



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



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## Executive summary

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Since the arrival of *Chrysanthemoides monilifera* subsp. *rotundata* (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 unabated, within a decade there will be no area of the NSW coast unaffected. It forms dense infestations that smother sand dune, headland and hind dune vegetation communities including coastal grasslands, heathlands, woodlands, swamps/wetlands and forests.

Invasion of native plant communities by bitou bush and boneseed (*C. monilifera*) was listed as a key threatening process under the NSW *Threatened Species Conservation Act 1995* (TSC Act) in 1999. In accordance with the TSC Act, the Department of Environment and Conservation has finalised a Threat Abatement Plan (TAP) which proposes actions to reduce the impacts of *C. monilifera* on biodiversity, particularly threatened species, populations and ecological communities. This document is hereafter referred to as the Bitou TAP.

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 such threatened biodiversity. While this TAP establishes a strategic approach to deliver statewide conservation benefits, other *C. monilifera* management programs will occur independently 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.

Nationally, *C. monilifera* poses a direct threat to at least 30 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 55 threatened plant species, three endangered plant populations and 15 endangered ecological communities (EEC) listed under the TSC Act. It also threatens another 103 plant species and 11 ecological communities not formally recognised as threatened (i.e. under threatened species legislation). In addition, there are potentially many other plant species and ecological communities that are under threat for which limited information is available, particularly with respect to fauna.

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 biodiversity at greatest risk from invasion) independent of land tenure
- ▶ monitor the effectiveness of control programs in terms of the recovery of the biodiversity at risk
- ▶ 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 ecological communities in New South Wales. The Bitou TAP determines priority plant species, populations and ecological communities that are at risk and identifies locations of such biodiversity to determine priority sites for the control of

*C. monilifera*. 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 the broader conservation of over 185 threatened entities at 349 sites, independent of land tenure.

In order to implement best practice management techniques for the control of *C. monilifera*, information on the respective site and the threatened biodiversity present is needed. To ensure best practice management, site-specific management plans are to be developed for priority sites. These plans will maximise effectiveness of control programs while minimising any negative impacts on native species, particularly the biodiversity identified at risk at each priority site.

Monitoring the effectiveness of the control programs at priority sites is a core component of the Bitou TAP, not just in terms of *C. monilifera* control, but the response of priority species, populations and ecological communities to control. Data collected from these monitoring programs is critical in determining the success of this plan and to refine future control methods and guide future priorities.

While the development of this plan has substantially increased our understanding of the impact of *C. monilifera* on native plant communities, significant additional information is still needed. For example, with respect to: i) the effects of *C. monilifera* and its control on fauna species, ii) how native species decline following invasion, and iii) impact of herbicide on native species.

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 2005–06 financial year is presented here as a guide to the estimated cost of implementing this TAP. The cost of implementing these actions in 2005–06 was \$2,845,500. This included expenditure by the DEC, Department of Lands (DoL), numerous councils, the five coastal Catchment Management Authorities (CMAs) 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 2005–06 is a reasonable estimate of the actual annual cost of implementing this plan, assuming that a similar level of commitment is maintained by these organisations in the future (i.e. over the life of this plan).

The Bitou TAP will be implemented over a five year period, being from 2006 until 2011. Actions in this TAP will be undertaken by the NSW Department of Environment and Conservation (specifically the *Parks and Wildlife Division*) and the NSW Department of Lands. At present a range of other stakeholders are currently involved with the actions outlined in this TAP. These groups along with local government, CMAs, private landholders and the community are encouraged to participate in the implementation of this TAP.



Lisa Corbyn  
**Director General**



Hon Bob Debus  
**Minister for the Environment**

## Preface

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### What is a threat abatement plan?

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A threat abatement plan or TAP is a statutory document prepared in accordance with the NSW *Threatened Species Conservation Act 1995* (TSC Act), for a key threatening process (KTP) listed under the Act. The TAP's principle aim is to **reduce, abate or ameliorate** the threat posed by the KTP to threatened species, populations 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 under the TSC Act.

### The draft Bitou TAP and this final TAP

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In September 2004, the draft *NSW Threat Abatement Plan for the Invasion of native plant communities by bitou bush/boneseed* (*Chrysanthemoides monilifera*) was released for public comment (see DEC 2004). After the public exhibition period, the draft TAP was revised based on the written submissions received. A statement of how these submissions were addressed in the amended plan formed part of the approval process for the final TAP. While the objectives of the TAP have not changed in terms of the actions, the major amendments to the TAP between the draft and this final version include:

- a) a revision of the species model
- b) the development of a population and ecological community model
- c) the inclusion of 95 additional species, 1 population and 17 ecological communities at risk
- d) the addition of 391 locations for the entities examined, including new information for those entities presented in the draft.
- e) a revision to the site model to address sites that contained multiple entities at risk
- f) a revised process for ranking sites
- g) a revised number and list of priority sites (i.e. Category 1 sites)
- h) a new action relating to the northern and southern containment zones
- i) a new action relating to the mapping of boneseed and the development of a management strategy
- j) updated costings
- k) several sections were enhanced by the inclusion of additional information (most of which was new since the draft)
- l) revised order of the text.

### The time-frame and review of the TAP

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This TAP will be implemented over a five year period from its release (i.e. from 2006 until 2011). At the end of this five year period the plan will be reviewed and a revised plan prepared in accordance with the TSC Act.

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## List of abbreviations used

<i>Abbreviation</i>	<i>expanded text</i>
Agvet Act	<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
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AWC	Australian Weeds Committee
BC Act	<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
CAP	Catchment Action Plan
CCP	Commonwealth Coastal Policy
CMA	Catchment Management Authority
CRC	Cooperative Research Centre
DAFF	Department of Agricultural Forestry and Fisheries Australia
DEC	Department of Environment and Conservation (NSW: <i>incorporating the former NPWS and EPA</i> )
DEH	Department of the Environment and Heritage
DoD	Department of Defence
DoL	Department of Lands (NSW)
DPI	Department of Primary Industries (NSW)
DWM	Defeating the Weeds Menace
EEC	Endangered Ecological Community as defined under the NSW TSC Act and the EPBC Act
EPA	Environment Protection Authority [now part of the Department of Environment and Conservation (NSW)]
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i> (NSW)
ESBS	Eastern Suburbs Banksia Scrub
GIS	Geographical Information System
IWM	Integrated Weed Management
JAMBA	Japan–Australia Migratory Bird Agreement
KDF	Kurnell Dune Forest
KTP	Key Threatening Process
LCA	Local Control Authorities (referring to regions under the <i>Noxious Weeds Act 1993</i> )
LGA	Local Government Area
LG Act	<i>Local Government Act 1993</i> (NSW)
NCWAC	North Coast Weeds Advisory Committee
NHT	Natural Heritage Trust
NP	National Park
NPW Act	<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)
NRC	Natural Resource Commission
NRM	Natural Resource Management
NRMSC	Natural Resource Management Standing Committee
NW Act	<i>Noxious Weeds Act 1993</i> (NSW)
NWAC	NSW Noxious Weeds Advisory Committee
NWS	National Weeds Strategy
PAS	Priorities Action Statement
PoM	Plan of Management
POEA	polyoxethylene amine
POEO Act	<i>Protection of the Environment Operations Act 1997</i>
QNR&M	Queensland Department of Natural Resources and Mines
RCC	Regional Competitive Component
RBG	Royal Botanic Gardens
RMP	Regional Management Plans
ROTAP	Rare or threatened Australian plants
SCA	State Conservation Area (formerly SRA: State Recreation Area)
SCARM	Standing Committee on Agricultural and Resource Management
SEPP	State Environmental Planning Policy
subsp.	Subspecies (also referenced as ssp. in some texts)
TAP	Threat abatement plan
TSC Act	<i>Threatened Species Conservation Act 1995</i> (NSW)
WINS	Weed Impacts on Native Species assessment tool
WONS	Weeds of National Significance

# 1 Introduction

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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. Today, bitou bush poses the greatest threat in New South Wales, while boneseed poses a serious threat in Victoria, Tasmania and South Australia. Their combined impact has been such that they were collectively listed as one of the 20 Weeds of National Significance (WONS) by the Australian 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*.

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 natural enemies 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 van Groenou and Wolfenden 2002). These strategies prioritise and coordinate management objectives across different levels of government, interest groups and local communities, resulting in a more focused and extensive control effort within New South Wales. However, these strategies are not specifically designed to combat the threat of bitou bush or boneseed invasion to threatened species and ecological communities. As such, both the national and state strategies identified the development of a threat abatement plan 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). The NSW 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).

Prior to the development of the draft of this plan (see DEC 2004), bitou bush and boneseed had been documented to threaten at least 18 plant species and three ecological communities, collectively (see ARMCANZ *et al.* 2000). However, these numbers are a gross under-representation of the impact, as outlined in the draft TAP, which identified 63 species, two populations and nine ecological communities at risk from bitou bush in New South Wales alone; numbers which were greatly increased here (see Appendices 3 and 5).

This plan or final TAP (hereafter referred to as the Bitou TAP) aims to address the KTP listings for *Chrysanthemoides monilifera*, specifically with respect to bitou bush. Information on boneseed is also presented where relevant however, 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 also to include the threat and proposed management of boneseed where appropriate.

This plan outlines and identifies:

- ▶ legislation, programs and strategies relevant to bitou bush management with respect to the development of a TAP (see Chapter 2 and Appendix 1 for NSW Noxious Weed listings)
- ▶ the biology and ecology of bitou bush and boneseed (see Chapter 3)
- ▶ impacts of bitou bush on native plant communities (see Chapter 4), especially the plant species, populations and ecological communities identified to be at risk from invasion along with the selection process for such entities (as outlined in Appendices 2–5)
- ▶ impacts to fauna and the need for additional information (see Chapter 5)
- ▶ priority sites for the control of bitou bush which will have the greatest benefit to biodiversity conservation, in terms of the biodiversity identified at risk, and outlines the site selection process (see Chapter 6 and Appendices 6–8)
- ▶ current control/management techniques and options for bitou bush along with the impacts of these programs on biodiversity (including off-target effects) (see Chapter 7)
- ▶ additional management information, such as a proforma for developing site-specific management plans (see Appendix 9), the flora and fauna species that may be susceptible to herbicide and hence should be considered in all control programs (see Appendix 10), a NSW bitou bush distribution map (see Appendix 11) and the distribution maps of the priority biodiversity at risk (see Appendix 12)
- ▶ monitoring required to assess the effectiveness of such control programs at priority sites, especially with respect to protecting biodiversity (see Chapter 8)
- ▶ objectives and actions to abate, ameliorate or eliminate the threat of bitou bush to native threatened plant species, populations and ecological communities within New South Wales (along with performance criteria for each) (see Chapter 9)
- ▶ economic and social implications of the Bitou TAP (see Chapter 10)
- ▶ costs associated with implementing each of the actions and the likely stakeholders (see Chapter 11).

## **2 Relevant legislation, policies, strategies and programs**

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

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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**

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The *Environment Protection and Biodiversity Conservation Act 1999* (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.

#### **2.1.2 Agricultural and Veterinary Chemicals Code Act**

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All pesticides, including 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 pesticide) 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. As of June 2005, there were 178 herbicide products registered by the APVMA for use in the control of bitou bush and/or boneseed in Australia.

All APVMA approved chemicals (or products) have affixed product labels that 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. The Parks and Wildlife Division of the DEC (formerly NSW NPWS) currently holds an off-label permit for aerial application of herbicides (e.g. glyphosate), used in the control of bitou bush in New South Wales.

### 2.1.3 Biological Control Act

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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 the Department of Agricultural Forestry and Fisheries Australia: DAFF), the Australian Quarantine and Inspection Service (AQIS), and the Department of Environment and Heritage (DEH). 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 February 1986 the Standing Committee on Agriculture (SCA: a predecessor of NRMSC) approved a biological control program for bitou bush in New South Wales as conventional control methods were deemed ineffective at suppressing the spread and impact of large-scale bitou bush infestations.

Host-specificity testing undertaken in South Africa identified 19 potential agents for the control of *C. monilifera* (bitou bush and boneseed) in Australia (being 17 insects and two pathogens: see Adair and Edwards 1996). Nine of these agents have been released in Australia, with an additional agent recently approved for release on boneseed. Several other agents have been rejected after initial testing (for a full review of the biological control program for *C. monilifera* in Australia see Downey *et al.* submitted). Of the remaining agents several are identified as having potential for boneseed, and one for bitou bush, however all these agents will require significant additional resources and time (see Downey *et al.* submitted). Of the six agents released for the control of bitou bush to date, only four have established, being the bitou tip moth (*Comostolopsis germana* Prout), bitou tortoise beetle (*Cassida* sp.), bitou seed fly (*Mesoclanis polana* Munro) and bitou leaf roller moth (*Tortrix* sp.).

### 2.1.4 Commonwealth Coastal Policy

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In May 1995 the Australian Government 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' (DEH 2005). 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:

- ▶ to conserve and manage areas and features of significant ecological, physical, cultural, historic, landscape and scientific importance, so that their values are maintained
- ▶ 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:

- ▶ to ensure that there is informed public participation in open, consultative processes dealing with planning and management of coastal resources
- ▶ 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

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The National Weeds Strategy (NWS: ARMCANZ *et al.* 1997) targets the management of nationally significant weeds 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.

In 2005 the Australian Government initiated a review and revision of the NWS. A discussion paper from the revision process recommended a number of changes to the NWS, however the revised NWS was not available at the time of writing.

### 2.1.6 Weeds of National Significance

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The WONS (Weeds of National Significance) 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 WONS 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 and boneseed
- ▶ minimise adverse impacts of bitou bush and boneseed on biodiversity
- ▶ maintain national commitment to the coordination and management of bitou bush and boneseed.

### 2.1.7 Cooperative Research Centre for Australian Weed Management

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The Cooperative Research Centre for Australian Weed Management (Weeds CRC) is a cooperative organisation which aims to combat Australia's weed problem, involving Australian Government 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 (2004–08) program.

### 2.1.8 Natural Heritage Trust initiatives

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There are four programs in the second stage of the Natural Heritage Trust (NHT) (2002–07): Landcare, Bushcare, Rivercare and Coastcare (NHT 2005). The **Landcare** program invests in activities that contribute to reversing land degradation and promoting sustainable agriculture. The **Bushcare** program invests in activities that 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 that contribute to improved water quality and environmental conditions in our river systems and wetlands. The **Coastcare** program invests in activities that contribute to protecting our coastal catchments, ecosystems and the marine environment (NHT 2005).

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 (this funding averaged approximately \$400,000 p.a. prior to the cessation of funding in 2003).

The four NHT programs 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.

The NHT program also addresses issues that affect multiple Natural Resource Management (NRM) regions through its Regional Competitive Component (RCC) (there are 56 NRM regions in Australia – for further information see NRM (2005) and in NSW see Section 2.2.12 below). Weed related projects were funded through the RCC until 2004, after which such projects are to be funded through the Defeating the Weeds Menace initiative (see below). However, as this plan also addressed several of the key themes of the RCC, including coastal management and threatened species, RCC funding was granted in 2005 to help with its implementation over the period 2005–06 through to 2007–08. This RCC funding is administered through the Southern Rivers Catchment Management Authority (see below) in conjunction with the other four coastal NRM regions in New South Wales and the DEC.

