoln National Park. On Yorke Peninsula, sub-populations are associated with similar soil characteristics, such as skeletal loamy organic matter with a pH of 8.5, formed over limestone, in gently undulating terrain (DEH Recfind file 40/1477).



Note: Annual Candles details are held on internal DEH files and are available on request.

Figure 26.1. Distribution of Annual Candles on Eyre Peninsula

Vegetation associations

Associated vegetation is generally described as coastal woodland containing Dryland Tea-tree (*Melaleuca lanceolata*) on thin soils above sheet limestone. Associated vegetation communities are listed in Table 26.2 and have been sourced from DEH-EGIS (2006).

Table 26.2. Vegetation associated with Annual Candles on Eyre Peninsula

Primary species	Secondary species	Understorey species
Yorrell (*Eucalyptus gracilis*) mid mallee woodland	Dryland Tea-tree (*Melaleuca lanceolata*), +/-Broombush (*M. uncinata*) tall shrubs	Open
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	Coast Daisy-bush (*Olearia axillaris*), Coast Beard-heath (*Leucopogon parviflorus*), Dryland Tea-tree (*M. lanceolata*) tall shrubs	+/- Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs
Port Lincoln Mallee (*Eucalyptus conglobata* ssp. *conglobata*), +/- Yorrell (*E. gracilis*), +/- Red Mallee (*E. oleosa*) mid mallee woodland	Dryland Tea-tree (*M. lanceolata*) tall shrubs	+/- Pale Turpentine Bush (*Beyeria lechenaultii*), +/- Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs

Climate

Annual Candles inhabits the 450-500 mm rainfall zone. On Lower Eyre Peninsula the species experiences a similar climate to Port Lincoln, which has mean annual maximum and minimum temperatures of 20.8 °C and 11.7 °C respectively, and a mean annual rainfall of 490.9 mm.

Known sub-populations within reserves

There are only three records of Annual Candles growing on Eyre Peninsula and all are within Lincoln National Park (observed by J Briggs in 1983 and D Murfet in 1995).

Benefits to other species

The conservation of Annual Candles is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data are expected to benefit other plant species growing in association, such as those that have a similar annual life form, flowering response and/or pollination needs. Collection of Annual Candles baseline data is expected to develop our understanding of vegetation succession, weed invasion, fire management and the conservation of threatened flora within Lincoln National Park.

26.4 Biology and ecology

Annual Candles is an annual herb that grows to approximately 19 cm tall. It is hairless (glabrous) and slender. Leaves are 7-25 mm long and grade from basal leaves that are generally narrowly spoon-shaped (spathulate), to upper leaves that are narrowly obovate[14] to linear (Barker 1986).

Flowering occurs between September to October. The cream coloured flowers grow at the terminal in a dense, cylindrical floral spike. Fertile flowers of *Stackhousia* species are hermaphrodites (Macfarlane, Watson & Marchant 2002).

[14] Obovate leaves are generally shaped like the longitudinal section of an egg. Their length does not exceed twice their breadth, and the greatest width is slightly above the middle.

Pollination of Annual Candles is unknown; however, moths are presumed to be a pollination vector for some *Stackhousia* species (DPIW 2003; DPIW 2003a). Seed longevity, size of seed soil bank, seed predation levels and dispersal are also unknown.

Germination triggers are unknown, but assumed to be influenced by available soil moisture, with dry conditions resulting in a lack of germination in some years (Leigh, Boden & Briggs 1984). Annual Candles has been observed growing in rolled firebreaks at Warrenben Conservation Park on Yorke Peninsula (Lang 1984).

Stackhousia species have been observed doing well after fire (Leigh, Boden & Briggs 1984); however, it is unknown how this relates to the ecology of Annual Candles.

26.5 Previous management actions

Table 26.3. Previous management actions to conserve Annual Candles

	Previous management actions
1989	Annual Candles cultivated at the Adelaide Botanic Gardens and Australian National Botanical Gardens (Meredith and Richardson) (DEH Recfind file 40/1477).
1989	Photo-point photos taken for Annual Candles sub-populations in Lincoln National Park.
2004	Seed collection made by D Durval from the Seed Conservation Centre, Adelaide, for the Millennium Seed Bank Project.

26.6 Threats to Annual Candles and associated recovery goals

The long-term goals are to down-list Annual Candles conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Annual Candles conservation status at Vulnerable.

Annual Candles has been ranked as a Priority 2 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). It is suspected that the species may respond well to fire.

Table 26.4 details the key threats and summarises performance criteria relevant to Annual Candles recovery (Tables 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 26.4. Key threats to Annual Candles and summary of associated performance criteria

Direct threat: Restricted distribution/isolated sub-populations	**Risk**
Risk: Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases **Likelihood:** Likely **Consequence:** Moderate Limited distribution range on Lower Eyre Peninsula may mean this species has low genetic variability and genetic flow.	**High**
Direct threat and knowledge gap: High grazing pressure	
Risk: Loss of germinated juveniles and seed source, resulting in unstable life class structure and increased risk of population decline **Likelihood:** Possible **Consequence:** Moderate Annual Candles is thought to be a highly palatable species and rabbits are known grazers (Green 1988). If grazing occurs before the plant has set seed, seed production for the next generation is threatened. Seed predation from the soil seed bank also requires further study.	**High**
Direct threat and knowledge gap: Inappropriate fire and disturbance regimes	
Risk: Localised species extinction and/or changes in critical habitat that no longer suit species survival **Likelihood:** Possible **Consequence:** Moderate The species grows in open areas maintained as firebreaks, e.g. along rolled firebreaks in Warrenben Conservation Park on Yorke Peninsula. Changing firebreak maintenance regimes could directly alter Annual Candles population density (Green 1988). Disturbance needs to coincide with favourable weather conditions and there is thought to be a strong relationship between rainfall, germination and seed set (DEH Recfind file 40/1477). Changes in climate patterns, even for a relatively short period of time (e.g. a decade), may result in localised extinction.	**High**
Direct threat and knowledge gap: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival **Likelihood:** Likely **Consequences:** Moderate As with other annuals, this species is susceptible to competition and crowding-out from weeds. Annual weedy herbs and grasses have been identified as a management issue in Warren Conservation Park where the weeds invade Annual Candles habitat (Green 1988). A similar threat from periodic weed invasion is likely on Eyre Peninsula.	**High**

	Objective 1 Baseline information	**Objective 2 Community involvement**	**Objective 3 Manage threats and improve habitat**	**Objective 4 Research critical to management**	**Objective 5 Monitoring and evaluation**
Performance criteria	1a.2 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3d.2 3a.3 3d.3 3a.4 3e.3 3b.1 3f.4 3b.3 3f.8 3c.2	4b.2 4d.2	5a.5 5a.9 5b.2

26.7 Main references

Barker, WR 1986, 'Stackhousiaceae-Stackhousia', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

Leigh, J, Boden, R & Briggs, J 1984, *Extinct and endangered plants of Australia*, MacMillan, Australia.

27 Yellow Swainson-pea *Swainsona pyrophila* J Thomps

27.1 Status

When assessing Eyre Peninsula Yellow Swainson-pea vital attributes against IUCN criteria (IUCN 2001), this species could be considered Vulnerable (Table 27.1). Yellow Swainson-pea is recognised as Vulnerable at the Regional, State and National levels (Table 27.1).

Table 27.1. Yellow Swainson-pea vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status	Vulnerable	Vulnerable	Vulnerable
Extent of occurrence (km²)	12 980		
Area of occupancy (km²)	Unknown		
Sub-populations	14		
Estimated # of individuals	330 (severely fluctuating)		
IUCN Criteria	**Justification**		
VU B1	Extent of occurrence estimated to be less than 20 000km² on Eyre Peninsula		
VU B1b(v)	Continuing decline inferred in number of mature individuals on Eyre Peninsula		
VU B1b(v),c(iii)*	Extreme fluctuations in number of locations or sub-populations on Eyre Peninsula		

27.2 Distribution

Yellow Swainson-pea, also known as Yellow Darling Pea, occurs in South Australia, New South Wales and Victoria (Briggs & Leigh 1996; Thompson 1993). South Australian Yellow Swainson-pea populations are known to grow in the Murraylands, Yorke Peninsula and Eyre Peninsula regions. The species' extent of occurrence on Eyre Peninsula is approximately 12 900 km², occurring within latitude 31°49'0"E to longitude 133°27'28"S (Yumbarra Conservation Park near Ceduna) in the north, and latitude 33°25'56"E to longitude 135°49'28"S (Hambidge Conservation Park) in the south (DEH-EGIS 2006) (Figure 27.1).

Yellow Swainson-pea sub-populations grow in the district councils of Ceduna, Elliston and Franklin Harbour.

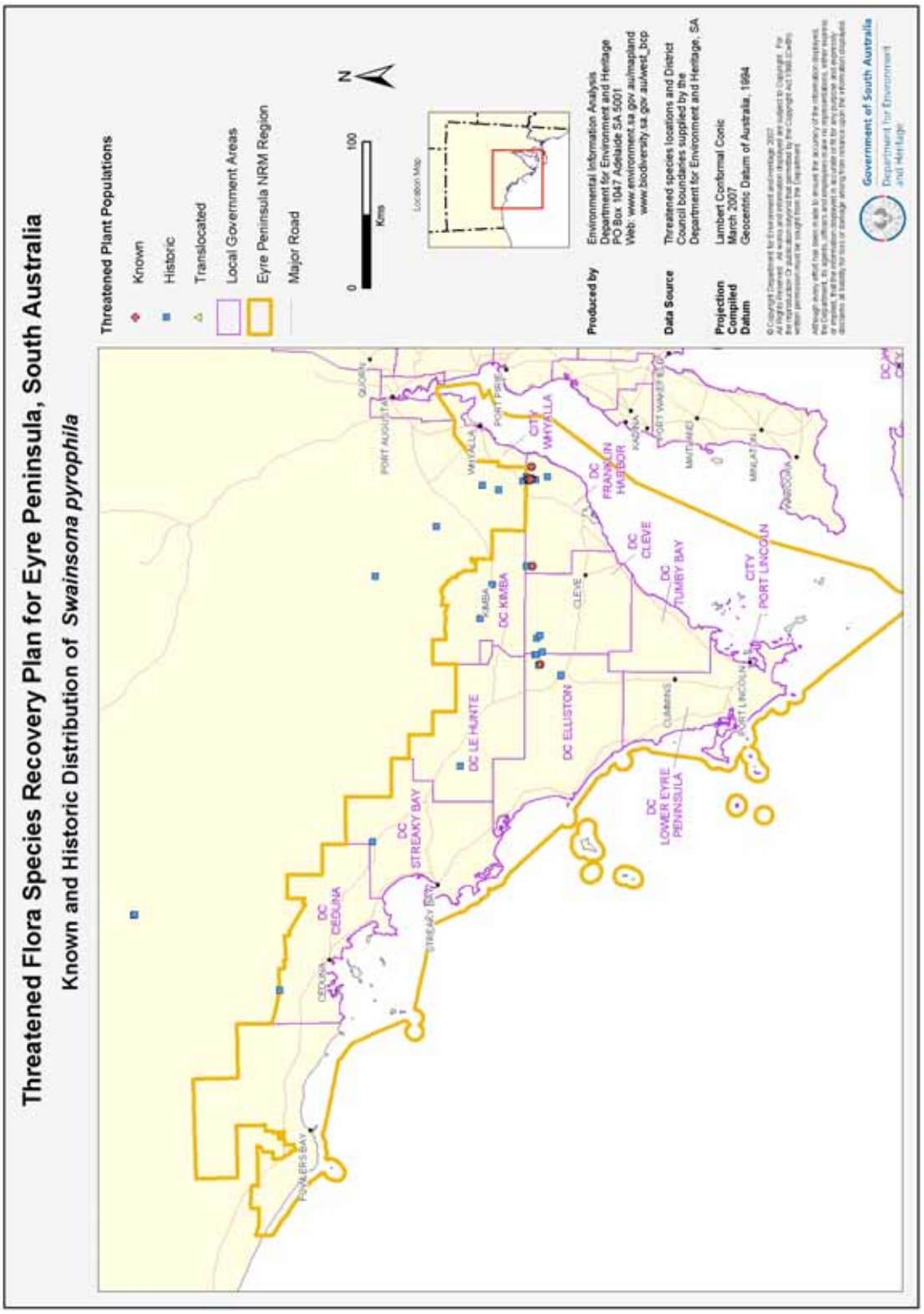
27.3 Habitat critical to survival

All known habitat of Yellow Swainson-pea is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Yellow Swainson-pea is known to occur on sandy or loamy soil in mallee scrub and is usually found after fire (Thompson 1993). The northern sub-populations occupy topography around 100 m above sea level, whereas southern sub-populations (near Munyaroo) occupy a broader topographic range of 40-140 m above sea level. Sub-populations recorded in Heggaton Conservation Park occupy the highest areas at 380 m above sea level.

On Eyre Peninsula, Yellow Swainson-pea has been recorded growing in claypans and ashes in Hambidge Conservation Park (observed by Alcock in 1966), shallow reddish brown loams over calcrete near Yumbarra Conservation Park (observed by Copley in 1987), deep white sand ridges near Munyaroo Conservation Park (observed by D Kraehenbuehl in 1986), through to yellowish-brown fine sandy clay loams (pH 9) within Munyaroo Conservation Park (observed by RJ Davies in 1992).



Note: Yellow Swainson-pea details are held on internal DEH files and are available on request.

Figure 27.1. Distribution of Yellow Swainson-pea on Eyre Peninsula

Vegetation associations

Associated vegetation communities that occur where Yellow Swainson-pea has been recorded are listed in Table 27.2 (DEH-EGIS 2006). The vegetation assemblages growing with Yellow Swainson-pea post-fire are young vegetation structures with open canopy.

Two years post-fire, Yellow Swainson-pea was recorded growing in low mallee (less than 3 m tall) in Munyeroo Conservation Park (observed by RJ Davies, TM Reynolds and F Trissi in 1992). At this time, associated low shrubs consisted of Pointed Twinleaf (*Zygophyllum apiculatum*), Small Hop-bush (*Dodonaea bursariifolia*), Grey Bindyi (*Sclerolaena diacantha/uniflora*), Stiff Westringia (*Westringia rigida*), Erect Mallee Bluebush (*Maireana pentatropis*) and Tar Bush (*Eremophila glabra*), and ground covers included Clustered Lawrencia (*Lawrencia glomerata*) and Rough Spear-grass (*Austrostipa scabra*).

Table 27.2. Vegetation associated with Yellow Swainson-pea locations, Eyre Peninsula

Primary species	Secondary species	Understorey species
Northern Eyre Peninsula: Yumbarra Conservation Park		
Gilja (*Eucalyptus brachycalyx*), Western Myall (*Acacia papyrocarpa*), +/- Red Mallee (*Eucalyptus oleosa* ssp. *oleosa*), Quandong (*Santalum acuminatum*) mid mallee woodland	Broom Emubush (*Eremophila scoparia*), Sheep Bush (*Geijera linearifolia*) mid sparse shrubland over Mueller's Daisy-bush (*Olearia muelleri*), Spiny Fanflower (*Scaevola spinescens*), Erect Mallee Bluebush (*Maireana pentatropis*), Bladder Saltbush (*Atriplex vesicaria*), Fleshy Saltbush (*Rhagodia crassifolia*) low open shrubland	Oblique-spined Bindyi (*Sclerolaena obliquicuspis*), Bladder Saltbush (*Atriplex vesicaria*)
Central Eyre Peninsula: Hambidge and Heggaton conservation parks		
Ridge-fruited Mallee (*Eucalyptus incrassata*), Beaked Red Mallee (*E. socialis*) mid mallee woodland over Brrombush (*Melaleuca uncinata*) tall shrubland	Ribbed Thryptomene (*Thryptomene micrantha*), Silvery Phebalium (*Phebalium bullatum*), Small Hop-bush (*Dodonaea bursariifolia*), Desert Baeckea (*Baeckea crassifolia*) low open shrubland	Woolly Spinifex (*Triodia lanata*), Satin Everlasting (*Helichrysum leucopsideum*), Black-anther Flax-lily (*Dianella revoluta* var. *revoluta*), Sticky Sword-sedge (*Lepidosperma viscidum*), Half-beard Spear-grass (*Austrostipa hemipogon*)
Gilja (*Eucalyptus brachycalyx*), Yorrell (*E. gracilis*), +/- Red mallee (*E. oleosa*) mid mallee woodland	+/- Broom Emubush (*Eremophila scoparia*), +/- Hook-leaf Wattle (*Acacia ancistrophylla* var. *lissophylla*) tall shrubs	Mueller's Daisy-bush (*Olearia muelleri*), Grey Bindyi (*Sclerolaena diacantha*) low shrubs
Eastern Eyre Peninsula: Munyaroo Conservation Park		
Square-fruit Mallee (*Eucalyptus calycogona*), +/- Dumosa Mallee (*E. dumosa*) mid mallee woodland	Broombush (*Melaleuca uncinata*), +/- Hard-leaf Wattle (*Acacia sclerophylla* var. *sclerophylla*), +/- Dryland Tea-tree (*Melaleuca lanceolata*) tall shrubs	+/- Spinifex (*Triodia scariosa*) mid hummock grasses
Ridge-fruited Mallee (*Eucalyptus incrassata*), +/- Narrow-leaf Red Mallee (*E. leptophylla*) mid mallee woodland	Dune Tea-tree (*Leptospermum coriaceum*), Broombush (*Melaleuca uncinata*), Scrub Cypress Pine (*Callitris verrucosa*), Silver Broombush (*Babingtonia behrii*) shrubs	Guinea-flower (*Hibbertia australis*), Golden Pennants (*Glischrocaryon behrii*) shrubs

Climate

Yellow Swainson-pea inhabits the 250-400 mm rainfall zone (DEH-EGIS 2006). The mean annual maximum and minimum temperatures for Minnipa, in the vicinity of the most northern sub-population, are 24 °C and 10.9 °C respectively, with a mean annual rainfall of 327.3 mm (BOM 2007). The mean annual rainfall for Munyaroo is 286.4 mm (BOM 2007).

Known sub-populations within reserves

Yellow Swainson-pea has been recorded within the South Australian reserve system. Of the 14 historical records shown in Figure 27.1, five of these sub-populations are recorded within reserves (Table 27.3) and nine are located very close to reserves. Records of Yellow Swainson-pea also fall within Heritage Agreement 977 adjoining Munyaroo Conservation Park.

Table 27.3. Yellow Swainson-pea sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Munyaroo Conservation Park	6	AG Spooner 1990 RJ Davies; TM Reynolds and F Trissi 1992
Hambidge Conservation Park	3	CR Alcock 1966 DE Symon 1966 (at 2 sites)
Heggaton Conservation Reserve	1	DE Murfet and RL Taplin 1998

Benefits to other species

The conservation of Yellow Swainson-pea is expected to benefit multiple species through protection and management of habitat. Broad-scale management techniques and collection of baseline data are expected to benefit other plant species growing in association with the pea species, particularly those species with similar fire and environmental disturbance regime needs, flowering response and/or pollinator needs.

27.4 Biology and ecology

Yellow Swainson-pea is an erect, renascent[15], perennial legume that grows to 1 m tall (Thompson 1993). Plants have several stems and 5-15 cm long leaves, with approximately 17 leaflets on a short leaf stalk (petiole) (Thompson 1993).

Flowering occurs from July to October. Between 15-20 yellow pea-shaped flowers grow along a 15-25 cm long main stalk. Flowers develop and flower in succession along the stalk. The flowers closest to base of the plant are the oldest, and those progressively further along the stalk are younger and flower later.

The pollinator(s) and pollination process of Yellow Swainson-pea are unknown. There is very little information on pollination of *Swainsona* species; however, Halictid bees in the *Lasioglossum* genus are recorded as visitors to *Swainsona* species from around Australia (Victorian Museum 2007). Once pollinated, fruits develop and usually grow 20-30 mm long and 10-15 mm wide (Thompson 1993).

In general, *Swainsona* species (and particularly mallee *Swainsona* species like the Yellow Swainson-pea) are known to re-sprout from persistent rootstock via vegetative reproduction (Earl, Barlow & Moorrees 2001). *Swainsona* species produce hard-coated seeds that generally require treatment to break dormancy (Earl, Barlow & Moorrees 2001). In Victorian sub-populations, Scarlett and Parson (1993) suspect that a gradual depletion in the Yellow Swainson-pea's soil seed bank is caused by absence of regular fires. Seed dispersal has not been studied for Yellow Swainson-pea on Eyre Peninsula.

The species' scientific name, *pyrophila*, is derived from *pyro* (i.e. fire) and *philos* (i.e. loving). Yellow Swainson-pea is a short-lived plant that appears only one to two years after

[15] Renascent plants show renewed growth or vigour.

fire. It can flower in the first spring following fire (Earl, Barlow & Moorrees 2001). Examples of fire dependence can be found on Eyre Peninsula where sub-populations near Munyaroo Conservation Park were recorded by multiple observers in 1992 after a 1990 fire, and in Heggaton Conservation Park where Yellow Swainson-pea was recorded in 1998 after a 1997 fire (DEH-EGIS 2006).

Twenty *Swainsona* species occur on Eyre Peninsula, including three that are currently considered state Rare. These threatened species include Lee's Swainson-pea (*Swainsona leeana*), Wild Violet (*S. microcalyx*) and Ashy-haired Swainson-*pea (S. tephrotricha*).

27.5 Previous management actions

To date, the initial surveys locating Yellow Swainson-pea populations on Eyre Peninsula are the only known steps towards conservation. Surveys were conducted between 1966 and 1992 on an ad hoc basis, and were recorded by nine different observers (DEH Recfind File 40/1479).

27.6 Threats to Yellow Swainson-pea and associated recovery goals

The long-term goals are to down-list Yellow Swainson-pea conservation status from Vulnerable to Near Threatened, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Yellow Swainson-pea conservation status at Vulnerable.

