

*draft* – NSW Threat Abatement Plan

**Invasion of native plant  
communities by  
bitou bush/boneseed  
(*Chrysanthemoides monilifera*)**



*draft for public comment*  
September 2004

Department of  
Environment and Conservation (NSW)

NSW  
NATIONAL  
PARKS AND  
WILDLIFE  
SERVICE

© Department of Environment and Conservation (NSW), 2004.

This work is protected by copyright. No part of this publication may be reproduced without the prior written permission of the Department of Environment and Conservation (NSW DEC), except where permitted under the *Copyright Act 1968*.

Department of Environment and Conservation (NSW)  
Pest Management Unit  
Parks and Wildlife Division  
43 Bridge Street  
PO Box 1967  
Hurstville NSW 2220  
Telephone: 02 9585 6444  
Website: <http://www.nationalparks.nsw.gov.au/NPWS.nsf/Content/Home>

For further information regarding this plan contact:

Bitou bush threat abatement plan coordinator  
Pest Management Unit  
Parks and Wildlife Division  
Department of Environment and Conservation (NSW)  
PO Box 1967  
Hurstville NSW 2220

Cover photo: *Chrysanthemoides monilifera* subsp. *rotundata* (bitou bush) infestation on the sand dunes at Station Creek, Yuraygir National Park, northern New South Wales.

Cover photo © NPWS – Jeff Thomas.

**This plan should be cited as:**

DEC (Department of Environment and Conservation) (2004). *Draft Threat Abatement Plan for Invasion of Native Plant Communities by Bitou bush/Boneseed (Chrysanthemoides monilifera)*. Department of Environment and Conservation (NSW), Hurstville.

**ISBN 0 7313 6688 3**

The NSW National Parks and Wildlife Service is now part of the Department of Environment and Conservation (NSW)

Table of contents		Page
<b>Executive summary</b>		<b>iv</b>
<b>Relevant background information</b>		<b>vii</b>
The listing of a key threatening process		vii
What is a threat abatement plan?		vii
Threat abatement plan preparation		vii
Threat abatement plan exhibition		viii
Threat abatement plans and Aboriginal cultural heritage values		viii
<b>Acknowledgments</b>		<b>xi</b>
<b>List of Acronyms used</b>		<b>x</b>
<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Relevant legislation, policies, strategies and programs</b>	<b>4</b>
2.1	National legislation, policies, strategies and programs	4
2.1.1	Environment Protection and Biodiversity Conservation Act	4
2.1.2	Agricultural and Veterinary Chemicals Code Act	4
2.1.3	Biological Control Act	5
2.1.4	Commonwealth Coastal Policy	6
2.1.5	National Weeds Strategy	6
2.1.6	Weeds of National Significance	7
2.1.7	Cooperative Research Centre for Australian Weed Management	8
2.1.8	National Heritage Trust initiatives	8
2.1.9	Other national legislation, policies, strategies and programs	9
2.2	NSW legislation, policies, strategies and programs	10
2.2.1	NSW Noxious Weeds Act	10
2.2.2	NSW Threatened Species Conservation Act	11
2.2.3	Pesticide Act	13
2.2.4	NSW National Parks and Wildlife Act	13
2.2.5	Environmental Planning and Assessment Act	14
2.2.6	Local Government Act	15
2.2.7	Protection of the Environment Operations Act	15
2.2.8	NSW Coastal Policy	15
2.2.9	NSW Weeds Strategy	16
2.2.10	NSW Biodiversity Strategy	16
2.2.11	Strategies to manage bitou bush in New South Wales	17
2.2.12	Other NSW legislation, policies, strategies and programs	19
<b>3</b>	<b>The biology and ecology of bitou bush and boneseed</b>	<b>20</b>
3.1	Plant descriptions and biology	20
3.1.1	Bitou bush ( <i>Chrysanthemoides monilifera</i> subsp. <i>rotundata</i> )	20
3.1.2	Boneseed ( <i>Chrysanthemoides monilifera</i> subsp. <i>monilifera</i> )	21
3.2	Bitou bush and boneseed as environmental weeds	22
3.2.1	Arrival and spread of bitou bush in Australia	22
3.2.2	Arrival and spread of boneseed in Australia	23
3.2.3	Invasion of bitou bush and boneseed	24
3.2.4	Habitats invaded by bitou bush and boneseed	24
<b>4</b>	<b>The impact of bitou bush and boneseed invasions</b>	<b>25</b>
4.1	Bitou bush and boneseed invasions and biodiversity	25
4.1.1	Disturbance and bitou bush and boneseed invasions	26
4.2	Threatened species, populations and ecological communities	27
4.2.1	High priority threatened species	28

Table of contents		Page
<b>4</b>	<b>The impact of bitou bush/boneseed invasions (continued)</b>	
4.2.2	Endangered populations	34
4.3.3	Endangered ecological communities	35
4.3.4	Other species, populations and ecological communities potentially at risk from bitou bush/boneseed invasion	37
<b>5</b>	<b>Control of bitou bush and boneseed</b>	<b>39</b>
5.1	Control techniques	39
5.2	Issues associated with bitou bush and boneseed control	41
5.3	Follow-up treatments	43
5.4	Site specific management	44
5.5	A framework for site-specific management plans	44
5.6	Infestation levels and control options	45
5.7	Monitoring of control programs	47
5.7.1	Monitoring more generally	48
5.8	Areas at risk of invasion by bitou bush and boneseed	48
5.8.1	Maintain areas presently free of bitou bush and boneseed in NSW	48
5.9	The ‘no change in current management’ control option	49
5.10	Roles and responsibilities with respect to bitou bush control	50
5.10.1	The role of the Bitou TAP within bitou bush management in NSW	50
<b>6</b>	<b>A strategy to minimise the impact of <i>Chrysanthemoides monilifera</i> on priority native plant communities in New South Wales</b>	<b>51</b>
6.1	Background	51
6.2	Aims and objectives of the Bitou TAP	51
6.3	Priority sites for bitou bush control programs	52
6.3.1	Selection process for priority threatened species, populations and ecological communities	53
6.3.2	Selection process for priority sites	54
6.3.3	A staged approach to bitou bush control	55
6.3.4	Bitou bush control and non-priority species	56
6.3.5	Site-specific management plans	58
6.3.5.1	Consideration of recovery plans and other threat abatement plans	58
6.3.6	Consultation with indigenous people/communities	58
6.3.7	Actions and performance criteria	59
6.4	Monitor the effectiveness of bitou bush control programs	59
6.4.1	Measuring the response of threatened species, populations and ecological communities to bitou bush control	60
6.4.2	Measuring recruitment	61
6.4.3	Measuring the impact of control programs on bitou bush	61
6.4.4	Measuring the response of priority species to herbicide	62
6.4.5	Measuring the spread of bitou bush and boneseed in NSW	63
6.4.6	Actions and performance criteria	63
6.5	Native plant species and bitou bush	64
6.5.1	Determine the processes by which native plant species decline during bitou bush invasions	64
6.6	Public involvement and awareness	65
6.6.1	Community involvement and training	65
6.6.2	Public awareness of bitou bush and boneseed	66
6.6.3	Community groups and bitou bush control	66
6.6.4	Actions and performance criteria	66

Table of contents		Page
<b>6</b>	<b>A strategy to minimise the impact of <i>Chrysanthemoides monilifera</i> on priority native plant communities in New South Wales (continued)</b>	
6.7	Bitou TAP coordinator	67
6.7.1	Plan coordination	67
6.7.2	Actions and performance criteria	68
<b>7</b>	<b>Impact of bitou bush invasion on fauna</b>	<b>69</b>
7.1	Interactions between bitou bush and vertebrates (birds and mammals)	70
7.2	Interactions between bitou bush and invertebrates	71
7.3	Objectives and actions	72
7.3.1	Response of fauna to bitou bush invasion	72
7.3.1.1	Actions and performance criteria	72
7.3.2	Response of fauna to bitou bush control	73
7.3.2.1	Actions and performance criteria	73
7.3.3	Re-evaluate bitou bush management and <b>research</b> aims	74
7.3.3.1	Actions and performance criteria	74
<b>8</b>	<b>Social and economic impacts of the Bitou TAP</b>	<b>76</b>
<b>9</b>	<b>Costs and implementation of this TAP</b>	<b>78</b>
9.1	Summary of the current expenditure associated with proposed actions outlined in this TAP	78
9.2	Breakdown of the current costs (2003/04)	79
9.2.1	Bitou bush control at priority sites (Action 1.1)	79
9.2.2	Development of site-specific management plans (Actions 1.2 and 1.3)	80
9.2.3	Monitor bitou bush control programs at priority sites (Action 2.1)	80
9.2.4	Determine effects of herbicide on threatened species (Action 2.2)	80
9.2.5	Monitor the spread of bitou bush and boneseed (Action 2.3)	81
9.2.6	Decline in native plants due to bitou bush (Action 3.1)	81
9.2.7	Coordination and training of volunteers (Action 4.1)	81
9.2.8	Public awareness of the Bitou TAP (Action 4.2)	81
9.2.9	Bitou TAP coordinator (Action 5.1)	82
9.2.10	Case study – bitou bush and fauna (Actions 6.1–8.2)	82
<b>10</b>	<b>References</b>	<b>83</b>
<b>11</b>	<b>List of personal communications cited</b>	<b>86</b>
<b>Appendix 1</b>	<b><i>Chrysanthemoides monilifera</i> listings under the NSW Noxious Weeds Act</b>	<b>87</b>
<b>Appendix 2</b>	<b>Development of a model to rank plant species threatened by bitou bush invasion</b>	<b>88</b>
<b>Appendix 3</b>	<b>Species, populations and ecological communities considered in the TAP</b>	<b>93</b>
<b>Appendix 4</b>	<b>Selecting priority sites for bitou bush control</b>	<b>96</b>
<b>Appendix 5</b>	<b>Species at risk from herbicide application</b>	<b>105</b>
<b>Appendix 6</b>	<b>Map of bitou bush density in NSW</b>	<b>106</b>
<b>Appendix 7</b>	<b>Submission: Draft Threat Abatement Plan [form]</b>	<b>107</b>

## Executive summary

---

Since the arrival of *Chrysanthemoides monilifera* (bitou bush) from South Africa in 1908, this highly invasive shrub has spread to occupy approximately 80% of coastal New South Wales. It now poses the single greatest threat to NSW coastal ecosystems and coastal biodiversity especially along the north coast. If it continues to expand, within a decade there will be no area of the NSW coast unaffected. It forms dense infestations that smother sand dunes, headlands and hind dune vegetation communities including coastal grasslands, heathlands, woodlands, swamps/wetlands and forests.

Invasion of native plant communities by bitou bush/boneseed (*Chrysanthemoides monilifera*) was listed as a key threatening process under the NSW *Threatened Species Conservation Act 1995* (TSC Act) in 1999. Under the TSC Act, the Department of Environment and Conservation (which includes the former NSW National Parks and Wildlife Service) must prepare a threat abatement plan (TAP) which proposes actions to reduce, abate or ameliorate the impacts of *C. monilifera* on biodiversity, particularly threatened species, populations and ecological communities. This document (hereafter referred to as the Bitou TAP) fulfils this requirement.

To meet the requirements of a TAP, control of *C. monilifera* must be prioritised to target the species, populations and ecological communities at greatest risk and where *C. monilifera* control programs are likely to have the most significant outcome for threatened biodiversity. While this TAP establishes a strategic approach to deliver statewide conservation benefits, other *C. monilifera* management programs will occur independent of this TAP, for example, at high visitation areas within National Parks, or where small isolated patches can be easily treated before they become problematic.

Due to the severity and scale of the problem, *C. monilifera* has been listed as a Weed Of National Significance (WONS), however the estimated \$1–2 million p.a. spent nationally, on control programs has not contained this aggressive invader. This is in part due to the need for a strategic framework for control programs, similar to that proposed here. Such a framework can ensure that resources are used effectively to deliver strategic control programs. This is extremely important given the significant commitment currently in place, both in terms of labour and money.

Nationally, *C. monilifera* poses a direct threat to at least 14 threatened plant species and one ecological community listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Within New South Wales, it poses a direct threat to at least 30 threatened plant species, two endangered plant populations and seven endangered ecological communities (EEC) listed under the TSC Act. It also threatens another 33 plant species which are not formally recognised as threatened (i.e. under

threatened species legislation), and two EECs. There are potentially many other plant species that are under threat for which limited information is available. In addition to the threats imposed on biodiversity, *C. monilifera* is aesthetically unappealing as it converts coastal landscapes into weed monocultures.

The Bitou TAP has five underlying components, which aim to:

- develop a strategic framework for delivering control of *C. monilifera* to areas of high conservation value (in terms of threatened biodiversity)
- monitor the effectiveness of control programs in terms of the recovery of threatened biodiversity
- develop and promote best practice management
- foster community education, involvement and awareness
- identify and fill knowledge gaps where possible

The Bitou TAP provides a strategy for *C. monilifera* control that will have positive outcomes for the conservation of native plant species and communities in New South Wales. The Bitou TAP determines priority plant species, populations and ecological communities that are at risk. It also determines priority sites at which to undertake the actions, including control programs. This matrix of threatened entities (species, populations and ecological communities) by sites establishes statewide as well as regional priorities for *C. monilifera* control which will aid in broader conservation of over 70 threatened entities. Establishing collaborative control programs at priority sites, independent of land tenure, is a core action of this TAP.

In order to implement best practice management techniques for the control of *C. monilifera*, information on the respective site is needed, specifically (i) site attributes e.g. topography, (ii) the density of *C. monilifera*, and (iii) the threatened entities present – each will dictate a different control strategy. For example, where the sensitivity of threatened species to herbicide is not known, cut and paint techniques must be used. However, if the species are tolerant of glyphosate then herbicide may be sprayed. At all sites a ‘best practice’ control strategy will be developed during the preparation of site-specific management plans. These plans will maximise effectiveness of control programs while minimising their impacts on non-target species at each priority site.

The Bitou TAP outlines experiments to measure the response of priority species, populations and ecological communities to *C. monilifera* control. Data collected from monitoring these control programs will help refine future control methods and guide future priorities. The Bitou TAP also identifies additional research objectives/projects to examine the effects of *C. monilifera* and the control of *C. monilifera* on fauna species, for which there is currently limited information.

As a number of actions, or parts thereof, outlined in this plan are already being implemented, the actual cost associated with each of these actions in the 2003/04 financial year is presented here as a guide to the estimated cost of implementing this TAP. The cost of implementing these actions in 2003/04 was \$882,557. This included expenditure by the DEC, Department of Lands, several Councils and the University of Wollongong. Those actions currently unfunded are not presented in the costing of this TAP (these are research actions which target the knowledge gaps identified during the preparation of this TAP). It is anticipated that the actual expenditure in 2003/04 is a reasonable estimate of the actual cost of implementing this plan, assuming that a similar level of commitment is maintained by these organisations in the future. However, the actual cost of implementing this plan will be finalised during the public exhibition stage and subsequent preparation of the final plan in consultation with all relevant stakeholders.

The Bitou TAP will be implemented over a five-year period. Actions in this TAP will be undertaken by the NSW Department of Environment and Conservation (which includes the *NSW National Parks and Wildlife Service*) and the NSW Department of Lands. At present a range of other stakeholders is currently, involved with proposed actions outlined in this TAP. These groups along with local government, private landholders and the community are encouraged to participate in the implementation of this TAP.



Lisa Corbyn  
**Director General**

## Relevant background information

---

### The listing of a key threatening process

---

Any process can be listed as a key threatening process (KTP) under schedule 3 of the NSW *Threatened Species Conservation Act 1995* (TSC Act), provided the process and its nomination meet the specific requirements and criteria established under the Act. The NSW Scientific Committee makes a determination on each nomination. In essence, a nominated process must threaten two or more threatened species or ecological communities that are listed under the TSC Act or cause species that are not threatened (under the Act) to become so. This plan is for one KTP listed under the TSC Act. It aims to reduce, abate or ameliorate the threat posed by the KTP to threatened entities.

### What is a threat abatement plan?

---

A threat abatement plan or TAP is a statutory document prepared in accordance with the TSC Act, for a KTP (see above) listed under the Act. The TAP's principle aim is to **reduce, abate or ameliorate** the threat posed by the KTP to threatened species and ecological communities, or those species which may become threatened as a result of the KTP. A TAP is a five year plan to reduce, abate or ameliorate the threat, rather than an eradication strategy *per se*. This is because the nature of some KTPs precludes eradication in the short term and the best approach involves setting priorities to reduce, abate or ameliorate the threat, specifically targeting its impacts on threatened entities identified in the TSC Act.

### Threat abatement plan preparation

---

Under the TSC Act, the Director General of the Department of Environment and Conservation (NSW) is required to prepare threat abatement plans for all Key Threatening Processes listed on schedule 3 of the TSC Act. The TSC Act includes specific requirements regarding both the matters to be addressed by threat abatement plans and the process for preparing them. This bitou bush/boneseed TAP satisfies those requirements. The plan also addresses the points outlined in the nomination and the Scientific Committee's final determination of the KTP.

## **Threat abatement plan exhibition**

---

This draft TAP will be placed on public exhibition and submissions invited from the public. To make your submission as effective as possible, please:

- ▶ refer to the section or action of the plan you wish to address
- ▶ briefly explain the reasons for your comments, providing source information or examples where possible
- ▶ provide your name and postal address so receipt of your submission can be acknowledged.

Submissions must be in writing. A form has been created to assist you with your submission. Should you wish to use it a copy is provided in Appendix 7 of this document or at <http://www.nationalparks.nsw.gov.au/NPWS.nsf/Content/Home>

DEC will consider all submissions on the threat abatement plan received during the exhibition period and must provide a summary of those submissions to the Minister for the Environment prior to final approval of the plan. Following adoption of the TAP by the Minister, copies of all submissions are made available for public inspection.

Please be aware that submissions may contain information defined as ‘personal information’ under the NSW *Privacy and Personal Information Protection Act 1998* and any person who does not want their personal details to become public needs to give a clear indication of this on their submission. All submissions are kept in the DEC record system.

## **Threat abatement plans and Aboriginal cultural heritage values**

---

Under the NSW *National Parks and Wildlife Act 1974* (NPW Act), the Director General of the Department of Environment and Conservation (NSW) is responsible for the proper care, preservation and protection of any relic or Aboriginal place on any land reserved or dedicated under that Act. Recent amendments to the NSW *Threatened Species Conservation Act 1995* outline the role of Aboriginal communities in the development of threat abatement plans. This draft plan satisfies those provisions. Submissions from Aboriginal/indigenous people with respect to the TAP’s impact on Aboriginal cultural heritage values, as well as in any other respect, are encouraged.

## Acknowledgments

---

This document was prepared by Dr Paul Downey (DEC: Pest Management, Policy and Science Division), based on a partial draft prepared by Jeff Thomas (DEC).

The authors wish to thank Dr Jack Baker (DEC), Dr Andrew Leys (DEC), Dr Paul Mahon (DEC), Ruth Armstrong (DEC), Doug Beckers (DEC), Di Brown (DEC), Joanne Edney (DEC), Tanya Leary (DEC), Brendon Neilly (DEC), Samantha Olson (DEC), Tim Scanlon (DEC), Mel Schroder (DEC), Craig Shepherd (DEC), Martin Smith (DEC), Jeff Thomas (DEC), Maxine Walker (DEC), Ross Wellington (DEC), Rod Ensby (NSW Agriculture), Paul Flower, Joe Cummins (Department of Lands), Daniel Hirschfeld (Randwick Council), Rhonda James, David Pomery (Illawarra District Noxious Weeds Authority), Graham Matthews (Eurobodalla Shire Council), Ian Borrowdale (Shoalhaven City Council), Daintry Gerrand, Steven Griffith, Phil Craven (DEC), Rod Kidd (DIPNR), Russ Glover (DIPNR), Darren Williams (Wyong Shire Council), Geoff Doret (Sutherland Shire Council), Christine Guthrie (Sutherland Shire Council), John Hughson (Lake Macquarie City Council), Andrew Benwell (Sydney Central Regional Weeds Committee), Annette McKinley (Sydney Central Regional Weeds Committee), Jo Lynch (Sydney Central Regional Weeds Committee), Gerard Proust, Ian Turnbull (Bellingen Shire Council), and Graham Wilson (DEC) who made comments on earlier drafts and/or provided information about species and sites. Useful discussions were also held with Dr Jack Baker (DEC), Mike Dodkin (DEC), Paul Ibbetson (DEC), Dr Andrew Leys (DEC), Jeff Thomas (DEC), Lisa Wellman (DEC) and Ron Haering (DEC) during the development of this TAP. Catherine Munro made comments and provided editorial advice on this draft.

Parts of this threat abatement plan were derived from the Fox Threat Abatement Plan (NPWS 2001c).

## List of acronyms used

---

<i>Acronym</i>	<i>expanded text</i>
Agvet	<i>Agricultural and Veterinary Chemicals Code 1994</i> (Commonwealth) [also Agvet Chemicals]
ANZECC	Australian and New Zealand Environment and Conservation Council
APVMA	Australian Pesticides and Veterinary Medicines Authority (formerly NRA)
AQIS	Australian Quarantine Inspection Service
AWC	Australian Weeds Committee
BC	<i>Biological Control Act 1984</i> (Commonwealth)
Bitou TAP	TAP for invasion of native plant communities by bitou bush/boneseed ( <i>Chrysanthemoides monilifera</i> )
CAMBA	China–Australia Migratory Bird Agreement
CCP	Commonwealth Coastal Policy
CRC	Cooperative Research Centre
DEC	Department of Environment and Conservation (NSW: <i>incorporating the former NPWS and EPA</i> )
DLWC	former NSW Department of Land and Water Conservation (references to DLWC in this text primarily refer to what is now the NSW Department of Lands)
DIPNR	NSW Department of Infrastructure, Planning and Natural Resources
EA	Environment Australia
EIS	Environmental Impact Statement
EPA	Environment Protection Authority (now part of the Department of Environment and Conservation (NSW))
EPBC	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
EP&A	<i>Environmental Planning and Assessment Act 1979</i> (NSW)
GIS	Geographical Information System
JAMBA	Japan–Australia Migratory Bird Agreement
LG	<i>Local Government Act 1993</i> (NSW)
LCA	Local Council Authorities (referring to regions under the <i>Noxious Weeds Act 1993</i> )
LGA	Local Government Area
NHT	Natural Heritage Trust
NP	National Park
NPW	<i>National Parks and Wildlife Act 1974</i> (NSW)
NPWS	NSW National Parks and Wildlife Service (now part of the Department of Environment and Conservation (NSW))
NR	Nature Reserve
NRA	National Registration Authority for agricultural and veterinary chemicals (now APVMA)
NRMSC	Natural Resource Management Standing Committee
NW	<i>Noxious Weeds Act 1993</i> (NSW)
NWAC	NSW Noxious Weeds Advisory Committee
NWS	National Weeds Strategy
PoM	Plan of Management
POEO	<i>Protection of the Environment Operations Act 1997</i>
REF	Review of Environmental Factors
RMP	Regional Management Plans
SCA	Standing Committee on Agricultural
SCA	State Conservation Area (formerly SRA: State Recreation Area)
SCARM	Standing Committee on Agricultural and Resource Management
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
subsp.	Subspecies (also referenced as ssp. in some texts)
TAP	Threat abatement plan
TSC Act	<i>Threatened Species Conservation Act 1995</i> (NSW)
WONS	Weeds of National Significance

---

# 1 Introduction

---

Two subspecies of *Chrysanthemoides monilifera* have been introduced to Australia from South Africa; both are now widely established and are major environmental weeds. Since their introduction, bitou bush (subsp. *rotundata*) and boneseed (subsp. *monilifera*) have invaded a wide range of coastal habitats, including sand dunes, coastal grasslands, heathlands, woodlands and forests. Bitou bush poses the greatest threat in New South Wales, while boneseed poses serious threats in Victoria, Tasmania and South Australia. Collectively, they have been documented to threaten at least 18 plant species and three ecological communities (see ARMCANZ *et al.* 2000) and there are many other species and communities that are likely to be at risk. In 2000 *Chrysanthemoides monilifera* was listed as one of the 20 Weeds Of National Significance (WONS) by the Commonwealth Government (Thorp and Lynch 2000).

A recent survey of bitou bush in New South Wales showed that it was present along approximately 900 km (80%) of the coastline (Thomas and Leys 2002), an increase of approximately 240 km (36%) over the last 20 years (see Love 1984 for previous survey results). The current survey recorded bitou bush up to 10 km inland and noted that it was the dominant species along 400 km of the coast. The extent of the bitou bush problem in New South Wales has resulted in it being declared a noxious weed under the NSW *Noxious Weeds Act 1993* in all coastal councils/control areas in New South Wales.

Boneseed is not as widespread in New South Wales. It mainly occurs as isolated small infestations, however, larger infestations occur around Sydney and south of the Hunter River. Boneseed can occur further inland than bitou bush. As boneseed is a major weed in Victoria, Tasmania and South Australia it could pose a serious threat to New South Wales in the future if it is not managed.

Bitou bush and boneseed proliferate because of their rapid growth, large seed production, the capacity to develop large dormant soil seed banks, and their lack of predators in Australia (native or otherwise). They have the potential to grow in a wide range of coastal environments. The combination of these factors has allowed bitou bush to predominate and signals the potential threat from boneseed within New South Wales. The worst case scenario for bitou bush/boneseed invasion would be dense monocultures that displace native species and alter ecosystem dynamics; such infestations occur along approximately 400 km of the NSW coastline (Thomas and Leys 2002). Effective control is well beyond the current resources of most land managers.

A national strategy for bitou bush and boneseed was developed in 2000 (ARMCANZ *et al.* 2000). Other strategies include the NSW Bitou bush Strategy (NPWS 2001a) and specific regional strategies within New South Wales (Gerrand 2000; Scanlon 2001; Broese and Wolfenden 2002). These strategies prioritise and coordinate management

objectives across different levels of government, interest groups and local communities, resulting in a more focussed and extensive control effort within New South Wales. These strategies are not specifically designed to combat the threat of bitou bush or boneseed invasion to threatened species and ecological communities however. As such, both the national and state strategies identified the development of threat abatement plans for bitou bush and boneseed as a high priority.

In 1999 ‘*Invasion of native plant communities by bitou bush and boneseed (Chrysanthemoides monilifera)*’ was listed as a key threatening process (KTP) to biodiversity under the NSW *Threatened Species Conservation Act 1995* (TSC Act: NSW SC 1999a). The Scientific Committee listed bitou bush as a KTP because of the area occupied, its biology and dominance, and the number of species and ecological communities that are potentially at risk from invasion (NSW SC 1999a). After a key threatening process has been listed, there is a legal obligation to develop a threat abatement plan (TAP).

The current TAP (hereafter referred to as the Bitou TAP) deals principally with bitou bush, however information on boneseed is also presented where relevant as this subspecies could pose a similar problem in New South Wales if its distribution were to increase substantially as has occurred in Victoria and Tasmania. To avoid repeated usage of the compound term ‘bitou bush/boneseed’ all mentions of bitou bush within this TAP are to be understood to include the threat and proposed management of boneseed where appropriate.

Chapter 2 outlines the legislation, programs and strategies relevant to bitou bush management and the development of a threat abatement plan, while Chapter 3 details the biology and ecology of bitou bush and boneseed.

The impacts of bitou bush on threatened species, populations and ecological communities are discussed in Chapter 4, along with the species, populations and ecological communities that were used to select priority species.

Chapter 5 discusses the current control/management programs for bitou bush along with the impacts of these programs on biodiversity (including off-target effects).

A strategy to abate, ameliorate or eliminate the threat of bitou bush on native threatened species, populations and ecological communities within New South Wales is presented in Chapter 6. This chapter also outlines objectives, actions and performance criteria, along with the priority sites at which these actions are to be undertaken.

Chapter 7 identifies a series of case study objectives, actions and performance criteria to improve our knowledge of the interactions of bitou bush and fauna, while Chapter 8 contains a discussion of the economic and social implications of the Bitou TAP.

Chapter 9 outlines the costs associated with implementing each of the actions proposed in Chapter 6 and a breakdown of the in-kind and additional funds required is also presented.

Appendix 1 lists the noxious weed category for each local control authority area in which bitou bush and/or boneseed is declared noxious under the Noxious Weeds Act. Appendix 2 describes the model used to rank the threatened species most at risk from invasion/competition from bitou bush, while a complete list of the species examined and their respective ranks is presented in Appendix 3. The model used to rank the sites for each species, population and ecological community outlined in this plan, along with their respective ranks, is presented in Appendix 4. Species that are or may be susceptible to herbicide and hence should be considered in all control programs are outlined in Appendix 5. Appendix 6 contains a map of priority sites showing the density of bitou bush and Appendix 7 provides a form to assist with the development of submissions in response to the Bitou TAP.

## 2 Relevant legislation, policies, strategies and programs

---

### 2.1 National legislation, policies, strategies and programs

---

The Commonwealth legislation and national policies, strategies and programs that influence bitou bush and/or boneseed management are presented below.

#### 2.1.1 Environment Protection and Biodiversity Conservation Act

---

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) repealed five previous Commonwealth Acts (the *Endangered Species Protection Act 1992*, the *Environment Protection Act 1974*, the *National Parks and Wildlife Conservation Act 1975*, the *Whale Protection Act 1980* and the *World Heritage Properties Conservation Act 1983*). The EPBC Act provides a national framework for environmental management (including the recognition of nationally threatened species and ecological communities), thereby directing resources towards the delivery of improved environmental protection.

With respect to threatened species and ecological communities, the EPBC Act provides for:

- ▶ identification and listing of threatened species and threatened ecological communities
- ▶ development of recovery plans for such species and ecological communities
- ▶ recognition of key threatening processes
- ▶ reducing these processes through threat abatement plans.

The EPBC Act applies where bitou bush and/or boneseed threatens any listed species or ecological community or where its control may have adverse effects on matters of national environmental significance on Commonwealth land. In New South Wales, bitou bush currently poses serious threats to several species/ecological communities listed on schedules of the EPBC Act (these are discussed further in Chapter 4).

#### 2.1.2 Agricultural and Veterinary Chemicals Code Act

---

All pesticides (herbicides, insecticides and fungicides) used, supplied or distributed in Australia must be registered under the *Agricultural and Veterinary Chemicals Code Act 1994* (Agvet Act) by the Australian Pesticides and Veterinary Medicines Authority (APVMA: formerly the National Registration Authority for agricultural and veterinary chemicals (NRA)). Before any chemical or product (e.g. commercially formulated

herbicide) is registered for use, supply or distribution the APVMA is required under the Agvet Act to conduct a rigorous assessment of potential impacts on the environment, human health and trade. All APVMA approved chemicals (or products) have affixed product labels which contain specific usage requirements and application rates. Label breaches can result in prosecutions under the Agvet Act. The APVMA also grants permits for minor use of specific unregistered chemicals in certain circumstances as well as off-label use of registered chemicals.

As of June 2003, there were 156 herbicide products registered by the APVMA for use in the control of bitou bush and/or boneseed in Australia. An APVMA off-label permit has been granted for the aerial application of herbicides (e.g. glyphosate) to control bitou bush. The Parks and Wildlife Division of the DEC (formerly NSW NPWS) currently holds off-label permits to control bitou bush aurally in New South Wales.

### 2.1.3 Biological Control Act

---

The use of non-native biological organisms (the agent) to control a specific pest or weed species (the target) is governed by the *Biological Control Act 1984* (BC Act). The BC Act establishes a detailed set of procedures and a framework for the selection of agents (through host-specificity testing), the importation of agents into Australian quarantine and the intentional release of agents from quarantine. Prior to allowing importation and intentional release from quarantine, the impacts of the agent on the target as well as non-target species are assessed. In addition, the importation of biological control agents requires approval from Biosecurity Australia (part of Agricultural Forestry and Fisheries Australia: AFFA), the Australian Quarantine and Inspection Service (AQIS), and Environment Australia (EA). The Australian Weeds Committee (AWC), in conjunction with the Natural Resource Management Standing Committee (NRMSC: formerly the Standing Committee on Agriculture and Resource Management (SCARM)) must also approve all biological control proposals before any control is attempted. Approval includes wide consultation with all stakeholders.

In 1985 the NSW Government passed the *NSW Biological Control Act 1985*, to complement to the BC Act.

In February 1986 the Standing Committee on Agriculture (SCA: a predecessor of NRMSC) approved a biological control program for bitou bush in New South Wales because conventional control methods were deemed ineffective at suppressing the spread and impact of large-scale bitou bush infestations. Since 1986 six biological control agents have been released and another one is being investigated (further discussion is presented in Chapter 5). The biological control program for bitou bush in New South Wales has to date identified the majority of potential agents and undertaken the appropriate action to

release the ones that are likely to have the greatest impact on bitou bush. Most of these species have now been released in Australia, all in accordance with the BC Act.

#### 2.1.4 Commonwealth Coastal Policy

---

In May 1995 the Commonwealth initiated its Coastal Policy. The Commonwealth Coastal Policy (CCP) arose in response to several government reports on the status of Australia's coastline/coastal zone. The CCP addresses the nature and complexity of coastal management. The CCP acknowledges that coastal management cannot be achieved by any one jurisdiction and that the management of Australia's coastal zone needs to be shared across all levels of government and the community. The CCP is a blueprint for the management and use of Australia's coastal zone with the aim to 'promote ecologically sustainable use of Australia's coastal zone' (EA 2002a). The CCP acknowledges that indigenous Australians manage a significant proportion of the Australian coastal zone and as such need to be included in the development and implementation of the CCP.

Several objectives of the CCP are of direct relevance/importance to the management of bitou bush. The relevant resource conservation objectives are:

- 1 to conserve and manage areas and features of significant ecological, physical, cultural, historic, landscape and scientific importance, so that their values are maintained
- 2 to maintain the biological diversity and productivity of marine and terrestrial ecosystems and natural processes within the coastal zone for present and future generations. Where environmental qualities have been degraded remedial action should be taken to restore them.

The relevant public participation objectives are:

- 1 to ensure that there is informed public participation in open, consultative processes dealing with planning and management of coastal resources
- 2 to recognise the interests in the coastal zone of Australia's indigenous peoples and incorporate these interests in management arrangements

#### 2.1.5 National Weeds Strategy

---

The National Weeds Strategy (NWS: ARMCANZ *et al.* 1997) targets the management of weeds of national significance through four principles:

- ▶ Weed management is an essential and integral part of the sustainable management of natural resources and the environment, and requires an integrated multi-disciplinary approach.
- ▶ Prevention and early intervention are the most cost-effective techniques that can be deployed against weeds.

- ▶ Successful weed management requires a coordinated national approach, which involves all levels of government in establishing appropriate legislative, educational and coordination frameworks in partnership with industry, landholders and the community.
- ▶ The primary responsibility for weed management rests with landholders/land managers, but collective action is necessary where the problem transcends the capacity of the individual landholder/land manager to address it adequately.

The goals of the NWS are to:

- ▶ prevent the development of new weed problems
- ▶ reduce the impact of existing weed problems of national significance
- ▶ provide cost efficient and effective means for harnessing national action on weed management.

Before the second goal could be achieved, a list of the Weeds Of National Significance (or WONS) had to be developed. A further discussion of WONS and how they were determined is presented below.

#### 2.1.6 Weeds of National Significance

---

The WONS were determined from a list of 71 ‘major’ weed species, which were derived using set criteria (see Thorp and Lynch (2000) for more information). A species was included if it:

- ▶ threatens the profitability or sustainability of Australia’s principal primary industries
- ▶ threatens conservation areas or environmental resources of national significance
- ▶ may require remedial action across several states and territories
- ▶ constitutes a major threat to Australia’s biodiversity.

*Chrysanthemoides monilifera* was listed as one of the 20 Weeds of National Significance in 2000 (see Thorp and Lynch 2000), following which a national strategy was produced (see ARMCANZ *et al.* 2000). The national strategy aims to:

- ▶ prevent further introduction and spread of bitou bush/boneseed
- ▶ minimise adverse impacts of bitou bush/boneseed on biodiversity
- ▶ maintain national commitment to the coordination and management of bitou bush/boneseed.

### 2.1.7 Cooperative Research Centre for Australian Weed Management

---

The Cooperative Research Centre for Australian Weed Management (Weeds CRC) is a cooperative organisation which aims to combat Australia’s weed problem, involving Commonwealth and state agencies, research institutions, industries and stakeholders.