NHT funds have been secured to employ a full-time National Bitou Bush and Boneseed Coordinator for the period 2005–08. The National Coordinator's role is to facilitate a National Management Group and coordinate the implementation of the National Bitou Bush and Boneseed WONS Strategy across Australia.

In addition, the second stage of the NHT includes a new initiative, the **Australian Government Envirofund**. Grants of up to \$50,000 are available from the Envirofund for community groups to address local land management issues and to carry out on-ground actions. Numerous community groups have received Envirofunds to work on bitou bush and boneseed control.

### 2.1.9 Defeating the Weeds Menace initiative

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In 2004, the Australia Government made an election promise to tackle weeds. The 'Defeating the Weeds Menace' (DWM) program was thus initiated in 2005 (spanning 2005–08). The DWM funding is \$40 million, of which \$32 million is new money allocated for weeds. One of the aims

of this program is to fund programs relating to the WONS, especially where this leads to on-ground management. In the first round of the DWM program funds were secured to produce a Boneseed Management Manual (DEC *in prep.*). Numerous bitou bush and boneseed applications were submitted to the second round of funding, but no decision on the success of these projects was available at the time of writing.

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

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The Australian 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 5), 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**

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

### **2.2.1 NSW Noxious Weeds Act**

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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.

Amendments to the NW Act in 2005 repealed the NSW *Seeds Act 1982* and introduced a new classification system of weed control classes based on the degree of threat and the distribution of the introduced plant within the state. These new control classes are:

- Control Class 1* – State Prohibited Weeds
- Control Class 2* – Regionally Prohibited Weeds
- Control Class 3* – Regionally Controlled Weeds
- Control Class 4* – Locally Controlled Weeds
- Control Class 5* – Restricted Plants.

Under this new classification system Control Class 1, 2 and 5 noxious weeds are referred to as notifiable weeds.

Prior to these amendments bitou bush and boneseed were declared noxious in all designated coastal councils/control areas of New South Wales (including metropolitan Sydney). These declarations have remained under the new classification system and amended listings that came into force on 1 March 2006 (see Appendix 1).

## 2.2.2 NSW Threatened Species Conservation Act

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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.

Contained within the TSC Act are three schedules: Schedule 1 contains lists of critically endangered species and communities, endangered species, populations and communities, and extinct species; Schedule 2 contains lists of vulnerable species and communities; and Schedule 3 contains a list of key threatening processes (KTPs).

A KTP is eligible to be listed under the TSC Act if, in the opinion of the New South Wales 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.

The *Invasion of native plant communities by bitou bush and boneseed* was listed as a KTP in March of 1999 (see NSW SC 1999a).

Until the 2004 amendments to the TSC Act the preparation of a threat abatement plan (TAP) for each listed KTP was mandatory. However, this is no longer the case, with the requirement for preparation of a TAP being at the discretion of the Director General, DEC.

Irrespective, a TAP must outline how the threatening process is to be 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 authority's CEO approves its inclusion. This plan meets the requirements of a TAP for the *Invasion of native plant communities by bitou bush and boneseed* as per the TSC Act.

Where recovery plans are prepared and implemented for species, populations and ecological communities listed under the TSC Act they must identify any relevant threatening processes and how they are to be ameliorated. As such some recovery plans may require the control or management of bitou bush. For example, the *Zieria prostrata* recovery plan requires the control of bitou bush at several locations (NPWS 1998). 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 under the TSC Act, or for lands managed by the DEC a Section 171 authority issued under the *National Parks and Wildlife Act 1974*
- ▶ a certificate of exemption under Section 95 of the TSC Act
- ▶ a licence under Section 132C of the *National Parks and Wildlife Act 1974*.

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

### ***Recent Amendments to the TSC Act***

#### *TSC Amendment Act 2002*

In 2002 several amendments were made to the TSC Act. 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 9 along with requirements included in the development of site-specific management plans for each of the sites in the TAP.

#### *TSC Amendment Act 2004*

In 2004 several additional amendments were made to the TSC Act. The amendments relevant to this TAP are: i) as outlined above, the preparation of a TAP is no longer mandatory; ii) the addition of critically endangered species and critically endangered ecological communities; and iii) the development of a Priorities Action Statement (PAS: see below).

The draft PAS outlines recovery and threat abatement actions for the biodiversity listed under the TSC Act (see DEC 2006a). The actions contained in this TAP for each of the TSC listed entities identified in this plan as being at risk from bitou bush and boneseed invasion are included in the draft PAS, in addition to a specific action for preparing this TAP.

### **2.2.3 NSW Pesticides Act**

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The *Pesticides Act 1999* regulates the use of all pesticides in NSW, after the point of sale. This includes pesticides used in agriculture, on public lands and on domestic and commercial premises.

Under the provisions of the Pesticides Act all pesticide users in NSW are required to ensure that they:

- ▶ use only pesticides registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA) which are approved for the intended situation of use
- ▶ read the pesticide registration label on pesticide containers (or have them read to them) and strictly follow the label directions
- ▶ not risk injury to persons, property and non-target plants and animals through the use of a pesticide
- ▶ obtain an APVMA permit if they wish to vary the label directions or use pattern
- ▶ follow the instructions on any Pesticide Control Order relevant to the pesticide being used
- ▶ make a record of all pesticide applications
- ▶ become trained or licensed where required under the Pesticides Act and the Pesticides Regulation 1995, and
- ▶ in some circumstances provide notice of their pesticide use.

### ***Pesticides Regulations***

The Pesticides Regulations establish the legislative requirements for the licensing of aerial pesticide applicator companies and the prescribed qualifications that pilots must hold before an aerial agricultural licence will be issued to them. The Regulations also outline the requirements for the control of prohibited residues and restricted pesticides.

Additional amendments have been included under the *Pesticides Regulation 1995* to include:

*Pesticide Record Keeping:* Records must be kept by all people who use pesticides for commercial or occupational purposes such as on a farm, on produce, or as part of their occupation or business.

*Pesticide Training:* People who use pesticides in their business or as part of their occupation must be trained in how to use those pesticides. Any person employed or engaged to use pesticides must also be trained.

*Pesticide Notification:* From 1 February 2007, new notification requirements apply to pesticides applications by public authorities in outdoor public places and to pesticide applications by licensed pest management technicians in common areas of multi-occupancy residential complexes.

### **2.2.4 Protection of the Environment Operations Act**

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Under the *Protection of the Environment Operations Act 1997* (POEO Act), the DEC regulates general pollution and waste matters in New South Wales. This control also applies to pesticides. The selection and use of herbicides should be undertaken in accordance with relevant legislation and regulations to prevent the pollution of water.

### **2.2.5 NSW National Parks and Wildlife Act**

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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, Aboriginal areas, state conservation areas, karst conservation reserves, marine parks and 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 Chapters 5 and 9).

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.

### **2.2.6 Environmental Planning and Assessment Act**

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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.

### 2.2.7 Local Government Act

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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.

### 2.2.8 Catchment Management Authorities

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The Australian Government in conjunction with the states and territories established 56 Natural Resources Management (NRM) regions, based primarily on catchments. In New South Wales there are 13 NRM regions, which are called Catchment Management Authorities (CMAs). The CMAs are responsible for managing natural resources at the catchment scale, through strategic investment. Each CMA has a Catchment Action Plan (or CAP) that details their actions for achieving statewide targets established by the Natural Resource Commission (NRC). The five coastal CMAs are committed to bitou bush management through an RCC project (see 2.1.8 above) and for the Hunter/Central Rivers, Northern Rivers and Southern Rivers CMAs more specifically through their CAPs.

### 2.2.9 NSW Coastal Policy

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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 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).
- ▶ Protecting areas or items of high aesthetic value will be considered when preparing plans of management (Action 3.1.2).

### 2.2.10 NSW Weeds Strategy

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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 plan:

- ▶ 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.

### 2.2.11 NSW Biodiversity Strategy

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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. This strategy is currently undergoing a review and the actions within the strategy relevant to the Bitou TAP are unknown.

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

The NSW Biodiversity Strategy 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 initial development of the draft of this plan (DEC 2004).

### 2.2.12 Strategies to manage bitou bush in New South Wales

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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 management strategy***

The NSW North Coast bitou bush management strategy (Scanlon 2001) was 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 (RMPs) 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 prepared the NSW South Coast regional bitou bush strategy (see Broese van Groenou 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.

The South Coast Bitou Bush Task Force was formed to address bitou bush management in southern New South Wales (i.e. from the Illawarra to the Victorian border). This task force oversees the implementation of the South Coast regional bitou bush strategy. In addition, the NWAC requires the preparation of an RMP for all noxious weed species.

#### ***Local government strategies***

Many North Coast councils or LCAs (i.e. Byron, Greater Taree, Hastings, Great Lakes, Kempsey, Bellingen, Nambucca, Port Stephens, Tweed Shire) 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. the plan for Sydney encompassing several councils).

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

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Many other plans and strategies have been prepared that are relevant to the management of bitou bush in New South Wales, such as plans of management (PoM) for specific reserves or sites [e.g. the PoMs for Bundjalung NP, Broadwater NP and Iluka NR (NPWS 1999b)] and regional pest strategies developed by the NPWS (see NPWS 2002b). 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) or to a more strategic management approach (e.g. North Coast Coastal Weeds Management Plan – see NCWAC 2005). The realisation that the control of one species may pave the way for invasion by other weed species aided this change. These approaches to weed management are discussed in more detail in Chapter 7.

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

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### 3.1 Plant descriptions and biology

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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 (Gosper 2004a). 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*)

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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 (see photo on the cover). 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 endocarp or seed coat. Up to 13 fruits are produced per inflorescence (Weiss *et al.* 1998; Vranjic 2000).

The age at which sexual reproduction (flowering) begins varies, but on average is 2–3 years after germination. In northern New South Wales however, seedlings may flower within their first year. In mature plants, flowering occurs during April–July, with flowers occasionally present all year round, although Gosper (2004a) found the peak was March to May. Peak seed production generally occurs during June–September (Weiss *et al.* 1998; Vranjic 2000), again Gosper (2004a) found a different peak being May to June. 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 silvereyes, see Dodkin and Gilmore 1984) and mammals (e.g. foxes, see 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 relatively 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 salt spray, mild frost and, to a limited extent, water-logged soil (e.g. it can invade the edges of swamps and wetlands). 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*)

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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, with the hairs being shed with age. 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 (see photo on the cover). 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 endocarp 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, salt spray and mild frosts. It is relatively 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

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*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

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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 (Gray 1976; Cooney *et al.* 1982).

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 (Cunningham *et al.* 1981). 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). Concerns over the impact of bitou bush have led to an eradication program on Lord Howe Island being initiated.

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 (82%), 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, with 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 11.

### 3.2.2 Arrival and spread of boneseed in Australia

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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 widespread 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 historic infestations in Western Australia near Perth, the status of which is unclear. 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

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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. Over the past 20 years six biological control agents have been released on bitou bush, four of which have established, and six agents for boneseed, none of which have established (see Downey *et al.* submitted). 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 in Australia.

### 3.2.4 Habitats invaded by bitou bush and boneseed

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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 on native plant communities

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The impacts of bitou bush and boneseed invasions on biodiversity are outlined below (e.g. flora in this chapter and fauna in Chapter 5), 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. Such values are not directly addressed in this TAP (with the exception of a brief discussion in Chapter 10), but the control of bitou bush and boneseed for the purposes of conserving biodiversity, will help to alleviate the problem at specific locations.

### 4.1 Bitou bush and boneseed invasions and biodiversity

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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), and more recently to threatened biodiversity in New South Wales (Coutts-Smith and Downey 2006). 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 was poorly documented, prior to the release of the draft of this TAP (see DEC 2004; Downey 2004). Of the studies conducted to date investigations have only been confined to a few native plant species (i.e. Weiss and Noble 1984a, b; Matarczyk 1999; Vranjic *et al.* 2000), or generic groups (i.e. for vertebrates (French and Zubovic 1997; Gosper 1999; Gosper *et al.* 2005) and insects (French and Eardley 1997) - a further discussion on the impacts to fauna is presented in Chapter 5). However, such studies have not been resulted in a comprehensive assessment of the impacts or the species most at risk.

Despite this lack of information, many assumptions have been made as to the extent of the impacts across a broader range of species. For example, bitou bush impacts on other plant species through increased competition, shade and litter level. Objective data quantifying the impacts are limited, especially with respect to the impacts on entire communities (see Dodkin and Gilmore 1984; Vranjic 2000); a situation that is now being rectified mainly by the University of Wollongong. Insufficient data with respect to bitou bush invasions has long been acknowledged (Dodkin and Gilmore 1984) and this deficiency has influenced the development of some aspects of this TAP (e.g. with respect to fauna). Research to address the lack of information forms key actions in this TAP (see Chapter 9). Despite this lack of quantitative data, bitou bush had been assessed as a threat to several species listed under the TSC Act, leading to its listing as a KTP (NSW SC 1999a), and more recently to many species listed under the TSC Act (see Coutts-Smith and Downey 2006). However, the initial number thought to be at risk has been greatly increased since the KTP listing in 1999, both in terms of TSC listed species and native plants more generally (see Coutts-Smith and Downey 2006, and Downey 2004, respectively). For example, the draft of this plan identified 63 plant species, two plant populations and nine endangered

ecological communities at risk in New South Wales (see DEC 2004), while this plan has significantly increased these numbers (see below).

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. In addition, initial investigations into the biodiversity at risk from boneseed in Tasmania suggest a similar level of impact to bitou bush (see Downey *in press*). 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 subsequent chapters.

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

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Historically there has been a common assumption that weeds only invade following some form of disturbance, and in the past this assumption has been applied to bitou bush and boneseed. 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, however no objective scientific data are available regarding how this process occurs.

It is extremely important to understand how weeds affect ecosystems once they invade. Weeds impact upon several ecosystem properties (Gordon 1998) and physical properties (e.g. decomposition rates – see Lindsay and French 2004a) which can modify 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. A weed 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, as well as alter fire behaviour through structural habitat modification, 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 with increased germination and rapid seedling growth rates may have led to substantial vegetation changes, as observed in Yuraygir NP (Thomas *pers. obs.*) and Billinudgel NR (Bower *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.*). It should be noted that failure to implement adequate controls following such disturbances has led to major establishment events.

## 4.2 Plant species, populations and ecological communities at risk

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### 4.2.1 Why select biodiversity at risk?

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While some may argue that it is more cost effective to eradicate or control new or isolated infestations in the first instance, such arguments do not consider the cost of not addressing large infestations, the loss of species which are currently under threat, or the fact that such economic assessments are based on static points in space and time (i.e. it is more cost effective to control **any** infestation today than to wait till tomorrow, when it has expanded and achieved its full potential). In addition, the cost of impacts to biodiversity has rarely been accounted for in such economic assessments. For example, the loss of an individual species due to invasion from widespread weeds was recently calculated to be \$86,700 per year (Sinden *et al.* 2004), which when applied to the 63 species identified in the draft TAP (see DEC 2004) results in a loss of species cost of \$5.46 million per year. Also, there are a range of initiatives that address new and isolated infestations (under the Noxious Weeds Act) and containment (the northern and southern containment lines – see NPWS 2001a and Chapter 9). In addition, given the five year life of the TAP and the current impact to biodiversity, this plan focuses in the **first instance** on reducing the present impacts, rather than reducing future ones.