Yellow Swainson-pea has been ranked as a Priority 3 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 27.4 details the key threats and summarises performance criteria relevant to Yellow Swainson-pea recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 27.4. Key threats to Yellow Swainson-pea and summary of associated performance criteria

Direct threat: Restricted distribution/isolated sub-populations	**Risk**
Risk: Species sub-populations become smaller than the minimum viable population limit **Likelihood:** Possible **Consequence:** Moderate Restricted by fire frequency and soil disturbance, and occurs in isolated populations, thereby potentially affecting the species ability to survive climate change and catastrophic events. To date, no Yellow Swainson-pea seed has been collected from Eyre Peninsula. It is not known how long *in situ* seed will remain viable. Changes in seed viability and germination are expected to influence long-term population size (i.e. number of individuals) and long-term species survival.	**High**
Direct threat: Inappropriate fire regimes	
Risk 1: Species (including soil seedbank) will become extinct due to exclusion of fire from its critical habitat **Risk 2:** Species (including soil seedbank) will become locally extinct if too frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely **Consequence:** Moderate Records for seven of the 14 Yellow Swainson-pea sub-populations on Eyre Peninsula were made 1-2 years after fire. Fire is regarded as a necessary trigger for Yellow Swainson-pea germination and vegetative regrowth, but this remains unstudied on Eyre Peninsula. *Swainsona* species are known to regenerate after fire (e.g. *Swainsona plagiotropis* in Victoria and New South Wales) (Scarlett & Parson 2003). Yellow Swainson-pea may have similar responses to *S. plagiotropis*, which germinates and stimulates seedling growth facilitated by increased light from an open canopy (Scarlett & Parson 2003). Inappropriate fire frequency and intensity, and a lack of springtime moisture, may threaten recruitment and long-term survival of Yellow Swainson-pea and result in localised extinction.	**High**

Direct threat: Inappropriate disturbance regimes	
Risk: Localised species extinction and degradation of critical habitat from inappropriate disturbance regimes **Likelihood:** Possible **Consequence:** Moderate Depending on the frequency and intensity of disturbance, earthworks and firebreak construction/maintenance may have a positive and/or negative effect on Yellow Swainson-pea. Site disturbance, including maintenance activities associated with roadside and rail reserves, is thought to influence *Swainsona* survival (Earl, Barlow & Moorrees 2001). Yellow Swainson-pea records are associated with firebreaks, along roadsides, fence lines, or vegetation clearance and earth disturbance. The potential overlap between fire disturbance and other types of disturbance, and appropriate disturbance frequency and intensity, requires further investigation and research. This will enable a better understanding of population dynamics of Yellow Swainson-pea on Eyre Peninsula.	**High**
Direct threat: Weed invasion, High grazing pressure	
Risk: Failure of species to recruit and failure of adult plants to grow and produce seed in the limited time (1-3 years) that is available to colonise bare ground after fire or disturbance **Likelihood:** Likely **Consequences:** Moderate There is a potential for weeds to invade after disturbance and compete with emerging and established Yellow Swainson-pea plants. Following fire, sub-populations recolonising firebreaks within Munyaroo Conservation Park were recorded growing with Smooth mustard (**Sisymbrium erysimoides*) and White Horehound (**Marrubium vulgare*) (Davies 1992). Annual weeds that flourish under favourable wet spring conditions have been shown to threaten sub-populations in Victoria, particularly when rabbit control has been undertaken (Earl, Barrow & Moorrees 2001). Grazing impact is unknown. Based on observations of Victorian *Swainsona* populations, grazing should be regarded as a threat. *Swainsona* species are known to be highly palatable, and even toxic (Coventry 2004; McKenzie 2004), and are grazed by stock, rabbits and native herbivores (Earl, Barrow & Moorrees 2001). Grazing is most damaging to the species during the spring flowering and seeding period, whereas grazing outside of this sensitive growing time might actually benefit *Swainsona* (Earl, Barrow & Moorrees 2001).	**High**

	Objective 1 **Baseline information**	Objective 2 **Community involvement**	Objective 3 **Manage threats and improve habitat**	Objective 4 **Research critical to management**	Objective 5 **Monitoring and evaluation**
Performance criteria	1a.3 1c.1 1c.3 1d.2 1d.3	2a.5 2a.6 2b.2 2b.3 2c.3	3a.4 3b.1 3d.2 3d.3 3e.3 3f.1 3f.4 3f.5 3f.8	4b.3 4c.2	5a.6 5a.9 5b.2

27.7 Main references

Briggs, JD & Leigh, JH 1996, *Rare or threatened Australian plants*, CSIRO Publishing, Canberra.

Earl, G, Barlow, T & Moorrees, A 2001, *Action Statement: Twelve threatened Swainson-peas and Darling peas (*Swainsona *species)*, Department of Natural Resources and Environment, Victoria.

Scarlett, NH & Parson, RF 1993, 'Rare and threatened plants in Victoria', in DB Foreman & NG Walsh (eds), *Flora of Victoria, Volume 1: Introduction*, Inkata Press, Melbourne.

Thompson, J 1993, 'Swainsona pyrophila', *Telopea*, vol. 5, no. 3, p. 448.

28 Metallic Sun-orchid *Thelymitra epipactoides* F Muell

28.1 Status

When assessing Eyre Peninsula Metallic Sun-orchid vital attributes against IUCN criteria (IUCN 2001), this species could be considered Endangered (Table 28.1). Metallic Sun-orchid is recognised as Endangered at the Regional, State and National levels (Table 28.1).

Table 28.1. Metallic Sun-orchid vital attributes

	Eyre Peninsula	South Australia (NPW Act)	Australia (EPBC Act)
Conservation status*	Endangered	Endangered	Endangered
Extent of occurrence (km²)	500-900?		
Area of occupancy (km²)	0.0275		
Sub-populations	19		
Estimated # of individuals	100		
IUCN Criteria	**Justification**		
EN B1	Extent of occurrence estimated to be less than 500 km² on Eyre Peninsula		
EN B1a	Severely fragmented habitat on Eyre Peninsula		
EN B1a,c(iv)*	Extreme fluctuations in number of mature individuals on Eyre Peninsula		

28.2 Distribution

Metallic Sun-orchid, also known as Stout Sun-orchid, has a distribution that spans Lower Eyre Peninsula, parts of the Murraylands and South East regions of South Australia, and parts of Victoria (Coates 2003). The orchid species is thought to have once been widespread in coastal regions of south-eastern Australia (Cropper 1993). Its extent of occurrence on Eyre Peninsula reflects this; however, currently the area of occupancy of this species is thought to be highly restricted (Table 28.1). The extent of occurrence of Metallic Sun-orchids on Eyre Peninsula is approximately 900 km², growing within latitude 34°23'35" to longitude 135°34'33" (Edillilie) in the north, and latitude 34°52' to longitude 135°40'30" (Mikkira) in the south (DEH-EGIS 2006) (Figure 28.1).

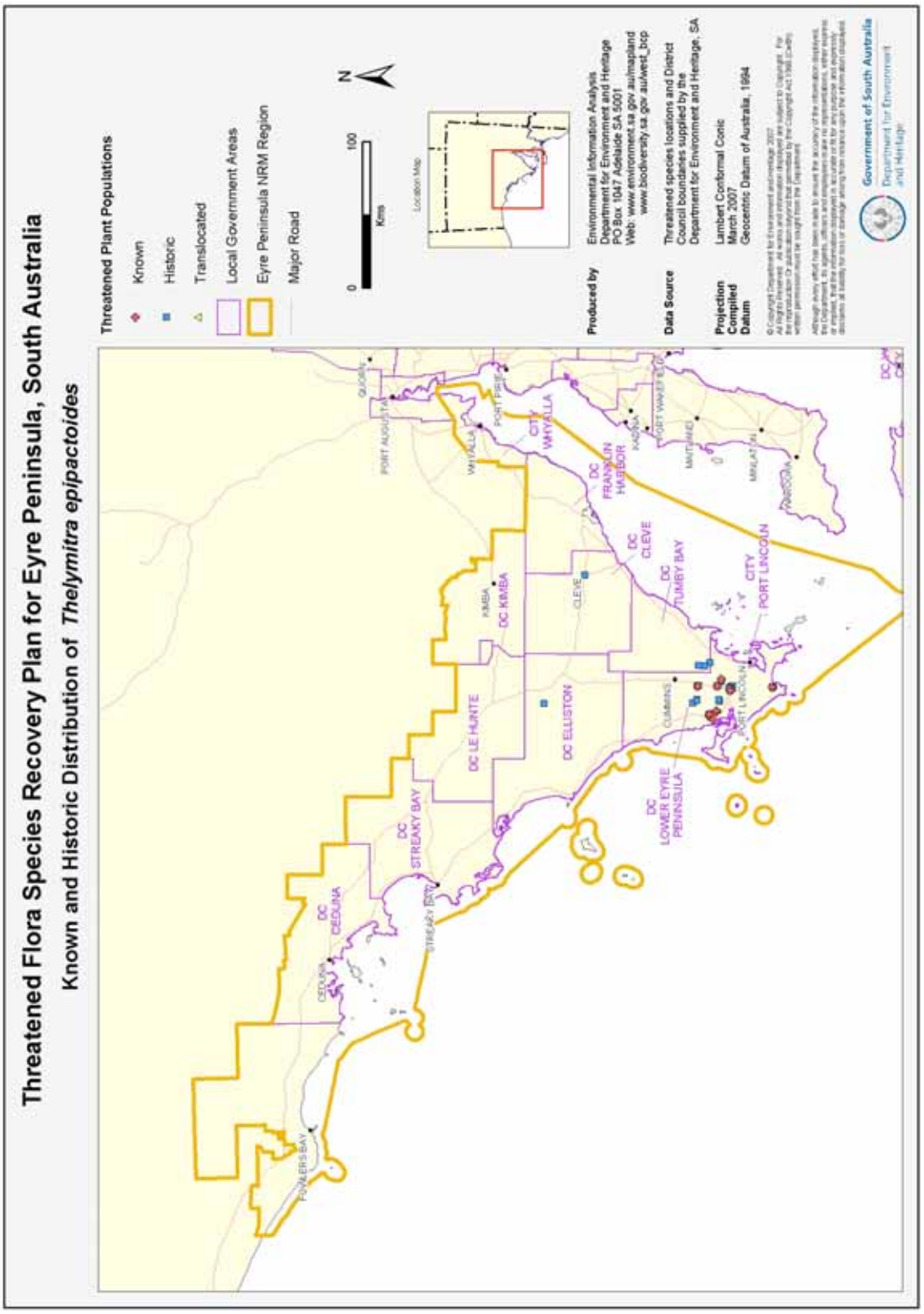
On Eyre Peninsula, approximately half of all known Metallic Sun-orchid sub-populations, including the largest sub-population, are located on roadsides managed by the District Council of Lower Eyre Peninsula. Metallic Sun-orchid plants also grow within rail reserves maintained by the Australian Railroad Group Pty Ltd (ARG), on land managed by SA Water, and in ETSA Utilities powerline easements.

28.3 Habitat critical to survival

All known habitat of Metallic Sun-orchid is considered to be habitat that is critical to its survival. It is likely that additional critical habitat is yet to be identified.

Topography and soil type

Metallic Sun-orchid grows in fertile loams that are often covered by open forest, open heathland, or grasslands (Weber & Bates 1986). On Lower Eyre Peninsula, soil types are typically red friable loams at heights of 40-290 m above sea level (DEH-EGIS 2006). In the species' central distribution the orchid grows on mottled-yellow duplex soils, while at its western extent it has been rercorded on the slopes of quartzite hills (DEH-EGIS 2006).



Note: Metallic Sun-orchid details are held on internal DEH files and are available on request.

Figure 28.1. Distribution of Metallic Sun-orchid on Eyre Peninsula

Vegetation associations

Metallic Sun-orchid has been recorded growing in association with vegetation communities listed in Table 28.2 (DEH-EGIS 2006); however, in many cases individual orchids frequently grow in the more open niches within or on the edges of these vegetation associations (Calder, Cropper & Tonkinson 1989).

Table 28.2. Vegetation associated with Metallic Sun-orchids on Eyre Peninsula

Primary species	Secondary species	Understorey species
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	+/- Yacca (*Xanthorrhoea semiplana*) shrubs	Kangaroo Grass (*Themeda triandra*), Hill Raspwort (*Gonocarpus elatus*), Hard Mat-rush (*Lomandra multiflora* ssp. *dura*), Crested Spear-grass (*Austrostipa blackii*) tussock grasses
Drooping Sheoak (*Allocasuarina verticillata*) low woodland	+/- Sticky Hop-bush (*Dodonaea viscosa* ssp. *spatulata*) tall shrubs	Bearded Oat (**Avena barbata*), Annual Rock-fern (*Cheilanthes austrotenuifolia*), +/- Sticky Sword-sedge (*Lepidosperma viscidum*), +/- Broad-leaf Raspwort (*Gonocarpus mezianus*) low forbs
Sugar Gum (*Eucalyptus cladocalyx*) mid woodland	+/- Golden Wattle (*Acacia pycnantha*) over Rock Wattle (*Acacia rupicola*), +/- Yacca (*Xanthorrhoea semiplana*), +/- Broombush (*Melaleuca uncinata*) mid shrubs	Peach Heath (*Lissanthe strigosa* ssp. *subulata*), Small-flower Wallaby-grass (Austrodanthonia setacea) low shrubs over Broad-leaf Raspwort (*Gonocarpus mezianus*), and Coarse Lagenifera (*Lagenophora huegelii*)
Coast Ridge-fruited Mallee (*Eucalyptus angulosa*), Coastal White Mallee (*E. diversifolia* ssp. *diversifolia*) mid mallee woodland	Yacca (*Xanthorrhoea semiplana*), Broombush (*Melaleuca uncinata*), +/- Dryland Tea-tree (*M. lanceolata*) tall shrubs	+/- Guinea-flower (*Hibbertia* sp. *Glabriuscula*) (DJ Whibley 9012) low shrubs
Coastal White Mallee (*Eucalyptus diversifolia* ssp. *diversifolia*) mid mallee woodland	+/- Dryland Tea-tree (*Melaleuca lanceolata*), +/- Broombush (*Melaleuca uncinata*) tall shrubs	Prickly Ground-berry (*Acrotriche patula*), +/- Coast Velvet-bush (*Lasiopetalum discolor*) low shrubs
Broombush (*Melaleuca uncinata*) tall open shrubland	Silver Broombush (*Babingtonia behrii*), +/- Cup Fringe-myrtle (*Calytrix involucrata*) low shrubs	+/- Spinifex (*Triodia irritans*), +/- Guinea-flower (*Hibbertia* sp. *Glabriuscula*) (DJ Whibley 9012)

Climate

Metallic Sun-orchid predominantly inhabits the 500 mm rainfall zone (DEH-EGIS 2006).

Northern sub-populations in Barwell Conservation Park would experience similar climatic conditions to Lock, which has a mean annual rainfall of 391.6 mm. Southern most sub-populations may be expected to experience a similar climate to Port Lincoln, with maximum and minimum temperatures of 20.8 °C and 11.7 °C respectively, and a mean annual rainfall of 490.9 mm.

Known populations within reserves

Metallic Sun-orchids grow within the South Australian reserve system. The orchid species also occurs within four Roadside Marker segments within the District Council of Lower Eyre Peninsula, and one under the management of Transport SA. There is one record of Metallic Sun-orchid within Wanilla Forest, which is managed by the Port Lincoln Aboriginal Community Council.

Table 28.3. Metallic Sun-orchid sub-populations in reserves on Eyre Peninsula

NPWS Reserve	Sub-populations	Observers
Barwell Conservation Reserve	1	R Bates 1986
Wanilla Conservation Park	1	JZ Weber 1979

Benefits to other species

The conservation of Metallic Sun-orchid habitat is expected to produce broader biodiversity benefits for associated vegetation communities and the animals that depend on these areas. An ecological community that may benefit from orchid recovery actions is Purple-flowered Mallee Box (*Eucalyptus lansdowneana* ssp. *albopupurea*), Drooping Sheoak (*Allocasuarina verticillata*), +/- Coastal White Mallee *(E. diversifolia*) mallee woodland.

Other threatened flora species growing within Metallic Sun-orchid habitat include Ironstone Mulla Mulla (*Ptilotus beckerianus*) (nationally Vulnerable), Silver Daisy-bush (*Olearia pannosa* ssp. *pannosa*) (nationally Vulnerable) and Gill's Wattle (*Acacia gillii*) (regionally Uncommon on Eyre Peninsula). Other *Thelymitra* species, many of which are regionally Rare or have unknown conservation status, also grow within Metallic Sun-orchid habitat.

28.4 Biology and ecology

Metallic Sun-orchid is the tallest native orchid on Eyre Peninsula, growing 21-25 cm tall (Weber & Bates 1986). It is easily distinguished by its metallic flowers, which range from iridescent greyish-green to pinkish or bronze tints (Weber & Bates 1986). The orchid is deciduous, dying back to below-ground tubers in summer. If conditions are right, the orchid will re-emerge each year signalled by the growth of a new leaf. Leaves may be seen protruding as early as April and continue to grow throughout winter.

Flowering occurs from August through to November, and fruits mature from December to January. An exceptionally quick flowering period in 2006 during drought conditions, and after the 2005 bushfire, coincided with simultaneous podding, flowering and seed set on different plants within the same sub-populations (K Pobke [DEH] 2006, pers. comm.). This variation in reproductive advancement within a sub-population was more evident than in previous years, where orchids within a sub-population usually progressed through budding and flowering together at a similar rate. Intense north wind weather patterns in late spring and an unseasonally early decrease in soil moisture coincided with drying and early finishing (i.e. September) of Metallic Sun-orchids during 2007 (K Pobke [DEH], J Hutchinson, P Hewstone & S Deslandes 2006-2007, pers. comm.).

Metallic Sun-orchid flowers are faintly scented and are pollinated by insects (Weber & Bates 1986). Three pollinator species, i.e. *Nomia* and *Lasioglassum* bee species and Blow Fly (*Calliphora stygia*), have been recorded on Metallic Sun-orchid flowers (Cropper & Calder 1990). Pollinators are thought to visit *Thelymitra* species because they mimic the main food sources of pollinators (Bates 1984). The flowers contain highly reflective polychromatic epidermal cells, which attract pollinators; however, there is no obvious food reward for visiting insects (Cropper & Calder 1990). Successful pollination results in the flowers' ovary swelling and producing microscopic seeds contained within a seed capsule.

Metallic Sun-orchid grows in association with soil mycorrhiza. *Tulasnella asymmetrica* is one fungi species known to grow in association with the orchid (Cropper, Calder & Tonkinson 1989). *T. asymmetrica* is a common fungi, widely associated with many orchid species (Warcup & Talbot 1967).

Fire dependence triggers

Metallic Sun-orchids are known to flower abundantly after late summer burns (observed at Weecurra, Victoria and Lower Eyre Peninsula, South Australia) (Calder, Cropper & Tonkinson 1989; K Pobke [DEH] 2007, pers. comm.). Beardsell (1980-1984) suggests burn regimes for sub-populations within Victoria of once every 5-10 years in heathland and every 3-4 years in grasslands. Late summer burning results in increased flowering and increased long-term orchid numbers (Beardsell 1980-1984). A lack of summer-autumn fires has contributed to a decline in Metallic Sun-orchid recruitment (Calder, Cropper & Tonkinson 1989).

Disturbance triggers

Metallic Sun-orchid is known as a post-disturbance coloniser (Cropper 1993). It utilises natural disturbances such as salt pruning, wind damage and plant dieback, which provide openings in the upper canopy (Calder, Cropper & Tonkinson 1989). Echidna diggings are also thought to provide suitable habitat for Metallic Sun-orchid colonisation (Calder, Cropper & Tonkinson 1989).

Grazing pressure

Grazing of orchid leaves, and occasionally flowers, occurs on Lower Eyre Peninsula (K Pobke [DEH] 2007, pers. comm.); however, it is yet to be determined how significant a threat herbivory is to the species.

28.5 Previous management actions

Table 28.4. Previous management actions to conserve Metallic Sun-orchid

	Previous management actions
1998-ongoing	Annual Metallic Sun-orchid monitoring of all sub-populations on Lower Eyre Peninsula. Majority of sub-populations monitored by volunteers P Hewstone and J Hutchinson. Population counts, flowering and seed set success recorded.
2000	A Freebairn and members of the Port Lincoln Aboriginal Community Council searched the Wanilla Forest for Metallic Sun-orchid, but on this occasion it was not found.
2001	Metallic Sun-orchid community awareness raising article was printed in the local *Port Lincoln Times* newspaper as part of the 'Threatened Flora Census' series (author A Freebairn).

28.6 Threats to Metallic Sun-orchid and associated recovery goals

The long-term goals are to down-list Metallic Sun-orchid conservation status from Endangered to Vulnerable, and continue to recover its critical habitat. However, the immediate short-term goal is to stabilise Metallic Sun-orchid conservation status at Endangered.

Metallic Sun-orchid has been ranked as a Priority 1 species, based on degree of threat, potential for recovery, level of endemism and focus work areas (Appendix E). The species is regarded as a plant that requires fire to complete its life cycle.

Table 28.5 details the key threats and summarises performance criteria relevant to Metallic Sun-orchid recovery (Table 31.2 to 31.4 give an overview of performance criteria for all species and their associated recovery costs).

Table 28.5. Key threats to Metallic Sun-orchid and summary of associated performance criteria

Direct threat: Weed invasion	
Risk: Species out-competed and/or change in site specific habitat critical to species survival Likelihood: Almost certain Consequences: Moderate	Extreme
Direct threat: Small population/lack of recruitment	
Risk: Species subpopulations become smaller than minimum viable population limit. Loss of species ability to recruit causes destabilisation of population life class structure (i.e. old and new underground tubers), resulting in population decline Likelihood: Almost certain Consequence: Moderate The primary threat to Metallic Sun-orchid is lack of seed set (A Freebairn [DEH] 2004, pers. comm.). Monitoring between 2001 and 2003 has indicated that for this species, the flower to fruit conversion rate is less than 5% (Freebairn Unpublished).	Extreme
Direct threat: Habitat fragmentation	Risk
Risk: Reduction in species resilience to environmental changes, pests or diseases Likelihood: Likely Consequence: Major The majority of known populations are small and occur in highly fragmented vegetation on road and rail reserves. These fragmented populations of Metallic Sun-orchid may have low genetic variability and genetic flow because of their small size and isolation. Low genetic variability may reduce the resilience of the species to environmental changes, pests or diseases.	Extreme
Direct threat: Inappropriate fire and disturbance regimes	
Risk 1: Species (including soil seed-bank) will become extinct due to exclusion of fire from its' critical habitat **Risk 2:** Species (including soil seed-bank) will become locally extinct if frequent fires are experienced **Likelihood:** Risk 1 long unburnt/no fire is most likely = Likely (links strongly with lack of recruitment) **Consequence:** Moderate	High

	Objective 1 Baseline information	Objective 2 Community involvement	Objective 3 Manage threats and improve habitat	Objective 4 Research critical to management	Objective 5 Monitoring and evaluation
Performance criteria	1a.1 1d.3 1b.1 1c.1 1c.2 1c.4 1c.5 1d.2	2a.5 2a.6 2b.2 2b.3 2c.3	3a.1 3f.1 3a.2 3f.2 3a.4 3f.4 3b.1 3f.6 3b.2 3f.7 3c.2 3f.8 3d.1 3d.2 3d.3	4b.4 4g.1 4b.5 4g.2 4b.7 4h.1 4b.8 4c.2 4c.5 4d.1 4e.1 4f.1	5a.4 5a.7 5a.8

28.7 Main references

Coates, F 2003, *Action Statement No. 156 Metallic Sun-orchid* Thelymitra epipactoides, Department of Sustainability and Environment, Victoria.

Cropper, S 1993, Management of endangered plants, CSIRO Publications, Australia.

Cropper, SC & Calder, DM 1990, 'The floral biology of *Thelymitra epipactoides* (Orchidaceae), and the implications of pollination by deceit on the survival of this rare orchid', *Plant Systematics and Evolution*, vol. 170, pp. 11-27.

Cropper, SC, Calder, DM & Tonkinson, D 1989, '*Thelymitra epipactoides* F. Muell. (Orchidaceae): The Morphology, biology and conservation of an endangered species', *Proceedings of the Royal Society of Victoria*, vol. 101, pp. 89-101.

Weber, JZ & Bates, R 1986, 'Orchidaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part IV: Alismataceae-Orchidaceae*, South Australian Government Printer, Adelaide, pp. 2132 - 2137.

29 Prioritisation of threatened flora species for recovery on Eyre Peninsula

In comparison with other regions within the state, Eyre Peninsula has one of the highest numbers of threatened flora species in South Australia. Strategic allocation of resources is necessary to ensure best use of limited resources and funding. All threatened flora species within this plan were assessed using a threat matrix (Appendix E) and were then ranked according to their priority for recovery (Table 29.1).

Species scoring between 130 and 90 were ranked as Priority 1, meaning those species require the most immediate attention and priority funding. Species with scores between 89 and 80 were ranked as Priority 2, and those scoring between 79 and 70 were ranked as Priority 3 species.

