



Bitou bush

**Current management and
control options for bitou bush
(*Chrysanthemoides monilifera* ssp. *rotundata*)
in Australia**



Weeds of National Significance

Bitou bush management manual

Current management and control options for bitou bush
(*Chrysanthemoides monilifera* ssp. *rotundata*)
in Australia

Edited by MA Winkler, H Cherry and PO Downey

Weeds of National Significance
2008



Australian Government



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Published by:

Department of Environment and Climate Change
59–61 Goulburn Street
PO Box A290
Sydney South NSW 1232

Ph: (02) 9995 5000 (switchboard)
Ph: 131 555 (environment information and publications requests)
or 1300 361 967 (national parks information and publication requests)
Fax: (02) 9995 5999
TTY: (02) 9211 4723

Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

For further information contact:

Pest Management Unit
Parks and Wildlife Group
Department of Environment and Climate Change (NSW)
Phone: 1300 361 967

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Bitou bush management workshops

Workshops and discussions were held along the coast of New South Wales and were attended by dedicated agency staff and community volunteers from around Australia. These workshops provided valuable information on current bitou bush management and control practices, much of which forms the basis of this manual. Thanks to all workshop participants.

Valuable comments, information and review provided by

Lee Andresen and Shirley White, Angels Beach Landcare, New South Wales
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Janet Mackay, Trees in Newcastle, New South Wales
Paul Marynissen, Wyong Shire Council, New South Wales
Ellen White, Dirrawong Trust, New South Wales
Tim Woodward, Nambucca Shire Council, New South Wales
Anthony Marchment, Port Stephens Shire Council, New South Wales
Matt Leary, Randwick Council, New South Wales
Ian Burnett, South West Rocks Dunecare, New South Wales
Leonie Whiffen and Alan Kwok

Case study authors

Stephen Booth, Technical Officer, Cape Byron Trust, New South Wales
Alana Burley, Department of Environment and Climate Change, New South Wales
Dainry Gerrand, Manning Coastcare Group Coordinator, New South Wales
Susie Hester, University of New England, New South Wales
Jim Kelly, Tathra Landcare Coordinator, New South Wales
David Pomery, Illawarra District Noxious Weeds Authority, New South Wales
Jack Sinden, University of New England, New South Wales
Andrew Staniland, Great Lakes Council, New South Wales
Jeffery Thomas, Department of Environment and Climate Change, New South Wales
Kerry Thompson, Shoalhaven City Council, New South Wales
John Toth, Management of Environmental Weeds Pty Ltd, New South Wales

National Bitou Bush and Boneseed Management Group

Bruce Thom, Chair and community representative, New South Wales
Hillary Cherry, National Bitou Bush and Boneseed Coordinator
Jamie Cooper, community representative, Feral Management Solutions, Tasmania
Anne Dennis, Department of Sustainability and Environment, Victoria
Paul Downey, Department of Environment and Climate Change, New South Wales
David Lane, Department of Primary Industries and Water, Tasmania
Margaret MacDonald, community representative, ANGAIR, Victoria
Clyde McGaw, Department of Primary Industries and Fisheries, Queensland
Peter McGlone, former Chair and community representative, Flagstaff Gully Landcare, Tasmania
Tom Morley, Department of Primary Industries, Victoria
Shauna Potter, Department of Water, Land and Biodiversity Conservation, South Australia
David Roberts, Parks Victoria, Victoria
Peter Tucker, community representative, Rural Solutions, South Australia
Ian Turnbull, Bellingen Shire Council, New South Wales

Foreword

One hundred years ago the first bitou bush plant was recorded as naturalised in Australia, growing in coastal vegetation at Stockton north of Newcastle, New South Wales. Since this time it has had a chequered history. It was promoted by the NSW Soil Conservation Board who recognised its rapid growth and ability to stabilise soils following mining in coastal sand dunes. Deliberate planting occurred along the New South Wales coastline for several decades until its weedy status was acknowledged and it was declared a noxious weed. Due to its rapid spread and ability to form monocultures, it was later listed as a key threat to biodiversity and a Weed of National Significance (WoNS).

Through this combination of deliberate plantings and natural spread bitou bush now occurs along 80% of the New South Wales coastline. Populations also occur in north-eastern Victoria and in South-East Queensland. An eradication program has been underway in Queensland since 1981.

Bitou bush is unique in its WoNS status as a purely environmental weed, affecting a range of native species. A recent assessment of the biodiversity at risk in New South Wales showed that bitou bush posed a significant threat to over 150 native plants and 24 different coastal vegetation communities.

In my role as the Chair of the National Bitou Bush and Boneseed Management Group, and in my years working on coastal geomorphology, investigating sand mining history and acting as a member of the Wentworth Group of Concerned Scientists, I have seen the changes and dramatic effects that bitou bush can have on the environment. I have also seen the results that committed groups and individual community members can achieve in restoring and repairing degraded environmental systems.

This manual brings together some of their findings and the most up-to-date research on how to best carry out bitou bush management and site rehabilitation in coastal regions. It covers aspects of holistic site management for bitou bush, from initial pre-planning and site-specific planning, to follow-up mechanisms and monitoring, and the methods available to treat or remove bitou bush from ecosystems. It also deals with issues relating to soil stabilisation and secondary weed invasion, which may become more significant issues than bitou bush if left to persist. This is a companion document to the boneseed manual produced in 2006 (Brougham *et al.* 2006) as part of the WoNS program.

This manual is intended to present the best practices currently known but acknowledges that changes in understanding are likely to come with time. Contributions to this manual have been generously made by a wide range of experienced practitioners from both agency and community, and their willing and extensive provision of information is very much appreciated.

Bruce Thom
Chair
National Bitou Bush and Boneseed Management Group

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National management

A National Strategy for bitou bush and boneseed was developed (ARMCANZ *et al.* 2000) to guide Australia towards: ‘working together to arrest the spread and minimise the impact of bitou bush and boneseed in natural ecosystems’.

The National Strategy aims to deliver three outcomes:

- The further introduction and spread of bitou bush and boneseed is prevented.
- The adverse impacts of bitou bush and boneseed on biodiversity are minimised.
- The national commitment to the coordination and management of bitou bush and boneseed is maintained.

The implementation of the strategy is being guided by the National Bitou Bush and Boneseed Management Group (NBBBMG), composed of agency and community representatives from across Australia, and a national coordinator. The outcomes set out in the strategy are being achieved through a series of priority actions involving the community and all levels of government.

Using this manual

Who should use this manual?

This manual has been written to assist anyone who either wants or needs to manage bitou bush, from site managers, contractors, community groups, private landholders and volunteers to government agency staff. This manual is intended to help people in their decision making about bitou bush management by providing a comprehensive guide.

This manual provides information on:

- Bitou bush and its impacts,
- Habitats invaded and their management considerations,
- How to choose an appropriate control method,
- How to plan management,
- Restoration, revegetation and repairing invaded habitats,
- Monitoring progress,
- Legislation and information for volunteers, and
- Further resources.

How to use this manual

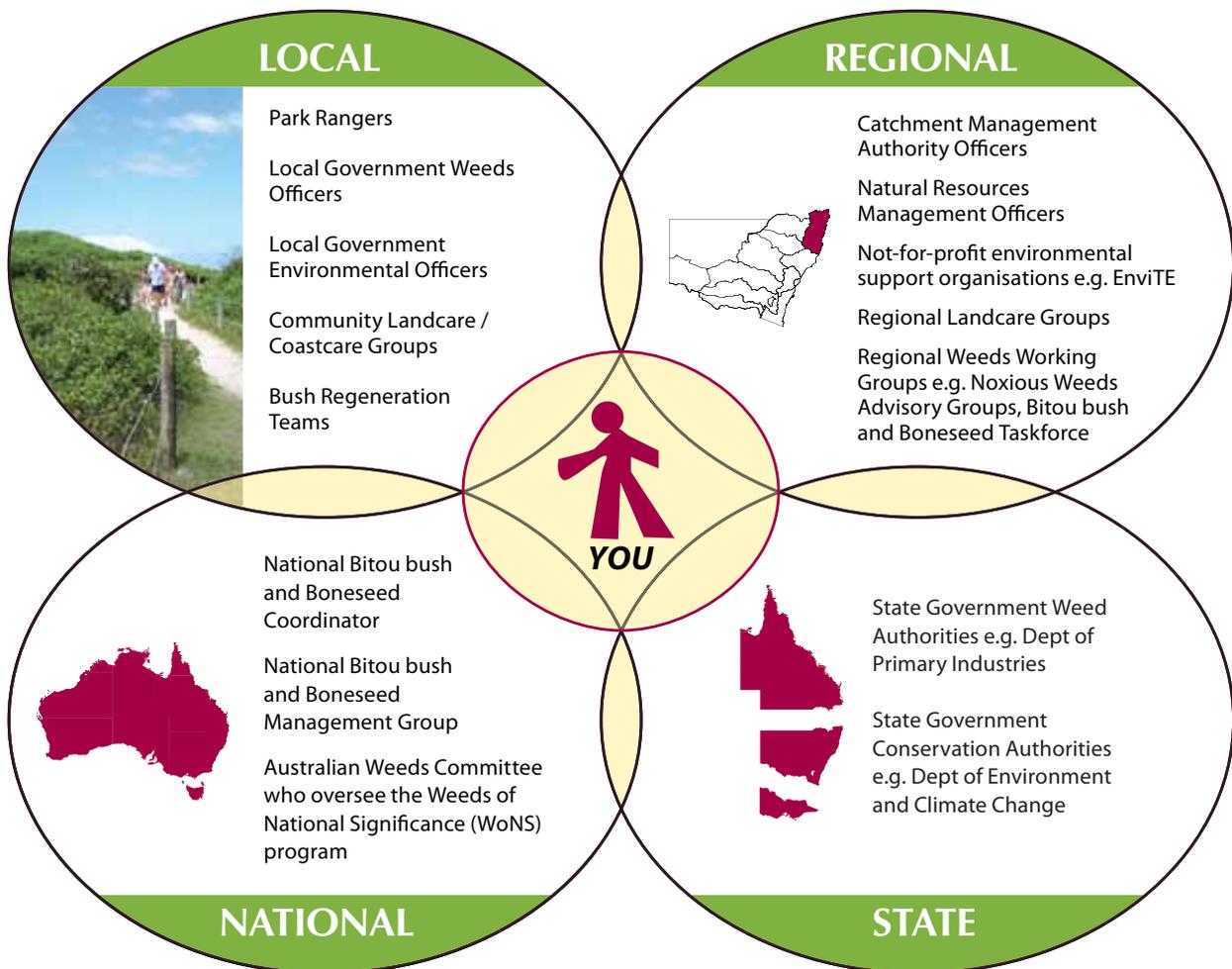
Sections can be read in isolation, or collectively if one’s goal is to comprehensively investigate specific topics. To increase the usability of this manual, the following have been provided:

- A checklist for the planning stage,
- A decision matrix – especially for selecting an appropriate control method,
- Advantages/disadvantages of each control method,
- Important considerations for management,
- A site-plan template,
- Case studies, and
- Contacts and references for more information.

Bitou bush network in Australia

Many groups of people are involved in bitou bush management in Australia across a range of levels. Part of effective management is understanding where you fit within the ‘bitou bush network’ in Australia. The diagram below illustrates the diversity of people and agencies involved, and their relationships. Relevant contact details are provided in Section 8 of this manual, and a portion of these are on the Australian Government Caring for our Country web page www.nrm.gov.au/contacts.

Consult with other groups working on bitou bush in surrounding areas to help understand your potential role in bitou bush management nationally, as well as within your state, region and locality. For example, management at individual sites can feed into local government pest management plans, which feed into regional pest strategies at the natural resource management (NRM) board and catchment management authority (CMA) scale. These in turn feed into the National Bitou Bush and Boneseed Strategy. Thus your actions benefit not just your site, but ultimately the regional, state and national bitou bush effort.





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Section One

Biology and threat



Hilary Cherry



Marion Winkler



Marion Winkler

The bitou bush profile 2

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The ability to invade natural areas, impact negatively on biodiversity and spread rapidly has led to bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) and the closely related boneseed (ssp. *monilifera*) being recognised together as one of the 20 Australian Weeds of National Significance (Thorp and Lynch 2000).

In its native range in southern Africa, bitou bush is restricted to coastal or near-coastal areas. In Australia it has invaded large tracts of coastal New South Wales and southern Queensland, as well as parts of north-eastern Victoria. Boneseed, also native to southern Africa, is widespread throughout southern Australia, including low rainfall areas.

The bitou bush profile

Identifying bitou bush

Form Bitou bush is a perennial evergreen shrub in the daisy (Asteraceae) family that grows to 3 m high and 6 m wide (sometimes to 10 m wide). It grows differently in different habitats, for example in a sprawling or prostrate form on the foredune, an erect shrub in hind dunes and as a climber in woodlands and rainforest areas where stems can reach up to 10 m in length (referred to as decumbent stems), often supported by neighbouring vegetation.

Roots Bitou bush has a shallow but extensive root system. It does not produce a primary tap root. The decumbent stems can also produce roots at the nodes when those nodes are in contact with soil or moisture or become buried. Rooting of decumbent stems can lead to the formation of hummocks (see page 23).

Leaves The semi-succulent leaves are arranged alternately along the stem. They are broadly oval to rounded in shape (hence the subspecies name '*rotundata*') and 3–7 cm long and wide. The leaf edges or margins are generally smooth (or only slightly serrated or



Hilary Cherry

Sprawling form of bitou bush on foredunes



Terry Inkson, Great Lakes Council

Shrub form of bitou bush on beach dunes



Paul Downey

Climbing form of bitou bush in coastal banksia woodland

toothed). New growth, especially at branch tips, is covered with white downy hairs (looks like a cottony fluff) that are shed as the leaves mature.

Flowers Each of the yellow daisy ‘flowers’ consists of a composite flower head (or inflorescence) of many tiny bisexual flowers (disc florets) clustered together in the centre, surrounded by 11–13 ‘petals’ (each ‘petal’ or ray is attached to a tiny flower called a ray floret). The disc florets are sterile, while the ray florets are fertile and produce the fruit. Each inflorescence is 2–3 cm across. Inflorescences are clustered on the ends of branches. While ‘flowers’ may be present all year round, the main flowering period occurs between April and July, usually with a second smaller peak in November or December.

A marked reduction in flowering has been observed since the introduction of biological control agents such as the foliage-feeding tip moth and leaf roller moth, and the seed-feeding bitou seed fly (see Section 4).

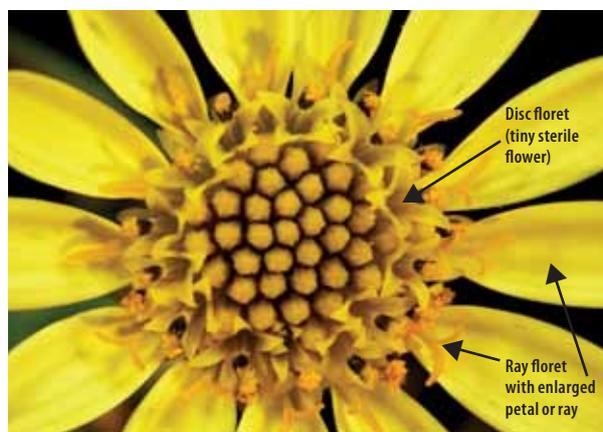
Fruit The egg-shaped, fleshy fruits turn from green to black when mature and each fruit (achene) contains a single seed. Fruit develop from the tiny flowers (ray florets) and mature differentially, so individual inflorescences may have both green (unripe) and black (ripe) fruits present at the same time. Within the daisy family, fleshy fruits are unique to the six subspecies of *Chrysanthemoides* – the rest have wind dispersed seeds. The tiny seed is contained within a hard, rough and egg-shaped endocarp (seed coat) that is 5–7 mm long, 3–4 mm across and dark brown to black when dry. Peak fruiting is between June and September, with a second smaller peak in December/January.

Each inflorescence can produce up to 13 single-seeded fruits (one fruit per ray floret or ‘petal’) and up to 48,000 can be produced per plant (Weiss 1983). Not all fruit will contain viable seed.



Marion Winkler

Bitou bush leaves (mature, and young with downy hairs)



Alan Kwok

A bitou bush inflorescence is composed of many tiny disc and ray florets (flowers)

 **Bitou bush can be confused with the closely related boneseed (see page 4). Boneseed occurs in New South Wales and Victoria, as well as in non-bitou bush infested areas in Tasmania, South Australia and Western Australia.**

Distinguishing between bitou bush and boneseed

bitou bush (ssp. <i>rotundata</i>)			boneseed (ssp. <i>monilifera</i>)	
	spreading shrub, 1–2 m high, sometimes erect	habit	erect shrub, up to 3 m high	
	3–7 cm long, broader oval shape, smooth or only slightly toothed edges	leaves	3–9 cm long, elongated oval shape, irregularly toothed edges	
	11–13 'petals' flowers year round with a peak from April to July	flowers	4–8 'petals' flowers from late winter to spring (mainland), to early summer (Tas.)	
	egg-shaped fruit, black when ripe	fruit	round fruit, black when ripe	
	seed coat is egg-shaped, rough, dark brown to black	seeds	seed coat is round, smooth, bone-coloured (seed also shown)	
	leaves with smooth edges	seedlings	leaves with toothed edges	

In different regions, bitou bush may be confused with several native species. Thus it is important that you are familiar with its appearance to prevent accidental damage to the natives while undertaking bitou bush management.

Native look-a-likes

Bitou bush can be confused with native species such as **boobialla** (*Myoporum boninense*) and **sea box** (*Alyxia buxifolia*), both of which are found in coastal habitats (mostly on sea cliffs) and have round or fleshy leaves. Boobialla is the most similar with fleshy bright green leaves, however it has tubular flowers with purple spots inside and succulent purple fruits. Sea box also has round leathery leaves, but small white flowers and red berries.

Other native bitou bush look-a-likes include *Acacia longifolia* ssp. *sophorae*, *Scaevola calendulacea*, *Hibbertia scandens*, *Melanthera biflora*, *Coprosma hirtella* and *Goodenia* spp. The weed *Senecio angulatus* can also be confused with bitou bush.

You should familiarise yourself with these species if they occur in your region, especially when not in fruit or flower, to avoid mistaking them for bitou bush.