The Weeds CRC is currently in its second phase. *Chrysanthemoides monilifera* was one of six target weeds identified in the original Weed CRC’s environmental weeds program. This resulted in funding for research and the biological control program as well as the production of best practice management guides for bitou bush (see Vranjic 2000) and boneseed (see Adair and Ainsworth 2000). There is no such commitment to bitou bush and boneseed under the current Weeds CRC (2001–08) program.

### 2.1.8 Natural Heritage Trust initiatives

---

There are four programs in the second stage of the Natural Heritage Trust (NHT) (2002–07): Landcare, Bushcare, Rivercare and Coastcare (EA 2003a). The **Landcare** program invests in activities which contribute to reversing land degradation and promoting sustainable agriculture. The **Bushcare** program invests in activities which contribute to conserving and restoring habitat for our unique native flora and fauna which underpin the health of our landscapes. The **Rivercare** program invests in activities which contribute to improved water quality and environmental conditions in our river systems and wetlands. The **Coastcare** program invests in activities which contribute to protecting our coastal catchments, ecosystems and the marine environment (EA 2003a).

The Coastcare program was started in 1995 as part of the Natural Heritage Trust’s Coast and Clean Seas initiative. Coastcare ceased as a separate funding source in 2003, but the program still provides a framework for NRM initiatives, particularly at the regional level. Coastcare aims to protect and manage Australia’s coastal and marine environments through community based management of coastal ecosystems.

The NHT, through Coastcare, has funded a range of projects in New South Wales that have incorporated some component of bitou bush control (average project funding of approximately \$400,000 p.a.).

The four NHT programs will target 10 Natural Heritage Areas of Activity. Actions identified in the Bitou TAP address six of the ten Areas of Activity:

- ▶ protecting and restoring the habitat of threatened species, threatened ecological communities and migratory birds
- ▶ reversing the long-term decline in the extent and quality of Australia’s native vegetation

- ▶ protecting and restoring significant freshwater, marine and estuarine ecosystems
- ▶ preventing or controlling the introduction and spread of feral animals, aquatic pests, weeds and other biological threats to biodiversity
- ▶ providing landholders, community groups and other natural resource managers with understanding and skills to contribute to biodiversity conservation and sustainable natural resource management
- ▶ establishing institutional and organisational frameworks that promote conservation and ecologically sustainable use and management of natural resources.

In addition, the second stage of the NHT includes a new initiative, the **Australian Government Envirofund**. Grants of up to \$30,000 are available from the Envirofund for community groups to address local land management issues and to carry out on-ground actions.

### *Catchment Management Authorities*

In January 2004 Catchment Management Authorities (CMAs) were formally established as statutory bodies in New South Wales. The 13 CMAs replaced the state's existing 20 Regional Vegetation Committees and 19 Catchment Management Boards. The CMAs will handle all natural resource matters. They will develop catchment action plans which integrate regional vegetation management plans and catchment blueprints and investment strategies. State and Commonwealth natural resource funds such as the National Action Plan for salinity and water quality and the Natural Heritage Trust, will be directed through CMAs. It is anticipated that the impact of environmental weeds on natural resource values will be recognised as a priority within each catchment action plan. The Bitou TAP identifies priorities that would be appropriate to include in each of the five coastal catchment action plans, viz. Northern Rivers, Hunter/Central Rivers, Hawkesbury–Nepean, Sydney Metro, and Southern Rivers CMAs.

#### **2.1.9 Other national legislation, policies, strategies and programs**

---

The Commonwealth Government is a signatory to a number of international conventions, including the Ramsar convention on wetlands of international importance, migratory bird conventions including JAMBA (Japan–Australia Migratory Bird Agreement) and CAMBA (China–Australia Migratory Bird Agreement). These agreements are for the protection of migratory birds and their habitats.

Many migratory birds use coastal regions (including dunes and coastal vegetation) for feeding, nest sites and roosting. While the link between bitou bush infestations and

declines in migratory bird populations is not clear (see Chapter 7), some initial evidence indicates that it may be extremely important. For example, little terns will not nest in areas containing dense bitou bush infestations. Any link between bitou bush infestation and migratory bird decline or destruction of wetlands could have major consequences for the management of bitou bush, as well as wetlands and migratory birds.

## 2.2 NSW legislation, policies, strategies and programs

---

The NSW specific legislation, policies, strategies and programs that influence bitou bush management are presented below:

### 2.2.1 NSW Noxious Weeds Act

---

The *NSW Noxious Weeds Act 1993* (NW Act) provides for the identification, classification and control of noxious weeds in New South Wales. The NW Act aims to identify noxious weeds and their respective control measures, as well as the roles and responsibilities for their control for both public and private land managers/owners.

All weed species declared under the NW Act are classified according to the level of control or management required to suppress and/or destroy them. A weed species may have more than one classification depending on its severity within different regions of the state. There are four noxious weed categories:

- W1** The presence of the weed on the land must be notified to the local control authority and the weed must be fully and continuously suppressed and destroyed.
- W2** The weed must be fully and continuously suppressed and destroyed.
- W3** The weed must be prevented from spreading and its numbers and distribution reduced.
- W4** Noxious weed, the action specified in the declaration must be taken in respect of the weed.

Bitou bush/boneseed has been declared a noxious weed under the NW Act in all designated coastal councils/control areas (or LCAs) of New South Wales (including metropolitan Sydney). Regionally, bitou bush has been classified as W3 in 54 coastal LCAs, W2 in 11 and W1 on Lord Howe Island (see Appendix 1 for a complete list of the councils/controls areas in which bitou bush is declared and the classification for each).

### 2.2.2 NSW Threatened Species Conservation Act

---

In January 1996 the *NSW Threatened Species Conservation Act 1995* (TSC Act) commenced to conserve threatened species, populations and ecological communities in New South Wales. The objectives of the TSC Act are to:

- ▶ conserve biological diversity and promote ecologically sustainable development
- ▶ prevent the extinction and promote the recovery of threatened species, populations and ecological communities
- ▶ protect the critical habitat of those threatened species, populations and ecological communities that are endangered
- ▶ eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities
- ▶ ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed
- ▶ encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving cooperative management.

Species listed under the TSC Act are classified as either endangered or vulnerable. Recent amendments (see below) to the TSC Act will also allow ecological communities to be listed as vulnerable, in addition to the existing endangered classification. This vulnerable classification is yet to be enacted. Populations can only be listed as endangered.

A key threatening process is eligible to be listed under the TSC Act if, in the opinion of the Threatened Species Scientific Committee, it:

- ▶ adversely affects two or more listed threatened species, populations or ecological communities
- or
- ▶ could cause species, populations or ecological communities that are not threatened to become threatened.

In 1999 ‘Invasion of native plant communities by *Chrysanthemoides monilifera*’ was listed as a key threatening process under the TSC Act. A threat abatement plan (TAP) must be prepared by the DEC within 3 years of the listing date. A TAP must outline the process by which the threatening process is managed so as to abate, ameliorate or eliminate its adverse effects on threatened species, populations or ecological communities. As a legal document under the TSC Act, a TAP requires ministers and public authorities to undertake the actions where appropriate, however a measure must not be included in a threat abatement plan for implementation by a public authority unless the minister responsible for the public authority approves of the inclusion of the measure.

Species, populations and ecological communities listed under the TSC Act require recovery plans to be prepared and implemented. Individual recovery plans must identify

any relevant threatening processes and how they are to be ameliorated and therefore may require the control/management of bitou bush. For example, the *Zieria prostrata* recovery plan requires the control of bitou bush at several locations (NPWS 1998a). This interaction between recovery plan and TAP objectives and actions needs to be considered when developing any recovery plan or TAP.

Any action that is likely to harm or damage threatened species, populations or ecological communities listed under the TSC Act requires one of the following:

- ▶ a Section 91 licence where actions are not being carried out in accordance with an approval under parts 4 or 5 of the NSW *Environmental Planning and Assessment Act 1979* (see below), with the exception of a routine agricultural activity, or as part of an approved property management plan
- ▶ a certificate of exemption under section 95 of the TSC Act
- ▶ a licence under section 132C of the *National Parks and Wildlife Act 1974* (see below).

The control of bitou bush in some areas may require such a licence or certificate to be issued by DEC.

### *Amendments to the TSC Act*

In 2002 several amendments were made to the TSC Act. In January 2003 many of these changes were proclaimed. One such amendment with direct relevance to the Bitou TAP is the requirement for consultation with indigenous people during the development of TAPs. The preparation of a threat abatement plan under the TSC Act ‘must consider any special knowledge or interests that indigenous people may have in the species, population or ecological community concerned, along with appropriate measures to address them’. Actions have been established to address this requirement and these are outlined in Chapter 6.

Other amendments to the TSC Act relevant to this TAP are the inclusion of species, populations and ecological communities not currently threatened that could become threatened. Under the amendments ecological communities will be able to be nominated, listed and categorised as vulnerable as well as threatened, however the vulnerable category has not yet been proclaimed or enacted.

### **2.2.3 Pesticides Act**

---

The *Pesticides Act 1999*, administered by the Department of Environment and Conservation (Environment Protection and Regulation Division), regulates the use of pesticides (e.g. herbicides, insecticides and fungicides) in New South Wales. Under the

Pesticides Act it is illegal to possess, prepare or use a pesticide in New South Wales unless the APVMA (or its predecessor the NRA) has previously registered or permitted it. The Pesticides Act also makes it an offence to use a pesticide in a way that harms any non-target animal or plant (except where reasonable precautions are undertaken or in instances where it is beyond the applicators' control).

Regulations under the Pesticides Act require all users of pesticides in New South Wales to keep and retain detailed records on pesticide usage (including the chemicals used, rate used, application method, weather/wind conditions, monitoring of spray drift, applicator and date). An additional regulation soon to come be enacted will require all users of pesticides to attain a designated level of competency in the use, handling and storage of pesticides. Anyone who applies herbicides to control bitou bush or boneseed in New South Wales must meet the competency level established by the Act and keep the appropriate records to avoid prosecution.

#### 2.2.4 NSW National Parks and Wildlife Act

---

The NSW *National Parks and Wildlife Act 1974* (NPW Act) established the National Parks and Wildlife Service (NPWS), now part of DEC. The Parks and Wildlife Division of DEC is responsible for the care, control and management of all national parks, historic sites, nature reserves, reserves, Aboriginal areas, state game reserves, state recreation areas, karst conservation reserves and certain regional parks within New South Wales in accordance with the NPW Act. DEC is also responsible under the Act for the protection of native fauna and flora and Aboriginal relics. DEC is responsible for the administration of the TSC Act and the *Wilderness Act 1987*.

Bitou bush projects fall within the main responsibilities of the Parks and Wildlife Division of DEC under the NPW Act (i.e. education, maintenance of and scientific research with respect to preservation, protection and management). DEC currently undertakes education and awareness programs with respect to the impacts and management of bitou bush. The Parks and Wildlife Division also undertakes maintenance with respect to control of bitou bush on their land. In addition, DEC contributes to the statewide coordination of bitou bush management in conjunction with other agencies. Research into the effects/impacts of bitou bush on native ecosystems and threatened species, populations and ecological communities needs to be increased and the scope broadened however (see Chapter 7).

It is an offence under the NPW Act to knowingly destroy, deface and/or damage an Aboriginal site without the prior written approval of the DEC Director General. The control or management of bitou bush may in some instances impact, damage and/or destroy Aboriginal cultural heritage and therefore will require a licence. Consultation

with Aboriginal communities relating to potential impacts on Aboriginal cultural heritage related to bitou bush control and management is required and will occur during the development of site-specific management plans for each priority Bitou TAP site (see below).

### *NPW Act and weed control*

The NPW Act also requires the preparation of a Plan of Management (PoM) for each reserve managed by the Parks and Wildlife Division of DEC. The conservation of wildlife, including the conservation of threatened species, populations and ecological communities and their habitats is a goal of each PoM. Thus, a PoM provides a process for examining the occurrence and distribution of weed species, investigating management strategies and setting priorities for weed control programs. Regional weed strategies have also been developed to address weed problems over a broader area.

#### **2.2.5 Environmental Planning and Assessment Act**

---

The *Environmental Planning and Assessment Act 1979* (EP&A Act) provides the framework for the environmentally, socially and economically sound planning, use, conservation and development of land in New South Wales. The main objects of the EP&A Act that relate to the Bitou TAP are to encourage:

- ▶ protection of the environment, including the conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats
- ▶ proper management, development and conservation of natural and artificial resources... for the purpose of promoting the social and economic welfare of the community and a better environment.

The EP&A Act has specific sections which deal directly with impacts on threatened species, populations and ecological communities as well as critical habitats within New South Wales as per the TSC Act and the NPW Act. In addition, the EP&A Act has specific sections that outline the requirements for environmental impact assessments for proposed activities (e.g. control of bitou bush) under the Act. The mechanism to carry out this assessment is a Review of Environmental Factors (REF). Where a significant effect is likely or anticipated an Environmental Impact Statement (EIS) is required and in the case of threatened species, populations or ecological communities a Species Impact Statement (SIS) is also required. The Parks and Wildlife Division of DEC (and the former NPWS) has prepared a number of REFs in relation to bitou bush control activities under the EP&A Act.

## 2.2.6 Local Government Act

---

The *Local Government Act 1993* (LG Act) defines the powers, duties and functions of all local councils in New South Wales. The LG Act provides a framework for the use and management of council-managed public land (or *community* land). The LG Act requires councils to use and manage community land in accordance with a plan of management, prepared by the council. Where a threat abatement plan requires a council to implement certain measures on or in respect to community land, the plan of management must:

- ▶ state that the land, or relevant part, is affected by a threat abatement plan
- ▶ identify objectives and performance targets that take account of the council's obligations under the threat abatement plan.

In addition, local councils are required under the LG Act to control pests (including weeds) and undertake environmental conservation and protection. The control of bitou bush on council lands should be undertaken where bitou bush is declared *noxious* in accordance with the NW Act.

## 2.2.7 Protection of the Environment Operations Act

---

The *Protection of the Environment Operations Act 1997* (POEO Act) provides a framework for environmental protection in New South Wales. Under the POEO Act it is an offence to pollute water. The selection and use of herbicides should be undertaken in accordance with relevant legislation and regulations to prevent the pollution of water.

## 2.2.8 NSW Coastal Policy

---

The NSW Coastal Policy (NSW Government 1997) is a framework to manage the NSW coastal zone in an ecologically sustainable way through the balanced and coordinated management of the coast's unique physical and economic attributes. The NSW Coastal Policy is designed to coordinate coastal management across state and local governments as well as the community. The NSW Coastal Policy has nine goals, with three of relevance to the management of bitou bush:

- ▶ protecting, rehabilitating and improving the natural environment of the coastal zone
- ▶ recognising and accommodating the natural processes of the coastal zone
- ▶ protecting and enhancing the aesthetic qualities of the coastal zone.

These nine goals incorporate 138 strategic actions of which the following have direct relevance to the management of bitou bush in New South Wales:

- ▶ The implementation of State Environmental Planning Policy (SEPP) 14 (Coastal Wetlands) and SEPP 26 (Littoral Rainforests) will continue (Action 1.1.8).
- ▶ Recovery plans and TAPs will be implemented to protect coastal threatened species (Action 1.2.6).
- ▶ Threatening processes will be identified for coastal species in accordance with the TSC Act (including preparation of TAPs), and where possible controlled (Action 1.2.7).
- ▶ Coastal development proposals which pose a threat to the physical ‘well being’ of the coastline will be approved subject to conditions which minimise impacts, or rejected where they pose unacceptable threats (Action 1.4.5).
- ▶ Methods will continue to be developed and implemented to control the spread and impact of bitou bush on coastal dunes and foreshore environments (Action 1.4.8).
- ▶ Protect areas or items of high aesthetic value will be considered when preparing plans of management (Action 3.1.2).

### 2.2.9 NSW Weeds Strategy

---

The goal of the NSW Weeds Strategy is ‘a sustainable reduction in the negative impact of weeds on the economy, community, industries and environment of New South Wales’ (NSW Agriculture 1998). One outcome of the strategy is ‘the development and implementation of programs to reduce environmental degradation and the loss of biodiversity through weed invasion’. To achieve this outcome the NSW Weeds Strategy outlines seven main processes, of which four are of direct relevance to this Bitou TAP:

- ▶ implement control programs for weeds, such as bitou bush, which cause major environmental problems
- ▶ support TAPs for environmental weeds listed as threatening processes under the TSC Act
- ▶ undertake and promote research into the development and release of biological control agents for major weeds
- ▶ support community bush-regeneration projects and improve coordination and follow-up control to provide sustainable long-term benefits.

### 2.2.10 NSW Biodiversity Strategy

---

The main goal of the NSW Biodiversity Strategy (NPWS 1999a) is to ‘protect the native biological diversity of NSW and the maintenance of ecological processes and systems’.

The strategy establishes priority actions to address the major threats to biodiversity and maximise conservation benefits within New South Wales. Actions relevant to the Bitou TAP are:

- ▶ identify threatening processes and prepare and implement threat abatement plans (priority action 33)
- ▶ improve cooperative approaches to weed and pest management (priority action 39).

Priority action 33 is addressed under the TSC Act, but priority action 39 is not addressed under any other legislation, scheme or plan. Priority action 39 objectives are:

- ▶ ongoing research into methods of control of weeds
- ▶ the impacts of control programs on biodiversity and threatened species will be minimal
- ▶ community information on weeds will be improved and widely distributed.

These objectives will be addressed for bitou bush under this Bitou TAP (see Actions 6.1, 7.1 and 8.1 (research); Action 2.3 (monitoring), and; Actions 4.1 and 4.2 (community awareness and involvement), respectively).

### *NSW Biodiversity Strategy and bitou bush initiatives*

The NSW Biodiversity Strategy has funded the development of the NSW bitou bush strategy (NPWS 2001a), the recent mapping of bitou bush in New South Wales (see Thomas and Leys 2002), as well as part of the development of this TAP.

#### **2.2.11 Strategies to manage bitou bush in New South Wales**

---

There are many strategies to manage bitou bush in New South Wales. A summary of the main strategies is presented below.

##### *NSW bitou bush strategy*

The NSW bitou bush strategy (NPWS 2001a) aims to deliver a coordinated and strategic approach to bitou bush management in New South Wales, irrespective of land tenure, by:

- ▶ preventing the further introduction and spread of bitou bush
- ▶ minimising the adverse impacts of bitou bush on biodiversity
- ▶ expanding the commitment to the management of bitou bush across all sectors (e.g. governments, community and private).

The strategy provides a framework for the development of regional and local management plans, which direct on ground action. One of its key actions is the preparation of a threat abatement plan for bitou bush in New South Wales.

*NSW North Coast bitou bush strategy*

The NSW North Coast bitou bush management strategy (Scanlon 2001) has been prepared by the North Coast Weeds Advisory Committee to coordinate bitou bush control by a number of stakeholders including community groups. This strategy has three objectives:

- ▶ coordinate management between stakeholders and compile all relevant information
- ▶ raise community awareness and involvement
- ▶ implement on-ground integrated management.

In addition to the strategy, the North Coast Weeds Advisory Committee is required by the NSW Noxious Weeds Advisory Committee (NWAC) to prepare Regional Management Plans (RMP) for all noxious weed species in their region in accordance with the NW Act. These RMPs outline the actions and responsibilities of stakeholders for noxious weed control within a given time frame. They are also the mechanism by which local control authorities (LCAs) obtain funding for noxious weed control from the NSW Government's Noxious Weeds Fund.

*NSW South Coast bitou bush strategy*

The Southern Tablelands and South Coast Noxious Plants Committee has prepared the NSW South Coast regional bitou bush strategy (see Broese and Wolfenden 2002) to coordinate bitou bush control by a number of stakeholders including community groups. The strategy sets out four regional priorities:

- ▶ prevent the further introduction and spread of bitou bush
- ▶ give high priority to control in lightly infested areas
- ▶ reduce adverse impacts of bitou bush on biodiversity, aesthetic and recreational value of public lands
- ▶ support concerted control programs that result in shifting the southern containment line north.

In addition, the NWAC requires the preparation of an RMP for all noxious weed species.

*Local government strategies*

Seven North Coast councils or LCAs (*viz.* Greater Taree, Hastings, Great Lakes, Kempsey, Bellingen, Nambucca, Port Stephens) have developed local bitou bush management strategies (see Port Stephens Coastal Weed Action Group 1997; Gerrand 2000). These strategies:

- ▶ identify the levels of bitou bush infestation in the local government area
- ▶ highlight significant environmental features

- ▶ identify control priorities which reflect environmental significance, heritage values and visual amenity
- ▶ provide appropriate control mechanisms and propose key actions and time frames to facilitate on-ground action.

Other councils are in the process of developing bitou bush management plans (e.g. Tweed Shire Council and a plan for Sydney encompassing several councils).

#### **2.2.12 Other NSW legislation, policies, strategies and programs**

---

Many other plans and strategies have been prepared that are of relevance to the management of bitou bush in New South Wales, e.g. the plans of management (PoM) for specific reserves or sites (e.g. the PoMs for Bundjalung NP, Broadwater NP and Iluka NR (NPWS 1999b)). In recent years such plans have changed the management focus from specifically targeting one weed species (e.g. bitou bush) to managing weeds in the context of habitat restoration (i.e. the control of numerous weeds at once, see Joseph 1995). The realisation that the control of one species may pave the way for the invasion by other weed species aided this change. These approaches to weed management are discussed in more detail in Chapter 5.

## 3 The biology and ecology of bitou bush and boneseed

---

### 3.1 Plant descriptions and biology

---

The genus *Chrysanthemoides* (Asteraceae) has two species, both of which are endemic to South Africa. The species *C. monilifera* has six subspecies, all described on the basis of fruit shape. Two of these, subsp. *rotundata* (DC.) T. Norl. (bitou bush) and subsp. *monilifera* (L.) T. Norl. (boneseed), were introduced to Australia, where they have subsequently become major environmental weeds (Weiss *et al.* 1998). The two subspecies are capable of hybridising to produce fertile plants with intermediate characteristics (Weiss *et al.* 1998). The fruit of *Chrysanthemoides* is different from that of other members of the Asteraceae, being a fleshy drupe which is readily dispersed by animals, in contrast to other members of the Asteraceae which are dispersed by wind. Dispersal of fruits by animals can lead to greater dispersal distances than wind alone and faster dispersal/invasion rates (Smith 2000).

#### 3.1.1 Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*)

---

Bitou bush is a perennial, fast growing semi-succulent, spreading or somewhat prostrate woody shrub, 1–3 m high and 2–6 m wide, with long stems that lie along the ground or over other vegetation. These almost prostrate stems have erect ends. This decumbent habit is accentuated if a plant grows under shade, where stems may reach more than 10 m, giving it the appearance of a creeper rather than a shrub. The leaves are entire or slightly toothed, bright green, glossy, broadly oval shaped, 3–8 cm long. The leaves and stems of juvenile plants are typically covered with cobweb like hairs. The inflorescences are a compound head of tiny male and female flowers, surrounded by 11–13 bright yellow floral bracts or ligulate. The fruits when mature are black, <10 mm in length and contain a single egg-shaped seed, 5–7 mm in length. The seeds have a hard bone-like testa or seed coat. Up to 13 fruits are produced per inflorescence (Weiss *et al.* 1998; Vranjic 2000).

The age at sexual reproduction (flowering) varies, but on average is 2–3 years after germination. In northern NSW however, seedlings may flower within their first year. In mature plants, flowering occurs during April–July, with flowers occasionally present all year round. Peak seed production generally occurs during June–September (Weiss *et al.* 1998; Vranjic 2000). Initial seed dispersal occurs either by fruit falling off the parent plant or by animals ingesting the fruits and either defecating or regurgitating viable seeds in a different location. The latter can result in long distance dispersal events. Dispersal agents are typically birds (e.g. honeyeaters, currawongs and pigeons (Dodkin and Gilmore 1984)) and mammals (e.g. foxes (Meek 1998)). Following the initial dispersal, seeds can be re-dispersed through mechanisms such as wind, water, vehicles and the transportation of soil.

Once mature, an individual bitou bush plant can produce up to 48,000 seeds in a year (Weiss *et al.* 1998). Seed dormancy is short, i.e. several years, but, the maximum dormancy period is unknown, as are the mechanisms of seed dormancy. Seed viability (the ability of a seed to germinate) decreases with seed age; viability is very low in seed that is four or more years old (Vranjic 2000). Anecdotal evidence suggests that some seeds may remain viable for up to 10 years (Holtkamp *pers. comm.*). The soil seed bank beneath mature infestations ranges from 2,000 to 5,000 seeds/m<sup>2</sup> (Vranjic 2000).

Seed germination occurs throughout the year, mainly following rainfall. Other factors known to promote germination are fire, exposure of seeds to heating (e.g. temperatures of 60°C), removal of the seed coat and seed age (Weiss *et al.* 1998). The response of bitou bush to fire is influenced by the fire conditions. For example, moist soils can limit the soil temperatures attained during a fire, which directly influences the level of seed mortality and heat-stimulated germination that occurs (Downey 1999). Seed germination occurs from depths of up to 8 cm (majority up to 5 cm) in the absence of soil disturbance (Vranjic 2000).

Bitou bush can tolerate water-logged soil conditions in some instances (e.g. it can invade the edges of swamps and wetlands), salt spray and mild frosts. Following fire or mechanical damage (e.g. cutting), plants have the ability to regenerate from adventitious buds at the base of the plant or along the stems. Vegetative reproduction occurs when the prostrate stems are buried by soil or sand (Weiss *et al.* 1998).

### 3.1.2 Boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*)

Boneseed is a perennial, fast growing semi-succulent, erect woody shrub, 1–2 m wide and 1–3 m high (rarely to 6 m). The leaves have toothed margins and are dull green, more or less broadly obovate, and 5–7 cm long. Juvenile growth is typically covered by cobweb like hairs. The inflorescences are a compound head of tiny male and female flowers, surrounded by 5–8 (mostly 5–6) bright yellow floral bracts or ligulate. The fruits when mature are black, <10 mm in length and contain a single globular bone-coloured seed, 6–7 mm in length. The seeds have a hard bone-like testa or seed coat. Up to 8 fruits are produced per inflorescence (Weiss *et al.* 1998; Adair and Ainsworth 2000).

The average age at sexual reproduction (flowering) is 18–24 months after germination (Weiss *et al.* 1998; Adair and Ainsworth 2000). In mature plants, flowering peaks during August–October and fruiting peaks during November–January. Initial seed dispersal occurs either by fruit falling off the parent plant or by animals ingesting the fruits and either defecating or regurgitating viable seeds in a different location. The latter can result in long distance dispersal events. Dispersal agents are birds and mammals (Adair and

Ainsworth 2000). Following the initial dispersal, seeds can be re-dispersed through mechanisms such as wind, water, vehicles and the transportation of soil.

Once mature, an individual boneseed plant can produce up to 50,000 seeds per year (Weiss *et al.* 1998). Seed dormancy is short, i.e. several years, but the maximum dormancy period is unknown, as are the mechanisms of seed dormancy. Seed viability decreases with seed age; viability is very low in seed that is three or more years old, with a low percentage remaining viable for up to 10 years (Weiss *et al.* 1998). The soil seed bank beneath mature infestations ranges from 800 to 3,000 seeds/m<sup>2</sup> (Adair and Ainsworth 2000).

Seed germination occurs mainly in autumn, although germination can occur at other times following rainfall. Other factors known to promote germination are fire, heating of the seeds, removal of the seed coat, and seed age, weathering of seeds, and ingestion by animals (Adair and Ainsworth 2000). Seed germination occurs from depths of up to 8 cm (majority up to 5 cm) in the absence of soil disturbance (Weiss *et al.* 1998).

Boneseed is fire-sensitive (i.e. is killed by fire), intolerant of water-logged soil conditions, tolerant of salt spray and mild frosts. It is short-lived (10–20 years). It has a shallow root system and unlike bitou bush, is not capable of vegetative reproduction (Adair and Ainsworth 2000).

## **3.2 Bitou bush and boneseed as environmental weeds**

---

*Chrysanthemoides monilifera* is an environmental weed in Australia, New Zealand, France, the Islands of St. Helena (South Atlantic Ocean) and Sicily (Weiss *et al.* 1998).

### **3.2.1 Arrival and spread of bitou bush in Australia**

---

The exact date of arrival of bitou bush to Australia is unknown. The first known record is a herbarium specimen dated 1908, collected from the Stockton area near Newcastle in New South Wales. It is thought that this infestation originated from ballast carried from South Africa (see references in Weiss *et al.* 1998).

From 1946–1968, bitou bush was deliberately planted by the NSW Soil Conservation Service to stabilise sand dunes along the NSW coast. It was also planted along the northern NSW coast to stabilise and revegetate coastal sand dunes after they were mined for rutile and zircon (Barr 1965). Bitou bush was recommended as one of several useful secondary stabilisers for use following such mining operations (Barr 1965).

The main areas where bitou bush was deliberately planted include Ballina, Byron Bay, Crescent Head, Diamond Head, Hastings Point, Iluka, Lake Munmorah, Mylestom, Port Macquarie, Redhead, The Entrance and Tweed Heads. Bitou bush was also planted to stabilise sand dunes near Broken Hill and Menindee in western New South Wales (see references in Weiss *et al.* 1998). It was also introduced to Lord Howe Island, the first record of which was in 1968 near the dump; today there are about 1,500 plants scattered across the north and east of the island (e.g. Neds Beach and Middle Beach).

Currently bitou bush occurs along most of the NSW Coast, with the densest infestations in the north of the state (NPWS 2001a). It also persists around Broken Hill and Menindee, as well as on Lord Howe Island. Outside New South Wales it occurs in coastal areas from the Qld/NSW border to Hervey Bay, on a number of offshore islands in Queensland, and at a limited number of sites in Victoria.

A comprehensive survey of the distribution of bitou bush in New South Wales in 1981–82 showed that 660 km of the NSW coastline was infested (Love 1984). Of the area surveyed, bitou bush was the dominant plant along approximately 220 km. The NSW coast was re-surveyed in 2000–01, revealing that the length of coastline infested had increased to 900 km (80%), of which bitou bush was the dominant plant along approximately 400 km (36%) (Thomas and Leys 2002). With a few exceptions, bitou bush occurs continuously from the Shoalhaven River north to the Queensland border; most of the north coast being heavily infested. South of the Shoalhaven River to Batemans Bay, areas free of bitou bush are interspersed with heavy infestations. South of Batemans Bay, bitou bush only occurs in isolated disjunct infestations. The survey undertaken in 2000 (see Thomas and Leys 2002) estimated that more than 36,000 ha of private and public land in New South Wales were infested with bitou bush. Of this area 6,700 ha was heavily infested (bitou bush dominant), 9,000 ha was infested at a medium level (bitou bush present but not dominant) and 20,100 ha had light infestations (scattered plants). In addition, the survey recorded bitou bush up to 10 km inland. A map of the density of bitou bush in New South Wales is presented in Appendix 6 along with the priority sites.

### **3.2.2 Arrival and spread of boneseed in Australia**

---

The exact date and manner of arrival of boneseed to Australia is unknown. The first known record is from a Sydney garden in 1856. The first known locations elsewhere in Australia include Melbourne 1858, Adelaide 1892, Ulverstone (Tasmania) 1931 and Perth 1948 (Weiss *et al.* 1998). Since its introduction, boneseed has been cultivated widely in most states. The majority of the present day infestations can be attributed to escapes from gardens and nurseries (Adair and Ainsworth 2000). Today, boneseed is wide spread in South Australia (Mt Lofty Ranges), Victoria (e.g. the Mornington Peninsula, the You

Yangs, Ottways NP, Dandenong Ranges NP and near Wimmera) and Tasmania (parts of the East Coast), with small infestations in Western Australia near Perth. In New South Wales, boneseed occurs in coastal areas from the Hunter River southwards, as well as in south-west New South Wales (e.g. Dareton). Additional scattered infestations occur on the Central Coast, where it usually grows together with bitou bush in non-dunal areas, and in the Sydney Metropolitan Area, where dense infestations are found on clay soils along railway corridors.

### 3.2.3 Invasion by bitou bush and boneseed

---

Bitou bush and boneseed possess a range of attributes that contribute to their invasiveness and ability to compete: rapid growth (including seedlings), a range of growth forms (bitou bush: shrub or creeper), the capacity to grow in a wide variety of habitats, high fecundity, various vectors for seed dispersal (particularly vertebrates) and seed dormancy. These attributes do not always result in invasion or species dominance however.

Some native species have the ability to persist despite bitou bush's vigorous growth rate and dominance. For example, bitou bush has higher seedling vigour and greater survival at each life stage than the native shrub coastal wattle (*Acacia longifolia* subsp. *sophorae*) (Weiss *et al.* 1998; Vranjic *et al.* 2000), which nonetheless persists in bitou bush infested areas.

Bitou bush and boneseed, like many invaders, have an increased capacity to invade due to the absence of their natural predators. Recently biological control agents have been released to address this. The lack of natural predators, and deliberate plantings to stabilise sand dunes and remediate sand mining sites, has increased the dominance and spread of bitou bush and boneseed in Australia.

### 3.2.4 Habitats invaded by bitou bush and boneseed

---

Both subspecies of *C. monilifera* have the ability to grow in a range of habitats, where they have invaded various ecological communities. Bitou bush occurs in coastal ecosystems containing fore-dune grasslands, dune scrub, dune forests/woodland, open and closed heaths and littoral rainforests (Dodkin and Gilmore 1984). Boneseed occurs in coastal woodlands, shrublands and open forest, dry and wet sclerophyll forests, foothills, open forest, woodlands and mallee (Adair and Ainsworth 2000). Bitou bush and boneseed both occur in coastal regions in their native South Africa, with boneseed occurring on the east and south-east coasts and adjacent mountains, while bitou bush is restricted more to coastal areas in the east (see Weiss *et al.* 1998).

## 4 **The impact of bitou bush and boneseed invasions**

---

The impacts of bitou bush and boneseed invasions on biodiversity are outlined below, however it is also important to discuss their impacts on the aesthetic value of coastal landscapes (e.g. sand dunes, beaches and headlands). Through the formation of a dense shrub layer, these plants can obscure entire sand dunes, converting picturesque coastal landscapes into significant weed infestations. In many areas, pristine beaches (and adjacent dunes and coastal vegetation) have been covered with dense infestations of bitou bush.

### 4.1 **Bitou bush and boneseed invasions and biodiversity**

---

Biodiversity encompasses three levels: genetic diversity, species diversity and ecosystem diversity (Commonwealth of Australia 1996; TSC Act). Scientists and governments concur that biological invasions are one of the greatest threats to biodiversity globally (IUCN 2000). Plants that invade native ecosystems can have devastating impacts on biodiversity, although the level of such impacts has rarely been quantified (Adair and Groves 1998).

The extent of the impact of bitou bush on biodiversity across its range is poorly documented. Information is available on the impacts of bitou bush on biodiversity for a few species of plants (Weiss and Noble 1984a, b; Matarczyk 1999; Vranjic *et al.* 2000), vertebrates (French and Zubovic 1997; Gosper 1999; Gosper *et al.* in preparation) and insects (French and Eardley 1997).

Despite recent information (see above), many assumptions are made as to the extent of the impacts across a broader range of species. For example, bitou bush impacts on the other plant species present through increased competition, shade and litter level. Objective data quantifying the impacts are lacking, especially with respect to the impacts on entire communities (see Dodkin and Gilmore 1984; Vranjic 2000). Insufficient data with respect to bitou bush invasions has long been acknowledged (Dodkin and Gilmore 1984) and this lack influenced the development of some aspects of this TAP. Research to address the lack of information forms key actions in this TAP (see Chapters 6 and 7). Despite this lack of quantitative data, bitou bush has been assessed as a threat to several species listed on the TSC Act, leading to its listing as a KTP (NSW SC 1999a).

In New South Wales very little has been documented on the distribution, abundance and impact of boneseed. Data from elsewhere in Australia (Weiss *et al.* 1998; Adair and Ainsworth 2000) suggests that boneseed could pose a similar problem in New South Wales to bitou bush if it was to increase dramatically. Due to the low levels of boneseed

in New South Wales, Section 4.2 deals exclusively with bitou bush and further discussions on boneseed are presented in Chapter 5.

#### 4.1.1 Disturbance and bitou bush and boneseed invasions

---

Historically there is a common assumption that weeds only invade following some form of disturbance, and this assumption has been applied to bitou bush and boneseed in the past. It is based on the idea that disturbance events create new resources or opportunities for invaders. Many studies have illustrated that disturbance is a precursor to weed invasion (Elton 1958; Hobbs 1991; Hobbs and Huenneke 1992; D’Antonio *et al.* 1999), however recent evidence suggests that for invasion to occur, the invading plant species must be able to utilise these resources more effectively than existing native species (Davis *et al.* 2000).