Table 29.1. Prioritised threatened plant species

Species name	Current threats score	Future threats score	Combined scores	Priority
Metallic Sun-orchid	38	90	128	Priority 1 species
Whibley Wattle [EP]	39	84	123	
Fat-leaved Wattle [SA]	40	74	114	
Ironstone Mulla Mulla [SA]	30	74	104	
Silver Daisy-bush	28	68	96	
Jumping-jack Wattle	27	66	93	
Chalky Wattle [EP]	32	60	92	
Winter Spider-orchid [SA]	27	64	91	
Nodding Rufous-hood [EP]	27	62	89	Priority 2 species
Resin Wattle	31	56	87	
Prickly Raspwort [EP]	27	60	87	
Sandalwood	25	62	87	
Bead Samphire	28	58	86	
West Coast Mintbush [EP]	22	64	86	
Desert Greenhood	20	64	84	
Annual Candles [SA]	32	52	84	
Tufted Bush-pea [EP]	23	58	81	
Yellow Swainson-pea	22	56	78	Priority 3 species
Club Spear-grass	29	48	77	
Silver Candles [SA]	25	50	75	
Mt Olinthus Greenhood [EP]	19	56	75	
Granite Mudwort	24	50	74	
Microlepidium alatum	22	48	70	

[SA] Species is endemic to South Australia; [EP] Species is endemic to Eyre Peninsula.

30 Prioritisation of Focus Work Areas

Prioritised species (Table 29.1) sites were assessed using ArcMap Geographic Information Systems and data from the Biological Databases of South Australia (DEH-EGIS 2007) to determine Focus Work Areas. From this assessment, 96% of Priority 1 species sub-populations fall within the Eyre Hills IBRA subregion (Table 30.1). This result is reinforced by the Threatened Habitat Areas identified in the *Biodiversity Plan for Eyre Peninsula*, which sets apart the Cleve Hills, South West and Koppio Hills as significant areas for threatened flora conservation (DEH 2002).

Table 30.1. Summary of percentage of threatened flora populations within Eyre Hills IBRA Subregion

	# of species records within EPNRMB region	# of species records within Eyre Hills IBRA Subregion	% of known EPNRM population in Eyre Hills IBRA Subregion
Priority 1 species	680	651	96
Priority 2 species	502	287	57
Priority 3 species	158	28	18
Total	**1340**	**966**	**-**

Mapping and prioritising Focus Work Areas

Important threatened flora recovery sites on Eyre Peninsula have been mapped as Focus Work Areas. Priority 1, 2 and 3 threatened flora species occurring across Eyre Peninsula are mapped into prioritised areas based on where the most threatened and largest number of threatened flora taxa overlap (Figure 30.1). There are some limitations to this basic type of overlapping prioritisation, which underestimates the importance of outlier sub-populations. Core and outlier sub-populations were used by Taylor (2003) for threatened flora recovery on Kangaroo Island; however, Eyre Peninsula's threatened flora baseline data is not comprehensive enough (i.e. lack of population count data) to distinguish core and outlier populations. During the implementation of this plan, outlier populations will be checked as part of the Key Monitoring Sites performance criteria (i.e. Performance Criteria 5a.1, 5a.4, 5a.5 and 5a.6). Gaps in baseline data will be addressed under Objective 1, and true core and outlier populations will be verified through genetic testing (recovery Action 4e).

Focus Work Areas have been prioritised using a decision making table (Table 30.2). Prioritised Focus Work Areas are presented in Figure 30.2 (Northern Eyre Hills) and Figure 30.3 (Southern Eyre Hills), and these figures show the Focus Work Areas divided into units 1A-D, 2E-G and 3H-I. This division is intended to assist those implementing the plan in deciding which area should be the focus of the most immediate on-ground actions. Priority areas ranked second and third are important to the recovery of threatened flora on Eyre Peninsula, but ideally should only be the focus of recovery actions after the threats to Priority 1 Focus Work Areas have been sufficiently addressed. Priority 2 and 3 areas should definitely be considered within the five years of this plan if funding becomes available, otherwise they should become the focus of recovery actions following the next phase of this plan.

Other species within Priority 1 Focus Work Areas

While the rationale for determining Priority Focus Work Areas is aimed specifically at the recovery of the threatened flora taxa addressed within this plan, these areas also include many other species of conservation significance. For example, 32 other state threatened flora and fauna occur within habitat defined as Priority 1A-D Focus Work Areas (DEH-EGIS 2007) (Table 30.3).

Table 30.2. Decision making table used to prioritise Focus Work Areas

	1 A	More than one Priority 1 species record within 20 metres of land parcel
	1 B	At least one Priority 1 species record and one Priority 2 species record within 20 metres of land parcel
	1 C	At least one Priority 1 species record and one Priority 3 species record within 20 metres of land parcel
	1 D	Only one Priority 1 species record within 20 metres of land parcel
	2 E	More than one Priority 2 species record within 20 metres of land parcel
	2 F	At least one Priority 2 species record and one Priority 3 species record within 20 metres of land parcel
	2 G	Only one Priority 2 species record within 20 metres of land parcel
	3 H	More than one Priority 3 species record within 20 metres of land parcel
	3 I	Only one Priority 3 species record within 20 metres of land parcel

Table 30.3. State threatened flora and fauna species within Priority 1A-D Focus Work Areas

Flora scientific name	Common name	National rating	State rating
Acacia dodonaeifolia	Hop-bush Wattle		Rare
Acacia hexaneura	Six-nerve Spine-bush		Rare
Acacia iteaphylla	Flinders Ranges Wattle		Rare
Acacia imbricata	Feathery Wattle	Vulnerable	Rare
Acacia praemorsa	Senna Wattle		Endangered
Acacia rhigiophylla	Dagger-leaf Wattle		Rare
Centrolepis glabra	Smooth Centrolepis		Rare
Daviesia benthamii ssp. *humilis*	Mallee Bitter-pea		Rare
Daviesia pectinata	Zig-zag Bitter-pea		Rare
Desmocladus diacolpicus	Bundled Cord-rush		Vulnerable
Eremophila gibbifolia	Coccid Emubush		Rare
Eucalyptus behriana	Broad-leaf Box		Rare
Levenhookia stipitata	-		Rare
Poa fax	Scaly Poa		Rare
Schoenus sculptus	Gimlet Bog-rush		Rare
Sphaerolobium minus	Leafless Globe-pea		Rare
Spyridium spathulatum	Spoon-leaf Spyridium		Rare
Thelymitra flexuosa	Twisted Sun-orchid		Rare
Xanthorrhoea semiplana ssp. *tateana*	Tate's Grass-tree		Rare
Fauna scientic name	**Common name**	**National rating**	**State rating**
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		Vulnerable
Cinclosoma castanotus	Chestnut Quail-thrush		Rare
Egretta sacra	Eastern Reef Egret		Rare
Falco peregrinus	Peregrine Falcon		Rare
Gerygone fusca	Western Gerygone		Rare
Ixobrychus minutus	Little Bittern		Rare
Leipoa ocellata	Malleefowl	Vulnerable	Vulnerable
Malurus pulcherrimus	Blue-breasted Fairy-wren		Vulnerable
Pyrrholaemus brunneus	Redthroat		Rare
Stagonopleura guttata	Diamond Firetail		Vulnerable
Stipiturus malachurus	Southern Emu-wren		Rare
Turnix varia	Painted Button-quail		Vulnerable
Bassiana trilineata	Western Three-lined Skink		Rare

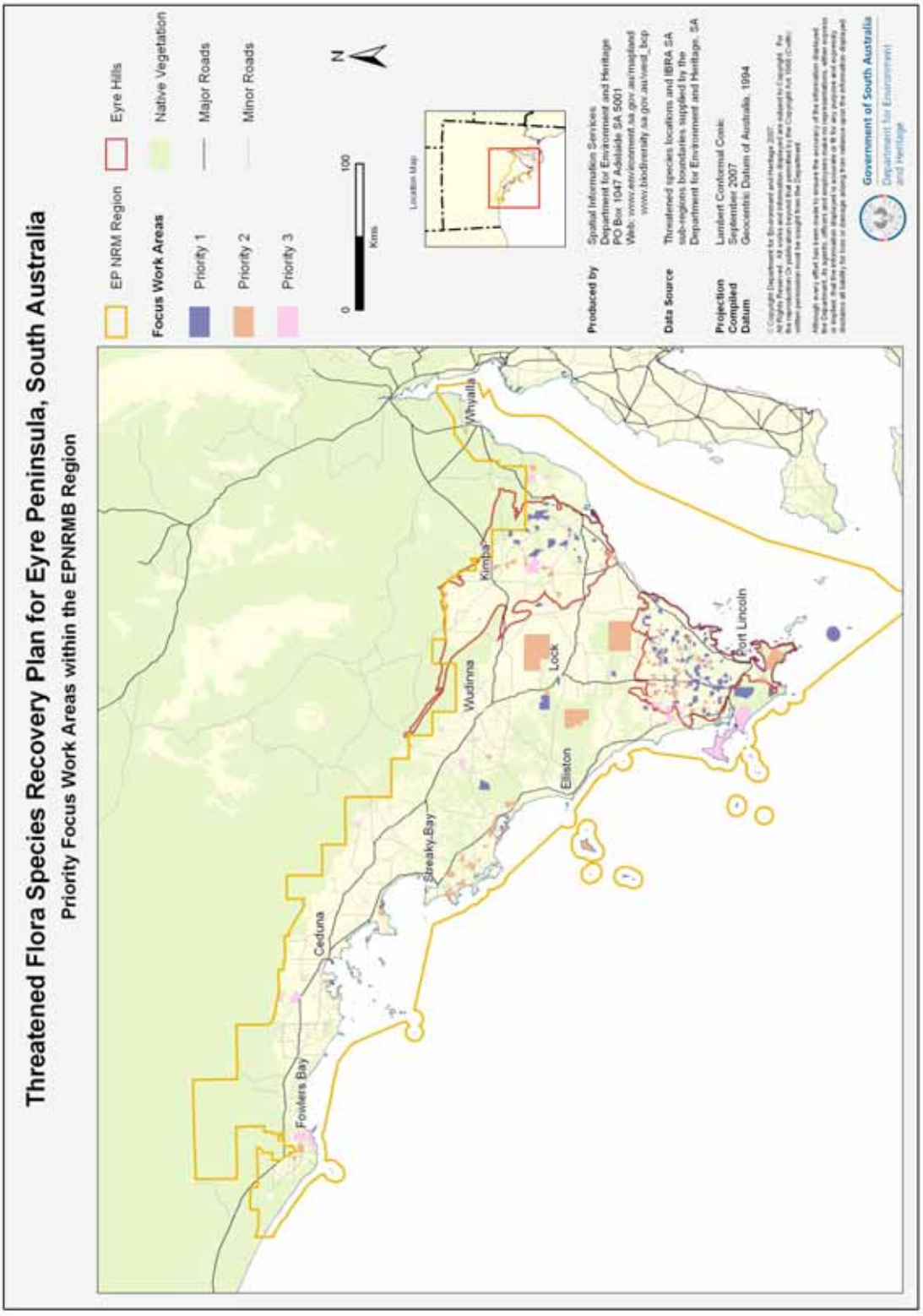


Figure 30.1. Focus Work Areas within Eyre Peninsula Natural Resources Management Board region

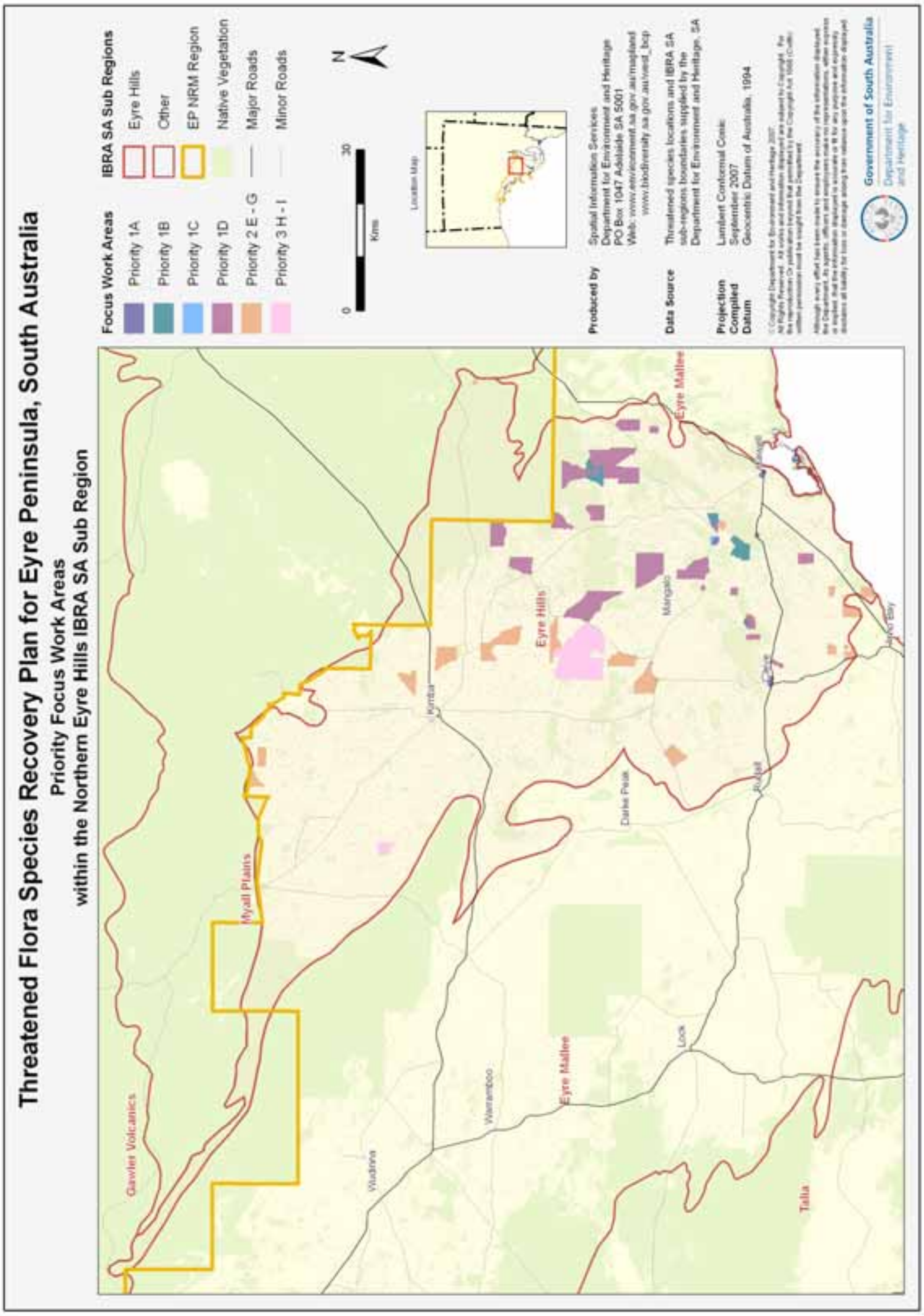


Figure 30.2. Prioritised Focus Work Areas within the northern Eyre Hills IBRA sub region, SA

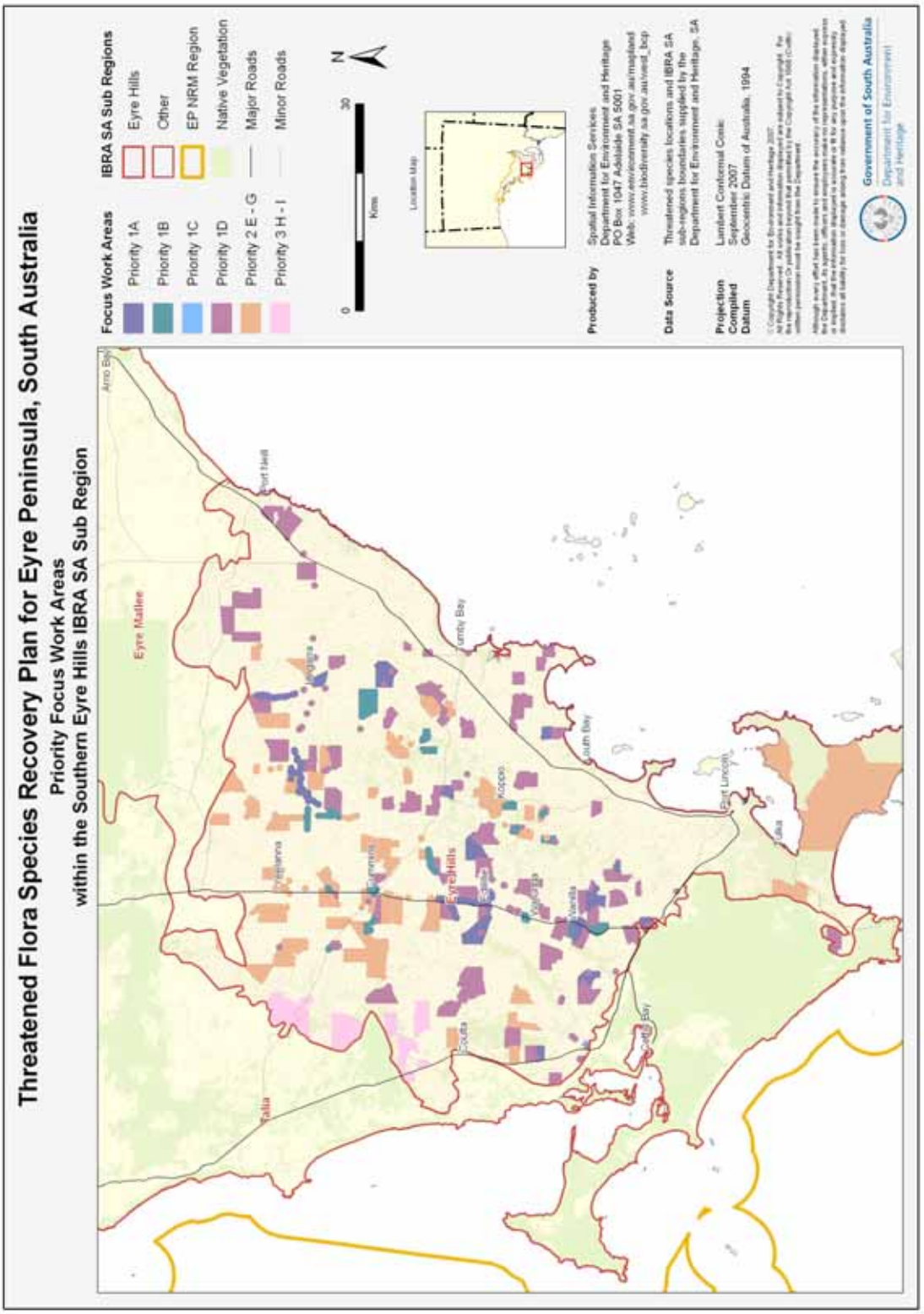


Figure 30.3. Prioritised Focus Work Areas within the Southern Eyre Hills IBRA sub region, SA

Five year timetable and associated costs

Recovery costs

The costs associated with threatened flora recovery are separated into three funding tiers, i.e. Core Operating budget, Tier 2 funding and Tier 3 funding (Table 31.1). Each funding tier has an associated colour code (refer to Table 31.1). All 93 performance criteria have been allocated to a funding tier (Section 4.5 and Appendix D).

Table 31.1. Key to budget tables

Colour code	Budget name	Description
	Core Operating budget	Minimum financial investment required to start meeting conservation needs of Priority 1 threatened flora taxa
	Tier 2 funding	Minimum financial investment required to start meeting conservation needs of Priority 1 and 2 threatened flora taxa
	Tier 3 funding	Minimum financial investment required to start meeting conservation needs of all threatened flora taxa and critical habitat identified within this plan

Recovery time frame

The timing of each recovery action is based on the current extent and predicted future extent of threatening processes (determined using a threat matrix; see Appendix E: Threat matrix and assessment tables for threatened plant species, Eyre Peninsula
The timing and seasonal requirements for each performance criterion are outlined in the full 5 year timetable provided in Table 31.2. Colour-coded squares within Table 31.2 show the times at which performance criteria should be undertaken.

Table 31.2. Timetable of recovery actions and performance criteria (Part 1of 3)

Summary of performance criteria	2007		2008		2009		2010		2011		2012		2013		Cost over 5 years Grey = in kind costs
Financial Year (Quarters)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun		
1a.1 Survey 90% Priority 1 species sub-populations																									**49,500**
1a.2 Survey 70% Priority 2 species sub-populations																									**47,500**
1a.3 Survey 50% of Priority 3 species sub-populations																									**15,000**
1b.1 Minimum dataset analysed via GIS Priority 1 species																									*25,000*
1c.1 All species critical habitat identified & mapped																									*25,000*
1c.2 Map potential habitat Priority 1 species																									*25,000*
1c.3 Map potential habitat Priority 2 & 3 species																									**34,650**
1c.4 Critical habitat ground truthed Priority 1 species																									**35,000**
1c.5 Corridors identified Priority 1 species																									*100*
1d.1 Searches in Priority 1 species potential habitat																									**4,000**
1d.2 Searches for fire & disturbance dependant species																									*Included in 2a.1*
1d.3 Plant samples verified by State Herbarium staff																									**2,500**
2a.1 1x FTE maintained (including on-costs)																									**450,000**
2a.2 External funds sought & managed																									*6,000*
2a.3 Resources secured for plan duration																									**78,500**
2a.4 Eyre Peninsula Flora Recovery Team established																									*8,000*
2a.5 Log volunteer, in-kind, technical support hours																									*Included in 2a.1*
2a.6 Support staff assist in field work, logistics																									**210,000**
2b.1 Communication strategy developed																									*50*
2b.2 Information shared state, interstate & international																									*Included in 2a.1*
2b.3 Updates readily accessible to stakeholders																									**500**
2c.1 Volunteer group formalised																									*Included in 2a.1*
2c.2 One annual meeting with volunteers																									**750**
2c.3 Training for volunteers																									**4,000**
3a.1 Threats Priority 1 & 2 species local database																									**41,600**
3a.2 Prioritise threats at Priority 1 sub-populations level																									
3a.3 Prioritise threats at Priority 2 sub-populations level																									
3a.4 Prioritise weed & grazing control in FWAs 1, 2 & 3																									
3b.1 Weed control high risk weeds in 80% of FWA 1																									**42,500**
3b.2 Weed control, med. risk weeds, 50 m Priority 1 sp.																									**16,000**

Table 31.2 continued. Timetable of recovery actions and performance criteria (Part 2 of 3)

	2007		2008				2009				2010				2011				2012				2013		
Financial Year (Quarters)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Summary of performance criteria	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Cost over 5 years Grey = in kind costs
3b.3 Weed control, high risk weeds, in 50% of FWA 2 & 3																									*Included in 2a.1*
3c.1 Determine grazing damage																									*Included in 2a.1*
3c.2 Implement grazing control																									**26,000**
3d.1 *Phytophthora* soil tests Priority 1 species																									**1,200**
3d.2 *Phytophthora* information to stakeholders																									*Included in 2a.1*
3d.3 DEH *Phytophthora* hygiene practices																									**3,000**
3e.1 Establish Road Marker System in councils																									**200,000**
3e.2 Railway Marker System maintained & improved																									*Included in 2a.1*
3e.3 Provide land holders with species & grant info																									*Included in 2a.1*
3e.4 Negotiate Has or conservation covenants																									*Included in 2a.1*
3f.1 Soil sampling – salinity or acidification																									*Included in 2a.1*
3f.2 Determine strategic buffers of Priority 1 species																									*Included in 2a.1*
3f.3 Salinity abatement for critical habitat																									***10,000***
3f.4 Strategic vegetation buffers for critical habitat																									***60,000***
3f.5 Enhance connectivity Priority 3 species																									**10,000**
3f.6 Feasibility of translocation Priority 1 species																									*Included in 2a.1*
3f.7 Undertake translocation Priority 1 species																									**4,000**
3f.8 Seed collection Millennium Seed Bank																									*Included in 2a.1*
4a.1 Honours student(s) (minimum one per year)																									**15,000**
4a.2 List of plant knowledge deficiencies																									*Included in 2a.1*
4b.1 Break downs in Priority 1 species life cycle																									*Included in 4a.1 2a.1*
4b.2 Break downs in Priority 2 species life cycle																									*Included in 4a.1 2a.1*
4b.3 Break downs in Priority 3 species life cycle																									*Included in 4a.1 2a.1*
4b.4 Pollinators & vector(s) for Priority 1 species																									**9,000**
4b.5 Germination & recruitment Priority 1 species																									**1,000**
4b.6 Average longevity for Priority 1 species																									*Included in 2a.1*
4b.7 Soil & pH level Priority 1 & 2 species																									*Included in 2a.1*
4b.8 Symbiotic mycorrhiza Priority 1 orchids																									**3,000**
4c.1 Literature review fire & disturbance needs																									**1,000**
4c.2 Determine & identify prescribed burn needs																									*In kind multiple*