Jackie Miles

Boobialla (*Myoporum boninense*)



Jackie Miles

Sea box (*Alyxia buxifolia*)



Marion Winkler

Golden Guinea flower (*Hibbertia scandens*)



Jackie Miles

Scented fan flower (*Scaevola calendulacea*)

Life cycle

Seasonal pattern for bitou bush

	Summer			Autumn			Winter			Spring		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Flowering	Consistently present	Present in suitable conditions	Present in suitable conditions	Present in suitable conditions	Consistently present	Consistently present	Consistently present	Consistently present	Present in suitable conditions	Present in suitable conditions	Present in suitable conditions	Consistently present
Fruiting	Consistently present	Consistently present	Present in suitable conditions	Consistently present	Consistently present	Consistently present	Consistently present	Present in suitable conditions	Present in suitable conditions			
Germination	Present in suitable conditions	Present in suitable conditions	Present in suitable conditions	Consistently present	Consistently present	Consistently present	Present in suitable conditions					

Consistently present
 Present in suitable conditions

Germination

Germination occurs throughout the year, but more commonly after favourable conditions such as rainfall or fire, as germination occurs most readily from weathered seeds. The hard, black seed coat beneath the flesh of the fruit protects the seed. However, once the coat is cracked or weathered, the seed inside is exposed and germination soon follows.

Fire can stimulate a large proportion of the bitou bush seed bank to germinate as heat can crack the seed coat. In addition, once the fire has opened up an area (i.e. burnt away adult plants), the combination of increased light to the soil and associated heating of the soil may stimulate further germination from the seed bank.

Growth, flowering and pollination

Bitou bush can live for many years, and older plants may have stems up to 20 cm in diameter. They do not exhibit a dormant growing period, so will grow all year round although growth is slowed in winter. Mature plants have the greatest shoot growth in summer. Bitou bush plants may flower (and set seed) within one year of germination where conditions are favourable, such as on the north coast of New South Wales where high rainfall and higher temperatures are common.



Glen Saunders

Seed and young seedlings of bitou bush (almost life size)

On the south coast of New South Wales where temperatures are lower, plants generally take up to 18 months to reach first flowering.

Seed dispersal

Bitou bush produces fleshy fruits which are consumed by a wide range of animals that in turn spread the seeds. For example, many birds feed on bitou bush fruits including silvereyes, currawongs, bowerbirds and emus; however any fruit-eating native or exotic bird can be a potential seed disperser (Gosper 1999). Foxes can also disperse bitou bush seed, with seedlings able to germinate directly from fox scats.

Wallabies eat the foliage of bitou bush plants and fruit may be incidentally consumed. Near Ulladulla in New South Wales, seedlings are commonly found near kangaroo camps, suggesting that they might either ingest the fruit and spread the seed, or create suitable areas for germination in the disturbed soil. Seeds have also been observed stacked up around blue-tongue lizard habitats suggesting they may also consume the fruits.

The hard seed coat allows seeds to remain viable when transported via either fresh or salt water, and ocean currents are believed to play an important role in the spread of bitou bush along the coast (Batianoff 1997). Seeds can also be dispersed by humans via the dumping of garden refuse or contaminated soil, and by transporting seeds on machinery. Transportation of bitou bush plants and seeds is strictly prohibited under legislation in all Australian states (see Section 8).

Seed bank longevity

Bitou bush seeds can remain dormant in the soil if the seed coat remains intact. While the exact longevity of seeds is unknown, a single seed may persist for at least five years (Aveyard 1971). Research is currently investigating seed persistence in the soil for both bitou bush and boneseed.

Preferred habitat and climate

Bitou bush occurs on a range of soil types but the majority of infestations are found on sandy or medium-textured, low fertility soils. It is unlikely to grow in constantly wet or inundated soils, however, it can grow on the edges of estuaries and mangroves, and damp margins of coastal dune 'swale' lakes and lagoons. It prefers disturbed areas, particularly near the sea, where it tolerates saline conditions. The optimal temperature for growth is between 17 and 27°C and plants have a low tolerance for frost (Howden 1984).



Glen Saunders

Bitou bush flowers are pollinated by a range of insects, but especially bees



Marion Winkler

Volunteers helped to collect bitou bush seeds for seed longevity research trials that started in winter 2008



Terry Inkson, Great Lakes Council

A bitou bush plant growing in light to medium clay to sandy clay loam soil. Inset: close up of the flower

Current distribution

Bitou bush is presently restricted to coastal regions of eastern Australia, from southern Queensland, along the coast of New South Wales to Mallacoota in Victoria. Isolated, small infestations occur in Melbourne, on Lord Howe Island and in western New South Wales around Broken Hill and Menindee. The western New South Wales populations were deliberately planted on sand dunes and are now being eradicated, as are the small infestations around Melbourne. An eradication strategy has been implemented in Queensland over the past 20 years, with any new infestations managed annually (see *Bitou bush eradication opportunities at a regional level in Queensland case study* on page 83).

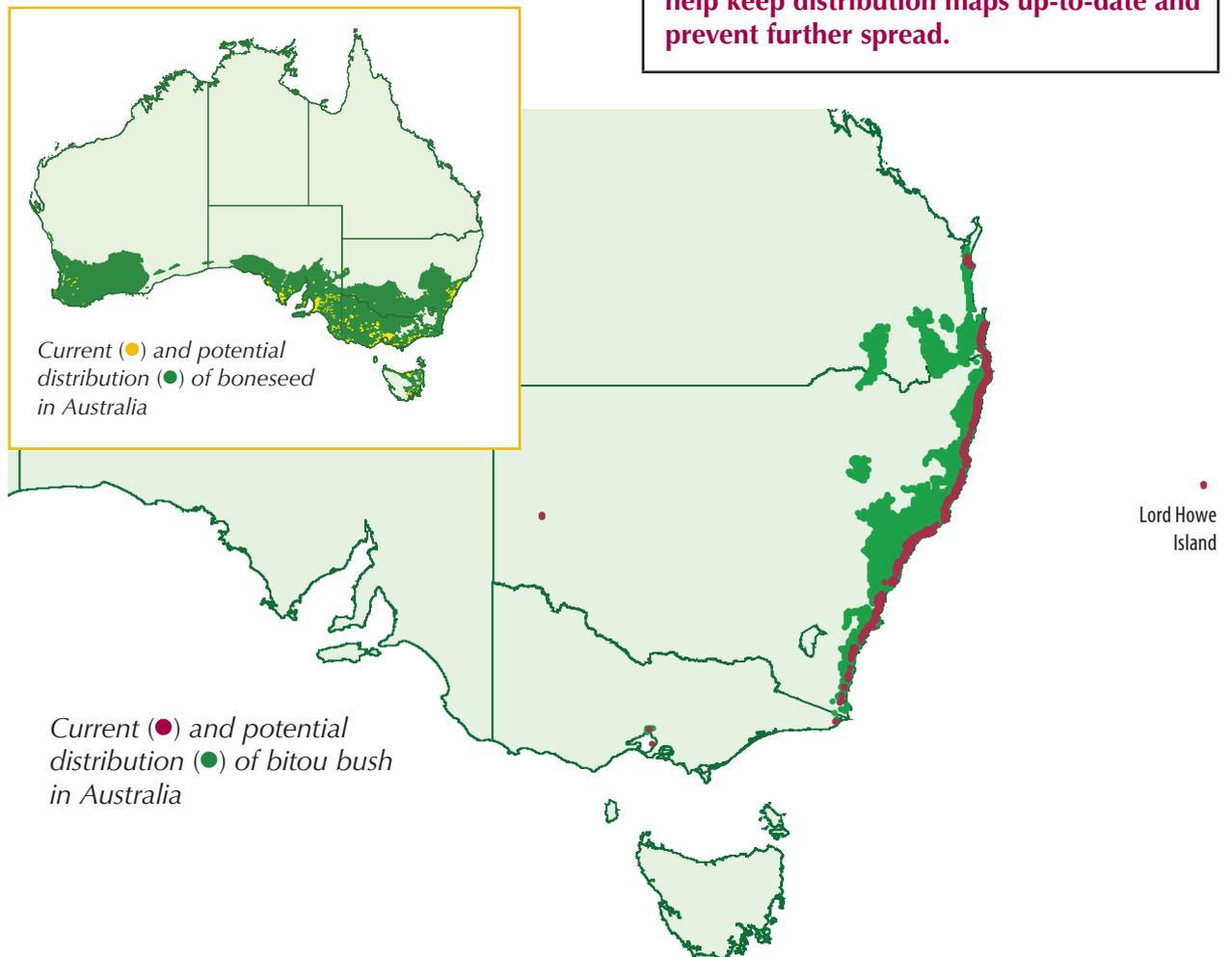
Recently, several new bitou bush infestations have been discovered in non-coastal areas of New South Wales, an inland movement

that was observed during the 2001 mapping project (Thomas and Leys 2002). These populations include areas near Stroud (50 km from the coast) and Girvan (30 km from the coast) – both in the Great Lakes area – and in the Shoalhaven area (20 km inland on the banks of the Nowra River).

Potential distribution

A climate-based analysis using BIOCLIM was used to predict the potential distribution of bitou bush in Australia (under current climate conditions). This analysis showed that, with the exception of a potential westward expansion, bitou bush is not likely to spread further than its current distribution as long as existing containment and eradication efforts are maintained.

 **Report all new bitou bush infestations to your local government weeds officer to help keep distribution maps up-to-date and prevent further spread.**



Impact of bitou bush in Australia

 **Bitou bush is a highly invasive coastal weed that seriously impacts native ecosystems.**

History of invasion

The first known record of bitou bush is a herbarium specimen collected in 1908 from Stockton, near Newcastle on the Hunter River in New South Wales. It is thought that this early infestation came from dry ship ballast that was dumped on the north bank of the river by a ship that had sailed from South Africa. While this initial introduction 100 years ago is thought to be accidental, it was subsequently planted widely to stabilise coastal sand dunes, particularly in New South Wales, but also in Queensland during the 1940–1960s. By the late 1960s it was recognised as a problem.



Paul Downey

In many areas, bitou bush forms dense monocultures, under which few native species persist

Impact to ecosystems and plant communities

Ecosystems particularly susceptible to invasion by bitou bush are coastal sand dunes (specifically beach foredunes and hind dunes), coastal grasslands, heaths, woodlands and rainforests, as well as headlands, wetlands and riparian areas along tidal rivers. The coastal zone has a very diverse assembly of native species within a small area (i.e. from the king tide mark to the coastal rainforests that

adjoin the hind dunes) and given that bitou bush forms dense monocultures in many of these coastal ecosystems, its impact on native species is extremely high.

Competition between bitou bush and native species appears to be most pronounced in the seedling stage (French and Mason unpublished data) which suggests a single new seedling may be able to out-compete native seedlings. The immediate removal of any new outlying seedling is therefore critical for the protection of native plants because native species may be impacted even at low bitou bush densities.

The invasion of bitou bush into windward edges of coastal plant communities like littoral rainforests can have devastating impacts on the whole community. Bitou bush replaces the native species that protect these communities from salt spray, and their absence allows salt spray to reach plants within the rainforest core, which may result in ‘salt-burning’ of foliage and even plant death.

Bitou bush can also change dune morphology by preventing natural erosion patterns. Bitou bush roots initially hold the sand in place so that mounds of trapped windblown sand build up around the bushes, leading to the formation of sand mounds or **hummocks** (see page 23). Bitou bush plants in turn grow up and over the mounds. Erosion may then be enhanced between these hummocks by channelling wind. This may lead to the displacement and loss of native plants and seed banks (Stanley *et al.* 1989).



Mark Hamilton

The breaking apart of the protective vegetation barrier on the dunes makes sand susceptible to erosion

Bitou bush plants can change the soil chemistry by exuding chemicals from their roots and leaves that are not naturally found in coastal soils, which in turn can suppress the germination and recruitment of native seedlings, a process known as allelopathy (Ens 2007). However, the exact processes by which these chemicals potentially inhibit native plant growth are not yet known. These chemicals identified are volatile and not likely to remain in the soil long-term. They may evaporate or leach away and cease inhibiting growth. This may be reflected in the observed increase in native species 12 months or more after mature bitou bush plants have been killed.

Bitou bush leaves are held parallel to the ground, as opposed to coastal wattle leaves which are more pendulous. Thus the replacement of coastal wattle by bitou bush leads to increased soil shading and a cooler, darker microclimate beneath the plants (Lindsay and French 2004a). This in itself can have significant effects on native species. For example, it can alter the litter invertebrate composition, which may increase the rate of cycling of nitrogen and phosphate through the system by increasing litter decomposition (Lindsay and French 2004b).

Protecting native plants

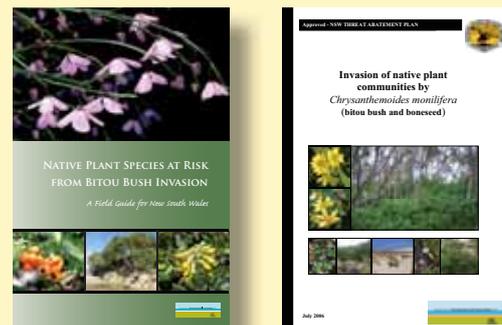
In response to these impacts and threats, ‘the invasion of native plant communities by bitou bush and boneseed’ was listed in 1999 as a key threatening process under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act). In accordance with the TSC Act, a Threat Abatement Plan (TAP) to reduce, abate or ameliorate the threat posed by bitou bush and boneseed to native species was produced (DEC 2006).

The Bitou TAP identified 157 native plant species, three threatened plant populations and 24 ecological communities as being at risk from bitou bush and boneseed invasion in New South Wales (see *Protecting native plants from bitou bush invasions* case study on page 99). While many of these plants and ecological communities susceptible to bitou bush invasion are already classified (as threatened)

under the TSC Act, including *Themeda* grasslands, littoral rainforest and eastern suburbs banksia scrub, some of the most susceptible are not listed, for example coastal banksia woodland. Thus the TAP ensures their protection as well.

Native plant field guide

Many of the species at risk from bitou bush invasion are rare or poorly known, so a field guide has been produced (Hamilton *et al.* 2008) to help land managers, volunteers and community groups recognise these species and ensure their preservation while bitou bush control efforts are being undertaken. To receive a free copy of the field guide or learn more about the Bitou TAP visit the Bitou TAP website at www.environment.nsw.gov.au/bitoutap/.



A field guide (left) to identify native plant species threatened by bitou bush invasion is a companion to the NSW Bitou Bush Threat Abatement Plan (Bitou TAP) (right)



Some of the native species at risk from bitou bush invasion, clockwise from top left, *Cryptostylis hunteriana*, *Dianella congesta*, *Pultenaea maritima* and *Spyridium scortechinii*

Use of bitou bush historically: revegetation of coastal sand dunes after mining

A large portion of the New South Wales coast was mined from 1933, for gold and tin (in very small amounts), and more extensively for zircon and rutile. This resulted in significant areas of cleared, unstable sand. *“The methods of restoring, or more precisely, stabilising sand dunes after mining, (were) aimed at producing as quickly as possible a cover of vegetation which will protect the mined area from wind erosion”* – Barr (1965).

Bitou bush had begun spreading naturally from its initial introduction point, thought to be near Newcastle, New South Wales, in 1908 and it was proclaimed a noxious weed within a few decades in the Newcastle area. However, when its ability to stabilise sandy soils and sand drifts was recognised, it was removed from the noxious weeds list (Mort and Hewitt 1953).

When experimental trials by the Soil Conservation Service in the 1940s, using bitou bush for stabilisation of coastal sand drift, produced favourable results, extensive sowing of seeds followed in the years between 1946 and 1968 (Weiss *et al.* 2008). Propagated seedlings are reported to have been given to school children to plant for a few pence reward on the Ballina coast at this time. It was intensively used

to revegetate coastal dunes after mining at Redhead, Diamond Head, Port Macquarie, Crescent Head, Byron Bay, Hastings Point and Tweed Heads. Planting of bitou bush also occurred for sand stabilisation around Jervis Bay, Tathra and inland near Broken Hill and Menindee.

It was later acknowledged that bitou bush was so effective in stabilising the dunes that it was becoming invasive. The Soil Conservation Service withdrew recommendations for its use on mined areas and sand drift projects in March 1971 (Cooney *et al.* 1982).

Bitou bush continued to spread and by 1982 occurred on 660 km (60%) of the New South Wales coastline where it was the dominant species along 220 km (Love 1984). Remapping of the New South Wales coastline in 2001 showed a 36% increase in the distribution over the intervening 20 year period, with 80% (900 km) of the coastline then infested and it was the dominant species along 400 km of the coast, despite no deliberate plantings (Thomas and Leys 2002). In 2000 it was listed as one of Australia’s most significant weeds (Thorp and Lynch 2000) and legislation restricting its sale, movement and propagation came into force nationally.



Hillary Cherry

Sand mining equipment used to filter sand for mineral extraction near Jervis Bay, New South Wales

Impact to native animals

Bitou bush is likely to pose a significant threat to native animals. The determination of bitou bush as a key threatening process identified three threatened bird species as being potentially at risk in New South Wales – the eastern bristlebird (*Dasyornis brachypterus*), little tern (*Sterna albifrons*) and beach stone-curlew (*Esacus neglectus*). The threat arises from bitou bush invading their habitat, particularly nesting sites, in coastal environments. Little terns, for example, like to nest on exposed beaches or bare stretches of sand, which rarely exist within bitou bush infested areas. However, the TAP does not specifically address impacts to animals.

Birds that feed solely on plant parts (e.g. flowers and fruits) tend to be less diverse in habitats invaded by bitou bush because it reduces the diversity of plant species and thus food options (French and Zubovic 1997). Also, large predatory birds such as raptors are less abundant around bitou bush habitats. This may be because their ability to hunt for prey is hindered by dense bitou bush foliage or because there is a reduced amount of prey in the invaded habitats.

There are fewer ants, spiders and millipedes under bitou bush than would be found in comparable uninvaded habitats. These are the invertebrates that are favoured by warm and dry conditions. The more common species in bitou bush invaded habitats are the moisture loving, decomposer species such as worms and slaters. Higher proportions of these species, which are suited to the shade induced microclimate under bitou bush, are likely to increase the rate of nutrient cycling (French and Eardley 1997).

Bitou bush invasions do not always have negative impacts on native animals. For example, little penguins (*Eudyptula minor*) use bitou bush as protection in the absence of other native vegetation in foreshore areas. Bitou bush also provides an additional food source to some birds when native fruits are less abundant, particularly during winter (Gosper 2004).

On the Far North Coast of New South Wales, insect-eating bird species such as fairy wrens that prefer ground level habitats readily adapt to bitou bush habitat; their small nests are frequently found when bitou bush is removed. Several species of giant skinks as well as diamond pythons also use bitou bush as habitat – skinks are protected at ground level from carnivorous predators such as domestic cats and dogs, and pythons shelter under bushes in winter.