Evidence is now mounting that for a wide range of species disturbance is not necessary for invasion to occur (Weeda 1987; Rejmánek 1989; Daehler and Strong 1996; Ehrenfeld 1997; Pemberton 1998; Downey and Smith 2000; Williams *et al.* 2001; Downey 2002), thus disputing the well entrenched assumption. Invasion in the absence of disturbance (Dodkin *pers. comm.*) has also been noted for bitou bush/boneseed, however no objective scientific data are available regarding how this process occurs.

It is extremely important to understand how alien plants affect ecosystems once they invade. The main way alien plants impact upon biodiversity is through the modification of pre-invasion disturbance regimes (Mack and D’Antonio 1998). Modification of disturbance regimes often has a greater impact on biodiversity than the invasion itself (Mack and D’Antonio 1998). Knowledge of these modifications is lacking however, as is the understanding of how these modifications impact upon the invaded communities. An alien species has the potential to modify the disturbance regime in more than one way (e.g. Scotch broom can enhance soil disturbance by encouraging the actions of feral pigs and alter fire behaviour (see Downey 2002)), the impact of which is different for each type of disturbance. The ability of bitou bush or boneseed to modify disturbance regimes is unknown, however its ability to respond to fire, in terms of increased germination and rapid seedling growth rates may have led to substantial vegetation changes, as observed in Yuraygir NP (Thomas *pers. obs.*). These changes may in turn promote fire or result in greater changes following fires. Similar observations have been made for boneseed in the You Yangs, Victoria, following experimental fires (Melland *pers. comm.*).

## 4.2 Threatened species, populations and ecological communities

---

Given the lack of information and the need to determine plant species, populations and/or ecological communities at risk from bitou bush invasion in New South Wales, the distribution of bitou bush and all plants in New South Wales were matched for the purposes of this TAP. ArcView Geographic Information System (GIS) software was used. The distribution of bitou bush collected during the latest survey (see Thomas and Leys 2002 for methods) was matched with flora records contained within the NPWS Atlas of NSW Wildlife (incorporating the Royal Botanic Gardens (RBG) database of scheduled threatened species). The flora dataset was supplemented with information from published literature, local knowledge from individuals or community groups working in areas infested with bitou bush, and site inspections. The impacts on animal species are discussed in Chapter 7.

The data derived from the distribution GIS analysis showed a total of 850 plant species, spanning 151 families, occurred within the bitou bush infested areas of New South Wales. Of these, 52 species were listed as either endangered or vulnerable under the Commonwealth EPBC Act or the NSW TSC Act, thirty of which were considered to be threatened by bitou bush.

Sixty-four species not covered by threatened species legislation occurring within the distribution of bitou bush in New South Wales were also classified as threatened because they were:

- ▶ on the Rare Or Threatened Australian Plants (ROTAP: Briggs and Leigh 1996) list
- ▶ on the Australian Threatened Flora list (ANZECC 1999)
- ▶ listed by Sheringham and Westaway (1995)
- ▶ referred to as threatened in other publications
- ▶ deemed to be threatened in the opinion of recognised botanists or land managers due to limited or a reduced distribution or where a direct threat was identified.

Thirty-three of these additional species were deemed to be threatened by bitou bush, giving a total of sixty-three threatened species (formally listed as threatened or likely to become listed as threatened).

The species identified as under threat from bitou bush were ranked using the model developed for this TAP (see Appendix 2). A list of the species considered, along with their ranks and scores, is given in Appendix 3 (Table A3.1). Eleven species were deemed to be high priority (see Table 4.1), 22 medium priority and 30 low priority. An additional 76 species could be threatened by bitou bush but lacked sufficient information to be modelled. These species are presented in Appendix 3 (Table A3.2). The 11 high priority species are described in detail below, along with the other threats present.

In addition to these threatened species, two threatened populations and eight endangered ecological communities (under the TSC Act) occurred within the distribution of bitou bush in New South Wales, all of which were given a high priority (Table 4.1).

**Table 4.1** High priority threatened plant species, populations and ecological communities for bitou bush control (alphabetical order) as determined using the model (see Appendix 3 for individual rankings).

<b>Threatened Entity</b>	<b>Threatened Status</b>	<b>Recovery Plan</b>
<b>Species</b>		
<i>Acacia terminalis</i> subsp. <i>terminalis</i>	endangered (EPBC Act & TSC Act)	no
<i>Acronychia littoralis</i>	endangered (EPBC Act & TSC Act)	no
<i>Chamaesyce psammogeton</i>	endangered (TSC Act)	no
<i>Diuris praecox</i>	vulnerable (EPBC Act & TSC Act)	no
<i>Fontainea oraria</i>	endangered (EPBC Act & TSC Act)	yes & in prep. <sup>1</sup>
<i>Gleichenia mendellii</i>	rare (expert opinion)	no
<i>Pimelea spicata</i>	endangered (EPBC Act & TSC Act)	early prep.
<i>Plectranthus cremnus</i>	ROTAP (3K)	no
<i>Senecio spathulatus</i>	endangered (TSC Act)	no
<i>Sophora tomentosa</i>	endangered (TSC Act)	no
<i>Zieria prostrata</i>	endangered (EPBC Act & TSC Act)	yes
<b>Populations</b>		
<i>Glycine clandestina</i> (broad leaf form)	endangered (TSC Act)	no
<i>Zieria smithii</i> (low growing form)	endangered (TSC Act)	no
<b>Ecological Communities</b>		
Eastern Suburbs Banksia Scrub	endangered (EPBC Act & TSC Act)	draft released
Kurnell Dune Forest	endangered (TSC Act)	no
Littoral Rainforest	SEPP 26 <sup>2</sup>	some <sup>3</sup>
Sutherland Shire Littoral Rainforest	endangered (TSC Act)	no

<sup>1</sup> A recovery plan was written by Hunter *et al.* (n.d.) and revised plan is being prepared by DEC

<sup>2</sup> Not all littoral rainforests are classified as SEPP 26, particularly those which occur within conservation reserves. SEPP 26 classification also includes a 100 m buffer zone.

<sup>3</sup> Management or non-statutory recovery plans exist for a few individual rainforests or wetlands.

#### 4.2.1 High priority threatened species

Information is provided below for each of the high priority species, as determined by the model (see Appendices 2 and 3), presented in alphabetical order. All species descriptions were extracted from Harden (1991–2002).

***Acacia terminalis* subsp. *terminalis* (Salisb.) J.F. Macbr. (Mimosaceae)**

*Acacia terminalis* subsp. *terminalis* (sunshine wattle) is a bipinnate shrub 1–5 m in height. It grows in scrub and dry sclerophyll woodlands between Botany Bay and the northern foreshore of Port Jackson and is now known from only 13 locations. Seven locations are in Sydney Harbour NP, three in council reserves and three on land potentially subject to development. Some of these populations consist of only a single plant (Hirschfeld *pers. comm.*). In the eastern suburbs of Sydney the subspecies has been lost from many locations due to development. The risk posed by bitou bush is not high due to its preference for sandstone habitats in dry sclerophyll forest, however further surveys are needed at all sites to establish the degree of threat bitou bush poses. Weeds (including bitou bush and boneseed) are known to threaten several populations, e.g. bitou bush at Bunnerong Road, and boneseed (and other weeds) at Sydney Harbour NP (south side). Bush regeneration programs at some of the sites have reduced the abundance of bitou bush and its impact on this species, as well as the threat of other weed species, at least in the short term.

***Acronychia littoralis* T. Hartley & J. Williams (Rutaceae)**

*Acronychia littoralis* (scented *Acronychia*) is a small tree to 6 m in height, which grows in littoral rainforests on sandy soils, between Sea Acres NR (Port Macquarie) and Cooloola NP (Qld). This species is often confused with other *Acronychia* species. Populations typically contain few individuals, despite the appearance of many more individuals, because plants are often connected to one another via their roots. Recent genetic analysis suggests two distinct forms: one with bigger glossy leaves and fertile fruits, and the other a non-fruiting plant with smaller leaves which occurs in clonal stands (Hunter *pers. comm.*).

There are 59 known locations for *Acronychia littoralis*, 26 of which are in conservation reserves (NSW NPWS n.d.). Nine of the known locations are infested with bitou bush: Cudgen NR and to the north (heavy infestation); South Golden Beach (light infestation – private property); Bongil Bongil NP (2 locations – light and medium infestations); Pelican Point (Point Macquarie: SEPP 26 No. 107 – light to heavy infestation); Hat Head NP (Smoky Cape: 3 locations – light infestations); Limeburners Creek NR (Big Hill: heavy infestation); Brunswick Heads NR (heavy infestation); and Byron Bay (recent record (Murray *pers. comm.*)). Threats to *A. littoralis* include fire, weed invasion (including bitou bush), road works, 4WD usage and habitat clearing (NSW NPWS n.d.; NPWS 2000b).

***Chamaesyce psammogeton* (P.S. Green) P.I. Forst & R.J.F. Hend.  
(Euphorbiaceae)**

*Chamaesyce psammogeton* (synonyms: *Chamaesyce sparrmani*, *Euphorbia sparrmani*) is a prostrate perennial herb that forms mats to 1 m in diameter. It grows on incipient foredunes in *Spinifex hirsutus* communities, and exposed headlands, as well as on the beach aspect of the foredune with a range of herbs, vines, shrubs and grasses. It occurs sporadically north from Jervis Bay into Queensland, as well as on Lord Howe Island. Some botanists considered it to be in danger of extinction (Clarke and Carolin 1991) and the final determination was based on the fact that it was formerly widespread and is now only known from a few small populations (see NSW SC 1998a). A comparison of present and historical records in New South Wales showed that it had disappeared from some areas (e.g. Sydney: Heyligers 1998). Despite this, new populations have been recorded (e.g. Yuraygir NP: Flower and Clarke 2001). The majority of the records in the NPWS Atlas of NSW Wildlife are from one survey (see Clarke 1989), which suggests that the exact status of this species can only be determined through a targeted survey.

Bitou bush is one of the main threats to *C. psammogeton* (i.e. by growing over it due to its prostrate habit and preference for sand dunes). Populations on the seaward edge of incipient dunes are less threatened, as bitou bush rarely establishes in these areas. These populations are threatened by other factors however (e.g. beach erosion and the removal of habitat). Populations at Wamberal Lagoon NR, Myall Lakes NP, Booti Booti NP, Yuraygir NP (between Minnie Waters and Sandon) and Bundjalung NP (Middle Bluff) are all at risk from bitou bush invasion. The other sites recorded by Clarke (1989) need to be revisited to establish if the species is still present, and if so, the threat posed by bitou bush.

***Diuris praecox* D.L. Jones (Orchidaceae)**

*Diuris praecox* is a terrestrial orchid which occurs in dry sclerophyll forest between Nelson Bay and Ourimbah. There are a total of 13 records on the NPWS Atlas of NSW Wildlife and Royal Botanic Gardens databases. Recently an additional location was discovered at Tomaree Peninsula, Nelson Bay. Five of the database records occur within bitou bush infestations: Glenrock SRA (four records – medium infestations) and Crackneck Lookout, Wyrabalong NP (medium–heavy infestations). A bush regeneration program has started at Glenrock SRA to remove bitou bush from *D. praecox* habitat but this needs to be maintained and expanded. Bitou bush and lantana have been controlled at Crackneck and these programs also need to be maintained and expanded.

***Fontainea oraria* Jessup & Guymer (Euphorbiaceae)**

*Fontainea oraria* (Coastal fontainea) is a dioecious shrub or small tree to 5 m in height which grows as part of the regrowth of inner edges of littoral rainforest. It is known from only one location near Lennox in northern New South Wales, on a basaltic headland within 1 km of the ocean. It is not known within conservation reserves (NPWS 1999c). This population supports only 10 mature trees, of which one or two are known to bear fruit (NPWS 1999c). Other populations may exist but suitable habitat appears limited (Hunter *et al.* n.d.). Threats include development, recreational use of the area, salt dieback, competition from weeds, trampling of seedlings, seed removal by plant collectors, exposure to sea-winds and possibly fire (Hunter *et al.* n.d.). While bitou bush is not mentioned by Hunter *et al.* (n.d.) as being present, bitou bush does occur in the region and is known to invade littoral rainforests, particularly the edges.

***Gleichenia mendellii* (G. Schied.) S.B. Andrews (Gleicheniaceae)**

*Gleichenia mendellii* is a terrestrial rhizome long-creeping fern. It grows in and around swamps, drainage lines, sheltered vertical faces of permanently moist coffee rock and along creek banks of coastal lowlands north from Minnie Water into Queensland. This is a recently described species. Its distribution is disjunct, with the main populations occurring in Bundjalung NP and smaller populations in Yuraygir NP, Dirrawong Reserve and Minnie Water Foreshore Reserve. Bitou bush threatens some populations, especially those in non-water logged sites where bitou bush grows less readily. In addition, bitou bush may occupy habitats which could otherwise provide connectivity of the disjunct populations. There is some suggestion that the control of bitou bush in more exposed areas close to the sea may lead to salt spray damage to *G. mendellii* (see NPWS 2001d), but this needs further investigation. Other threats include fire, abiotic factors like decreased moisture levels, and potentially aerial herbicide application as used to control bitou bush (Flower *pers. comm.*).

***Pimelea spicata* R. Br. (Thymelaeaceae)**

*Pimelea spicata* is a small spreading or erect shrub to 50 cm in height which occurs in two disjunct areas: the Cumberland Plain (near Penrith) and coastal regions around the Illawarra (Landsdowne to Shellharbour). There are 42 known sites (NPWS 2000a) which occur on Commonwealth, state, local government and private land. In the Illawarra area it grows in grassland or open woodlands on coastal headlands and hill tops (NPWS 2000a).

Records from the NPWS Atlas of NSW Wildlife show that *P. spicata* occurs in many areas affected by bitou bush infestation, including: Mt Warrigal; Mahoneys Bay, Bass Point Reserve; Blackbutt Reserve; Killalea State Park; and Black Point, Gerroa and

Minnamurra Headland. *Pimelea spicata* was not found at the Shellharbour site (NPWS 1993) and may be locally extinct. This site is heavily infested with bitou bush.

Several sites need to be surveyed to determine the threat posed by bitou bush. Threats include altered fire regimes, weed invasion (including bitou bush) land clearing and disturbance. The weed species other than bitou bush that are a threat include kikuyu (*Pennisetum clandestinum*), lantana (*Lantana camara*) and blackberry (*Rubus* sp.). Some methods used to control these weeds can also pose a threat to *P. spicata*. Competition from bitou bush (and kikuyu) resulted in significant reductions across a range of growth responses of *P. spicata*, when compared with competition from the native kangaroo grass (*Themeda australis*) alone (Matarczyk 1999). At Mahoneys Bay and Black Point, *P. spicata* plants are covered prior to applications of herbicide to control bitou bush, as they are sensitive to glyphosate based herbicides (see Matarczyk *et al.* 2002).

#### ***Plectranthus cremnus* Conn (Lamiaceae)**

*Plectranthus cremnus* is a compactly branched, prostrate to decumbent aromatic herb, growing to 30 cm in height and spreading to 2 m across. The white-blue purple flowers are present all year as are the dry fruits. *Plectranthus cremnus* grows in shallow sandy soils that have been deposited by wind into the crevices of coastal headlands where it is rare. *Plectranthus cremnus* is also reported to occur in dunes (including stabilised dunes). The species only occurs on the north coast of New South Wales from Lennox Head to the Kendall district, where it is restricted to a small number of sites. *Plectranthus cremnus* occurs in Hat Head NP, Bundjalung NP, Yuraygir NP and Cape Byron NR, with locations on Crown land at Lennox Head and Coffs Harbour.

Threats to *P. cremnus* include trampling from beach goers and weed invasion (including bitou bush). The stabilisation of sand by bitou bush may also reduce the level of wind blown material that can lodge into headland crevices and provide suitable substrate and habitat for *P. cremnus*. In addition, bitou bush grows over many headlands, potentially occupying suitable habitats. As the species flowers all year round it may be damaged by aerial application of herbicide to control bitou bush because it is physiologically active at all times (NPWS 2001d).

#### ***Senecio spathulatus* A. Rich (Asteraceae)**

*Senecio spathulatus* is a prostrate perennial herb with ascending or erect ends 15–50 cm in length. A recent taxonomic revision incorporated *S. anacampserotis* DC into this species (see Walsh and Entwisle 1999). *Senecio spathulatus* occurs on seashores from Eden, Victoria to Myall Lakes NP. Recent botanical surveys did not observe it between Nadgee and Sydney however (McDougall *pers. comm.*). Herbarium specimens were

collected in the 1980s from Mungo Corner, Myall Lakes NP, Fingal Spit, Port Stephens, Connell Hill, Kurnell and Cronulla Recreation Reserve. Bitou bush is present at all of the locations documented in the 1980s. Control programs are in place in the Kurnell–Cronulla area. Information on the impact of bitou bush and the infestation level at many of these locations is required, as well as a determination of the threats present.

### ***Sophora tomentosa* L. (Fabaceae)**

*Sophora tomentosa* is a shrub or small tree to 5 m in height, which grows in sand on frontal coastal dunes or along the seashore. Field observations also indicate that this species prefers coarse sands on the ends of beaches (e.g. Woody Head, Bundjalung NP, Shelley Beach, Port Macquarie) or at the base of headlands (e.g. Woolgoolga Headland), or protected areas adjacent to creeks or intermittently open lagoons draining across beaches (e.g. Sandon River). It occurs north from Port Macquarie into Queensland and Papua New Guinea. Historically it occurred as far south as Port Stephens. Several populations are now thought to be extinct. One of the main threats in New South Wales is from bitou bush invasion (i.e. competition with adults and seedlings). Bitou bush control programs at several locations (e.g. Casuarina Beach, Woody Head, Sandon River, Sandon Bluffs, Woolgoolga Beach, Woolgoolga Headland, Park Beach, Sea Acres) in the last few years have reduced the immediate threat to known individuals. Several other populations, currently do not have bitou bush control programs (e.g. the Wooli and Sandon populations).

### ***Zieria prostrata* J.A. Armstrong (Rutaceae)**

*Zieria prostrata* is a small multi-stemmed prostrate shrub 0.5–1 m in diameter which forms a low mat. It occurs on exposed headland sites in low coastal heath. In more sheltered aspects, it grows in association with open to sparse shrublands, characterised by coast banksia (*Banksia integrifolia* var. *integrifolia*) and coastal wattle (*Acacia sophorae*) (NPWS 1998). It has a very restricted distribution and is known from only four headlands within Moonee Beach NR, 20 km north of Coffs Harbour. The four sites have approximately 1,000 plants in total. There is some genetic variation between the four sites (NPWS 1998). To maintain the full genetic diversity, all four locations need be protected.

Two recovery plans have been prepared and implemented for *Z. prostrata* (see Griffith 1992; NPWS 1998). The main threat is displacement by exotic weeds, including bitou bush, lantana and kikuyu. Bitou bush poses a major threat as it shades individual plants with its dense canopy. A pest management plan has been prepared for Moonee Beach NR. Weed control has been undertaken for many years and the immediate threat of weed invasion has been alleviated at all four sites. Bitou bush still poses a serious threat of re-

invasion and ongoing follow-up maintenance/control is required in the immediate vicinity of the four sites and in the surrounding regions.

#### 4.2.2 Endangered populations

---

##### *Glycine clandestina* Wendl. (Fabaceae) – broad leaf form (R. Pullen 13342)

*Glycine clandestina* broad leaf form (hereafter referred to as *G. clandestina* (blf)) occurs in coastal grasslands at Scotts Head on the mid-north coast. It is a distinctive form of the widespread species *G. clandestina* not found elsewhere. *Glycine clandestina* is thought to be a species complex (Harden 2002), which is a species with several distinct forms present. It is threatened by loss of its grassland habitat and from the risk of bitou bush invasion (NSW SC 2001). At present, bitou bush occurs on the margins of this grassland site and in higher densities in nearby coastal banksia vegetation. Monitoring of the population and removal of bitou bush seedlings (and adults) is currently not being undertaken (Johnson *pers. comm.*).

##### *Zieria smithii* Jackson (Rutaceae) – low growing form (or *Z. sp. aff. smithii*)

*Zieria smithii* low growing form, headland form, or *Z. sp. aff. smithii* (hereafter referred to as *Z. smithii* (lgf)) is a low growing semi-prostrate shrub similar in habit to *Z. prostrata*, unlike the type species (*Z. smithii*), which is an erect robust shrub to 2 m in height. Recent genetic work showed this taxon to be a distinct form, a headland ecotype of *Z. smithii* (Hogbin and Crisp 2003) or *Z. smithii* (lgf). The population at Diggers Head (north of Coffs Harbour) was listed as endangered because it contained <3 individual plants (NSW SC 1998d). The known threats are weed invasion from bitou bush, kikuyu (NSW SC 1998d) and lantana (Hogbin 1999). The Coffs Harbour City Council has undertaken bitou bush control at this site over the last few years.

Since the listing of *Z. smithii* (lgf) at Diggers Head as an endangered population several additional populations have been discovered. A targeted *Z. prostrata* and *Z. smithii* (lgf) survey of 51 sites (mostly headlands) from Treachery Head (near Myall Lakes) to Bare Bluff (north of Coffs Harbour) recorded *Z. smithii* (lgf) at 10 of these sites (Hogbin 1999), nine of which were new locations. The distribution of *Z. smithii* (lgf) stretches from Boomerang Point (south of Forster) to Cape Byron (Hogbin 1999). Population sizes ranged from a few to several hundred individual plants. Weed invasion (primarily bitou bush) was the main threat at the majority of these ‘new’ sites, specifically: Boomerang Point (medium–heavy infestation); Grants Headland (light infestation); Nobby Head, Port Macquarie (heavy infestation); Big Hill, south of Crescent Head (medium infestation); and the track to Connors beach, Hat Head (medium infestation). *Zieria smithii* (lgf) has

also been recorded on Cabbage Tree Island (adjacent to Tea Gardens) and at Byron Bay (Hogbin 1999). As bitou bush poses one of the major threats to these additional populations they were included in this TAP.

#### 4.2.3 Endangered ecological communities

---

##### *Eastern Suburbs Banksia Scrub (Sydney)*

The Eastern Suburbs Banksia Scrub (ESBS) is a heath/scrubland community (occasionally forming woodland or low forest) confined to aeolian sand deposits. It currently occupies <3% (137.5 ha) of its original distribution (5,300 ha). Approximately 26 hectares of the ESBS occurs in conservation reserves (Botany Bay NP, La Perouse and Sydney Harbour NP, North Head: NPWS 2003a). The remaining isolated remnants are restricted to the Eastern Suburbs region of Sydney in the LGAs of Botany, Randwick, Waverley and Manly (NSW SC 1997; 2002b; NPWS 2003a). There are 23 main sites, many of which contain several patches of scrub. Threats to the community are: fragmentation; altered nutrient, water and fire regimes; habitat loss or degradation from development; weed invasion; grazing and erosion by horses and rabbits; erosion by bicycles and motorcycles; excessive pedestrian use; seed collection; and physical damage from illegal access and dumping. A draft recovery plan for ESBS encompasses the broader range of threats (see NPWS 2003a). Bitou bush co-occurs at various densities at 13 of the 23 ESBS sites and control programs have commenced in Botany Bay NP and the NSW Golf Course (NSW Golf Club), at St Michael's Golf Course and in several smaller patches administered by Randwick Council, and on York Road.

##### *Kurnell Dune Forest (Sydney)*

Kurnell Dune Forest (KDF) is a low open sclerophyll forest community with a distinct mesophyll element. It is found on sand, often in association with areas of sclerophyll heath and scrub (NSW SC 1999b). The KDF community has been greatly reduced since European settlement. Patches occur within the Sutherland Shire (including the Kurnell Peninsula and the City of Rockdale) on a range of public and private land. Threats are disturbance and weed invasion (including bitou bush), particularly on the Kurnell Peninsula. Since the early 1990s the former NPWS (now the Parks and Wildlife Division of DEC) has conducted extensive bitou bush control programs including aerial spraying, involving contractors, NPWS staff and a number of volunteer groups. In 1998 Sutherland Shire Council began a major bitou bush control program on the Kurnell Peninsula. To date, bitou bush has been managed on the eastern margins of the KDF community, specifically in Charlotte Breen Reserve (Kurnell). Recently, a joint bitou bush control program between Sutherland Shire Council, DIPNR and the Parks and Wildlife Division

of DEC commenced in the Boat Harbour Reserve and adjacent areas. A detailed survey needs to be conducted of a patch of KDF reported from Towra Point NR, where a dense infestation of bitou bush occurs.

### *Littoral Rainforests (SEPP 26)*

Littoral rainforests occur close to the coast. They are vegetation communities recognised as having high conservation significance because they contain elements of both subtropical and dry rainforests and a high diversity of plants and animals, including many rare and threatened species (Mills 1996; McDonald 1999). They provide habitat for many migratory and nomadic animals. Less than a quarter of their original extent remains.

There are at least 130 stands of littoral rainforest of state significance which are not encompassed within a formal conservation reserve. These stands are small, mostly degraded remnants extending from the South Coast to the Tweed River, with a total area less than 100 ha (Mills 1996). The largest individual stand of littoral rainforest occurs in Iluka NR which contributed to its listing as a World Heritage Area.

Littoral rainforests have a high conservation value and as such, most of those not in formal conservation reserves have been gazetted under the State Environmental Planning Policy Number 26 (SEPP 26). The SEPP 26 gazettal includes a 100 m buffer around each remnant.

Bitou bush poses a serious threat to littoral rainforest, especially in northern New South Wales. It threatens littoral rainforests in two main ways. Firstly, it invades the margins, where it competes with or suppresses the species that protect the rainforest. The exposed margins are then subject to further degradation particularly on the seaward fringes which are exposed to salt spray and desiccating winds. Secondly, bitou bush establishes in canopy gaps where it suppresses regrowth and reduces recruitment of native plants. Canopy gaps can occur naturally or through the competitive effect of bitou bush at the margins. There are a number of other processes that can contribute to the invasion of littoral rainforests by bitou bush, for example, where the forest margins are cleared, burnt or where storm damage occurs. Long-term monitoring of bitou bush-infested littoral rainforests shows that where small gaps in the canopy occur, lantana and native species may replace bitou bush. However, in larger gaps and on the margins, bitou bush remains the dominant species (Hunter *pers. comm.*).

Over the last 10 years, land managers and/or community groups in New South Wales have commenced many littoral rainforest restoration programs. Many of these programs have involved weed control, however control of bitou bush is often a low priority because it occurs primarily at the margins and other weeds are more prevalent within the core of the rainforest (e.g. climbing asparagus fern (*Asparagus plumosus*)). Detailed restoration

plans for several littoral rainforests in northern New South Wales have been prepared. These plans outline the restoration works required including staged removal of bitou bush. On the south coast of New South Wales, many littoral rainforests are free of significant weed infestations (Mills 1996), except for a few sites with lantana and mirror bush (*Coprosma repens*). Bitou bush-infested littoral rainforests on the south coast occur in the Jervis Bay area, Bass Point Reserve (near Kiama), Minnamurra Spit (near Kiama) and Bannisters Head (near Mollymook).

The remaining remnants of littoral rainforest within the Sydney bioregion have been listed as the Sutherland Shire Littoral Rainforest endangered ecological community under the TSC Act (see below).

### *Sutherland Shire Littoral Rainforest (Sydney)*

There are few patches of littoral rainforest left within the Sydney region and those that remain are within the Sutherland Shire. The Sutherland Shire Littoral Rainforest is found on soils derived from Hawkesbury sandstone and on dune sands located on private land, council managed land and reserves administered by DEC (NSW SC 1998b). The main threats are weed invasion (including bitou bush), removal and structural change to the rainforest, and dumping of rubbish and garden waste. Sutherland Shire Littoral Rainforest occurs in Towra Point NR where bitou bush and other weeds affect two out of the six sites (Eldershaw *pers. comm.*). Bush regeneration has recently commenced at these sites. Bitou bush is not known to threaten any other Sutherland Shire Littoral Rainforest sites.

#### **4.2.4 Other species, populations and ecological communities potentially at risk from bitou bush invasion**

---

There is anecdotal evidence that bitou bush poses a threat to plant species, populations and ecological communities that are not listed under either the TSC Act or the EPBC Act. The identification of such entities is important to prevent them from becoming threatened by bitou bush in the future. The NSW Scientific Committee in making the determination to list bitou bush as a KTP discussed the importance of this phenomenon, i.e. that it could cause species that are not threatened to become threatened (NSW SC 1999a). Recognition of these entities and/or categories of significance is fundamental to biodiversity conservation, which aims to conserve biodiversity at the genetic, species and community level (NPWS 1999a).

For the purposes of this TAP, a wide range of species that were not formally listed (i.e. under the EPBC Act or the TSC Act), were considered (see above and full list in Appendix 3). These species include Rare Or Threatened Australian Plants (ROTAP)

listed species (Briggs and Leigh 1996), those considered to have conservation significance (i.e. species at the limit of their range, species for which their habitat has been reduced, either destroyed or degraded, or species that are endemic in New South Wales: see Sheringham and Westaway 1995; Keith *et al.* 1999), or species considered by experts or in published literature to be threatened (see Appendix 2 for a more information). For many non-threatened taxa however, there is insufficient information to determine if bitou bush impacts upon them. A list of species possibly at risk is presented in Appendix 3 (Table 3.2). There may be other species which are threatened which were not considered. It is anticipated that such species will be brought to the attention of the TAP coordinator. Only the highest priority species are covered in this TAP, however the other priority species listed in Appendix 3 should also be used to establish conservation priorities outside of this TAP (i.e. at a regional or local scale).

Non-threatened populations that may become threatened by bitou bush invasion are difficult to identify because such information is rarely unavailable.

The majority of coastal ecological communities are potentially at risk from bitou bush invasion in New South Wales, due to its distribution. Those not listed as threatened that are considered to be at greatest risk of becoming threatened by bitou bush include *Themeda triandra* headland grasslands, *Banksia integrifolia* coastal forests, spinifex grasslands and dune vegetation communities. A list of ecological communities potentially at risk is presented in Appendix 3 (Table 3.4) based on the lists of Dodkin and Gilmore (1984). The NSW Scientific Committee listed dune grasslands and heathlands, heathlands on headlands, scrub sclerophyll woodland and forest, and littoral rainforests as at risk (NSW SC 1999a). The mapping of bitou bush in New South Wales (see Thomas 2002; Thomas and Leys 2002) could not be used to determine communities at risk because there is no comparable set of vegetation maps covering all of coastal New South Wales (Benson 1999). Research is needed to determine the exact status of coastal ecological communities and further to determine their susceptibility to, or potential threat from bitou bush invasion (and to a lesser extent boneseed). Preliminary data from a recent assessment of headland heath communities on the north coast indicates that they may differ from non-coastal heath communities (Dodkin *pers. comm.*). It is important that these communities be used to establish conservation priorities outside of this TAP. This information highlights the need to identify species, populations and ecological communities that may become threatened by bitou bush in the future.

## 5 Control of bitou bush and boneseed

---

### 5.1 Control techniques

---

A range of techniques is available for the control of bitou bush and boneseed and often a combination of methods is used: aerial and ground application of herbicides; biological control; physical removal; slashing; and burning. In addition, revegetation can be used to suppress recruitment of seedlings once the initial control has occurred. These techniques have changed little over the past decade (see earlier review by Stanley *et al.* 1989). In part this is because site-specific conditions dictate which methods can be used (Stanley *et al.* 1989; Adair and Ainsworth 2000; Vranjic 2000: further discussion presented below). The introduction of new biological control agents is the main exception. Best practice guidelines recommend an integrated approach to control spanning several years, with the final combination of control treatments being site-specific (see Adair and Ainsworth 2000; Vranjic 2000).

**Physical techniques** include the use of machinery, hand pulling (e.g. the removal of individual plants by hand) and fire. These techniques are typically employed in densely infested areas containing few native species. Any potential disturbance to aboriginal sites as a result of these techniques needs to be addressed in site-specific plans (see below). **Machinery** is used to slash or knock down dense infestations, often as an initial operation to allow other techniques to be used. It is impractical for use over large areas. As many plants resprout after such treatments, follow-up control is nearly always required. The cost of using machinery varies depending on access, topography, vegetation and the equipment being used. Average costs are \$900–1,200/ha. **Hand pulling** is used to remove small to medium sized plants, particularly in lightly infested areas or for isolated plants. Hand pulling can be very effective following previous control programs. The cost of hand pulling varies depending on access, topography, vegetation, and the infestation level. Average costs are \$30–300/ha. This method is best suited to volunteers and the costs can be reduced substantially if volunteers are used. **Fire** can kill mature plants and reduce the seed bank through heat/smoke stimulated germination. The effects will depend on the intensity and duration of the fire (see Downey 1999). The need to consider impacts to non-target species, protection of life and property and the need to obtain a permit adds considerably to the time and cost involved in using this technique. In addition, follow-up control is essential because of increased seedling recruitment. Fire may also cause additional problems such as erosion, habitat loss for fauna and the provision of a suitable environment for other weed species to establish.

The use of **herbicides** is the most effective method of controlling bitou bush. Glyphosate is the most commonly used herbicide, although when impacts on grasses need to be avoided metsulfuron methyl is preferred. Glyphosate and metsulfuron methyl are usually

applied in winter when bitou bush is flowering and the growth or activity of native plants is reduced. Herbicide application during winter reduces off target effects in most native plant communities. Herbicides can be applied as a foliar spray or by painting the herbicide onto cut stumps. Average costs are \$1,200/ha for spot-spraying using a vehicle mounted spray-rig, and \$100–300/ha for painting cut stumps, depending site conditions (as documented above for hand pulling). Aerial application using low rates of glyphosate (0.76 kg active ingredient/ha) is a very effective technique that is used widely for the control of bitou bush. This application technique is very cost-effective (\$100–150/ha) and allows large areas to be treated rapidly. Consideration should be given to the size of the area sprayed using this method in relation to the resources available to undertake follow-up control actions. The NPWS (now the Parks Division of DEC) recently gained approval from APVMA to aerial spot-spray bitou bush using a helicopter. Average costs are not yet available but should be similar to that of other forms of aerial spraying.

Some formulations of glyphosate contain a polyoxethylene amine (POEA) surfactant which is toxic to some frogs (see Bidwell and Gorrie 1995; Mann and Bidwell 1999). Only formulations of glyphosate containing non-POEA surfactants are registered for use in aquatic situations (NRA 1996). Consideration should also be given to using these formulations in any terrestrial situation that is a potential habitat for frogs, particularly those frog species listed under the threatened species legislation (TSC or EPBC Acts) and at sites identified in respective recovery plans, e.g. for the green and gold bell frog (NPWS 2003b). Any other herbicide, surfactant or adjuvant that may have adverse effects on aquatic organisms should be avoided in any terrestrial situation buffering an aquatic ecosystem.

**Herbicides and physical techniques** are often combined to give more effective control, e.g. cutting and painting the stumps of mature plants with herbicide, and strategic burning preceding or following the use of herbicides. In heavily infested areas the cost of this combined technique may exceed \$30,000/ha (Jack *pers. comm.*). Many of these combined techniques form the basis for Integrated Weed Management (discussed further below).

**Biological control** involves the use of other live organisms to control weeds (or other pests). A national research program on biological control of bitou bush has been operating since 1986. The biological control program for bitou bush in New South Wales has to date identified the majority of potential agents and undertaken the appropriate action to release the ones that are likely to have the greatest impact on bitou bush in accordance with the BC Act (see section 2.1.3). Seven biological control agents have now been released as a result of this program: bitou tip moth (*Comostolopsis germana*), bitou seed fly (*Mesoclanis polana*), bitou leaf rolling moth (*Tortrix* sp.), black boneseed beetle (*Chrysolina* sp.), blotched boneseed beetle (*Chrysolina picturata*), painted boneseed beetle (*Chrysolina* sp.), and the bitou tortoise beetle (*Cassida* sp.). Research is continuing into two other potential agents; a rust fungus (*Aecidium osteospermi*) and the leaf buckle mite (*Aceria neresi*). One of the released agents, the bitou seed fly is now well established

along the NSW coastline and populations of the fly have commonly reduced seed production by over 50%. The latest introduction, the bitou leaf roller moth has been released in a number of areas, e.g. Bongil Bongil, Botany Bay, Broadwater, Bundjalung, Crowdy Bay, Ku-ring-gai Chase, Sea Acres and Yuraygir national parks. Recently, it was considered to be established at Botany Bay NP. At high densities, larvae of the moth are capable of decimating plants and it is the most destructive agent found to date. It is too early to draw any conclusions from these releases, but Australian and South African scientists are confident of the bitou leaf roller moth's potential to have a major impact on bitou bush in Australia.