Table 31.2 continued. Timetable of recovery actions and performance criteria (Part 3 of 3)

Summary of performance criteria	2007		2008				2009				2010				2011				2012				2013		Cost over 5 years Grey = in kind costs
Financial Year (Quarters)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	
4c.3 Experiment designs completed for burning																									***365,000***
4c.4 Two prescribed burns conducted																									***7,500*** **23,000**
4c.5 Two disturbance experiment designs																									**40,000**
4c.6 Two disturbance trials																									*Links with 4a.1*
4d.1 Two canopy-cover trials conducted																									*Links with 4a.1*
4d.2 Two grazing pressure exclosures trials																									**1,000**
4e.1 Genetics for Whibley's & Chalky wattles																									**10,000**
4e.2 Genetics remaining Priority 1 species																									**50,000**
4f.1 Chemical drift effect threatened flora species																									**5,000**
4f.2 Hydrology influence on critical habitat																									*Links with 4a.1 & other*
4g.1 Model impact climate change Priority 1 sp.																									*Interagency multiple*
4g.2 Research climate Priority 1 sp. reproduction																									**5,000**
4h.1 Minimum viable population Priority 1 species																									**1,500**
4h.2 Minimum viable population Priority 2 species																									*Links with 4a.1 & other*
5a.1 List of Key Monitoring Sites																									*Included in 5a.3*
5a.2 Upgrade local threatened plant database																									***3,500*** **4,700**
5a.3 Twice yearly storing, archiving and storage																									**9,000**
5a.4 Priority 1 sp. Key Monitoring Sites monitored																									*Included in 2a.1*
5a.5 Priority 2 sp. Key Monitoring Sites monitored																									*Included in 2a.1*
5a.6 Priority 3 sp. Key Monitoring Sites monitored																									*Included in 2a.1*
5a.7 Life-class structure Priority 1 species																									*Included in 2a.1*
5a.8 All translocated populations monitored																									*Included in 2a.1*
5a.9 Prescribed burn monitoring data analysed																									*Included in 2a.1*
5a.10 Herbivore exclosures trials monitored																									*Included in 2a.1*
5a.11 Weed control effectiveness in FWAs																									*Included in 2a.1*
5a.12 Herbivore density Chalky Wattle																									*Included in 2a.1*
5a.13 Incorporate recommendations re impacts																									*Included in 2a.1*
5b.1 Progress check criteria/schedule																									*Included in 5a.3*
5b.2 Incorporate research findings into actions																									*Included in 5a.3*
5c.1 Re-evaluation of recovery plan																									*Included in 5a.3*
5c.2 Review second stage of program																									*Included in 5a.3*

Table 31.3. Break down of performance criteria and associated funding tier by species

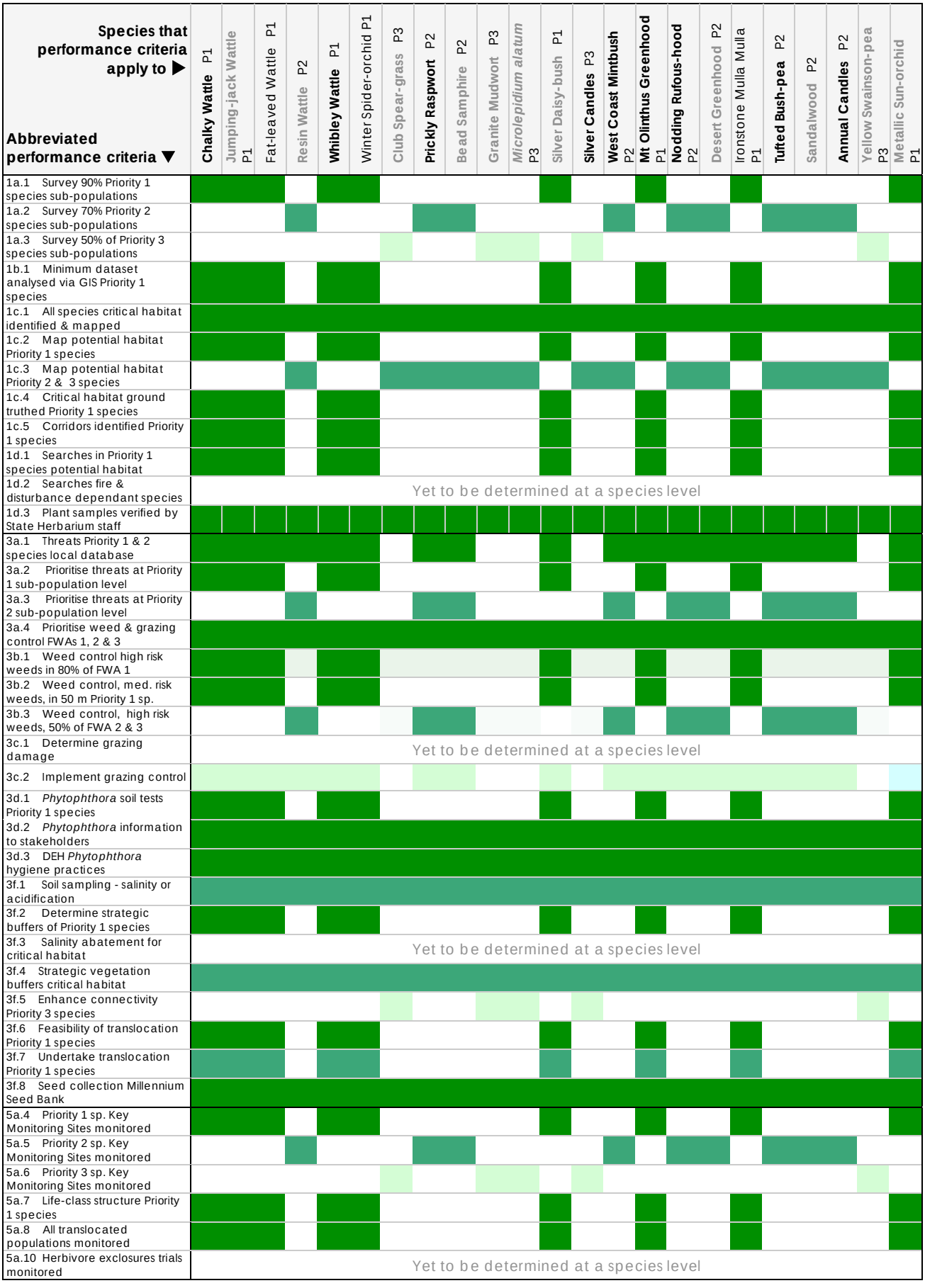
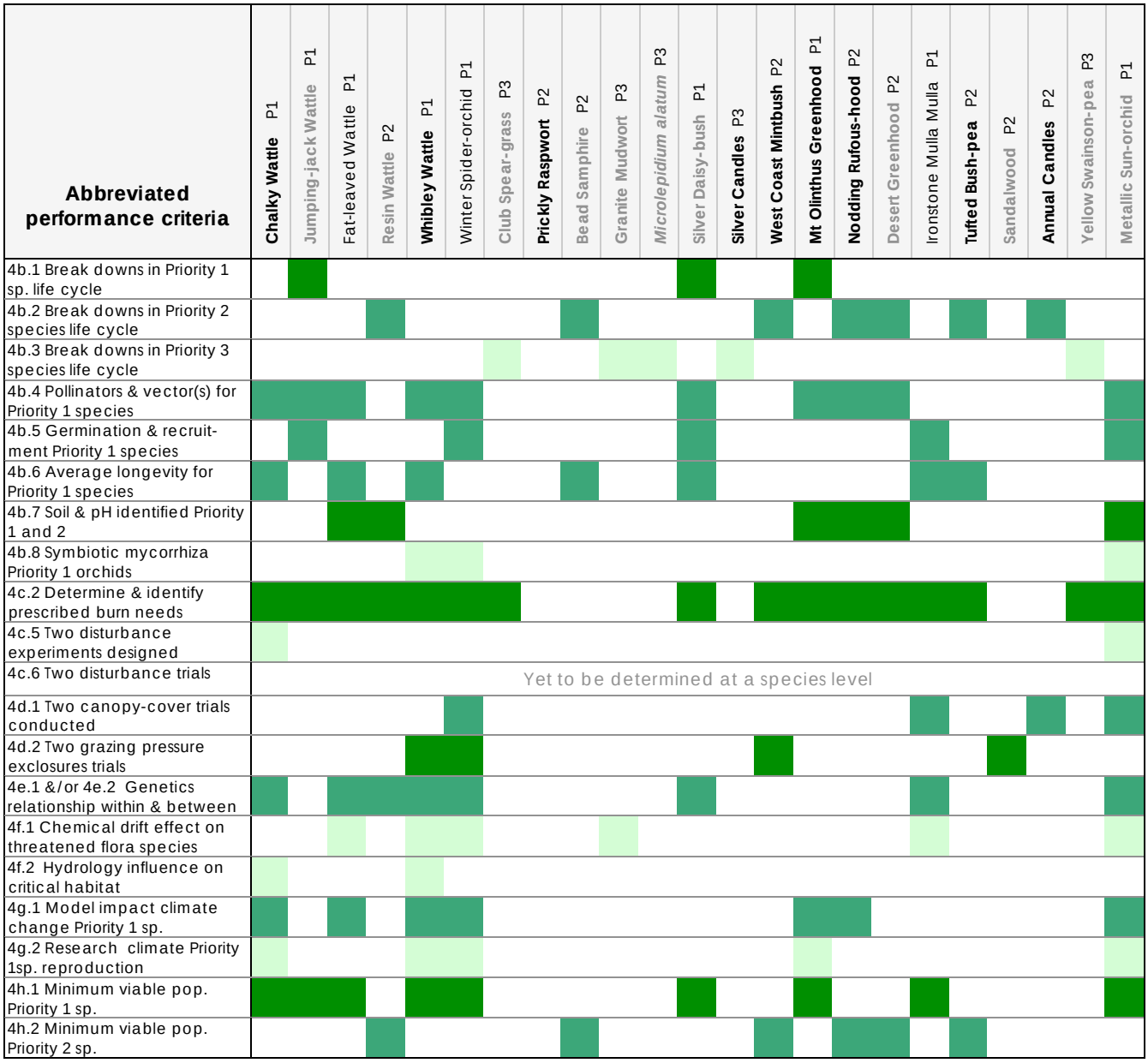


Table 31.4. Species by species breakdown of research performance criteria only



32 Management practices

As a general guide, any management practice undertaken in or directly adjacent to critical or potential habitat of the nationally threatened plant species addressed in this plan should be considered carefully. Where possible, activities should be avoided if they might promote the spread and/or impact of the threatening processes identified within this plan. Table 32.1 provides a selection of examples of such activities and potential management pitfalls that may limit the success of threatened flora recovery. This list is by no means exhaustive and should be treated as a guide only. Table 32.1 also highlights that management inaction is a key practice that may increase the spread and impact of threatening processes on nationally threatened flora species.

Table 32.1. Examples of management practices that may contribute to the extent and impact of identified threats and impediments to the recovery of nationally threatened flora species on Eyre Peninsula

Threat to recovery	Management activities that may contribute to each threat
High grazing pressure	• Grazing of livestock in critical and potential threatened plant species habitat that does not take into account ecological requirements of species • Failure to determine, monitor and manage the impact of native herbivore grazing on nationally threatened plant species
Illegal collection or harvest	• Illegal take of seed or plant material from a threatened species
Mineral exploration/ extraction	• Failure to follow environmental impact assessment process and use data stored in Biological Databases of South Australia (custodian DEH)
Off-road vehicles and rubbish dumping	• Use and parking of vehicles in roadside vegetation, in critical and potential habitat • Rubbish dumping in critical habitat
Pest and disease (*Phytophthora*)	• Any activity contributing to the transfer of soil material without adequate hygiene precautions • Any activity, without precautionary measures, that increases risk of plant pathogens and diseases spreading into wild threatened flora populations on Eyre Peninsula
Roadside management (including railway and other easements)	• Upgrading road carriageways, annual road maintenance, and weed/vegetation control along roadsides or rail corridors, on both Transport SA and local government roads • Installation and maintenance of services (e.g. power, water and communication cables) • Weed/vegetation control along roadsides or rail corridors by mechanical or chemical means
Salinity/changes in hydrology	• Any activity that contributes to the rise and salinisation of water tables in areas of critical of potential habitat • Any activity that significantly changes natural flows of ground-surface water to, from and within areas of critical or potential habitat
Spray drift	• Off-target or deliberate use of insecticides in the vicinity of known orchid sub-populations may reduce the abundance of pollinators of the orchid and other species, and consequently the plant population numbers
Urban development/ subdivision	• Failure to follow environmental impact assessment process and use data stored in Biological Databases of South Australia (custodian DEH)
Vegetation clearance	• Any activity that reduces the size and increases the isolation of threatened flora sub-populations • Small scale vegetation clearance and firewood collection in narrow strips of roadside vegetation identified as critical and potential habitat
Weed invasion	• Failure to target weed management activities to reduce the impact of environmental weed species on nationally threatened plant species

Table 32.1. continued.

Impediments to recovery	Management activities that may contribute to each threat
Availability of resources	• Failure to apply for and allocate sufficient funding to the recovery of nationally threatened flora species on Eyre Peninsula
Lack of coordination of Recovery Actions	• Failure to obtain and maintain a coordinator dedicated to the task of implementing the recovery plan • Failure to maximise potential multiple outcomes for threatened flora as part of broad biodiversity conservation efforts • Failure to adequately engage the community in threatened flora recovery activities through a lack of provision of training, supervision and ongoing support
Habitat fragmentation	• Any activity that reduces the size and increases the isolation of threatened flora sub-populations
Inappropriate disturbance regimes	• Initiation of disturbance events, which do not take into account the ecological requirements of nationally threatened flora species • Small-scale vegetation clearance and firewood collection in narrow strips of roadside vegetation identified as critical and potential habitat • Maintenance and establishment of walking trails in critical or potential habitat • Any activity that contributes to the rise and salinisation of groundwater tables in areas of critical or potential habitat • Any activity that promotes soil disturbance in areas of critical habitat susceptible to soil erosion • The placement of bee hives in the vicinity of known nationally threatened orchid sub-populations may adversely affect the orchids' pollinators
Inappropriate fire regimes	• Failure to undertake fire management activities (including ecological burns and the control of wildfire), which establish appropriate fire regimes for nationally threatened plant species and their habitat
Lack of involvement of stakeholders	• Failure to recognise the importance of potential habitat in the recovery of threatened flora species and undertake protection measures • Lack of support for any activities
Lack of knowledge (ecology and biology) and baseline information (understanding of threats)	• Failure to place an emphasis on research into biology and ecology of threatened flora species as a means of improving the management of threatened flora species • Failure to recognise the importance of research to determine the true impact of threats on nationally threatened flora species • Failure to develop a cooperative approach to research with relevant research organisations
Lack of recruitment/ small population size Restricted distribution/ isolated sub-populations	• Links with management activities listed under Habitat fragmentation, Inappropriate disturbance regimes, and Lack of knowledge and baseline information

33 Reference list

ANBG 2007, *Introduction to Australia Orchidaceae*, Australian National Botanical Gardens, viewed 17 November 2007, <http://www.anbg.gov.au/cpbr/cd-keys/orchidkey>.

Barker, WR 1984, 'Scrophulariaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

Barker, WR 1986, 'Stackhousiaceae-Stackhousia', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

Barker, W, Barker, R, Jessop, J & Vonow, H 2005, *Census of South Australian Vascular Plants*, The Botanical Gardens and State Herbarium, South Australia.

Barrett, DR 1987, 'Initial observations on flowering and fruiting in *Santalum spicatum* (R.BR.) A.DC. the Western Australian Sandalwood', *Mulga Research Centre Journal*, no. 9.

Bartley, MJ 1990, 'Notes on fruit condition, germinability and seedling morphology of *Olearia pannosa* Hook (Velvet Daisy-bush)', *The Victorian Naturalist*, vol. 107.

Bates, R 1984, 'Australia's colourful sun-orchids: *Thelymitra*', *Australian Orchid Review*, vol. 49.

Bates, R 2006, CD-ROM, *South Australian native orchids*, unpublished, Adelaide.

Bates, RJ & Weber, JZ 1990, *Orchids of South Australia*, South Australian Government Printer, Adelaide.

Beardsell, C 1980-1984, 'A register of rare and endangered native plant species in Victoria', unpublished report on *Thelymitra epipactoides*, La Trobe University, Melbourne.

Bickerton, D & Robertson, M 2000, *Lowly Greenhood (*Pterostylis despectans*) 'Mt. Bryan' Recovery Plan*, Threatened Species Network, Threatened Plant Action Group, Adelaide, viewed 8 November 2007, <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/p-despectans/index.html>.

Black, JM 1977, *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

Black, JM 1986, *Flora of South Australia, Part I: Lycopodiaceae-Rosaceae*, 4th edn, South Australian Government Printer, Adelaide.

Black, JM 1986a, *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, 4th edn, South Australian Government Printer, Adelaide.

BOM 2007, *Climate statistics for Australian sites: South Australia*, Bureau of Meteorology, Melbourne, viewed 25 July 2007, <http://www.bom.gov.au/climate/averages/tables/ca_sa_names.shtml>.

Bonney, N 1997, *Economic trees and shrubs for South Australia*, Graphic Print Group, Richmond.

Bradstock, R, Williams, J & Gill, A 2002, *Flammable Australia: the fire regimes and biodiversity of a continent,* Cambrige University Press, Tasmania.

Brand, J 1999b, *Conserving sandalwood (*Santalum spicatum*) in the rangelands, Western Australia*, information sheet, Department of Conservation and Land Management, Perth.

Brand, J 1999c, 'Ecology of Sandalwood (*Santalum spicatum*) near Paynes Find and Menzies, Western Australia: Size structure and dry-side stems', *Rangeland Journal*, vol. 21, no. 2, pp. 220-8.

Brand, JE 2000, 'The effect of management regime and host species on sandalwood (*Santalum spicatum*) recruitment near Paynes Find, Western Australia', *Rangelands Journal*, vol. 22, no. 2, pp. 243-55.

Brand, J 2002, 'Review of the influence of Acacia species on establishment of Sandalwood *(Santalum spicatum*) in Western Australia', *Conservation Science Western Australia*, vol. 4, no. 1, pp. 125-129.

Brand, J & Jones, P 1999a, *Growing Sandalwood (*Santalum spicatum*) on farmland in Western Australia*, information sheet, Department of Conservation and Land Management, Perth.

Brand, JE, Crombie, DS & Mitchell, MD 1999, 'Establishment and growth of sandalwood (Santalum spicatum) in south-western Australia: the influence of host species', *Australian Forestry*, vol. 63, no. 1, pp. 60-65.

Briggs, JD & Leigh, JH 1996, *Rare or threatened Australian plants*, CSIRO Publishing, Canberra.

Byrne, M, MacDonald, B, Broadhurst, L & Brand, J 2003, 'Regional genetic differentiation in Western Australian sandalwood (*Santalum spicatum*) as revealed by nuclear RFLP analysis', *Theoretical Applied Genetics*, vol. 107, pp. 1208-1214.

Calder, D, Cropper, S & Tonkinson, D 1989, 'The ecology of *Thelymitra epipactoides* F. Muell. Orchidaceae, in Victoria, Australia, and the implication for management of the species', *Australian Journal of Botany*, vol. 37.

Carter, O 2005, *DRAFT Recovery Plan for* Halosarcia flabelliformis *(Bead Glasswort) in South Australia, Western Australia and Victoria 2006 - 2010*, Arthur Rylah Institute for Environmental Research & Department of Sustainability and Environment, Heidelberg, Victoria.

CILR 2007, *Legumes and the nitrogen cycle*, ARC Centre of Excellence for Integrative Legume Research, St Lucia, Queensland, viewed 8 November 2007, <http://www.cilr.uq.edu.au/pages.aspx?id=111>.

Coates, F 2003, *Action Statement No. 156 Metallic Sun-orchid* Thelymitra epipactoides, Department of Sustainability and Environment, Victoria.

Coleman, P & Cook, F 2005, *Habitat preferences of* Halosarcia flabelliformis, Microsoft PowerPoint display, viewed on 8 September 2005, Delta Environmental Consulting, Adelaide.

Commonwealth of Australia 2006, *EPBC Act Policy Statement 1.1: Significant impact guidelines - matters of national environmental significance*, Department of the Environment and Heritage, Canberra.

Cooke, DA 1986, 'Compositae (Asteraceae)', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

Coventry, J 2004, *Agnote: 'Swainsona' poisoning in cattle and horses*, Department of Primary Industry, Alice Springs, viewed 8 November 2007, <https://transact.nt.gov.au/ebiz/dbird/TechPublications.nsf/6C9AD180E91630EF69256EFE004F6758/$file/647.pdf?OpenElement>.

Cowan, RS & Maslin, BR 2001, in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

Cropper, S 1993, *Management of endangered plants*, CSIRO Publications, Australia.

Cropper, SC & Calder, DM 1990, 'The floral biology of *Thelymitra epipactoides* (Orchidaceae), and the implications of pollination by deceit on the survival of this rare orchid', *Plant Systematics and Evolution*, vol. 170, pp. 11-27.

Cropper, SC, Calder, DM & Tonkinson, D 1989, '*Thelymitra epipactoides* F. Muell. (Orchidaceae): The Morphology, biology and conservation of an endangered species', *Proceedings of the Royal Society of Victoria*, vol. 101, pp. 89-101.

CSIRO Australia 2007, *Ecosystem Services*, CSIRO Sustainable Ecosystems, Canberra, viewed 8 November 2007, <http://www.cse.csiro.au/research/ecosystemservices.htm>.

Datson, B 2002, *Samphires of Western Australia: A field guide to Chenopodiaceae tribe Salicornieae*, Department of Conservation and Land Management, Perth.

Davies, RJP 1986, *Threatened plant species of the Mt Lofty and Kangaroo Island regions of South Australia*, Conservation Council of South Australia Inc, Adelaide.

Davies, R 1992, Swainsona pyrophila *survey data - Threatened Plant Species Population Database*, unpublished, Department for Environment and Heritage, South Australia.

Davies, R 1995, *Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia*, Botanic Gardens of Adelaide and State Herbarium, South Australia.

DEC 2005, *A spear-grass – profile*, Department of Environment and Climate Change NSW, Sydney, viewed 8 November 2007, <http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10081>.

DEC 2007, *Butterfly gardening - food plants*, Department of Environment and Conservation, viewed 8 November 2007, <http:www.naturebase.net/content/view/276/306>.

DEH 2002, *Biodiversity plan for Eyre Peninsula*, Department for Environment and Heritage, South Australia.