Introduced animals have also been observed using bitou bush stands. For example, foxes often consume the fruits and rabbits, rats and mice use dense foliage as protective habitat.



Marion Winkler

Evidence of wallaby browsing on bitou bush after a fire



Glen Saunders

Rabbit scats within a bitou bush monoculture

Section Two

Planning and pre-control considerations

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Steve McRae



Marrion Winkler



Terry Inkson, Great Lakes Council

Planning and pre-control considerations

Planning is one of the most important aspects of any weed control program. Long-term success relies heavily on a planned approach, which encompasses initial control, targeted follow-up control, site restoration and monitoring. It requires you to set an appropriate time line for your work and to identify any potential collaborators, as well as the necessary resources, before you begin management activities.

A plan will help you identify the most appropriate control methods for all stages of control and the best time to use each method. This can save you time and money in the long-term by directing effort and resources to where they will be most effective. A plan will guide you towards achieving your objectives.

This section of the manual addresses the main issues you should consider when developing a management plan for your site, as well as information on where to start and a checklist (in a chronological order) to help you prepare a plan. This manual is not the sole source of information and other texts should be referred to where appropriate. For example, a good resource is the *Introductory Weed Management Manual* (available by download from www.weedsrc.org.au); the *NSW Bitou TAP* has a section on site planning specifically for biodiversity conservation; the *NSW Bitou Bush Monitoring Manual* has detailed information on site mapping and monitoring; and *Ask First: a guide to respecting Indigenous heritage places and values* can also be useful (see Section 8 for resource information).

Eradication or containment?

 **Eradication is often erroneously adopted as the objective for weed control programs. The decision to eradicate should be made only after giving consideration as to whether or not this outcome is actually achievable. Containment is generally a more achievable goal.**

Eradication is the total removal of every plant and seed from an area where there is *no potential (or very limited potential) for re-invasion*. Eradication is time consuming and labour intensive. To eradicate a weed, an appropriate time frame and resources are needed to seek out every last plant and seed and ensure that all recruitment is treated before it can set seed. For widespread weed species like bitou bush, eradication is unlikely, except for isolated populations. Thus, containment is a more realistic goal.

Containment is where control measures are put in place to restrict a weed infestation to its current boundaries, to contain spread within areas of high conservation value or to reduce core infestations. Control measures are focused on reducing spread, treating outlier populations and managing the weeds around assets like threatened species.

 **Any bitou bush management plan should be:**

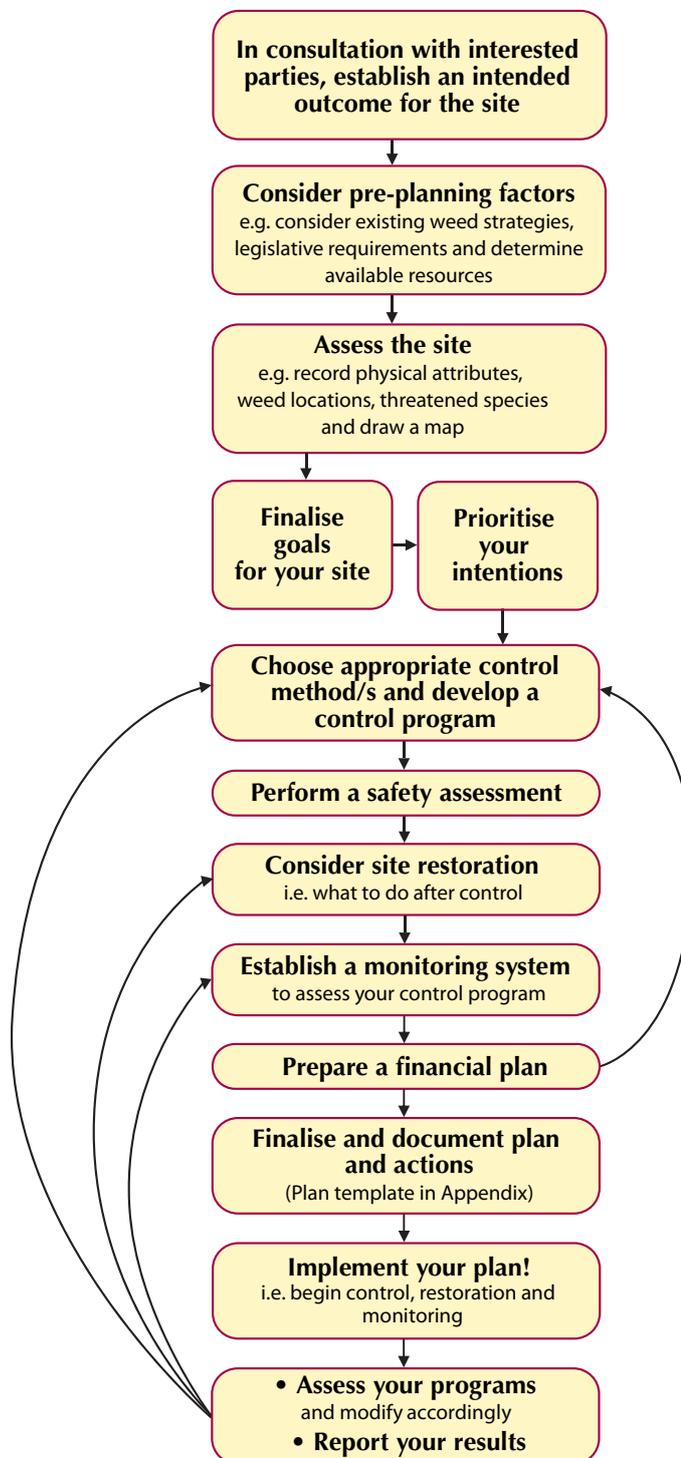
- Targeted to achieve both long- and short-term objectives,
- Able to respond to changes in the environment (e.g. fires, storms and other weeds),
- Based on immediate site conditions with respect to the broader landscape (e.g. neighbouring weed and native populations and how they may affect your program),
- Consistent with existing strategies,
- Aware of work already occurring in the community or region etc., and
- Equipped with monitoring actions.

The planning process

Where to start

- **If you are concerned about bitou bush on public land in your area**, contact either the council or local parks office and discuss with them how to become involved. They may already be doing valuable work in your area, or there may be an active community group you can join. If not and you obtain an agreement to start work at a new site on public land, your planning process needs to start at the top of the flow chart shown – the flow chart will then guide you through the planning process required to develop an effective management plan for the site.
- **If you are a private landholder or custodian of public lands and want to start work on bitou bush**, you will also need to start your planning process at the top of the flow chart shown. In addition, it is important to talk with other landholders, custodians or groups working on bitou bush in your area to see what they have done and if you can add to such programs.
- **If you become involved with an existing bitou bush control program**, there should already be a plan in place, so the planning process outlined here is only for information purposes. If there is not a plan in place then you should discuss with the program leader the need for a plan using the flow chart shown.
- **If your site is identified in the NSW Bitou Bush Threat Abatement Plan (Bitou TAP)**, you should also consult the TAP, the Bitou TAP Coordinator (bitou.tap@environment.nsw.gov.au) or the website for information on preparing plans in accordance with the TAP (www.environment.nsw.gov.au/bitoutap).

Planning flow chart



Management plan checklist

The stages outlined in the planning flow chart on page 15 are expanded here to help guide you through the planning process and prepare a site management plan.

Steps in the planning process (as per flow chart)	Short explanation about each step
<p><input type="checkbox"/> In consultation with interested parties, establish an intended outcome for the site</p>  <p>Hilary Cherry</p>	<p>Firstly, determine what you would like to achieve. It is important to establish your long-term vision at the outset and to revisit it regularly, as it will direct your approach to all areas of planning and management.</p> <p>To help establish a clear outcome, ask yourself:</p> <ol style="list-style-type: none"> 1. Why are you managing the site? 2. What are the long-term goals? 3. What are your expectations? 4. What will the end result look like? 5. Why control bitou bush specifically? <p>Managing bitou bush in isolation may not necessarily lead to your desired outcome. Thus broader and more holistic measures may be needed.</p> <p>It is also critical at this early stage that you consult with others who may have some vested interest in the site, as they may have other ideas or concerns which also need to be considered. For example, the site may be part of a broader management plan, or it may be beneficial to complement other existing programs.</p>
<p><input type="checkbox"/> Who should I talk to?</p> <p>People you may like to consult or talk to about your intentions include (in alphabetical order):</p> <ul style="list-style-type: none"> • Community Support Officers (CMA/NRM), • Local council officers (weeds or bushland), • Local Aboriginal communities, • Local and/or regional Landcare/Coastcare groups, • Local weed authority officers, • National Park rangers, and • (Other) volunteer groups. 	<p>Building working partnerships strengthens your plan and increases the possibility of success across the landscape. Collaborative partnerships may also help you to attract funding.</p> <p>To help you identify where everyone fits into bitou bush management in Australia, see the 'bitou bush network in Australia' diagram on page vii. A collection of relevant bitou bush contacts is also provided at the back of this manual for your reference, see Section 8.</p>
<p><input type="checkbox"/> Consider pre-planning factors</p>  <p>Consider existing strategies that are relevant to your site</p>	<p><input type="checkbox"/> Existing strategies</p> <p>Determine if there are any other strategies already prepared that encompass your site or control program, such as:</p> <ul style="list-style-type: none"> • Local or regional weeds strategies, • Specific bitou bush strategies (e.g. regional strategies, NSW Bitou TAP), • Conservation strategies (e.g. threatened species recovery plans). <p>Explore how your vision relates to these and how this might influence your planning and control works. Your actions may benefit not just your site, but ultimately regional and national bitou bush efforts.</p> <p><input type="checkbox"/> Legislation</p> <p>Legislative requirements will need to be considered, such as:</p> <ul style="list-style-type: none"> • Appropriate use of herbicides under the relevant state pesticides acts and APVMA regulations. See Section 4 for more information on the use of chemicals. • Permits may be required to undertake work in and around threatened species under relevant threatened species/conservation acts in your state. Section 8 contains information on these acts and who to contact. • Bitou bush is listed as noxious in many areas so you will also need to know your obligations for controlling it at your site or on your property. See Section 8 for declaration details.

Steps in the planning process (as per flow chart)

Short explanation about each step

Determine available resources



Barry Sullivan, Qld DPI&F

Finances and other resources such as person hours and equipment may determine the type and amount of work you can undertake on your site. Determine how much money and what resources you have, so that you can appropriately match your actions on the site with the available resources.

Talk to people about the cost of various management options before you establish your plan (see 'who should I talk to?' page 16). Plan to expand your resources over a time frame suitable for your goal.

Seeking additional resources

Community grants and government funding opportunities are available in different forms. Preparing a funding application may take some time but having a sound plan will greatly increase your chance of a successful application. See Section 8 for funding opportunities.

Assess the site



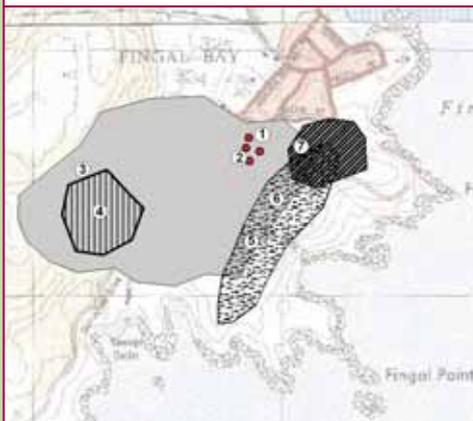
Hillary Cherry

To help you plan your weed control activities, carry out a site assessment of the area you intend to manage. The site assessment will help you to:

- Accurately target weed control,
- Determine habitats that may require specific control methods,
- Allocate time and funds according to what's there (e.g. amount of bitou bush),
- Identify the location of other weeds, and native species at risk from bitou bush,
- Prepare for follow-up control, site restoration and monitoring,
- Identify any other important issues (e.g. safety, access, cultural heritage sites),
- Identify the locations of existing or potential erosion 'blowouts', and
- Identify fauna habitat such as 'bird-roost' trees which may be already dead or dying but are important to be left intact for recruiting bird-dispersed natives.

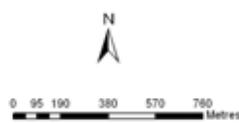
During the assessment, you will need to record information about the observations you make. Start with a site map (see below).

Map of priority weeds, threatened species and monitoring sites



Legend

- *Acronychia littoralis*
- *Zieria smithii*
- ▨ Littoral rainforest
- ▨ Bitou bush
- ▨ Lantana
- Photopoints



Prepare a site map

A map of your site is a critical component of your plan and is the basis for recording information from your site assessment. It forms the basis for planning all control activities as it shows where control areas are located, where significant environmental and cultural sites occur and sets the boundaries for your site. Your map can effectively demonstrate changes in weed location and density over time.

Your site map may be a hand-drawn 'mud map', or a map sketched over topographic maps or aerial photos, for example downloaded from Google Earth: www.earth.google.com, borrowed from the local library, council or purchased at a newsagent or map shop. Maps can alternatively be produced in a geographical information system (GIS) where the computer software is available.

Record the following on your map: natural features (cliffs, swamps, rivers etc.), built amenities, cultural sites, significant fauna habitat, significant native vegetation, bitou bush and other weed locations and density. These aspects will be located during your site assessment (see page 18 for a checklist and more details). You can use separate transparent overlays for each aspect and coloured markers can also make the map easier to interpret. Include a map legend, north orientation, and a scale.

Distinguishing discrete areas for control may be helpful, for example you might draw a line on your map around the areas you intend to target first (e.g. control stage 1). These management areas should correspond with your priorities (see 'prioritise intentions' page 18).

Steps in the planning process (as per flow chart)

 Assess the site (continued)

Marion Winkler

Contractors may be required to access remote plants on cliffs



Jeff Thomas

A carpet python amongst bitou bush and native plants



Marion Winkler

Other weeds such as mother of millions (*Bryophyllum delagoense*) may co-occur with bitou bush



Ian Burnett

Cultural heritage includes historic building sites, such as lighthouses

Short explanation about each step

 Physical attributes

Identify inaccessible and difficult-to-access areas, as you may need to engage trained contractors or other professionals to control bitou bush in such areas.

Removal of bitou bush may result in soil erosion depending on plant density and the nature of the substrate. Assessment of landform stability can be undertaken by ground survey, with reference to local soil/geology maps and consultation with appropriate authorities in your area. (Also see details in Section 3 – Managing bitou bush in different environments).

 Record threatened species

Check for locally rare or threatened fauna and flora. Contact your local council (ask for the environmental officer) or parks office. They can advise if there are records of threatened fauna or flora on your site and what permission you need to work near them. Add locations to your map for each species. The NSW Bitou TAP outlines a range of plant species and ecological communities at risk from bitou bush – not all of which are listed under legislation as threatened. Use the *NSW Field Guide to Native Plant Species at Risk from Bitou Bush Invasion* to assist with determining if such species or communities occur on your site (see page 10).

During your site assessment, if you find species listed in the Bitou TAP, contact the Bitou TAP coordinator for more information and management advice bitou.tap@environment.nsw.gov.au, and add locations to your map.

 Fauna species

It is useful to include information about native fauna at your site, regardless of whether these species are listed as threatened. This will ensure you are aware of and manage the relationship between bitou bush and native animals (both positive and negative). Add locations of fauna sightings to your map.

 Other weeds

Identify all other significant weed species present and highlight those that are likely to invade following the removal of bitou bush. Some major weeds that have been identified as commonly replacing bitou bush are listed in Section 3. Add locations to your map along with the species names and their densities – density keys are provided in Section 6, page 78.

 Management history

Make a record of the site history in relation to bitou bush control and any other historical factors that may influence your management (e.g. recent fire history, soil disturbance such as sand mining, and any revegetation or restoration works that have occurred). Where possible, mark sites on your map.

 Cultural heritage

Determine if the site holds any historical or cultural significance. See the 'who should I talk to?' item on page 16, as well as consulting with the local Aboriginal community. A valuable resource to consider is *Ask First: a guide to respecting Indigenous heritage places and values* (available at www.environment.gov.au/heritage/ahc/index.html). Also see Section 8. Add locations to your map, if appropriate.

Steps in the planning process (as per flow chart)	Short explanation about each step
<p><input type="checkbox"/> Finalise goals for the site</p>  <p>Stephen Booth</p> <p><i>Goals explicitly represent your vision for the site</i></p>	<p>Based on your site assessment and intended outcome/vision for the site, set realistic goals that focus on what you are trying to protect or restore, rather than on weed control alone. Discuss your goal with others before finalising.</p> <p>For example, your goal may be:</p> <ul style="list-style-type: none"> • Preservation/protection of threatened native species, • Protection of sacred sites for cultural heritage, • Improving visual amenity, or • Removing bitou bush to manage erosion problems. <p>Be sure you understand the difference between eradication and containment (see page 14) before setting either as a goal.</p> <p>Once you establish an objective or goal then you should consider the time frame over which you plan to achieve this goal and the exact area where this will occur.</p>
<p><input type="checkbox"/> Prioritise intentions</p>  <p>Hillary Cherry</p>	<p>Prioritise your intentions in consultation with others as well as the areas within your site for control. Your priorities might be:</p> <ul style="list-style-type: none"> • Areas containing threatened species, • New bitou bush infestations and isolated plants, • Areas for follow-up control, or • Easy-to-access areas where you are able to deliver control.
<p><input type="checkbox"/> Choose appropriate control method/s and develop a control program</p>  <p>Stephen Booth</p>	<p>Determine the best bitou bush control methods for your site for initial and follow-up treatments by using the decision matrix in Section 4. This matrix will help assess the appropriateness of each method for your site. Ensure the methods are consistent with the resources available and will meet your goals.</p> <p>Establish a long-term control program (i.e. more than three years), and schedule control and follow-up activities at the time of year they will be most effective. For more information on control options see Section 4.</p>
<p><input type="checkbox"/> Perform a safety assessment</p>  <p>Steve McRae</p>	<p>Be sure to consider the safety aspects of each control method and the work you intend to do on the site. It will be valuable to carry out a safety assessment that addresses the possible risks associated with working on slopes, in remote areas, or with chemicals, and how to mitigate against any risks. Ensure that all workers are familiar with the safety assessment each time you work on the site.</p> <p>Also include safety considerations for neighbouring residents and for visitors who may walk around or through the site whilst work is being done and, if necessary, consider temporary fencing and/or signage.</p>
<p><input type="checkbox"/> Consider site restoration</p>  <p>Jeff Thomas</p> <p><i>Revegetation may be necessary</i></p>	<p>Restoring a site may involve active measures beyond weed removal. Planning at the outset for restoration after bitou bush control is essential to ensure resources will be available to meet long-term objectives. Further details on restoration and rehabilitation methods are included in Section 5.</p> <ul style="list-style-type: none"> • Consider the need for active restoration measures with respect to your site conditions. Active restoration may only be needed if erosion is likely to be an issue, or if vegetation cover is needed for suppressing invasions by other weeds. • Consider the level of resilience of native plant species present and the need for replanting. Resilience is not easy to estimate in advance, but allow time and opportunity for the site to respond to treatment, before beginning a replanting program. • If partial or full rehabilitation is necessary then preparation for replanting may need to start one or even two years in advance of the planting. Seeds or other propagules may need to be collected from the site itself or some adjacent or similar site, then propagated.