Biological control programs are a long-term option for control. The time frame of which can be influenced by the longevity of the target species. For example, the actions of a seed fly which parasitises the seeds of a long-lived plant (e.g. 25 years) do not alter the longevity of an individual plant. Rather, they reduce the seed bank, leading to a reduction in recruitment and plant density over subsequent generations. A comparison between Scotch broom plant densities in the native range (with biological control agents) and the exotic range (without or with limited biological control) showed that plant densities were higher in the exotic range where biological control agents are absent or limited (Paynter *et al.* 2003).

**Integrated weed management (IWM) strategies and best practice management guidelines** (see Adair and Ainsworth 2000; Vranjic 2000) outline holistic approaches using a combination of control techniques (Sindel 2000). This is because the use of a single technique is rarely successful in the long-term (Groves 1989) and may lead to negative outcomes (e.g. herbicide resistant biotypes). In essence, an holistic approach aims to remove existing plants, deplete the soil seed bank, reduce re-invasion (either by the same or other weed species), and rehabilitate and re-vegetate the site with desirable indigenous species (i.e. locally occurring natives). In addition, IWM establishes a framework to manage sites following the initial control event. The nature of bitou bush invasions means that an IWM strategy for this weed needs to be long-term if it is to reduce the initial infestation as well as deplete the soil seed bank. Lack of appropriate follow-up controls or commitment to follow-up controls will quickly result in re-infestation by bitou bush (Vranjic 2000).

## 5.2 Issues associated with bitou bush and boneseed control

---

Often there is **more than one weed species** present at a site and in many cases, the control of one species may provide an opportunity for another weed species to proliferate. Where there is more than one weed species present, bush regeneration techniques should be adopted (see Buchanan 1989). The ideal strategy is to replace bitou bush with native species in such a way that the process of natural regeneration and succession is

sustainable and bitou bush is not simply replaced by other weeds or re-invades itself. Some of the species that flourish after bitou bush control are even more difficult to control, e.g. glory lily (*Gloriosa superba*), asparagus fern (*Asparagus* spp.), mirror bush (*Coprosma repens*) and ehrharta (*Ehrharta villosa*), or at least as difficult to control, e.g. lantana (*Lantana camara*). The cost of multiple weed control varies depending on the weed species present, the density and age of the infestation/plants, and the control methods used. Average costs are \$600–30,000/ha.

**Concerns over the use of herbicides** have been raised with respect to their potential impacts on non-target species. DEC is currently undertaking a review of the effectiveness and environmental impacts of aerial bitou bush spraying (primarily glyphosate). Information from this review is not available at the time of writing this draft TAP. Recent studies/reviews have revealed that some native species (plant and animal) are susceptible to herbicide application as used to control bitou bush (e.g. *P. spicata*). Species that are susceptible to or potentially susceptible to herbicides (flora or fauna) are presented in Appendix 5, and should be considered along with any other species identified in the future, when undertaking herbicide control of bitou bush or boneseed. In addition, herbicide should be used with extreme caution in areas where priority species, populations and ecological communities occur. Information on the effects of herbicide is not known for many of the priority species (including those in priority ecological communities) and therefore they should be considered as potentially at risk until data are available.

Low rates of glyphosate used for aerial application (0.76 kg active ingredient/ha) have minimal impact on most native species, with less than 10% of them exhibiting mortality or severe damage (Toth 2002). No threatened species were examined in Toth's (2002) study. In addition, the study only looked at adult plants; the impact to seedlings was not examined. Studies that have investigated the effects of glyphosate on seedlings show that seedlings experience greater impacts than adults. For example, *Acacia sophorae* seedlings were affected by herbicide while the adults were not (Toth *et al.* 1996), but *Pimelea spicata* seedlings and adults were both affected by the herbicides and rates used to control bitou bush (Matarczyk 1999; Matarczyk *et al.* 2002). In the case of *P. spicata* this knowledge has influenced control programs (Pomery *pers. comm.*).

The effects of herbicides on herbs or annuals have not been examined, however several native terrestrial orchids appear to be susceptible to glyphosate (Jones and Weston *pers. comm.*). Studies (flora only) on the impact of metsulfuron methyl, also used in aerial spraying, have begun recently (Toth *pers. comm.*). As already noted, the use of formulations of glyphosate containing non-POEA surfactants should be considered for use in any potential frog habitats. A list of the aquatic organisms most likely to be impacted is presented in Appendix 5 and should be considered in all control programs.

A new regulation soon to be enacted under the *Pesticides Act 1999* will require all persons using pesticides to obtain a determined level of competency in their use, handling and storage. Other regulations under the Pesticides Act already in force require all pesticide users to take and retain, for at least 2 years, detailed records on pesticide usage (see Pesticide Act or DEC (including the former EPA) for further details).

In addition, training is also required to avoid non-target impacts to native plants which may be similar in appearance to bitou bush, as well as to ensure that threatened species, populations and ecological communities are adequately protected during bitou bush control activities.

When using **other control techniques with biological control** agents it may be important to leave untreated patches of the target weed to maintain populations of the biocontrol agents.

If **bush regeneration** techniques/activities are to be undertaken within the habitat of threatened entities (species, populations or endangered ecological communities) they must follow an interim draft checklist developed by DEC for such instances. This interim draft checklist can be obtained from the Bitou TAP coordinator.

### 5.3 Follow-up treatments

---

Lack of appropriate follow-up treatments will result in reinvasion by bitou bush (Stanley *et al.* 1989; Vranjic 2000). The extent and duration of any follow-up treatment will depend on many factors. The original seed bank size, length of seed dormancy period (>5 years), distance to other bitou bush infestations (i.e. reinvasion source), control technique employed (e.g. fire can deplete soils seed banks), and the extent and condition of the invaded native plant communities that are present will determine the nature of any follow-up treatment. Biological control agents can be employed to help limit these factors, particularly in the longer term where they can reduce spread and lower plant vigour.

Follow-up techniques must be employed prior to seed production from any new cohort or regrowth of surviving plants. Seedlings are capable of producing seed within 24 months, with some observations on the north coast of New South Wales suggesting that newly germinated plants can set seed within 12 months (Thomas *pers. comm.*). The timing of follow-up control treatments must be sufficiently flexible to allow maximum recruitment, as well as prevent seed production. Follow-up controls should also ensure that enough time has elapsed for most bitou bush seedlings to reach a size/age that makes them easy to see amongst the resprouting native vegetation. Seedling mortality appears to be high, therefore delaying follow-up control techniques will also be more cost-effective, provided the follow-up treatment occurs prior to first flowering.

Follow-up control techniques will vary depending on the level of recruitment observed for bitou bush and the other weed species present. The two most common methods are hand pulling or spot-spraying of seedlings.

#### **5.4 Site-specific management**

---

Best practice management guidelines (Vranjic 2000) and the NSW bitou bush strategy (NPWS 2001a) both emphasise the importance of site-specific strategies or management plans for the control of bitou bush. There is no framework to develop such strategies however. Rather, Vranjic (2000) outlines a range of control techniques followed by a series of suggested control options for a range of different bitou bush densities. The use of site-specific management strategies should not result in broader management objectives being compromised. To avoid this occurring, a framework to develop site-specific management strategies/plans is required.

#### **5.5 A framework for site-specific management plans**

---

While the development of site-specific management plans is dependent on local factors/conditions each plan must be based on a framework. A framework for the development of site-specific management plans for the control of bitou bush at priority sites is presented here.

Each site-specific management plan must:

- ▶ be developed in consultation with relevant stakeholders
- ▶ clearly identify and determine the roles and responsibilities of all stakeholders for each stage of the plan
- ▶ identify Aboriginal cultural heritage sites (including those covered under the NPWS Aboriginal Heritage Information System)
- ▶ involve consultation with indigenous people with respect to any special knowledge or interest in the site or the species, population or ecological community and control programs at that site, including the likely social, cultural and economic consequences
- ▶ specify the priority species, populations and ecological communities present as per threat abatement or recovery plans (or for any other legislative requirement), as well as any other species of high conservation value
- ▶ identify relevant actions outlined in such TAPs or recovery plans (e.g. the Green and Gold Bell Frog Recovery Plan: see NPWS 2003b)
- ▶ identify the most appropriate management techniques for the level of bitou bush present, as well as for other aspects of the site including the native flora, non-target effects, the terrain, access, and other local conditions, as well as for the

- priority species, etc. identified above (including remediation methods, e.g. fencing)
- ▶ ensure all pesticide applications comply with the Pesticides Act (see Chapter 2) and APVMA regulations
  - ▶ assess the potential environmental impacts of management strategies in accordance with the EP&A Act (as described in Chapter 2), e.g. the mechanical control of bitou bush (see Sullivan 1997). This may involve the preparation of a REF (Review of Environmental Factors)
  - ▶ identify the milestones, performance criteria and measures to be achieved during the life of the plan
  - ▶ outline a follow-up control program to prevent reinvasion/reinfestation of the site after the initial control
  - ▶ outline any monitoring programs being undertaken to evaluate the effectiveness of bitou bush control programs
  - ▶ identify other weed species that are likely to invade following the removal of bitou bush and outline a control program to address the problem
  - ▶ identify training requirements for all stakeholders and/or persons who will undertake the management actions (including volunteers), e.g. the application of herbicides
  - ▶ incorporate all threat abatement and recovery plan actions relevant to the site.

## 5.6 Infestation levels and control options

---

In all instances the control of bitou bush must be tailored to the requirements of issues of conservation significance, irrespective of the level of the infestation. As bitou bush infestations increase in density and area, control programs need to follow a strategic staged approach which will help reduce reinfestation of treated areas. Below are some generic options for use as a guide only.

### *Light infestations*

Lightly infested areas consist of isolated bitou bush plants and/or small clumps of plants. The impact on the native flora from light infestations is typically low. Control of bitou bush in lightly infested areas is best achieved with application of herbicides and/or hand removal (hand pulling or cut/stump techniques), as these techniques can limit non-target impacts. Control at the light infestation level prevents a worsening scenario. Sites need to be monitored regularly to control and prevent infestation.

### *Medium infestations*

Medium infestations consist of areas where bitou bush is present throughout the area but is not the dominant plant species. Some impacts to native flora are evident. Control of bitou bush in medium infestations is best achieved with application of herbicides and/or hand removal, as these techniques can limit non-target impacts. Sites need to be actively managed to control recruitment.

### *Heavy infestations*

Heavily infested areas are dominated by bitou bush; the extreme scenario being a virtual monoculture. Control techniques for heavily infested areas vary as follows, depending on the invaded vegetation community (based on Vranjic 2000).

**In coastal fore-dunes and headlands**, control can be achieved using a combination of biocontrol, herbicide and mechanical removal. Fire is generally not recommended because it increases the risk of erosion, however fire may be considered if dune areas are stable or follow-up techniques such as installing brush-matting can be implemented immediately following any fire event.

**In coastal heath, woodlands and grasslands on hind-dunes**, control can be achieved using a multi-stage, spray–burn–spray strategy incorporating biocontrol agents (see Vranjic 2000 for more details). The re-establishment of bitou bush biocontrol agents within controlled areas is dependent on the proximity of agents to the treated area and their abundance in such areas, the size of the area treated, the level of bitou bush recruitment following control, and the impact of the biocontrol agent on seedlings and adult plants. The timing of the use of fire as a control technique varies from site to site. Control burns are most effective in autumn on the south coast of New South Wales, and in spring on the north coast. The full implications of a biocontrol–spray–burn–spray strategy to control bitou bush in coastal vegetation communities have not been determined. The use of fire should be approached with caution and planned carefully as fire will not be suitable in all instances.

**Rainforests (littoral or otherwise)** are typically fire-sensitive and therefore should be managed to prevent fires occurring. In rainforests, bitou bush can be most effectively controlled using a combination of biocontrol, spot-spraying and hand removal of plants. Germination of bitou bush seedlings within rainforests occurs at a low level, except where the canopy has been damaged, increasing light penetration. Bitou bush seeds are typically dispersed into the rainforest from surrounding infestations, rather than from seeds produced on plants within the rainforest because seed production is greatly reduced in shaded conditions. Priority should be given to the control of bitou bush infestations surrounding rainforests rather than plants within the forest. Control of bitou bush on the seaward side of littoral rainforests needs to be staged carefully to maintain the forest's

protective buffer from wind and salt spray. Bitou bush often invades and replaces this protective vegetation (see further discussion in the littoral rainforest section of Chapter 4).

## 5.7 Monitoring of control programs

---

To determine the effectiveness of any weed control program, a monitoring program must be developed and implemented. Monitoring programs must take measures from both controlled and uncontrolled areas in order to detect any changes attributed to the control program. Many variables can be measured and a number of monitoring techniques can be used. The following measures must be addressed at all sites described in the TAP:

- ▶ the response of **bitou bush** (adults and seedlings) to the control program, measured by detailed and frequent assessments of plant abundance and vigour, as well as through regular observations from photo points both prior to and post control
- ▶ the response of the **priority threatened species, populations and ecological communities** to the control program, measured by a similar range of measures as described for bitou bush above.

Additional measures can help to determine the effectiveness of control programs with respect to the broader invaded community and should be collected where resources are available:

- ▶ the response of **other weed species** to the control program, measured by regular surveys of the other weed species along with their relative abundance. More detailed measures can be obtained using similar response variables as described for measuring the response of bitou bush above (i.e. plant vigour)
- ▶ the response of a **broader suite of native species** (both plants and animals), populations and ecological communities to the control program, measured by similar range of measures as described for other weed species above
- ▶ the response of **biocontrol agents** following the control program, measured by the rate of attack and density of the agents taken at regular intervals following control.

Measuring these variables is difficult and any sampling methods need to consider several factors:

- ▶ the timeframe required to measure a response, for example, to determine bitou bush recruitment/seed bank depletion rates accurately a timeframe of at least five years is required to account for seed dormancy
- ▶ differences between controlled areas and non-controlled areas, or before and after control need to be accounted for
- ▶ the timing of individual measures or samples (e.g. summer) and interval between them
- ▶ the level of replication needed to provide credible results
- ▶ how the data will be analysed/presented

- ▶ a balance between too simplified and too complicated data collection techniques
- ▶ a standard and consistent way of collecting data
- ▶ commitment to maintaining the integrity of the sampling design and regime over the course of the monitoring program.

Monitoring of the Bitou TAP control programs will follow the two-tier system outlined in Chapter 9 (see section 9.2.3 and Action 2.1), where each site will be designated as having either a tier one or tier two monitoring program.

### **5.7.1 Monitoring more generally**

---

Monitoring should be undertaken regularly (i.e. annually) to identify new infestations/populations of bitou bush and boneseed, as well as to identify those existing populations that are re-invading coastal and surrounding regions of New South Wales. Such populations should be treated soon after detection to prevent further spread. This is best done prior to first flowering. While the impact of a single plant may be insignificant, it is prudent to remove it as a preventative strategy.

## **5.8 Areas at risk of invasion by bitou bush and boneseed**

---

Some vegetation communities are known to be susceptible to bitou bush invasion (e.g. fore-dunes, hind-dunes and headlands). Our knowledge of other vegetation communities is rudimentary however, for example, across a range of forest communities. Anecdotal evidence suggest that open coastal forests lacking a true shrub layer, on both clay and sandy soils, are more susceptible to invasion than closed ones. Bitou bush also poses a threat to the outer margins of closed forests (e.g. littoral rainforests). Dry heath may also be susceptible, especially where disturbance reduces plant competition near bitou bush infestations. Boneseed poses a similar threat, but to communities further inland.

### **5.8.1 Maintain areas presently free of bitou bush and boneseed in NSW**

---

Maintaining areas that are presently free of bitou bush and boneseed will be beneficial to biodiversity, as species, populations and ecological communities in these areas will remain unaffected by bitou bush invasions. This however, is outside of the scope of this plan and should be addressed through other strategies e.g. the national WONS strategy for bitou bush/boneseed (ARMCANZ *et al.* 2000).

## 5.9 The ‘no change in current management’ control option

---

An alternative control option is the ‘no change in current management’ approach. At present there is a range of bitou bush control programs in place to conserve native flora and limit bitou bush spread, at various sites throughout New South Wales. These control programs involve many agencies (e.g. Parks and Wildlife Division of DEC, Department of Lands, NSW State Forests and local councils), the community (through community groups) and private landholders and companies. In addition, there is a national strategy (ARMCANZ *et al.* 2000) and state strategy (NPWS 2001a) to prioritise bitou bush management. There is a need for an overall strategy for bitou bush control for threatened species however, because:

- ▶ some control programs do not have conservation objectives, apart for the assumption that control alone will result in biodiversity outcomes (see Downey 2003a, b for further discussion)
- ▶ the objectives of some control programs are unclear. In particular, the species that are expected to benefit from bitou bush control are not always identified
- ▶ where species are identified, an objective basis for predicting that the species is susceptible to bitou bush invasion is not always provided. In particular, there may be no information that species targeted by bitou bush control will benefit other than the observation that they are present or absent from their ‘preferred’ habitat
- ▶ some programs are likely to be ineffective because control is not targeted at priority species and follow-up programs are inadequate, or control occurs over too small an area or too short a timeframe to prevent re-infestation
- ▶ there is no consistent plan applying across all land tenures. Greater collaboration between landholders is fundamental to the success of control programs
- ▶ measures of effectiveness for these programs are often inadequate and, in particular, do not measure the response of targeted species to bitou bush control. Thus, no measure is available on the effectiveness of control programs, or whether target species recover following removal of bitou bush therefore indicating they were limited by bitou bush invasion
- ▶ years of bitou bush control have not provided information on which species are affected by bitou bush invasions.

An integrated approach to broad scale weed management that incorporates plant conservation is long overdue. Such an approach is needed in order to deliver conservation outcomes from weed management (Downey 2003a, b). Thus, the ‘no change in current management’ control option would be a retrograde step which will not benefit biodiversity conservation.

## **5.10 Roles and responsibilities with respect to bitou bush control**

---

The declaration of bitou bush as a noxious weed under the Noxious Weeds Act requires land managers to control bitou bush. In carrying out those responsibilities, land managers must not breach the EP&A Act. In addition, under the TSC Act there are restrictions on control programs undertaken in areas where threatened entities are present (see Chapter 2 for further details on legislation with respect to roles and responsibilities associated with bitou bush control). This TAP outlines various other roles and responsibilities for bitou bush control (see earlier in this chapter as well as Chapter 6).

### **5.10.1 The role of the Bitou TAP in bitou bush management in NSW**

---

The role of the Bitou TAP is to prioritise the control of bitou bush in New South Wales to those threatened entities and their locations where control will have the greatest biodiversity outcomes. The TAP aims to address high priority species, populations and ecological communities at high priority sites (see Appendices 3 and 4). Identified lower priorities (both threatened entities and sites) should be used to set regional priorities for bitou bush control programs. The priority lists are not definitive and other species and ecological communities in New South Wales threatened by bitou bush invasion may be identified in the future. The control of bitou bush other than for the priorities established in this TAP is outside the scope of this TAP, except for the species that co-occur at high priority sites. Control of bitou bush in areas where non-priority entities occur is the responsibility of local land managers and other strategies e.g. regional bitou bush strategies. Other funding sources should be maintained to combat bitou bush where programs are already in place or in other important areas, e.g. the northern and southern containment zones.

## 6 **A strategy to minimise the impact of *Chrysanthemoides monilifera* on priority native plant communities in New South Wales**

---

### 6.1 **Background**

---

The rapid expansion of bitou bush along the NSW coast over the last 20 years has had significant impacts on coastal ecosystems and native plant communities. In 1999, these impacts were acknowledged when the ‘invasion of native plant communities by *Chrysanthemoides monilifera*’ was listed as a key threatening process under the TSC Act. *Chrysanthemoides monilifera* has also been listed as a Weed Of National Significance (WONS) and in New South Wales, bitou bush is declared as a noxious weed (under the NW Act) in all coastal LCAs. Recently, national and statewide management (including regional) strategies have been developed to combat the problem. This TAP focuses bitou bush and boneseed control programs across New South Wales on specific areas where the threat to biodiversity is greatest.

Bitou bush control programs have been undertaken across coastal New South Wales for several decades. However, these control programs have not prevented its spread, in part due to the scale of the problem and until recently, the absence of a statewide approach to combat it.

There are currently insufficient resources to control bitou bush effectively in all areas in which it occurs. In order to utilise resources effectively, control and management efforts need to be focused on the areas where the benefits of control will be greatest. This TAP will focus on identifying those threatened species, populations or ecological communities that are at the greatest risk from bitou bush invasion. Once these are identified they can be used to establish priority sites for control programs.

The distribution of boneseed in New South Wales is such that it currently poses limited threats to threatened entities and the remainder of this chapter deals with bitou bush only.

### 6.2 **Aims and objectives of the Bitou TAP**

---

The main objective of the Bitou TAP is to prioritise bitou bush control to areas where the outcomes of such controls are beneficial to native biodiversity, particularly threatened flora (species, populations and ecological communities). The effectiveness of the control programs will be measured through comprehensive monitoring programs.

A core component of this TAP is the coordination of control programs across different land tenures and land management organisations throughout New South Wales. The Bitou TAP does **not** aim to replace or reduce **existing** priority control programs identified in the national, NSW and regional strategies. For example, the northern and southern containment zones as specified in the state strategy (NPWS 2001a), or lightly infested areas where preventing further spread/increase in density is currently cost-effective.

The Bitou TAP has eight objectives, listed in Table 6.1, and the following sections outline proposed strategies to address each of these objectives. A summarised list of proposed actions for each of the eight objectives is also given in Table 7.2 in Chapter 7. Links to other TAPs and recovery plans will be considered when implementing the actions under this TAP.

**Table 6.1** Bitou TAP objectives (objectives 5–7 are discussed in Chapter 7)

<b>No.</b>	<b>Objective</b>
<b>1</b>	<b>Ensure that bitou bush (and boneseed) control is undertaken in areas where the impacts on threatened species, populations and ecological communities are greatest</b>
<b>2</b>	<b>Evaluate the effectiveness of control programs with respect to the response of priority species, populations and ecological communities</b>
<b>3</b>	<b>Evaluate the ways in which bitou bush causes the decline of native plant species</b>
<b>4</b>	<b>Ensure that all stakeholders are involved/participate at each of the priority sites</b>
<b>5</b>	<b>Seek funding and support for the implementation and administration of the Bitou TAP</b>
<b>6</b>	<b>Determine the effects of bitou bush <u>invasions</u> on fauna</b>
<b>7</b>	<b>Determine the effects of bitou bush <u>control</u> on fauna</b>
<b>8</b>	<b>Establish guidelines for future control programs and research projects based on the outcomes of this TAP</b>

### **6.3** Priority sites for bitou bush control programs

<i>Objective 1</i>	<b>Ensure that bitou bush (and boneseed) control is undertaken in areas where the impacts on threatened species, populations and ecological communities are greatest</b>
--------------------	--

The widespread distribution of bitou bush (and to a lesser degree boneseed) in New South Wales makes it impossible and impractical to control all infestations across its entire range. Therefore, control programs must be targeted to result in the greatest benefit to biodiversity.

In developing the actions and setting priorities for this objective the key assumptions underlying effective control programs for bitou bush (and boneseed) include:

- 1 no single management strategy is recommended. Thus, site-specific management plans need to be developed and implemented for each priority site (Objective 2).
- 2 follow-up control is needed to prevent re-infestation and/or re-invasion. Therefore, all control programs must be long-term and account for more than an initial control area in year one (i.e. a staged approach to control: see Section 6.3.3). Sources for re-infestation should also be identified where possible. Follow-up controls are outlined in Chapter 5 (above).
- 3 other threats are present at many of the priority sites. Managing these additional threats is beyond the scope of the Bitou TAP. The mechanism to address these other threats is through recovery plans, as specified under the TSC Act and EPBC Act. The exception is where the threat comes from another weed species which may either increase or replace bitou bush following control. At such sites, control programs must address these weed species
- 4 resources are limited and must be directed to species, populations and ecological communities and sites where the benefits will be greatest.
- 5 commitment to the priority species, populations and ecological communities and sites outlined in this TAP are to be maintained for its 5 year duration.
- 6 best practice management acknowledges that sustainable control is a medium to long-term undertaking.
- 7 the effect of control measures on target and non-target species needs to be considered at all sites.

### 6.3.1 Selection process for priority species, populations and ecological communities

---

#### *Species*

The model used to prioritise plant species is described in Appendix 2. This adaptive model can be modified as new data become available. The priority species are described in Chapter 4.

Results from the model produced a natural division in the rankings which was used to separate the high priority species, which the Bitou TAP will address, from the medium

and low priority ones (see Appendix 3). Bitou bush control for species that received a low priority ranking is outside the scope of this Bitou TAP, unless they co-occur in priority sites with high priority species and populations.

### *Populations*

Threatened populations listed under the TSC Act that occur within the distribution of bitou bush (as determined by Thomas and Leys 2002) were determined to be of high priority. There are therefore no medium or low priority threatened populations presented here. The priority populations are described in Chapter 4.

### *Ecological communities*

Endangered ecological communities listed under the TSC Act, EPBC Act or SEPP that occur within the distribution of bitou bush (as determined by Thomas and Leys 2002) were arbitrarily ranked. The ranking of high, medium or low priority was based on the threat posed by bitou bush to the ecological community as a whole (i.e. across its distribution). The ecological communities considered here are presented in Appendix 3. Individual patches were then ranked using the site model (see Appendix 4) to provide priorities for individual remnants of these endangered ecological communities. The priority ecological communities are described in Chapter 4.

#### **6.3.2 Selection process for priority sites**

---

Specific sites for all priority [high, medium and low] species, populations or ecological communities within New South Wales were determined initially with the aid of distribution information supplied by a wide range of people (including staff from DEC and local councils). This information was combined with data from the NPWS Atlas of NSW Wildlife (including the Royal Botanic Gardens Database) and other sources (e.g. Harden 1993–2002; local site surveys and inspections). It is acknowledged that this list is not definitive, as some locations have inadvertently been overlooked here, the distribution data for some species is incomplete, and additional locations may be discovered in the future.

For each site the density of bitou bush present was recorded (high, medium and low, as used by Thomas 2002). Sites without bitou bush, or sites where the density/abundance of bitou bush was extremely low were excluded from the final list of priority sites (Appendix 4). This information was combined with an assessment of current control being undertaken at each site, to provide a measure of the effectiveness of control. An

assessment was also made of the actual impact from bitou bush and other threats present at each site. Thirdly, a measure of the status of the entity at each site, along with the importance of the site to the entity's overall status, was determined. This information was used to rank the sites (see Appendix 4). Insufficient information was available at the time of writing this draft to adequately rank some sites.

Land tenure did not influence the selection of sites or their priority. Agreement from the land-holder/owner or manager for actions outlined in this TAP was only sought for high priority sites. The complete list of priority sites is presented in Appendix 4.

The assessment process used in this draft TAP identified **60 high priority sites** for bitou bush control. Some of these sites already have control programs in place, however the objectives of many of these are different from those outlined in this TAP. Many simply aim to control bitou bush over the entire site rather than focusing on the protection of threatened entities. None of the high priority sites are known to contain boneseed, however if boneseed is detected at any of the priority sites, it should be controlled in a similar manner to bitou bush. The highest priority sites for each high priority entity, are presented in Table 6.2. The complete matrix of priority entities (high, medium and low) by priority sites (high, medium and low) is presented in Appendix 4.

### 6.3.3 A staged approach to bitou bush control

---

At many sites the density and area infested by bitou bush is such that it cannot be controlled in a single control event/action. Thus, the control of bitou bush at these sites needs to occur in stages.

The **first stage** is the removal of bitou bush, and other weed species, from the immediate vicinity of the threatened species, population or ecological community. This will reduce the direct threat in the short-term.

The **second stage** is the expansion of stage one to cover a larger area of the bitou bush infestation at the site. In this stage, the removal of bitou bush should be prioritised to areas containing suitable habitat for the priority species, populations and ecological communities to expand into in the future and decrease the threat by providing a bigger buffer zone between bitou bush and the threatened entity. Stage two involves the follow-up control of bitou bush seedlings that germinate within all previously controlled areas (including stage one areas).

The **third and subsequent stages** involve the further expansion of earlier stages with the aim of removing all bitou bush from the site and surrounding areas to prevent re-invasion.

This stage also includes the continual follow-up control of bitou bush seedlings in all previously controlled stages/areas of the site (i.e. stages one and two areas).

This staged approach can be beneficial for a number of reasons:

- ▶ control is focused on an area for which there are sufficient resources available.
- ▶ land managers are forced to think about the follow-up control constraints.
- ▶ control can be focused initially on areas where priority species, populations or ecological communities occur, or on other priority areas.
- ▶ a staged approach aids in the protection of threatened ecological communities (e.g. littoral rainforests as discussed in Chapter 4).
- ▶ a plan can be drawn up to manage large infestations

The staged approach must:

- ▶ be planned before any control is undertaken, with all stages clearly marked and the timing of each stage determined, preferably incorporated into the management plan for the site
- ▶ only control areas for which there are resources available to undertake the subsequent stages including most importantly the follow-up treatment of seedlings. Irrespective of the initial control measure implemented, follow-up treatments are required to control recruitment (as described by Vranjic 2000).

#### 6.3.4 Bitou bush control and non-priority species

---

Control of bitou bush (and boneseed) currently occurs at many sites across New South Wales, including many of those identified in Table 6.2. However, a substantial increase in resources is necessary for bitou bush (and boneseed) control to be effective in protecting populations of threatened species, populations and ecological communities at these sites, let alone limit the spread and reduce the area occupied by bitou bush (and boneseed) more generally. Thus, bitou bush control specifically targeting non-threatened species, populations and ecological communities is not a priority in this plan. Despite this, bitou bush (and boneseed) control programs independent of this TAP must continue, as these control programs have broad biodiversity benefits for a wide range of species, populations and ecological communities not covered in this TAP. Such control programs include priorities established in the national strategy (ARMCANZ *et al.* 2000), the state strategy (NPWS 2001a) and regional strategies (e.g. Scanlon 2001), for example, the northern and southern containment zones. In addition, control must be undertaken for other reasons, for example, maintenance of walking tracks and picnic areas.

Table 6.2 Priority sites for each of the priority species, populations and ecological communities. Complete list of sites is presented in Appendix 4.

Rank	Species, population or ecological community	Land manager	Priority site	Other priority entities present	No.
	<b>Species</b>				
1	<i>Zieria prostrata</i>	DEC	Bare Bluff, Moonee Beach NR	<i>Thesium australe</i>	1
	<i>Zieria prostrata</i>	DEC	Look at me Now Headland, Moonee Beach NR	<i>Thesium australe</i>	2
	<i>Zieria prostrata</i>	DEC	Dammerals Head, Moonee Beach NR	<i>Thesium australe</i>	3
2	<i>Sophora tomentosa</i>	DEC	Sandon River, Yuraygir NP		4
	<i>Sophora tomentosa</i>	DEC	Sandon Bluffs, Yuraygir NP		5
	<i>Sophora tomentosa</i>	DOL/PWC	Wooli River		6
	<i>Sophora tomentosa</i>	CHCC	Woolgoolga Headland, Coffs Harbour Regional Park		7
	<i>Sophora tomentosa</i>	DEC	Sea Acres, Port Macquarie		8
3	<i>Fontainea oraria</i>	Ballina Council	South of Lennox Head		9
	<i>Fontainea oraria</i>	Private landholder	South of Lennox Head		10
4	<i>Plectranthus cremnus</i>	??	Hat Head - east of town		11
	<i>Plectranthus cremnus</i>	??	Hat Head – near camping ground		12
	<i>Plectranthus cremnus</i>	DEC	Connors–Hat Head, Hat Head NP		13
5	<i>Chamaesyce psammogeton</i>	??	Mungo Brush – opposite camping	<i>Senecio spathulatus</i>	14
	<i>Chamaesyce psammogeton</i>	DEC/DOL	Sandon south beach, Yuraygir NP	<i>Stackhousia spathulata</i>	15a
	<i>Chamaesyce psammogeton</i>	DEC/DOL	Sandon north beach, Yuraygir NP	<i>Stackhousia spathulata</i>	16
	<i>Chamaesyce psammogeton</i>	DEC	Middle Bluff, Bundjalung NP	<i>Calystegia soldanella</i>	17
	<i>Chamaesyce psammogeton</i>	DEC	Spoon Bay track, Wamberal Lagoon NR	<i>Senecio spathulatus</i>	18
				<i>Syzygium paniculatum</i>	
	<i>Chamaesyce psammogeton</i>	DEC	Banksia Green, Myall Lakes NP		19
6	<i>Senecio spathulatus</i>	??	Mungo Brush – opposite camping	<i>Chamaesyce psammogeton</i>	20
	<i>Senecio spathulatus</i>	DEC	Mungo Brush, Myall Lakes NP		21
7	<i>Acronychia littoralis</i>	DEC	Brunswick Heads NR	SEPP 14, 26; <i>Syzygium moorei</i>	15b
				<i>Grevillea hilliana</i>	
	<i>Acronychia littoralis</i>	DEC/??	Cape Byron	SEPP 26; <i>Cryptocarya foetida</i>	22
	<i>Acronychia littoralis</i>	Private landholder?	7 Mile Beach (south)	SEPP 26	23
	<i>Acronychia littoralis</i>	??	North Creek, Ballina	SEPP 14	24
	<i>Acronychia littoralis</i>	DEC	Big Hill, Limeburners Creek NP		25
8	<i>Acacia terminalis</i> subsp. <i>terminalis</i>	RTA/RC	Bunnerong Rd, Chifley Bushland		26
9	<i>Diuris praecox</i>	DEC	Crackneck, Wyrabalong NP		27
10	<i>Gleichenia mendellii</i>	DEC	Sandon south (coffee rock), Yuraygir NP	<i>Acianthus exiguus</i> , <i>Vigna marina</i> <i>Stackhousia spathulata</i>	28
	<i>Gleichenia mendellii</i>	CVC?	Angourie Bay/Reserve		29
	<i>Gleichenia mendellii</i>	DEC	Rocky Pt, Yuraygir NP	<i>Chamaesyce psammogeton</i>	30
11	<i>Pimelea spicata</i>	DOL/Trust	Killalea State Park/Bass Point Quarry Boundary		31
	<i>Pimelea spicata</i>	DOL/Trust	Killalea State Park - Mahoneys Bay		32
	<i>Pimelea spicata</i>	Council/??	Mahoneys Bay, Bass Point Reserve		33
	<b>Population</b>				
	<i>Glycine clandestina</i> (Blf)	DOL/NSC	Scotts Head	<i>Pultenea maritima</i>	34
	<i>Zieria smithii</i> (lgf)	DOL/CHCC	Diggers Headland		35
	<b>Ecological community</b>				
	Eastern Suburbs Banksia Scrub	DEC	Botany Bay NP		36
	Eastern Suburbs Banksia Scrub	DOL/St MGC	St Michaels Golf Course		37
	Eastern Suburbs Banksia Scrub	??	Malabar West		38
	Eastern Suburbs Banksia Scrub	??	Malabar East		39
	Eastern Suburbs Banksia Scrub	Aboriginal Land	Jennifer Street (1), La Perouse		40
	Eastern Suburbs Banksia Scrub	Telstra	Jennifer Street (2), La Perouse		41
	Eastern Suburbs Banksia Scrub	RTA/DOL/RC	Bunnerong Rd		42
	Kurnell Dune Forest	DEC?	East of Continental Carbon, Botany Bay NP		43
	Kurnell Dune Forest	SSC/DOL	Charlotte Breen Reserve		44
	Kurnell Dune Forest	Sydney Water	South-east of Charlotte Breen Reserve		45
	Littoral rainforest	DEC	Iluka NR	World Heritage Area	46
	Littoral rainforest	DEC	Billinudgel NR		47
	Littoral rainforest	DEC	Sea Acres NR		48
	Littoral rainforest	DEC	Ten Mile Beach & Iluka Peninsula, Bundajlung NP		49
	Littoral rainforest	DEC	Brunswick Heads (SEPP 18?)		50
	Littoral rainforest	DEC	Broken Head NR		51
	Littoral rainforest	DEC	Cape Byron SCA		52
	Littoral rainforest	KC?	SEPP 26 (173a - Bass Point Reserve)	<i>Cynanchum elegans</i>	53
				<i>Zieria granulata</i>	
	Littoral rainforest	GTCC	SEPP 26 (152c - Black head, Hallidays Point)	<i>Cynanchum elegans</i> , <i>Senna acclinis</i>	54
	Littoral rainforest	DEC?	SEPP 26 (10 - Upper Wooyung)	<i>Acronychia littoralis</i>	55
	Littoral rainforest	DEC?TSC	SEPP 26 (11 - Lower Wooyung)	<i>Cryptocarya foetida</i>	56
	Littoral rainforest	DOL	Angels Beach, Lennox Head (SEPP no. needed)	rare old trees	57
	Littoral rainforest	DOL	Evans head/Dirrawong Reserve (SEPP no. needed)	<i>Gleichenia mendellii</i> , <i>Pultenaea maritima</i>	58
	Littoral rainforest	DOL	Crowdy Bay, Harrington (SEPP no. needed)		59
	Sutherland Shire Littoral Rainforest	SSC	Quibray Bay, Towra Point NR		60

CHCC = Coffs Harbour City Council, DOL = Department of Lands, DEC = Department of Environment and Conservation, NSC = Nambucca Shire Council, PWC = Pristine Waters Council, RC = Randwick Council, RTA = Roads and Traffic Authority, SSC = Sutherland Shire Council, Greater Taree City Council, Clarence Valley Council, Tweed Shire Council

?? = not determined at this time

Non-priority (i.e. medium and low priority) sites that contain priority species, populations and ecological communities are also outside the scope of this TAP. These sites should be considered and given priority during the establishment of any new bitou bush control programs in New South Wales, or if extra resources become available for bitou bush control, or to help develop new priorities for existing control programs.