DEH 2004, Phytophthora cinnamomi *causing dieback in plants: Spread the word – not* Phytophthora, Department for Environment and Heritage, South Australia.

DEH 2004a, *Naturelinks: Implementing the Wild Country philosophy in South Australia*, Department for Environment and Heritage, South Australia.

DEH 2007, 'Species found to be endangered: *Acacia pinguifolia*', in DEH Recfind File 40/1498, Department for Environment and Heritage, South Australia, pp. 23-27.

DEH 2001, 'Provisional list of threatened ecosystems of South Australia', unpublished and provisional list, Department for Environment and Heritage, South Australia.

DEH-EGIS 2006, Environmental GIS, Department for Environment and Heritage, South Australia.

DEH-EGIS 2007, Environmental GIS, Department for Environment and Heritage, South Australia.

DPIW 2003, Stackhousia gunnii*: Threatened flora of Tasmania*, Department of Primary Industries and Water, Hobart, viewed 8 November 2007, <http://www.dpiw.tas.gov.au/inter.nsf/Attachments/SSKA-76P3SC/$FILE/Stackhousia%20gunnii.pdf>.

DPIW 2003a, Stackhousia viminea*: Threatened flora of Tasmania*, Department of Primary Industries and Water, Hobart, viewed 8 November 2007, <http://www.dpiw.tas.gov.au/inter.nsf/Attachments/SSKA-76P4BW/$FILE/Stackhousia%20viminea.pdf>.

Driscoll, D & Halliday, L 2007, *Project brief for Implementing Nature Links: can dune-top and roadside native vegetation act as connecting habitat or stepping stones for plant and animal species?*, unpublished report in DEH Recfind file 40/1588 by School of Biological Sciences Flinders University to the Department for Environment and Heritage, South Australia.

Duncan, M 2005, *Draft Recovery Plan for* Pterostylis xerophila *(Desert Greenhood) In Victoria and South Australia 2006-2010*, Department of Sustainability and Environment, Heidelberg, Victoria.

DWLBC 2006, *State Natural Resources Management Plan*, Department of Water, Land and Biodiversity Conservation, South Australia.

Earl, G, Barlow, T & Moorrees, A 2001, *Action Statement: Twelve threatened Swainson-peas and Darling peas (*Swainsona *species)*, Department of Natural Resources and Environment, Victoria.

Ecological Associates 2006, *Threatened flora threat assessment,* report to the Department for Environment and Heritage, South Australia.

Ecological Associates 2007, *Eyre Peninsula Bushfire Recovery Program: Vegetation monitoring*, report to the Department for Environment and Heritage, South Australia.

Environment Australia 2001, *Threat abatement plan for dieback caused by the root-rot fungus* Phytophthora cinnamomi, Commonwealth of Australia, Canberra.

Environment Australia 2002 *Revised recovery plan guidelines for nationally listed threatened species and ecological communities under the Commonwealth* Environment Protection and Biodiversity Conservation Act 1999, Department of the Environment and Heritage, Canberra.

EPNRMB 2007, *Regional information and maps: Salinity on Eyre Peninsula*, Eyre Peninsula Natural Resources Management Board, Port Lincoln, viewed 8 November 2007, <http://www.eprnm.sa.gov.au/nrm/boards/ep/wrp/info/regional.html>.

Everett, J 1986, 'Stipa - Gramineae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide, pp. 1454-1455.

Feuerherdt, L & Petit, T 2004, *The role of echidnas in soil disturbance and the conservation of endangered orchids in South Australia,* Australian Mammal Society Scientific Conference Presentation, Adelaide.

Fox, F 1997, 'Why is Santalum spicatum common near granite rocks?', *Journal of Royal Society of Western Australia*, vol. 80, pp. 209-220.

FPC 2007, *Tree facts Sandalwood (*Santalum spicatum*): guide for farmers,* Forest Products Commission, viewed 18 November 2007, <http://www.fpc.wa.gov.au>.

Freebairn, A 2003, *Roadside markers: Protecting threatened flora within the District Council of Lower Eyre Peninsula 2001/2002*, report to the Native Vegetation Research Fund.

Green, P 1988, Stackhousia annua *survey data - Threatened Plant Species Population Database*, unpublished, Department for Environment and Heritage, South Australia.

Green, P 1993, *Threatened plants of Yorke Peninsula*, Conservation Council of South Australia, Adelaide.

Grey, P & Grey, E 2005, *Fungi downunder: the Fungimap guide to Australian fungi*, Fungimap, Melbourne.

Hewson, H 1986, 'Cruiferae (Brassicaceae)', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part I: Lycopodiaceae-Rosaceae,* South Australian Government Printer, Adelaide.

Hewson, HJ & George, AS 1984, 'Santalaceae', in *Flora of Australia*, Australian Government Publishing Services, Canberra.

Hussey, BMJ 2002, 'Wattle I plant for wildlife?', *Conservation Science Western Australia*, vol. 4, no. 3, pp. 62-71.

IUCN 1994, *IUCN Red List Categories*, IUCN, Gland, Switzerland.

IUCN 2001, *IUCN Red List Categories and Criteria*, version 3.1, IUCN Species Survival Commission, Gland, Switzerland.

Jessop, J, Dashorst, G & James, F 2006, *Grasses of South Australia: An illustrated guide to the native and naturalised species*, The Board of Botanic Gardens of Adelaide and State Herbarium, South Australia.

Jessop, JP & Toelken, HR (eds) 1986, *Flora of South Australia, Part I: Lycopodiaceae-Rosaceae*, South Australian Government Printer, Adelaide.

Jessop, JP & Toelken, HR (eds) 1986a, *Flora of South Australia, Part IV: Alismataceae-Orchidaceae*, South Australian Government Printer, Adelaide.

Jessop, JP & Toelken, HR (eds) 1986c, *Flora of South Australia, Part III: Polemoniaceae-Compositae*, South Australian Government Printer, Adelaide.

Johnson, G 1996, *Action Statement: Northern Sandalwood* Santalum lanceolatum, Department of Sustainability and Environment, Victoria.

Jones, D 2006, *A complete guide to native orchids of Australia including the island territories*, Reed New Holland, Australia.

Jones, DL 2007, 'Two new species of *Oligochaetochilus* (Orchidaceae) from South Australia', *The Orchadian*, vol. 15, no. 9.

Jones, DL & Clements, MA 2001, 'Arachnorchis brumalis (D.L. Jones)', *Orchadian*, vol. 13, no. 9, pp. 393.

Jones, DL & Clements, MA 2002, 'A reassessment of *Pterostylis* R.Br (Orchidaceae)', *Australian Orchid Research*, vol. 4, pp. 6-63.

Jusaitis, M 1997, 'Experimental translocations: implications for the recovery of endangered plants' in DH Touchell, KW Dixon, AS George & AT Wills (eds), *Conservation into the 21st Century: Proceedings of the 4th International Botanic Gardens Conservation Congress, Perth, Western Australia*, Kings Park and Botanic Garden, Western Australia.

Jusaitis, M 1998, *Recovery plan* Acacia whibleyana*,* South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide.

Jusaitis, M 1991, *Recovery plans* Prostanthera eurybiodes, Pterostylis arenicola, Acacia cretacea, Pultenaea trichophylla, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Jusaitis, M 2005, 'Translocation trials confirm species factors affecting the establishment of three endangered plant species', *Journal of Ecological Management and Restoration*, vol. 6, no. 1.

Jusaitis, M, Bond, A, Smith, K, Sorensen, B & Polomka, L 2000, Acacia cretacea *recovery plan: Annual report*, Plant Biodiversity Centre, Department for Environment and Heritage, South Australia.

Jusaitis, M, Bond, A, Smith, K & Polomka, L 2000, Haloragis eyreana *Research Plan*, Department for Environment and Heritage, South Australia.

Jusaitis, M, Bond, A, Smith, K & Polomka, L 2000a, *Annual Report for* Haloragis eyreana *Research Plan*, Department for Environment and Heritage, South Australia.

Jusaitis, M & Polomka, L in press, *Weeds and founder propagules influence translocation success in endangered Whibley Wattle,* Acacia whibleyana *(Leguminosae)*, unpublished paper, Department for Environment and Heritage, South Australia.

Jusaitis, M & Smith, K 1997, *Progress report* Haloragis eyreana, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Jusaitis, M & Smith, K 1998, Haloragis eyreana *Research Plan: Annual report*, Department for Environment, Heritage and Aboriginal Affairs, South Australia.

Jusaitis, M & Sorensen, B 1994, *Conservation studies on endangered plant species from South Australia's agricultural regions*, Black Hill Flora Centre, Botanic Gardens of Adelaide.

Jusaitis, M & Sorensen, B 1997, *Research Plan Annual Report January 1997,* Acacia whibleyana, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 1997a, *Progress Report August 1997* Acacia whibleyana, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 1998, *Conservation Biology of* Acacia whibleyana, South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide.

Jusaitis, M & Sorensen, B 2007, 'Successful augmentation of an *Acacia whibleyana* (Whibley Wattle) population by translocation', *Australian Plant Conservation, Bulletin of the Australian Network for Plant Conservation*, vol. 16, no. 1.

Lang, P 1984, Stackhousia annua *survey data - Threatened Plant Species Population Database*, unpublished, Department of Environment and Heritage, South Australia.

Laut, P, Heyligers, C, Keig, G, Loffler, E, Margules, C, Scott, RM & Sullivan, ME 1977, *Environments of South Australia, Province 4 Eyre and Yorke Peninsulas*, CSIRO, Canberra.

Leigh, J, Boden, R & Briggs, J 1984, *Extinct and endangered plants of Australia*, MacMillan, Australia.

Lepp, H 2005, *Truffle-like fungi in Australia,* Australian National Botanical Gardens, viewed 18 November 2007, <http://www.andg.gov.au/fungi/truffle-like.html>.

Lindenmayer, DB & Burgman, MA 1998, *Conservation Biology for the Australian Environment*, Surrey Beatty & Sons Pty Ltd, Sydney.

Lindenmayer, D & M, Burgman 2005, *Practical conservation biology*, CSIRO Publishing, Australia.

Lucas, C, Hennessy, K, Mills, G & Bathols, J 2007 *Bushfire weather in southeast Australia: Recent trends and projected climate change impacts*, report to The Climate Institute of Australia, Sydney.

Luke, RH & McArthur, AG 1978, *Bushfires in Australia*, Australian Government Publishing Service, Canberra.

Macfarlane, T, Watson, L & Marchant, N 2002, *Flora of Western Australia: Stackhousia, Western Australian Genera and Families of Flowering Plants*, Western Australian Herbarium, viewed 2007, <http:florabase.calm.wa.gov.au/browsa/flora?f=202&level=g&id=987>.

Maslin, BR & Whibley, DJE 1987, 'The taxonomy of some South Australian *Acacia* section *Phyllodineae* species (*Leguminosae: Mimosoideae*)', *Nuytsia*, vol. 6, no. 1, pp. 19-32.

McKenzie, R 2004, *Australian native poisonous plants*, The Marsupial Society of Australia, viewed 8 November 2007, <http://www.marsupialsociety.org/members/04au02.html>.

Moritz, KN & Bickerton, DC 2007, *Draft Recovery Plan for the Nationally Endangered Jumping-jack Wattle* Acacia enterocarpa *(R.V. Smith)*, report to the Species Listing, Recovery and Policy Section, Australian Government Department of the Environment and Water Resources, Canberra.

Murphy, M, Garkaklis, M & Hardy, G 2005, 'Seed caching by Woylies *Bettongia penicillata* can increase Sandalwood *Santalum spicatum* regeneration in Western Australia', *Austral Ecology*, vol. 30, pp. 747-755.

National Parks & Wildlife Council 2003, *Review of the status of threatened species in South Australia: Proposed schedules under the South Australian* National Parks and Wildlife Act 1972, discussion paper, Department for Environment and Heritage, South Australia.

Nicolle, D 1997, *Eucalypts of South Australia*, Lane Print Group, Adelaide.

NSW RFS 2004, *Threatened species hazard reduction list: Part 1 - Plants*, NSW Rural Fire Service, viewed 8 November 2007, <http://www.rfs.nsw.gov.au/file_system/attachments/State/Attachment_20050304_5C7BDF1C.pdf>.

NVMB 1987, *Remaining vegetation in the Agricultural Regions of South Australia*, unpublished, Native Vegetation Management Branch, Adelaide.

NVM 2002, *Remnant vegetation data within Environmental Associations for South Australia*, unpublished, Native Vegetation Management, Adelaide.

Obst, C 2005, *South Australian Murray-Darling Basin Threatened Flora Recovery Plan*, report to the Threatened Species and Communities Section, Department of the Environment and Heritage, Canberra.

Orchard, AE 1986, 'Haloragaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, PartIII: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide.

Overman, T & Venn, D 2004, *Action Statement Jumping-jack Wattle* Acacia enterocarpa*,* Department of Sustainability and Environment, Victoria.

Peeters, PJ, Jennings, S, Carpenter, RJ & Axford, G 2005, *Assessing the abundance and impacts of feral camels in the Great Victoria Desert*, Department for Environment and Heritage, Port Lincoln.

Peeters, P & Way, S 2005, *The fire-response and future conservation of biodiversity in the Lower Eyre Peninsula bushfire area*, Department for Environment and Heritage, Port Lincoln.

Pound, L, Obst, C & How, T 2004, *Draft recovery plan for* Acacia pinguifolia *(Fat-leaved Wattle)*, report to the Threatened Species and Communities Section, Australian Government Department of the Environment and Heritage, Canberra.

Prider, J 2005, *Ptilotus beckerianus monitoring plan: memorandum*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

Prider, J 2006, *Study design: Fire response monitoring*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

Prider, J 2006a, *Threatened flora threat assessment*, report prepared by Ecological Associates to the Department for Environment and Heritage, Port Lincoln.

Quarmby, J 2006, *Recovery plan for twelve threatened orchids in the Lofty Block region of South Australia 2007-2012*, Department for Environment and Heritage, South Australia.

Rugkhla, A, McComb, J & Jones, M 1997, 'Intra- and inter-specific pollination of *Santalum spicatum and S. album*', *Australian Journal of Botany*, vol. 45, pp. 1083-1095.

Russell, VJ, Mercer, K & Watt, M 2004 *Communicating for recovery: a guide to developing a recovery plan communications strategy*, TSN Network: WWF Australia, Sydney.

Scarlett, NH & Parson, RF 1993, 'Rare and threatened plants in Victoria', in DB Foreman & NG Walsh (eds), *Flora of Victoria, Volume 1: Introduction*, Inkata Press, Melbourne.

Schaumann, M, Barker, J & Greig, J 1987, *Australian Daisies: for gardens and floral art*, Lothian Publishing Company Pty Ltd, Melbourne.

Steed, Y 2002, *Threatened Plant Action Group site action plan* Olearia pannosa ssp. pannosa *Silver-leaved daisy bush, Roadside populations near Pt. Vincent*, Threatened Plant Action Group, Adelaide.

Stoutamire, WP 1983, 'Wasp-pollinated species of *Caladenia* (Orchidaceae) in South-Western Australia', *Australian Journal of Botany*, vol. 31, no. 4, pp. 383-394.

Stuwe, J 1980, 'Rare and endangered Victorian plants 1. *Acacia enterocarpa*', *Victorian Naturalist*, vol. 97, pp. 157-8.

Sweedman, L & Merritt, D 2006, *Australian seeds: a guide to their collection, identification and biology,* CSIRO Publishing, Australia.

Talbot, L 1983, 'Wooden gold: early days of the Sandalwood industry', *Forest Focus*, vol. 30, pp. 21-31.

Tame, T 1992, *Acacias of southeast Australia*, Kangaroo Press, Singapore.

Taylor, DA 2003, *Recovery plan for 15 nationally threatened plant species on Kangaroo Island, South Australia*, report to the Threatened Species and Communities Section - Department of the Environment and Heritage.

Thackway, R & Cresswell, ID (eds) 1995, *An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves*, version 4.0, Australian Nature Conservation Agency, Canberra.

Thompson, J 1993, 'Swainsona pyrophila', *Telopea*, vol. 5, no. 3, p. 448.

UNEP-WCMC 2007, *UNEP-WCMC Species database: CITES Listed species (Summary listed plants -Australian)*, United Nations Environment Programme - World Conservation Monitoring Centre, viewed 8 November 2007, <http://sea.unep-wcmc.org/isdb/CITES/Taxonomy/country_list.cfm?country=AU&col=all&source=plants&displaylanguage=eng>.

Usher, G 1966, *The Wordsworth dictionary of botany*, Wordsworth Editions Ltd, Great Britain.

Vallee, L, Hogbin, T, Monks, L, Makinson, B, Matthes, M & Rossetto, M 2004, *Guidelines for the translocation of threatened plants in Australia,* Australian Network for Plant Conservation, Canberra.

Velzeboer, R, Stubbs, W, West, A & Bond, A 2005, *Threatened plant species at risk from Phytophthora in South Australia*, Department for Environment and Heritage, South Australia.

Venn, DR 2005, *Action Statement No. 95 Bead Glasswort* Halosarcia flabelliformis, Department of Sustainability and Environment, Victoria.

Vernes, K 2007, 'Mammals, ectomycorrhizal fungi and ecosystem processes', *Proceedings of the national forum of the Australian Network for Plant Conservation: What lies beneath? The role of soil biota in the health and rehabilitation of native vegetation*, Australian Network for Plant Conservation, Canberra, p. 5.

Victorian Museum 2007, *The Native Bees of Australia - Australian Native Bee Database*, Museum Victoria, Melbourne, viewed 8 November 2007, <http://flyaqis.museum.vic.gov.au/bees>.

Warcup, J & Talbot, P 1967, 'Perfect states of rhizoctonias associated with orchids II', *The New Phytologist*, vol. 70.

Way, S 2006, *Strategic management of Aleppo Pines on Lower Eyre Peninsula to maximise biodiversity conservation outcomes*, Department for Environment and Heritage, Port Lincoln.

Way, S & Bates, R 2005, *Biological survey reports from five properties in the Koppio Hills, Southern Eyre Peninsula, South Australia*, Department for Environment and Heritage, South Australia.

Weber, JZ & Bates, R 1986, 'Orchidaceae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part IV: Alismataceae-Orchidaceae*, South Australian Government Printer, Adelaide, pp. 2132 - 2137.

Whibley, D 1986, 'Mimosoideae', in JP Jessop & HR Toelken (eds), *Flora of South Australia, Part II: Leguminosae-Rubiaceae*, South Australian Government Printer, Adelaide, pp. 511-568.

Whibley, DJE & Symon, DE 1992, *Acacias of South Australia*, South Australian Government Printer, Adelaide.

Wilson, P 1986, 'Halosarcia', in Jessop, JP & Toelken, HR (eds), *Flora of South Australia, Part I: Lycopodiaceae- Rosaceae*, South Australian Government Printer, Adelaide, pp. 267-268.

Appendix A: Commonly used acronyms and abbreviations

Acronyms

BDBSA	Biological Databases of South Australia
DEH	Department for Environment and Heritage, South Australia
EPBC	Environment Protection and Biodiversity Conservation (in reference to the *EPBC Act 1999*)
EPBC Act 1999	*Environment Protection and Biodiversity Conservation Act 1999*
EPNRMB	Eyre Peninsula Natural Resources Management Board
HA	Heritage Agreement(s)
IUCN	The World Conservation Union: The International Union for the Conservation of Nature and Natural Resources
NRM	Natural Resources Management
NPW	National Parks and Wildlife (in reference to the *National Parks and Wildlife Act 1972*, South Australia)
PIRSA	Primary Industries and Resources, South Australia

Abbreviations

aff.	Affinity
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
syn.	Synonym
var.	Variety

Appendix B: Glossary

Aril (or *arillus*)	The fleshy covering of certain seeds formed from the funiculus (attachment point of the seed).
Down-listing	To move a threatened flora species to a less threatened conservation status; minimise the threat to a species so that the potential of extinction is low, e.g. down-list an Endangered species to Vulnerable (IUCN 2001).
Direct threats	Processes that directly impact on the short-term survival of threatened plant populations, e.g. weed invasion.
Ex situ	Refers to the conservation of different species by taking care of them outside of their natural habitat(s). This method complements *in situ* conservation, especially when measures to recover and rehabilitate threatened species, and reintroduce them to their natural habitats, are used.
Focus Work Area(s)	Focus Work Areas are defined within this plan as prioritised zones where recovery actions will be of the most benefit to the highest number of threatened flora species addressed within this plan. The Focus Work Areas are considered the same as 'project areas' as designated under the *EPBC Regulations 2000*.
Impediments to recovery	Processes that will significantly influence the long-term survival of threatened plant species, but will not necessarily impact on the current day-to-day species survival. Impediments to recovery also include processes that restrict the ability of managers to stop or prevent threatening processes.
In situ	Situated in the original, natural, or existing place or position.
Phytophthora	Pronounced fy-TOFF-thora (often also called root-rot). Species of water moulds that are carried in soil and water. They cause root-rot disease symptoms, and eventually death to native plants, fruit trees, vines, nuts and ornamental plant species (DEH 2004).
Playa	An almost level area at the bottom of an undrained desert basin (in the case of this document, it refers to a coastal area), sometimes temporarily covered with water. Playas have no vegetation and are among the flattest geographical features in the world. Also called a 'sink'.
Population	Under the *EPBC Act* 1999, a population is the occurrence of a species or community in a particular area. Specifically, it is a group of conspecific individuals (belonging to the same species), commonly forming a breeding unit within which the exchange of genetic material is more or less unrestricted; a group sharing a particular habitat at a particular time (Lindenmayer & Burgman 1998). The IUCN use of the term population is slightly different and is defined as the total number of individuals of the taxon, e.g. the total global population of West Coast Mintbush (IUCN 2001).

Population size	Population size is measured as numbers of mature individuals only. In the case of taxa that are obligatory dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used (IUCN 2001).
Recruitment	In this plan, the term recruitment defines a threatened flora population's ability to germinate new plants and the ability for those plants to reach reproductive maturity.
Senescence	Stage in an individual plant's life history when the rate of metabolic activities decline (reproduction in particular) and there is a change in the physiology prior to death (Usher 1966).
Species	A division of the genus, each species (group of individual plants) possessing characters that distinguish it from other species of the same genus. Each species has two names, e.g. *Acacia cretacea*, the first being the generic (genus) name, the second the specific (species) name (Black 1986).
Sub-populations	Geographically or otherwise distinct groups in the population, between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (IUCN 2001).

Appendix C: Previous recovery plans, reports and similar documents

Some species within this plan have been included in previous recovery plans and similar documents. These documents have been listed below and range from national, interstate, South Australian and Eyre Peninsula based recovery plans for individual species, through to documents with brief species sections.