Steps in the planning process (as per flow chart)	Short explanation about each step
<p><input type="checkbox"/> Establish a monitoring program</p>  <p>Alana Burley</p> <p><i>Monitoring can be as simple as photopoints</i></p>	<p>Monitoring is an essential component of any weed management program and thus sufficient resources need to be allocated for monitoring. Monitoring allows you to:</p> <ul style="list-style-type: none"> • Assess the effectiveness of your control measures and program costs, • Assess the rate of establishment or recovery of desirable vegetation, • Identify new weed infestations or changes to weed species compositions, • Identify any new issues that will affect your control program (e.g. erosion), • Demonstrate progress to your group or funding body, • Observe loss or gain of fauna as habitats are altered, and • Monitor erosion. <p>Good monitoring results rely on an ability to assess and analyse the data, so ensure that your monitoring program is within your capabilities (see Section 6).</p>
<p><input type="checkbox"/> Prepare a financial plan</p>  <p>Hilary Cherry</p>	<p>Assess the costs associated with control, restoration and monitoring, and develop a financial plan. There are obvious costs associated with each technique such as herbicide, spray equipment, machinery and labour. But do not forget the less obvious expenses such as protective gear, lockable storage for herbicides and training. It is important to budget over the long-term and allow for follow-up work, and monitoring and restoration.</p> <p>To save costs, check if you can borrow equipment from councils, Landcare organisations or catchment authorities.</p> <p>Natural events such as fire and high swells can affect your program. Allocating a proportion of your budget for unexpected circumstances (they will happen) and building flexibility into your work plan can help you cope with such events.</p>
<p><input type="checkbox"/> Finalise and document plan and actions</p>  <p><i>A site-plan template is provided in the Appendix</i></p>	<p>This is the final stage of your planning. For your reference, a blank site management plan template is provided in the Appendix, which can be used to help finalise your plan and intended actions on paper.</p> <p>If your site contains species listed in the NSW Bitou TAP, you should consult the TAP which includes a site management plan proforma specifically for biodiversity conservation. If your site is specifically identified in the Bitou TAP then you will need to use the appropriate proforma from the TAP; contact bitou.tap@environment.nsw.gov.au for an electronic copy.</p>
<p><input type="checkbox"/> Implement your plan</p>	<p>You are now ready to put your plan into action!</p>
<p><input type="checkbox"/> While your plan is being implemented... Assess your programs and modify accordingly</p>	<p>Each year you should assess your programs (control, monitoring and restoration) to establish how effective your actions were towards achieving your goal. This will include analysis of your monitoring data as well as other information you might collate during the year.</p> <p>If your actions don't seem to be achieving the goal, then you might need to revisit the priorities or revise your control methods or restoration options.</p>
<p><input type="checkbox"/> Report your results</p>  <p><i>Public awareness can generate support</i></p>	<p><input type="checkbox"/> Reporting It is important to report your successes or failures to funding bodies, your relevant agency contacts such as local council or national parks office, as well as all the stakeholders identified at the beginning of your planning process. Check with them about important reporting dates. If you are working with a scientific licence, check reporting requirements.</p> <p><input type="checkbox"/> Raising awareness Raising awareness of your work is an excellent way to maintain momentum and gain interest from the general public. See Section 8, under information for community volunteers, for more ideas on communication with the local community.</p>

Section Three

Managing bitou bush in different habitats



Terry Intison, Great Lakes Council



Paul Downey



Marion Winkler

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Habitats invaded by bitou bush

Bitou bush invades a range of native habitats. Habitat type will influence the control options available, as some methods may have negative impacts if used in some environments.

In all native habitats, control and management must:

- Minimise damage to desirable vegetation,
- Minimise soil disturbance,
- Encourage native plant regeneration, and
- Treat bitou bush at a rate that allows for natural regeneration or restoration processes to occur.

This section describes the major habitats invaded by bitou bush, along with corresponding management considerations. This information is best used in conjunction with the control methods outlined in Section 4 and restoration options in Section 5.

Coastal sand dunes

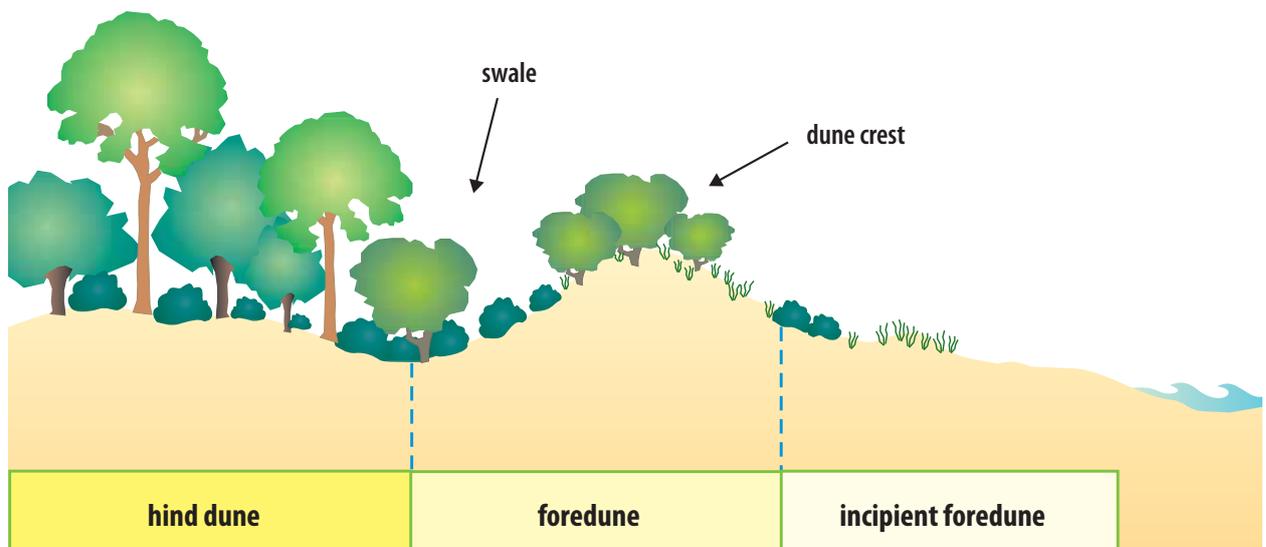
Coastal sand dunes run parallel to the shoreline as a series of crests and swales (parallel depressions) above the high-tide mark, often stabilised by vegetation. There is a succession of vegetation from the incipient foredune into the hind dune woodland areas, which are protected from salt spray and wind

erosion by the preceding vegetation. While native plants are generally specific to one part of the dune system (e.g. spinifex grass is restricted to foredunes, banksias mostly in hind dune woodlands etc.), bitou bush is able to invade across the dune landscape.

Mineral mining in sand dunes drastically altered the original structure of many coastal dunes. *“In many areas, the natural dune structure has been lost; there is no incipient foredune left, no dune crest, no hind dune – there is just sand.”* – Peter Gollan, Hallidays Point Landcare.

Foredunes

The foredune is the first sand dune at the back of the beach beyond the high-tide mark. Transient, windblown sand may accumulate immediately seaward of the established foredune and form a small bench or platform (incipient foredune) which is highly susceptible to erosion by wind and wave action. The vegetation community on the foredune of strandline plants leading into woody shrubs is highly dynamic and is affected by coastal changes.



Typical coastal dune profile from incipient foredune through to hind dune. Figure replicated with permission from *Coastal Dune Management: A manual of coastal dune management and rehabilitation techniques* (NSW DLWC 2001)

The dune crest (the peak or ridgeline between two parallel low lying areas of sand) may not be very high in elevation (i.e. <1 m), although it may reach up to 6 m. Dune crests protect hind dunes and the associated vegetation from wind erosion and salt spray. Thus the height of the crest may influence the height of the vegetation in the swale or hind dune.

Hind dunes

The hind dune consists of a series of ridges and swales inland behind the most seaward dune. Generally, the hind dune area has high native species richness, compared with foredune areas. Hind dune vegetation communities include banksia woodlands, casuarina woodlands, littoral rainforests and coastal heaths.

Hummocks

Bitou bush plants that colonise dunes can lead to the formation of 'hummocks'. Hummocks are isolated mounds of sand held together by bitou bush roots which form when sand is trapped around the base of the bitou bush plant. The ability to produce roots at the nodes on decumbent stems enables bitou bush to grow over the accumulated sand, enhancing the mounded growth form.

As the hummocks start to form, wind is channelled through gaps between the hummocks, causing erosion. This in turn increases the height of the hummocks. Often the original native species have long since died out of the seed bank, or been eroded away and do not recolonise the exposed sand.



Jeff Thomas

Coastal heath

Heath is a low growing vegetation community, averaging a height of 50 cm (with emergents to 2 m), often in exposed areas or on shallow soils. There are several coastal heath communities that are invaded by bitou bush including headland heath (pictured below). Heath species commonly mix with littoral rainforest and *Themeda* grasslands forming 'ecotonal' alliances or mixed flora habitats.



Jackie Miles

Coastal scrub

Coastal scrub is a closed low forest community with a canopy height to 4 m that often grows on sedimentary substrates, particularly on hill slopes, or on coastal sand dunes.



Ruth Armstrong

Littoral rainforest

Littoral rainforest is a unique community of low rainforest, heavily influenced by coastal forces. Littoral rainforest typically occurs within close proximity to the beach, in many instances right behind the foredune where sandy soil is highly visible, or on headlands. Plants that grow on the windward side protect the interior of the forest from salt spray and excessive winds.



Shane Ruming

Woodlands

Coastal woodlands are plant communities dominated by tree species, often *Banksia*, *Eucalyptus* or *Casuarina* species with a shrub understorey, which occur on deep sandy soils in hind dunes or on headlands.



Deb Stevenson

Headlands and steep slopes

Coastal headlands are rocky, exposed areas usually with steep cliffs that drop to the ocean. Tops of headlands are often characterised by open grasslands, heathlands or shrublands. The steeply sloping areas are generally erosion-prone and difficult to access.



Mark Hamilton

Riparian areas

Riparian habitats typically occur as a strip on either side of a watercourse or around a body of water (e.g. lake or wetland). These areas include swale lagoons that run parallel to the beach and empty onto the beach through small creeks. The plant species that occur here have a higher water dependency or tolerance than those that occur outside the riparian zones. Tidal or estuarine areas (influenced by saltwater movement) support plant species that are salt tolerant.



Shane Ruming

Management considerations within specific habitats

Habitat	Considerations for management (to be used with Sections 4 and 5)
<p>Sand dunes (foredune, hind dunes, dune crests and swales)</p>  <p>Glen Saunders</p>  <p>Marion Winkler</p>  <p>Hillary Cherry</p>	<p>Sand is held in place by vegetation (including bitou bush) in these habitats. Treating or removing bitou bush from sand dunes can therefore lead to erosion via wind or wave action. To avoid major erosion events during or following bitou bush control, you can:</p> <ul style="list-style-type: none"> • Plan to remove bitou bush in stages to minimise erosion. Various patterns of staged removal have been found effective, depending on the character of each particular location. For example, treat a strip along the dunes, leaving a parallel, untreated strip adjacent to it to act as a buffer against wind erosion. This works best if run parallel to the shoreline. The rate and stages of bitou bush removal should depend on the rate of native plant regeneration. Alternatively, clear bitou bush in a mosaic or 'maze' fashion. • Revegetate (where appropriate) simultaneously with bitou bush removal to maximise dune stability, or even begin revegetation prior to weed control, particularly if dunes have been degraded from sand mining and/or long-term bitou bush invasion. • Erosion control structures or restricted access may be required, during or after bitou bush control, particularly on degraded dunes. <p>On the top of dune crests, bitou bush can protect the swale and hind dune vegetation from wind shear and salt spray, so removing it may have negative impacts on native plants in those areas. If removing bitou bush from the dune crest, either:</p> <ul style="list-style-type: none"> • Work in combination with native regeneration or revegetation activities on both the front and back of the dune simultaneously, with particular focus on the windward side of crest to enhance the vegetation barrier protecting swale/hind dune vegetation, or • Start removing bitou bush from the western (landward) edge of the densest infestations and work in stages eastwards towards the beach, always leaving standing bitou bush ahead as a windbreak, until natives have established. <p>When using herbicides on sand dunes you should:</p> <ul style="list-style-type: none"> • Be aware that sand is extremely porous and there is minimal organic matter within the dune profile. This may allow higher levels of herbicide to leach through the soil profile than in other habitats. Carefully consider the types of herbicide, application methods, and intervals between each application. • As sand dunes are highly mobile and access through dense infestation may be difficult, ensure you use equipment appropriate to the habitat. For example, a vehicle carrying a spray rig can cause less damage if it has wide-tread tyres (see Section 4). <p>Hummocks Control of bitou bush plants that have formed hummocks will require a staged approach to avoid excessive erosion. This is likely to include extensive revegetation and remedial work depending on the size and shape of the hummocks. See Section 5 and case study – <i>Staged removal of bitou bush to protect Aboriginal sites and conserve biodiversity on the Yaccaba Peninsula</i> on page 90.</p>
<p>Coastal heath and scrub</p>  <p>Paul Downey</p>	<p>Bitou bush invasions in heath and coastal scrub tend to form thickets at the same height as surrounding vegetation. When treating bitou bush in heath or coastal scrub:</p> <ul style="list-style-type: none"> • Use control methods that minimise the impact on native species and maximise native plant regeneration. • Ensure control methods will not contribute to erosion, particularly where invasions occur on headlands.

Habitat	Considerations for management (to be used with Sections 4 and 5)
<p>Littoral rainforests</p>  <p>Stephen Booth</p>	<p>In rainforests, bitou bush can climb up into the canopy in dense thickets, supported by surrounding trees. Where bitou bush has invaded the windward component of this community, it may be protecting the rest of the community from salt spray and wind shear. When removing bitou bush from rainforests:</p> <ul style="list-style-type: none"> • Stage the treatment of bitou bush on the windward edge to ensure a robust barrier remains to protect the rest of the community from salt spray and wind shear. • Within the rainforest, remove bitou bush as quickly as possible to capitalise on the rapid regeneration potential of rainforest species. See case study <i>Replacing bitou bush the natural way</i> on page 92.
<p>Woodlands</p>  <p>Paul Downey</p>	<p>Woodlands support both shrub and climber growth forms of bitou bush. When removing bitou bush from the windward sections of coastal woodlands:</p> <ul style="list-style-type: none"> • Stage bitou bush removal to allow for native plants to replace this windward edge. This will provide protection to the woodland community from salt spray and wind shear as well as protect native species at risk.
<p>Headlands and steep slopes (including sea cliffs)</p>  <p>Glen Saunders</p>	<p>Headlands and steep slopes are commonly erosion-prone. Water erosion can occur after the removal of bitou bush particularly on sloping loam and clay soils, such as headlands. When treating bitou bush on headlands and steep slopes:</p> <ul style="list-style-type: none"> • Always consider occupational health and safety guidelines during the planning stage. People with appropriate training and experience using safety equipment such as harnesses and ropes may be required on cliff faces, steep slopes and inaccessible areas. • Do not leave large areas of bare ground. Use control methods that limit soil disturbance, especially on slopes. Manual control (handweeding) should only be used on small infestations when the soil is moist to minimise further soil disturbance. Chemical control methods are the most suitable because roots remain in the ground and soil is not disturbed. • Take into account drainage patterns, and always work from the top of a slope to the bottom to avoid erosion and spreading of seed down slopes. • Aerial spraying may be an option for inaccessible headland locations (see Section 4 on control methods).
<p>Riparian areas (including tidal rivers and estuaries)</p>  <p>Marion Winkler</p>	<p>Bitou bush can grow in riparian areas including river edges, floodplains, edges of inter-dunal 'swale' lakes, outer edges of saltmarshes and mangroves. It does not grow in permanently inundated areas. When controlling bitou bush near water bodies:</p> <ul style="list-style-type: none"> • Use control methods that minimise bank erosion. Treat small areas one at a time to allow native plants to regenerate and stabilise the bank. In addition, try to prevent large amounts of plant material falling into pooled water, as large inputs of organic matter can impact on aquatic organisms by reducing oxygen levels. For these reasons, mechanical control such as slashing should be avoided in riparian areas. • Remove plants from the edge of watercourses to prevent seeds moving downstream. <p>Some herbicides contain surfactants that are toxic to aquatic organisms such as frogs. When working in riparian or wetland areas use only herbicides registered for use in aquatic situations and follow all label directions. See Section 4 for information on herbicides.</p>

Management considerations across all habitats

There are a range of broader management considerations that apply to **all** habitats and which should be taken into account when planning a bitou bush control program.