Control of bitou bush (and boneseed) at all priority sites outlined in this TAP is expected to have biodiversity benefits beyond reducing, abating or ameliorating the threat of bitou bush (and boneseed) to the priority species, populations and ecological communities identified here, e.g. increased habitat for non-threatened species.

### **6.3.5 Site-specific management plans**

---

Site-specific management plans are required for all priority sites. Each plan will follow the framework established in Chapter 5.

#### **6.3.5.1 Consideration of recovery plans and other threat abatement plans**

---

The actions identified in recovery plans and other threat abatement plans that have direct relevance to bitou bush control at priority sites or the actions outlined in this TAP, will be addressed in site-specific management plans. In addition, the actions outlined in this TAP must be considered in any recovery plan or threat abatement plan that targets the priority species, populations or ecological communities, or priority sites identified in this TAP.

### **6.3.6 Consultation with indigenous people/communities**

---

Indigenous people/communities are encouraged to comment on any aspect of this draft TAP. In addition, consultation with the respective indigenous people/communities for all priority sites, species, populations and ecological communities should occur during the development of site-specific management plans (Action 1.3 and Chapter 5).

### 6.3.7 Actions and performance criteria

---

**Action 1.1** DEC and the Department of Lands will undertake bitou bush control programs at priority sites on their estate (Table 6.2). In addition, these agencies will seek agreement from councils to undertake bitou bush control programs at priority sites on council administered land. The Department of Lands will liaise and encourage Trust managers of Crown land to undertake bitou bush control programs at priority sites. DEC will liaise with landholders to undertake bitou bush control programs at priority sites on private lands. To measure the biodiversity benefits, bitou bush will not occur in areas designated as experimental ‘no-treatment’ areas (see Objective 2).

**Performance criteria**

- ▶ Control programs will be established at 75% (45 sites) of the priority sites within two years of publication date of this TAP.
- ▶ Existing bitou bush control programs that occur in priority sites or in areas where threatened species, populations or ecological communities occur will continue.

**Action 1.2** At high priority sites DEC and the Department of Lands will develop site-specific management plans for bitou bush control programs, based on currently available best practice guidelines. DEC will work with councils and private landholders that agree to Action 1.1, to develop site-specific management plans.

**Action 1.3** Indigenous communities will be encouraged to assist with the development of site-specific management plans.

**Performance criteria**

- ▶ Site-specific management plans to control bitou bush will be developed for 75% (45 sites) of the priority sites within two years of the publication date of this TAP.

## 6.4 Monitor the effectiveness of bitou bush control programs

---

**Objective 2** Evaluate the effectiveness of control programs with respect to the response of priority species, populations and ecological communities

#### 6.4.1 Measuring the response of threatened species, populations and ecological communities to bitou bush control

---

The primary objective of the Bitou TAP is to reduce the impacts of bitou bush on threatened species, populations and ecological communities. To achieve this objective bitou bush populations will have to be reduced. Although control programs may result in visible or obvious reductions in the density of bitou bush, it is still important to undertake an evaluation of the control program(s) used. Such evaluations must consider:

- ▶ the effectiveness of the control programs on bitou bush infestations (including re-infestation rates of bitou bush, either from the seed bank or surrounding populations)
- ▶ the response of the priority threatened species, populations or ecological communities to the control of bitou bush
- ▶ the response of other weed species to the removal and/or the control of bitou bush.

The effectiveness of bitou bush control programs can be measured directly by the response of the threatened species, population or ecological communities or indirectly by the response of bitou bush. Factors which confound the latter are bitou bush recruitment levels from the seed bank; re-invasion rates of bitou bush post-control; the percentage of the overall bitou bush infestation treated; and the percentage of plants that persist after control actions. These confounding factors can be accounted for during any monitoring program with an appropriate experimental design and methodology (see section 9.2.3 below).

A two-tier monitoring program is required for measuring responses (for details see Section 9.2.3 below). Where populations of priority species or the size of priority populations/ecological communities are sufficiently robust, the following protocol should be followed (second tier):

- ▶ treated and untreated plots, replicated to allow statistical analysis of data
- ▶ before and after measurements of bitou bush, threatened species, populations and ecological communities and other weed species continued over time
- ▶ frequency of measurement adequate to allow reliable analysis/interpretation of the results/trends.

Where populations of priority species or the size of priority populations/ecological communities are not sufficiently robust the following protocol should be followed (first tier):

- ▶ before and after measurements of bitou bush, threatened species, populations and ecological communities and other weed species continued over time.

In some instances the populations of priority species or the size of priority populations/ecological communities are such that it is impossible to undertake

monitoring. The two-tier monitoring program should be used to monitor robust (tier two) and less robust (tier one) species, populations and ecological communities.

#### 6.4.2 Measuring recruitment

---

Recruitment from the seed bank will have important implications for the long-term success of any bitou bush control program. Firstly, the time taken to exhaust bitou bush seed banks is unknown, but is thought to be 5–10 years (Stanley *et al.* 1989; NPWS 2001a). An understanding of seed population dynamics will allow more effective control programs to be developed, in part from better predictions of the follow-up control period. Secondly, some control measures will reduce bitou bush seed bank densities more than others. For example, fire stimulates seeds to germinate as well as killing others (Downey 1999). Thus, a combination of fire and herbicide is likely to reduce soil seed banks to a lower level than either method would if used alone.

The probability of a seed becoming a reproductive adult is unknown. Therefore, the optimal period in terms of maximum impact on bitou bush between the initial control and any follow-up treatment is also unknown. Data from the environmental weed Scotch broom (*Cytisus scoparius*) showed that less than 2% of seedlings became reproductive adults (Downey and Smith 2000). This information provides insights into when follow-up control programs should be undertaken. If seedling mortality in bitou bush is similarly high, follow-up treatments should target older seedlings because they have a greater probability of becoming reproductive. In addition, premature follow-up control treatments may kill seedlings that would die anyway, as well as miss many seeds that have not yet emerged. Lastly, the location of bitou bush seedlings may suggest invasion patterns (i.e. under roosting trees). This information can be used to target specific areas in follow-up control programs or subsequent stages of control, to prevent re-invasion.

The recruitment levels of the other species present also have important implications for the long-term success of any bitou bush control program. The number of seedlings of priority taxa can indicate their ability to recover/regenerate following bitou bush control programs. A lack of seedlings may require additional recovery techniques like revegetation, but such techniques are outside the scope of this TAP. The number of other weed seedlings will indicate the need for other control programs. Thus, any monitoring program needs to measure the recruitment of bitou bush and other species present.

#### 6.4.3 Measuring the impact of control programs on bitou bush

---

Most control methods do not result in 100% mortality. A measure of bitou bush plants that survive control treatments (e.g. missed totally, treated but resprout, or unaffected)

needs to be determined for each method used. Plants that survive control treatments can produce seed in a shorter timeframe than plants that germinate following the same control treatment, because they do not need to reach reproductive maturity. The implication of this is that plants that survive initial treatments will require earlier follow-up treatment than plants that have subsequently germinated, if the input of fresh seed is to be limited. Control of weed seed banks is a crucial component in weed management (Downey 2002).

#### 6.4.4 Measuring the response of priority species to herbicide

---

Herbicides have been used successfully to control bitou bush in Australia for many years. Concerns have arisen over the use of herbicides and in some instances this requires further investigation (see discussion in section 5.2 above). The following discussion refers primarily to assessment of the impact of herbicide to control bitou bush on the priority species listed in this TAP. The impacts on non-target species should also be determined during any such assessment.

A review of the effectiveness and environmental impacts of aerial spraying of bitou bush is being prepared, however, the outcomes were not available during the writing of the draft TAP. Provision has been made in this plan to accommodate these findings, through the inclusion of a list of species at risk (Appendix 5) and proposed research (see Action 2.2 below).

Extensive trials using herbicides to control bitou bush showed that application during winter can reduce the impact on the native species present (see: Toth *et al.* 1996; Toth 2002), while maintaining a high level of bitou bush control. These results led to the inclusion of winter herbicide application in the current best practice guidelines for bitou bush (see Vranjic and Groves 1999; Vranjic 2000). Recent studies have shown that herbicide application as used for bitou bush control can adversely effect some individual native species (e.g. *P. spicata*: Matarczyk 1999; Matarczyk *et al.* 2002). Apart from *P. spicata* the effect of herbicide application on the Bitou TAP priority species is unknown. A list of species for which the adverse effects of herbicide are known is presented in Appendix 5.

A list of species known or thought to be at risk from herbicide application (Appendix 5) should be considered when developing monitoring programs as well as site-specific management plans. Such lists should be used when developing any control program for bitou bush.

The effect on native seedlings of herbicide application for bitou bush control is not known. Examination of the impacts of herbicide application on priority taxa, at both the adult and seedling stages, is extremely important to the outcomes of this TAP. Due to the

generally small population size of the priority species and the unknown effect of herbicide application to the vast majority of them, *in situ* testing is not recommended. Monitoring programs must assess the impacts of herbicide use on both seedlings and adults of each priority species, as well as a range of non-target species. Where a priority species exhibits signs of herbicide damage, action must be taken immediately to prevent further damage, as in case of *P. spicata*.

#### 6.4.5 Measuring the spread of bitou bush and boneseed in NSW

---

Bitou bush has significantly increased its distribution within New South Wales in the last 20 years (see NPWS 2001a). It is important that continual monitoring of its spread be undertaken. This will provide a better understanding of the rates of spread, knowledge of which will help in the long-term control strategy for bitou bush in New South Wales.

In the final year of this TAP, the NSW coastline should be re-surveyed (see Love 1984; NPWS 2001a) to determine the status of both bitou bush and boneseed. Information on the distribution can be used to determine future initiatives and control programs, as well as to help determine the overall success of the initiatives currently being implemented as well as those proposed in the TAP.

#### 6.4.6 Actions and performance criteria

---

<i>Action 2.1</i>	<b>DEC will coordinate the monitoring/measurement of bitou bush control programs at priority sites.</b>
-------------------	---

##### ***Performance criteria***

- ▶ Establish an experimental protocol to collect data/information.
- ▶ Establish experiments at 75% of the sites to critically determine the effects of bitou bush control on bitou bush, and priority and non-target species (including other weed species), using either the tier one or tier two monitoring program outlined above, within 12–18 months of the publication date of this TAP.
- ▶ Maintain commitment to undertaking the monitoring programs started at each site over the course of this TAP.
- ▶ Publish and report the results in the *final year of the Bitou TAP* (including incorporation of results into best practice guidelines) to land managers and researchers. Results from both tiers of monitoring to be presented.

<i>Action 2.2</i>	<b>DEC will foster research into the effects of herbicide on priority species.</b>
-------------------	--

***Performance criteria***

- ▶ Establish experiments to determine the effects of herbicides, as used for bitou bush control, on priority species (including seedlings). Species of highest concern are listed in Appendix 5.
- ▶ Collect data where possible during the tier one monitoring programs.

**Action 2.3 DEC will coordinate a statewide (NSW) survey of bitou bush and boneseed infestations (including offshore islands).**

***Performance criteria***

- ▶ Re-survey the NSW coastline (including offshore islands) to determine the extent of bitou bush and boneseed in New South Wales in the *final year of the Bitou TAP*.
- ▶ Special attention to be given to areas free of bitou bush/boneseed during the last survey.

## 6.5 Native plant species and bitou bush

---

**Objective 3 Evaluate the ways in which bitou bush causes the decline of native plant species**

### 6.5.1 Determine the processes by which native plant species decline during bitou bush invasions

---

The way in which weed invasions contribute to native plant species decline is not clearly understood. Native species respond in a range of ways to plant invasions, such as rapidly going extinct, declining slowly, persisting at lower densities, or surviving only in the seed bank. The response observed is in part dependent on the length of time the weed species remains in the ecosystem. Weed invasions have the ability to modify ecosystem processes once they have invaded, for example, fire regimes (Mack and D'Antonio 1998). In addition, some introduced weed species exhibit differing characteristics between their exotic and native ranges. For example, in its exotic range Scotch broom has a larger seed size (Buckley *et al.* 2003 [large seeds can result in greater seedling establishment (Harper 1977)]), higher plant densities (Paynter *et al.* 2003) and larger seed banks (Downey 2002). While some information is available on how bitou bush impacts on native species (see chapter 4), it is imperative that we obtain a greater understanding of the processes involved and the magnitude of any impacts.

**Action 3.1**      **DEC will foster research into the decline in native plant species as a result of bitou bush invasions.**

**Performance criteria**

- ▶ Establish experiments to determine the ways in which bitou bush causes a decline in native species.
- ▶ Collect data where possible during the monitoring programs (tier one only).

## 6.6              Public involvement and awareness

---

**Objective 4**      **Ensure that all stakeholders are involved/participate at each of the priority sites**

### 6.6.1            Community involvement and training

---

A recent study estimated that expenditure on bitou bush and boneseed control programs in Australia was between \$1–2 million p.a. (Centre for International Economics 2001). Approximately half the input into bitou bush control is estimated to come from in-kind support from the work of volunteers involved in community programs like Dunecare and Coastcare (NPWS unpublished data). In line with the Commonwealth and state governments' commitment to community involvement in natural resource management, the Bitou TAP encourages community involvement at all priority sites. Some members of the community and stakeholders may however require training before they can undertake some control actions to:

- ▶ limit damage associated with implementing control techniques, especially where specific techniques are required (e.g. *P. spicata*)
- ▶ prevent inadvertent damage to conservation values through incorrect identification of plant species, (e.g. the need to distinguish between juveniles/seedlings of bitou bush and *Scaevola calendulacea* which are both common on foredunes
- ▶ ensure that threatened species, populations and ecological communities are adequately protected under the TSC Act (see Section 2.2.3)
- ▶ comply with regulations under the Pesticide Act. Accreditation may require some stakeholders/community members to gain specific skills.

Similar training for volunteers and stakeholders is also a priority in both the NSW bitou bush strategy (see NPWS 2001a) and the North Coast strategy (see Scanlon 2001).

### 6.6.2 Public awareness of bitou bush and boneseed

---

Public understanding of the issues involved with environmental weeds has increased in recent years through initiatives like *Weed Buster Week* and *Australia's 20 Worst Weeds* (or the Weeds Of National Significance). It is extremely important that public awareness is maintained, especially for environmental weeds like bitou bush.

It is important to keep the public informed of new conservation initiatives, such as threat abatement plans. As the Bitou TAP is the first TAP for a weed species in Australia it is paramount that it receives positive public support. A public awareness campaign will also help to maintain volunteer commitment over the five year period of the TAP and seek valuable support for the TAP from the wider community.

### 6.6.3 Community groups and bitou bush control

---

There is strong community support for bitou bush management in New South Wales. Hundreds of volunteers along the coast have contributed significantly to its control. These efforts require external support due to the scale of the problem, the number of individuals involved, their ages and to maintain their long-term commitment. A further discussion on the role of community groups and bitou bush is presented in the NSW Strategy (NPWS 2001a).

While there are many community groups working in coastal ecosystems in New South Wales, not all of them are undertaking work associated with bitou bush management. It is important from the perspective of this TAP to know which groups are undertaking bitou bush control, for several reasons. Firstly, to raise awareness of the TAP and its objectives. Secondly, to provide training and guidance where needed to achieve wider implementation of the TAP. Lastly, to increase the numbers of volunteers working at priority sites, especially if there are few or no volunteers currently working there.

Evaluation of the work undertaken by volunteers would help with identification of training needs for volunteers, as well as providing an assessment of the volunteer component at each priority site.

### 6.6.4 Actions and performance criteria

---

<i>Action 4.1</i>	<b>DEC and other agencies will coordinate and train volunteers (and other stakeholders) who wish to participate in control programs at high priority sites.</b>
-------------------	---

***Performance criteria***

- ▶ Source training providers and develop training courses/programs.
- ▶ Maintain accredited training programs throughout the five year duration of the TAP, to accommodate new volunteers and offer updates and refresher courses.
- ▶ Establish a database of those who are working/volunteering at priority sites, and monitor their progress at regular intervals during the life of the Bitou TAP.

**Action 4.2      DEC and other agencies will undertake public awareness programs on the impacts of bitou bush and the importance of its control.**

***Performance criteria***

- ▶ Establish a poster, fact sheet and webpage for the Bitou TAP and place signage at priority sites.
- ▶ Establish a program to report significant events in bitou bush management to the general public, or provide for regular updates, especially at priority sites.

## **6.7              Bitou TAP coordinator**

---

**Objective 5      Ensure implementation and administration of the Bitou TAP is undertaken**

### **6.7.1            Plan coordination**

---

The biodiversity outcomes established in this TAP can only be achieved through statewide coordination and implementation of the Bitou TAP. Full implementation will require the establishment of bitou bush control programs at over 60 priority sites across a range of land tenures throughout New South Wales. Once established, coordination of these sites will be needed for five years to maintain the integrity of the TAP. The design, implementation and analysis of experiments to measure the responses of threatened species, populations and ecological communities to bitou bush control at these sites will need to be undertaken. Given the scale of these actions it is essential that a coordinator be appointed to effectively implement this TAP.

The specific role of the TAP coordinator will be to:

- 1      coordinate the implementation of bitou bush control at priority sites (including guidance where needed for private landholders and other stakeholders, e.g. in the development of site-specific management plans)
- 2      establish and implement a protocol for monitoring the effectiveness of control programs at priority sites (including best practice management)

- 3 liaise with research organisations to establish herbicide trials on nominated non-target species
- 4 liaise with research organisations to establish sites where the impact and control of bitou bush on fauna is studied (including supervision of postgraduate students and development of experimental protocols)
- 5 liaise with training providers and/or regional stakeholders
- 6 collate and analyse data collected through the implementation of the plan, especially with regard to improving best practice methodology, and report results
- 7 revise the species and site models and produce new lists annually to account for changes during the TAP
- 8 monitor the spread of bitou bush and boneseed in New South Wales
- 9 prepare a revised plan within five years of the date of commencement of this plan
- 10 prepare and implement an education and awareness program to promote the TAP
- 11 perform day to day administration of the TAP including providing regular program reports to the DEC Executive and other stakeholders.

#### 6.7.2 Actions and performance criteria

---

<i>Action 5.1</i> <b>DEC will support a position to coordinate the implementation of the Bitou TAP.</b>
---

<b><i>Performance criteria</i></b>
------------------------------------

- |   |
|---|
| <ul style="list-style-type: none"> <li>▶ A position is established, following the approval of the Bitou TAP, to coordinate its implementation.</li> <li>▶ Progress reports are provided on a regular basis.</li> <li>▶ The coordinator reviews the current TAP and prepares a second plan within five years of the date of commencement of this TAP.</li> </ul> |
|---|

## 7 Impact of bitou bush invasion on fauna

---

In the past, studies on the effect of plant invasions on fauna have received little attention (French and Eardley 1997; Adair and Groves 1998). However, recent studies involving a range of weed species have highlighted the diverse ways in which birds and mammals (Lawrie 2002), invertebrates (French and Eardley 1997), reptiles (Hoefer *pers. comm.*) and amphibians (Wellington *pers. comm.*) interact with weeds. Some interactions have negative effects on fauna. For example, *Spartina* invasions can convert tidal mudflats into grasslands, resulting in the loss of habitat for many wading birds (see Lane 1992). Some interactions have positive effects on fauna. For example, introduced plants with spines or thorns can provide protection to rare mammals like the southern brown bandicoot (see Regel *et al.* 1996). Such weed–fauna interactions can also affect groups of species in different ways. For example, bird species were both negatively (8 species) and positively (10 species) affected following Scotch broom invasion (see Bell 1990). Weeds affect fauna in different ways: altering food resources, feeding substrate, nesting/breeding sites, shelter and protection from predators, roosting and perching sites, and movement corridors.

An audit system has been proposed by Lawrie (2002), based on observations of animals (or animal signs such as scats) within infested areas, to determine weed–fauna interactions. In Australia 225 bird species have been recorded interacting with 482 introduced plant species, and 43 mammals interacting with 55 introduced plant species (Lawrie 2002). The information obtained by this audit system does not provide a complete picture however, rather it is biased towards positive interactions. For example, declines in fauna density are unlikely to be recorded without rigorous studies. In addition, the proposed audit system does not provide detailed information on the exact nature of effects on fauna. Therefore, detailed studies are needed in some areas to provide information in addition to that obtained from the proposed audit system.

The removal of weeds from sites that have been infested for many years may affect fauna that have modified their lives as result of these infestations. For example, the removal of blackberries in Belair NP (see Regel *et al.* 1996) may lead to a decline in the threatened southern brown bandicoot, as blackberries provide protection from predators. Therefore, blackberry removal programs need to consider the introduction of replacement measures to protect these bandicoots. Historically, such impacts have rarely been considered in weed control programs.

Information on the interactions between weeds and fauna, both positive and negative, needs to be collected and incorporated into weed management strategies (Lawrie 2002). In addition, information on the effect of controlling weeds on fauna also needs to be collected and incorporated into these strategies.

## 7.1 Interactions between bitou bush and vertebrates (birds and mammals)

---

Information on the impact of bitou bush invasion (and its control programs) on vertebrates (native or introduced) is very limited, especially for mammals. Dodkin and Gilmore (1984) highlighted the need to collect information on the impacts of bitou bush on fauna, however, few studies have been published since. Anecdotal and observational evidence suggests that bitou bush can result in the decline of some native bird populations, for example, those that nest or roost in hind-dunes e.g. little terns (*Sterna albifrons*: Ross pers. comm.). In addition, monthly counts of shorebirds on Pelican Island, off Port Macquarie, showed that as bitou bush and lantana increased on the island bird densities declined (NPWS 2002). The contribution of bitou bush and lantana to this decline is unknown. The impact of bitou bush invasion on fauna was acknowledged by the NSW Scientific Committee in its determination of bitou bush as a KTP (NSW SC 1999a). The determination identified three threatened fauna species potentially at risk: eastern bristlebird (*Dasyornis brachypterus*), little tern (*Sterna albifrons*) and beach stone-curlew (*Esacus neglectus*: NSW SC 1999a).

The effects of bitou bush invasion on bird communities are not consistent across bird species. On the South Coast, canopy-feeding generalists and understorey insectivores were found to be more abundant in bitou bush infested areas, while species richness and abundance of nectarivores, granivores, scavengers and raptors were lower in infested habitats (French and Zubovic 1997).

The sprawling branches, dense foliage cover, long flowering period and abundant fleshy fruit production of bitou bush may provide shelter and food for some animals (French and Eardley 1997). However, simply because bitou bush offers a potential food resource does not mean that animals utilise or prefer this resource to their typical diet. The presence of bitou bush did not appear to affect fruit removal rates by birds for co-occurring native shrub species (Gosper *et al.* in prep.). Bitou bush may only be a minor food resource for birds, as many of the species observed feeding on bitou bush were generalist feeders (Dodkin and Gilmore 1984).

Not all bird species that consume bitou bush fruits are effective dispersers (e.g. crimson rosella), and for many other birds effective dispersal is only assumed (e.g. from the occurrence of bitou bush plants beneath emergent trees/perching sites). European red foxes consume high quantities of bitou bush fruits and are effective dispersers of its seeds (Meek 1998). Unlike many native coastal plants, bitou bush flowers in winter and provides an important food source for many animals during late winter/early spring (French and Eardley 1997). Conversely, the reduction in native species that flower in summer due to bitou bush infestation may result in a food shortage for many animals such as specialist frugivores, nectarivores and insectivores (Dodkin and Gilmore 1984).

Twenty-three bird species and three mammal species have been reported to feed on bitou bush (Table 7.1).

French and Zubovic (1997) recommend further study to elucidate the responses of individual bird species to bitou bush invasions. Similar studies for mammals are also needed, especially given that the only mammal species for which there is information are introduced ones (Table 7.1).

Table 7.1 Birds and mammals that feed on bitou bush/boneseed (alphabetical order)

	Species	Reference
<b>Birds</b>	common blackbird*	1
	black-faced cuckoo-shrike	2
	common koel	1
	crimson rosella	2, 5
	eastern rosella	2
	emu	1
	grey currawong	4
	house sparrow*	2
	lewins honeyeater	1, 2
	noisy miner	1
	mistletoebird	1, 2
	olive-backed oriole	1, 2
	pieb currawong	1
	red wattlebird	1, 2
	red-whiskered bulbul*	2
	regent bowerbird	1
	silveryeye	1, 2
	satin bowerbird	2
	southern figbird	1
	superb fairy-wren	2
common starling*	1, 2	
white-cheeked honeyeater	1	
yellow-faced honeyeater	2	
<b>Mammals</b>	cattle*	1
	rabbit*	1
	European red fox*	1, 3

**Reference:** 1. Dodkin and Gilmore (1984); 2. Gosper (1999);  
3. Meek (1998); 4. Loyn and French (1991); 5. Weiss (1983).

\* = Introduced species

## 7.2 Interactions between bitou bush and invertebrates

Interactions between plant invasions and invertebrates are much less understood than that for birds and mammals. On the South Coast of New South Wales, examination of the composition of litter invertebrates (i.e. species richness and relative abundance) between sites with and without bitou bush showed no difference in overall species richness or abundance (French and Eardley 1997). However, Collembola (springtails) were more abundant in infested sites, while Dermaptera (earwigs), Hymenoptera (wasps, sawflies, bees and ants) and Blattodea (cockroaches) were more abundant in uninfested sites. Litter invertebrates were not identified to species level, which may mask actual differences. For

example, a particular genus may occur across a range of habitats, while the species within that genus may vary within these habitats. Several other studies on insects and bitou bush are currently being conducted (Wilkie *pers. comm.*).

### 7.3 Objectives and actions

---

#### 7.3.1 Response of fauna to bitou bush invasion

---

<b>Objective 6 Determine the effects of bitou bush <u>invasions</u> on fauna</b>
--

The final determination of the NSW Scientific Committee for listing of bitou bush/boneseed as a KTP identified three threatened fauna species potentially at risk (NSW SC 1999a). Ground-nesting shorebirds such as little terns are affected by bitou bush through its incursion onto breeding/roosting sites, for example, on the southern shores of Quibray Bay in Towra Point NR (Shepherd *pers. comm.*). Observations suggest that bitou bush can lead to the decline in a range of native shorebirds (NPWS 2002).

Detailed studies of the impacts of bitou bush (and boneseed) invasions on a range of fauna species are lacking. For example, the host plant *Viola betonicifolia* of the endangered butterfly *Argyreus hyperbius* subsp. *inconstans* appears to be threatened by bitou bush invasion in northern New South Wales, from Port Macquarie to the NSW/Qld boarder (Moss *pers. comm.*), but no data are available to determine the impacts. If data shows that *V. betonicifolia* is threatened by bitou bush then any reduction in bitou bush should have positive outcomes for this species as well as for an endangered butterfly.

#### 7.3.1.1 Actions and performance criteria

---

<b>Action 6.1 DEC will foster research into the effects of bitou bush invasions on fauna.</b>
---

<b>Performance criteria</b>
-----------------------------

- |   |
|---|
| <ul style="list-style-type: none"> <li>▶ Establish a system to prioritise fauna species (or groups of species, e.g. waders) that are at risk from bitou bush invasions.</li> <li>▶ Develop research projects on the effects of bitou bush invasions on priority fauna species.</li> <li>▶ Initiate these research projects during the TAP. The results of this works could then inform subsequent Bitou TAP's.</li> </ul> |
|---|

### 7.3.2 Response of fauna to bitou bush control

---

<b>Objective 7 Determine the effects of bitou bush <u>control</u> on fauna</b>
--

Very little is known about the effects on fauna of removing a weed from any ecosystem, especially when the weed has become dominant and may have been so for many years or decades. Weed infestations may change the density and/or abundance of fauna as well as how they interact with their ‘new’ environment containing these weeds, and as such they may be seriously affected if these weeds are suddenly removed. Some weeds may play an important role in the conservation of some threatened species, e.g. the southern brown bandicoot (see Regel *et al.* 1996), and thus their removal could further threaten them. The disturbance involved in removing weeds may also affect many fauna species long after the actual control event has taken place (i.e. from increased light, soil disturbance, trampling of the ground and/or the effects of management techniques like fire). The vast majority of bitou bush control programs, like those for most other weed species, have operated on the assumption that the removal of the weed and restoration of native vegetation will result in improved habitats for native fauna. This may not be the case for all fauna species however.

The techniques used to control bitou bush may also impact on fauna. For example, as has already been discussed in Chapter 5, the surfactants used with some herbicides may have adverse effects on some frog species. Information on such impacts is scarce. A preliminary list of the species likely to be affected is presented in Appendix 5. Some frog species (e.g. green and gold bell frogs) are known to utilise bitou bush in their habitat, and the removal of bitou bush may therefore have adverse effects especially during broad scale control programs (Wellington *pers. comm.*). The draft green and gold bell frog recovery plan raises the concern that the control of bitou bush with herbicide could pose a real threat to the species and warrants further investigation (NPWS 2003b). This section aims to address such issues through research.

#### 7.3.2.1 Actions and performance criteria

---

<b>Action 7.1 DEC will foster research into the effects of bitou bush control on fauna.</b>
---

<b>Performance criteria</b>
-----------------------------

- |  |
|--|
| <ul style="list-style-type: none"> <li>▶ Establish a system to prioritise fauna species (or groups of species, e.g. waders) that are at risk from bitou bush control.</li> <li>▶ Establish sites where studies can be undertaken to determine the effects of bitou bush control on fauna.</li> <li>▶ Develop research projects on the effects of bitou bush control on fauna.</li> </ul> |
|--|

- ▶ Initiate these research projects during the TAP. The results of this works could then inform subsequent Bitou TAP's.

### 7.3.3 Re-evaluate bitou bush management and research aims

---

#### **Objective 8 Establish guidelines for future control programs and research projects based on the outcomes of this TAP**

The best practice management guides for bitou bush (see Vranjic and Groves 1999; Vranjic 2000) and boneseed (see Adair and Ainsworth 2000) should be revised as new information becomes available. In addition, the concept of focusing weed control on biodiversity outcomes as presented in this TAP, is a new approach in weed management (see Downey 2003a, b), therefore the outcomes of this TAP should determine future management and research objectives for bitou bush and boneseed in Australia.

#### 7.3.3.1 Actions and performance criteria

---

**Action 8.1 DEC and other stakeholder will examine new data and integrate it into future control/management strategies and best practice guidelines for bitou bush.**

##### **Performance criteria**

- ▶ Re-evaluated management plans and control strategies based on data collected in Actions 6.1 (fauna and bitou bush), 7.1 (fauna and control), 3.1 (decline of native plants), 2.1 (monitoring of control programs) and 2.2 (herbicide impacts), as well as any other data available, during the final year of the Bitou TAP.

**Action 8.2 DEC and other stakeholders will examine new data and establish future priorities for bitou bush research.**

##### **Performance criteria**

- ▶ Determine future research objectives based on data collected in Actions 6.1 (fauna and bitou bush), 7.1 (fauna and control), 3.1 (decline of native plants), 2.1 (monitoring of control programs) and 2.2 (herbicide impacts), as well as any other data available, during the final year of the Bitou TAP or the development of subsequent Bitou TAP's.

**Note:** 'other stakeholders' as identified in Actions 8.1 and 8.2 refers to those stakeholders who participate in Actions 2.2, 3.1, 6.1 and 7.1, which have not been identified at this time.

Table 7.2 Summary of the Bitou TAP objectives and actions

<b>Objective 1</b>	<b>Ensure that bitou bush (and boneseed) control is undertaken in areas where the impacts on threatened species, populations and ecological communities are greatest</b>
<i>Action 1.1</i>	DEC and the Department of Lands will undertake bitou bush control programs at priority sites on their estate (Table 6.2). In addition, these agencies will seek agreement from councils to undertake bitou bush control programs at priority sites on council administered land. The Department of Lands will liaise and encourage Trust managers of Crown land to undertake bitou bush control programs at priority sites. DEC will liaise with landholders to undertake bitou bush control programs at priority sites on private lands. To measure the biodiversity benefits, bitou bush will not occur in areas designated as experimental ‘no-treatment’ areas (see Objective 2).
<i>Action 1.2</i>	At high priority sites DEC and the Department of Lands will develop site-specific management plans for bitou bush control programs, based on currently available best practice guidelines. DEC will work with councils and private landholders that agree to Action 1.1, to develop site-specific management plans.
<i>Action 1.3</i>	Indigenous communities will be encouraged to assist with the development of site-specific management plans.
<b>Objective 2</b>	<b>Evaluate the effectiveness of control programs with respect to the response of priority species, populations and ecological communities</b>
<i>Action 2.1</i>	DEC will coordinate the monitoring/measurement of bitou bush control programs at priority sites.
<i>Action 2.2</i>	DEC will foster research into the effects of herbicide on priority species.
<i>Action 2.3</i>	DEC will coordinate a statewide (NSW) survey of bitou bush and boneseed infestations (including offshore islands).
<b>Objective 3</b>	<b>Evaluate the ways in which bitou bush causes the decline of native plant species</b>
<i>Action 3.1</i>	DEC will foster research into the decline in native species as a result of bitou bush invasions.
<b>Objective 4</b>	<b>Ensure that all stakeholders are involved/participate at each of the priority sites</b>
<i>Action 4.1</i>	DEC and other agencies will coordinate and train volunteers (and other stakeholders) who wish to participate in control programs at high priority sites.
<i>Action 4.2</i>	DEC and other agencies will undertake public awareness programs on the impacts of bitou bush and the importance of its control.
<b>Objective 5</b>	<b>Ensure implementation and administration of the Bitou TAP is undertaken</b>
<i>Action 5.1</i>	DEC will support a position to coordinate the implementation of the Bitou TAP.
<b>Objective 6</b>	<b>Determine the effects of bitou bush <u>invasions</u> on fauna</b>
<i>Action 6.1</i>	DEC will foster research into the effects of bitou bush invasions on fauna.
<b>Objective 7</b>	<b>Determine the effects of bitou bush <u>control</u> on fauna</b>
<i>Action 7.1</i>	DEC will foster research into the effects of bitou bush control on fauna.
<b>Objective 8</b>	<b>Establish guidelines for future control programs and research projects based on the outcomes of this TAP</b>
<i>Action 8.1</i>	DEC and other stakeholders will examine new data and integrate it into future control/management strategies and best practice guidelines for bitou bush.
<i>Action 8.2</i>	DEC and other stakeholders will examine new data and establish future priorities for bitou bush research.

## 8 Social and economic impacts of the Bitou TAP

---

The implementation of the Bitou TAP will have positive social benefits. As a major environmental weed infesting 80% of the coastline and threatening many plant communities, any reduction in the distribution of bitou bush will result in enhanced protection of beaches and a reduction in impacts on coastal biodiversity. The reductions proposed in this TAP are for specific areas, rather than general reductions in distribution, the latter being outside the scope of this TAP.