Given the extent of bitou bush in New South Wales (occurring over 80% of the coastline), its rapid expansion (36% increase in 20 years, see Thomas and Leys 2002), the duration of the invasion (50+ years since wide-scale plantings), and the level of biodiversity present in the coastal zone (i.e. a high diversity of species over a small area), the impact from bitou bush invasion on biodiversity is likely to be significant. In addition, the eradication of bitou bush in the short term is not feasible. Thus, a system is needed to assess the biodiversity at greatest risk and the sites at which control will lead to the greatest conservation outcomes for those species most at risk.

### 4.2.2 Selecting and prioritising plant species at risk from invasion

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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 distributions 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 5.

The data derived from the distribution GIS analysis showed a total of 850 plant species, spanning 151 families within the bitou bush infested areas of New South Wales. Of these, 55 were listed as either endangered or vulnerable species under the Commonwealth EPBC Act or the NSW TSC Act, 30 of which were considered to be threatened by bitou bush. In addition, those species not covered by such threatened species legislation occurring within the distribution of bitou bush in New South Wales may also be classified as threatened if 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

While this approach provided a basis for establishing those threatened plant species which may be at risk from bitou bush invasions, and thus be subjected to analysis of the threat, it does not address plant species not formally listed as threatened but which are likely to be or are at risk from invasion. Therefore consideration of both threatened species and non-threatened species that are potentially at risk by bitou bush is needed to establish a complete list of the species at risk. Such an approach is supportive of the KTP determination in which it was acknowledged that bitou bush invasion may cause species that are not threatened to become so (NSW SC 1999a).

In order to determine the full extent of the species at risk, the Weed Impacts to Native Species (WINS) assessment process or tool was established (see Downey in press). The WINS assessment process involves four stages, being 1) a review of the literature; 2) collation and assessment of the knowledge from land managers and botanists with specific involvement, either in managing bitou bush, or the native species in bitou bush infested areas; 3) rigorous evaluation and examination of an interim list of species potentially at risk; and 4) ranking the revised list using a model. While, stage 1 does not differ from previous attempts to determine biodiversity at risk (i.e. Grice *et al.* 2004; Vidler 2004), stages 2 and 3 outline a new process for rapidly collating information that would otherwise not be available, and evaluating the quality of that information in order to determine its integrity, respectively. When the list of species potentially at risk, as produced in stage 3, is then modelled, i.e. during stage 4, and emphasis is given to the highest priorities, a robust process for quickly assessing the biodiversity at risk from weed invasions can be determined without quantitative data (see Downey in press, for further details and discussion).

The outcomes of stages 1 and 2 of the WINS assessment process are not presented here, instead the final list of species identified as potentially at risk from bitou bush invasion, i.e. the outcome of Stage 3, is presented in Appendix 3, while the model used for Stage 4 is presented in Appendix 2. The 63 plant species identified in the draft TAP as potentially at risk from bitou bush invasion using the WINS approach, was expanded to 158 here. The additional 95 species arose from re-running various stages of the WINS assessment process. For example, stage 1 included newly published information (see Coutts-Smith and Downey 2006) along with new threatened species determinations, while stage 3 involved evaluation and revisions to the list of species at risk as a result of the comments received during the public exhibition, and in stage 4 most of the 70 species identified in the draft which were not modelled were added and modelled. Some species identified as potentially at risk during this process were not modelled however (see Table A3.2). Irrespective, the changes highlight the flexibility of the WINS assessment process and its value in rapidly determining species at risk.

The four stage WINS system identified 19 species as being at greatest risk from bitou bush invasion (i.e. high priority species, see Table 4.1), 41 medium priority and 98 low priority species (see Appendix 3).

**Table 4.1** The 19 plant species at greatest risk from bitou bush invasion in rank order, as determined from the species model (see Appendix 3), and their threatened status along with the formal processes for recovery.

species name	family name	threatened status <sup>a</sup>			recovery plan	actions in PAS <sup>e</sup>
		TSC Act <sup>b</sup>	EPBC Act <sup>c</sup>	ROTAP <sup>d</sup>		
<i>Plectranthus cremnus</i>	Lamiaceae			3K	no	no
<i>Zieria prostrata</i>	Rutaceae	E	E	2E	yes	yes
<i>Chamaesyce psammogeton</i>	Euphorbiaceae	E			no	yes
<i>Senecio spathulatus</i>	Asteraceae	E			no	yes
<i>Acianthus exiguus</i>	Orchidaceae			3RC-	no	no
<i>Calystegia soldanella</i>	Convolvulaceae				no	no
<i>Chamaecrista maritima</i>	Caesalpiniaceae				no	no
<i>Sophora tomentosa</i>	Fabaceae	E			no	yes
<i>Lepturus repens</i>	Poaceae				no	no
<i>Pultenaea maritima</i>	Fabaceae	V			no	yes
<i>Stackhousia spathulata</i>	Stackhousiaceae				no	no
<i>Ischaemum triticeum</i>	Poaceae				no	no
<i>Vigna marina</i>	Fabaceae				no	no
<i>Gleichenia mendellii</i>	Gleicheniaceae				no	no
<i>Actites megalocarpa</i>	Asteraceae				no	no
<i>Poa poiformis</i>	Poaceae				no	no
<i>Fontainea oraria</i>	Euphorbiaceae	E	E	2E	draft	yes
<i>Diuris praecox</i>	Orchidaceae	V	V	2VC-	no	yes
<i>Westringia fruticosa</i>	Lamiaceae				no	no

<sup>a</sup> E = Endangered, V = Vulnerable, as defined under the various legislation.

<sup>b</sup> TSC Act = NSW *Threatened Species Conservation Act 1995*.

<sup>c</sup> EPBC ACT = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

<sup>d</sup> ROTAP – Rare or Threatened Plants of Australia (see Briggs and Leigh 1996). ROTAP codes: 2 = geographic range in Australia less than 100km; 3 = geographic range in Australia greater than 100km; E = endangered; V = vulnerable; K = conservation status poorly known; C = reserved; (-) = reserved population size is not accurately known.

<sup>e</sup> Actions in the draft Priority Action Statement (PAS – see DEC 2006a) other than those associated with implementation of this plan (i.e. the Bitou Bush Threat Abatement Plan).

### 4.2.3 High priority species

A short summary of each of the 19 high priority species, as determined by the species model (see Appendices 2 and 3) are presented below in rank order. Species descriptions were extracted from Harden (1990–2002) unless otherwise noted. Information is also presented on the other threats to these species where known.

#### 1. *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. It 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.

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 and Appendix 10A).

## 2. *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 and in the surrounding areas.

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

*Chamaesyce psammogeton* (synonyms: *C. sparrmani*, *Euphorbia sparrmani*) is a prostrate perennial herb that forms mats to 1 m in diameter. It grows on incipient fore-dunes in *Spinifex hirsutus* communities, and exposed headlands, as well as on the beach aspect of the fore-dune 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 its final determination under the TSC Act 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 distribution of this species is not fully known.

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). The 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.

## 4. *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 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 other threats present.

**5. *Acianthus exiguus* (D.L.Jones) Juss. (Orchidaceae)**

*Acianthus exiguus* is a rare terrestrial orchid that grows in moist areas, favouring littoral rainforest, dry rainforest, wet sclerophyll forests, dry sclerophyll forests, grassy sclerophyll forests and dunes (including stabilised sands). The upper leaf surface is dark green, while the lower surface is light reddish purple. Flowers are translucent greenish white with a pink and green labellum with lateral sepals having a faint red central stripe. Since its identification in 1987 it has been identified from 11 sites along the NSW coast north from Wyrabalong. Several of these locations are now infested with bitou bush, and bitou bush is suspected as being a threat to this species.

**6. *Calystegia soldanella* (Roem. & Schult) Juss. (Convolvulaceae)**

*Calystegia soldanella* is a glabrous perennial herb/vine with trailing stems, which prefers growing along the ground. This species is widespread in northern and southern temperate zones growing in sandy and rocky coastal areas, but few recent records exist for New South Wales. Leaves are heart-shaped, waxy and fleshy, and provide protection from water loss in coastal habitats. The flowers are pink to purple with white bands that are similar to that of the weed morning glory (*Ipomea* sp.). The low growing habit of *C. soldanella* makes it susceptible to invasion by bitou bush. The species may also be at threat from bush regeneration as it could be mistaken for one of the weedy morning glory species.

**7. *Chamaecrista maritima* (Pedley) R.Br. (Caesalpiaceae)**

*Chamaecrista maritima* (synonym: *C. mimosoides*) is a prostrate or tufted perennial sub-shrub, less than 15 cm high. It grows on grassy windswept headlands and hillsides on a variety of soils north from Port Macquarie. There are few records of this species (i.e. from Norries Head, Bogangar, Korogoro Point, Hat Head, Hastings Point, Lennox Head, Boambee Head, Port Macquarie), with very few being post 1990 (i.e. Cape Byron, Sawtell, Smoky Cape, Hat Head NP). *Chamaecrista maritima* can be locally common but most known populations are small. Its major habitat type is Themeda grasslands, an Endangered Ecological Community (EEC) listed under the TSC Act. Many of the known locations are infested by bitou bush.

**8. *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), 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 have reduced the immediate threat, however, several other populations do not currently have bitou bush control programs in place.

**9. *Lepturus repens* (G.Forst.) R.Br. (Poaceae)**

*Lepturus repens* is a prostrate spreading perennial grass that grows to about 50 cm tall, with long trailing stolons that root at the nodes. It grows in sandy soils along the coast and is known from

four locations on the north coast of New South Wales, as well as on Lord Howe Island. Little information is available on this species and its threats.

**10. *Pultenaea maritima* (de Kok) Lindl. (Fabaceae)**

*Pultenaea maritima* is a prostrate mat forming shrub with hairy stems. This species, once considered a prostrate form of *P. vilosa*, is now listed as vulnerable under the TSC Act. This species predominantly occurs within Themeda grasslands, an Endangered Ecological Community, on sea cliffs and coastal headland communities. *Pultenaea maritima* occurs north from Newcastle into Queensland. Within New South Wales *P. maritima* is only known from 16 headlands and information on the population dynamics at these sites is unknown.

**11. *Stackhousia spathulata* (Sieber ex Spreng.) R.Br. (Stackhousiaceae)**

*Stackhousia spathulata* is a perennial herb growing to 50 cm high in heath and dry sclerophyll forest in sandy areas. The inflorescence is a dense cylinder spike of white tubelike flowers. Although widely distributed in coastal districts of New South Wales, populations are often small and infrequently encountered (Thomas *pers. comm.*). It usually grows on partly stabilised coastal sand dunes, occasionally on the margins of coastal lagoons and on headlands. This species has been found in Themeda grasslands, an Endangered Ecological Community, on sea cliffs and coastal headland communities.

**12. *Ischaemum triticeum* (R.Br.) R.Br. (Poaceae)**

*Ischaemum triticeum* is a trailing perennial grass, rooting and branching at the nodes with stems to 2 m long. It grows on the fore-dune of coastal sand dunes and in sandy soils deposited on headlands and cliffs. This species is restricted to the north coast of New South Wales, from Laurieton north. *Ischaemum triticeum* was probably more common in the past but sandmining and bitou bush invasion have impacted heavily and large populations are now infrequent.

**13. *Vigna marina* (Burm.) Lindl. (Fabaceae)**

*Vigna marina* is a climbing or trailing legume with hairy stems to about 2 m long. Flowers are yellow, with 2–6 seeds in a pod, giving rise to its common name of ‘dune bean’. This species occurs on the incipient dune and in exposed locations on headlands along the north coast of New South Wales, north of Port Macquarie, as well as on Lord Howe Island. It is uncommon in the southern part of its range (i.e. Richmond River to Hastings River). On Lord Howe Island, *V. marina* is a characteristic species of the Lagunaria Swamp Forest Community, an Endangered Ecological Community under the TSC Act.

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

*Gleichenia mendellii* is a rhizomatous terrestrial long-creeping fern. This is a recently described species, 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. 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 more readily. Bitou bush may also 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 2001b), 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.* and Appendix 10A).

**15. *Actites megalocarpa* (Hook.f.) Lander (Asteraceae)**

*Actites megalocarpa* is a fleshy perennial herb growing to 40 cm high in large clumps. The flowers are yellow florets that are sometimes pale purple at the base. This species is often referred to as dune thistle. It grows in coastal sand dunes and on coastal headlands and cliffs. This species is occasionally mistaken for a weed. Many locations contain bitou bush.

**16. *Poa poiformis* (Labill.) R.Br. (Poaceae)**

*Poa poiformis* is a densely tufted erect perennial grass to 1 m high, rarely with vertical or oblique rhizomes. It grows along estuaries and ocean foreshores, occasionally on coastal sand dunes and cliffs, especially south facing cliffs south from Port Stephens. Recently the species was also found near Port Macquarie (Dodkin *pers. comm.*). The species has been found in Themeda grasslands, an Endangered Ecological Community, particularly low on cliffs that are exposed to sea spray.

**17. *Fontainea oraria* Jessup & Guyer (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 Head 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, it does occur in the region and is known to invade littoral rainforests, particularly the edges.

**18. *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.

**19. *Westringia fruticosa* (Willd.) Lindl. (Lamiaceae)**

Commonly referred to as coastal rosemary, *Westringia fruticosa* is a shrub that grows to about 1.5 m high. It grows near the sea and harbour foreshores, often on exposed cliffs in skeletal soils. This species has been widely cultivated for its hardy nature and small white flowers. *Westringia fruticosa* can be found scattered in Themeda grasslands, an Endangered Ecological Community, on sea cliffs and coastal headlands. Bitou bush occurs at or within close proximity to many locations.

**4.2.4 Selecting and prioritising plant populations at risk**

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Under the TSC Act threatened native biodiversity can be listed as either an individual species, a specific population of a species (either listed as threatened or not) or an ecological community. While the assessment process for determining the plant species at risk has been presented above,

this process does not account for the other types of threatened biodiversity that may be at risk from bitou bush invasion (i.e. plant populations and ecological communities). Here the process for determining and prioritising plant populations is outlined, while ecological communities are presented below (see Section 4.2.6).

In the draft plan, the prioritisation of populations and ecological communities was not subjected to any form of modelling (see DEC 2004). However, for those plant populations and ecological communities deemed to be at risk (see below) a modified version of the species model was used here to determine their priority (see Appendix 4). In essence the model is the same, minus the attribute for persistence which could not be easily determined for specific populations, as such information was rarely available, or for ecological communities, as amalgamating such information for multiple species is extremely difficult and may not provide a useful assessment as the effects of individual species may be masked.

As the site model (see below) allows for individual populations of species at risk to be assessed based on the relative threat from bitou bush, only those populations listed under the TSC Act were examined here. The locations of each of these populations were matched against the distribution of bitou bush. Only those populations that occurred within the distribution or within close proximity to bitou bush were selected and modelled. Three endangered plant populations fitted the criteria (see Appendix 5, Table A5.1), two of which were ranked as at greatest risk from bitou bush invasion (i.e. high priority, see Table 4.2) and the other as a low priority.