Management issue	Considerations for management (to be used with Sections 4 and 5)
<p>Infestation density</p> <div data-bbox="236 577 587 869" style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-right: 5px;">Marion Winkler</div>  </div> <p style="text-align: center; font-size: small;"><i>Outlier or small infestations</i></p> <div data-bbox="236 969 587 1261" style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-right: 5px;">Stephen Booth</div>  </div> <p style="text-align: center; font-size: small;"><i>Heavy infestations – monoculture</i></p>	<p>Outlier, small or isolated infestations</p> <p>Outlier infestations may be individual plants, or small pockets of a few plants away from a concentration or core infestation of bitou bush. These plants should be given a high priority for control and be eradicated as quickly as possible to limit further spread.</p> <p>Also:</p> <ul style="list-style-type: none"> • All outlier infestations should be mapped and monitored post-control to ensure areas are maintained bitou bush free for at least 10 years and future recruitment is prevented. • It is more cost efficient to manage outlier or small infestations before they expand. Also it is advantageous for native species as it reduces competition. Note: Locating (accessing) and controlling such plants may pose a range of management challenges (e.g. safety). <p>Heavy infestations</p> <p>Bitou bush may form monocultures or discrete (isolated) heavy infestations. These infestations can result in adverse effects such as erosion (see hummocks, page 25), soil slippage or fire in decaying stands of bitou bush.</p> <p>When controlling heavy infestations:</p> <ul style="list-style-type: none"> • Use a staged approach with intensive follow-up over a long period as well as some type of restoration. • Only treat areas where you can commit to follow-up works (i.e. ensure the area for follow-up control is manageable). Avoid the temptation to treat large areas without follow-up as it will rarely achieve long-term success, rather it can increase the problem and put native plants under additional stress by depleting seed banks. • Monocultures of bitou bush may be difficult to treat due to the density of plants. Some groups have found removing bitou bush in a strip or mosaic pattern, either by hand or machinery, to be effective. Always leave some bitou bush standing in the early stages, and preferably on the seaward side for protection against wind and salt spray erosion.
<p>Unstable soils</p> <div data-bbox="236 1570 587 1973" style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-right: 5px;">Scotts Head Dunecare</div>  </div> <p style="text-align: center; font-size: small;"><i>Sloping land and exposed soil are particularly susceptible to erosion</i></p>	<p>Unstable soils (on sand dunes, cliff faces, exposed slopes, headlands and riparian areas) are all particularly susceptible to wind and water erosion or land slips when vegetation, including bitou bush, is absent or removed. Erosion management must be considered during planning, implementation and restoration of habitats containing bitou bush on unstable soils.</p> <p>Where erosion is a risk:</p> <ul style="list-style-type: none"> • Use control techniques that minimise soil disturbance, such as those which kill the bitou bush plants but leave the roots in the soil. Bitou bush canes left standing <i>in situ</i> after control protect soil to some extent from wind erosion. • Stage your treatment of bitou bush according to the rate of native revegetation or natural regeneration so that some form of stabilisation remains constant. • Use specific methods to limit erosion (e.g. eco-logs – see Section 5).

Management issue	Considerations for management (to be used with Sections 4 and 5)
<p>Native plant species at threat from bitou bush invasions</p>  <p>Mark Hamilton Tanja Lenz</p> <p>Some of the native species at risk from bitou bush in New South Wales include <i>Cordyline congesta</i> and <i>Thysanotus juncifolius</i></p>	<p>The <i>NSW Bitou Bush Threat Abatement Plan</i> (Bitou TAP) identifies 157 plant species, three threatened plant populations and 24 ecological communities at risk from bitou bush invasions and a process for protecting them through bitou bush control. If you have one of these species, populations or ecological communities present at your site:</p> <ul style="list-style-type: none"> • Check the Bitou TAP website (www.environment.nsw.gov.au/bitoutap) or contact the Bitou TAP coordinator (bitou.tap@environment.nsw.gov.au) for further information on managing your site. If you don't know whether or not you do, the <i>Native Plant Species at Risk from Bitou Bush Invasion</i> field guide will be of assistance (Hamilton <i>et al.</i> 2008). The field guide shows photographs and gives a description of each species at risk (see page 10). <p>In all states in Australia:</p> <ul style="list-style-type: none"> • Certain activities are regulated around listed threatened species and communities under the threatened species legislation in your state. Use of herbicide around threatened species, for example, is prohibited without an appropriate licence. • If you are in New South Wales and have completed an approved Bitou TAP site management plan, you will be issued with a scientific licence to work in areas where threatened species are present. • For more information on licences and threatened species, contact the threatened species authority in your state. See Section 8 for further details.
<p>Native (and alien) animals</p>  <p>Glen Saunders Jeff Thomas</p>	<p>Bitou bush may pose a threat to a number of native animals, although the exact nature of that impact is not fully understood. Bitou bush also provides benefits (e.g. shelter, nesting sites or food) to native and alien animals. It may not be immediately apparent how birds, mammals or reptiles are utilising the habitat provided by bitou bush, but care should be taken to avoid harming the fauna that is living on your site.</p> <p>In all situations:</p> <ul style="list-style-type: none"> • Assess your site for native (and alien) animals before control. A staged approach may be required for habitat or food preservation. Also see Section 2.
<p>Depleted native seed bank</p>  <p>Glen Saunders</p> <p>Long-term disturbance can leave sites species poor</p>	<p>Bitou bush invasions can deplete native seed banks through suppression of germination and loss of seed bank viability over time, which therefore hampers natural regeneration. Degradation of habitats via sand mining, or hummock formation and sand blowouts, can also drastically alter the seed bank. In response to a depleted native seed bank:</p> <ul style="list-style-type: none"> • Assess the potential resilience of the seed bank and allow opportunities for natural germination before you consider planting. Some native species may not regenerate, depending on the ecosystem you are managing, however responsive native seed banks only become evident as plants start to emerge. Allow time for vegetation to naturally recruit after control before other methods of revegetation are applied. • See Section 5 and case study <i>Replacing bitou bush the natural way</i> (see page 92).
<p>Culturally significant sites</p>  <p>Hilary Cherry</p> <p>Cultural heritage includes historic buildings such as lighthouses</p>	<p>Sites of significant indigenous or non-indigenous (i.e. European) heritage may occur where bitou bush grows, as coastal areas hold great significance to both indigenous and non-indigenous Australians. Places of significance may include sacred sites, burial sites, middens, rock art or other sites that bear particular significance to historical events (e.g. heritage listed buildings). It is important to:</p> <ul style="list-style-type: none"> • Identify cultural heritage sites in your planning stage (see Section 2) and develop your control program accordingly. • Ask first before you begin any control work around known, or suspected cultural heritage sites – Aboriginal heritage sites will have different management priorities depending on site specifics and the desires of the local community. • If a cultural heritage site is discovered while undertaking control, contact the relevant authority, for example the local council or Aboriginal community in your area.

Managing other weeds: an holistic approach

 **Other weed species either co-occur with bitou bush or invade following bitou bush control, so it is essential to develop your bitou bush control strategy to encompass these other weeds.**

Many weeds are likely to pose a similar threat to native species and in some instances are more difficult to control (e.g. glory lily) than bitou bush. Thus, knowledge of these other weeds (e.g. their identity, ecology and density at your site), and how to control them is essential when developing your bitou bush program.

A small list of the major weeds (by region) that are known to co-occur with bitou bush is provided to help you plan for their concurrent management (see page 30).

Recognition of such weeds and their likely effect on your management program will provide valuable foresight in gauging future resource commitments and ensuring appropriate measures are put in place to control them. Three of the major weeds that invade after bitou bush control, all of which are more difficult to remove than bitou bush, are profiled below and on page 30. Consult your local weeds officer for advice on controlling these species.

Glory lily (flame lily)

Glory lily (*Gloriosa superba*), Liliaceae, is an herbaceous annual climber with perennial underground tubers and red and yellow flowers. The plant's green fruit resembles a small choko and contains up to 180 bright red, fleshy seeds, highly attractive to birds. Glory lily may form dense understorey carpets in coastal dune systems, competing strongly with native flora. It reproduces by division of the underground tubers or from seed, which may remain dormant for 6–9 months. Glory lily aggressively colonises bare soil after bitou bush control and has been recorded in densities of up to 70 stems per m². Glory lily is extremely difficult to control.



Andrew Storrie, NSW DPI

Lantana

Lantana (*Lantana camara*), Verbenaceae, is a sprawling, thicket-forming perennial shrub to 5 m high or climbing shrub to 15 m high. It produces black fleshy fruits and is spread mainly by bird-dispersed seed. Once established, plants out-compete native seedlings and can smother vegetation. Lantana poses a significant threat to native species and may be more difficult to control than bitou bush.



Pete Turner

SECTION 3: Managing bitou bush in different habitats

Ground (basket) asparagus

Ground asparagus (*Asparagus aethiopicus*), Asparagaceae, is a multi-stemmed, bushy, prostrate, perennial herb that forms a thick mat of fibrous roots spreading from a central corm. It grows particularly well in shaded areas and in low fertility, shallow, sandy soils, and is spread by bird-dispersed seeds. In established colonies, the mass of above ground foliage, together with thick mats of underground corms and roots, can suppress growth of native species. Ground asparagus is very difficult to control.



Paul Downey

Strategic practices to prevent other weeds from replacing bitou bush

Hastings Bush Regeneration Services teams on the New South Wales Mid-North Coast treat 'hard to manage' weeds first, before treating bitou bush. This allows time for the seed bank of 'hard to manage' weeds to germinate and be partially reduced before tackling the infestation a second time. Bitou bush is gradually removed in the second phase after the difficult weeds have been initially controlled.

Major weeds occurring with bitou bush from SE Queensland to NE Victoria

List created through discussion and stakeholder consultation at national bitou bush workshops in Feb/March 2008.

Scientific name	Common name	SE Qld to Mid-North Coast NSW	NSW Central Coast	NSW South Coast to NE Victoria
<i>Acacia saligna</i>	Golden wreath wattle	✓		
<i>Acetosa sagittata</i>	Turkey rhubarb	✓	✓	✓*
<i>Anredera cordifolia</i>	Madeira vine	✓	✓	
<i>Araujia sericifera</i>	Moth vine	✓		
<i>Asparagus aethiopicus</i>	Ground asparagus	✓*	✓*	✓*
<i>Asystasia gangetica</i>	Asystasia		✓	
<i>Bryophyllum delagoense</i>	Mother of millions	✓	✓	
<i>Cestrum parqui</i>	Green cestrum		✓	
<i>Cortaderia jubata</i>	Pampas grass		✓	
<i>Euphorbia cyathophora</i>	Painted spurge	✓		
<i>Euphorbia paralias</i>	Sea spurge			✓
<i>Gazania linearis</i>	Gazania		✓	
<i>Gloriosa superba</i>	Glory lily	✓*	✓*	
<i>Ipomoea cairica</i>	Coastal morning glory	✓		
<i>Ipomoea indica</i>	Morning glory, mile-a-minute	✓		
<i>Lantana camara</i>	Lantana	✓*	✓*	✓*
<i>Lilium formosanum</i>	Formosa lily		✓	
<i>Macroptilium atropurpureum</i>	Siratro	✓		
<i>Ochna serrulata</i>	Ochna, Mickey mouse plant	✓		
<i>Opuntia stricta</i>	Prickly pear	✓		
<i>Passiflora suberosa</i>	Corky passion flower	✓		
<i>Passiflora subpeltata</i>	White passion flower	✓		
<i>Polygala myrtifolia</i> var. <i>myrtifolia</i>	Polygala	✓	✓	✓
<i>Senna pendula</i> var. <i>glabrata</i>	Senna, winter senna, winter cassia	✓		✓
<i>Yucca</i> sp.	Yucca/agave	✓		
	Grasses – various	✓		

* Weed considered as one of the top three major weeds occurring with bitou bush.

Section Four

Control methods



Alan Kwok



Terry Inkson, Great Lakes Council



Hillary Cherry

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Manual methods	34
Chemical methods	37
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Comparison of control methods	58

Plan before you control

It is critical that you plan your control program thoroughly before undertaking any control activities. *Have you conducted appropriate planning and prepared a site management plan?* Information to help you prepare a management plan for bitou bush is provided in Sections 2 and 3.

Key control considerations

1. Choose appropriate methods

Choose appropriate control methods for your site according to the terrain, habitat, sensitivity of your site, the size and density of the bitou bush infestation and the objectives of your management plan. For example, if you are managing for biodiversity, use the control method and time of application which coincides with the least vulnerable growth stage of the native species you are trying to protect.

Which method should I use?

There are many methods available to control bitou bush. They vary in cost, not all are applicable in every situation, and all have advantages and disadvantages. The choice of method will be dependent upon your resources, the specifics of your site and the objectives of your management plan (see Section 2). Thus selecting an appropriate control method for each situation may be challenging.

To help you decide on an appropriate method, a decision matrix has been created (see page 33) which assesses the appropriateness of each control method within each habitat type invaded by bitou bush (see Section 3 for habitat descriptions and environmental considerations).

2. Integrate methods

Often the most successful and cost-effective approach to controlling weeds is to combine or integrate several control methods over time – known as integrated weed management.

An integrated approach does not need to be complicated. It may be as simple as using different methods for initial and follow-up control – for example, mature plants might be treated with a herbicide application, whilst the seedlings that subsequently germinate might be handweeded.

3. Follow-up what you started

One of the greatest contributors to the success of any bitou bush control program is commitment to an appropriate follow-up control program. Often the initial control is undertaken over too large an area for follow-up control to occur, or follow-up control is not maintained for sufficient time to achieve a successful outcome. Post-control germination of bitou bush can be high initially, however sustained control of these seedlings, over several years before they mature and set seed, can greatly reduce numbers and the size of the seed bank. Exhausting the seed bank may take a decade or more, hence follow-up activities will be needed over this period. Also consider potential ongoing re-infestation particularly through birds bringing in seeds from neighbouring untreated infestations.



Stephen Booth

Control method decision matrix

To choose an appropriate method, identify the methods suitable for your habitat type (below). Then, read about how to apply each method (following pages) and compare their advantages for your situation (page 58) before you finalise your decision.

		Control method										
		Hand weeding	Crowning	Cut-and-paint	Stem injection / scrape-and-paint	Foliar spraying	Splatter gun	Aerial boom spraying	Aerial spot spraying	Mechanical methods	Fire	Biological control
Page		34	35	42	43 / 44	45	47	48	50	51	52	55
Habitat type #	Foredures	22	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
	Dune crests	22	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
	Hind dunes	23	✓	✓	✓	✓	✓	○	✓	○	○	✓
	Coastal heath and scrub	23	✓	✓	✓	✓	✓	○	✓	○	○	✓
	Littoral rainforest	24	✓	✓	✓	✓	✓	✗*	✗*	✗	✗	✓
	Woodlands	24	✓	✓	✓	✓	✓	○	○	○	○	✓
	Headlands	24	✓	✓	✓	✓	✓	✓	✓	○	○	✓
	Steep slopes	24	○	○	○	○	✓	✓	✓	✗	✗	✓
	Riparian areas (incl. tidal rivers & estuaries)	24	✓	✓	✓	✓	○	✓	✗	○	✗	✓
Management issue #	Outlier, small or isolated infestations	27	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓
	Heavy infestations	27	✓	✓	✓	✓	✓	✓	✓	○	○	✓
	Unstable soils	27	○	○	✓	✓	✓	✓	✓	✗	✗	✓
	Native species at threat from bitou bush	28	✓	✓	✓	✓	○	○	○	✗	○	✓
	Depleted native seed bank	28	✓	✓	✓	✓	✓	✓	✓	✓	○	✓
	Culturally sensitive areas	28	○	○	○	○	○	○	○	✗	○	✓

Described in Section 3.

✓ Suitable control method.

✗ Control method NOT RECOMMENDED.

○ Further considerations are required – see specific description of the method along with the advantages/disadvantages of the method before using it.

* Aerial boom or spot spraying of littoral rainforest is NOT LEGALLY PERMITTED in New South Wales because it is an Endangered Ecological Community (see Section 8 for information on the *NSW Threatened Species Conservation Act 1995*).

Detailed overview of control methods

Manual methods



Handweeding
page 34



Crowning
page 35

Chemical methods



Cut-and-paint
page 42



Stem injection / scrape-and-paint pages 43 / 44



Foliar spraying
page 45



Splatter gun
page 47



Aerial boom spraying
page 48



Aerial spot spraying
page 50

Other control methods



Mechanical methods
page 51



Fire
page 52



Biological control
page 55

Manual methods

Manual control methods use no tools or only hand tools – methods include handweeding and crowning.

Handweeding

Bitou bush has a relatively shallow root system with no taproot, therefore seedlings and young plants can be pulled out by hand without the need for tools – this is called handweeding (or handpulling).



Grasp the stem close to the ground

Hilary Cherry

Applying the method

For small seedlings, take hold of the stem at ground level and pull out vertically. The young stem bends abruptly at almost 90 degrees after it enters the soil and the plant tends to break at this point unless extracted slowly. Young plants should ideally be removed before they first flower and set seed.

Larger plants should be rocked backwards and forwards gently until they come away cleanly, or use a leverage tool (e.g. the 'Peter Lever'). In areas of heavier soils you may need to wait until the soil is moist (i.e. after rain). Adult plants should ideally be removed when they are not in fruit to limit the spread of seeds.

It is important to replace any disturbed soil as you go to reduce erosion and encourage regeneration of native seedlings. Plants must be left to decay on site; it is illegal to transport bitou bush in all Australian states

and territories (see Section 8). Branches can be cut to form a mulch layer which may be beneficial in sandy or exposed areas (see page 67). Ensure the roots are not left in contact with the soil to prevent re-establishment. Dead plants can help you to locate areas for follow-up. Follow-up will be required to control recruitment of bitou bush seedlings.

Timing

Any time of the year.

Suitability of the method

Plant age – seedlings and young plants.

Habitat type – any, except where bitou bush roots are stabilising soils (e.g. cliffs or steep dune faces); ideal for natural areas.

Size of infestation – isolated infestations, scattered plants or infestations that cover a small area.

Advantages

- Causes no or minimal damage to desirable vegetation.
- Selective (i.e. only bitou bush is removed).
- Whole plants are removed preventing regrowth.
- Provides easy access for follow-up works.
- No chemicals or equipment required.
- Low cost.
- Applicable for use with threatened species.

Disadvantages

- Labour intensive and time consuming.
- Limitations if working with very large plants.
- Not applicable in some situations.

Crowning

The manual control method known as ‘crowning’ works by cutting the stem away from the roots below the ground level, or cutting out the ‘crown’ of the plants. This is effective as the fibrous network of roots do not regrow if the primary stem (or crown) is entirely cut out.

Applying the method

Remove all small bitou bush seedlings or other weeds and topsoil from around the base of bitou bush plants you want to treat to expose the roots. Check for native roots entangled in bitou bush roots and if present, work carefully.

Cut off higher branches to expose the stem and base, if necessary. Using loppers or a pruning saw, sever all bitou bush roots around the crown – near the base of the primary stem of the plant. Check for and cut off all heels (small pieces of stem still connected to the top of the root) on roots.

Leave plants to decay on site. Branches can be cut into lengths to form a mulch layer (see page 67). If leaving branches and foliage in the canopy, prop the cut base off the ground to prevent re-rooting.

Replace topsoil and cover disturbed area with surrounding leaf litter, if necessary. Follow-up will be required to control recruitment of bitou bush seedlings.



Marion Winkler



Ellen White

Sever roots close to the crown using loppers or a bush saw

Timing

Any time of the year.

Suitability of the method

Plant age – all plants; ideal alternative to handweeding large plants.