The raising of public awareness of bitou bush through many of the outcomes in this TAP will help to maintain and augment the historically strong community support for bitou bush control across the state. Improved understanding of the threats to biodiversity posed by bitou bush, in particular to fauna, will help to ensure that support for bitou bush control programs continues into the future. In addition, these actions will raise the awareness of the potential threat posed by boneseed in New South Wales.

There is widespread public appreciation that bitou bush is a threat to native flora and that it impacts upon coastal environments. There is also widespread public expectation that bitou bush should be controlled on all public lands. The prioritisation of bitou bush control sites may be unpopular where support for existing programs is reduced (e.g. lower priority sites, or where control does not occur in more conspicuous areas, such as in urban reserves, along roadsides, popular beaches and coastal recreation areas). This TAP aims to counteract this possibility through a public education program – Action (4.2). Given that bitou bush occupies 80% of the NSW coastline and potentially threatens all terrestrial coastal plant communities, it is expected that the community will generally support a plan that prioritises and directs control programs to areas which are at the greatest risk from invasion, rather than only where bitou bush is most conspicuous. Nevertheless, DEC, the Department of Lands and local governments will continue to be involved in many existing collaborative programs outside the scope of this TAP, which have broader conservation objectives, public support or address priorities identified in the national, state and regional bitou bush management strategies (e.g. control in the northern and southern containment zones or removal of light infestations).

An economic analysis of the cost of bitou bush and boneseed control has not been undertaken, which is the case for the vast majority of environmental weeds in Australia. However, information derived from a model used for Scotch broom shows that for small infestations, control provides significant long-term economic benefits. Biological control programs can provide economic benefits, however, the cost of such programs is beyond the reach of individual control programs. In addition, control strategies that targeted both weed and seed bank densities resulted in lower control costs in the long term (see Odom *et al.* 2002).

The economic benefits of the Bitou TAP are difficult to determine, especially given the difficulty of developing an accurate estimate of the cost of environmental weeds, let alone the economic benefit of reducing threats to specific species, populations or ecological communities. The main economic benefit of the Bitou TAP is that it provides a consistent framework for control measures to be undertaken at priority sites for the five years of the TAP (Action 1.1). As with this TAP, previous control programs have been dependent on the continuity of funding, either in the form of community grants or recurrent funds. Where funding has ceased prior to the completion of a control strategy, any successes of that control program may be quickly lost as bitou bush can re-invade rapidly. In these cases, continuity of funds would most likely have resulted in greater long-term control of bitou bush. Where funds cease and re-invasion occurs there are also likely to be negative social impacts, for example, disillusionment of volunteer groups. The Bitou TAP seeks to ensure that funding is maintained at priority sites for the duration of the TAP, and thus prevent such failures.

No other economic or social impacts from this plan are envisaged. There are no public health issues related to the implementation of the plan. Actions 2.2 (research into herbicides and threatened species), 2.3 (monitoring of control programs), 6.1 (bitou bush impacts on fauna) and 7.1 (bitou bush control and fauna) aim to obtain further data on bitou bush control methods with respect to native plants and animals. Thus, identifying any potential effects of the TAP on flora and fauna, combined with Action 8.1 (re-evaluated new control programs), will lessen any such impacts in the future.

The Bitou TAP will not significantly affect public access or recreational use of public lands, although some existing control programs to protect threatened species and ecological communities may limit the use of some coastal areas during the TAP. The plan will not significantly affect development applications or other activities that require approval under the EP&A Act (Section 2.2.6), except where a condition of consent refers to the removal of all bitou bush on a particular site. No impacts on aboriginal/indigenous heritage are expected. Any site-specific impacts will be addressed during the development of site-specific management plans (Action 1.2).

There are significant adverse social and economic impacts that could arise from not implementing this plan. Bitou bush is a major threat to the entities identified in this plan (Appendix 2). These entities will continue to be threatened in the absence of such a plan. The continued threat posed by bitou bush will add to the cost of recovering these entities, and this cost will increase with time. The longer the threat is imposed the greater the risk of additional entities becoming threatened and those entities that are threatened becoming extinct. Any such extinction is likely to have major social implications, especially if a plan to prevent such extinctions was prepared but not adopted.

## 9 Costs and implementation of this TAP

---

As a number of Actions, or parts thereof, outlined in Chapter 6 were implemented in the 2003/04 financial year, the actual costs associated with each of these Actions is presented here as a reflection of the estimated cost of implementing each action in this TAP. This assumes that these stakeholders will maintain a similar level of commitment in the future and that there is minimal variation between years in the cost of implementing Actions.

Those proposed Actions not funded in 2003/04 are not presented in the costings table, but are discussed below. These Actions are predominantly associated with future research objectives, which are aimed at filling the knowledge gaps identified during the preparation of this TAP and are crucial for the longer term management of bitou bush as well as to understand better its impact on biodiversity.

The actual cost of implementing this plan will be finalised during the public exhibition stage and subsequent preparation of the final plan in consultation with all relevant stakeholders. Implementing this TAP in the future will depend on similar levels of commitment from government authorities, private industry and the community. Where possible, additional funds will be sought from new sources, by the respective land managers, researchers, and the community to implement unfunded actions.

### 9.1 Summary of the current expenditure associated with proposed actions outlined in this TAP

---

During the 2003/04 financial year, several of the proposed Actions, or parts thereof, outlined in this plan (see Chapter 6) were undertaken. The cost of implementing these Actions in 2003/04 (hereafter referred to as the current expenditure) was \$882,557 (see Table 9.1). This included expenditure by the DEC, Department of Lands, several councils and the University of Wollongong. It must also be noted that the current cost is not a reflection of any commitment to this plan in the future. However, it is anticipated that these bodies will provide a similar level of commitment for these Actions in the future.

The current expenditure highlights the:

- ▶ degree to which Actions within this plan are already being undertaken, across a range of land tenures by a range of stakeholders, and
- ▶ estimated cost of implementing this plan

Table 9.1 partitions the current expenditure for a range of Actions outlined in the TAP by various agencies/land managers responsible. The current expenditure is presented as agency expenditure, both ‘in-kind’ i.e. NPWS staff time and cash, as well as external contributions, which includes volunteer ‘in-kind’ and cash grants.

Table 9.1 The expenditure in 2003/04 by various agencies for implementing a range of proposed Actions, or parts thereof, identified in the Bitou TAP.

Action	Description	Priority	Current expenditure in 2003/04 (\$ 000)	Responsibility/ funding source #	In-Kind (\$ 000)	Cash expenditure (\$ 000)	External contribution (\$ 000)
1.1	Bitou bush control	1	437	DEC	99.5	78	259.5
			72	DoL	-	72	-
			107.8	Councils	14.7	32.7	60.4
2.1	Monitor control programs	1	53.9	DEC	20.5	14.9	18.5
			1.6	Councils	0.5	0.4	0.7
3.1	Decline of native plant species due to bitou bush	1	57	University of Wollongong	10.5	40	6.5
4.1	Coordination and training of volunteers	1	61.5	DEC	5.5	26	30
			7.3	Councils	0.3	7	-
4.2	Public awareness of bitou bush	2	7.3	DEC	3.1	2	2.2
			0.2	Councils	0.2		
5.1	TAP coordinator	1	77	DEC	-	77	-
<b>Total</b>			<b>882.6</b>		<b>154.8</b>	<b>350.0</b>	<b>377.8</b>

\*Priority' ratings are: 1 Action critical to meeting plan objectives, 2 Action contributing to meeting plan objectives

\*Current expenditure in 2003/04' represents the funds spent on each action by various agencies in the 2003/04 financial year.

# DEC (Department of Environment and Conservation), DoL (Department of Lands), and Councils (Randwick Council, Sutherland Shire Council, Bellingen Council, Illawarra District Weeds Authority and a local community group)

'In-Kind' funds represents the salary component of permanent staff.

'Cash expenditure' represents the salary component for temporary staff and other costs such as the purchasing of survey and laboratory equipment.

'External contributions' includes both volunteer's in-kind time and cash grants

The majority of unfunded Actions, in 2003/04, had a priority rating of 2 or 3 (see below). The only unfunded Actions with a priority rating of 1 – Action critical to meeting plan objectives – were Actions 1.2 and 1.3, which are concern the development of site-specific management plans (see below).

## 9.2 Breakdown of the current costs (2003/04)

### 9.2.1 Bitou bush control at priority sites (Action 1.1)

Control programs are currently being undertaken at 45 of the 60 priority sites identified in this plan (see Chapter 6), on a range of land tenures. Expenditure on bitou bush control programs at these priority sites (Action 1.1) in the 2003/04 financial year totaled \$882,557 (see Table 9.1).

In addition, bitou bush control occurred at a large number of the other lower priority sites identified in Appendix 4 during 2003/04. The costs associated with control programs at these lower priority sites are not presented here, but are likely to be substantial.

### **9.2.2 Development of site-specific management plans (Actions 1.2 and 1.3)**

---

There was no expenditure in 2003/04 for the preparation or updating of site-specific management plans for the control of bitou bush at priority sites (Action 1.2), because no plans were developed or updated. As no plans have been developed or updated, there has been no consultation with indigenous people (Action 1.3). Site-specific management plans are a major component of the TAP and hence, have been given a priority rating of 1. The development of such plans is imperative to ensure control is effective and that the impact to threatened species, populations or ecological communities is minimal at each priority site.

### **9.2.3 Monitor bitou bush control programs at priority sites (Action 2.1)**

---

Monitoring is the key to evaluating the success or failure of the Bitou TAP. The total expenditure on monitoring bitou bush control programs and the response of threatened biodiversity at 20 priority sites in 2003/04 was \$55,500 (see Table 9.1). The cost of monitoring at priority sites varied widely.

There are a number of problems with the current monitoring programs with respect to meeting the objectives of this TAP which include: (i) the aims and objectives of existing monitoring programs differ, (ii) the level of monitoring and the methods used varies at different sites, (iii) numerous managers ‘own’ the data making compilation difficult, and (iv) such variation makes analysis across sites and species virtually impossible. Thus, future monitoring programs must be uniform if comparable data is to be collected and analysed.

### **9.2.4 Determining the effects of herbicide on threatened species (Action 2.2)**

---

There was no expenditure in 2003/04 for determining the effects on herbicides on threatened species, except where it occurred as a part of an existing monitoring program. Data on the impact of herbicide on threatened species, or more generally native species, is limited, and most of it is anecdotal. Such information is necessary to manage and protect threatened biodiversity better and hence has been given a priority rating of 2 (contributing to the plan objectives). Rigorous examination needs to be undertaken by researchers into the effects of herbicides on threatened species.

### **9.2.5 Monitoring the spread of bitou bush and boneseed (Action 2.3)**

---

There was no expenditure in 2003/04 on monitoring the spread of bitou bush and boneseed, as the distribution of bitou bush was extensively mapped in 2001 (see Thomas 2002; Thomas and Leys 2002). However, it is proposed to re-survey the distribution and abundance of bitou bush and boneseed in years 4 and 5 of this TAP. Changes prior to this are unlikely to be significant. Thus, this action was given a priority rating of 3 (being desirable, but not essential for the implementation of this TAP).

### **9.2.6 Decline in native plants due to bitou bush (Action 3.1)**

---

In 2003/04, expenditure on research into how bitou bush contributes to native plant species decline was \$57,000. This represents the stipend of several PhD students, an honours student and the in-kind contribution by an Associate Professor.

### **9.2.7 Coordination and training of volunteers (Action 4.1)**

---

At present a number of volunteers and community groups undertake actions outlined in this TAP, primarily Action 1.1 – control at priority sites. The value of such volunteers and community groups in delivering the objectives of this TAP is substantial. Coordination and training of such volunteers and community groups is essential if the objectives of this TAP are to be achieved. In addition, there are a number of other reasons why coordination and training are essential, e.g. legal requirements under the *Pesticides Act*, and *Threatened Species Conservation Act*, as well as insurance issues. In 2003/04, the expenditure associated with coordinating and training volunteers with respect to the actions outlined in this TAP was \$68,800 (Table 9.1). However, such coordination and training should be standardized in order to meet the objectives of the TAP. In addition, there is an on-going need for coordination and training of volunteers.

### **9.2.8 Public awareness of the Bitou TAP (Action 4.2)**

---

Estimated expenditure on education programs at a limited number of priority sites in 2003/04 was \$7,500 (Table 9.1). The implementation of this TAP will require continual support from all stakeholders. Such support can only be achieved through an on-going public awareness campaign.

### 9.2.9 Bitou TAP coordinator (Action 5.1)

---

Expenditure on preparing and coordinating the Bitou TAP in 2003/04 was \$77,000 (Table 9.1). This comprised the salary of a Project Officer (\$71,777) plus an operating budget for travel, editing and printing (\$5,223).

### 9.2.10 Bitou bush and fauna (Actions 6.1–8.2)

---

There was no expenditure in 2003/04 for undertaking research into the impacts of bitou bush on fauna (Action 6.1) or the impacts of bitou bush control on fauna (Action 7.1). Data on the impact of bitou bush and its control on fauna is limited and most of it is anecdotal. Such information is necessary to manage and protect threatened biodiversity better and hence has been given a priority rating of 2 (contributing to the plan objectives). Rigorous examination needs to be undertaken by researchers into the effects on bitou bush invasion and its control on fauna.

New information collected on the (i) impact of herbicides used to control bitou bush on native species (Action 2.2), (ii) reasons for native species decline (Action 3.1), and (iii) interaction of bitou bush and fauna (Actions 6.1 and 7.1) should to be collated and incorporated into best practice guidelines (Action 8.1). This action is proposed for the final year of the TAP and thus this Action is given a priority rating of 3 (being desirable, but not essential for the implementation of this TAP).

## 10 References

- Adair, R.J. and Ainsworth, N. (2000). *Best Practice Management Guide 4: Boneseed* *Chrysanthemoides monilifera subsp. monilifera*. Cooperative Research Centre for Weed Management Systems, Adelaide.
- Adair, R.J. and Groves, R.H. (1998). *Impact of Environmental Weeds on Biodiversity: A review and development of a methodology*. Environment Australia, Canberra.
- ANZECC (Australian and New Zealand Environment and Conservation Council) (1999). *Threatened Australian Flora*. Prepared by the Endangered Flora Network, Environment Australia, Canberra.
- ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), ANZECC (Australian and New Zealand Environmental and Conservation Council) and Forestry Ministers (1997). *The National Weeds Strategy: A strategic approach to weed problems of national significance*. Commonwealth of Australia, Canberra.
- ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), ANZECC (Australian and New Zealand Environmental and Conservation Council) and Forestry Ministers (2000). *Weeds of National Significance Bitou Bush and Boneseed (Chrysanthemoides monilifera ssp. rotundata and monilifera) Strategic Plan*. National Weeds Strategy Executive Committee, Launceston.
- Barr, D.A. (1965). Restoration of coastal dunes after beach mining. *Journal of Soil Conservation Service of New South Wales* **21**, 199–209.
- Bell, S.A.J. (1990). *Effects of the Weed Scotch broom on Bird Communities in Open Forests on Barrington Tops*. Bachelor of Science, Honours Thesis, University of Newcastle, Newcastle, NSW.
- Benson, J. (1999). *Setting the Scene: The native vegetation of New South Wales*. Native Vegetation Advisory Council of New South Wales, Sydney.
- Bidwell, J.R. and Gorrie, J.R. (1995). *Acute toxicity of a herbicide to selected frog species*. Technical series 79, Western Australian Department of Environmental Protection, Perth.
- Briggs, J.D. and Leigh, J.H. (1996). *Rare or Threatened Australian Plants*, 1995 revised edition. CSIRO, Australia.
- Broeze, E.A. and Wolfenden, J.A.J. (2002). *South Coast Regional Bitou Bush Strategy*. Arnhem Environmental Impact Assessors, Armidale.
- Buchanan, R.A. (1989). *Bush Regeneration Recovering Australian Landscapes*. TAFE (Technical And Further Education) NSW, Sydney.
- Buckley, Y.M., Downey, P.O., Fowler, S.V., Hill, R., Memmot, J., Norambuena, H., Pitcairn, M., Shaw, R., Sheppard, A.W., Winks, C., Wittenberg, R. and Rees, M. (2003). Are invasives bigger? A global study of seed size variation in two invasive shrubs. *Ecology* **84** (6), 1434–1440.
- Centre for International Economics (2001). *Impact Assessment*. Technical Series 6. CRC for Weed Management Systems, Adelaide.
- Clarke, P.J. (1989). *Coastal Dune Vegetation of New South Wales*. Technical Report No. 89/1, Coastal Studies Unit, University of Sydney and Soil Conservation Service of New South Wales, Sydney.
- Clarke, P.J. and Carolin, R.C. (1991). *Beach Plants of New South Wales*. Sainty and Associates, Sydney.
- Commonwealth of Australia (1996). *A National Strategy for the Conservation of Australia's Biological Diversity*. Department of Education, Science and Technology (DEST), Canberra.
- D'Antonio, C.M., Dudley, T.L. and Mack, M. (1999). Disturbance and biological invasions: Direct effects and feedbacks. In: Walker, L.R. (ed.) *Ecosystems of Disturbed Ground: Ecosystems of the world 16*. pp. 413–452. Elsevier, Amsterdam.
- Daehler, C.C. and Strong, D.R. (1996). Status, prediction and prevention of introduced cordgrass *Spartina* spp. invasions in Pacific estuaries, USA. *Biological Conservation* **78**, 51–58.
- Davis, M.A., Grime, J.P. and Thompson, K. (2000). Fluctuating resources in plant communities: A general theory of invasibility. *Journal of Ecology* **88**, 528–534.
- Dodkin, M.J. and Gilmore, A.M. (1984). Species and ecosystems at risk – a preliminary review. In: Love, A. and Dyason, R. (eds) *Proceedings of a Conference on Chrysanthemoides monilifera, Port Macquarie*. pp. 33–52. NSW National Parks and Wildlife Service and NSW Department of Agriculture, Sydney.
- Downey, P.O. (1999). Fire and Weeds: A management option or Pandora's box? In: *Bushfire '99: Australian Bushfire Conference, Albury, July 1999*, pp. 111–117. Charles Sturt University, Albury.
- Downey, P.O. (2002). *Disturbance and Invasion Ecology of Scotch broom (Cytisus scoparius (L.) Link) in Australia*. PhD. Dissertation. University of New England, Armidale.
- Downey, P.O. (2003a). Invasive Species and Plant Conservation: woody weeds. In: Brown, C.L., Hall, F. and Mill, J. (eds) *Plant Conservation: approaches and techniques from an Australian perspective*. Module 4 (pages unnumbered). Australian Network for Plant Conservation, Environment Australia, Canberra.
- Downey, P.O. (2003b). Threat Abatement Plans: weeds and plant conservation. In: *The Proceedings of the 12th Biennial Noxious Weeds Conference, Taree, NSW, 1st–3rd July 2003*, (pages unnumbered). Greater Taree City Council, Taree.
- Downey, P.O. and Smith, J.M.B. (2000). Demography of the invasive shrub Scotch broom (*Cytisus scoparius*) at Barrington Tops, NSW: insights for management. *Austral Ecology* **25** (5), 477–485.
- EA (Environment Australia) (2002a). *The Commonwealth Coastal Policy: Commonwealth of Australia, May 1995*. website: <http://www.ea.gov.au/coasts/publications/coastal-policy/index.html> (Last updated: 12/2/2002).
- EA (Environment Australia) (2002b). *Environment Protection and Biodiversity Conservation Act 1999: Threatened flora*. website: <http://www.ea.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora> (Last updated: 6/11/2002).
- EA (Environment Australia) (2002c). *Nomination for listing a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. Website: <http://www.ea.gov.au/biodiversity/threatened/nominations/public-comment/c-camphora.html> (Last updated: 27/9/2002).
- EA (Environment Australia) (2003a). *Natural Heritage Trust Programs*. website: <http://www.nht.gov.au/programs/index.html> (Last updated: 2/4/2003).
- EA (Environment Australia) (2003b). *Cinnamomum camphora, Camphor Laurel most toxic chemotypes*. website: <http://www.ea.gov.au/biodiversity/threatened/ktp/unsuccesful/c-camphora.html> (Last updated: 3/9/2003).
- Ehrenfeld, J.G. (1997). Invasion of deciduous forest preserves in the New York metropolitan region by Japanese barberry (*Berberis thunbergii* DC.). *Journal of the Torrey Botanical Society* **124** (2), 210–215.
- Elton, C.S. (1958). *The Ecology of Invasions by Animals and Plants*. Chapman and Hall, London.
- Flower, P. and Clarke, M.J. (2001). *Review of Environmental Factors: the control of bitou bush by aerial application of glyphosate in central Yuraygir National Park 2001–2005*. NSW National Parks and Wildlife Service, North Coast Region, Hurstville.

- French, K. and Eardley, K. (1997). The impact of weed infestation on litter invertebrates in coastal vegetation. In: Klomp, N. and Lunt, I. (eds) *Frontiers in Ecology: Building the links*, pp. 89–102. Elsevier Science, Amsterdam.
- French, K. and Zubovic, A. (1997). Effect of the weed *Chrysanthemoides monilifera* (bitou bush) on bird communities. *Wildlife Research* **24**, 727–735.
- Gerrand, D. (2000). *Hastings Council Bitou Bush Control Strategy*. Hastings Council and Coastcare.
- Gosper, C.R. (1999). Plant food resources of birds in coastal dune communities in New South Wales. *Corella* **23** (3), 53–62.
- Gosper, C.R., Whelan, R.J. and French, K. (in preparation). An environmental weed does not alter the rate of removal of fruit of two vertebrate-dispersed plant species.
- Griffith, S.J. (1992). *Species Recovery Plan Zieria prostrata* ms. Endangered Species Program Project No 195. Australian National Parks and Wildlife Service, Canberra.
- Groves, R.H. (1989). Ecological control of invasive terrestrial plants. In: Drake, J., di Castri, F., Groves, R.H., Kruger, F., Mooney, H.A., Rejmánek, M. and Williamson, M. (eds) *Biological Invasions: A global perspective*, pp. 437–461. John Wiley, New York.
- Harden, G.J. (1990). *Flora of New South Wales Volume 1*. New South Wales University Press, Sydney.
- Harden, G.J. (1993). *Flora of New South Wales Volume 3*. New South Wales University Press, Sydney.
- Harden, G.J. (1994). *Flora of New South Wales Volume 4*. New South Wales University Press, Sydney.
- Harden, G.J. (2000). *Flora of New South Wales Volume 1: supplement*. New South Wales University Press, Sydney.
- Harden, G.J. (2002). *Flora of New South Wales Volume 2*, 2<sup>nd</sup> edition. New South Wales University Press, Sydney.
- Harper, J.L. (1977). *Population Biology of Plants*. 9th impression (1994), Academic Press, London.
- Heyligers, P.C. (1998). Some New South Wales coastal plant distributions: A comparison of herbarium records with transect survey data. *Cunninghamia* **5** (3), 645–664.
- Hobbs, R.J. (1991). Disturbance a precursor to weed invasion in native vegetation. *Plant Protection Quarterly* **6** (3), 99–104.
- Hobbs, R.J. and Huenneke, L.F. (1992). Disturbance, diversity, and invasion: Implications for conservation. *Conservation Biology* **6** (3), 324–337.
- Hogbin, P. (1999). *Targeted Survey for Zieria prostrata and Zieria sp. aff. smithii (headland form)*. Report to Northern Zone, NSW National Parks and Wildlife Service, Coffs Harbour.
- Hogbin, P.M. and Crisp, M.D. (2003 – in press). The evolution of the coastal neospecies *Zieria prostrata* and its relationship to the *Zieria smithii* species complex. *Australian Systematic Botany* **16** (3), page numbers not yet known.
- Hunter, J., Jay, A., Nicholson, N., Nicholson, H. and Horton, S. (n.d.). *Species recovery plan for Fontainea oraria (Jessup and Guymer)*. Australian National Parks and Wildlife Service Endangered Species Program Project No. 155.
- IUCN (the World Conservation Union) (2000). *IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species*. Species Survival Commission, website: <http://www.iucn.org/themes/ssc/pubs/policy/invasivesEng.htm>
- Joseph, R. (1995). *Rainforest Remnants Restoration and Rehabilitation Project Brunswick Heads Nature Reserve*. Unpublished report to NSW National Parks and Wildlife Service, Lismore.
- Keith, D.A., Miles, J. and Mackenzie, B.D.E. (1999). Vascular Flora of the South-East Forests Region, Eden, New South Wales. *Cunninghamia* **6** (1), 219–234.
- Lane, B.A. (1992). Impact of *Spartina* on international migratory waders: In: Fraser-Quick, G. and Phillips, A. (eds) *The Sea Has Weeds Too! Proceedings of a conference on the problem of Spartina, May 1991*. pp. 14–20. Bird Observers Club, Marine Education Society of Australasia, Australasian Wader Studies Group, Department of Conservation and Environment, South Gippsland Conservation Society, Inverloch.
- Lawrie, S. (2002). An audit system to account for birds and mammals utilising weed species. In: Spafford Jacob, H., Dodd, J. and Moore, J.H. (eds) *Thirteenth Australian Weeds Conference: papers and proceedings, 8–13 September 2002, Perth, WA*, pp. 108–111. R.G. and F.J. Richardson, Melbourne.
- Love, A. (1984). Distribution of bitou bush along the New South Wales coast. In: Love, A. and Dyason, R. (eds) *Proceedings of a Conference on Chrysanthemoides monilifera, Port Macquarie*, pp. 53–64. NSW National Parks and Wildlife Service and NSW Department of Agriculture, Sydney.
- Loyn, R.H. and French, K. (1991). Birds and environmental weeds in south-eastern Australia. *Plant Protection Quarterly* **6** (3), 137–149.
- Mack, M.C. and D'Antonio, C.M. (1998). Impacts of biological invasions on disturbance regimes. *TREE* **13** (5), 195–198.
- Mann, R.M. and Bidwell, J.R. (1999). The toxicity of glyphosate and several glyphosate formulations to four species of southern Australian frogs. *Archives of Environmental Contamination and Toxicology* **36**, 193–199.
- Matarczyk, J.A. (1999). *Impacts of Environmental Weeds on Pimelea spicata R.Br. (Thymelaceae)*. BSc. Honours Thesis, Australian National University, Canberra.
- Matarczyk, J.A., Willis, A.J., Vranjic, J.A. and Ash, J.E. (2002). Herbicides, weeds and endangered species: management of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) with glyphosate and impacts on the endangered shrub, *Pimelea spicata*. *Biological Conservation* **108** (2), 133–141.
- McDonald, T. (ed.) (1999). *Tweed Coast Littoral Rainforests (SEPP 26) Management Plan*. Report prepared for Tweed Shire Council.
- Meek, P. (1998). Weed seeds and whoopsie daisies: Viability of bitou bush *Chrysanthemoides monilifera* seeds in fox (*Vulpes vulpes*) scats. *Plant Protection Quarterly* **13** (1), 21–23.
- Mills, K. (1996). *Littoral Rainforest in Southern New South Wales: Inventory, Characteristics and Management*. Illawarra Vegetation Studies (1). Coachwood Publishing, Jamberoo, NSW.
- NPWS (National Parks and Wildlife Service) (n.d.). *The Scented Acronychia Acronychia littoralis Draft Recovery Plan*. Unpublished internal report, NSW National Parks and Wildlife Service.
- NPWS (National Parks and Wildlife Service) (1993). *Conservation Research Statement and Species Recovery Plan Pimelea spicata*. Unpublished report to the Australian Nature Conservation Agency, NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (1998). *Zieria prostrata Recovery Plan*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (1999a). *NSW Biodiversity Strategy*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (1999b). *Broadwater National Park, Bundjalung National Park and Iluka Nature Reserve Plan of Management*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (1999c). *Threatened Species Information: Fontainea oraria*. Fact Sheet, NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2000). *Threatened Species Information Pimelea spicata*. NSW National Parks and Wildlife Service, Hurstville.

- NPWS (National Parks and Wildlife Service) (2000b). *Threatened Species of the Lower North Coast of New South Wales*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2001a). *NSW Bitou Bush Strategy*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2001b). *Statewide Prioritisation for Recovery Plan Preparation*. Threatened Species Management Policy and Procedure Statement No 8, NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2001c). *Threat Abatement Plan for Predation by the Red Fox (Vulpes vulpes)*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2001d). Aerial Spraying of bitou bush: Bunjalong NP 2002-2006. Volume 2, unpublished report, NSW National Parks and Wildlife Service, Grafton.
- NPWS (National Parks and Wildlife Service) (2002). *The Birds of Pelican Island*. Internal unpublished report, NSW National Parks and Wildlife Service, Port Macquarie.
- NPWS (National Parks and Wildlife Service) (2003a). *Eastern Suburbs Banksia Scrub Endangered Ecological Community Draft Recovery Plan*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (National Parks and Wildlife Service) (2003b). *Draft: Green and Golden Bell Frog Litoria aurea (Lesson 1829)*. Internal unpublished report, NSW National Parks and Wildlife Service, Port Macquarie.
- NRA (National Registration Authority for agricultural and veterinary chemicals) (1996). NRA Special Review of Glyphosate. NRA special review series 96.1, Canberra, 23 pages.
- NSW Agriculture (1998). *New South Wales Weeds Strategy*. NSW Department of Agriculture, Orange.
- NSW Government (1997). *NSW Coastal Policy 1997: A sustainable future for the New South Wales Coast*. Department of Urban Affairs and Planning, Sydney.
- NSW SC (Scientific Committee) (1997). *Final Determination to list Eastern Suburbs Banksia Scrub as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1998a). *Final Determination to list Chamaesyce psammogeton as an Endangered species*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1998b). *Final Determination to list Sutherland Shire Littoral Rainforest as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1998c). *Final Determination to list Low Heath on Indurated Sand at Norah Head as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1998d). *Zieria smithii population, Diggers Head - endangered population listing: final determination*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1999a). *Invasion of native plant communities by bitou bush and boneseed – key threatening process declaration*. Final Determination, NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (1999b). *Final Determination to list the Kurnell Dune Forest in Sutherland Shire and City of Rockdale as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (2000a). *Final Determination to list the Byron Bay Dwarf graminoid clay heath community as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (2000b). *Final Determination to list the Sydney Freshwater Wetlands in the Sydney Basin Bioregion as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (2001). *Final Determination to list the population of Glycine clandestina (broad leaf form) (R. Pullen 13342) as an Endangered Population*. NSW Scientific Committee, Hurstville.
- NSW SC (Scientific Committee) (2002). *NSW Scientific Committee: Threatened Species Conservation Act Schedules 1, 2 and 3*. website: <http://www.nationalparks.nsw.gov.au/wildlife/Ts041002.pdf> (Last updated: 4/10/2002).
- NSW SC (Scientific Committee) (2002b). *Amendment to the Final Determination to list Eastern Suburbs Banksia Scrub as an Endangered Ecological Community*. NSW Scientific Committee, Hurstville.
- Odom, D., Cacho, O., Sinden, J.A. and Griffith, G.R. (2002). Policies for the Management of Weeds in Natural Ecosystems: a dynamic programming approach. In: *Proceedings of the 46<sup>th</sup> Annual Conference of the Australian Agricultural and Resource Economics Society, Canberra, February 2002*, no page numbers. Canberra.
- Payne, R. (2000). *Lake Macquarie Tetratheca juncea Conservation Management Plan*. Report for Lake Macquarie City Council, NSW National Parks and Wildlife Service and Broken Hill Propriety.
- Paynter, Q., Downey, P.O. and Sheppard, A.W. (2003). Age structure and growth of the woody legume weed Cytisus scoparius in native and exotic habitats: implications for control. *Journal of Applied Ecology* **40**, 470-480.
- Pemberton, R.W. (1998). The potential of biological control to manage Old World climbing fern (*Lygodium microphyllum*), an invasive weed in Florida. *American Fern Journal* **88** (4), 176–182.
- Port Stephens Coastal Weed Action Group (1997). *Port Stephens Bitou Bush Management Plan*. Port Stephens Shire Council.
- Quinn, F.C., Williams, J.B., Gross, C.L. and Bruhl, J.J. (1995). *Report on Rare and Threatened Plants of North Eastern New South Wales*. Report prepared for NSW National Parks and Wildlife Service and Australian Nature Conservation Agency, University of New England, Armidale.
- Regel, R., Lehmeyerl, T., Heath, D., Carr, S., Sanderson, K. and Lane, M. (1996). Small mammal survey in Belair National Park. *South Australian Naturalist* **70**, 25–30.
- Rejmánek, M. (1989). Invasibility of plant communities. In: Drake, J., di Castri, F., Groves, R.H., Kruger, F., Mooney, H.A., Rejmánek, M. and Williamson, M. (eds) *Biological Invasions: A global perspective* pp. 369–388. John Wiley, New York.
- Scanlon, T. (2001). *NSW North Coast Bitou Bush Management Strategies*. North Coast Weeds Advisory Committee. Location unknown.
- Sheringham, P. and Westaway, J. (1995). *Significant Vascular Plants of Upper North East New South Wales*. A report by New South Wales National Parks and Wildlife Service for the Natural Resources Audit Council, NSW National Parks and Wildlife Service, Sydney.
- Sindel, B.M. (2000). The History of Integrated Weed Management. In: Sindel, B.M. (ed.) *Australian Weed Management Systems*, pp 253–266. R.G. and F.J. Richardson, Melbourne.
- Smith, J.M.B. (2000). Trends in invasion by alien woody plants of the New England region, New South Wales. *Plant Protection Quarterly* **15** (3), 102–108.
- Stanley, R., Dodkin, M., Love, A. and Dyason, R. (1989). *Bitou Bush Control Handbook*. NSW Agriculture and Fisheries, Soil Conservation Service NSW and NSW National Parks and Wildlife Service, Sydney.

- Sullivan, A. (1997). Legislative requirements for environmental impact assessment of bitou bush control activities on NPWS managed lands. In: Holtkamp, R., Groves, R. and Corey, S. (eds) *Bitou Bush Workshop, North Head Conference Centre, 3–4 September 1997*, pp. 14–15. CRC Weed Management Systems, Adelaide.
- Thomas, J. (2002). *Bitou Bush 2001 Mapping Report*. Unpublished internal report, NSW National Parks and Wildlife Service, Grafton.
- Thomas, J. and Leys, A. (2002). Strategic management of bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata* (L.) T. Norl.). In: Spafford Jacob, H., Dodd, J. and Moore, J.H. (eds) *13<sup>th</sup> Australian Weeds Conference: papers and proceedings*, 8–13<sup>th</sup> September 2002, Perth. Shannon Books, Melbourne.
- Thorp, J.R. and Lynch, R. (2000). *The Determination of Weeds of National Significance*. National Weeds Strategy Executive Committee, Launceston.
- Toth, J. (2002). *Reporting of Toxicity of Roundup® to Native and Some Introduced Plants: a compilation of results from 1989 to 2002 for the spraying of 2 L of Roundup® in 30 L of water ha<sup>-1</sup> from a helicopter during winter (1 June to 31 August)*. Unpublished report, Management of Environmental Weeds Pty Ltd.
- Toth, J., Milham, P.J., Meszaros, I., Kaldor, C.J., Fullerton, R.N. and Burrows, F. (1996). Research on chemical control of bitou bush in New South Wales. *Proceedings 11th Australian Weeds Conference, Melbourne*, pp 468–475. Weed Science Society of Victoria, Frankston, Victoria.
- Vranjic, J. (2000). *Best Practice Management Guide 3: Bitou bush Chrysanthemoides monilifera subsp. rotundata*. Cooperative Research Centre for Weed Management Systems, Adelaide.
- Vranjic, J. and Groves, R. (1999). “Best-practice” management strategies for the South African weed, bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*). *Proceedings 12th Australian Weeds Conference, Hobart* - pp.288–293. Tasmanian Weeds Society, Devonport Tasmania.
- Vranjic, J.A., Woods, M.J. and Barnard, J. (2000). Soil-mediated effects on germination and seedling growth of coastal wattle (*Acacia sophorae*) by the environmental weed, bitou bush (*Chrysanthemoides monilifera* ssp *rotundata*). *Austral Ecology* **25**, 445–453.
- Walsh, N.G. and Entwisle, T.J. (1999). *Flora of Victoria Volume 4: Dicotyledons, Cornaceae to Asteraceae*. Flora of Victoria Series, Reed Books, Melbourne.
- Weeda, E.J. (1987). Invasions of vascular plants and mosses into the Netherlands. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen C* **90**, 19–29.
- Weiss, P.W. (1983). *Invasion of Coastal Acacia Communities by Chrysanthemoides*. PhD Thesis, Australian National University, Canberra.
- Weiss, P.W. and Noble, I.R. (1984a). Status of coastal dune communities invaded by *Chrysanthemoides monilifera*. *Australian Journal of Ecology* **9**, 93–98.
- Weiss, P.W. and Noble, I.R. (1984b). Interactions between seedlings of *Chrysanthemoides monilifera* and *Acacia longifolia*. *Australian Journal of Ecology* **9**, 107–115.
- Weiss, P.W., Adair, R.J. and Edwards, P.B. (1998). *Chrysanthemoides monilifera* (L.) T. Norl. In: Panetta, F.D., Groves, R.H. and Shepherd, R.C.H. (eds) *The Biology of Australian Weeds*, Volume 2, pp. 49–61. R.G. and F.J Richardson, Melbourne.
- Williams, P.A., Timmins, S.M., Smith, J.M.B. and Downey, P.O. (2001). The biology of Australian weeds 38. *Lonicera japonica* Thunb. *Plant Protection Quarterly* **16** (3), 90–100.