**Table 4.2** The two plant populations at greatest risk from bitou bush invasion in rank order, as determined using the model (see Appendix 5), and their threatened status along with the formal processes for recovery.

plant population <sup>a</sup>	family name	threatened status <sup>b</sup>	recovery plan	actions in PAS <sup>c</sup>
<i>Glycine clandestina</i> (broad leaf form)	Fabaceae	E	no	no
<i>Zieria smithii</i> (low growing form)	Rutaceae	E	no	yes

<sup>a</sup> As outlined defined and listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act).

<sup>b</sup> E = Endangered, as defined under the TSC Act.

<sup>c</sup> Actions in the draft Priority Action Statement (PAS – DEC 2006b) other than those associated with implementation of this plan (i.e. the Bitou Bush Threat Abatement Plan).

#### 4.2.5 High priority plant populations

A short summary of each of the two high priority plant populations, as determined by the population and ecological community model (see Appendices 4 and 5) are presented below in rank order. Species descriptions were extracted from Harden (1990–2002) unless otherwise noted. In addition, information is also presented on the other threats to these species where known.

##### 1. *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, 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*).

**2. *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 1998b). The known threats are weed invasion from bitou bush, kikuyu (NSW SC 1998b) 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 (see Appendices 7 and 8).

#### 4.2.6 Selecting and prioritising ecological communities at risk

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While the majority of coastal ecological communities in New South Wales are potentially at risk from bitou bush invasion due to its wide distribution (along 80% of the coastline), information on those at risk is limited. The distribution of bitou bush in New South Wales (see Thomas 2002; Thomas and Leys 2002) could not be used to determine those ecological communities at risk based on the degree of overlap, because there is no comparable dataset for coastal vegetation communities (see Benson 1999). The selection of the ecological communities potentially at risk was therefore undertaken using the WINS assessment process. As outlined above, this also allows for examination of both formally listed Endangered Ecological Communities (EECs) and non-listed communities. Stage 4 of the WINS system used the model presented in Appendix 4.

Using the WINS system 26 ecological communities were identified as being potentially at risk from bitou bush invasion. Fifteen are EECs and 11 were not formally listed ecological communities. Eight of these 26 ecological communities were ranked as at greatest risk from bitou bush invasion (i.e. high priority, see Table 4.3), eight as medium priority and 10 as a low priority (see Appendix 5, Table A5.2). Another nine ecological communities were identified as being potentially at risk from bitou bush invasion but were not modelled due to insufficient information (see Appendix 5, Table A5.3).

**Table 4.3** The eight ecological communities at greatest risk from bitou bush invasion in rank order, as determined using the model (see Appendix 5), and their threatened status along with the formal processes for recovery.

ecological communities	threatened status <sup>a, b</sup>	recovery plan	actions in PAS <sup>c</sup>
Eastern Suburbs Banksia Scrub	EEC (EPBC & TSC Act)	yes	yes
Littoral Rainforest (including SEPP26 and Sutherland Shire Littoral Rainforest)	EEC (TSC Act), SEPP 26 <sup>d</sup>	some <sup>e</sup>	yes
Kurnell Dune Forest	EEC (TSC Act)	no	yes
Coastal Banksia Woodlands ( <i>Banksia integrifolia</i> )		n/a	n/a
Themeda ( <i>Themeda triandra</i> ) grassland on sea cliffs & coastal headlands in the NSW North Coast, Sydney Basin and South East Corner bioregions	EEC (TSC Act)	no	no
Eastern Suburbs Banksia Scrub equivalent communities (i.e. Coastal Sand Wallum Heath)		n/a	n/a
Frontal Dune Vegetation Complex		n/a	n/a
Coastal Sand Dune complex ( <i>Acacia longifolia</i> var. <i>sophorae</i> )		n/a	n/a

<sup>a</sup> EEC = Endangered Ecological Community as defined under the threatened species legislation, SEPP = State Environment Planning Policy.

<sup>b</sup> TSC Act = NSW *Threatened Species Conservation Act 1995*, and EPBC ACT = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

<sup>c</sup> Actions in the draft Priority Action Statement (PAS – DEC 2006b) other than those associated with implementation of this plan (i.e. the Bitou Bush Threat Abatement Plan).

<sup>d</sup> Littoral rainforests are classified as SEPP 26 (i.e. those which do not occur within conservation reserves) and an EEC. The SEPP 26 classification includes a 100 m buffer zone.

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

#### 4.2.7 High priority ecological communities

A short summary of each of the eight high priority ecological communities, as determined by the population and ecological community model (see Appendices 4 and 5) are presented below in rank order. Information is also presented on the other threats to these ecological communities where known.

##### 1. 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 33 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, 2002; 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. The recovery plan for ESBS encompasses a broader range of threats (i.e. *Phytophthora cinnamomi*, 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.

## **2. Littoral rainforests (including SEPP 26 and Sutherland Shire Littoral Rainforest)**

Littoral rainforests occur only on the coast and are found at locations in the NSW North Coast Bioregion, Sydney Basin Bioregion and South East Corner Bioregion (NSW SC 2004). Littoral rainforests are 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). The plant species in this ecological community are predominantly rainforest species with evergreen mesic or coriaceous leaves, and vines may be a major component of the canopy, however, there is considerable floristic variation between stands (NSW SC 2004). Littoral rainforests also provide habitat for many migratory and nomadic animals.

Littoral rainforests are very rare and occur in many small stands – less than a quarter of their original extent remains. In total, littoral rainforests comprise less than one percent of the total area of rainforest in New South Wales. Although a number of stands exist in reserves (e.g. 90 ha stand in Iluka NR), 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), and most 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. Note that not all stands of this community have been included in mapping for SEPP 26, especially stands which are already protected by formal reserves. In 2004, littoral rainforests in the NSW North Coast, Sydney Basin and South East Corner bioregions were listed as an EEC under the TSC Act. While this listing replaces and incorporates the Sutherland Shire Littoral Rainforest listing under the TSC Act (NSW SC 1998c), it does not make the SEPP 26 classification defunct. The term littoral rainforest as used here encompasses those littoral rainforests listed under both the TSC Act and SEPP 26.

Bitou bush poses a serious threat to littoral rainforest, especially in northern New South Wales. 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 general 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.

## **3. 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 and in 1999 was listed as an EEC under the TSC Act. 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, and 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 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.

#### 4. Coastal Banksia Woodland

Coastal Banksia Woodland communities are an open forest to shrubland on deep sand soils usually in close proximity to the ocean. The ecological community comprises numerous small banksia tree species including coast banksia (*Banksia integrifolia* var. *integrifolia*), which is the most prolific species. Other dominant species include *Casuarina glauca*, *Hibiscus tiliaceus*, *Acacia sophorae*, *Casuarina equisetifolia*, *Lophostemon confertus*, *Acacia melanoxylon*, *Glochidion* spp., *Callitris columellaris* and *Acacia aulacocarpa* (Tweed Shire Council 2004). Bitou bush readily invades Coastal Banksia Woodland communities in New South Wales.

#### 5. Themeda grasslands on sea cliffs and coastal headlands

Themeda grasslands on sea cliffs and coastal headlands in New South Wales are described as a unique ecological community (see Adam *et al.* 1989). This ecological community is found in the NSW North Coast, Sydney Basin and South East Corner bioregions, on sea cliffs and coastal headlands. The structure of the community is typically closed tussock grassland, but may be open shrubland or open heath with a grassy matrix between the shrubs (NSW SC 2005). The community belongs to the *Maritime Grasslands* vegetation class of Keith (2004). Due to its highly restricted distribution, small patch size and ongoing threats to the community, it was recently listed as an EEC under the TSC Act (NSW SC 2005).

The dominant species is *Themeda triandra*, but some suggest that it may be a separate headland form or subspecies (Dodkin *pers. comm.*). This ecological community also contains scattered shrubs in many stands, most frequently *Pimelea linifolia*, *Banksia integrifolia* and *Westringia fruticosa*. These and other woody species often have dwarf growth forms. Although a number of woody species are listed as part of the community, these are usually sparsely distributed and may be absent from some stands. Tussocks of *Poa poiformis* may be found in some stands of the community. A number of threatened species occur in some stands of the community, including *Diuris byronensis* (Synonym: *Diuris* sp. aff. *Chrysantha*), *Pultenaea maritima*, *Rutidosus heterogama*, *Thesium australe* (Cohn 2004) and *Zieria prostrata* (Hogbin 2001). The endangered population of the low growing form of *Zieria smithii* at Diggers Head is also found in this community. The community is the major habitat for a number of other species, including *Chamaecrista maritima*, *Plectranthus cremnus* and *Stackhousia spathulata* examined here. Invasion of bitou bush and other weeds is acknowledged as a major threat to the persistence of Themeda grasslands (NSW SC 2005).

#### 6. Coastal sand wallum heath

Coastal sand wallum heaths are a heath assemblage dominated by a shrub layer of wallum banksia (*Banksia aemula*), *Leptospermum trinervium*, *Isopogon anemonifolius*, and *Ricinocarpus pinifolius* to a height of 2 m. Wallum sand heaths are scattered along the NSW coast north from Sydney with some areas being exposed to intense disturbance from tourism and recreation. This disturbance can lead to erosion and dune destabilisation. Sand mining has destroyed some areas with many of these areas being invaded by bitou bush (Keith 2004). Coastal sand wallum heath is a known habitat for several threatened species including the grey-headed flying fox, black flying fox, eastern blossom bat and squirrel glider; all of which are identified in Chapter 5 as potentially at risk from bitou bush invasion.

#### 7. Frontal dune vegetation complex

The frontal dune vegetation complex ecological community occurs as a low to mid-high tussock grassland of variable crown cover, dominated by *Spinifex sericeus*, that occurs on the exposed

fore-dunes and to a lesser extent on exposed parts of dunes a short distance inland, but still within the coastal dune zone. Dominant species in this ecological community include: *S. sericeus*, *Carex pumila*, and *Vigna marina*, along with occasional species like coast wattle (*Acacia sophorae*), coast banksia (*Banksia integrifolia* var. *integrifolia*) and a number of non-endemics (Tweed Shire Council 2004). This ecological community is closely associated with other frontal dune vegetation communities, like coastal Acacia communities and coastal banksia woodland. In some instances this ecological community may include an intergrade with littoral rainforest (Tweed Shire Council 2004).

#### **8. Coastal sand dune complex (*Acacia longifolia* var. *sophorae*)**

The coastal sand dune complex ecological community forms on sand substrates and is dominated by species such as coastal wattle (*Acacia longifolia* var. *sophorae*) which in some situations have been actively planted as part of a dune stabilisation program. Other species present include blackwood wattle (*Acacia melanoxylon*), hickory wattle (*A. aulacocarpa*) and golden wattle (*A. saligna*) (a non-local native species). In northern New South Wales, other species that sometimes occur in this community include umbrella cheese tree (*Glochidion sumatranum*), cheese tree (*G. ferdinandii*), brown kurrajong (*Commersonia bartramia*), macaranga (*Macaranga tanarius*), coast banksia (*Banksia integrifolia* var. *integrifolia*), broad-leaved paperbark (*Melaleuca quinquenervia*), swamp mahogany (*Eucalyptus robusta*), pink bloodwood (*Corymbia intermedia*), and coast teatree (*Leptospermum laevigatum*). Bitou bush and other weeds like camphor laurel (*Cinnamomum camphora*) pose a threat (Brewer and Whelan 2003; Tweed Shire Council 2004).

#### **4.2.8 Revising the priority lists of species, populations and ecological communities**

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While an extensive investigation of the biodiversity that was potentially at risk from bitou bush invasion in New South Wales was undertaken here, there may be other species, populations and ecological communities which are threatened by bitou bush which were not considered. Thus this prioritisation process is not static, especially given that there were species and ecological communities identified, but not modelled (see Appendices 3 (Table A3.2) and 5 (Table A5.3)). These models can be re-run at any time. Given the objectives of the TAP however, any such changes are unlikely to influence the implementation of the TAP actions, as the TAP aims to maintain commitment to priority sites for its five year duration. After this a full review will be undertaken, at which stage new priorities may be established.

## 5 The impact of bitou bush and boneseed invasions on fauna

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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 (Hofer *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, as 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 and 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 a result of these infestations. For example, the removal of blackberries in Belair National Park, South Australia may lead to a decline in the threatened southern brown bandicoot, as blackberries provide protection from predators (see Regel *et al.* 1996). Blackberry removal programs therefore need to consider the introduction of replacement measures to protect these threatened 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). Information on the effect on fauna of controlling weeds also needs to be collected and incorporated into such strategies.

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

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Information on the impact of bitou bush invasion (and its control programs) on vertebrates (native or introduced) is limited. Dodkin and Gilmore (1984) highlighted the need to collect information on the impacts of bitou bush on fauna, however, only a handful of studies have been published since. 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 from bitou bush, namely the eastern bristlebird (*Dasyornis brachypterus*), little tern (*Sterna albifrons*) and beach stone-curlew (*Esacus neglectus*).

Anecdotal and observational evidence suggests that bitou bush invasion can result in the decline of some native bird populations, for example those that nest or roost in hind-dunes such as little terns (*S. 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 2002a). The contribution of bitou bush and lantana to this decline, while suspected, is unknown. 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 some bitou bush infested areas than some areas of native vegetation (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.* 2005). Bitou bush may only be a minor food resource for birds, as fruits are only present for a short period of the year, however during fruiting, this temporary food source may be exploited by generalist feeders, rather than specialists as highlighted by the list of species reported to consume bitou bush fruits (Dodkin and Gilmore 1984 and Table 5.1).

Not all bird species that consume bitou bush fruits are effective dispersers (e.g. crimson rosella (*Platycercus elegans*)), 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 (*Vulpes vulpes*) 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 5.1).

French and Zubovic (1997) recommend further study to elucidate the responses of individual bird species to bitou bush invasions. Of particular concern is the role of coastal habitats in providing sources of nectar for fauna over winter, a period of regional shortage, following bitou bush invasion and competition (Dodkin and Gilmore 1984; Law *et al.* 2000; Gosper 2004b). Similar studies for mammals are also needed, especially given that the only mammal species for which there is information are introduced ones, and nectar/pollen feeding bats (see Table 5.1).

Subsequent to the release of the draft TAP (see DEC 2004), information has been compiled on fauna species which may be at risk from bitou bush invasion (Table 5.2). Unfortunately, most of this information was not available prior to completion of this plan and thus no assessments have been made of the exact nature of the threat or how the impacts due to bitou bush invasion might be reduced or sites where control will be beneficial. In addition, it appears that the WINS assessment tool (see Downey in press) may also be useful in determining fauna at risk, based on

trials for lantana. Again this was discovered too late to be of use in the development of this TAP. It is anticipated that during the five years of this plan that such information be formulated and that priority sites for fauna be established. However, given that some of the sites or plant species identified in Table 5.2 are also listed in Appendix 7 it is hoped that control at these sites will also have positive benefits for such species.