Habitat type – any; ideal for natural areas.

Size of infestation – isolated infestations, scattered plants or infestations that cover a small area.

Advantages

- Causes minimal soil disturbance.
- Selective (i.e. only bitou bush is removed).

- Causes no or minimal damage to desirable vegetation.
- Provides easy access for follow-up works.
- A gradual defoliation of the plant *in situ* may have benefits for the protection of native species.
- No chemicals required.
- Low cost.

Disadvantages

- Labour intensive and time consuming.
- Not applicable in some situations (e.g. on steep slopes).

'Crowning' successful on bitou bush at Dirawong Headland

The Dirawong Reserve, just north of Bundjalung National Park in New South Wales, is an example of large scale removal of bitou bush and other associated weeds using the 'crowning' method and handweeding.

Ellen White of the Dirawong Trust explains, "Because of the environmental sensitivity and cultural significance of the Dirawong, we use the 'crowning' method instead of using herbicides on bitou bush plants which are not easily pulled and may be up to 4–5 m tall. We use spot spraying by contractors only on steep, inaccessible slopes."

Ellen explains, "On the Dirawong, we have found that the manual techniques of handweeding and crowning bitou bush plants is less time consuming and expensive than the use of a cut-and-paint method. From a risk management perspective, it does far less environmental damage than ground or aerial spraying. It also has the advantage of instant accessibility for follow-up compared to spraying and it can be used in all weathers.

"In the large areas completely dominated by bitou bush, the ground is often apparently bare immediately after removal, so erosion is prevented by coverage with the uprooted bitou bush."

Local volunteers, EnviTE (Environmental Training and Employment Inc.), and people on Community Service Orders have worked on the reserve consistently since 2003. This contributed to the longer running bush regeneration program to remove bitou bush, particularly after the wildfire in 2000, so by early 2007, three kilometres of coastline were virtually bitou bush free (about 40 hectares).



Ellen White



Ellen White

At the beginning of work (above) and after control (below)

Chemical methods

When used as part of an integrated management strategy, chemicals (herbicides) can be a practical and efficient way of controlling bitou bush. Six herbicide application methods are currently registered and/or permitted for use on bitou bush:

- Cut-and-paint,
- Stem injection,
- Scrape-and-paint,
- Foliar spraying,
- Aerial boom spraying, and
- Aerial spot spraying.

Important information below is to assist you to use herbicides in a safe manner and in accordance with the relevant legislation.

Herbicide labels and legislation

The Australian Pesticides and Veterinary Medicines Authority (APVMA) controls and regulates the use of all pesticides (this includes herbicides). The APVMA approves the use of herbicides to control a weed and sets the label recommendations. By law, only herbicides registered for bitou bush control (by the APVMA) can be used on bitou bush, and only in the manner specified on the label. Keep a written record of all herbicide use.

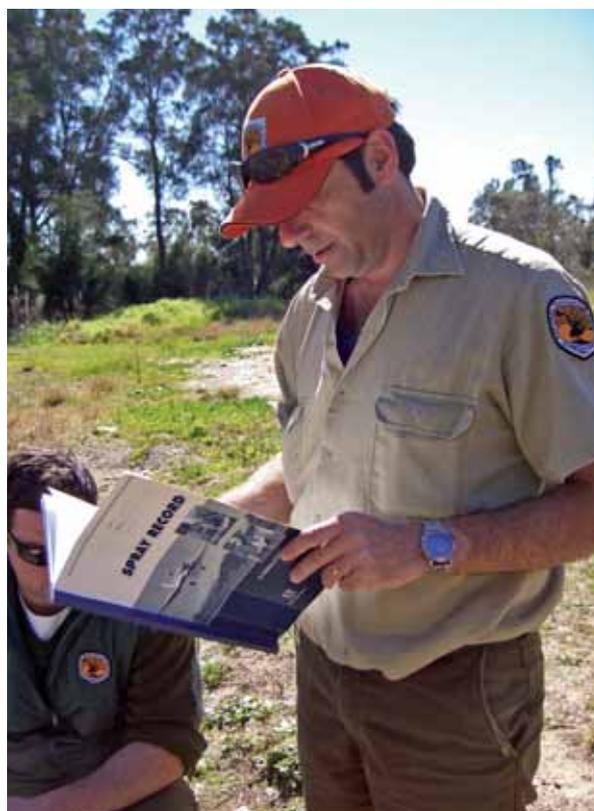
Because new chemical products are registered on a regular basis and existing chemicals are reviewed routinely, you should check the APVMA website regularly to ensure you are not breaching any laws (www.apvma.gov.au). A search engine for registered herbicides is also available at www.pestgenie.com.au.

The APVMA also issues permits for herbicide applications that are not otherwise registered, these are often referred to as 'off-label' permits. A variety of off-label permits for bitou bush control are held by government departments and individuals and can be used by other individuals or groups with permission from the permit holder. See the APVMA website for more information.

Be aware of legislation in your state regarding herbicide use – for example, some chemicals

are restricted in certain states or in specific areas of the state. Herbicides must be stored in properly labelled containers, preferably in the original container and in a locked cabinet. Only chemicals that are registered for use in aquatic situations may be used in and around aquatic areas.

 **By law, you must read the label (or have it read to you) before using any herbicide product. Always follow the label instructions. The same applies for off-label permits.**



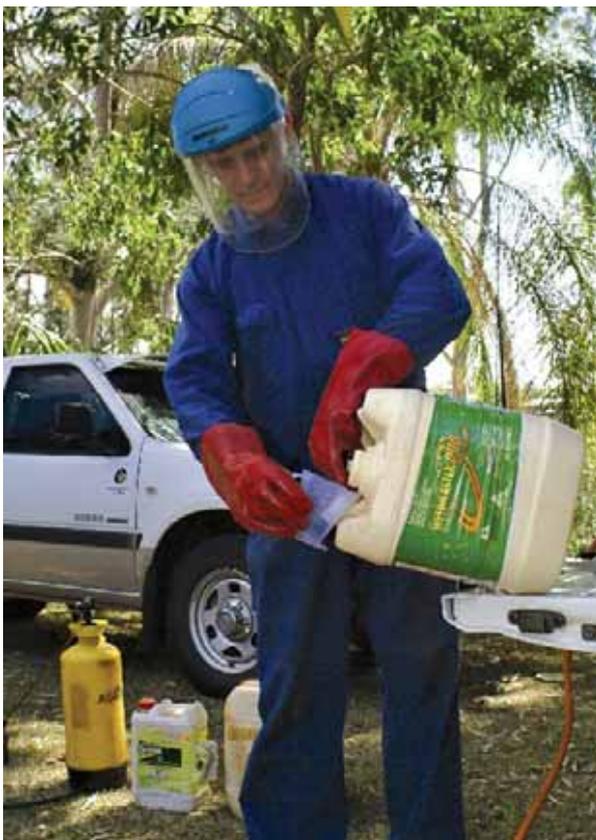
Marion Winkler

All herbicide use should be recorded in a record book

Safety and training

Personal protective equipment (such as protective clothing, eye or face shields, and respiratory protection) must be used in accordance with the recommendations stated on the herbicide label or permit. Chemical use training is required for people using herbicides as part of their job or business. Training is

recommended for community groups and may be required if working on public land. Training courses are run by ChemCert and TAFE in each state. Other training courses may be available through state agencies (e.g. AgTrain in Victoria, SMARTtrain in New South Wales, and AgForce in Queensland), local councils or non-government organisations (see Section 8).



Mick Richards

Wear personal protective equipment when using herbicides

Registered herbicides

There are many different herbicide products registered for use on bitou bush. It is important to check that each herbicide product is registered in *your* state or territory for the particular application method you are planning to use.

The table on page 40 lists the herbicides registered for use on bitou bush and the states in which these registrations apply. Herbicides that are not registered for use on bitou bush but which have off-label permits covering

their use are also shown. Check the APVMA website for current registration and permit information (www.apvma.gov.au), and always check the label for the correct application rate.

It may be beneficial to choose herbicides that can treat multiple weed species at one time. For information on which herbicide is most appropriate in your patch, contact your local weeds officer.

The active ingredients in herbicides registered for use on bitou bush are glyphosate, metsulfuron methyl, picloram, 2,4-D amine and bromoxynil; some of these are used in combination. The characteristics of the most commonly used herbicides are described below. This information does not imply any recommendation of a specific herbicide, and individual site requirements must be considered when choosing a herbicide.

The information below comes from *The Pesticide Manual* by C. Tomlin, published in 2003 by the British Crop Protection Council and relevant herbicide labels (for these herbicide labels see the APVMA website).

Glyphosate

Glyphosate is a non-selective herbicide (it targets both grasses and broad-leaved plants) that is absorbed through leaves and green stems and then moves rapidly (translocates) to actively growing parts of the plant. It is usually applied diluted in solution to the leaves, or neat (100% strength) to cut stems. The herbicide then interferes with the formation of amino acids which are essential for the growth of plant cells. The particular amino acids disrupted are present in plants, fungi and bacteria, but not in animals.

Glyphosate is rapidly deactivated on contact with the soil because it binds to soil particles. It is broken down in the soil by microbial activity. The average half-life of glyphosate in soil is 32 days (half-life is the time taken for the concentration of herbicide to be halved). The rate of decomposition depends on temperature, soil moisture and the organic matter content of the soil.

Success using glyphosate

Numerous Bushcare and Coastcare programs have consistent success using glyphosate in their control efforts. Volunteers who are trained in the safe use of chemicals find “glyphosate is effective, has few restrictions on its use, is cost-effective and requires less safety training than other chemicals, making it ideal for use by community groups”. – Peter Tucker, Technical Officer with *Bush for Life*.

Metsulfuron methyl

Metsulfuron methyl is a selective herbicide (it targets only broad-leaved plants) that is absorbed through both roots and leaves. It is usually applied in solution to the leaves, then moves rapidly through the plant (translocates) and inhibits the enzyme required for the production of amino acids necessary for cell division. The particular enzyme affected is not present in animals.

The residual activity of metsulfuron methyl varies with soil type, soil pH and organic matter. The soil activity of metsulfuron methyl may be reduced by the presence of high carbon levels following fires. Metsulfuron methyl is broken down by microbial activity and chemical hydrolysis. The average half-life of metsulfuron methyl in soil ranges from five days in acidic soils to 69 days in alkaline soils. Also, leaching of metsulfuron methyl is greater in alkaline soils and sands.

Success using metsulfuron methyl

Bush regenerator Stephen Booth has had particular success using metsulfuron methyl in littoral rainforest areas. Stephen accepts the trade-off that “metsulfuron methyl can be residual for a short time in the soil, which *could* inhibit native seed germination in the short-term, but it is not likely due to the free draining sandy soils in the area”. He says, “we use metsulfuron methyl because we can use the same rate of application (1 g/10 L) all year round, plus metsulfuron methyl is effective in treating a suite of other weeds on the site, particularly where glory lily, mistflower, crofton weed, etc. are present”.

Picloram

Picloram is a selective herbicide (it targets only broad-leaved plants) which is absorbed through roots and cut stems and moves (translocates) throughout the plant. For bitou bush it is usually applied in a thick gel directly to cut stumps. It is slow-acting and can take 2–3 months for the symptoms to appear and up to six months or two growing seasons after application to completely kill the plant. The herbicide can remain active within the plant for up to two years. It affects the synthesis of proteins, disrupting cell growth.

Picloram is a very persistent herbicide. It may remain active in the soil for more than a year depending on the rate of application, soil characteristics and climatic conditions. It does not bind strongly with soil and can suppress seed germination and plant growth for some time after treatment. Picloram is degraded in soil and water mainly by microbial activity.

Success using picloram

Terry Inkson, the Noxious Weeds Inspector at Great Lakes City Council says the council chooses to use picloram in a gel application especially for volunteer use because “it is easy to apply and is a highly effective product. The thick gel form that we use also minimises spillage.” Safety is an important concern when working with volunteers. “The picloram product we use improves our OH & S” because of the gel formulation.

“We also find the use of picloram beneficial because we can purchase small (240 g) containers, that each come with individual applicator caps and herbicide labels. The small size of the container also means volunteers can use it without the need for ChemCert training, although we do provide in-house training and inductions for our volunteers on the correct techniques for use of chemicals.”

Summary of registered herbicides for bitou bush control (as at September 2008)

Application method	Active ingredient	Commercial product examples ^A	State or territory ^B	Rate	Situation (as per label/permit)	Comments (PERXXXX denotes permit number)
Cut-and-paint page 42	picloram 43 g/kg	Vigilant [®]	All	Undiluted (gel form)	Native vegetation, conservation areas, gullies, reserves and parks	Apply 3–5 mm layer of herbicide gel to cut stump from 'brushbottle' supplied
	picloram 75 g/L + 2,4-D 300 g/L	Tordon [™] 75-D	QLD, NSW, VIC, SA, WA	1 L/10 L water	Pastures, rights of way, commercial and industrial areas	Apply as spray to freshly cut stump at any time of year
	glyphosate 360 g/L ^C	Roundup [®] , Roundup [®] Biactive [™] , Weedmaster [®] Duo, Nuturf Razor, Biochoice [™] 360	NSW	1:1.5 with water	Urban bushland and forests, and coastal reserves	PER9158, expires 31/3/2010 • In coastal reserves, only products registered for use in aquatic areas should be used • Best applied in winter months
		Roundup [®] , Roundup [®] Biactive [™] , Weedmaster [®] Duo, Nuturf Razor, Biochoice [™] 360	QLD	Undiluted to 1 L/12 L water	Non-agricultural areas, bushland, forests, wetlands, coastal and adjacent areas	PER7485, expires 30/6/2009 • Applicable method valid if bitou bush is woody • Paint stump immediately after cutting
	metsulfuron methyl 600 g/kg	Brush-off [®]	NSW	1–2 g/10 L water	Urban bushland and forests, and coastal reserves	PER9158, expires 31/3/2010 • In coastal reserves, only products registered for use in aquatic areas should be used • Best applied in winter months
	glyphosate 360 g/L + metsulfuron methyl 600 g/kg	Roundup [®] + Brush-off [®]	NSW	Tank mixes of 1:1.5 glyphosate + 1 g metsulfuron methyl per 1 L water	Areas of native vegetation e.g. subtropical rainforest remnants, littoral rainforest and other bushland reserves	PER9907, expires 31/3/2012 Application method valid if bitou bush is woody
Stem injection page 43	glyphosate 360 g/L ^C	Roundup [®] , Roundup [®] Biactive [™] , Weedmaster [®] Duo	NSW	Undiluted herbicide to 1:1.5 in water	Areas of native vegetation e.g. subtropical rainforest remnants, littoral rainforest and other bushland reserves	PER9907, expires 31/3/2012 Application method valid if bitou bush is woody
		Roundup [®] , Roundup [®] Biactive [™] , Weedmaster [®] Duo	QLD	Undiluted to 1 L/2 L water at 1 mL per 2 cm of hole or cut	Non-agricultural areas, bushland, forests, wetlands, coastal and adjacent areas	PER7485, expires 30/6/2009 • Applicable method valid if bitou bush is woody • Paint stump immediately after cutting
Scrape-and-paint page 44	glyphosate 360 g/L ^C	Roundup [®] , Roundup [®] Biactive [™] , Weedmaster [®] Duo	NSW	Undiluted herbicide to 1:1.5 water	Areas of native vegetation e.g. subtropical rainforest remnants, littoral rainforest and other bushland reserves	PER9907, expires 31/3/2012 Application method valid if bitou bush is woody
Foliar spraying page 45	glyphosate 360 g/L ^C	Roundup [®] , Roundup [®] Biactive [™]	QLD, NSW, VIC, TAS	5 or 10 mL/1 L water	All situations	Best results achieved when treated at peak flowering during winter. Use higher rate on plants over 1.5 m high ^D
		Roundup [®] , Roundup [®] Biactive [™] , Nuturf Razor, Biochoice [™] 360	NSW	1 mL/100–200 mL water	Urban bushland and forests, and coastal reserves	PER9158, expires 31/3/2010 • In coastal reserves, only products registered for use in aquatic areas should be used • Best applied in winter months
	glyphosate 540 g/L ^C	Roundup PowerMAX [™]	All	50–100 mL/15 L water	Around buildings, commercial and industrial areas, domestic and public service areas, right of ways, dry drains and channels only, forests and farm situations	• Best results achieved when treated at peak flowering during winter • Use higher rate on plants over 1.5 m high ^D • Do not apply to weeds growing in or over water
	glyphosate 680 g/L ^C	Roundup [®] Dry	QLD, NSW, VIC, TAS	5 g/L water	Around buildings, commercial and industrial areas, domestic and public service areas, right of ways, dry drains and channels only, forests and farm situations	Apply when plants are actively growing. Do not apply to weeds growing in or over water
	metsulfuron methyl 600 g/kg	Brushmaster	All	10 g/100 L water	Native pastures, rights of way, commercial and industrial areas	Spray thoroughly to wet all foliage
		Bushwacker [®] WG Brushkiller [™] 600, Brush-Off [®]	QLD, NSW, VIC, SA,	10 g/100 L water	Pastures, right of way, commercial and industrial areas	Spray thoroughly to wet all foliage

Application method	Active ingredient	Commercial product examples ¹	State or territory ²	Rate	Situation (as per label/permit)	Comments (PERXXXX denotes permit number)
Foliar spraying (continued) page 45	glyphosate 760.5 g/kg + metsulfuron methyl 63.2 g/kg	Cut-Out®	QLD, NSW, VIC, SA, ACT	95 g/100 L water	Pastures, rights of way, commercial and industrial areas	Spray thoroughly to wet all foliage
	picloram 75 g/L + 2,4-D amine 300 g/L	Tordon™ 75-D	QLD, NSW, VIC, SA, WA	650 mL/100 L water	Pastures, rights of way, commercial and industrial areas	Spot spray when flowering or fruiting
	bromoxynil 200 g/L	Bronco 200, Bromo 200, Bromicide® 200	VIC, TAS	160 mL/100 L water + Spraymate Activator (125 mL/100 L spray)	Pastures, roadsides and rights of way	Spot spray for young seedlings
Splatter gun page 47	glyphosate 360 g/L ^C	Roundup®, Roundup® Biactive™, Wipe-Out 360	QLD, NSW, VIC, TAS	1:29 or 1:19 with water	All situations	Use higher rate (1:19) on bushes over 1.5 m high ⁴
		Weedmaster® Duo	All	1:29 or 1:19 with water	For general weed control in domestic areas, commercial, industrial and public service areas, agricultural buildings and other farm situations	Spray thoroughly to wet all foliage. Use higher rate (1:19) on bushes over 1.5 m high ⁴
	metsulfuron methyl 600 g/kg	Bushwacker® WG	QLD, NSW, VIC, SA	1 g/L water + Spraymate Freeway (10 mL/5 L spray)	Pastures, right of way, commercial and industrial areas	Spray thoroughly to wet all foliage
Aerial boom spraying page 48	glyphosate 360 g/L ^E	Roundup®	NSW	2 L/ha	Coastal sand dunes and coastal bushland	Permit available to qualified people who hold a current pilot licence in New South Wales to apply herbicide by air. For wetlands and other aquatic areas ONLY use glyphosate based herbicides approved for use in aquatic areas
				1.8–3.0 L/ha	Coastal sand dunes	Permit available to qualified people who hold a current licence in New South Wales to apply pesticide by air and who comply with the requirements of Pesticide Order AIR-1
	metsulfuron methyl 600 g/kg	Brush-Off®	NSW	20–30 g/ha	Coastal sand dunes	Permit available to qualified people who hold a current licence in New South Wales to apply pesticide by air and who comply with the requirements of Pesticide Order AIR-1
Aerial spot spraying page 50	glyphosate 360 g/L ^E	Roundup®	NSW	0.5–1.0 L/100 L water	Coastal sand dunes and coastal bushland	Permit available to qualified people who hold a current pilot licence in New South Wales to apply herbicide by air. For wetlands and other aquatic areas ONLY use glyphosate based herbicides approved for use in aquatic areas
				1:100 with water	Natural ecosystems	Permit available to staff or contractors employed/contracted by the NSW DECC or agencies/organisations represented on regional weeds advisory boards
	metsulfuron methyl 600 g/kg	Brush-Off®	NSW	10 g/100 L water	Coastal sand dunes, bushland and grassland	Permit available to staff or contractors of NSW DECC or agencies/organisations represented on the Far North Coast or Mid-North Coast regional weeds advisory boards
				1–2 g/10 L water	Natural ecosystems	Permit available to staff or contractors employed/contracted by the NSW DECC or agencies/organisations represented on regional weeds advisory boards

^A Commercial products listed here are examples only, and many other products containing these active ingredients are registered for use on bitou bush, visit www.apvma.gov.au.