***Acacia cretacea* (Chalky Wattle)**
Jusaitis, M 1991, *Recovery plans* Prostanthera eurybiodes, Pterostylis arenicola, Acacia cretacea, Pultenaea trichophylla, Black Hill Flora Centre, Botanic Gardens of Adelaide. Jusaitis, M, Bond, A, Smith, K, Sorensen, B & Polomka, L 2000, Acacia cretacea *recovery plan: Annual report*, Plant Biodiversity Centre, Department for Environment and Heritage, South Australia. Jusaitis, M 2005, 'Translocation trials confirm species factors affecting the establishment of three endangered plant species', *Journal of Ecological Management and Restoration*, vol. 6, no. 1.
***Acacia enterocarpa* (Jumping-jack Wattle)**
Moritz, KN & Bickerton, DC 2007, *Draft Recovery Plan for the Nationally Endangered Jumping-jack Wattle* Acacia enterocarpa *(R.V. Smith)*, report to the Species Listing, Recovery and Policy Section, Australian Government Department of the Environment and Water Resources, Canberra. Overman, T & Venn, D 1999, *Action Statement No. 85 Jumping-jack Wattle*, Department of Sustainability and Environment, Victoria.
***Acacia pinguifolia* (Fat-leaved Wattle)**
Pound, L, Obst, C & How, T 2004, *Draft recovery plan for* Acacia pinguifolia *(Fat-leaved Wattle)*, report to the Threatened Species and Communities Section, Australian Government Department of the Environment and Heritage, Canberra. Obst, C 2005, *South Australian Murray-Darling Basin Threatened Flora Recovery Plan*, report to the Threatened Species and Communities Section, Department of the Environment and Heritage, Canberra.
***Acacia rhetinocarpa* (Resin Wattle)**
Davies, R 1995, *Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia*, Botanic Gardens of Adelaide and State Herbarium, South Australia. Obst, C 2005, *South Australian Murray-Darling Basin Threatened Flora Recovery Plan*, report to the Threatened Species and Communities Section, Department of the Environment and Heritage, Canberra.
***Acacia whibleyana* (Whibley Wattle)**
Jusaitis, M 1998, *Recovery plan* Acacia whibleyana*,* South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide. Jusaitis, M & Polomka, L in press, *Weeds and founder propagules influence translocation success in endangered Whibley Wattle,* Acacia whibleyana *(Leguminosae)*, unpublished paper, Department for Environment and Heritage, South Australia. Jusaitis, M & Sorensen, B 1997, *Research Plan Annual Report January 1997,* Acacia whibleyana, Black Hill Flora Centre, Adelaide. Jusaitis, M & Sorensen, B 1998, *Conservation Biology of* Acacia whibleyana, South Australian National Parks and Wildlife Service, Black Hill Flora Centre, Adelaide. Jusaitis, M & Sorensen, B 2007, 'Successful augmentation of an *Acacia whibleyana* (Whibley Wattle) population by translocation', *Australian Plant Conservation, Bulletin of the Australian Network for Plant Conservation*, vol. 16, no. 1.

***Caladenia brumalis* (Winter Spider-orchid)**

Quarmby, J 2006, *Recovery plan for twelve threatened orchids in the Lofty Block region of South Australia 2007-2012*, Department for Environment and Heritage, South Australia.

***Haloragis eyreana* (Prickly Raspwort)**

Jusaitis, M, Bond, A, Smith, K & Polomka, L 2000a, Annual Report for Haloragis eyreana Research Plan, Department for Environment and Heritage, South Australia.

Jusaitis, M & Smith, K 1998, Haloragis eyreana *Research Plan: Annual report*, Department for Environment, Heritage and Aboriginal Affairs, South Australia.

***Halosarcia flabelliformis* (Bead Samphire)**

Carter, O 2005, *DRAFT Recovery Plan for* Halosarcia flabelliformis *(Bead Glasswort) in South Australia, Western Australia and Victoria 2006 - 2010*, Arthur Rylah Institute for Environmental Research & Department of Sustainability and Environment, Heidelberg, Victoria.

***Olearia pannosa* ssp. *pannosa* (Silver Daisy-bush)**

Steed, Y 2002, *Threatened Plant Action Group site action plan* Olearia pannosa ssp. pannosa *Silver-leaved daisy bush, Roadside populations near Pt. Vincent*, Threatened Plant Action Group, Adelaide.

Obst, C 2005, *South Australian Murray-Darling Basin Threatened Flora Recovery Plan*, report to the Threatened Species and Communities Section, Department of the Environment and Heritage, Canberra.

***Pterostylis* aff. *despectans* (Nodding Rufous-hood)**

Bickerton, D & Robertson, M 2000, *Lowly Greenhood (*Pterostylis despectans*) 'Mt. Bryan' Recovery Plan*, Threatened Species Network, Threatened Plant Action Group, Adelaide, viewed 8 November 2007, <http://www.environment.gov.au/biodiversity/threatened/publications/recovery/p-despectans/index.html>.

Quarmby, J 2006, *Recovery plan for twelve threatened orchids in the Lofty Block region of South Australia 2007-2012*, Department for Environment and Heritage, South Australia.

***Pterostylis xerophila* (Desert Greenhood)**

Duncan, M 2005, *Draft Recovery Plan for* Pterostylis xerophila *(Desert Greenhood) In Victoria and South Australia 2006-2010*, Department of Sustainability and Environment, Heidelberg, Victoria.

***Ptilotus beckerianus* (Ironstone Mulla Mulla)**

Davies, RJP 1986, *Threatened plant species of the Mt Lofty and Kangaroo Island regions of South Australia*, Conservation Council of South Australia Inc, Adelaide.

Davies, R 1995, *Threatened plant species management in National Parks and Wildlife Act Reserves in South Australia*, Botanic Gardens of Adelaide and State Herbarium, South Australia.

***Pultenaea trichophylla* (Tufted Bush-pea)**

Jusaitis, M 1991, *Recovery plans* Prostanthera eurybiodes, Pterostylis arenicola, Acacia cretacea, Pultenaea trichophylla, Black Hill Flora Centre, Botanic Gardens of Adelaide.

***Swainsona pyrophila* (Yellow Swainson-pea)**

Earl, G, Barlow, T & Moorrees, A 2001, *Action Statement: Twelve threatened Swainson-peas and Darling peas (*Swainsona *species)*, Department of Natural Resources and Environment, Victoria.

***Thelymitra epipactoides* (Metallic Sun-orchid)**

Coates, F 2003, *Action Statement No. 156 Metallic Sun-orchid* Thelymitra epipactoides, Department of Sustainability and Environment, Victoria.

Obst, C 2005, *South Australian Murray-Darling Basin Threatened Flora Recovery Plan*, report to the Threatened Species and Communities Section, Department of the Environment and Heritage, Canberra.

Appendix D: List of all goals, objectives, actions and performance criteria

Goals

Goal 1 Recover threatened plant species critical habitat on Eyre Peninsula.

Goal 2 Recover threatened plant species populations on Eyre Peninsula.

Overall recovery plan performance criteria

Down-list or stabilise threatened plant populations according to IUCN criteria (Table 1).

Improvement of species critical habitat, ecosystem function, and areas containing state or regionally rare species and threatened plant communities, are implied in the delivery of goal one.

Objective 1 Obtain baseline information, including critical and potential habitat, for each threatened flora species.

Actions

1a Re-survey known threatened plant sites ensuring minimum dataset information collection/records.

Performance criteria

1a.1 Surveys conducted and minimum dataset* information collected for 90% of Priority 1 species sub-populations by 31st December 2012. **[CORE]**

1a.2 Surveys conducted and minimum dataset* information collected for 70% of Priority 2 species sub-populations by 31st December 2012. **[TIER 2]**

1a.3 Surveys conducted and minimum dataset* information collected for 50% of Priority 3 species sub-populations by 31st December 2012. **[TIER 3]**

* Minimum dataset consists of Biological Database of South Australia (BDBSA) minimum dataset requirements (Appendix G).

1b Determine landscape attributes (including slope, aspect, soils, geology, altitude, vegetation, fire history, and surrounding land use) associated with priority species using Geographic Information Systems (GIS).

1b.1 All minimum dataset information analysed via GIS to determine patterns in variables such as landscape, associated vegetation, fire history, surrounding land use for Priority 1 species by 30th September 2008 (links to 1c.2). **[CORE]**

1c Map critical and potential threatened plant habitat and ground truth this information.

1c.1 Critical habitat identified and mapped for all threatened plant species within this plan by 31st March 2008. **[CORE]**

1c.2 Refined potential habitat identified and mapped for Priority 1 species by 30th September 2008 (links to 1b.1). **[CORE]**

1c.3 Broad potential habitat identified and mapped for Priority 2 and 3 species by 30th June 2010. **[TIER 2]**

1c.4 Critical habitat mapping ground truthed for Priority 1 species by 31st December 2010 (links with 1a.1). **[CORE]**

1c.5 Existing and potential corridors for Priority 1 species populations identified by 31st March 2011. **[CORE]**

1d Conduct targeted surveys for new populations.

1d.1 Active searches conducted for Priority 1 species in potential habitat completed by 31st December 2010 (links with 1c.2). **[CORE]**

1d.2 Opportunistic searches conducted for suspected fire and disturbance dependant species (Appendix I) in properties within most recently burnt habitat (ongoing-opportunistic). **[TIER 2]**

1d.3 100% of plant samples collected from potential new populations verified by State Herbarium staff and voucher specimens stored in State Herbarium by 29th March 2013 ^. **[CORE]**

Objective 2 Increase understanding, appreciation and involvement in threatened flora recovery efforts.

Actions

2a Maintain ability to coordinate and implement recovery program and support community involvement (including the ability to apply for and manage external funds).

2a.1 At least 1x FTE maintained to coordinate the recovery program for the duration of the plan. **[CORE]**

2a.2 Funds sought, and where successful, managed for the delivery of the recovery actions (ongoing). **[CORE]**

2a.3 Adequate resources (i.e. $ 767 250 for Core) secured to conduct recovery actions for the duration of the plan (ongoing). **[CORE]**

2a.4 Recovery Team for threatened flora on Eyre Peninsula established and functioning, as per Terms of Reference (Appendix H), by 31st December 2007 (links to 2c.1). **[CORE]**

2a.5 Log of volunteer hours, land holder in-kind contributions and technical support hours maintained (ongoing) ^. **[CORE]**

2a.6 Support staff engaged to assist with fieldwork, logistics and volunteer training and support where appropriate (ongoing). **[TIER 2]**

2b Implement a Communication Strategy to support and encourage the management of threatened plant species.

2b.1 Communication strategy developed for threatened plant information (based on Russell, Mercer & Watt 2004) by 31st March 2008. **[CORE]**

2b.2 Monitoring techniques, research results and data shared with state, interstate and international nature conservation agencies on an as needs basis and particularly for SA Government planning and *EPBCAct 1999* referral purposes (links to 2b.1). **[CORE]**

2b.3 Timely, accurate and easy to understand updates readily accessible to stakeholders through targeted media outlets, outlined in the threatened plant communication strategy (ongoing) (links to 2b.1). **[CORE]**

2c Support volunteer involvement in implementation of recovery actions.

2c.1 One threatened flora volunteer group on Eyre Peninsula formalised by 31st Dec 2007 (links to 2b.1). **[CORE]**

2c.2 At least one annual meeting for/with threatened flora volunteers hosted for the duration of the recovery plan (periodically throughout year) (links to 2b.1). **[CORE]**

2c.3 Yearly training provided to threatened flora volunteers on a needs basis (periodically throughout year) (links to 2b.1 and 2c.2). **[CORE]**

Objective 3 Manage immediate threats and improve threatened flora critical habitat.

3a Determine direct and potential threats to each sub-population.

3a.1 Compile and review current and potential threats affecting Priority 1 and 2 species sub-populations in local threat assessment database by 31st March 2011. **[CORE]**

3a.2 Prioritise current and potential threats, based on level of risk, at all Priority 1 species sub-populations by 31st March 2011 under the following headings: Weeds (identify high, medium and low risk weeds), Grazing, Pest and disease, Critical habitat issue (i.e. fire regime, salinity, disturbance, corridors, surrounding land use). **[CORE]**

3a.3 Prioritise current and potential threats, based on level of risk, at 50% Priority 2 sub-populations/population by 31st March 2011 (using the headings as in 3a.2). **[TIER 2]**

3a.4 Prioritise all weed and grazing control required within Focus Work Areas 1, 2 and 3 in consultation with Eyre Peninsula Natural Resources Management Officers by June 2008, June 2009, June 2010 and June 2011(links to 2c.1). **[CORE]**

3b Reduce weed competition within threatened plant species critical habitat

3b.1 Reduction in abundance and density of high-risk weeds, within 80% of Focus Work Area 1 by 31st December 2008, 2009, 2010 and 30th December 2011. **[CORE]**

3b.2 Reduction in abundance and density of medium risk weeds, within 50m of Priority 1 species populations by 31st December 2008, 2009, 2010 and 30th December 2011#. **[CORE]**

3b.3 Reduction in abundance and density of high risk weeds, within 50% of Focus Work Area 2 and 3 by 31st December 2008, 2009, 2010 and 30th December 2011. **[TIER 2]**

3c Reduce grazing damage to threatened plants and critical habitat

3c.1 Determine cause of grazing damage (native, livestock, feral animal or combination) to grazing prone or suspected grazing damaged species by 31st December 2008, 2009, 2010 and 30th December 2011. **[CORE]**

3c.2 Implement most appropriate control method, to prevent severe grazing to Priority 1 and 2 species (ongoing). **[TIER 2 & 3]**

3d Contain and prevent *Phytophthora* sp. infestation.

3d.1 Complete soil tests at all suspected *Phytophthora* spp. infestations within 5 km of Priority 1 species sub-populations by 30th September 2008, 2009, 2010 and 2011. **[CORE]**

3d.2 In collaboration with DEH and NRM staff, distribute up-dated *Phytophthora* spp. infestation information to relevant threatened flora stakeholders by 31st December 2008, 2009, 2010, 30th December 2011 and 31st December 2012 (links to 2b.1 and 2c.1). **[CORE]**

3d.3 Use DEH *Phytophthora* spp. hygiene practices in implementing all on-ground recovery actions (ongoing and links with 3c.2). **[CORE]**

3e Increase off reserve protection

3e.1 Establish Significant Roadside Marker System(s) within a minimum of two Eyre Peninsula District Councils by 29th June 2012. **[TIER 2 & 3]**

3e.2 Railway Marker System maintained and improved (ongoing, links with 2b.1). **[TIER 2]**

3e.3 Actively provide land holders with threatened plant species information, grants/funding and information on all varieties of land conservation agreements (ongoing). **[CORE]**

3e.4 Negotiate Heritage Agreements or conservation covenants based on critical habitat, potential habitat and/or translocation plans (ongoing). **[TIER 2]**

3f Increase probability for species to adapt to change.

3f.1 Complete soil sampling at threatened flora species sub-populations suspected of being, or becoming, affected by salinity or acidification by 30th September 2011. **[TIER 2]**

3f.2 Determine need and type of strategic vegetation buffers required to maintain Priority 1 species critical habitat and plant/population condition by 31st March 2009 and 2010 (links with 1c.4). **[CORE]**
Examples of strategic vegetation buffering activities include:

- address severe fragmentation/increase available habitat
- control dryland salinity
- enhance existing corridors
- arrest erosion / prevent top-soil loss/improve condition of soil biota
- address lack of pollinator food or shelter source
- reinstate vegetation communities (allowing for species succession).

3f.3 Implement salinity abatement specifically for threatened species critical habitat, in consultation with relevant agencies and in context with catchment salinity control projects by 31st December 2012. **[TIER 2 & 3]**

3f.4 Implement abatement/strategic vegetation buffers for threatened species critical habitat (as determined in 3f.2), in consultation with relevant agencies and in context with regional Natural Resource Management plan (ongoing). **[TIER 2 & 3]**

3f.5 Enhance connectivity between Priority 3 species sub-populations within the East meets West corridor (ongoing). **[TIER 2]**

3f.6 Determine feasibility of translocation for Priority 1 species, in accordance with the 'Guidelines for the translocation of threatened plants in Australia' by 31st December 2008 (Vallee et al. 2004). **[TIER 2]**

3f.7 Undertake translocation of Priority 1 species, after checks from Vallee et al. (2004) by 30th September 2011. **[TIER 2]**
Note: Highly recommended to complete recovery action 1b first at minimum, and with actions 4b, 4c and 4h if resources are available. Some species have known special translocation requirements. These are described in the species sections of this plan.

3f.8 Collect and store seed from priority threatened plant species in collaboration with Millennium Seed Bank & State Herbarium of SA (ongoing) **[CORE].**
Note: Includes initiate collection, collection of wider genetic stock, periodic recollection to replenish seed bank after viability testing, seed for planned translocation projects or educational purposes.

Objective 4 Conduct research critical to management by addressing knowledge deficiencies in threatened flora biology and ecology (including threat identification).

Actions

4a Secure funding for students (Honours and/or Post Graduate level) or local community members to conduct research into Eyre Peninsula threatened plant species

4a.1 One honours student per year (minimum) funded to work on critical management research recovery actions (ongoing). **[CORE]**

4a.2 One list of plant knowledge deficiencies and management critical research questions supplied to DEH research hub by March 2008, June 2010 and June 2012. **[CORE]**

4b Address basic deficiencies in knowledge of plant biology

4b.1 Break downs in Priority 1 species life cycle identified by 31st December 2012 ^. **[CORE]**

4b.2 Break downs in Priority 2 species life cycle identified by 31st December 2012 ^. **[TIER 2]**

4b.3 Break downs in Priority 3 species life cycle identified by 31st December 2012 ^. **[TIER 3]**

4b.4 Pollinators and pollination vector(s) for Priority 1 species determined by 31st December 2012 ^. **[TIER 2]**

4b.5 Germination trigger(s) and recruitment patterns determined for Priority 1 species by 31st December 2012 ^. **[TIER 2]**

4b.6 Average longevity for Priority 1 species determined (observed or estimated) by 31st December 2012 ^. **[TIER 3]**

4b.7 Sub-population soil classification and pH level identified for Priority 1 and 2 species by 30th December 2011. **[CORE]**

4b.8 Symbiotic mycorrhiza determined for Priority 1 threatened orchid species by 31st December 2012 ^. **[TIER 3]**

4c Investigate the role of fire and disturbance on threatened plant life cycles.

4c.1 One literature review of fire ecology and disturbance information for suspected fire and disturbance dependant plant species (Appendix I) completed, in consultation with DEH Fire Management Unit and experts in botanical disturbance requirements, by 31st December 2009 **[TIER 2]**

4c.2 Determine need for prescribed burn and identify which areas or sub-populations require burning by 31st December 2009 (i.e. state of threatened flora sub-population, extent of community senescence and fire sensitive fauna) (done in conjunction with recovery actions 1a.1, 1a.2, 1a.3 and 1c.4) #. **[CORE]**

4c.3 Two prescribed burn experiment designs completed (hypotheses, pre and post burn monitoring) in consultation with DEH Fire Management Unit and South Australian Country Fire Service by 31st December 2010.# **[TIER 2]**

4c.4 Two prescribed burns conducted for fire dependent threatened flora species recovery by December 2012 ^. **[TIER 2]**

4c.5 Two disturbance requirement experiments designed (hypotheses, pre and post disturbance monitoring) in consultation with experts in botanical disturbance requirements by 31st December 2010. **[TIER 3]**

4c.6 Two disturbance requirements trials conducted for disturbance dependent threatened flora species by 29th June 2012 ^. **[TIER 3]**

4d Investigate competition and grazing impact on threatened plants

4d.1 Two canopy-cover trials conducted for suspected disturbance dependant threatened plant species by 29th June 2012 (links with 3b and 4c)^. **[TIER 2]**

4d.2 Two grazing pressure exclosures trials determining herbivore(s) responsible, extent, timing and severity of grazing pressure and the long-term and short-term survival impacts by 29th June 2012. **[CORE]**

4e Investigate genetic relationships within and/or between populations

4e.1 Genetics relationship within and between sub-populations determined for Whibley Wattle, Resin Wattle and Chalky Wattle by 29th June 2012 (apply findings 3f.6 and 3f.7 criteria). **[TIER 2]**

4e.2 Determine genetic relationship between remaining Priority 1 species sub-populations by 31st December 2012 (apply findings 3f.6 and 3f.7 criteria). **[TIER 3]**

4f Determine the extent to which neighbouring land-uses indirectly affect threatened plant populations

4f.1 Determine if chemical drift is having a detrimental effect on threatened flora populations, critical habitat, pollinators and/or soil biota by 31st December 2012. **[TIER 3]**

4f.2 Investigate if changes in hydrology (e.g. soil moisture, salinity) are influencing critical habitat degradation or threatened flora decline by 31st December 2012. **[TIER 3]**

4g Research the implications of changing climatic conditions on threatened plant populations

4g.1 Model impact of climatic change on Priority 1 species critical habitat by 31st December 2010 (apply findings 3f.6 and 3f.7 criteria). **[TIER 2]**

4g.2 Research potential impact of climate variation on Priority 1 species reproduction by 31st December 2012. **[TIER 3]**

4h Conduct Population Viability Assessments for priority 1 threatened plant species recovery (closely linked to action 5c)

4h.1 Minimum viable population calculated for Priority 1 threatened flora by 31st December 2010 (links to IUCN projected decline or increase in species criteria) (links to 4h). **[CORE]**

4h.2 Minimum viable population calculated for Priority 2 threatened flora by 30th March 2012 (links to IUCN projected decline or increase in species criteria) (links to 4h). **[TIER 2]**

Objective 5 Monitor threatened flora populations and evaluate the success of recovery actions

Actions

5a Establish monitoring protocol and schedules for each threatened plant species.

5a.1 Establish list of Key Monitoring Sites for all threatened plant species finalised by March 2010. ** **[CORE]**

5a.2 Upgrade electronic local threatened plant monitoring and threat assessment database by 31st March 2008. **[CORE]**

5a.3 Twice yearly (during 2nd and 4th Quarters) storing and archiving of raw monitoring data and management critical research reports (e.g. ecological burn monitoring data/final report), including update of data into local monitoring database and DEH Biological Databases of South Australia (linked with 2f.1). **[CORE]**

5a.4 Priority 1 species Key Monitoring Sites monitored annually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 31st December 2008, 2009, 2010, and 30th December 2011. **[CORE]**

5a.5 Priority 2 species Key Monitoring Sites monitored biannually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 31st December 2008, 2009, 2010, and 30th December 2011. **[TIER 2]**

5a.6 Priority 3 species Key Monitoring Sites monitored biannually to meet all minimum dataset criteria (Appendix G) with particular attention to changes in current and potential threat by 30th December 2011. **[TIER 3]**

5a.7 Life class structure at Priority 1 species Key Monitoring Sites re-surveyed once every five years (^ 1a). **[CORE]**

5a.8 All translocated populations monitored biannually. **[CORE]**

5a.9 Prescribed burn monitoring data analysis and recommendations reported by 31st December 2012 (links to 4c.3). **[TIER 2]**

5a.10 Herbivore exclosures trials monitored annually (linked to 4d.3). **[CORE]**

5a.11 Weed control effectiveness in Focus Work Areas investigated seasonally for the duration of the plan ^ (links with 3b). **[CORE]**

5a.12 Herbivore density monitored, on needs basis, conducted within Chalky Wattle critical habitat. **[TIER 2]**

5a.13 Incorporate recommended actions to manage, prevent or eliminate impacts from surrounding land-use on critical habitat by 31st December 2012. **[TIER 3]**

5b Evaluate recovery actions against performance criteria and schedule

5b. 1 Recovery action progress check against performance criteria/schedule and IUCN criteria completed in the third year of project implementation by 30th June 2010. **[CORE]**

5c.2 Amend recovery actions and performance criteria to incorporate results from management critical research by 30th June 2010 (or before if research determined necessary). **[CORE]**

5b. 2 Final recovery action check against performance criteria and IUCN criteria completed in preparation for 5c.1 by 31st December 2012. **[CORE]**

5c Review and update Recovery Plan every five years

5c.1 Re-evaluation of recovery plan: full re-assessment of the status of nationally threatened plant species on Eyre Peninsula completed by 31st December 2012. **[CORE]**

5c.2 Review second stage of threatened flora recovery program by June 2013. **[CORE]**

Key

* = performance criteria linked to a list

** = Key Monitoring Sites may be based on, but are not limited to:

- Largest sub-population population
- Most outlying sub-population(s)
- Most genetically different sub-population(s)
- Oldest or youngest age class structured sub-population(s)
- Site with overlapping Priority 1, 2, or 3 species

^ = performance criteria has direct reporting criteria

= performance criteria is linked to management critical research

[CORE] = performance criteria is the bare minimum and must be completed as standard for other performance criteria to follow (Standard project)

[TIER 2] = performance criteria able to start with Tier 2 level of funding (Table 31.1)

[TIER 3] = performance criteria able to start with Tier 3 level of funding and the only level that covers all threatened flora species within this plan (Table 31.1)

Appendix E: Threat matrix and assessment tables for threatened plant species, Eyre Peninsula

Development of a threat matrix

The modified version of the threat matrix used in the Kangaroo Island threatened plant recovery plan (Taylor 2003) was used in this plan. The matrix incorporates direct threats and impediments to the recovery of nationally threatened plant species.