## 11 List of personal communications cited

Person	Organisation
Bremer, M.	DEC
Eldershaw, G.	DEC
Jones, D.L.	Centre for Plant Biodiversity Research, CSIRO
Flower, P.	DEC
Hirschfeld, D.	Randwick Council
Hoefler, A.	PhD student, ANU
Holtkamp, R.	NSW Department of Agriculture
Hunter, J.	DEC
Jack, W.	Sydney Bush Regeneration Company
Johnson, S.	DIPNR
McDougall, K.	DEC
Melland, R.	CRC for Weeds/University of SA
Moss, J.T.	Butterfly expert
Murphy, M.	DEC
Nally, S.	DEC
Pomery, D.	Illawarra Noxious Weeds Authority
Ross, J.	DEC
Thomas, J.	DEC
Toth, J.	Consultant for Management of Environmental Weeds Pty LTD.
Wellington, R.	DEC
Weston, P.	NSW Royal Botanic Gardens
Wilkie, L.	Australian Museum

## **Appendix 1      *Chrysanthemoides monilifera* listings under the NSW Noxious Weeds Act**

The noxious weed category for each local control authority area in which bitou bush/boneseed is declared noxious under the *Noxious Weeds Act 1993*.

<b>Council/control area</b>	<b>Control category</b>	<b>Council/control area</b>	<b>Control category</b>
Ashfield	W3	Lane Cove	W2
Auburn	W3	Leichhardt	W3
Ballina	W3	Lismore	W3
Bankstown	W3	Liverpool	W3
Bega Valley	W3	Lord Howe Island	W1
Bellingen	W3	Maclean	W3
Botany	W3	Manly	W3
Burwood	W3	Marrickville	W3
Byron	W3	Mosman	W3
Canada Bay	W3	Nambucca	W3
Canterbury	W3	Newcastle	W3
Clarence Valley Weeds Authority	W3	North Sydney	W2
Coffs Harbour	W3	Parramatta	W2
Copmanhurst	W3	Pittwater	W2
Eurobodalla	W3	Port Stephens	W3
Fairfield	W3	Pristine Waters	W3
Far North Coast County Council	W3	Randwick	W3
Gosford	W3	Richmond Valley	W3
Grafton	W3	Rockdale	W3
Great Lakes	W3	Ryde	W2
Greater Taree	W3	Shellharbour	W3
Hastings	W3	Shoalhaven	W2
Holroyd	W3	South Sydney	W3
Hornsby	W2	Strathfield	W3
Hunters Hill	W2	Sutherland	W3
Hurstville	W3	Sydney	W3
Illawarra District Weeds Authority	W3	Tweed	W3
Kempsey	W3	Warringah	W2
Kiama	W3	Waverley	W3
Kogarah	W3	Willoughby	W2
Ku-ring-gai	W2	Wollongong	W3
Kyogle	W3	Woollahra	W3
Lake Macquarie	W3	Wyang	W3

Declaration status under the NW Act:

- W1**      The presence of the weed on the land must be notified to the local control authority and the weed must be fully and continuously suppressed and destroyed
- W2**      The weed must be fully and continuously suppressed and destroyed
- W3**      The weed must be prevented from spreading and its numbers and distribution reduced
- W4**      Noxious weed, the action specified in the declaration must be taken in respect of the weed

## ***Appendix 2*      Development of a model to rank plant species threatened by bitou bush invasion**

---

Determination of the species, populations and ecological communities that are the most affected and impacted by bitou bush and bonseed is difficult. In part, this is due to the absence of information which quantifies the impacts of bitou bush and bonseed on plants, and especially animals and insects (see Chapter 7).

Invasion by bitou bush and bonseed is an enormous problem in New South Wales and its management requires planned use of limited resources. Establishing priorities is an important part of the planning process. Priorities for the Bitou TAP include the determination of species, populations and ecological communities threatened by bitou bush and sites where the Actions of the Bitou TAP can be achieved for each taxa (or biological entity). A model was developed for the Fox TAP (NPWS 2001c) to achieve similar objectives. The first stage of this model (species selection) does not work for invasive plants as the attributes used (i.e. predator-prey relationships) do not apply. Therefore, a model for invasive plants had to be developed.

The model presented here is not definitive. Information was not available for some threatened species, or specific information was not available (e.g. seed production and seedling recruitment and survival rates). The model can be modified and re-run when more comprehensive data becomes available. The present model does not encompass populations or ecological communities; the process for their inclusion in the TAP is described in Section 6.3.1.

After compiling a list of species potentially at risk from bitou bush invasion, as outlined in Chapter 4, a condensed list of species was determined using the following criteria:

- 1      Is bitou bush known to adversely affect the species?
- 2      Has the species been adversely affected by bitou bush invasion?
- 3      Does the species occur in habitats where bitou bush is present and is bitou bush likely to impact upon the species directly?

This condensed list of species was then run through the model described below. A complete list of the species tested through the model along with their score for each attribute and their final ranking is presented in Appendix 3 (below).

The ranking of priority species in the model uses five attributes: (A) susceptibility of the habitat to bitou bush invasion; (B) species distribution; (C) threatened status; (D) shade tolerance (or competition); and (E) persistence ((<sup>1</sup>) seed bank and (<sup>2</sup>) dispersal). Each attribute is scored with the highest score implying the highest priority.

The model for ranking threatened plant species is:

$$\text{priority rank} = \text{habitat susceptibility (A)} \times \text{distribution (B)} \times (\text{threatened status (C)} + \text{shade tolerance (D)} + \text{persistence (E}^1 + \text{E}^2))$$

## **A**                      **Susceptibility of the habitat to bitou bush invasion**

---

Some habitats are more prone to invasion by bitou bush than others. For example, a particular habitat may provide limited competition to bitou bush (e.g. tussock grasslands with inter-tussock spaces). Also, a particular disturbance regime may favour invasion (e.g. fire and soil disturbance). The density of bitou bush present is not necessarily a reflection (or measure) of the invasibility of that habitat, as many invasive plants exhibit a distinct lag period between initial occurrence and dominance. Therefore, a site with a light infestation of bitou bush may either present a barrier to invasion or the invasion process is in the early stages and heavier infestations may occur in the future if untreated.

<b>Score</b>	<b><i>Habitat invasibility</i></b>
0	Extremely low habitat invasibility – <i>non-coastal habitats or those habitats close to the coast in which boneseed (or rarely, bitou bush) occurs but are generally not susceptible to invasion</i>
1	Low habitat invasibility – <i>habitats with closed canopies (e.g. closed forests or heaths), or water logged habitats (e.g. margins of swamps)</i>
2	Medium habitat invasibility – <i>habitats with open canopies (e.g. open woodlands or shrublands), or forest margins</i>
3	High habitat invasibility – <i>habitats with no or low vegetation (e.g. sand dunes or spinifex grasslands), or habitats with a limited shrub layer, or sites where the native vegetation is disturbed such that there is no or patchy vegetation</i>

## B Distribution

---

This attribute describes the potential for bitou bush to have a major impact on an individual species because of its distribution. It must be noted that this is a threat abatement plan and not a recovery plan. The aim of a TAP is to reduce one specific threat which is applied to many threatened entities, whereas a recovery plan aims to reduce the major threat/s to one species. Therefore, if a species occurs in locations where there is no threat imposed from bitou bush their score for this attribute is low. For example, *Sophora tomentosa* occurs from New South Wales throughout Queensland and into New Guinea. While bitou bush threatens the southern limit of *S. tomentosa* (i.e. in New South Wales), it poses a relatively minor threat to this species in other parts of Australia. [note: this attribute **only** accounts for the species distribution, as shown by *S. tomentosa*, which scored low for this attribute but was ultimately ranked as a high priority.]

<i>Score</i>	<i>Distribution</i>
0	Not known from coastal habitats
1	Distributed across a range of habitats (some of which are coastal <50%)
2	Known predominantly from coastal habitats (>50% but <100%)
3	Known only from coastal habitats
4	Known only from coastal habitats in which all locations are within the distribution of bitou bush (and/or boneseed)

## C Threatened status

---

This attribute describes the threatened status of each species as determined by its legal status under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act: EA 2002b) and/or the *NSW Threatened Species Conservation Act 1995* (TSC Act: NSW SC 2002a). However, many species that are threatened or could become threatened in the future are not listed under these Acts. The threatened status attribute also encompasses such species.

The threatened status for species not listed under either Act was determined by their listing in Rare Or Threatened Australian Plants (ROTAP: Briggs and Leigh 1996) or Threatened Australian Flora (ANZECC 1999). Species that were not covered by the above listings, but which were considered to be threatened:

- ▶ under the listings of Sheringham and Westaway (1995)
- ▶ in published literature
- ▶ in the opinion of recognised botanists or land managers
- ▶ due to limited distribution
- ▶ due to a reduction in distribution

were given an appropriate value. Non-threatened species were not considered.

<i>Score</i>	<i>Threatened status *</i>
0	Not known to be or considered to be threatened
1	ROTAP listing as rare or poorly known, or Considered (opinion or published) to be rare or poorly known
2	ROTAP listing as vulnerable or endangered, or Listing as vulnerable or endangered on the ANZECC list of threatened flora, or Considered (opinion or published) to be vulnerable or endangered, or Vulnerable EPBC Act (nationally) but not listed under the TSC Act (NSW)
3	Vulnerable TSC Act but not listed under the EPBC Act, or Vulnerable TSC Act and vulnerable in EPBC Act
4	Vulnerable TSC Act and endangered EPBC Act, or Endangered TSC ACT but not listed under the EPBC Act
5	Endangered TSC Act and vulnerable EPBC Act, or Endangered TSC Act and EPBC Act

\* EPBC Act (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*), TSC Act (NSW *Threatened Species Conservation Act 1995*), ROTAP (Rare Or Threatened Plants (Briggs and Leigh (1996)) and ANZECC (Threatened Australian Flora (ANZECC 1999)).

## **D            Shade tolerance (a measure of susceptibility)**

---

A number of attributes can be used to describe the susceptibility of plants to weed invasion, however, many of them could not be used here as insufficient data was available. Shade tolerance describes the sensitivity of a plant species to light intensity (or shading). Many species are influenced by the level of available light. Some species may not grow in shady environments, preferring an open sunny position. The invasion of a plant species (like bitou bush) that change the light intensity beneath them could therefore impact greatly on some species (e.g. shade sensitive plants).

<i>Score</i>	<i>Shade tolerance</i>
0	Shade tolerant (i.e. readily occurs in shady areas or as an understorey species)
1	Information about shade tolerance unknown
2	Slightly sensitive to shade (occurs in part shade)
3	Shade sensitive (i.e. occurs only in full sun/does not occur in shade)

## **E Persistence (seed bank and dispersal)**

---

This attribute describes the ability of the species to persist at a site, as measured by its ability to survive and reproduce. The size of the seed bank present, or seed storage capabilities (i.e. seeds stored in cones), and the seed dispersal ability of each species is extremely important for the longer term survival of that species, as well as for the ability of a species to respond once bitou bush has been removed. Species with no, or poor seed banks may not be able to establish, or will have minimal recruitment following the removal of bitou bush. Those species with large seed banks are more likely to persist.

Seed dispersal is another attribute that describes a species' ability to persist. Species that can disperse their propagules to sites free of bitou bush, or to areas where bitou bush control has occurred, are more likely to persist than those that have poor dispersal mechanisms. Species for which there is limited information are given a low score because they may have some level of seed storage or seed dispersal mechanism. For many species examined this information is little known.

A score is given for each of the two attributes, seed bank ( $E^1$ ) and dispersal ( $E^2$ ), for each species. The two scores are then summed to give the value for E in the model.

<i>Score</i>	<i>Persistence</i>
1	Long-lived seed bank present, and/or effective seed storage ability, and/or high seed dispersal ability, or information about seed dormancy/storage and dispersal is unknown
2	Short-lived seed bank, or seed storage ability, or limited seed dispersal capability, or primarily a-sexual or vegetative reproduction
3	Limited seed bank, or seed storage ability, and no or poor seed dispersal capability and/or limited ability to regenerate vegetatively

## Appendix 3 Species, populations and ecological communities considered in the TAP

**Table A3.1** Species used and rank in the model

species name	family name	attribute						model	
		A 0–3 habitat invasibility	B 0–4 distribution	C 0–5 threatened status	D 0–3 shade tolerance	E <sup>1</sup> 1–3 seed bank	E <sup>2</sup> 1–3 dispersal	A*B*(C+D+(E <sup>1</sup> +E <sup>2</sup> )) max score (168)	species rank
<b>high priority species</b>									
<i>Zieria prostrata</i>	Rutaceae	3	4	5	1	2	3	132	1
<i>Sophora tomentosa</i>	Fabaceae	3	3	4	1	2	3	90	2
<i>Fontainea oraria</i>	Euphorbiaceae	2	4	5	0	3	3	88	3
<i>Plectranthus cremnus</i>	Lamiaceae	3	4	1	3	2	1	84	4
<i>Chamaesyce psammogeton</i>	Euphorbiaceae	3	3	4	1	2	2	81	5
<i>Senecio spathulatus</i>	Asteraceae	3	3	4	1	2	2	81	6
<i>Acronychia littoralis</i>	Rutaceae	2	4	5	2	2	1	80	7
<i>Acacia terminalis</i> subsp. <i>terminalis</i>	Mimosaceae	2	3	5	2	2	3	72	8
<i>Diuris praecox</i>	Orchidaceae	2	4	3	2	2	2	72	9
<i>Gleichenia mendellii</i>	Gleicheniaceae	3	3	1	3	1	2	63	10
<i>Pimelea spicata</i>	Thymelaeaceae	3	2	5	1	2	2	60	11
<b>medium priority species</b>									
<i>Acianthus exiguus</i>	Orchidaceae	3	3	1	3	1	1	54	12
<i>Calystegia soldanella</i>	Ipomoeaceae	3	3	1	3	1	1	54	13
<i>Chamaecrista maritima</i>	Caesalpiniaceae	3	3	1	3	1	1	54	14
<i>Ischaemum triticeum</i>	Poaceae	3	3	1	3	1	1	54	15
<i>Lepturus repens</i>	Poaceae	3	3	1	3	1	1	54	16
<i>Pultenaea maritima</i>	Fabaceae	3	3	1	3	1	1	54	17
<i>Stackhousia spathulata</i>	Stackhousiaceae	3	3	1	1	2	2	54	18
<i>Cryptocarya foetida</i>	Lauraceae	2	3	3	1	2	2	48	19
<i>Pterostylis</i> no 15. (Botany Bay orchid)	Orchidaceae	2	4	2	2	1	1	48	20
<i>Senna acclinis</i>	Caesalpiniaceae	2	2	4	3	2	3	48	21
<i>Syzygium paniculatum</i>	Myrtaceae	2	3	3	2	2	1	48	22
<i>Zieria granulata</i>	Rutaceae	2	2	5	2	2	3	48	23
<i>Dianella crinoides</i>	Liliaceae	3	3	1	2	1	1	45	24
<i>Vigna marina</i>	Fabaceae	3	3	1	3	1	0	45	25
<i>Thesium australe</i>	Santalaceae	3	2	3	1	2	1	42	26
<i>Cynanchum elegans</i>	Asclepiadaceae	2	2	5	1	2	2	40	27
<i>Eucalyptus camfieldii</i>	Myrtaceae	2	2	4	2	2	2	40	28
<i>Pterostylis woollsi</i>	Orchidaceae	2	4	1	2	1	1	40	29
<i>Acacia georgensis</i>	Mimosaceae	2	2	3	1	2	3	36	30
<i>Casuarina equisetifolia</i>	Casuarinaceae	3	3	1	2	1	0	36	31
<i>Pandanus pedunculatus</i>	Pandanaceae	2	3	1	2	1	2	36	32
<i>Tetradlea juncea</i>	Tremandraceae	2	2	3	2	2	2	36	33
<b>low priority species</b>									
<i>Diuris byronensis</i>	Orchidaceae	1	4	4	1	1	1	28	34
<i>Rulingia hermannifolia</i>	Sterculiaceae	2	2	1	3	2	1	28	35
<i>Phaius australis</i>	Orchidaceae	1	3	5	2	1	1	27	36
<i>Phaius tankervilleae</i>	Orchidaceae	1	3	3	2	2	2	27	37
<i>Acronychia imperforata</i>	Rutaceae	2	3	1	2	0	1	24	38
<i>Cordylina congesta</i>	Asteliaceae	2	2	1	2	2	1	24	39
<i>Vitex trifolia</i> var. <i>trifolia</i>	Verbenaceae	2	3	1	1	1	1	24	40
<i>Olax angulata</i>	Olacaceae	1	3	3	1	2	1	21	41
<i>Desmodium heterocarpon</i> var. <i>heterocarpon</i>	Fabaceae	2	2	1	2	1	1	20	42
<i>Typhonium eliosurum</i>	Araceae	2	2	1	2	1	1	20	43
<i>Caladenia tessellata</i>	Orchidaceae	2	1	3	2	2	2	18	44
<i>Prostanthera densa</i>	Lamiaceae	1	2	3	1	2	3	18	45
<i>Sarcostemma brunonianum</i>	Asclepiadaceae	3	1	1	3	1	1	18	46
<i>Allocastrum defungens</i>	Casuarinaceae	1	2	5	0	2	1	16	47
<i>Allocastrum simulans</i>	Casuarinaceae	1	2	5	0	2	1	16	48
<i>Melaleuca groveana</i>	Myrtaceae	2	1	3	1	2	2	16	49
<i>Gonocarpus salsoloides</i>	Haloragaceae	1	3	1	2	1	1	15	50
<i>Grevillea hilliania</i>	Proteaceae	1	2	4	1	1	1	14	51
<i>Acmena hemilampra</i>	Myrtaceae	1	3	1	0	2	1	12	52
<i>Bridelia exaltata</i>	Euphorbiaceae	1	3	1	0	2	1	12	53
<i>Eucalyptus paniculata</i> subsp. <i>matutina</i>	Myrtaceae	1	3	1	1	1	1	12	54
<i>Macrozamia flexuosa</i>	Zamiaceae	2	2	1	0	1	1	12	55
<i>Acianthus amplexicaulis</i>	Orchidaceae	1	2	1	2	1	1	10	56
<i>Pterostylis ophioglossa</i>	Orchidaceae	2	1	1	2	1	1	10	57
<i>Syzygium moorei</i>	Myrtaceae	1	2	3	0	1	1	10	58
<i>Cryptostylis hunteriana</i>	Orchidaceae	1	1	3	2	2	2	9	59
<i>Endiandra globosa</i>	Lauraceae	1	2	1	0	2	1	8	60
<i>Ailanthus triphysa</i>	Simaroubaceae	1	2	1	1	1	0	6	61
<i>Marsdenia liisae</i>	Asclepiadaceae	1	2	1	0	1	1	6	62
<i>Corybas undulatus</i>	Orchidaceae	1	1	1	0	1	1	3	63

**Table A3.2** Native plant species for which there was insufficient information available to model the threat posed to them by bitou bush (i.e. using the species model – see Appendix 2).

species	family	threatened status
<i>Abildgaardia ovata</i>	Cyperaceae	not listed
<i>Acacia bakeri</i>	Mimosaceae	vulnerable (TSC Act)
<i>Acalypha nemorum</i> (prostrate form)	Euphorbiaceae	not listed
<i>Acrostichum speciosum</i>	Pteridaceae	not listed
<i>Actites megalocarpa</i>	Asteraceae	not listed
<i>Asplenium difforme</i>	Aspleniaceae	not listed
<i>Bossiaea stephensonii</i>	Fabaceae	not listed
<i>Caesalpinia bonduc</i>	Caesalpinaceae	not listed
<i>Caesia parviflora</i> var. <i>minor</i>	Liliaceae	endangered (TSC Act)
<i>Caladenia quadrifaria</i>	Orchidaceae	not listed
<i>Callistemon acuminatus</i>	Myrtaceae	ROTAP (3RC)
<i>Carex brownii</i>	Cyperaceae	not listed
<i>Celtis paniculata</i>	Ulmaceae	not listed
<i>Chamaecrista mimosoides</i>	Caesalpinaceae	not listed
<i>Coelospermum paniculatum</i>	Rubiaceae	not listed
<i>Comesperma sphaerocarpum</i>	Polygalaceae	not listed
<i>Cryptocarya triplinervis</i>	Lauraceae	not listed
<i>Cupaniopsis anarcardioides</i>	Sapindaceae	not listed
<i>Cyperus scaber</i>	Cyperaceae	not listed
<i>Cyperus stradbrokeensis</i>	Cyperaceae	not listed
<i>Cyperus subulatus</i>	Cyperaceae	not listed
<i>Cryptandra propinqua</i>	Rhamnaceae	not listed
<i>Cryptandra scortechinii</i>	Rhamnaceae	not listed
<i>Cynanchum carnosum</i>	Asclepiadaceae	not listed
<i>Darwinia leptantha</i>	Myrtaceae	species in EEC 1*
<i>Dianella crinioides</i>	Phormiaceae	not listed
<i>Diuris arenaria</i>	Orchidaceae	vulnerable (TSC Act)
<i>Euphrasia collina</i> subsp. <i>paludosa</i>	Scrophulariaceae	not listed
<i>Fimbristylis polytrichoides</i>	Cyperaceae	not listed
<i>Galactia tenuiflora</i> var. <i>villosa</i>	Fabaceae	not listed
<i>Geodorum densiflorum</i>	Orchidaceae	endangered (TSC Act)
<i>Gleichenia rupestris</i>	Gleicheniaceae	not listed
<i>Glochidion sumatranum</i>	Euphorbiaceae	not listed
<i>Haemodorum austroqueenslandicum</i>	Haemodoraceae	not listed
<i>Haemodorum corymbosum</i>	Haemodoraceae	species in EEC 2*
<i>Hakea teretifolia</i> subsp. <i>teretifolia</i>	Proteaceae	not listed
<i>Hibiscus tiliaceus</i>	Malvaceae	not listed
<i>Hoya australis</i> subsp. <i>australis</i>	Asclepiadaceae	not listed
<i>Hypserpa decumbens</i>	Menispermaceae	not listed
<i>Isopogon anemonifolius</i>	Proteaceae	species in EEC 2, 3*
<i>Leucopogon esquamatus</i>	Epacridaceae	not listed
<i>Lindsaea fraseri</i>	Lindsaeaceae	endangered (TSC Act)
<i>Linum marginale</i>	Linaceae	not listed
<i>Liparis habenarina</i>	Orchidaceae	not listed
<i>Lipocarpha microcephala</i>	Cyperaceae	not listed
<i>Logania pusilla</i>	Loganiaceae	not listed
<i>Lygodium microphyllum</i>	Schizaeaceae	not listed
<i>Hedyotis galioides</i>	Rutaceae	endangered (TSC Act)
<i>Macarthuria neo-cambrica</i>	Aizoaceae	not listed
<i>Pandanus tectorius</i> var. <i>australianus</i>	Pandanaceae	not listed
<i>Pelargonium inodorum</i>	Geraniaceae	not listed
<i>Pelargonium australe</i>	Geraniaceae	not listed
<i>Persoonia conjuncta</i>	Proteaceae	not listed
<i>Persoonia katerae</i>	Proteaceae	not listed
<i>Persoonia linearis</i>	Proteaceae	species in EEC 1, 4–16*
<i>Persoonia pulchella</i>	Proteaceae	not listed
<i>Picris angustifolia</i> subsp. <i>carolorum-hericorum</i>	Astreaeaceae	not listed
<i>Pisonia umbellifera</i>	Nyctaginaceae	not listed
<i>Planchonella laurifolia</i>	Sapotaceae	not listed
<i>Planchonella myrsinioides</i>	Sapotaceae	not listed
<i>Poa poiformis</i>	Poaceae	not listed
<i>Polyalthia nitidissima</i>	Annonaceae	not listed
<i>Pterostylis nigricans</i>	Orchidaceae	endangered (TSC Act)
<i>Pultenea villifera</i>	Fabaceae	ROTAP (3RC)
<i>Scaevola aemula</i>	Goodeniaceae	not listed
<i>Streptothamnus moorei</i>	Flacourtiaceae	not listed
<i>Thozetia racemosa</i>	Asclepiadaceae	ROTAP (3RC)
<i>Thysanotus juncifolius</i>	Anthericaceae	species in EEC 11*
<i>Tricoryne simplex</i>	Anthericaceae	species in EEC 12*
<i>Triumfetta rhomboidea</i>	Tiliaceae	not listed
<i>Tylophora benthamii</i>	Asclepiadaceae	not listed
<i>Viola betonicifolia</i>	Violaceae	species in EEC 17*
<i>Viminaria juncea</i> (prostrate form)	Fabaceae	not listed
<i>Wahlenbergia littorcola</i>	Campanulaceae	not listed
<i>Westringia fruticosa</i>	Lamiaceae	not listed
<i>Wilsonia backhousei</i>	Convolvulaceae	vulnerable (TSC Act)

\* **Endangered Ecological Communities (EEC):** 1 Eastern Suburbs Banksia Scrub; 2 Agnes Banks woodland in the Sydney Basin Bioregion; 3 Low woodland with heathland on indurated sand at Norah Head; 4 Blue Gum High Forest; 5 Blue Mountains shale cap forest in the Sydney Basin Bioregion; 6 Elderslie banksia scrub forest community; 7 Hunter lowland redgum forest in the Sydney Basin and NSW North Coast bioregions; 8 Kurri sand swamp woodland in the Sydney Basin Bioregion; 9 O'Hares Creek shale forest community; 10 Quorrobolong scribbly gum woodland in the Sydney Basin Bioregion; 11 Shale/sandstone transition forest; 12 Southern Highlands shale woodlands in the Sydney Basin Bioregion; 13 Sun Valley cabbage gum forest in the Sydney Basin Bioregion; 14 Umina coastal sandplain woodland in the Sydney Basin Bioregion; 15 Warkworth Sands woodland in the Sydney Basin Bioregion; 16 Western Sydney dry rainforest in the Sydney Basin Bioregion; 17 EECs outside of bitou bush's distribution.

**Table A3.3** Populations and ecological communities listed under TSC Act which were considered during the development of this TAP and their priority (see Section 6.3.1 for details)

<b>populations</b>	<b>priority</b>
<i>Glycine clandestina</i> (broad leaf form)	high
<i>Zieria smithii</i> (low growing form)	high
<b>ecological communities</b>	
Eastern Suburbs Banksia Scrub	high
Kurnell Dune Forest	high
Littoral Rainforest (SEPP 26)	high
Sutherland Shire Littoral Rainforest	high
Byron Bay Dwarf Gramminoid Clay Heath	medium
Low Woodland with Heathland (Norah Head)	medium
Coastal Wetlands (SEPP 14)	medium
Sydney Coastal Estuary Swamp Forest Complex	medium
Sydney Freshwater Wetlands	medium
Pittwater Spotted Gum and equivalent communities (i.e. Wgastaff Spotted Gum forest)	not determined #
Eastern Suburbs Banksia Scrub equivalent communities (i.e. Coastal Sand Wallum Heath)	not determined #

# assessment is needed to determine exact ranking.

**Table A3.4** Ecological communities potentially at risk from bitou bush invasion in New South Wales (dominant species are presented in brackets), after Dodkin and Gilmore (1984).

<b>ecotype</b>	<b>ecological communities</b>
<b>Headland</b>	Grassy headland ( <i>Themeda triandra</i> ) Gramminoid Clay Heath ( <i>Hibbertia vestita/Pimelea linifolia/Pultenea villosa</i> plus <i>Themeda triandra</i> ) Headland heath Headland woodland
<b>Dune</b>	Coastal sand dune vegetation communities Frontal dune vegetation complex Dune dry heath ( <i>Acacia longifolia</i> var. <i>sophorae/Leucopogon parviflorus/Scaevola calendulaca</i> ) Coastal dune complex ( <i>Acacia longifolia</i> var. <i>sophorae</i> ) Dune grasslands ( <i>Spinifex hirsutus</i> )
<b>Coastal forest</b>	Coastal forest/woodlands ( <i>Banksia integrifolia</i> ) Coastal low forest Sclerophyll forest ( <i>Banksia integrifolia/Allocasuarina littoralis</i> ) Sclerophyll forest ( <i>Eucalyptus pilularis/E. gummifera/E. intermedia/Angophora costata</i> ) Sclerophyll mallee ( <i>Eucalyptus planchioriana</i> or <i>E. intermedia</i> )
<b>Scrub</b>	Coastal scrub ( <i>Leptospermum laevigatum/ longifolia</i> var. <i>sophorae</i> ) Coastal scrub ( <i>Drypetes australiscia/Elaeodendron australe</i> )

## ***Appendix 4***     **Selecting priority sites for bitou bush control**

---

In order to establish priority sites for bitou bush control, species, populations and ecological communities considered to be at risk from bitou bush invasion (see Table 4.1) were identified (see also Appendices 2 and 3). For each entity, a subjective assessment was made (high, medium or low) of:

- ▶ the ability to achieve effective bitou bush control at the site
- ▶ the actual impact present at each site, or the physical condition of the site
- ▶ the condition of the population of threatened entity present (i.e. plant health) at each site.

Priority sites for bitou bush control for each species, population and ecological community was then determined. Sites were attributed as:

- ▶ low priority (L) if they scored low in two or more of the three categories (effective, actual impact or condition)
- ▶ medium priority (M) if they scored medium in at least two categories, or one high and at least one medium in any category
- ▶ high priority (H) if they scored high in two or more of the three categories.

Sites were listed as requiring further assessment (A) where there was insufficient information.

### ***Effective***

The ability to achieve effective bitou bush control at a site was based on the *density of bitou bush* present and the *level of control* that had been undertaken previously or is being undertaken currently, particularly **with respect to the threatened entity concerned**. Thus, sites with high densities of bitou bush and for which there are no control programs in place around the threatened entities were assessed as high. In contrast sites with low densities of bitou bush and with extensive control programs in place (including follow-up programs) over a wider area than just in and around the immediate vicinity of the threatened entity, were assessed as low. These are the extreme scenarios, with a range of combinations in between. This attribute is suitable for most sites, however, at some sites a sub-attribute was required to accurately rank the site. The sub-attribute **threat not removed** was used when the *threat was reduced, but not removed, as a result control* and thus a halt to the control would likely lead to a re-occurrence of the threat. The feasibility of control was also considered at each site. At some sites the level of bitou bush present in the vicinity of the threatened entity was not known. These sites were listed as requiring more information.

### *Actual impact*

The actual impact of bitou bush at each site, or the physical condition of the site, was scored on the degree of degradation, not just by bitou bush invasion but from all other threats present (i.e. presence of other weed species, dumped rubbish, etc.). More than one threat occurs at many sites. While the control of other weed species, particularly those that will replace bitou bush following control, must occur within the confines of this TAP (see section 5.2), reduction of all other threats is outside its scope. Thus, sites where there are major threats other than bitou bush and associated weed species were assessed as medium. Sites at which bitou bush and associated weed species were the main threat were assessed as high. In contrast, sites at which the threat posed by bitou bush and associated weed species was limited received a low assessment. At some sites the range of threats, other than from the presence of bitou bush and associated weed species, was not known; these sites were listed as requiring more information.

### *Condition*

The condition of the population of threatened entity present (i.e. plant health) at each site, and the importance of the site to the entity's overall status, was determined in consultation with relevant threatened species recovery teams, species experts (including botanists) and people managing these sites in the field. Factors considered in rating sites included the size of the population (i.e. few or many individuals) in relation to the its natural occurrence (i.e. some species only occur in small populations, which are common), the area occupied or distribution of the population at the site, whether it occurred on the edge of the entities' range, and the overall health of the population present (i.e. individuals in poor health or where there are limited seedlings present, or all are old and sick plants, etc.). This attribute is suitable for most sites, however, at some sites a sub-attribute was required for accurate ranking. The sub-attribute **regeneration potential** was used when the *natural regeneration potential* was known (i.e. high or limited).