^B Products may be registered for use on bitou bush in all states and territories (shown as 'All') or only in the specific states and territories listed.

^C Products containing different concentrations of the active ingredients 2,4-D amine and/or glyphosate are also registered for use on bitou bush in various states, visit www.apvma.gov.au or www.pestgenie.com.au.

^D Some manufacturers specify using a higher rate on plants over 1.5 m high.

^E Other registered products containing 360 g/L glyphosate are included in this permit but have not been trialled in aerial spray trials for their impact on native plants.

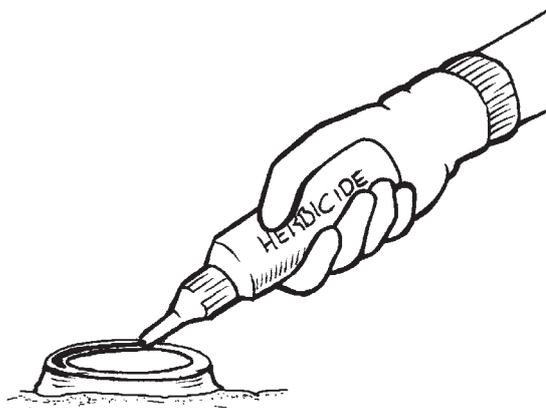
Cut-and-paint

Also called **cut-stump** or **cut-and-swab**, the cut-and-paint method involves cutting the plant off at the base of the stem and immediately applying herbicide to the stump.

 **Always read and follow all directions on the herbicide label and relevant permit, including usage restrictions (e.g. use is often restricted in wet weather).**



Kerry Brougham



Norman Yeend

Applying the method

Cut through the stem horizontally as close to the ground as possible with a bush saw, secateurs, loppers, chainsaw or brush-cutter. A horizontal cut is important so the herbicide does not run off.

Immediately (within 15 seconds) apply herbicide to the cut surface of the stump,

before the plant cells close up and inhibit entry of the herbicide.

Herbicide can be applied using a paint brush, a squeeze bottle, a sponge-tipped bottle or a spray bottle – some herbicide products even come with a special sponge-tipped attachment, see table on page 40. On large stems, apply the herbicide to the outer sapwood (cambium layer) only. Sapwood will transport the herbicide to the roots.

Leave plants on site to decay. Branches can be cut into lengths to form a mulch layer (see page 67). Follow-up will be required to target recruitment of bitou bush seedlings.

Timing

Any time of the year (weather permitting). Most effective when bitou bush is actively growing so that herbicide is rapidly transported to the roots.

Suitability of the method

Plant age – all plants; useful for plants that are too large to handweed or be crowned.

Habitat type – any; ideal for use in native ecosystems as there is limited chance of off-target damage or soil disturbance.

Size of infestation – isolated infestations, scattered plants or infestations that cover a small area.

Advantages

- Very high kill rate.
- Selective (i.e. only bitou bush is controlled).
- No soil disturbance.

Disadvantages

- Labour intensive.
- Time consuming when dealing with large infestations.
- Cannot be used in wet weather.
- May require training.
- Not applicable in some situations (e.g. on steep slopes or near cliffs without trained contractors).

Stem injection

Also called **drill-and-fill**, stem injection delivers herbicide directly to the sapwood.

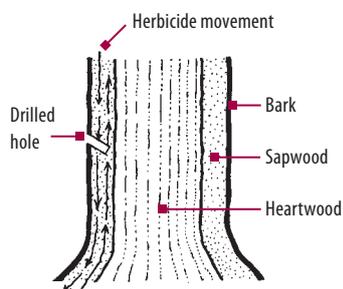
 **Always read and follow all directions on the herbicide label and relevant permit, including usage restrictions (e.g. use is often restricted in wet weather).**



Kym Smith

Applying the method

Use a cordless drill or hand drill to make holes around the base of the trunk, no more than 50 mm apart. Holes should go no deeper than the sapwood layer, as the heartwood layer will not transport herbicide around the plant.



Drill holes at a 45° angle (downwards) to aid herbicide retention by creating a reservoir. This will increase absorption by the plant. Alternatively, a chisel and hammer can be used to make a 45° angled incision down into the stem. Ensure the flat side of the chisel is facing upwards.

Inject the herbicide within 15 seconds of drilling/cutting the hole, using a squeeze bottle or plastic syringe. Do not overfill the holes. Excess herbicide can contaminate the environment. Injection guns are also available that can drill the hole and deliver a precise amount of herbicide at the same time.

Herbicide dyes can enable you to see where you have treated.

Follow-up will be required to target recruitment of bitou bush seedlings.

Timing

Any time of the year (weather permitting). Most effective when bitou bush is actively growing so that herbicide is rapidly transported to the roots.

Suitability of the method

Plant age – old, established bitou bush plants with thick woody stems that are too thick to cut-and-paint (e.g. >10 cm diameter).

Habitat type – any; particularly useful for plants that are entwined around native trees and shrubs in woodlands and rainforests (where removing the mass of bitou bush plants may damage the canopy of natives).

Size of infestation – isolated infestations, scattered plants or infestations that cover a small area.

Advantages

- Very high kill rate.
- Selective (i.e. only bitou bush is controlled).
- No soil disturbance.
- Gradual defoliation of the plant *in situ* may have benefits for the protection of native species.
- Also suitable for targeted control over a small area, when other methods are unacceptable (e.g. around threatened species).

Disadvantages

- Labour intensive.
- Time consuming when dealing with large infestations.
- Dead bitou bush vegetation remains *in situ* which may become a fire hazard.
- May require training.
- Not applicable in some situations (e.g. on steep slopes or near cliffs without trained contractors).

Scrape-and-paint

This method involves scraping away a small section of the bark and applying herbicide directly onto the sapwood. It is rarely used in the field to control bitou bush, but has been proven to be effective where used.

 **Always read and follow all directions on the herbicide label and relevant permit, including usage restrictions (e.g. use is often restricted in wet weather).**



Stephen Booth

Applying the method

Using a knife or sharp axe head, scrape a 15 cm long length of bark off the main trunk running vertically along the trunk. Only scrape off enough bark to expose the sapwood (i.e. a few millimetres deep).

Immediately (within 15 seconds) apply herbicide to the exposed surface (sapwood) using a squeeze bottle, sponge-topped applicator bottle or paint brush. Herbicide dyes can enable you to see where you have treated. Depending on the diameter of the stem, multiple scrapes may be required around the circumference of the stem. Place a few centimetres space between each scraped patch to ensure maximum herbicide uptake without ringbarking (removing a complete ring of bark and conductive tissue from the stem prevents herbicide transport to roots).

Follow-up will be required to target recruitment of bitou bush seedlings.

Timing

Any time of the year (weather permitting). Most effective when bitou bush is actively growing so that herbicide is rapidly transported to the roots.

Suitability of the method

Plant age – old, established bitou bush plants with thick woody stems that are too thick to cut-and-paint (e.g. >10 cm diameter).

Habitat type – any; it is particularly useful for plants that are entwined around native trees and shrubs in woodlands and rainforests (where removing the mass of bitou bush plants may damage the canopy of natives).

Size of infestation – isolated infestations, scattered plants or infestations that cover a small area.

Advantages

- Very high kill rate.
- Selective (i.e. only bitou bush is controlled).
- No soil disturbance.
- Also suitable for targeted control over a small area, when other methods are unacceptable (e.g. around threatened species).
- Gradual defoliation of the plant *in situ* may have benefits for the protection of native species.

Disadvantages

- Labour intensive.
- Time consuming when dealing with large infestations.
- Dead bitou bush vegetation remains *in situ* which may become a fire hazard.
- May require training.
- Not applicable in some situations (e.g. on steep slopes or near cliffs without trained contractors).

Foliar spraying

Foliar spraying is the application of herbicide solution to the leaves of a plant in the form of a fine spray. There are a number of foliar spray application techniques available, the selection of which depends on the:

- Size of and access to the infestation,
- Access to equipment and chemicals,
- Herbicide label recommendations/permits,
- Training and/or contractor availability,
- Funds, and
- Specifics of the technique relevant to your goal and site conditions.

The foliar spray application techniques available to control bitou bush include:

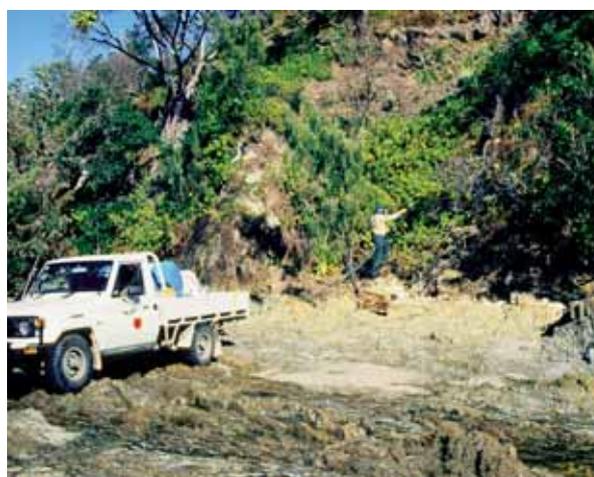
- Low-pressure spraying using a hand-held container or backpack sprayer (with either a wand or hand gun),
- High-pressure spraying using a vehicle mounted spray rig and hand gun (e.g. pump powered Quikspray® unit),
- Low-volume, high-pressure splatter gun (using either manual or gas powered equipment),
- Aerial spot spraying using a helicopter, or
- Aerial boom spraying using a helicopter.

Foliar spray application techniques use herbicides diluted in water. A range of other chemicals may also be added (e.g. penetrants, adjuvants, surfactants, wetting agents, etc.). The application rate, volume and concentration of herbicide in water varies depending on the application technique. For example, backpack spraying and vehicle mounted spray rigs apply a high volume of liquid with a low concentration of herbicide (e.g. 1:100 for glyphosate 360 g/L), while the splatter gun technique uses a low volume of liquid with a high concentration of herbicide (e.g. 1:29 for glyphosate 360 g/L).

 **Always read and follow all directions on the herbicide label and relevant permit, including usage restrictions (e.g. use is often restricted in wet weather).**



Phil Maughan



Jeff Thomas

No bitou bush-selective herbicide currently exists, so care needs to be taken not to damage desirable native vegetation by off-target spraying, over-spraying or spray drift.

Applying the method

Determine the training required and ensure you have been suitably trained. Select an appropriate herbicide and application technique. Read the herbicide label carefully and follow the instructions and any required conditions on the permits. Ensure you have adequate personal protective equipment.

When spot spraying you must ensure that the plants are sprayed thoroughly, wetting all foliage. On unstable soils, spraying areas in a patchwork fashion (e.g. leaving parallel strips unsprayed along sand dunes) can aid stabilisation and the transition to restoration.

Put in place measures to minimise spray drift and off-target damage. Consider weather conditions and only apply herbicide in accordance with the label (e.g. avoid spraying when rain is forecast). Herbicide dyes enable you to see where you have sprayed.

Follow-up will be required to target recruitment of bitou bush seedlings.

Timing

Any time of the year (weather permitting). Most effective during the peak flowering period (i.e. in winter) as bitou bush is actively growing so herbicide is rapidly absorbed through the leaves and transported to the roots. However, it is not as effective if plants are stressed by hot, dry, cold, wet or other extreme weather conditions.

Suitability of the method

Plant age – all plants.

Habitat type – any except where prohibited by legislation (e.g. threatened species legislation).

Size of infestation – the area treatable is dependant on the application technique, for example, a backpack spray unit is only suitable for small infestations or isolated plants. Larger areas can be treated with vehicle mounted spray units (e.g. quad bike, tractor or 4WD).

Protecting native species

Make sure you thoroughly check the area for native plant species prior to spraying, particularly for threatened species or those identified as being at risk in the *NSW Bitou Bush Threat Abatement Plan*.

If native species occur in the area to be sprayed, clear an area (buffer) of bitou bush away from such species using handweeding techniques prior to herbicide applications. Alternatively, small native plants can be covered with hessian or cardboard prior to spraying – ensure that these coverings are removed once the herbicide has dried.

If a native plant is inadvertently sprayed, remove the affected leaves or immediately rinse off the herbicide with water.

Advantages

- High kill rate.
- Large areas can be treated quickly.
- Not labour intensive.
- Can be used in steep or erosion prone areas.
- Minimal soil disturbance as plants are left to die *in situ*.

Disadvantages

- Risk of off-target damage.
- Cost of spray equipment.
- Cannot be used in wet weather.
- May require training.
- Successful control requires the plants to be free from coatings of salt-spray, water, dust or other vegetation (e.g. vines).
- Limitation on individual methods (e.g. backpack spraying requires the regular refilling of the tank, which increases time and costs and there may be long walking distances from the spray site to the nearest water supply).

Accessing sand dunes to spray bitou bush

Quad bikes (if registered for this use) can be used to drive over vegetated sand dunes to gain access to the hind dune to treat bitou bush. In a few instances a 4WD tractor with caterpillar tracks (or a wide-wheeled tractor) has been used. Caterpillar tracks or large tyres have the least impact on vegetation, and are least likely to cause sand compaction and erosion.

Volunteers at Lake Cathie Landcare have registered a small tractor to transport their mulching machinery which has proved more useful than a quad bike for some areas, and easier for the community group to register.

Off-target damage must be evaluated carefully before you drive over sand dunes, even though stable vegetation such as coastal wattle can recover within a short period of time. Alternatively, see *Mechanical methods* for ways of creating access pathways.

Make sure the vehicle is properly registered as there is no insurance without registration.

Splatter gun

Splatter guns administer large droplets of highly concentrated herbicide solution to target plants from a distance of 6–10 m. Due to the high concentrations of herbicide used, only a small amount of solution per plant is required for maximum effect; the herbicide translocates throughout the plant.

 **Always read and follow all directions on the herbicide label and relevant permit, including usage restrictions (e.g. use is often restricted in wet weather).**



Marion Winkler

Hand powered splattergun equipment



Marion Winkler

Gas powered splattergun equipment

Applying the method

Herbicide concentrations for splatter guns differ from that of normal foliar spray guns.

Splatter herbicide onto individual bitou bush plants in long arching vertical stripes placed

at intervals of 1–2 m. Then splatter a strip at the top and bottom of each plant, creating a square 'lattice' pattern.

Follow-up will be required to target recruitment of bitou bush seedlings.

Timing

Any time of the year. Most effective when bitou bush is actively growing (at peak flowering in winter) so that herbicide is rapidly transported to the roots. However, it is not as effective if plants are stressed by hot, dry, cold, wet or other extreme weather conditions.

Suitability of the method

Plant age – small to large mature plants; limited suitability for seedlings.

Habitat type – any; particularly within dense vegetation that is difficult to access using vehicles, or on steep slopes and cliff edges. Splatter gun is also useful on sand dunes where sand is clumping over bitou plants and part of the plant is layered under the sand.

Size of infestation – heavy infestations or scattered bushes.

Advantages

- Equipment is lightweight and portable.
- An entire plant can be treated with only a small amount of spraying effort.
- Requires minimal use of water.
- Very high kill rate for mature plants.
- Large areas can be treated quickly.
- Easy to operate in difficult terrain.
- Minimal soil disturbance.
- Reduced chance of spray drift.

Disadvantages

- Cost of spray equipment.
- Off-target damage can be amplified because of the concentrated nature of this technique.
- Cannot be used in wet weather.
- May require training.

Treating plants in difficult-to-access locations – cliff faces

1. Several people have used extension devices with foliar spray apparatus to reach plants in hard to access areas (e.g. steep area and cliff faces). These devices include an aluminium extension pole (similar to a swimming pool cleaner handle) with a sprayer attached to the end.
2. Machines with specialised attachments may also be used such as the pictured long armed tractor sprayer.
3. Another method used in steep areas is the splatter gun technique (see page 47) applied during abseiling into difficult-to-reach areas. Splatter guns can be used while abseiling because the equipment is lightweight, easy to use in difficult situations and accurate at a distance.



Dallas Gooding



Matt Craig



Marc Stettner, Apungu Ecological Management

Aerial boom spraying

Aerial boom spraying refers to the broad scale application of herbicide from a boom spray rig attached to a helicopter flying at very low altitude (i.e. 5 m above bitou bush plants).

Herbicide solution is then broad acre sprayed over vegetation from a long (12 m wide), medium (8 m wide) or mini (4 m wide) boom.