The threat matrix score allocated to individual threats for each species was determined by adding threat scores from the following two separate matrices:

- the current extent of impact a threat has on a threatened plant species (Table E1).
- the likelihood of a threat affecting a threatened plant species in the future (Table E2).

The higher the threat matrix score, the higher the threat based on current and potential impact to the threatened plant species. The highest threat matrix score for a threat to an individual species is 9. The highest threat matrix score for a threat to all 23 threatened plant species is 135.

Current extent of impacts of threats

Threat scores for the extent of each identified threat for all of the nationally threatened species were determined based on field observations of threats and the criteria identified under Table E3. The highest score allocated to any particular threat impacting an individual threatened species was 3 (Table E3).

Likelihood of threat effects in the future

The criteria used to determine the likelihood of a threatening process impacting upon a particular species in the future are presented in Table E4. The highest score allocated to any particular threat impacting an individual threatened species was 6 (Table E4).

Table E1. Matrix of extent of <u>current</u> threats and impediments to recovery of threatened plant species on Eyre Peninsula

Current threats	**Percentage of the Eyre Peninsula population with threat assessment completed (however not necessarily within last 10 years)**	**Vegetation clearance**	**Weed invasion**	**High grazing pressure**	**Salinity/changes in hydrology**	**Urban development/subdivision**	**Pest and disease (*Phytophthora*)**	**Spray drift**	**Roadside management (railway and other service easements included)**	**Illegal collection or harvest**	**Off-road vehicles and rubbish dumping**	**Mineral exploration/extraction**	**Habitat fragmentation**	**Inappropriate disturbance regimes**	**Inappropriate fire regimes**	**Lack of recruitment/small population size**	**Lack of knowledge (ecology and biology) and baseline information (understanding of threats)**	**Restricted distribution/isolated sub-populations**	**Lack of involvement of stakeholders**	**Available resources**	**Lack of coordination of Recovery Actions**	**Species threat subtotals**
Chalky Wattle [EP]	100%	0	3	3	1	0	0	1	1	0	0	0	3	2	2	3	1	3	3	3	3	**32**
Jumping-jack Wattle	13%	0	2	0	0	0	0	2	1	0	0	0	3	2	3	0	3	2	3	3	3	**27**
Fat-leaved Wattle[SA]	32%	3	2	2	1	0	2	1	2	0	1	1	3	3	3	1	3	3	3	3	3	**40**
Resin Wattle	27%	1	2	1	0	0	0	1	2	1	1	0	2	2	3	1	3	2	3	3	3	**31**
Whibley's Wattle [EP]	100%	1	3	2	2	1	1	2	1	0	1	0	3	2	3	3	2	3	3	3	3	**39**
Winter Spider-orchid[SA]	75%	0	3	3	0	0	1	0	1	0	1	0	1	2	2	0	3	1	3	3	3	**27**
Club Spear-grass	20%	0	3	3	2	0	0	0	0	0	0	2	0	2	3	0	3	2	3	3	3	**29**
Prickly Raspwort[EP]	86%	1	1	1	3	1	1	1	3	0	1	0	0	1	0	1	0	3	3	3	3	**27**
Bead Samphire	55%	1	1	0	2	2	0	0	2	0	2	1	1	2	0	0	2	3	3	3	3	**28**
Granite Mudwort	43%	0	3	0	2	0	0	0	0	0	1	0	0	3	0	0	3	3	3	3	3	**24**
Microlepidium alatum	*25%*	0	3	0	0	0	0	0	2	0	3	0	0	2	0	0	3	0	3	3	3	**22**
Silver Daisy-bush	94%	1	2	2	1	1	1	1	1	1	1	0	1	1	1	0	2	2	3	3	3	**28**
Silver Candles[SA]	24%	0	3	1	2	0	0	0	2	0	1	0	0	3	0	0	2	2	3	3	3	**25**
West Coast Mintbush [EP]	13%	0	1	2	0	0	1	0	1	0	0	0	1	1	1	1	3	1	3	3	3	**22**
Mt Olinthus Greenhood [EP]	50%	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	3	3	3	3	3	**19**
Nodding Rufous-hood[EP]	75%	2	3	3	0	0	0	2	0	0	0	0	1	2	2	0	3	0	3	3	3	**27**
Desert Greenhood	0%	1	1	1	0	0	0	0	0	0	0	1	0	1	1	1	1	3	3	3	3	**20**
Ironstone Mulla Mulla[SA]	67%	0	3	0	0	0	2	2	3	0	0	0	3	0	2	0	3	3	3	3	3	**30**
Tufted Bush-pea[EP]	79%	1	1	2	1	0	1	0	1	0	0	0	1	0	2	2	2	0	3	3	3	**23**
Sandalwood	11%	0	0	3	0	0	0	0	1	1	0	0	2	2	0	3	2	2	3	3	3	**25**
Annual Candles[SA]	67%	2	3	2	2	0	0	1	3	0	0	0	0	2	3	1	1	3	3	3	3	**32**
Yellow Swainson-pea	86%	1	2	0	0	0	0	0	0	0	0	0	1	2	2	0	3	2	3	3	3	**22**
Metallic Sun-orchid	60%	1	3	2	1	0	1	2	3	0	1	0	3	2	2	2	3	3	3	3	3	**38**
Current threat subtotals		**16**	**48**	**34**	**20**	**5**	**11**	**16**	**31**	**3**	**14**	**5**	**29**	**40**	**36**	**19**	**54**	**49**	**69**	**69**	**69**	

Table E2. Matrix of <u>future</u> threats and impediments to the recovery of threatened plant species on Eyre Peninsula

Future threats	Vegetation clearance	Weed invasion	High grazing pressure	Salinity/changes in hydrology	Urban development/ subdivision	Pest and disease (Phytophthora)	Spray drift	Roadside management	Illegal collection or harvest	Off-road vehicles & rubbish dumping	Mineral exploration/ extraction	Habitat fragmentation	Inappropriate disturbance regimes	Inappropriate fire regimes	Lack of recruitment/ small population size	Lack of knowledge and baseline information	Restricted distribution/ isolated sub-populations	Lack of involvement of stakeholders	Available resources	Lack of coordination of Recovery Actions	Species threat subtotals
Chalky Wattle [EP]	2	2	4	2	0	2	2	2	0	0	0	4	2	6	6	4	6	4	6	6	**60**
Jumping-jack Wattle	4	4	4	2	0	2	2	2	0	2	2	4	2	6	4	4	6	4	6	6	**66**
Fat-leaved Wattle[SA]	4	6	4	2	2	2	6	2	0	2	2	4	2	6	4	4	6	4	6	6	**74**
Resin Wattle	2	2	2	2	0	2	2	2	0	0	2	4	2	6	2	6	4	4	6	6	**56**
Whibley's Wattle [EP]	4	6	4	4	4	4	4	4	0	2	4	4	4	6	4	4	6	4	6	6	**84**
Winter Spider-orchid[SA]	2	6	4	0	0	2	2	0	2	4	2	4	0	6	4	6	4	4	6	6	**64**
Club Spear-grass	2	2	2	4	0	0	0	0	0	0	4	4	2	4	2	6	0	4	6	6	**48**
Prickly Raspwort[EP]	4	6	2	6	0	2	2	2	0	2	0	6	4	2	4	0	2	4	6	6	**60**
Bead Samphire	2	2	0	6	4	0	0	0	0	2	0	6	6	0	2	6	6	4	6	6	**58**
Granite Mudwort	0	6	0	4	0	2	2	0	0	2	2	2	2	0	2	4	6	4	6	6	**50**
Microlepidium alatum	2	2	2	2	0	0	0	2	0	0	0	4	2	2	2	6	6	4	6	6	**48**
Silver Daisy-bush	2	6	4	2	2	6	2	2	0	0	2	4	2	4	4	6	4	4	6	6	**68**
Silver Candles[SA]	2	4	0	6	0	0	0	2	0	4	0	4	4	2	2	4	0	4	6	6	**50**
West Coast Mintbush [EP]	4	2	4	0	6	2	2	2	0	0	0	6	4	4	2	6	4	4	6	6	**64**
Mt Olinthus Greenhood [EP]	2	2	2	0	0	2	0	0	4	0	0	2	2	6	6	6	6	4	6	6	**56**
Nodding Rufous-hood[EP]	2	4	2	0	2	2	0	2	2	0	2	4	2	6	6	6	4	4	6	6	**62**
Desert Greenhood	2	4	2	2	2	2	0	0	2	0	2	4	2	6	6	6	6	4	6	6	**64**
Ironstone Mulla Mulla[SA]	2	6	2	2	4	4	4	4	2	2	2	4	2	6	4	4	4	4	6	6	**74**
Tufted Bush-pea[EP]	4	4	4	0	2	4	0	2	0	2	2	4	2	4	2	4	2	4	6	6	**58**
Sandalwood	2	2	4	2	2	0	0	0	6	0	2	4	4	6	4	4	4	4	6	6	**62**
Annual Candles[SA]	0	6	2	2	0	0	0	0	0	2	0	0	4	4	6	6	6	2	6	6	**52**
Yellow Swainson-pea	2	6	2	0	0	2	2	0	0	0	2	2	2	6	4	4	6	4	6	6	**56**
Metallic Sun-orchid	4	6	4	2	2	6	4	4	6	2	2	6	4	6	6	4	6	4	6	6	**90**
Future threat subtotal	**56**	**96**	**60**	**52**	**32**	**48**	**36**	**34**	**24**	**28**	**34**	**90**	**62**	**104**	**88**	**110**	**104**	**90**	**138**	**138**	

Table E3. Criteria used to allocate threat scores for matrix of extent of current threats and impediments to the recovery of threatened plant species on Eyre Peninsula (Table E1)

Threat/impediment to recovery	Criteria used to determine extent of threat for all threatened plant species on Eyre Peninsula	Score
Vegetation clearance	Proportion of population affected by threat based on field observations (% of surveyed populations affected by threat).	**0** – 0% **1** – 1-33% or unknown **2** – 34-66% **3** – 67-100%
Weeds invasion	Proportion of population affected by threat based on field observations.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
High grazing pressure	Proportion of population affected by threat based on a mix of studies and preliminary field observations.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Salinity/changes in hydrology	Proportion of population affected by threat based on preliminary field observations.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Urban development/ subdivision	Proportion of population affected by threat based on preliminary field observations.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Pest and disease (*Phytophthora*)	Proportion of sub-populations with either a positive or probable *Phytophthora* site (according to Velzeboer et al. 2005). Proportion of sub-populations with observed pest and/or disease determined on site visits.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Spray drift	Proportion of population affected by threat based on preliminary field observations.	**0** – 0% **1** – potential but unknown **2** – observed
Roadside management (includes railway and essential services easements)	Proportion of population affected by threat based on field observations and assessed under current Roadside Marker Systems.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Illegal collection/ harvest	Proportion of population affected by threat based on reports to DEH Investigation and Compliance.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Off road vehicles or rubbish dumping	Proportion of population affected by threat based on field observations.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Mineral exploration/ extraction	Proportion of population affected by threat based on field observations and preliminary desktop investigation.	**0** – 0% **1** – is occurring within 5 km of critical habitat **2** – is occurring within critical habitat **3** – is currently known to be affecting population

Table E3. continued.

Threat/impediment to recovery	Criteria used to determine extent of threat for all threatened plant species on Eyre Peninsula	Score
Habitat fragmentation	Proportion of population existing in sub-populations with: • area of occupancy less than 10 km^2, • less than 1000 individuals.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Inappropriate disturbance regime	Proportion of sub-populations with disturbance needs (species life cycle or critical habitat) currently not being met, e.g. currently experiencing no disturbance, too frequent disturbance, too destructive disturbance.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Inappropriate fire regime	Proportion of sub-populations with fire needs (species life cycle or critical habitat) currently not being met, e.g. currently experiencing no fire, too frequent or infrequent fire, too intense or too moderate fire.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Lack of recruitment/ small population size	Proportion of population existing in sub-populations of less than 1000 individuals.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Lick of knowledge (ecology and biology) and baseline information (understanding of threats)	Percentage of sub-populations not surveyed and/or threat assessed since 1995.	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Restricted distribution/isolated sub-populations	Percentage of sub-populations considered restricted (based on review of literature of historical population range) and those sub-populations considered isolated (little or no chance of natural exchange of genetic material).	**0** – 0% **1** – 1-33% **2** – 34-66% **3** – 67-100%
Lack of involvement of stakeholders	All threatened plants are currently affected by the level of involvement of stakeholders in plant management.	**3**
Availability of resources	All species and all populations of those species are currently affected by the availability of resources to undertake management projects.	**3**
Lack of coordination of recovery actions	All species and all populations of those species are currently affected by the ability of managers to effectively and efficiently co-ordinate and deliver management actions.	**3**

Table E4. Criteria used to allocate threat scores for matrix of future threats and impediments to the recovery of threatened plant species on Eyre Peninsula (Table E2)

Threat/ impediment to recovery	Criteria and rationale used to determine future threat for all threatened plant species on Eyre Peninsula	Score based on risk of future threat if threat already present	Score based on risk of future threat if threat not already present
Vegetation clearance	Small scale vegetation clearance is expected to remain a constant problem for those species currently affected. It is considered unlikely that it will expand greatly to impact upon other currently unaffected species in the future.	**4** - threat will remain constant	**0** - no chance threat will affect species **2** - low chance threat will affect species
Weed invasion	The impact of Bridal Creeper and Veldt Grass is continuing to increase the longer it inhibits regeneration of native vegetation. These two weed species in particular are expected to expand in range and are likely to threaten all threatened plant species with a proportion of their population in small vegetation fragments in the future.	**4** - threat will increase in impact and extent	**0** - no chance threat will affect species **2** - low chance threat will affect species
High grazing pressure	The intensity of vertebrate herbivore grazing is likely to remain constant or increase for all threatened plant species on Eyre Peninsula. The impact of grazing may substantially increase if a species is actively regenerating following a disturbance event, such as bushfire.	**4** - threat will remain constant	**4** - medium chance threat will affect species
Salinity/ changes in hydrology	Increasing soil salinity is a localised, but widespread problem on Eyre Peninsula. In the future, dryland salinity may impact on presently unaffected sub-populations.	**0** - threat will stop completely **2** - threat will decrease slowly **4** - threat will remain constant **6** - threat will increase in impact and extent	**0** - no chance threat will affect species **2** - low chance threat will affect species **4** - medium chance threat will affect species **6** - high chance threat will affect species
Urban development /subdivision	Proportion of population affected by threat based on field observations and preliminary desktop investigation.	**0** - No chance **2** - Low chance **4** - Medium chance **6** - High chance	**0** - No chance **2** - Low chance **4** - Medium chance **6** - High chance
Pest and disease (*Phytophthora)*	The impact of phytophthora as a threat on the plant species has been assessed based on Risk Zones identified in Velzeboer et al. (2005).	**0** - threat will stop completely **2** - threat will decrease slowly **4** - threat will remain constant **6** - threat will increase in impact and extent	**4** - medium chance threat will affect species (0-50% of population within 1 km) **6** - high chance threat will affect species (51-100% of population within 1 km)
Spray drift	The impact of off-target herbicide, insecticide and fertiliser damage has been observed and places certain sub-populations at greater risk of death. While currently unknown, it is suspected that off-target insecticide application may be affecting the survival of threatened plant species, their pollinators and critical habitat.	**0** - threat will stop completely **2** - threat will decrease slowly **4** - threat will remain constant **6** - threat will increase in impact and extent	**0** - no chance threat will affect species **2** - low chance threat will affect species **4** - medium chance threat will affect species **6** - high chance threat will affect species

Threat/ impediment to recovery	Criteria and rationale used to determine future threat for all threatened plant species on Eyre Peninsula	Score based on risk of future threat if threat already present	Score based on risk of future threat if threat not already present
Roadside management (including railway and essential services easements)	Proportion of population likely to become affected by threat based on current field observations and assessed under current Roadside Marker Systems.	**0** - threat will stop completely **2** - threat will decrease slowly **4** - threat will remain constant **6** - threat will increase in impact and extent	**0** - no chance threat will affect species **2** - low chance threat will affect species **4** - medium chance threat will affect species **6** - high chance threat will affect species
Illegal collection or harvest	Susceptibility of species sub-populations being illegally collected or harvested based on: • previous reports to DEH Investigation and Compliance • listing within the Convention on International Trade in Endangered Species (CITES).	**0** - none likely **2** - slight probability (listed on CITES) **4** - species is reasonably visible and highly prized (has previously been collected illegally on Eyre Peninsula) **6** - species is remote and highly prized	**0** - none likely **2** - slight probability (listed on CITES) **4** - species is reasonably visible and highly prized **6** - species is remote and highly prized
Off road vehicles and rubbish dumping	Risk of population being affected by threat based on field observations.	**6** - threat will increase in impact and extent	**0** - no chance threat will affect species **2** - low chance threat will affect species
Mineral exploration/ extraction	Likelihood of population becoming affected by threat based on field observations and preliminary desktop investigation.	**0** - none likely **2** - within 5 km of minerals that are likely to be mined in future **4** - growing directly in mineral deposit	**0** - none likely **2** - within 5 km of minerals that are likely to be mined in future **4** - growing directly in mineral deposit
Habitat fragmentation	The threat of ongoing degradation of critical and potential habitat to each species was determined based upon the proportion of each species occurring within the fragmented landscape.	**4** – threat will remain constant (0-50%) **6** – threat will increase in impact and extent (51-100%)	**4** – medium chance threat will affect species (0-50%) **6** – high chance threat will affect species (51-100%)
Inappropriate disturbance regimes	Future risk of proportion of sub-populations with disturbance needs not being met (species life cycle or critical habitat), i.e. no disturbance, high likelihood of very destructive experience occurring.	**0** – not applicable **2** – poorly understood **4** – highly likely to require disturbance in life cycle	**0** – not applicable **2** – poorly understood **4** – highly likely to require disturbance in life cycle
Inappropriate fire regimes	Likelihood of species with needs (species life cycle or critical habitat) not being met without implementation of recovery actions, i.e. no fire, too frequent fire, high likelihood of very destructive fire experience occurring.	**0** – not applicable **2** – poorly understood **4** – highly likely to require fire in life cycle	**0** – not applicable **2** – poorly understood **4** – highly likely to require fire in life cycle
Lack of recruitment/ small population size	Species conservation status under IUCN.	**0** – not applicable **2** – threat will remain constant VU species **4** – threat will remain constant EN species **6** – threat will remain constant CR species	**0** – not applicable **2** – threat will remain constant VU species **4** – threat will remain constant EN species **6** – threat will remain constant CR species

Threat/ impediment to recovery	Criteria and rationale used to determine future threat for all threatened plant species on Eyre Peninsula	Score based on risk of future threat if threat already present	Score based on risk of future threat if threat not already present
Restricted distribution/ isolated sub-populations	The threat of declining genetic viability to species currently exposed to a high or medium level of declining genetic viability (matrix scores 3 or 2 under Table E3) is likely to increase in the future. In species currently exposed to a low level of declining genetic viability, this threat is likely to remain constant. Threatened plant species not currently affected by declining genetic viability have a medium chance of being impacted upon by this threat in the future based on low population sizes for all threatened plant species on Eyre Peninsula.	**0** – threat will stop completely **2** – threat will decrease slowly **4** – threat will remain constant **6** – threat will increase in impact and extent	**4** – medium chance threat will affect species
Lack of knowledge (ecology and biology) and baseline information (understanding of threats)	Knowledge of distribution and abundance will degrade over time unless efforts are made to update information. Our knowledge of the distribution of threatened plant species in unsurveyed potential habitat will remain constant. Our knowledge of the ecology/biology of threatened plant species will remain constant if no further research is conducted. Knowledge of threats to threatened plant species will degrade over time unless efforts are made to update information.	**6** – threat will increase in impact and extent	**6** – high chance threat will affect species
Lack of involvement of stakeholders	This threat is likely to remain constant for all species.	**4** – threat will remain constant	
Availability of resources	The financial and human resources required for effective threat abatement actions will increase over time as threats increase in extent and impact.	**6** – threat will increase in impact and extent	
Lack of coordination of recovery actions	The need for effective coordination of recovery actions will increase over time as threats increase in extent and impact.	**6** – threat will increase in impact and extent	

Appendix F: Percentage of threatened flora sub-populations within the Eyre Hills IBRA Subregion, SA

Table F1. Percentage of threatened flora sub-populations within the Eyre Hills IBRA Subregion, SA

Priority category		Species name	Species records (Eyre Peninsula NRM Region)	Species records (Eyre Hills IBRA Subregion)	% of known Eyre Peninsula NRM Region population in Eyre Hills IBRA Subregion	NSXCODE
	1	*Acacia cretacea* **Chalky Wattle**	29	28	**97**	E04606
	1	*Acacia enterocarpa* **Jumping-jack Wattle**	59	56	**95**	M01562
	1	*Acacia pinguifolia* **Fat-leaved Wattle**	412	409	**99**	S01601
	1	*Acacia whibleyana* **Whibley Wattle**	36	31	**86**	S05437
	1	*Caladenia brumalis* **Winter Spider-orchid**	20	13	**65**	W05147
	1	*Olearia pannosa* ssp. *pannosa* **Silver Daisy-bush**	31	31	**100**	Q04432
	1	*Ptilotus beckerianus* **Ironstone Mulla Mulla**	47	45	**96**	C01293
	1	*Thelymitra epipactoides* **Metallic Sun-orchid**	46	38	**83**	Q00860
	2	*Acacia rhetinocarpa* **Resin Wattle**	70	35	**50**	K01609
	2	*Haloragis eyreana* **Prickly Raspwort**	166	164	**99**	K03429
	2	*Halosarcia flabelliformis* **Bead Samphire**	45	5	**11**	U01938
	2	*Prostanthera calycina* **West Coast Mintbush**	140	14	**10**	A02616
	2	*Pterostylis* aff. *despectans* **Nodding Rufous-hood**	5	5	**100**	
	2	*Pterostylis xerophila* **Desert Greenhood**	1	1	**100**	K04413
	2	*Pultenaea trichophylla* **Tufted Bush-pea**	56	56	**100**	Z01767
	2	*Santalum spicatum* **Sandalwood**	12	0	**0**	C00953
	2	*Stackhousia annua* **Annual Candles**	7	7	**100**	E02026
	3	*Austrostipa nullanulla* **Club Spear-grass**	20	0	**0**	C04153
	3	*Limosella granitica* **Granite Mudwort**	17	0	**0**	G04675
	3	*Microlepidium alatum* **-**	11	0	**0**	A01452
	3	*Pleuropappus phyllocalymmeus* **Silver Candles**	64	22	**34**	U03034
	3	*Pterostylis "Mt Olinthus"* **Mt Olinthus Greenhood**	1	1	**100**	Q05460
	3	*Swainsona pyrophila* **Yellow Swainson-pea**	45	5	**11**	Z01791
		Total Records	**1311**	**938**	**72**	
		Priority1	**680**	**651**	**96**	
		Priority2	**502**	**287**	**57**	
		Priority3	**158**	**28**	**18**	

Appendix G: Biological Database of South Australia (BDBSA) minimum dataset requirements

Updated 4 April 2007

BDBSA
MINIMUM DATASET REQUIREMENTS FOR PROJECT BASED DATA COLLECTION

The DEH Biological Survey and Monitoring Group (BSM) have prepared these guidelines to ensure that field data collected for specific projects can be collected in a consistent and accurate format which, when appropriate, may readily be incorporated into the Biological Databases of SA (BDBSA). These fields represent the minimum required and do not limit the collection of any other data that may be relevant for a project. An example Excel Spreadsheet is available for reference. This contains the relevant Look Up Table information required to correctly enter field data. It is anticipated that data collected using this format will be able to be uploaded into the BDBSA databases via the DEH Intranet (with some minor changes) by the project officer, the Regional GIS Information Officers or BSM staff.