**Table 5.1** Birds and mammals that have been reported to feed on bitou bush/boneseed (alphabetical order).

birds		mammals	
common name	reference	common name	reference
Australia raven	2	cattle*	1
common blackbird*	1	rabbit*	1
black-faced cuckoo-shrike	2	European red fox*	1, 3
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		
pied currawong	1, 2		
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		

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

\* = Introduced species

## 5.2 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.*).

**Table 5.2** Fauna suspected of being threatened by bitou bush invasion in New South Wales (alphabetical order). The exact nature of the threat has not been determined and thus caution should be shown when inferring any threatened status.

fauna	common name	threatened status <sup>a</sup>		suspected reason for threat	suggested sites for possible control
		TSC Act	EPBC Act		
birds	beach-stone curlew	E		listed in NSW SC (1999a)	
	black-winged petrel	V		bitou bush grows in nesting sites	
	coastal emu	Population			
	eastern bristlebird	E	E	listed in NSW SC (1999a)	
	flesh footed shearwater	V		bitou bush grows in nesting sites	
	gould's petrel	E		bitou bush grows in nesting sites (Gosper 2004b)	Cabbage Tree and Boondelbah Islands, as well as adjacent sites on the mainland near Hawk's Nest.
	little shearwater	V		bitou bush grows in nesting sites	
	litte tern	E		bitou bush grows over or close to nesting sites, and listed in NSW SC (1999a)	Quibray Bay in Towra Point NR
	masked booby	V		bitou bush grows in nesting sites	
	pie oystercatcher	V		bitou bush grows close to preferred habitat and nesting sites	Five Islands NR
	red-capped plover			bitou bush grows close to preferred nesting sites	
	red-tailed tropic bird	V		bitou bush grows in nesting sites	
	regent honeyeater	E	E	bitou bush competes with food sources (Gosper 2004b)	swamp mahogany ( <i>Eucalyptus robusta</i> ) – in the central coast region
	sooty tern	V		bitou bush grows in nesting sites	
	swift parrot	E	E	bitou bush competes with food sources (Gosper 2004b)	swamp mahogany ( <i>Eucalyptus robusta</i> ) – i.e. Perkins Beach Reserve, Port Kembla
threatened shorebirds			encroaching on nest/roost sites (Bower <i>pers. comm.</i> )	Belongil Spit	
mammals	black flying fox	V		loss of coastal banksia woodland may impact on food source	
	common blossom bat	V		loss of coastal banksia woodland may impact on food source	
	eastern bentwing bat	V		loss of coastal banksia woodland may impact on food source	
	eastern long-eared bat	V		loss of coastal banksia woodland may impact on food source	
	greater broad-nosed bat	V		loss of coastal banksia woodland may impact on food source	
	grey-headed flying fox	V	V	loss of coastal banksia woodland may impact on food source	
	koala (Hawks Nest & Tea Gardens)	Population			Hawks Nest & Tea Gardens
	little bentwing bat	V		loss of coastal banksia woodland may impact on food source	
squirrel glider	V		loss of coastal banksia woodland may impact on food source		
yellow-bellied sheathtail-bat	V		loss of coastal banksia woodland may impact on food source		
invertebrates	Lord Howe Island placostylus	E			

<sup>a</sup> E = Endangered, V = Vulnerable, Population = Endangered Population, as defined under TSC Act = NSW *Threatened Species Conservation Act 1995*, EPBC ACT = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

## 6 Determining priority sites for bitou bush control

The widespread distribution of bitou bush (80% of the coastline), and to a lesser extent boneseed, in New South Wales makes it impossible and impractical to control all infestations across their entire range. Therefore, control programs should be targeted. When addressing biodiversity conservation, control efforts must result in the greatest benefit to biodiversity.

As outlined in Chapter 4 and Appendices 2–5, the biodiversity most at risk from bitou bush invasion has been determined and ranked in terms of the threat posed to native plant communities. This process identified 158 plant species, three plant populations and 26 ecological communities at risk from bitou bush invasion (see Table 6.1). Thus, these entities should be used as a basis for ensuring that control programs focus on biodiversity conservation.

**Table 6.1** The biodiversity at risk from bitou bush invasion and their priority as determined in the models (see Appendices 3 and 5).

biodiversity at risk <sup>a</sup>	priority			Total
	High	Medium	Low	
plant species	19	41	98	158
plant population <sup>b</sup>	2	0	1	3
ecological communities	8	8	10	26
<b>total entities</b>	<b>29</b>	<b>49</b>	<b>109</b>	<b>187</b>

<sup>a</sup> Including biodiversity listed as threatened (i.e. under the NSW *Threatened Species Conservation Act 1995*: TSC Act) and those not formally listed as threatened.

<sup>b</sup> Plant populations as defined under the TSC Act.

### 6.1 Selecting and prioritising sites

Specific locations for all priority species, populations or ecological communities (i.e. high, medium and low priority, hereafter collectively referred to as ‘entities’) within New South Wales were determined initially with the aid of distribution information supplied by a wide range of people (including staff from the 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 1990–2002; local site surveys and inspections). Locations were selected irrespective of land tenure. It is acknowledged that this list is not definitive, as some locations may have been inadvertently overlooked, the distribution data for some species is incomplete, and additional locations may be discovered in the future (as outlined in Section 4.2.8 this process can be re-run to establish additional priorities).

Once locations were identified for each entity they were given a unique name and number. Entity locations were grouped into multi-species sites when they occurred within close proximity to each other to prevent excessive numbers of sites, and to combine locations that would be best managed collectively (see Appendix 6 for further details).

For each location, the density of bitou bush present was recorded (high, medium and low, as used by Thomas 2002). Locations without bitou bush were excluded from the final list of priority sites

(Appendix 7). This information was combined with an assessment of current control being undertaken at each location 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. Last, a measure of the status of the entities at each location, along with the importance of the location to the entities' overall status, was determined.

These assessments were given numerical values and modelled to produce a score for each entity location (see Appendix 6). The assessment score for each entity location was then combined with the entity's priority (see Appendices 3 and 5) to give an *entity matrix score* (e.g. high priority species at a high priority location).

Sites were divided into one of five control categories according to the site's highest *entity matrix score*. The sites within each control category were then ranked by calculating a *site matrix value*. The *site matrix value* was simply the sum of the *entity matrix scores* for all entities at a site. Sites with higher *site matrix values* were ranked highest, thus favouring sites with high priority entities, which also had a large number of other entities present (an explanation of the site ranking process is given in full detail in Appendix 6). The complete list of sites and their ranks, split into the five categories is presented in Appendix 7.

### 6.1.1 Control categories

The site assessment process (see Appendix 6) identified 349 sites for the 151 entities for which locations were identified (no site locations were identified for 34 species and 2 ecological communities, see Table A7.7, Appendix 7). The 349 sites were separated into the five control categories as per Table 6.2, in which control category 1 represents the highest priorities for action.

**Table 6.2** The number of sites in each of the five control categories (see Appendices 6 and 7 for further information).

	control categories					total
	1	2	3	4	5	
number of sites	169	71	67	37	5	349

Complete lists of sites in each control category are presented in Appendix 7 (Tables A7.1–A7.5).

## 6.2 Bitou bush control

### 6.2.1 Control category 1 sites (high priority)

By undertaking control of bitou bush at the 169 control category 1 sites, significant biodiversity conservation will be achieved. In addition, control of bitou bush at these sites is expected to have biodiversity benefits beyond reducing, abating or ameliorating the threat to the high priority entities identified here, in terms of medium and low priority entities as well as those not identified in this plan. A list of the control category 1 sites is presented in Table A7.1 in Appendix 7. The control category 1 sites that will conserve each of the 29 high priority entities (19 plant species, 2 populations and 8 ecological communities) are listed in Appendix 8 (Tables A8.1, A8.2 and A8.3, respectively). These lists also contain information on the number of other entities present, and the

land tenure at each site. A summary of the site information for each of these 29 entities is presented in Table 6.3, comparing the number of control category 1 sites with the total number of sites examined here.

**Table 6.3** A site summary for each of the high priority plant species, populations and ecological communities identified in Appendices 3 and 5.

high priority entities	rank	number of control category 1 sites examined	total number of sites examined
<b>species</b>			
<i>Plectranthus cremulus</i>	1	13	17
<i>Zieria prostrata</i>	2	3	5
<i>Chamaesyce psammogeton</i>	3	21	26
<i>Senecio spathulatus</i>	4	7	9
<i>Acianthus exiguus</i>	4	4	4
<i>Calystegia soldanella</i>	4	1	4
<i>Chamaecrista maritima</i>	4	2	2
<i>Sophora tomentosa</i>	4	10	14
<i>Lepturus repens</i>	4	1	1
<i>Pultenaea maritima</i>	4	12	13
<i>Stachhouisia spathulata</i>	4	24	24
<i>Ischaemum triticeum</i>	4	10	11
<i>Vigna marina</i>	4	9	10
<i>Gleichenia mendellii</i>	14	8	9
<i>Actites megalocarpa</i>	14	3	3
<i>Poa poiformis</i>	14	2	3
<i>Fontainea oraria</i>	17	2	2
<i>Diuris praecox</i>	17	6	7
<i>Westringia fruticosa</i>	19	15	17
<b>populations</b>			
<i>Glycine clandestina</i> (broad leaf form)	1	3	3
<i>Zieria smithii</i> (low growing form)	1	8	10
<b>ecological communities</b>			
Eastern Suburbs Banksia Scrub	1	5	13
Littoral Rainforest (including SEPP 26 & Sutherland Shire Littoral Rainforest)	1	84	128
Kurnell Dune Forest	1	3	4
Coastal Banksia Woodlands ( <i>Banksia integrifolia</i> )	4	18	23
Themeda ( <i>Themeda triandra</i> ) grassland on sea cliffs & coastal headlands in the NSW North Coast, Sydney Basin & South East Corner bioregions	4	29	40
Eastern Suburbs Banksia Scrub equivalent communities (i.e. Coastal Sand Wallum Heath)	4	2	2
Frontal Dune Vegetation Complex	4	21	25
Coastal Sand Dune complex ( <i>Acacia longifolia</i> var. <i>sophorae</i> )	4	23	30

## 6.2.2 Control category 2–5 sites

In this plan control is not initially directed at sites in control categories 2–5. Through the identification of these lower priority entities and sites however, it is anticipated that individual landholders/managers will undertake control at category 2–5 sites that are significant at a regional or local level. Any control programs at such sites will have broader biodiversity benefits for a wide range of species, populations and ecological communities.

### 6.2.3 Control at locations not addressed in this plan

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Control of bitou bush currently occurs at many locations for a number of different reasons:

- ▶ biodiversity conservation (including many of the sites identified in Appendix 7)
- ▶ neighbour relations (including community relations)
- ▶ asset management (e.g. cultural heritage values)
- ▶ infrastructure management (e.g. control at picnic areas, walking tracks, camping grounds and roads)
- ▶ fostering research aimed at improved management
- ▶ delivering broader strategic outcomes [e.g. actions in other strategies such as the National Bitou Bush and Boneseed Strategy (ARMCANZ et al. 2000), the state strategy (NPWS 2001a) and regional strategies (e.g. Scanlon 2001)].

While this plan specifically targets the control of bitou bush for biodiversity conservation, there are other reasons for undertaking bitou bush control, as outlined above. Thus, it is important that control for these other reasons continues at locations not addressed in this plan, as it delivers broader outcomes as well as reducing the bitou bush problem.

## 7 Control of bitou bush and boneseed

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### 7.1 Control techniques

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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 removal (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 and Appendix 9). **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 re-sprout 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 removal** is used to remove small to medium sized plants, particularly in lightly infested areas or for isolated plants. Hand removal can be very effective following previous control programs. The cost of hand removal varies depending on access, topography, vegetation, and the infestation level. Average costs exceed \$600/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 add 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 typically 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 (see aerial spraying section below for more detailed information). Herbicides can be applied as a foliar spray or by painting the herbicide onto cut stumps. Average costs are \$300-500/ha for spot-spraying using a vehicle mounted spray-rig, and \$800+/ha for painting cut stumps, depending on site conditions (as documented above for hand removal).

The NSW aerial spraying program for bitou bush was developed following trials undertaken by NSW Agriculture (now DPI) in the late 1980s and early 1990s. Initial trials focused on ground

spraying to determine which herbicides were most effective in controlling bitou bush. Following this further trials were undertaken to determine the impact of over-spray on native species and thereby ascertain appropriate application rates. The results showed that spraying in winter reduced the impact on natives while delivering effective control of bitou bush. In addition, the rate of herbicide required to kill bitou bush during winter was very low (using glyphosate). Trials were subsequently undertaken using aerial techniques at four sites along the NSW coast from Jervis Bay to Yamba. The results supported the ground spraying trials, suggesting that effective control of bitou bush could be achieved using aerial spraying in winter, while limiting off-target damage. Recently best practice guidelines were developed for the aerial boom spraying of bitou bush in New South Wales (see Broese van Groenou and Downey 2006). All aerial spraying programs to control bitou bush in New South Wales should follow these guidelines. 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 technique is very cost-effective (\$100–205/ha) and allows large areas to be treated rapidly.

The NPWS (now the Parks and Wildlife Division of the 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.

The NSW *Pesticides Act 1999* encompasses a range of regulations which users must comply with (see Section 2.2.3 and the Act for further information).

**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 \$15,000/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 (see Downey *et al.* submitted). Host specificity testing in South Africa revealed 19 possible agents for the control of *Chrysanthemoides monilifera* (bitou bush and boneseed) in Australia (see Adair and Edwards 1996). Over the past 19 years extensive work has been undertaken to assess and release as many agents from this list as possible. The biological control program for bitou bush in New South Wales has all but exhausted this list; resulting in the release of six biological control agents, four of which have established in the wild: the bitou tip moth (*Comostolopsis germana* Prout), bitou tortoise beetle (*Cassida* sp.), bitou seed fly (*Mesoclanis polana* Munro) and bitou leaf roller moth (*Tortrix* sp.). 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 at 45 sites along the NSW coast, however it has only established at six sites, all of which are on headlands. Research shows that the bitou leaf roller suffers from predation in dune environments (see Downey *et al.* submitted). Future releases will be targeted to headlands to aid establishment. 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. Without further host-specificity testing in South Africa, it is unlikely that any additional agents will be released to control bitou bush in Australia. For boneseed, however, there

are several potential agents, three of which are currently being tested/examined (see Downey *et al.* submitted).

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) will not alter the longevity of an individual plant, but rather will reduce the seed bank, leading to a reduction in recruitment and plant density over subsequent generations.

**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 (Sindell 2000). This is because the use of a single technique is rarely successful in the long term (Groves 1989; Holtkamp *et al.* 1999) 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).

## 7.2 Issues associated with bitou bush and boneseed control

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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 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*), ground asparagus (*Asparagus aethiopicus*), 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 \$600–20,000/ha.

**Concerns over the use of herbicides** have been raised with respect to their potential impacts on non-target species. Best practice guidelines for aerial boom spraying have been developed to help limit some of these concerns (see Broese van Groenou and Downey 2006). Even so, recent studies and reviews have revealed that some native plant and animal species are susceptible to herbicide application as used to control bitou bush (e.g. *Pimelea spicata*). Species that are susceptible to or potentially susceptible to herbicides are presented in Appendices 10A and 10B as well as in the best practice aerial spraying guidelines. These species, along with any others identified in the future should be considered when undertaking herbicide control of bitou bush or boneseed. The lists in Appendix 10B contain information on the susceptibility of 280 species to Round-up® 360 and 85 species for metsulfuron methyl. **However, different formulations of glyphosate or the use of surfactants or other additives could alter the response of the species on these lists.** In addition, herbicides should be used with extreme caution in areas where priority plant species,

populations and ecological communities occur. The effects of herbicide are not known for many of the priority species (including those in priority ecological communities) and they should therefore be considered 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% exhibiting mortality or severe damage (Toth 2002). No threatened species were examined in Toth's 2002 study. The study also only looked at impacts on adult plants, not seedlings. 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 at 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.*). Studies have recently begun on the impact of metsulfuron methyl, which is also used in aerial spraying (Toth *pers. comm.*; Appendix 10B). 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.*).