**Table A4.1** Sites used for each threatened species and rank in the model

priority	species	site	effective	actual impact	condition	priority
High	<i>Zieria prostrata</i>	Bare Bluff, Moonee Beach NR	H	H	M	High
		Look at me now Headland, Moonee Beach NR	H	M	H	High
		Dammerels Head, Moonee Beach NR	H	M	H	High
		Diggers Point, Moonee Beach NR	M	M	M	Medium
		Sawtell Headland Recreation Reserve				A
High	<i>Sophora tomentosa</i>	Diamond Head, Sandy's Beach				A
		Sandon River, Yuraygir NP	H	H	H	High
		Sandon Bluffs, Yuraygir NP	H	H	M	High
		Wooli River	H	H	M	High
		Woolgoolga Headland, Coffs Harbour Regional Park	H	H	M	High
		Sea Acres, Port Macquarie	H	H	M	High
		Shark Bay, Bundjalung NP	M	M	L	Medium
		Woody Head, Bundjalung NP	H	M	M	Medium
		Iluka Bluff, Bundjalung NP	H	M	M	Medium
		Sandon backtrack, Yuraygir NP	H	M	L	Medium
		Casuarina Beach, Tweed Coastal Reserve?	M	M	L	Medium
		Cabins Beach, Mullaway, Coffs Harbour Regional Park	M	M	M	Medium
		Woolgoolga beach	L	L	M	Low
		Park Beach, Coffs Harbour	L	L	M	Low

priority	species	site	effective	actual impact	condition	priority
High	<i>Sophora tomentosa</i> (continued)	Shelly Beach, Port Macquarie				A
		Sapphire Gradens, Coffs Harbour				A
		Brooms Head, Yuraygir NP				A
		Flynn's Beach, Port Macquarie				A
		Woolgoolga Beach				A
High	<i>Fontainea oraria</i>	South of Lennox Head	H	M	H	High
		South of Lennox Head	H	M	H	High
		Lennox Head (sites 1 and 2)				A
High	<i>Plectranthus cremnus</i>	Hat Head - east of town	H	M	H	High
		Hat Head - headland near camping ground	H	M	H	High
		Connors-Hat Head, Hat Head NP	H	H	M	High
		Bare Pt, Yuraygir NP				A
		Cape Byron SCA				A
		Macauleys Headland Coffs Harbour				A
		Lennox Head				A
		Sawtell Headland				A
		Arararra Headland				A
		Wategos Gap, Byron Bay Beach				A
		Dammerels Head				A
		Bare Bluff				A
		Diggers Head				A
		Kendall				A
High	<i>Chamaesyce psammogeton</i>	Mungo Brush -opposite camping	H	H	M	High
		Sandon south beach, Yuraygir NP	H	H	?	High
		Sandon north beach, Yuraygir NP	H	H	?	High
		Middle Bluff, Bundjalung NP	H	H	?	High
		Spoon Bay, Wamberal Lagoon NR	H	H	?	High
		Banksia Green, Myall Lakes NP	H	M	H	High
		9 mile beach, Booti Booti NP	M	H	?	Medium
		Mungo - Myall Lakes NP	M	M	M	Medium
		Angourie Point, Yuraygir NP	H	M	?	Medium
		Middle Beach, Bundjalung NP	M	M	M	Low
		7 Mile Beach NP				A
		9 mile beach, Belmont				A
		Bogangar Beach				A
		Tallow Beach, Arakwal NP				A
		Bundagen Beach south, Bongil Bongil NP				A
		Nambucca Heads				A
		Pelican Point				A
		Yagon Gibber, Myall Lakes NP				A
		Bennetts Beach, Myall Lakes NP				A
		Birdie Beach, Budgewoi				A
		Wamberal NP				A
		Warrain Beach				A
		Look at me now Headland				A
		Avoca North - Terrigal				A
		Ocean beach, Crookhaven Heads				A
		Smoky Cape (Macleay River)				A
		Barrenjoey				A
High	<i>Senecio spathulatus</i>	Mungo Brush - opposite camping areas	H	H	M	High
		Mungo Brush, Myall Lakes NP	H	H	?	High
		Cape Howe (Victorian border)	L	L	?	low
		Fingal Spit				A
		Connell Hill, Kurnell				A
		Cronulla Recreation Reserve				A
		Wamberal Beach				A
		Kurnell, Botany Bay				A
		Cronulla Beach				A
High	<i>Acronychia littoralis</i>	Brunswick Heads NR	H	H	?	High
		Cape Byron	H	M	H	High
		North Creek, Ballina	M	H	H	High
		7 Mile Beach (south)	H	M	H	High
		Big Hill, Limeburners Creek NR	?	H	H	High
		near Scout Camp, Cudgen NR	M	M	?	Medium
		Sea Acres, Port Macquarie				A
		Lennox Head				A
		Bogangar				A
		Stokers Park, East Ballina				A
		Billinudgel/Yelgun wetland				A
		Wooyung Field Studies Centre				A
		Broken Head				A
		Chinderah				A
		Palm Valley, Byron Bay				A
		Cosy Corner, Byron Bay				A
		Red Rock, west of old Rubbish Tip				A
		Big Smoky 5, Hat Head NP				A
		Koala Beach				A
		Angels Beach				A
		Scotts Head/Grassy Head Rd				A
		Bongil Bongil				A
		Bundjalung NP				A
High	<i>Acacia terminalis</i> subsp. <i>terminalis</i>	Bunnerong Road, Chifley Bushland	M	H	H	High
		Nielsen Park, and Gap Bluff, Sydney Harbour NP	M	L	H	Medium
		Ashton Park, Sydney Harbour NP	?	L	M	Low
		Gap Park, Watsons Bay	?	L	M	Low
		North Head, Sydney Harbour NP	?	L	M	Low
		HMAS Watson - Watsons Bay	?	L	H	Low
		Bundock Rd Army Base	?	L	M	Low
		Kingsford, Randwick	?	L	M	Low
		Onslow St, Rose Bay	?	L	M	Low
		Loombah Rd, Dover Heights	?	L	L	Low
		Dover Rd, Rose Bay	?	L	L	Low
High	<i>Diuris praecox</i>	Crackneck, Wyrabalong NP	H	M	H	High
		Glenrock SRA (1) - Scout Camp Road	M	M	?	Medium
		Glenrock SRA (2) - Scenic Drive	M	M	?	Medium

priority	species	site	effective	actual impact	condition	priority	
High	<i>Diuris praecox</i> (continued)	Munmorah SCA				A	
		Birdie Beach Drive				A	
		Wyrabalong NP				A	
		South Wallarah Peninsula				A	
High	<i>Gleichenia mendellii</i>	Sandon south (coffee rock), Yuraygir NP	M	H	H	High	
		Angourie Reserve, Pristine Waters	H	H	M	High	
		Rocky Pt, Yuraygir NP	M	H	?	High ?	
		Angourie Back Beach, Yuraygir NP	M	H	?	Medium	
		Dirrawong Reserve	M	L	H	Medium	
		Coffee Rock (habitats), Bundjalung NP	M	L	H	Medium	
		Minnie Water Back beach	M	M	?	Medium	
		Snapper Rock				A	
		Broadwater NP				A	
High		<i>Pimelea spicata</i>	Killalea State Park/Bass Point Quarry Boundary	H	H	H	High
	Killalea State Park - Maloneys Bay		H	H	H	High	
	Mahoneys Bay, Bass Point Reserve		H	H	M	High	
	Minnamurra Headland		?	M	M	Medium	
	Blackbutt Reserve		L	L	M	Low	
	Mt Warragul		L	L	M	Low	
	Windang Island Shellharbour					A	
medium	<i>Acianthus exiguus</i>	Sandon south (coffee rock), Yuraygir NP	H	H	?	High	
		Sandon backtrack, Yuraygir NP	?	M	M	Medium	
		Sandon north	?	L	L	Low	
		Wyrabalong				A	
		Woody Head				A	
medium	<i>Calystegia soldanella</i>	Carrs road boat ramp, Maclean				A	
		Windang, Port Kembla				A	
		Joss Island, Oyster Channel - Wooloweyah Lagoon				A	
medium	<i>Chamaecrista maritima</i>	Bare Pt-Wilsons Headland, Yuraygir NP	H	H	M	High	
		Hat Head NP	M	H	M	Medium	
medium	<i>Ischaemum triticeum</i>	Sea Acres	H	H	H	High	
		Crowdy Bay NP	H	H	H	High	
		Hat Head NP	M	H	M	Medium	
		Kattang NR	M	H	M	Medium	
		Bare Pt-Wilsons Headland, Yuraygir NP	M	L	L	Low	
		Arakoon SCA	L	M	L	Low	
		Yamba Beach				A	
medium	<i>Lepturus repens</i>	Look at me Now Headland				A	
medium	<i>Pultenaea maritima</i>	Snapper Rock, Bundjalung NP	H	H	M	High	
		Bare Pt-Wilsons Headland, Yuraygir NP	M	M	?	Medium	
		Redcliff Yuraygir NP	M	H	?	Medium	
		Goanna Headland Dirrawong Reserve	?	M	M	Medium	
		Rocky Pt, Yuraygir NP	M	H	M	Medium	
		Shelley Headland, Yuraygir NP	M	M	?	Medium	
		Angourie Pt	L	L	?	Low	
		Coffs Harbour Regional Park	L	L	H	Low	
		Moonee Beach NR	L	L	H	Low	
medium		<i>Stackhousia spathulata</i>	Sandon south beach, Yuraygir NP	H	H	M	High
			Sandon south Beach	H	H	H	High
			Sandon north beach, Yuraygir NP	H	H	M	High
			Spoon Bay, Wamberal Lagoon NR	M	H	H	High
			Sandon south (coffee rock), Yuraygir NP	M	H	H	High
			Mungo Brush, Myall Lakes NP	H	H	?	High
	Crowdy Bay NP		H	H	H	High	
	Snapper Rock, Bundjalung NP		H	H	M	High	
	Bundjalung - high dunes		M	H	H	Medium	
	Seven Mile Beach (South Coast)		L	L	?	Low	
	Booti Booti NP					A	
	Wamberal NP					A	
	Blackhead - Taree					A	
	Goanna Headland					A	
	Berrara Beach					A	
	Cudmirrah Beach					A	
	Inyadda Beach					A	
	Manyanah Beach					A	
	Cunjurong Beach					A	
medium	<i>Cryptocarya foetida</i>		Angels Beach	H	H	?	High
			Fingal, Tweed Coastal Reserve	M	H	?	Medium
			North Head, Brunswick Heads NR	M	H	?	Medium
			Wooyung NR	M	H	?	Medium
			Ukerabagh Island NR	L	H	L	Low
			Lennox Head				A
			7 Mile Beach				A
			Broken Head NR, Kings Beach				A
		Cape Byron				A	
		Lacks Ck, Billinudgel				A	
		Cudgen Lake, Bogangar				A	
		Angels Beach, Ballina				A	
		Tyagarah NR				A	
medium		<i>Prerostylis</i> no 15. (Botany Bay orchid)	Malabar Headland				A
			Botany bay NP				A
medium	<i>Senna acclinis</i>	Booti Booti NP	L	L	?	Low	
		Mungo Brush, Myall Lakes NP	L	L	?	Low	
		Hallidays Point	L	L	?	Low	
		Cape Hawke, Booti Booti NP				A	
		Snapper Rock				A	
medium	<i>Syzygium paniculatum</i>	Spoon Bay, Wamberal Lagoon NR	H	H	?	High	
		Salt Bay	H	H	?	High	
		Seal Rocks area, Myall Lakes NP	H	H	?	Medium	
		Myall Lakes NP	M	HP	M	Medium	
		Yacaaba Head, Myall Lakes NP	M	H	?	Medium	
		Glenrock SRA	M	M	?	Medium	
		Green Point Reserve	M	M	?	Medium	
		Pulbah Island NR	M	M	?	Medium	
		Budgewoi, Munmorah SRA/Crown Reserve	M	M	?	Medium	

priority	species	site	effective	actual impact	condition	priority
medium	<i>Syzygium paniculatum</i> (continued)	Norah Head	M	M	?	Medium
		North Entrance, Wyrabalong NP	M	M	?	Medium
		Weedy Pond, Towra Point NR	M	M	?	Medium
		North Entrance, road reserve				A
		Urunga Lagoon				A
		Munmorah SCA				A
		Wyrabalong NP				A
		Wamberal NP				A
		Booti Booti				A
		Towra Pt, Botany Bay				A
		St Georges Basin, Jervis Bay				A
		Sanctuary Point				A
		Avoka Beach				A
		Budgewoi, Mackenzie Reserve				A
		Jenny Dickson Beach, Norah Head				A
medium	<i>Zieria granulata</i>	Bass Point, Bass Point Reserve	M	M	?	Medium
		Killalea State Park	M	M	?	Medium
		Minnamurra headland				A
medium	<i>Dianella crinoides</i>	Windang Beach, Port Kembla				A
medium	<i>Vigna marina</i>	Sandon south (coffee rock), Yuraygir NP	H	H	?	High
		Sea Acres NR	H	M	H	High
		Limeburners Creek NR	H	H	H	High
		Ten Mile Beach, Bundjalung NP	H	H	?	High
		Rocky Pt, Yuraygir NP	M	H	L	Medium
		Hat Head NP	M	H	M	Medium
		Arakoon SCA	L	M	L	Low
		Iluka Bluff, Bundjalung NP	?	L	L	Low
		Woody Head - North of Iluka				A
		Scotts Head				A
medium	<i>Thesium australe</i>	Connors-Hat Head, Hat Head NP	H	H	?	High
		Bare Bluff, Moonee Beach NR	H	H	M	High
		Look at me now Headland, Moonee Beach NR	H	M	H	High
		Crowdy Bay NP	H	H	H	High
		Perpendicular Pt, Kattang NR	H	H	?	High
		Big Nobby, Crescent Head	H	H	?	High
		Hat Head - east of town	H	M	M	Medium
		Dammerels Head, Moonee Beach NR	M	M	M	Medium
		Toragy Headland, Eurobodalla NP	M	M	?	Medium
		Bare Pt-Wilsons Headland, Yuraygir NP	L	L	?	Low
		Diamond Head, Crowdy Bay NP	L	L	?	Low
		Redcliff, Yuraygir NP				A
		Macauleys Headland				A
medium	<i>Cynanchum elegans</i>	Bass Point Reserve	H	H	?	High
		Sea Acres NR	H	H	H	High
		Flaggy Creek, Glenrock SRA	M	H	?	Medium
		Cape Hawke/ Lobster Pot Beach, Booti Booti NP	M	M	?	Medium
		Hallidays Point	L	L	?	Low
		Minnamurra Spit, Killalea SRA	L	L	?	Low
		Mungo Brush, Myall Lakes NP	M	L	?	Low
		Yacaaba Headland				A
		Green Point Reserve				A
medium	<i>Eucalyptus camfieldii</i>	Awabakal NR	L	L	?	Low
		Lake Macquarie				A
		Wyrabalong NP				A
		Munmorah SCA				A
		Norah Head				A
medium	<i>Pterostylis woollsi</i>	Angourie				A
medium	<i>Acacia georgensis</i>	Kianinny Bay, Bournda NP	L	L	?	Low
		Tathra Reserve				A
medium	<i>Casuarina equisetifolia</i>	Sea Acres NR	M	H	H	High
		Limeburners Creek NR	H	H	H	High
		Hat Head NP	M	H	M	Medium
		Broadwater NP				A
		Laurieton, Kattang NR				A
		Minnie Water				A
		Shelly Beach, Nambucca Heads				A
medium	<i>Pandanus pedunculatus</i>	Sea Acres NR	M	H	H	High
		Limeburners Creek NR	H	H	H	High
		Hat Head NP	M	H	M	Medium
medium	<i>Tetradlea juncea</i>	Gun Club Road, Glenrock SRA	M	M	?	Medium
		Dudley Bluff, Awabakal NR	L	L	?	Low
		Adamstown Heights, Defence Reserve	L	L	?	Low
		Green Point Reserve				A
		Jewels Swamp				A
		South of Fernleigh Loop, Council Reserve				A
		East of Glencott Drive				A
		Pelican Flat, Council Reserve				A
		Munmorah SCA				A
		Wallarah NP				A
Low	<i>Diuris byronensis</i>	Bray's Beach, Broken Head				A
Low	<i>Rulingia hermanniifolia</i>	Sth Morna Point, Tomaree NP	L	L	?	Low
		Bouddi NP				A
		Munmorah SCA				A
		La Perouse				A
		Jervis Bay				A
		Kurnell				A
Low	<i>Phaius australis</i>	Northern Bundjalung NP	?	H	H	High
		Yuraygir NP and Crown land south of Yamba	?	H	H	High
		Diggers Camp, Yuraygir NP				A
		Evans Head Beach, Broadwater NP				A
		Angels Beach, Ballina				A
		Angourie Rd, Crown Reserve				A
		Broadwater NP				A
Low	<i>Phaius tankervilleae</i>	Yuraygir NP and Crown land south of Yamba	?	H	H	High
		Cumbebin Swamp, Byron Bay				A

priority	species	site	effective	actual impact	condition	priority
Low	<i>Phaius tankervilleae</i> (continued)	Bundjalung NP, Woody Head				A
Low	<i>Acronychia imperforata</i>	Iluka NR	H	H	M	High
		Hungry Head				A
		Tuckers Rock				A
		Racecourse Headland				A
		Crescent Head				A
		Bundjalung NP				A
		Brunswick Heads NR				A
		Tyagarah NR				A
		Ukerebagh NR				A
		Bogangar				A
		Hastings Point				A
		Moonee Beach NR				A
		Yuraygir NP				A
		Woody Head				A
		Evans Head				A
		Coffs Harbour				A
Low	<i>Cordyline congesta</i>	Belongil Fields, Byron Bay				A
		Cape Byron				A
		Fingal Head				A
		Broken Head, Kings Beach				A
		Broken Head, 7 Mile Beach				A
		Ukerabagh Island NR				A
		Bogangar				A
		Tyagarah NR				A
Low	<i>Vitex trifolia</i> var. <i>trifolia</i>	Coffs Harbour				A
Low	<i>Oxal angulata</i>	Minnie Water Foreshore Reserve	L	L	?	Low
		Wooli, Yuraygir NP				A
		Diggers Camp				A
Low	<i>Desmodium heterocarpon</i> var. <i>heterocarpon</i>	sites unknown				A
Low	<i>Typhonium eliosurum</i>	Bass Point				A
		Minamurra Beach				A
Low	<i>Caladenia tessellata</i>	Big Bumpy Headland, Munmorah SRA				A
		Little Bumpy Headland, Munmorah SRA				A
		Soldiers Point - heath site				A
		Soldiers Point - woodland site				A
		Munmorah SCA				A
		Frazer Park, Mumora SRA				A
		Soldiers Point - West of Carpark				A
Low	<i>Prostanthera densa</i>	Nelson Bay, Pt Stephens				A
		Beecroft Head				A
		Cabbage Tree Beach, Beecroft Head, Jervis Bay				A
		Bass and Flinders Point, near Cronulla.				A
Low	<i>Sarcostemma brunonianum</i>	sites unknown				A
Low	<i>Allocasuarina defungens</i>	Crowdy Bay NP	H	H	M	High
		Green Point Rd/Lakes Way, Booti Booti NP	L	L	?	Low
		Yuraygir NP				A
		Limeburners Creek NR				A
Low	<i>Allocasuarina simulans</i>	Angourie Headland				A
		Lakes way	M	H	?	Medium
		Crowdy Bay NP				A
		Pacific Palms, Booti Booti				A
		Green Point, Booti Booti NR				A
Low	<i>Melaleuca groveana</i>	Tomaree NP, Stephens Peak	?	M	M	Medium
		Dooragan NP	M	L	L	Low
		Myall Lakes NP				A
		Scotts Head				A
Low	<i>Gonocarpus salsoloides</i>	La Perouse				A
		Diamond Head, Crowdy Bay NP				A
		Nelson Bay Rd, Port Stephens				A
Low	<i>Grevillea hilliana</i>	Brunswick Heads NR	H	H	?	High
Low	<i>Acmena hemilampyra</i>	Iluka NR	H	H	?	High
		Brunswick Heads NR				A
		Tyagarah NR				A
		King Beach				A
		Woody Head				A
Low	<i>Bridelia exaltata</i>	Iluka NR	H	H	?	High
Low	<i>Eucalyptus paniculata</i> subsp. <i>matutina</i>	Tomaree Head and Box Beach	M	H	?	Medium
		Tomaree NP				A
		Morning Bay - Towlers Bay				A
		Myall Lakes NP				A
Low	<i>Macrozamia flexuosa</i>	Gun Club Road, Glenrock SRA	M	M	?	Medium
		Lake Macquarie				A
		Munmorah SCA				A
		Awaba Bay, Lake Macquarie				A
		Tahlee, Port Stephens				A
		Warner's Bay				A
		Merewether and Dudley heads, Newcastle				A
Low	<i>Acianthus amplexicaulis</i>	Sandon north	L	L	L	Low
		Bookerhead, Ballina				A
		Woody Head, Iluka				A
		Broken Head, Byron Bay				A
		Red Rock, Woolgoolga				A
		Park Beach, Coffs Harbour				A
		Bundjalung NP				A
		Broadwater Beach				A
		Wyrrabalong NP				A
		Brunswick Heads				A
		Cosy Corner				A
		Iluka NR				A
Low	<i>Pterostylis ophioglossa</i>	Bundjalung NP				A
		Sawtell				A
		Coffs Harbour				A
Low	<i>Syzygium moorei</i>	Brunswick Heads NR				High

priority	species	site	effective	actual impact	condition	priority
Low	<i>Syzygium moorei</i> (continued)	Byron Bay				A
		Fingal Head, Tweed Heads				A
		Broken Head, near 7 Mile Beach				A
		Ocean Shores estate, Billinudgel				A
Low	<i>Cryptostylis hunteriana</i>	Tyagarah				A
		Ben Boyd NP				A
		opposite Stokes Is, Burrill Lake				A
		Green Point Road, Beecroft Peninsula				A
		Conjola NP				A
		Vincentia				A
Low	<i>Endiandra globosa</i>	Nelson Bay				A
		Callala Bay				A
Low	<i>Ailanthus triphysa</i>	Billinudgel				A
		Murwillumbah				A
Low	<i>Marsdenia liisae</i>	Brunswick Heads NR				A
		Iluka NR	H	H	?	High
		Woody Head				A
Low	<i>Corybas undulatus</i>	Cudgen				A
		Sandon, Yuraygir NP				Medium
		Racecourse Headland				A
		Banda Beech Reserve, Mt Boss SF				A
Low	<i>Corybas undulatus</i>	Coffs Harbour				A
		Smoky Cape				A
		Nth Bendalong, Conjola SF				A

? information was not available at this time

**Table A4.2** Sites used for each threatened population and rank in the model

priority	species	site	effective	actual impact	condition	priority
High	<i>Glycine clandestina</i> (blf)	Scotts Head	H	M	H	High
High	<i>Zieria smithii</i> (lgt) <sup>1</sup>	Diggers Head	H	H	H	High
		Boomerang Point				A
		Diamond Head				A
		Little Grants Head				A
		Nobbys Head				A
		Big Hill Point				A
		South Hat Head				A
		Hat Head				A
		Valla Headland				A
		Bongil Bongil NP				A

<sup>1</sup> additional locations of this endangered population (see Hogbin 1999)

**Table A4.3** Sites used for each threatened ecological community and rank in the model

priority	species	site	effective	actual impact	condition	priority		
High	Eastern Suburbs Banksia Scrub	Botany Bay NP	M	H	H	High		
		St Michaels Golf Course	M	H	H	High		
		Malabar West	M	H	H	High		
		Malabar East	M	H	H	High		
		Jennifer St (1), La Perouse	H	H	M	High		
		Jennifer St (2), La Perouse	H	H	M	High		
		Bunnerong Rd	H	H	M	High		
		Bunnerong Sub-station	?	H	M	Medium		
		NSW Golf Club	L	H	L	Low		
		Banksmeadow School	L	L	L	Low		
		Centennial Park	L	L	L	Low		
		Australian Golf Course	L	L	L	Low		
		Eastlakes	L	L	L	Low		
		North Head	L	L	M	Low		
		Prince Henry Hospital	L	L	M	Low		
		Bundock Rd Army Base	L	L	M	Low		
		High	Kurnell Dune Forest	East of Continental Carbon, Botany Bay NP	M	H	H	High
				Charlotte Breen Reserve	M	H	H	High
				South-east of Charlotte Breen Reserve	M	H	H	High
				Boat Harbour Reserve	?	M	M	Medium
North of Continental Carbon						A		
High	Littoral Rainforest	Towra Point NR				A		
		Iluka NR	H	H	H	High		
		Billinudgel	M	H	H	High		
		Sea Acres NR	H	H	H	High		
		Ten Mile Beach & Iluka Peninsula, Bundjalung NP	H	H	?	High		
		Brunswick Heads NR (south)	H	H	?	High		
		Broken Head NR	H	H	M	High		
		Cape Byron SCA	M	H	H	High		
		SEPP26 (173a – Bass Point Reserve)	H	H	M	High		
		SEPP26 (10 – Upper Wooyung)	?	H	H	High		
		SEPP26 (11 – Lower Wooyung)	?	H	H	High		
		SEPP26 (152c – Black Head, Hallidays Point)	?	H	H	High		

priority	species	site	effective	actual impact	condition	priority
High	Littoral Rainforest (continued)	Brunswick Heads NR (north)	M	M	?	Medium
		Wooyung NR	M	H	M	Medium
		Marshalls Creek NR	?	M	M	Medium
		Cudgen NR	M	H	M	Medium
		SEPP26 (5a - Bogangar)	?	M	M	Medium
		SEPP26 (6 - Hastings Point)	?	M	L	Medium
		SEPP26 (2a - Fingal)	?	M	L	Medium
		Killalea State Park	M	H	M	Medium
		Bundjalung NP	L	L	L	Low
		Seven Mile Beach, Lennox Head	L	M	L	Low
		Hallidays Point	?	L	L	Low
		Cape Hawke, Booti Booti NP	L	?	L	Low
		Angels Beach, Lennox Head				A
		Limeburners Creek NP				A
		Crowdy Bay NP				A
		Kattang NR				A
		Scrub Creek, Bongil Bongil				A
		Ukerabagh NR				A
		Tyagarah NR				A
		Arakawal NP				A
		Broadwater NP				A
		Yuraygir NP				A
		Moonee Beach NR				A
		Arakoon SRA				A
		Hat Head NP				A
		Khappinghat NR				A
		Booti Booti NP				A
		Myall Lakes NP				A
		Glenrock SCA (Flaggy Creek)	M	H	?	Medium-High
		Munmorah SCA				A
		Lake Macquarie SCA				A
		Wyrrabalong NP				A
		Boudii NP				A
		Towra Pt NR				A
		Square Head, Cullendulla Creek NR				A
		SEPP26 (2b)				A
		SEPP26 (4 - Cudgen)				A
		SEPP26 (9)				A
		SEPP26 (12)				A
		SEPP26 (13a)				A
		SEPP26 (13b)				A
		SEPP26 (13c)				A
		SEPP26 (32 - Broken Head)				A
		SEPP26 (34 - 7 Mile Beach (south))				A
		SEPP26 (34b - 7 Mile Beach (north))				A
		SEPP26 (37)				A
		SEPP26 (38)				A
		SEPP26 (38a)				A
		SEPP26 (52)				A
		SEPP26 (64a)				A
		SEPP26 (68b)				A
		SEPP26 (68c)				A
		SEPP26 (69)				A
		SEPP26 (70a)				A
		SEPP26 (71a)				A
		SEPP26 (71b)				A
		SEPP26 (75)				A
		SEPP26 (76)				A
		SEPP26 (78)				A
		SEPP26 (81 Uranga Lagoon)	M	H	?	Medium-High
		SEPP26 (82 - Hungry Head)	L	M	L	Low
		SEPP26 (86)				A
		SEPP26 (90)				A
		SEPP26 (91)				A
		SEPP26 (92)				A
		SEPP26 (93)				A
		SEPP26 (94)				A
		SEPP26 (96)				A
		SEPP26 (102)				A
		SEPP26 (104a)				A
		SEPP26 (105)				A
		SEPP26 (105a)				A
		SEPP26 (105b)				A
		SEPP26 (106)				A
		SEPP26 (107 - Pelican Point, Point Macquarie)				A
		SEPP26 (110)				A
		SEPP26 (116)				A
		SEPP26 (122)				A
		SEPP26 (125)				A
		SEPP26 (126)				A
		SEPP26 (131)				A
		SEPP26 (132)				A
		SEPP26 (134a)				A
		SEPP26 (135)				A
		SEPP26 (138)				A
		SEPP26 (142)				A
		SEPP26 (144)				A
		SEPP26 (145)				A
		SEPP26 (147)				A
		SEPP26 (148)				A
		SEPP26 (150)				A
		SEPP26 (152a)				A
		SEPP26 (155)				A
		SEPP26 (155b)				A
		SEPP26 (159)				A
		SEPP26 (160)				A
		SEPP26 (161)				A

priority	species	site	effective	actual impact	condition	priority
High	Littoral Rainforest (continued)	SEPP26 (162)				A
		SEPP26 (163a)				A
		SEPP26 (164)				A
		SEPP26 (165)				A
		SEPP26 (166)				A
		SEPP26 (170)				A
		SEPP26 (175)				A
		SEPP26 (175a – Gerroa, Kiama)				A
		SEPP26 (175j – Gerroa, Kiama)				A
		SEPP26 (175k – Gerroa, Kiama)				A
High	Sutherland Shire Littoral Rainforest	Quibray Bay, Towra Point NR	M	H	H	High
		Pelican Point, Towra Point NR	L	M	M	Medium
		Weedy Pond, Towra Point NR	L	M	L	Low
Medium	Byron Bay Dwarf Gramminoid Clay Heath Community	Island outlier east, Towra Point NR	L	M	L	Low
		Arakwal NP	M	H	H	High
Medium	Low Woodland with Heathland (Norah Head)	Norah Head, Wilfred Barrett Drive.				A
		Norah Head	?	H	H	High
Medium	Sydney Freshwater Wetlands	Coomaditchie Lagoon	M	M	M	Medium
		Jewells Swamp, Belmont area (site A)	L	M	L	Low
		Cape Bailey area, Botany Bay NP	L	M	L	Low
		Weedy Pond, Towra Point NR	L	M	L	Low
		Kurnell, Boat Harbour Reserve	L	M	L	Low
		Jewells Swamp, Belmont area (site B)				A
		Kurnell, Boat Harbour area, Botany Bay NP				A
Medium	Coastal Wetlands (SEPP14)	Brunswick Heads NR	H	H	M	High
		Bundjalung NP	H	M	H	High
		Brunswick Heads NR	M	M	M	Medium
		Ukerebagh NR	?	M	M	Medium
		Tweed Estuary NR	?	M	M	Medium
		Cudgen NR	L	M	M	Medium
		Wooyung NR	L	M	M	Medium
		Arakwal NP	M	H	L	Medium
		Broadwater NP	M	H	L	Medium
		Billinudgel NR	M	M	M	Medium
		Marshalls Creek NR	L	M	L	Low
		Tyagarah NR	L	H	L	Low
		Cumbebin Swamp NR	L	H	L	Low
		Ballina NR	?	M	L	Low
		Richmond River NR	L	M	L	Low
		Urunga Lagoon	M	L	H	Medium

? information was not available at this time

## Appendix 5 Species at risk from herbicide application

The species listed here are either known to be susceptible or are suspected to be vulnerable to herbicide used to control bitou bush. Consideration should be given to these species during bitou bush control programs and management plans.

**Table A5.1** Preliminary list of flora susceptible to herbicide

Species at risk	Status <sup>1</sup>	Information	Reference
<i>Acacia suaveolens</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Carpobrotus sp.</i> (pig face)		• susceptible to herbicide during aerial spraying	Flower <i>pers. comm.</i>
<i>Carpobrotus glaucescens</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Chamaesyce psammogeton</i>	E	• susceptible to herbicide	Thomas <i>pers. comm.</i>
<i>Gleichenia mendellii</i>	NL	• question marks over susceptibility	Flower <i>pers. comm.</i>
<i>Glycine clandestina</i>		• susceptible to herbicide	Toth <i>et al.</i> (1996)
<i>Hardenbergia violacea</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Kennedia rubicunda</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Plectranthus cremnus</i>	NL	• question marks over susceptibility	NPWS (2001d)
<i>Pimelia linifolia</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Pimelea spicata</i>	E	• susceptible to herbicide	Matarczyk (1999)
<i>Thesium australe</i>	V	• susceptible to herbicide	Thomas <i>pers. comm.</i>
<i>Scaevola calendulacea</i>		• mortality observed	Toth <i>et al.</i> (1996)
<i>Senecio spathulatus</i>	E	• susceptible to herbicide	Thomas <i>pers. comm.</i>
<i>Stackhousia spathulata</i>	NL	• susceptible to herbicide	Thomas <i>pers. comm.</i>
<i>Zieria prostrata</i>	E	• susceptible to herbicide	Thomas <i>pers. comm.</i>
<i>Zieria smithii</i> (lgf)	EP	• susceptible to herbicide	Thomas <i>pers. comm.</i>
Orchids		• susceptible to herbicide	Jones, Groves and Weston <i>pers. comm.</i>

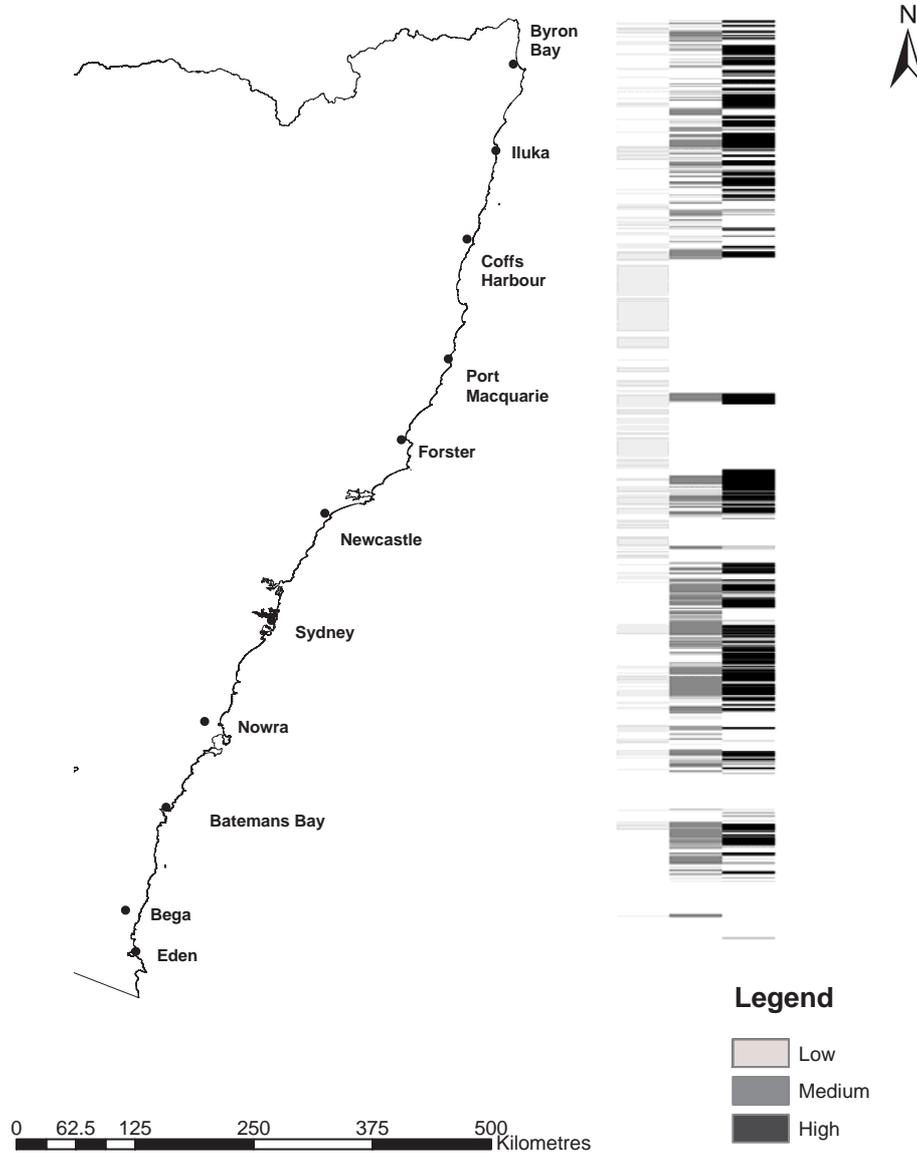
<sup>1</sup> E = endangered, V = vulnerable, EP = endangered population under the *NSW Threatened Species Conservation Act 1995*, and NL= not listed under the Act

**Table A5.2** Preliminary list of fauna susceptible to herbicide

Species at risk	Status <sup>1</sup>	Information	Reference
<b>Amphibians</b>			
<i>Crinia tinnula</i> (Wallum froglet)	V	• susceptible to herbicide contamination of aquatic habitats	Wellington <i>pers. comm.</i>
<i>Litoria aurea</i> (green and gold bell frog)	E	• susceptible to herbicide contamination of aquatic habitats	Wellington <i>pers. comm.</i>
<i>Litoria brevipalmata</i> (green-thighed frog)	V	• susceptible to herbicide contamination of aquatic habitats	Murphy <i>pers. comm.</i>
<i>Litoria olongburensis</i> (Olongburra frog)	V	• susceptible to herbicide contamination of aquatic habitats	Wellington <i>pers. comm.</i>
<b>Fish</b>			
<i>Nannaperca oxleyana</i> (Oxleyan pygmy perch)	En	• susceptible to herbicide contamination of aquatic habitats	Murphy <i>pers. comm.</i>
<b>Insects</b>			
<i>Petalura gigantia</i> (giant dragonfly)	E	• susceptible to herbicide contamination of aquatic habitats	Murphy <i>pers. comm.</i>

<sup>1</sup> E = endangered, V = vulnerable, EP = endangered population under the *NSW Threatened Species Conservation Act 1995*; and En = endangered under the *NSW Fisheries Management Act 1994*

## Appendix 6 Map of bitou bush density in NSW



The density of bitou bush in New South Wales, at three scales: high, medium and low (after Thomas 2002). Note: more than one density of bitou bush maybe present, at any one location.

## ***Appendix 7*      Submission: Draft Threat Abatement Plan**

---

**Submission:            THREAT ABATEMENT PLAN**

Name Individual/ \_\_\_\_\_

Organisation: \_\_\_\_\_

Postal Address: \_\_\_\_\_

\_\_\_\_\_

Postcode: \_\_\_\_\_ Contact Number(s): \_\_\_\_\_

Date: \_\_\_\_\_

**Draft Threat Abatement Plan:**

Invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush/boneseed)

The Department of Environment and Conservation (NSW) will consider all written submissions received during the period of public exhibition and must provide a summary report of those submissions to the Minister for the Environment prior to final approval of this threat abatement plan.

Please note that for the purposes of the *Privacy and Personal Information Protection Act 1988* (NSW) any comments on this draft threat abatement plan, including your personal details, will be a matter of public record and will be stored in the DEC records system. Following approval of the plan by the minister, copies of all submissions, unless marked ‘confidential’, will be available, by arrangement, for inspection at the DEC Office responsible for the preparation of the threat abatement plan.

Should you not wish to have your personal details disclosed to members of the public once the threat abatement plan has been adopted, please indicate below that you wish your personal details to remain confidential to the DEC and not available for public access. Further information on the *Privacy and Personal Information Protection Act 1998* may be obtained from any office of DEC or from the website: <http://www.nationalparks.nsw.gov.au/NPWS.nsf/Content/Home>

     Yes, please keep my personal details confidential to DEC

Submissions should be received no later than the advertised date. Submissions should be addressed to:



The Director General  
C/- Bitou Bush Threat Abatement Plan Co-ordinator  
Pest Management Unit  
Parks and Wildlife Division  
Department of Environment and Conservation (NSW)  
PO Box 1967 (43 Bridge Street)  
Hurstville NSW 2220







NSW  
NATIONAL  
PARKS AND  
WILDLIFE  
SERVICE



**Department of  
Environment and Conservation (NSW)**