This template represents only the minimum dataset for single visit species based observations. This should not prevent field staff from collecting data in a manner best suited to their project requirements. In particular, if the field data collection involves collecting quadrat data, physical site descriptions and repeat visits to the same site, the Biological Survey methodology or an adaptation of this method may suit your project. For a detailed description of the Biological Survey methodology follow the below links. For assistance in adapting your methodology contact BSM staff.

Biological Survey Fauna Manual:
http://www.environment.sa.gov.au/biodiversity/pdfs/vertebrate_survey_manual.pdf

Biological Survey Flora Manual:
http://www.environment.sa.gov.au/biodiversity/pdfs/vegetation_survey_manual.pdf

Specific database templates for collecting field data for Cockatoos (access database) and Malleefowl (grid method) already exist. If you are collecting data for these kinds of taxa these existing templates may suit your needs better than this minimum dataset template.

Field Names in green represent additional fields recommended for threatened species data collection.

BSM staff or the Regional GIS Information Officers can assist with any questions you may have about how to use these fields (or how best to incorporate these fields into your data storage method) when collecting data.

Recommended dataset

Details	Requirement	
TAXA	Desirable	Valid values are: P = PLANT, B = BIRD, R = REPTILE, A = AMPHIBIAN, M = MAMMAL
SOURCEID	Required	Must be a unique ID for each record, i.e. unique number of the project data
SURVEYNR	Required	BDBSA survey number assigned to the project – contact BSM for a number
NSXCODE	Desirable	Unique BDBSA code to describe a species
SPECIES	Required	Full scientific name of the species being observed
PLANTSNUM	Required	Number of plants recorded at the location
BUFFER	Required	Estimated area that the plant population extends
SUBPOPCODE	Required	Code/Name given to the plant sub-population
LOCDATUMNR	Required	BDBSA code for Geodetic datum for location geocode - usually a GPS datum - eg WGS84.
EASTING	Required	In UTM projection X axis coordinates - must be 6 digits
NORTHING	Required	In UTM projection Y axis coordinates - must be 7 digits
ZONE	Required	Universal Transverse Mercator (UTM) projection zone number; SA is covered by zones 52, 53, 54
RELIABNR	Required	BDBSA geocode precision code related to a location method
LOCMETHODNR	Required	BDBSA code for location method
SIGHTINGDATE	Required	Must be recorded as dd/mmm/yyyy (06-JUN_2007)
DATEACCURACY	Required	BDBSA code for date, as accurate to the Day = D, Month = M, Decade = T and Century = C
OBSERVERNR1	Required	Full name of first observer
OBSERVERNR2	Desirable	Full name of second observer
LATITUDE	Required	Decimal Degrees, if geodetic coordinate (latitude and longitude) was used as a primary coordinate system to capture data
LONGITUDE	Required	Decimal Degrees, if geodetic coordinate (latitude and longitude) was used as a primary coordinate system to capture data
LOCDESC	Desirable	Observation location description or site name
SIGHTINGCOMM (Flora)	Desirable	Comments (or other fields not accommodated) relating to the sighting are to be concatenated into a text string here
HABITATCOMM	Desirable	Brief description of habitat where observation has been made
METHODNR (Fauna)	Required	BDBSA Code for Observation/capture method
OBSERVEDNR (Fauna)	Desirable	Number observed

Description of details

Taxa
Valid values are: P = PLANT, B = BIRD, R = REPTILE, A = AMPHIBIAN, M = MAMMAL.

Sourceid
Must be a unique ID for each record, i.e. unique number of the project data. Preferred method is to use the Surveynr+_+unique numbers starting at 0001 and then increasing eg 199_0001, 199_0002, 199_0003 etc.

Surveynr
BDBSA survey number assigned to the project – contact BSM for a number. Survey header information must be filled out when a number is obtained. This is some minimal documentation about the project.

Nsxcode
As an alternative to typing/selecting species names, scientific names may be entered as a code. The BDBSA use unique codes (NSX codes) to describe a species. This enables better tracking of taxonomic changes since the code ties the record to the taxonomic entity valid at the time the data was collected. Current NSX codes may be obtained from the BSM group as this will assist in later integration of data into DEH BDBSA databases. Uncertainties about the validity of identification should be recorded in a comment field.

Species
Record the full scientific name of the species being observed. It is essential that the Genus and Species names be recorded, but sub-specific names may also be recorded if appropriate. Common names are regarded as optional since they may vary considerably in common usage.

Plantsnum
Number of plants recorded at that coordinate. For orchids the number of flowering plants. Assume this to be 1 if not collected.

Buffer
Estimated area that the plant population extends in metres. Use to create the polygon layer to define sub-population boundaries.

Subpopcode
Name or code given to the sub-population. This would be used in the polygon layer to link sub-population boundaries with species site locations.

Locdatumnr
The datum used to determine the coordinate must be recorded regardless of whether Lat/long (geodetic) or Grid coordinates are used. Without a recorded datum, the location accuracy of a record will be degraded up to +/- 200 m. This will make detailed use of the information in Geographic Information Systems impossible and certainly defeats the benefits of using accurate GPS positioning.

The current Australian standard recommends the use of MGA94 (Map Grid of Australia) for grid coordinates or GDA94 for geodetic coordinates. Since GPSs do not support this datum, it is recommended that the GPS Datum be set to WGS84 (World Geodetic System, 1984) since this closely approximates MGA94/GDA94. WGS84 is the default datum for GPS use, but this can be changed so the GPS should be re-checked for each new session.

LOCDATUMNR	LOCDATUMCODE	LOCDATUMDESC
1	WGS84	World Grid System 1984
2	AGD84	Australian Grid Datum 1984
3	AGD66	Australian Grid Datum 1966
4	GDA94	Geocentric Datum of Australia 1994

Easting
An Easting must be recorded as a full 6 digit number (i.e. 352678). Note that each value represents the number of metres from a fixed reference point so rounding the last number (i.e. 352670 above) will degrade the accuracy of the position by up to 9 metres.

Northing
A Northing must be recorded as a 7 digit number (i.e. 6065469). Note that each value represents the number of metres from a fixed reference point so rounding the last number (i.e. 6065460 above) will degrade the accuracy of the position by up to 9 metres.

Zone
Map Zones must be recorded since SA has three zones (52, 53, 54) and grid coordinates repeat in each Zone.

Reliabnr (Accuracy of Location Coordinates)
Record the error involved in the location coordinate in metres (e.g. +/- 10 m). Currently the accuracy of a Geographic Positioning System (GPS) is frequently better than +/- 5 m, but accuracy should probably be assumed to be +/- 10 m. Use the lookup table codes to choose the appropriate RELIABNR code.

RELIABNR	RELIABDESC	RELIABNR	RELIABDESC
0	0-5 m	13	0-0.02 m
1	5-50 m	14	0-0.001 m
2	51-100 m	15	0-0.005 m
3	101-250 m	16	0-0.01 m
4	251-500 m	17	0-0.1 m
5	501-1000 m	18	Not entered
6	1-10 km	20	101-150 m
7	11-25 km	21	11-30 km
8	> 25 km	22	31-125 km
9	0-1 m	23	< 625 km SA
12	0-0.5 m	24	< 2000 km AU

Locmethodnr
BDBSA code for location method

LOCMETHODNR	LOCMETHODDESC
8	Differential Kinematic Global Positioning System
1	Map
2	Aerial Photographs Digitised
3	Single Global Positioning System
4	Differential Global Positioning System
5	Gazetteer
99	Unknown location method
6	Surveyed (by Surveyor)

Sightingdate (Observation Date)
The date of the observation or collection must be recorded as dd/mmm/yyyy (12 May 2001) rather than in the dd/mm/yyyy (12/5/2001) format. This reduces possible confusion with the American date format (mm/dd/yyyy), which would read the above date as the 5th of December 2001.

Dateaccuracy
Any uncertainty about the accuracy of date should also be recorded. For example, the BDBSA describes a date as being accurate to the Day(D), Month(M) (i.e. Day unknown but Month and Year certain), Decade(T) and Century(C).

Observer1
First observer's name. It is preferable that the full details of the observer's name be recorded, but as a minimum, the first and last name as well as any middle name initials should be recorded. Ideally, some note should also be kept of the observer's address or affiliated organisation.

Observer2
Second observer's name.

Latitude
Decimal Degrees, if geodetic coordinate (latitude and longitude) was used as a primary coordinate system to capture data.

Longitude
Decimal Degrees, if geodetic coordinate (latitude and longitude) was used as a primary coordinate system to capture data

Locdesc
Observation location description or site name (especially if subject to repeat visits).

Sightingcomm (Flora Only)
Comments (or other fields not accommodated) relating to the sighting are to be concatenated into a text string here. Fields separated by the "^" character. For example, the number of plants or estimated number of plants observed could be placed in this field. Seek advice from Regional GIS Officers or BSM staff about what/how to place relevant data to particular projects in this field.

Habitatcomm
Brief description of habitat where observation has been made.

Observednr (Fauna Only) (Number Observed)
Number of specimens observed/captured (unless recorded this is assumed to be "one").

Appendix H: Terms of Reference for Recovery Team

Threatened Flora Recovery Team for Eyre Peninsula

Role

The Recovery Team is responsible for planning and facilitating efficient and effective implementation of the plan's recovery actions. The team is also responsible for:

- advising the direction of the recovery program and its environmental policies
- inviting specialty stakeholders to discuss specific agenda items and work with them in implementing actions
- ensuring that the program is working towards or within best practice standards.

Members

The Threatened Flora Recovery Team will comprise 11 core positions, including:

- Chairperson
- Project officer/executive support and coordination
- Coordinator of other conservation programs
- Local senior biologist/botanist/ecologist
- Coordinator of other threatened flora projects
- Liaison between State and Commonwealth in biology/botany/ecology
- Monitoring and evaluation
- Communications
- Volunteer support
- Community botanical representative
- Private land conservation.

The membership of the Recovery Team is skills based rather than representative of stakeholders. The Recovery Team will invite involvement from specialty stakeholders (listed briefly below, with a full list in Table 1.3) when there are agenda items or projects that warrant their advice. If this is not possible, comments from specialty stakeholders will be sought through Recovery Team members. Additionally, Recovery Team members will attempt to ensure that these stakeholder groups are informed of Recovery Team meeting outcomes that contain information pertinent to them and meeting minutes will also be forwarded to stakeholders.

Examples of specialty stakeholders include:

- Aboriginal group representatives
- Department of Transport, Energy and Infrastructure
- Department of Water, Land and Biodiversity Conservation
- ETSA Utilities
- Eyre Peninsula NRM Board staff, board members and group members
- industry sectors
- local councils
- non government organisations
- Primary Industries and Resources SA
- private land holders with threatened flora sub-populations
- SA Water.

Threatened Flora Volunteer Group

Role

The Threatened Flora Volunteer Group assists in the delivery of on-ground works and desk-top recovery actions.

Responsibilities

The responsibilities of the Volunteer Group are to:

- work as part of the larger Threatened Flora Recovery Team, with the guidance of the Project Officer
- adhere to DEH Safe Work Practices and Standard Operating Procedures
- communicate ideas or concerns to the Project Officer.

Members

The Volunteer Group comprises representatives from the community that have an interest in threatened flora recovery and who are concerned with the management of land for conservation purposes. They bring with them a diverse range of skills and experiences, and are encouraged to share these skills with other volunteers.

Delivery agent: Department for Environment and Heritage

Role

Within the Threatened Flora Recovery program, the role of the Department for Environment and Heritage is specifically to provide technical expertise, enable integration with other threatened species recovery programs and broker grant funds to enable threatened flora recovery actions to be taken.

Responsibilities

DEH is responsible for the provision of the following services to the program:

- ensuring that the land under its jurisdiction is managed consistently according to priorities listed within the Recovery Plan
- integration and collaboration with other threatened species recovery programs regionally and state-wide
- aligning the program with other DEH biodiversity activities
- provision of technical input
- assembling program progress and financial reports.

Appendix I: Suspected fire and disturbance dependant species

Table I1. Suspected fire and disturbance dependant species

Suspected fire dependent species	Supporting reference
Chalky Wattle	Study underway. Chalky Wattles are known to sucker from the base and along near-surface roots, particularly after fire (Maslin & Whibley 1987; Jusaitis et al. 2000).
Jumping-jack Wattle	Suspected.
Fat-leaved Wattle	Two years of study conducted. Fat-leaved Wattle seedlings were seen coming up on mass within the fire scar after the Wangary bushfire in 2005. Preliminary results from post-fire studies show short-term seedling die off (thought to be attributed to drought conditions); however, the number of juvenile plants remained high (Ecological Associates 2007).
Resin Wattle	Suspected.
Whibley Wattle	Suspected.
Winter Spider-orchid	Observed. Winter Spider-orchid plant numbers tripled in the southern sub-population following the 2005 Wangary Bushfire, but this requires long-term monitoring to identify trends (Ecological Associates 2007). Post fire data is held in DEH Recfind file 40/1185).
Club Spear-grass	Highly suspected. The New South Wales Rural Fire Service recommends that Club Spear-grass is not burnt more frequently than once every ten years (NSW 2004).
Silver Daisy-bush	Observed. Silver Daisy-bush was found to resprout from basal meristems at sub-populations burnt in the 2005 Wangary bushfire (Ecological Associates 2007). It was not clear if fire increased recruitment (new seedlings); however, there was anecdotal evidence that more sub-populations were found post-fire (Ecological Associates 2007; DEH Recfind file 40/1488).
Nodding Rufous-hood	Suspected.
Mount Olinthus Greenhood	Suspected.
Desert Greenhood	Suspected. Fire dependence triggers of Desert Greenhoods on Eyre Peninsula are unknown; however, plants have been observed flowering well in the absence of fire (Duncan 2005). Occasional, intense summer fires, particularly after the flowering period, are assumed to promote flowering of dormant plants, seed germination and seedling establishment (Duncan 2005).
Ironstone Mulla Mulla	Observed, poorly understood. The species flowered in abundance in the first year after the 2005 Wangary Bushfire. Limited data from monitoring results show no clear link between species regeneration and fire (Ecological Associates 2007). Regeneration was more likely to be linked with above average rainfall in the first growing period. Ironstone Mulla Mulla has fleshy underground rhizomes and physiologically the species could survival after fire (Ecological Associates 2007).

Suspected fire dependent species	Supporting reference
Tufted Bush-pea	Observed. Mass germination has been recorded from one sub-population after fire and good rain (M Jusaitis [DEH] 2007, pers. comm.). Before the fire, only two seedling recruits were observed over 10 years of monitoring the same sub-population.
Annual Candles	Suspected.
Yellow Swainson-pea	Known fire requirements. The scientific species name *pyrophila* means *pyro* = fire and *philos* = loving. Yellow Swainson-pea is a short-lived plant that appears only one to two years after fire and can flower in the first spring following fire (Earl, Barlow & Moorrees 2001). Examples of fire dependence can be found on Eyre Peninsula where sub-populations near Munyaroo Conservation Park were recorded by multiple observes in 1992 after a 1990 fire, and Heggaton Conservation Park where Yellow Swainson-pea was recorded in 1998 after a 1997 fire (DEH-EGIS 2006). Gradual depletion of soil-stored Yellow Swainson-pea seedbank in Victorian sub-populations caused by absence of regular fires is suspected by Scarlett and Parson (1993).
Metallic Sun-orchid	Observed via opportunistic observations and studies of Victorian populations after prescribed burns and bushfire (Calder et al. 1989). Ecological Associates (2007) reported differences in the number of flowers and plant height from a limited number of orchids after the 2005 Wangary Bushfire. Metallic Sun-orchids are known to flower abundantly after late summer burns (observed at Weecurra, Victoria and Lower Eyre Peninsula, South Australia) (Calder et al. 1989; K Pobke [DEH] 2007, pers. comm.). Beardsell (1980-1984) suggests burn regimes of once every 5-10 years, in heathland, and 3-4 years, in grasslands, for sub-populations within Victoria.

Table I1. continued.

Suspected disturbance dependent species	Supporting references
Fat-leaved Wattle	Observed on Lower Eyre Peninsula.
Resin Wattle	Data on Resin Wattle sub-populations in the Monarto region suggest plants tend to senesce after approximately 30 years of age (Green 1993). It is suspected that the establishment of the Monarto sub-population corresponds with vegetation rolling disturbance (Davies 1995).
Whibley Wattle	Possible. Seed coat nicking technique works well to break seed dormancy, suggesting that disturbance could break the outer hard seed coat and potentially promote germination.
Winter Spider-orchid	Suspected.
Club Spear-grass	Soil disturbance is thought to stimulate Club Spear-grass germination (L Bebbington 2004, pers. comm.), however this is yet to be tested.
Prickly Raspwort	Study nearly completed (refer to all Prickly Raspwort references by Jusaitis in reference list).
Nodding Rufous-hood	Suspected.
Mount Olinthus Greenhood	Suspected.
Desert Greenhood	Suspected.
Ironstone Mulla Mulla	Observed locally flowering along graded roadsides on Lower Eyre Peninsula, poorly understood.
Annual Candles	Observed. Annual Candles have been observed by P Lang in 1984 growing in rolled firebreaks at Warrenben Conservation Park on Yorke Peninsula. *Stackhousia* sp. have been observed doing well after fire (Leigh, Boden & Briggs 1984); however, it is unknown how this relates to the ecology of Annual Candles.
Yellow Swainsona-pea	Observed locally on Eyre Peninsula. In general *Swainsona* species, particularly mallee *Swainsona* species like Yellow Swainson-pea, are known to re-sprout via vegetative reproduction from persistent rootstock (Earl, Barlow & Moorrees 2001). *Swainsona* species produce hard-coated seeds that generally require treatment to break dormancy (Earl, Barlow & Moorrees 2001). On Eyre Peninsula, Yellow Swainson-pea records are associated with firebreaks, roadsides, fence lines, vegetation clearance and earth disturbance.
Metallic Sun-orchid	Known. Metallic Sun-orchid is known as a post-disturbance coloniser (Cropper 1993) and utilises natural disturbances such as salt pruning, wind damage and plant dieback that provide openings in the upper canopy (Calder et al. 1989). Echidna diggings are also thought to provide suitable habitat for Metallic Sun-orchid colonisation (Calder et al. 1989).
Suspected fire or disturbance sensitive (negative affect)	**Supporting references**
Microlepidium alatum	Suspected.
Sandalwood	Sandalwood is a slow growing species, thought to be fire sensitive, with poor re-sprouting observed post-fire (Brand 1999b).

Appendix J: Threatened flora populations within NPWSA Reserves on Eyre Peninsula

Table J1. Threatened flora populations within NPWSA Reserves on Eyre Peninsula

NPWSA Reserves	Flora species	Observers
Acraman Creek Conservation Park	Bead Samphire	D Fotheringham and G Pearce 1991 D Fotheringham 1996
Barwell Conservation Reserve	Metallic Sun-orchid	R Bates 1986
Bascombe Well Conservation Park	West Coast Mintbush	E Jackson; N Donner; R Alcock; H Eichler; J Wheeler, N Lothian1967
Calpatanna Waterhole Conservation Park	Silver Candles	P Canty and A Wright 2001 T Fuhlbohm 1989
	West Coast Mintbush	T Dennis 1978; T Fuhlbohm 1988 D Murfet, R Taplin 1989; F Davies1989; R Davies, J Briggs 1992.
Carappee Hill Conservation Park	Granite mudwort	D Symon 1979 D Murfet, R Taplin 1998
	Winter Spider-orchid	D Symon 1974 AD Freebairn 2001
Coffin Bay National Park	Silver Candles	J Cleland 1960 Reserves Committee 1960
Fowlers Bay Conservation Park	Bead Samphire	T Schultz 2005
	Microlepidium alatum	A Freebairn and M Horgan 2001
Hambidge Conservation Park	Resin Wattle	NRT Lothian1967
	Yellow Swainson-pea	CR Alcock 1966 DE Symon 1966 (at 2 sites)
Heggaton Conservation Reserve	Yellow Swainson-pea	DE Murfet and RL Taplin 1998
Hincks Conservation Park	West Coast Mintbush	D Symon; R Alcock; J Wheeler 1968
Kellidie Bay Conservation Park	Silver Candles	J Briggs 1983 NPWSA 1989
Lake Gairdner National Park	Sandalwood	C Malley and J Gillen 1985
Lake Gilles Conservation Reserve	Club Spear-grass	S Carruthers and S Kenny in 1998
	Sandalwood	Mason 1973 A Freebairn 2003
Middlecamp Hills Conservation Reserve	Jumping-jack Wattle	D Keane 1985
Middlecamp Hills Conservation Park	Silver Daisy-bush	K Pobke 2005
	Prickly Raspwort	R Davies 1982

Table J1. continued.

NPWSA Reserves	Flora species	Observers
Munyaroo Conservation Park	Sandalwood	A Spooner 1990
	Yellow Swainson-pea	AG Spooner 1990 RJ Davies; TM Reynolds and F Trissi 1992
Point Labatt Conservation Park	West Coast Mintbush	T Fuhlbohm1988; G Carpenter1993
Sceale Bay Conservation Park	Bead Samphire	L Bebbington 2005
The Plug Range Conservation Park	Jumping-jack Wattle	T Croft and K Lehman 1990
Tucknott Scrub Conservation Park	Tufted Bush-pea	B Bates 1994
Venus Bay Conservation Park	West Coast Mintbush	R Taplin 1987; T Fuhlbohm 1989 P Copley; P Canty 1992; G Carpenter 1993
Venus Bay Conservation Reserve	West Coast Mintbush	L Huebner 1999
Wanilla Conservation Park	Metallic Sun-orchid	J Z Weber 1979
	Silver Daisy-bush	A Freebairn 2001; J Prider 2006
	Winter Spider-orchid	J Z Weber 1989
Wanilla Land Settlement Conservation Reserve	Winter Spider-orchid	AD Freebairn, P Hewstone, J Hutchinson 2001
Winninowie Conservation Park	Sandalwood	Field Naturalist Society of South Australia 1970
Whyalla Conservation Park	Sandalwood	D Murfet and R Taplin 1998
Yellabinna Regional Reserve	*Microlepidium alatum*	AG Spooner 1972
	Sandalwood	A Robinson and P Canty 1984
Yumbarra Conservation Reserve	Granite Mudwort	A Freebairn, B Waining, M Horgan 2001

For further information please contact:
Department for Environment and Heritage
West Region
Telephone: (08) 8688 3111
Address: PO Box 22, Port Lincoln SA 5606
Email: WestBioConservation@saugov.sa.gov.au
Online information available at: http://www.biodiversity.sa.gov.au/west_bcp

Printed on recycled paper

Photography: P Lang, S Deslandes, K Pobke DEH

December 2007

ISBN
FIS