Some formulations of glyphosate contain a polyoxethylene amine (POEA) surfactant that 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 relevant 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. A list of the aquatic organisms most likely to be impacted is presented in Appendix 10A, Table 10.2, and should be considered in all control programs.

A recent examination of leaf litter invertebrates showed no significant effect of herbicides on these invertebrates (see Lindsay and French 2004b).

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.

A recent study of weed impacts on threatened species revealed that bush regeneration and incorrect identification of natives as weeds posed a significant threat to native species (Couts-Smith and Downey 2006). 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 [the final checklist was not available at the time of writing].

### 7.3 Follow-up treatments

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Lack of appropriate follow-up treatments will result in re-invasion by bitou bush (Stanley *et al.* 1989; Vranjic 2000). The extent and duration of any follow-up treatment will depend on many factors including:

- ▶ the original seed bank size
- ▶ the length of seed dormancy period (>5 years)
- ▶ the distance to other bitou bush infestations (i.e. re-invasion source)

- ▶ the control technique(s) employed (e.g. fire can deplete soils seed banks)
- ▶ the extent and condition of the invaded native plant communities that are present.

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 re-sprouting 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 removal or spot-spraying of seedlings. However, biological control agents can be employed to help limit establishment, particularly in the longer term where they can reduce spread and lower plant vigour.

#### 7.4 A staged approach to bitou bush control

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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 species, population or ecological community at risk. 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 below).
- ▶ 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 a site-specific management plan (see below)
- ▶ 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).

#### **7.4.1 Littoral rainforest - an example of a staged approach**

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Bitou bush poses a serious threat to littoral rainforest. It threatens littoral rainforests in two main ways. First, 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. Second, 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. 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.*).

The staged approach is necessary in the control of bitou bush invasion of margins to ensure that it does not result in exposure of the littoral rainforest following the removal of bitou bush from where it replaces the forest's protective vegetation. Thus stage 1 would involve a staggered removal of bitou bush from the forest edge, especially on the seaward side of littoral rainforests, to maintain the forest's protective buffer from wind and salt spray. For the control of bitou bush in canopy gaps, stage 1 would involve the systematic removal of all plants from within the canopy, especially in forest gaps, while stage 2 would involve the removal of bitou bush from the forest margins, and stage 3 removal from the surrounding habitat.

### **7.5 Site-specific management**

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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. Previously there has been no framework for developing such strategies, but rather information was presented on a series of bitou bush densities and invaded habitats along with a range of control options (see Vranjic 2000).

The use of site-specific management strategies should not result in broader management objectives being compromised. To avoid this occurring and still ensure effective site management, a framework has been developed for compiling site-specific management strategies/plans (see below) as well as a proforma for preparing a site-specific management plan (see Appendix 9).

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

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While the development of site-specific management plans is dependent on local factors and conditions, each plan [for the purposes of this TAP] must be based on a core set of attributes. These form a framework for the development of site-specific management plans for the control of

bitou bush at priority sites (i.e. control category 1 sites). Each site-specific management plan should:

- ▶ 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 (i.e. traditional foods) 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 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
- ▶ identify the milestones, performance criteria and measures to be achieved during the life of the plan (including the staged approach to management; see above)
- ▶ outline a follow-up control program to prevent re-invasion/re-infestation of the site after the initial control (in line with the staged approach)
- ▶ 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
- ▶ identify and incorporate all threat abatement and recovery plan actions relevant to the site (e.g. the Green and Gold Bell Frog Recovery Plan: see NPWS 2003b)
- ▶ identify and incorporate all relevant actions outlined in the draft Priority Action Statement (PAS – DEC 2006b)
- ▶ outline the long-term management of the site (i.e. site history).

For the purposes of achieving the outcomes of this plan a proforma has been prepared to help land managers prepare site-specific management plans (see Appendix 9). At all control category 1 sites, a site-specific management plan should be prepared using this proforma and the framework listed above.

## 7.6 Infestation levels and control options

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As bitou bush infestations increase in density and area, control programs need to follow a strategic staged approach to help reduce re-invasion of treated areas. Below are some generic options for consideration.

### *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 directed application of herbicides and/or hand removal (including cut/stump techniques), as these techniques minimise non-target impacts. Control at the light infestation level prevents a worsening scenario. Sites need to be monitored regularly to control and prevent re-invasion by bitou bush.

### ***Medium infestations***

Medium density 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 minimise non-target impacts. Such sites need to be actively managed to control recruitment.

### ***Heavy infestations***

Heavily infested areas are dominated by bitou bush, the extreme scenario being a 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. Fire may be considered however, 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 grassy 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 treated areas depends 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. 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.

## 7.7 Areas presently free of bitou bush and boneseed in NSW

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

### 7.7.1 Areas at risk of invasion by bitou bush and boneseed

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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 (e.g. forest communities) is rudimentary however. Anecdotal evidence suggests 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.

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

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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. In addition, there is a national strategy (ARMCANZ *et al.* 2000) and state strategy (NPWS 2001a) to prioritise bitou bush management. There is however a need for an overall strategy for bitou bush control for threatened species, 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, submitted 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 (Downey submitted).
- ▶ 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, submitted). Thus, the ‘no change in current management’ control option would be a retrograde step which will not benefit biodiversity conservation.

The cost of ‘doing nothing’ in terms of controlling bitou bush for biodiversity conservation can be assessed using the estimated cost of losing a species due to weed invasion, being \$86,700 per species per year (see Sinden *et al.* 2004) and the number of species identified here as being at risk (158). Thus, the cost of ‘doing nothing’ equates to \$13.7 million per year.

Lastly, given the scale of the problem the cost of doing nothing at sites where species are threatened far outweighs the economic benefits of controlling new or isolated infestations. Arguments have also been made that control for biodiversity should also address potential or future impacts. Again, given the scale of the problem, the limited nature of resources, and the aims of a threat abatement plan, the **current impacts to biodiversity are so great and immediate** that they outweigh any potential or future impacts to un-infested areas. Such control programs are thus outside the scope of this plan and should be addressed in other plans (i.e. regional strategies).

## 7.9 Roles and responsibilities with respect to bitou bush control

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The declaration of bitou bush as a noxious weed under the Noxious Weeds Act requires land managers to control bitou bush (a list of all the local control authorities in New South Wales, in which bitou bush or boneseed is declared noxious, is presented in Appendix 1). In addition, the control of bitou bush and boneseed in areas containing threatened species may require a licence (see Chapter 2 for further details).

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

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The role of the Bitou TAP is to prioritise the control of bitou bush in New South Wales for species, populations and ecological communities at risk and their locations where control will have the greatest biodiversity outcomes (see Chapters 4 and 6 and Appendices 3, 5 and 8). While the TAP aims to address the highest priorities, lower priorities (both threatened biodiversity and sites) should be used to establish regional and local priorities for bitou bush control. 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 here is outside the scope of this TAP, except for the species that co-occur at control category 1 sites. Control of bitou bush at lower priority sites (i.e. Category 2, 3, 4 and 5 sites) 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.

## 8 Monitoring the recovery of priority biodiversity and the control of bitou bush

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### 8.1 Developing a monitoring system for control category 1 sites

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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 in bitou bush attributed to the control program. In addition, given that this plan is focused on biodiversity at risk, monitoring must be tailored to those entities identified as being at risk. Many variables can be measured and a number of monitoring techniques can be used. The following measures must be addressed at control category 1 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 **high priority plant species, populations and ecological communities** to the control program, measured by a similar range of measures as described for bitou bush above
- ▶ 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 (e.g. plant vigour).

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 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 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
- ▶ experimental non-treatment and control sites
- ▶ commitment to maintaining the integrity of the sampling design and regime over the course of the monitoring program.

A more detailed discussion on monitoring bitou bush, the biodiversity at risk and other weeds is presented below, followed by a proposed monitoring system for this plan.

### 8.1.1 Measuring the effect of control programs on bitou bush infestations

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The effectiveness of bitou bush control programs can be measured directly from the response of bitou bush. For example, through plant survival and recruitment following control. While the exact techniques for collecting such information have not been finalised with regards to the monitoring of this plan, each measure is discussed with examples below.

#### *Measuring survival*

Most control methods do not result in 100% mortality, so it is important to monitor the number of plants that survive control treatments, both as an indicator of the success of a control program, and as an indicator for determining the interval for follow-up control.

Plants that survive control treatments can produce seed in a shorter timeframe than plants that germinate following the same control treatment. Hence, plants that survive initial treatments will require earlier follow-up treatment if the input of fresh seed is to be limited. In order to control weed seed banks, a measure of bitou bush plants that survive control treatments (e.g. missed totally, treated but re-sprouting, or unaffected) needs to be determined for each method used. This can be measured using quadrat counts or photopoints.

#### *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 (as examined for a range of weed species, see 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.

Recruitment can be measured in a number of different ways depending on the aim of the monitoring program, including seedling counts, soil seed bank counts, and seedling growth rates. Thus, monitoring for this component of the plan will be determined in consultation with stakeholders in the immediate future.

### **8.1.2 Measuring the response of high priority species, populations and ecological communities to bitou bush control**

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The effectiveness of bitou bush control programs can also be monitored by measuring the response of biodiversity (i.e. species, populations and ecological communities) to the control technique used. Unfortunately, many weed control programs do not monitor native species. Monitoring the response of native species is not that different from monitoring the response of the weed species. The main issue is choosing the native species to monitor and finding a suitable monitoring technique for those selected. With respect to this plan, the native species or biodiversity has been identified in Appendices 3 and 5. The ecology literature and textbooks cover monitoring in detail, so the specifics are not presented here. Note that factors which confound the response of biodiversity to bitou bush control can include 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.

Hence, monitoring for this component of the plan will be determined in the immediate future, based on the priority species present at each site, and in consultation with stakeholders.

### **8.1.3 Measuring the response of other weed species to bitou bush control**

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The control of one weed species, in this case bitou bush, can lead to the invasion of a site by another weed species. Sometimes this secondary invader can be more difficult to control than the original weed species, for example, glory lily following bitou bush control along the north coast of New South Wales. Hence, it is important to monitor the response of any such weed species during and after the control of bitou bush. This can be done using similar monitoring techniques to those outlined for bitou bush in Section 8.1.1.

### **8.1.4 Proposed monitoring system**

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It is not possible to monitor every species, population and ecological community at every site identified in this plan. Thus, a monitoring system is needed. While the mechanics of which methods to use for which biodiversity at which sites is still to be developed, an overview of the approach is presented here, using a two-tier monitoring program to measure responses. The two-tier monitoring program should be used to monitor robust (tier two) and less robust (tier one) species, populations and ecological communities. 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.

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, priority species, populations and ecological communities and other weed species continued over time.

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, priority 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.

Detailed monitoring protocols which outline the exact methods, biodiversity examined and sites will be developed in consultation with site-managers in the first year of this plan. These protocols are also likely to outline the monitoring required for other sites so that land managers can assess the effectiveness of their control programs. Again, this will occur in consultation with land managers.

## 8.2 Monitoring other variables of importance to the TAP

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There are a range of objectives and actions outlined in Chapter 9 in addition to the control of bitou bush at control category 1 sites, that are aimed at increasing our understanding of the impacts of bitou bush to biodiversity, and therefore developing more effective management strategies to reduce such impacts. A summary of the monitoring programs required for such actions is outlined below.

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

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Herbicides have been used successfully to control bitou bush in Australia for many years. However, as discussed in Section 7.2, there are concerns over the use of herbicides and in some instances this requires further investigation. For example, the herbicide application used for bitou bush control adversely affected *P. spicata* plants (see Matarczyk 1999; Matarczyk *et al.* 2002). Apart from *P. spicata* the effect of herbicide application on the priority species identified in this plan is limited. The following discussion refers primarily to assessment of the impact of herbicides used to control bitou bush on the priority plant species, populations and the species within those ecological communities listed in this TAP. The impacts on all non-target species should also be determined during any such assessment.

The best practice guidelines for the aerial boom spraying of bitou bush in New South Wales (see Broese van Groenou and Downey 2006) presents information on the impacts of herbicides to native species, based on visual assessments (both for species that are impacted and those that show tolerance). These lists are reproduced in Appendix 10B, and contain information on the susceptibility of 280 species to Round-up® 360 and 85 species for metsulfuron methyl. **Note that different formulations of glyphosate or the use of surfactants or other additives could alter the responses of the species on these lists.**

Information on the susceptibility of the priority biodiversity identified in Appendices 3 and 5 as being at risk, needs to be collected/collated. Thus, any monitoring program established as part of

the TAP should include some measure to assess herbicide damage/tolerance. The best practice guidelines suggest that as a starting point, data be collected in the manner used to date (i.e. visual observations at 8 weeks and 6 months after application), with records being forwarded to John Toth for inclusion in the current lists (see Broese van Groenou and Downey 2006).

In addition to monitoring herbicide impacts, this plan outlines the need for more detailed research associated with herbicide impacts (see Action 2.2 in Chapter 9). Potential research projects could focus on the effects of herbicide application for bitou bush control on: i) native seedlings; ii) priority taxa, at both the adult and seedling stages; and iii) other native species. Understanding the impacts on priority biodiversity is extremely important to the outcomes of this TAP. As many have small population sizes and the effect of herbicide is relatively unknown, *in situ* testing is not recommended. Monitoring programs must assess the impacts of herbicide use on both seedlings and adults of each priority species, and also on 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 the case of *P. spicata*.

### 8.2.2 Measuring the response of priority species to non-herbicide control

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A recent report showed that the control of weeds posed a significant threat to native species (Coutts-Smith and Downey 2006). For example, bush regeneration was a threat to 15 species and the misidentification of natives as weeds was a threat to eight. Other studies have also shown negative effects of weed control on native species. For example, some native species in South Australia were negatively affected by boneseed control that involved high levels of soil disturbance (Thomas *et al.* 2000). Thus, the effects of *any* control technique on native species should be assessed in order to reduce any adverse effects of that technique on biodiversity. **This is especially so for those species outlined here as being at risk when implementing control of bitou bush at priority sites.**

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

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Bitou bush has significantly increased its distribution within New South Wales in the last 20 years (see Thomas and Leys 2002). Such information can only be obtained from repeated surveys over a sufficient period to show change. Given the dramatic increase (i.e. 36%) observed between the last two surveys (i.e. Love 1984 and Thomas 2002), an interval of around 20 years appears to be too large to alter management strategies to compensate for any such changes in distribution. Based on previous results, it is important that on-going monitoring of bitou bush spread be undertaken at shorter intervals. This will provide a better understanding of the rates of spread, 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; Thomas 2002) 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 and those proposed in the TAP.

### 8.2.4 Specific monitoring and research to help reduce impacts

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A range of monitoring programs and research initiatives needs to be carried out in order to better understand the impacts of bitou bush and boneseed invasions. The monitoring and research programs outlined below would be of great benefit to the broader control of bitou bush and

boneseed, and if information is available, will help with the review of this plan at the end of five years.

Monitoring should be undertaken regularly (e.g. 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.

Understanding the ways in which bitou bush and boneseed threaten biodiversity is of great importance, as most of the species identified as being at risk from bitou bush invasion in this TAP were selected using anecdotal evidence (i.e. derived through the WINS assessment process) and not quantitative studies. Such studies are desperately needed, along with studies concerning the broader ecology of bitou bush and boneseed such as seed dormancy, germination rates, seedling survivorship and establishment rates. In addition, long-term studies are needed to determine the likely success of the biocontrol program.

#### **8.2.5 Monitoring fauna impacts**

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While the impacts of bitou bush invasion on fauna have not been defined here in the same manner as those for flora, in part due to a lack of information (see Chapter 5), monitoring the impacts of both invasion and control on fauna should be considered during any monitoring program associated with any bitou bush control program. Such monitoring could be focused on generic groups of fauna (i.e. birds) or more specifically on individual groups (e.g. shorebirds), depending on the resources available (time and dollars), skill/knowledge level of the observer and level of understanding required. As outlined in Section 8.1.4, more detailed information on monitoring techniques will be developed within the first year of the TAP, this will include investigations into monitoring requirements for determining the impacts on fauna. Monitoring of fauna will also help to meet Actions 6.1 and 7.1 and the shortcomings outlined in Chapter 5.

## 9 A strategy to minimise the impact of *Chrysanthemoides monilifera* on priority biodiversity in New South Wales

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### 9.1 Background

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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). Recently, national, statewide and regional management 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 in accordance with the TSC Act.

Bitou bush control programs have been undertaken across coastal New South Wales for several decades. While some local infestations have been successfully controlled and the containment lines are being moved, control programs have not prevented the spread of bitou bush, in part due to the scale of the problem and until recently, the absence of a statewide approach to combat it.

Currently, resources are insufficient 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 focuses on identifying those species, populations or ecological communities that are at the greatest risk from bitou bush invasion. The identification of such biodiversity is then used to establish priority sites for control programs. It is important to remember that control is still needed for reasons other than biodiversity conservation (e.g. around access roads, for public use of beaches and the prevention of new infestations).

The distribution of boneseed in New South Wales is such that it currently poses limited threats to biodiversity and most of the remainder of this chapter deals with bitou bush only, unless boneseed is specifically mentioned.

### 9.2 Aims and objectives of the Bitou TAP

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The main objective of this plan is to prioritise bitou bush control to areas where the outcomes of such controls are most beneficial to native biodiversity, particularly but not exclusively, 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, carrying out bitou bush control in lightly infested areas, where further spread and/or an increase in density is prevented, is currently cost-effective and should continue.

In addition, it must be noted that this is a threat abatement plan (TAP) 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/entity. Therefore intensive recovery efforts are not outlined in this plan other than control. Such recovery efforts are best addressed by recovery plan actions and/or Priority Action Statement (PAS) actions, and implemented by the individual land manager.

The Bitou TAP has eight objectives, listed in Table 9.1, and the following sections outline strategies to address each of these objectives. A summarised list of actions for each of the eight objectives is also given in Table 9.2 (presented at the end of this Chapter). Links to other TAPs, recovery plans and the PAS will be considered when implementing the actions under this TAP.

The justification for most of these actions has been outlined in the preceding chapters, however, where justification is needed, a short discussion is presented under each of the actions below.

**Table 9.1** Bitou TAP objectives

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

### 9.3 Objective 1: Priority bitou bush control programs

<i>Objective 1</i>	<b>Ensure that bitou bush (and boneseed) control is undertaken in areas where the benefits to species, populations and ecological communities are greatest.</b>
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In developing the actions and setting priorities for this objective, the key assumptions underlying effective control programs for bitou bush (and boneseed) include:

- ▶ no single management strategy is recommended. Thus, site-specific management plans need to be developed and implemented for each priority site (Objective 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 for control: see Section 7.4). Sources for re-infestation should also be identified where possible. The need for follow-up controls is outlined in Chapter 7 (above).
- ▶ 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, and more

recently the draft Priority Action Statement (PAS) as specified under the TSC 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 as well.

- ▶ resources are limited and must be directed to species, populations and ecological communities and sites where the benefits will be greatest.
- ▶ commitment to the priority species, populations and ecological communities and sites outlined in this TAP are to be maintained for its five year duration.
- ▶ best practice management acknowledges that sustainable control is a medium to long-term undertaking.
- ▶ the effect of control measures on target and non-target species needs to be considered at all sites.

### 9.3.1 Action 1.1

*Action 1.1* DEC and the Department of Lands (DoL) will undertake bitou bush control programs at high priority (control category 1) sites on their estate. In addition, the DEC and DoL will seek agreement from councils to ensure bitou bush control programs are undertaken at high priority sites on council administered land. The DoL will liaise and encourage Trust managers of Crown land to undertake bitou bush control programs at high priority sites. DEC will liaise and encourage landholders to undertake bitou bush control programs at high priority sites on private lands. To measure the biodiversity benefits, bitou bush control will not occur in areas designated as experimental ‘no-treatment’ areas (see Objective 2).

As outlined in Chapter 6 and Appendix 6, high priority sites are those identified as control category 1 sites. The list of control category 1 sites and the entities at risk they contain are presented in Table A7.1, Appendix 7. A list of control category 1 sites conserving each high priority entity is also presented in Appendix 8.

Although control is already occurring at some of these high priority sites, the objectives of many of these programs are different from those outlined in this TAP. For example, many programs simply aim to control bitou bush over the entire site rather than focusing on the protection of the biodiversity at threat. Thus, site-specific management plans will be used to help re-align such control programs with the objectives of the TAP (see Action 1.2 below).

While boneseed has not been recorded at the majority of control category 1 sites, it should be controlled if detected, in a similar manner to bitou bush.

#### ***Performance criteria for Action 1.1***

- ▶ Control programs will be established at 75% (127) of the high priority (control category 1) sites within two years of publication date of this TAP.
- ▶ Existing bitou bush control programs at all priority sites (i.e. control category 1, 2, 3, 4 and 5 sites) and in other areas where threatened species, populations and/or ecological communities occur will continue.

### 9.3.2 Actions 1.2 and 1.3

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<i>Action 1.2</i>	At control category 1 sites, DEC and the DoL will help to develop and implement 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.

#### ***Site-specific management plans (Action 1.2)***

Site-specific management plans are required for all control category 1 sites. Each plan will follow the framework established in Chapter 7, and should be completed using the proforma presented in Appendix 9.

#### ***Consultation with indigenous people/communities (Action 1.3)***

Indigenous people/communities are encouraged to participate in the implementation of this TAP. In the first instance indigenous people's/communities' views will be considered during the development of site-specific management plans, especially relating to cultural values of sites, species, populations and ecological communities, as well as potential impacts that may arise from control.

#### ***Performance criteria for Actions 1.2 and 1.3***

- ▶ Site-specific management plans to control bitou bush will be developed for 75% (127 sites) of the control category 1 sites within two years of the publication date of this TAP.
- ▶ Indigenous people are involved in the development of site-specific management plans.

### 9.3.3 Action 1.4

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<i>Action 1.4</i>	Control of bitou bush is to continue at both the northern and southern containment zones in NSW.
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The NSW bitou bush strategy outlines the need for the northern and southern containment zones to prevent the spread of bitou bush (see NPWS 2001a). However, the exact location of these containment zones and their management were not identified in the strategy. Work is currently being undertaken at both the northern and southern most distribution of bitou bush in New South Wales, being the Tweed and Moruya/Jervis Bay regions, respectively.

Commitment to these containment zones is crucial in limiting future impacts to biodiversity not just in New South Wales. However, what is needed to formalise the process is to: i) define and map the current northern and southern containment zones; ii) outline a strategy with all relevant stakeholders to move each containment zone during the course of this plan; iii) ensure that control undertaken in these areas follows best practice; iv) maintain controlled areas and prevent recruiting plants from seeding; and iv) determine the success of the program by assessing the level of recruitment within the 'contained' area.

**Performance criteria for Action 1.4**

- ▶ The density of bitou bush at both the northern and southern containment zones is reduced and the zones receded within five years of the publication date of this TAP.

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## 9.4 Objective 2: Monitor the effectiveness of bitou bush control programs

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*Objective 2* Evaluate the effectiveness of control programs at control category 1 sites with respect to the response of priority plant species, populations and ecological communities.

### 9.4.1 Action 2.1

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*Action 2.1* DEC will coordinate the monitoring/measurement of bitou bush control programs at control category 1 sites.

The primary objective of this TAP is to reduce the impacts of bitou bush on priority plant species, populations and ecological communities. To achieve this objective bitou bush populations will need 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 in terms of their success in achieving biodiversity conservation objectives. 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 plant 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.

Information on the monitoring process is outlined in Chapter 8 and a specific monitoring protocol will be developed in the near future.

**Performance criteria for Action 2.1**

- ▶ Establish monitoring objectives.
- ▶ Establish an experimental protocol to collect data/information.
- ▶ Establish experiments at as many sites as possible to critically determine the effects of control on bitou bush, priority species and non-target species (including other weed species), using the tier one or tier two monitoring program (discussed in Chapter 8), within 18 months of the publication date of this TAP.
- ▶ Maintain commitment to undertaking the monitoring programs established over the course of this TAP.
- ▶ Publish and report on the results as part of the *review of the TAP* (including incorporation of results into best practice guidelines) to land managers and researchers. Results from both tiers of monitoring to be presented.

#### 9.4.2 Action 2.2

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*Action 2.2* DEC will foster research into the effects of herbicide on priority species.

Herbicides have been used successfully to control bitou bush in Australia for many years. However, concerns have been raised about the impact of herbicides on native flora and fauna. The species listed in Appendix 10B were examined and their tolerance to herbicides was noted. These herbicide lists contain some of the priority species listed in Appendix 3 of the TAP, however the effect of herbicides on other priority species is unknown (see Section 8.2.1). This requires investigation so that high priority species are not threatened by the application of bitou bush control techniques using herbicides.

##### ***Performance criteria for Action 2.2***

- ▶ 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 Appendices 3 and 5, as well as those in Appendices 10A and 10B.
- ▶ Collect data where possible during the tier one monitoring programs.

#### 9.4.3 Action 2.3

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

Bitou bush has significantly increased its distribution within New South Wales in the last 20 years (see Section 8.2.3). The sample interval, while sufficient to show this dramatic increase, was too long to establish effective management strategies to reduce the problem. By re-mapping the distribution of bitou bush and boneseed in the final year of this plan, the information collected can be used to revise the plan and thus ensure it is addressed effectively. In addition, the interval between surveys will be half that of the previous ones.

#### 9.4.4 Action 2.4

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*Action 2.4* DEC and other stakeholders will determine the distribution of boneseed in New South Wales and develop a containment/eradication strategy.

Information on the distribution of boneseed is critical given that it is not yet widespread in New South Wales, but has the potential to become a serious environmental weed as evident in Tasmania, South Australia and Victoria. Once such information is collected/mapped (Action 2.3 above), effective management strategies can be developed to prevent impacts on biodiversity (i.e. containment or eradication).

##### ***Performance criteria for Action 2.3 and Action 2.4***

- ▶ 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 and boneseed during the last survey.
- ▶ Establish management objectives for boneseed following the completion of mapping.

## 9.5 Objective 3: Native plant species and bitou bush

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

### 9.5.1 Action 3.1

*Action 3.1* DEC will foster research into the decline in native plant species as a result of 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 properties and processes once they have invaded. For example, invasive weeds can alter fire regimes (Mack and D'Antonio 1998), biogeochemistry and hydrology (Gordon 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.

Recent research (i.e. Mason *et al.* 2004) has indicated that the type of bitou bush control undertaken (i.e. aerial spraying versus bush regeneration) has consequences for the floristic diversity of an ecosystem. Thus, there is a need for monitoring as outlined in Action 2.1 and a need for additional research into ecosystem impacts of both invasion and control.

#### *Performance criteria for Action 3.1*

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

## 9.6 Objective 4: Public involvement and awareness

*Objective 4* Ensure that all stakeholders are involved/participate at each of the control category 1 sites.

### 9.6.1 Action 4.1

*Action 4.1* DEC and other agencies will coordinate the training of volunteers (and other stakeholders) who wish to participate in control programs at control category 1 sites.

### ***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 over the past several decades. These efforts require external support due to the scale of the problem. 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. First, to raise awareness of the TAP and its objectives. Second, to provide training and guidance where needed to achieve wider implementation of the TAP. Last, to identify the high priority sites requiring the support of additional volunteers and/or other resources. 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 control category 1 site.

### ***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 Australian Government and state governments' commitment to community involvement in natural resource management, the Bitou TAP encourages community involvement at all sites, not just those in control category 1. 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 fore-dunes).
- ▶ ensure that threatened species, populations and ecological communities are adequately protected under the TSC Act (see Section 2.2.2).
- ▶ comply with regulations relating to undertaking work on threatened species, as per the TSC Act.
- ▶ comply with regulations under the Pesticides 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).

#### ***Performance criteria for Action 4.1***

- ▶ 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 high priority sites, and monitor their progress at regular intervals during the life of the Bitou TAP.

## 9.6.2 Action 4.2

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

### ***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 of weeds and their impacts on biodiversity 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. The public will be kept informed on the progress of the TAP's implementation.

### ***Performance criteria for Action 4.2***

- ▶ Establish a poster, fact sheet and webpage for the Bitou TAP and place signage at selected control category 1 sites.
- ▶ Establish a program to report significant events in bitou bush management to the general public, or provide for regular updates, especially at control category 1 sites.

## 9.7 Objective 5: Bitou TAP coordinator

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

### 9.7.1 Action 5.1

*Action 5.1* DEC will support a position to coordinate the implementation of the Bitou TAP.

### ***TAP 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 169 control category 1 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 priority plant 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, without which the actions of the plan could not be achieved.

The specific role of the TAP coordinator will be to:

- ▶ coordinate the implementation of bitou bush control at control category 1 sites (including guidance where needed for private landholders and other stakeholders, e.g. in the development of site-specific management plans).
- ▶ work with landholders to ensure commitment is maintained at control category 1 sites for the five years of the plan.
- ▶ establish and implement a protocol for monitoring the effectiveness of control programs at control category 1 sites (including best practice management).
- ▶ liaise with research organisations to establish herbicide trials on nominated non-target species.
- ▶ 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).
- ▶ liaise with training providers and/or regional stakeholders.
- ▶ collate and analyse data collected through the implementation of the plan, especially with regard to improving best practice methodology, and report results.
- ▶ monitor the spread of bitou bush and boneseed in New South Wales.
- ▶ prepare a revised plan within five years of the date of commencement of this plan.
- ▶ prepare and implement an education and awareness program to promote the TAP.
- ▶ perform day to day administration of the TAP including providing regular program reports to the DEC Executive and other stakeholders.

***Performance criteria for Action 5.1***

- ▶ A position is established, following the approval of the Bitou TAP, to coordinate its implementation.
- ▶ Progress reports are provided on a regular basis.
- ▶ The coordinator reviews the current TAP and prepares a second plan five years after the date of commencement of this TAP.

## 9.8 Objective 6: Impact of bitou invasions on fauna

*Objective 6* Determine the effects of bitou bush invasions on fauna.

### 9.8.1 Action 6.1

*Action 6.1* DEC will foster research into the effects of bitou bush invasions on fauna.

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). Several recent studies have started to fill these knowledge gaps, especially for birds (see French and Zubovic 1997; French and Eardley 1997; Gosper 2004b).

Detailed studies of the impacts of bitou bush (and boneseed) invasions on a range of fauna species are lacking (see Chapter 5). 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 border (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 the endangered butterfly.

**Performance criteria for Action 6.1**

- ▶ Establish a system to prioritise fauna species (or groups of species, e.g. waders) that are at risk from bitou bush invasions.
- ▶ Develop research projects on the effects of bitou bush invasions on priority fauna species.
- ▶ Initiate these research projects during the TAP. The results of these works could then inform subsequent Bitou TAP's.

## 9.9 Objective 7: Effect of bitou bush control on fauna

*Objective 7* Determine the effects of bitou bush control on fauna.

### 9.9.1 Action 7.1

*Action 7.1* DEC will foster research into the effects of bitou bush control on fauna.

There have been a few studies on the effects of removing a weed from an ecosystem on fauna (see review in Gosper 2004b), 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 (e.g. from increased light, soil disturbance, trampling of the ground and/or the effects of management techniques like fire). Also, some native species may take many years to recover following control (i.e. Turner and Virtue *in press*). 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 species (see Downey submitted).

The techniques used to control bitou bush may also impact on fauna. For example, as has already been discussed in Chapter 7, 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 10A. 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).

While some studies on the effects of herbicide on litter invertebrates were inconclusive (see Lindsay and French 2004b), other studies showed that herbicide did have an effect on invertebrates (Eijsackers and Van de Bund 1980).

***Performance criteria for Action 7.1***

- ▶ Establish a system to prioritise fauna species (or groups of species, e.g. waders) that are at risk from bitou bush control.
- ▶ Establish sites where studies can be undertaken to determine the effects of bitou bush control on fauna.
- ▶ Develop research projects on the effects of bitou bush control on fauna.
- ▶ Initiate these research projects during the TAP. The results of these works could then inform subsequent Bitou TAP's.

## 9.10 Objective 8: Review data and set future priorities

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

### 9.10.1 Action 8.1 and 8.2

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

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

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. Also, 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, submitted), and therefore the outcomes of this TAP should determine future management and research objectives for bitou bush and boneseed in Australia.

***Performance criteria for Action 8.1***

- ▶ 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.

***Performance criteria for Action 8.2***

- ▶ 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 TAPs.

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

**Table 9.2** 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 benefits to species, populations and ecological communities are greatest.</b>
<i>Action 1.1</i>	DEC and the Department of Lands (DoL) will undertake bitou bush control programs at high priority (control category 1) sites on their estate. In addition, the DEC and DoL will seek agreement from councils to ensure bitou bush control programs are undertaken at high priority sites on council administered land. The DoL will liaise and encourage Trust managers of Crown land to undertake bitou bush control programs at high priority sites. DEC will liaise and encourage landholders to undertake bitou bush control programs at high priority sites on private lands. To measure the biodiversity benefits, bitou bush control will not occur in areas designated as experimental 'no-treatment' areas (see Objective 2).
<i>Action 1.2</i>	At control category 1 sites, DEC and the DoL will help to develop and implement 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.
<i>Action 1.4</i>	Control of bitou bush is to continue at both the northern and southern containment zones in NSW.
<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 control category 1 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).
<i>Action 2.4</i>	DEC and other stakeholders will determine the distribution of boneseed in NSW and develop a containment/eradication strategy.
<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 control category 1 sites.</b>
<i>Action 4.1</i>	DEC and other agencies will coordinate and contribute to training volunteers (and other stakeholders) who wish to participate in control programs at control category 1 sites.
<i>Action 4.2</i>	DEC and other agencies will undertake public awareness programs on the impacts of bitou bush, especially on biodiversity, 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.

## 10 Social and economic impacts of the Bitou TAP

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The implementation of the Bitou TAP will have positive social benefits. As a major environmental weed infesting 80% of the NSW 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 in New South Wales. 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.

Raising the awareness of bitou bush with the public 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. These actions will also 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 to specific sites may be unpopular where such priorities do not match existing programs (e.g. control in more conspicuous areas, such as in urban reserves, along roadsides, popular beaches and coastal recreation areas). However, it must be noted that this TAP is solely directed at reducing the threat to biodiversity and not control *per se*. This TAP aims to address this issue 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.

An economic analysis of the cost of bitou bush and boneseed control has not been undertaken, as 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 and the bitou bush and boneseed program has almost exhausted the list of potential agents (see Downey *et al.* submitted). 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. Investigations are currently under way to establish if an economic analysis can be undertaken of the TAP with the University of New England.

The main economic benefit of the Bitou TAP is that it provides a consistent framework for control measures to be undertaken at control category 1 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 control category 1 sites for the duration of the TAP, and thus prevent such failures. It is also anticipated that by identifying sites in the other control categories this enables regional and local priorities to be developed, which should help to maintain control programs currently in place at these locations.

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 a number of social impacts on indigenous people that arise from bitou bush invasion. For example, the impact of bitou bush on availability, abundance and access to traditional foods, and the impact of bitou bush invasion on the degradation of and access to culturally significant sites. It is anticipated that indigenous people will make such social impacts known during the development of site-specific management plans so that they are accounted for in this plan.

There are significant adverse social and economic impacts that could arise from not implementing this plan. Bitou bush is a major threat to the biodiversity identified in this plan (see Appendices 3 and 5). 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.

## 11 Costs and implementation of this TAP

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It is a requirement of the TSC Act that a TAP outlines the cost of implementing the proposed actions. As a number of actions, or parts thereof, outlined in Chapter 9 were implemented in the 2005–06 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 2005–06 are not presented in the costings table, but are discussed below. These actions are predominantly associated with future research objectives aimed at filling the knowledge gaps identified during the preparation of this TAP. These are crucial for the longer-term management of bitou bush and to understand better the impact on biodiversity.

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 or parts thereof.

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

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During the 2005–06 financial year, several of the actions proposed in this plan, or parts thereof were undertaken. The cost of implementing these actions in 2005–06 (hereafter referred to as the current expenditure) was \$2,845,500 (see Table 11.1). This included expenditure by the DEC, Department of Lands, the five coastal CMAs, Lord Howe Island Board, numerous coastal 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 11.1 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. staff time) and cash, and external contributions, which includes volunteer ‘in-kind’ and cash grants.

**Table 11.1** The expenditure in 2005–06 by various agencies for implementing a range of proposed actions, or parts thereof identified in the Bitou TAP.

Action	Description	Priority <sup>a</sup>	Responsibility/ funding source <sup>c</sup>	Expenditure in 2005–06 (\$) <sup>b</sup>				Total across all funding sources (\$ 000)
				Cash expenditure (\$ 000) <sup>d</sup>	In-kind (\$ 000) <sup>e</sup>	External contribution (\$ 000) <sup>f</sup>	TOTAL (\$ 000)	
1.1	bitou bush control	1	DEC	300	344	354	998	2,176
			DoL	72	0	-	72	
			Councils	110	132	71	313	
			Coastal CMAs	-	-	460	460	
			Other*	27	204	102	333	
1.2	site-specific management plans	1	DEC	46	38	2	86	104
			Councils	1	16	1	18	
1.3	include indigenous values in site management plans	1	DEC	0.6	-	-	0.6	0.6
1.4	strategy containment of bitou bush (i.e. northern and southern containment zones)	1	Councils	20	16	32	68	68
2.1	monitoring of priority sites	1	DEC	3	5	15	23	45
			Councils	15	-	7	22	
2.2	research into herbicide impacts to native plants	2	DEC	2.1	0	0	2.1	2.1
2.3	survey bitou bush	3	DEC	1	0.3	-	1.3	17.8
			Councils	0.5	-	3	3.5	
			Other*	-	2	11	13	
2.4	survey boneseed in NSW and develop a containment and eradication strategy	3	DEC	-	-	-	-	-
3.1	understanding native plant species decline in bitou bush invaded areas	1	Other**	253	-	62	315	315
4.1	training of volunteers to work with bitou bush	1	DEC	8	1	-	9	15
			Councils	2	2	2	6	
4.2	public awareness of the TAP and the impacts of bitou bush	2	Councils	-	-	0.3	0.3	0.3
5.1	TAP coordination	1	DEC	91	0.4	-	91.4	96.4
			Councils	-	1	4	5	
6.1	determine impact on fauna from bitou bush	2		-	-	-	-	-
7.1	impacts of bitou bush control on fauna	2		-	-	-	-	-
8.1	review data and develop guidelines	3	Councils	-	1.3	0	1.3	1.3
8.2	establish future priorities	3	DEC	-	0.2	-	0.2	4
			Councils	-	-	0.6	0.6	
			Other	-	3.2	-	3.2	
<b>Total</b>				<b>952.2</b>	<b>766.4</b>	<b>1,126.9</b>	<b>2,845.5</b>	<b>2,845.5</b>

<sup>a</sup> Priority ratings are: 1–action critical to meeting plan objectives, 2–action contributing to meeting plan objectives, 3–action desirable, but not essential for the implementation of this TAP

<sup>b</sup> The funds spent on each action by various agencies in the 2005–06 financial year

<sup>c</sup> DEC (Department of Environment and Conservation), DoL (Department of Lands), Coastal CMAs (Northern Rivers CMA, Hunter Central Rivers CMA, Hawkesbury Nepean CMA, Sydney Metro CMA and Southern Rivers CMA), and Councils (Ballina Council, Bellingen Council, Kempsey Council, Hastings Council, Greater Taree City Council, Great Lakes Council, Port Stephens Council, Pittwater Council, Warringah Council, Randwick Council, Sutherland Council, Illawarra District Weeds Authority, Shoalhaven City Council, Eurobodalla Shire Council). Other\* – Lord Howe Island Board; Other\*\* – University of Wollongong

<sup>d</sup> Cash expenditure represents the salary component for temporary staff and other costs such as the purchasing of survey and laboratory equipment

<sup>e</sup> In-kind contribution represents the salary component of permanent staff and volunteer time

<sup>f</sup> External contributions including cash grants

## 11.2 Breakdown of the current costs (2005–06)

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

Control programs are currently being undertaken at 126 of the 169 control category 1 sites identified in this plan (see Appendix 7), on a range of land tenures. Expenditure on bitou bush control programs at these sites (Action 1.1) in the 2005–06 financial year totalled \$2,176,000 (see

Table 11.1). Not all these control programs are directed at conserving the species identified in this plan.

In addition, bitou bush control occurred at a large number of the other sites identified in Appendix 7 (i.e. control categories 2, 3, 4, 5) during 2005–06. Expenditure on control programs at these lower priority sites are not presented here, but are likely to be substantial.

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

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The expenditure in 2005–06 for the preparation or updating of site-specific management plans for the control of bitou bush at priority sites (Action 1.2) was \$104,000. This amount is likely to increase during the implementation of the TAP, as site-specific management plans will need to be developed and updated for additional sites. The development of site-specific management plans is imperative to ensure control is effective and that the impact to priority plant species, populations or ecological communities is minimal at each priority site.

There has been limited consultation to date with indigenous people during the development of site-specific management plans (Action 1.3), as reflected in only \$600 being spent during the 2005–06 financial year for this action (see Table 9.1). It is expected that this amount will increase as more site plans are developed in consultation with indigenous people.

### **11.2.3 Bitou control in northern and southern containment zones (Action 1.4)**

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Total expenditure for control at control category 1 sites in the southern containment zone was \$68,350 in 2005–06 (see Table 11.1). A value for control in control category 1 sites in the northern containment zone was not available at the time of writing. It is expected that the amount of control undertaken in the northern containment zone was similar to, but probably more than in the southern containment zone, hence a realistic total estimate for Action 1.4 in 2005–06 would be approximately \$140,000.

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

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Monitoring is the key to evaluating the success or failure of the Bitou TAP, as well as bitou bush control programs and the recovery of species at risk. The total expenditure on monitoring bitou bush control programs and the response of biodiversity at risk at **some** of the control category 1 sites in 2005–06 was \$45,260 (see Table 11.1). The cost of monitoring at priority sites varied widely and is expected to be significantly greater during the implementation of the TAP.

There are a number of problems with the current monitoring programs with respect to meeting the objectives of this TAP. These 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.

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

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The expenditure in 2005–06 for determining the effects of herbicides on threatened species was \$2,100 (Table 11.1). In most cases, this occurred as 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.

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

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The expenditure in 2005–06 on monitoring the spread of bitou bush and boneseed was \$17,778 (Table 11.1). This was mostly for localised surveys rather than for a comprehensive statewide survey like that carried out 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).

#### **11.2.7 Developing a management strategy for boneseed (Action 2.4)**

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There was no expenditure on mapping boneseed and creating a containment and/or eradication strategy for boneseed in 2005–06. As outlined in Chapter 9 and elsewhere in this text, boneseed is not currently a major problem in New South Wales, however it has the potential to be, given its distribution in Tasmania, South Australia and Victoria. Thus it is important that we have information on the distribution of boneseed, from which effective management strategies can be developed to contain or eradicate it. Given that boneseed is currently not posing a significant threat to biodiversity and is unlikely to do so in the next five years, this action was given a priority rating of 3 (being desirable, but not essential for the implementation of this TAP).

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

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In 2005–06, expenditure on research into how bitou bush contributes to native plant species decline was \$315,261. This represents the stipend of several Ph.D. students, an external grant, and the in-kind contribution by several staff members and students at the University of Wollongong.

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

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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 2005–06, the expenditure associated with coordinating and training volunteers with respect to the actions outlined in this TAP for control category 1 sites, was \$14,955 (Table 11.1). There is an on-going need for coordination and training of volunteers, which needs to be standardised to meet the objectives of the TAP.

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

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Estimated expenditure on education programs at a very limited number of control category 1 sites in 2005–06 was \$320 (Table 11.1). 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.

#### **11.2.11 Bitou TAP coordinator (Action 5.1)**

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Expenditure on preparing and coordinating the Bitou TAP in 2005–06 was \$96,440 (Table 11.1). This comprised the salary of a DEC Project Officer (\$79,000) plus an operating budget for travel, editing and printing (\$12,400), in addition to (\$5,040) for council coordination.

#### **11.2.12 Bitou bush and fauna (Actions 6.1–7.2)**

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There was no expenditure in 2005–06 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 are limited. Such information is necessary to manage and better protect threatened biodiversity, and hence it has been given a priority rating of 2 (contributing to the plan objectives). In addition, such information is needed in order to address the impacts of bitou bush invasion on fauna when the TAP is revised (i.e. five-years from the release of this plan). Rigorous examination needs to be undertaken by researchers into the effects of bitou bush invasion and its control on fauna.

#### **11.2.13 Establish future priorities (Actions 8.1 and 8.2)**

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The expenditure for integrating new data into management strategies/guidelines (Action 8.1) in 2005–06 was \$1,280 and for establishing future priorities (Action 8.2) was \$4,099.

New information collected on i) the 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 between bitou bush and fauna (Actions 6.1 and 7.1) should be collated and incorporated into best practice guidelines (Action 8.1) and assessment of future priorities (Action 8.2). This action is proposed for the final year of the TAP and thus is given a priority rating of 3 (being desirable, but not essential for the implementation of this TAP).

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Person	Organisation
Bower, H.	Byron Shire Council
Dodkin, M.	DEC
Flower, P.	DEC
Groves, R.H.	CSIRO Plant Industry
Hoefer, A.	PhD student, ANU
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