This technique (for bitou bush) was developed in New South Wales in the early 1990s after substantial trials with both bitou bush and native species (see case study *Developing aerial spraying techniques in natural ecosystems* in Section 7 for more information). These trials showed that if used in winter, a very low rate of herbicide (e.g. 2 L/ha) could control bitou bush while having limited impacts on native species. However, the actual herbicides used in aerial boom spraying are not strictly selective for bitou bush and therefore all plant species may potentially be affected.

 **A permit and specialised training is required for aerial spraying – always read and follow all directions on the herbicide label and relevant permits.**

Applying the method

Aerial boom spraying should be incorporated into a broader integrated weed management program and not used in isolation. Plan to



Terry Inkson, Great Lakes Council

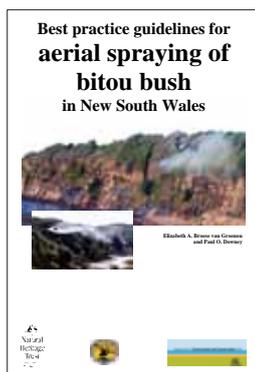
Aerial boom spraying along a beach from a 12 m wide boom

commit to long-term control over the entire treatment area as follow-up control using other techniques will most likely be required.

 **If you can't afford to manage the follow-up work in consecutive years, then you should reconsider the size of the area you intend to treat.**

Best practice guidelines for aerial boom spraying of bitou bush in New South Wales have been produced and should be used in any aerial spray program. These guidelines are in the form of a checklist of activities in chronological order from preliminary planning through to post control.

Best practice guidelines for aerial spraying of bitou bush in New South Wales can be downloaded from www.environment.nsw.gov.au/pestsweeds/BitouSprayingGuidelines.htm



Timing

Aerial boom spraying is best undertaken in winter, when bitou bush plants can be killed while limiting off-target damage to native plants.

Suitability of the method

Plant age – mature plants, but is also effective on young plants.

Habitat type – Ideal for cliff faces, rocky headlands and other hard to access areas and where bitou bush is the dominant plant, particularly where bitou bush does *not* grow under a native canopy; native plants are more susceptible to off-target damage when a protective bitou bush canopy is absent.

Aerial boom spraying in littoral rainforests in New South Wales is not legally permitted as it is an Endangered Ecological Community.

Size of infestation – monocultures, spread over large areas.

Advantages

- Large areas can be treated in a single event.
- Cost per unit area is low.
- Plants in otherwise inaccessible areas can be controlled.
- Detailed best practice guidelines developed.

Disadvantages

- Significant planning and extensive community consultation and notification required beforehand.
- Requires the closure of the areas to be treated from public access.
- Labour intensive before and on the day of operation.
- Very weather dependant, which may delay the operation.
- Helicopter availability and access required.
- Use restricted to winter months.
- Off-target damage possible.
- Contractor only.
- Public concerns over aerial spraying use.
- Extensive follow-up is required.

Impact to native species

Information continues to be gathered on the effect of aerially applied herbicide on native species. Eighty-three species (natives and weeds) have now been assessed for their response (or lack of response) to metsulfuron methyl as applied from aerial boom spraying, and 220 species have been assessed for their response to glyphosate application. Lists of the species are available within the aerial spraying guidelines, or can be downloaded from www.environment.nsw.gov.au/pestsweeds/BitouSprayingGuidelines.htm. See *Developing aerial spraying techniques in natural ecosystems for bitou bush case study* on page 95.

Aerial spot spraying

Aerial spot spraying is a relatively new foliar spraying application technique. It uses the ground based spot spraying technique, but applies it from a helicopter rather than a backpack or spray rig. This technique was developed by the NSW National Parks and Wildlife Service and uses a modified spray rig and hose and nozzle assembly protected by a cone which is suspended from beneath the helicopter. Aerial spot spraying enables treatment of individual plants or small clumps that may not otherwise be treatable due to limited or difficult access (e.g. on cliff faces).

 **Aerial spot spraying is used to treat individual plants with ground based spray rates, as opposed to aerial boom spraying which uses a specific aerial spray rate of herbicide applied across a large area.**

 **To apply this technique you need a permit and a specially trained pilot – always read and follow all directions on the herbicide label and the permit.**



NSW DECC

Spot spraying using a conical device suspended from a helicopter



NSW DECC

Applying the method

The pilot/co-pilot selects a specific bitou bush plant. The helicopter hovers over it and lowers the cone so it is as close to the target plant as possible and then the operator pulls the trigger. Herbicide covers the plant with the aid of gravity and downward wind from the rotors.

Many aspects of the aerial boom spraying guidelines also apply here (e.g. notification, helipads, limiting public access etc.).

Follow-up will be required to target recruitment of bitou bush seedlings which may require repeated aerial application.

Timing

Aerial spot spraying is best undertaken in winter, when bitou bush plants can be readily controlled, while limiting off-target damage to native plants. Mature plants are also easiest to locate and identify when flowering in winter.

Suitability of the method

Plant age – mature plants.

Habitat type – anywhere bitou bush does *not* grow under a canopy. Particularly useful for treating plants on cliff edges and steep slopes.

Size of infestation – isolated bitou bush plants.

Advantages

- Plants in otherwise inaccessible areas can be controlled.
- Very effective control can be achieved.
- Decreases safety issues with regards to treating plants on steep slopes or cliff faces.

Disadvantages

- The hose can sway and thus it may be difficult to treat the right plant.
- Off-target damage in immediate area may be high.
- Highly weather dependent, but less so than aerial boom spraying.
- Public concerns over the use of aerial spraying.
- At present this method is only employed by the NSW National Parks and Wildlife Service.
- Not suitable for treating large areas.
- Specialised equipment.
- High cost.
- Extensive planning required.

Other control methods

Mechanical methods

Mechanical methods of control involve the use of machinery such as brushcutters, or heavy machinery such as tractors, mulchers and excavators. While not commonly used in the control of bitou bush, mechanical methods have been used in a few instances.

Heavy machinery can be used to control bitou bush plants (by slashing or mulching the standing biomass) or to create access paths into areas that are otherwise difficult to reach for spraying. However, the use of such machinery can have negative effects on native plant communities and may lead to erosion.

Mechanical methods using slashing (mowing) attachments on a vehicle can be used on both live and dead bitou bush plants to reduce the biomass of standing plants, enabling faster decomposition and reducing the chance of arson in sprayed dead bitou bush. Slashing live plants also prevents further seeding. When used on live plants, the cut stumps may resprout and will need to be treated with herbicide before the next flowering period.

If you are using heavy machinery, make sure it is registered appropriately and that you are licenced to use all equipment.



Reece Luxton, Clarence Valley Shire Council

Mechanical methods (e.g. slashing) can be used to create access pathways through bitou bush monocultures

Applying the method

Heavy duty slashing equipment can simultaneously fell bitou bush plants and cut them into pieces. Slashing attachments can be

used with a tractor or purpose built machine, which is then driven over the infestation. Dead bitou bush can be mulched on site with a hand-fed mulching machine (see page 67).

Alternatively, a front end loader/backhoe can be used to deconstruct dead bitou bush material after it has been sprayed. The teeth of the bucket are turned facing the operator and the outer section of the bucket is used to flatten the bitou bush. The results are an instant rough mulched layer with less resprouting from bitou bush stumps.

There will be little regrowth from the stumps of the original infestation if it has already been sprayed, however follow-up spraying of germinating seedlings is necessary.

 **With all vehicular movement there is a risk of transporting undesirable plant species via seed, so ensure correct vehicle hygiene procedures are implemented prior to and directly after any control.**

Timing

Any time of the year, except during fruiting periods to prevent the machinery spreading bitou bush seeds.

Suitability of the method

Plant age – mainly mature adult plants.

Habitat type – mechanical slashing from a vehicle is not selective so has limited use in natural areas as it can damage native vegetation. It is also not recommended on highly mobile sand dunes. Be aware of areas that are sensitive and where the use of heavy machinery may increase the risk of erosion (e.g. only use on stable soils). This technique also has limitations in steep or hilly terrain.

Size of infestation – mechanical slashing from a vehicle is not suitable for broad scale control of bitou bush, but is applicable within monocultures of bitou bush on a scale where follow-up is feasible.

Advantages

- Can open up areas for further control.

- Less labour intensive than manual or chemical control for large infestations.
- Can be cost-effective for large infestations.
- Herbicides are not needed pre-slashing.

Disadvantages

- Follow-up effort required.
- Damages desirable vegetation.
- Can lead to erosion and/or soil compaction.
- Can open up areas quickly which may have adverse effects (e.g. increased public access or erosion).
- Machinery is expensive and can only be used by trained operators.
- Not applicable in most situations.

Fire

Fire can be used to control bitou bush, but must be part of an integrated control strategy. Fire may be very advantageous as it can kill bitou bush plants and seeds in the top 2–3 cm of soil. Fire may also stimulate germination of the soil seed bank, thus helping to deplete the seed bank more quickly. The success of fire in controlling bitou bush is highly dependent on commitment to treat the resulting germination before young plants flower and set seed. Also, even the hottest fire may not stimulate seeds below 3–8 cm, as soil is a good insulator.

☀ While it may look as though the problem has grown worse when you see a carpet of seedlings after a fire, this mass germination will significantly deplete the seed bank, but you must ensure follow-up.



Daintry Gerrand

☀ In the event of a wildfire in bitou bush infestations, all effort should be taken to capitalise on the depletion of the bitou bush seed bank. Failure to do so may lead to bitou bush out-competing germinating native species. Incorporate contingency planning in your management plan for follow-up control for several years after a wildfire.



Jeff Thomas

Spray bitou bush prior to burning to establish the fuel load



Mike Dodkin

Involve the local fire authority when planning and carrying out a prescribed burn



Hillary Cherry

Capitalise on native species germination after fires – remove bitou bush when it is still small and young

Applying the method

 **You need to consult with the local fire authorities and council in your area before considering a burn and you will need a permit to undertake a prescribed burn.**

Determine if fire is appropriate, practical or possible at your site (e.g. what will be the response of native vegetation and other weeds at the site? What are the costs versus benefits of burning/not burning?).

Develop a fire management plan in consultation with all relevant stakeholders and authorities. In many instances you may need to spray the bitou bush beforehand, as 'green' bitou bush does not burn readily.

After a fire, a protective crust is formed on the soil surface. This crust reduces erosion and retains soil moisture. Working in a newly burnt area can disturb the protective crust and cause soil compaction. Therefore delay the initial follow-up work until at least three months after burning.

Commitment to follow-up control is essential, ensure it occurs before first flowering (e.g. within six months of the fire). Follow-up needs to occur regularly each year for several years to gain the maximum benefit from the fire, so ensure the area you burn is not larger than the area you can manage to follow-up.

Fire may also be beneficial for restoration (see Section 5 for further information).

 **Note: It can be more efficient to spray regrowth after a fire, however research indicates that handweeding (or targeted spot spraying) may cause less damage to regenerating native species (French *et al.* 2008).**

Timing

Dependent on the issuing of a permit and weather conditions. Consult the relevant fire authorities and council.

Suitability of the method

Plant age – all plant ages.

Habitat type – fire is not suitable in all situations (e.g. rainforests, exposed sand dunes which may erode, or within some Endangered Ecological Communities or near threatened species).

Size of infestation – medium to large infestations where follow-up control is ensured across the entire area.

Advantages

- Can deplete the soil seed bank via seed mortality and germination.
- Stimulates germination of some native seedlings which can aid restoration.
- Can open areas to access.
- Planned use of fire can reduce the threat of undesirable arson attacks.

Disadvantages

- Not suitable in all vegetation types.
- Fire can kill native plants as well.
- Follow-up of mass bitou bush recruitment is time consuming and expensive.
- May increase erosion.
- Other weeds may invade after control.
- Weather dependent.
- Extensive planning required.
- It is not a method that community groups can carry out on their own.

Iluka Bluff and the successful use of fire to control bitou bush

Fire has been used successfully to control bitou bush on the headland at Iluka Bluff on the North Coast of New South Wales. The successful restoration was based on using fire in a manner suitable to the landform and through extensive long-term commitment to follow-up control by community members and the NSW National Parks and Wildlife Service (NPWS) staff.

Iluka Bluff had been infested with bitou bush for many years. The rocky headland, bounded in the west by littoral rainforest and in the east by coastal beaches, was covered in a near monoculture of bitou bush plants. In August 1997, the area was sprayed, leaving bands of green bitou bush as firebreaks around the few remnant trees in preparation for a controlled burn. The dead bitou bush plants were burnt three months later by NPWS staff, and the bare area brush-matted. With the assistance of Conservation Volunteers Australia and Landcare volunteers, initial plantings occurred six months later, after an assessment of soil seed bank regeneration. In June 1998, staff controlled a dense carpet of bitou bush seedlings, which were approximately 50 cm tall; few plants had commenced flowering. Subsequent follow-up has been minimal, although selective treatment of other weeds such as *Sida rhombifolia*, *Solanum* sp. and *Eleusine indica* was required to promote native regeneration in the first two years. Maintenance weeding in the area continues under the guidance of a very committed community group with NPWS support.

Growth from native plantings is extensive on Iluka Bluff and the surrounding area, and the area has been completely transformed to a thriving native plant community in less than 10 years.



Site with bitou bush before control, 1997



Six months after burn, 1998



The site in 2000



The site in 2008

Jeff Thomas

Jeff Thomas

Jeff Thomas

Jeff Thomas

Biological control

Biological control (biocontrol) is the use of a weed's natural enemies (biocontrol agents) to suppress a weed population. The aim of biological control is to:

- Suppress plant vigour,
- Reduce seed production,
- Slow plant growth, and
- Reduce the density of the weed infestation.

For more information on biological control see the CRC for Australian Weed Management website www.weedsrc.org.au/weed_management/biological_control.html.

Brief history

A biological control program to combat bitou bush and boneseed was established in 1987 which examined the insects that attacked these plants in their native South Africa to determine potential effectiveness in Australia. Following extensive host-specificity testing and approvals from AQIS, several insects have been released. To date, four of the six insect species (agents) released on bitou bush in Australia have established, with the bitou tip moth (*Comostolopsis germana*) and the bitou seed fly (*Mesoclanis polana*) now widely distributed and causing damage (see Downey *et al.* 2007 for more information).

Bitou tip moth

The bitou tip moth (*C. germana*) is a foliage-feeding insect and was the first agent to be released on bitou bush in 1989. It destroys the developing leaves, buds and flowers of bitou bush plants by feeding on new stem tips. The tip moth is now widespread in New South Wales.

At some sites bitou tip moth is attacked by two native parasites (up to 50% of the moth larvae can be killed), but in many areas it is having a significant impact on the flowering and seed production of bitou bush (Holtkamp 2002).



Larva



Adult



Plant damage

CSIRO (left and right), Tom Morley (centre)

Bitou seed fly

The bitou seed fly (*M. polana*) is a seed-feeding insect that lays its eggs into developing flower buds. The larvae feed on developing flowers and seeds, causing major reduction in seed production. The seed fly is now widespread, with flies observed from Fraser Island in Queensland to Tathra in southern New South Wales. Seed production of bitou bush has been halved in many areas.



Larva



Adult



Plant damage

Jessica Schoeman (left), Tom Morley (centre and right)

Bitou leaf roller moth

The bitou leaf roller moth (*Tortrix* sp.) is a foliage-feeding insect. It destroys the developing leaves, buds and flowers of bitou bush plants by feeding on the new stem tips. The larvae roll leaves together around a stem tip, forming an enclosed shelter in which they feed on the developing leaves, buds and flowers.

The leaf roller moth has only established at a few sites in New South Wales. Studies show that these moths establish most easily on bitou bush plants on headlands, and thus new release sites should be on headlands rather than dunes.



Royce Holtkamp, NSW DPI

Reece Luxton, Clarence Valley Shire Council

Reece Luxton, Clarence Valley Shire Council

Larval feeding shelter (top), adult (left), plant damage and larva (right)

Bitou tortoise beetle

The bitou tortoise beetle (*Cassida* sp.) is a leaf-feeding insect that attacks older leaves, which complements the damage caused by the bitou tip moth. It was first released on the Central Coast of New South Wales in 1995. However, it has failed to establish widely despite several attempts and its natural spread appears to be very slow.



Larva

Adult

Royce Holtkamp, NSW DPI (both)

Biocontrol agents and other control techniques

Biocontrol alone will not remove bitou bush. These insects need to be used as part of an integrated approach to bitou bush control. When developing your control program where these insects have established, leave patches of bitou bush as nurseries so the insects can rapidly attack any bitou bush recruitment following control. Conventional control methods may still be undertaken.

Redistribution of bitou bush biocontrol agents

Anyone can help in the redistribution of bitou bush biocontrol agents in the field by deliberately moving insects to a new location. The leaf roller moth is relatively easy to locate and redistribute. Given that the tip moth and seed fly are already widespread, redistributing them is of limited use.

Firstly you need to be familiar with all the biocontrol insects, then collect as many as you can find, up to about 100 if possible (it is best to collect numerous individuals, to ensure you have a collection of breeding pairs and genetic variety). The leaf roller moth and tip moth can be easily confused in the larvae stage so you might need to wait to confirm identification when they become adults.

Larvae of the leaf roller moths can be found on the tips of stems, inside a white webbing (the larval feeding shelter) or crawling over the tip foliage or stems. Cut leaves or branches carrying the larvae off the infected plant, and store these branches in a cool, shaded container, for example an esky, prior to transportation.

Carefully transport the larvae directly to a new site prior to any wilting of the bitou bush branches, and lay branches over uninfected bitou bush plants. Be sure to place them in the same situation (i.e. for the leaf roller, lay them onto newly forming stem tips). The larvae are mobile and quickly move off the dying branches onto the new food source.

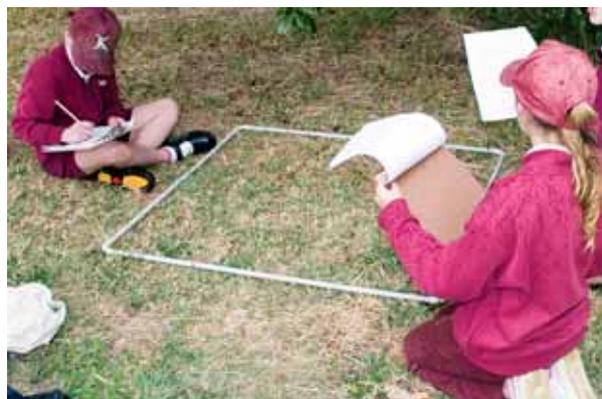
 **Notify the land manager or local council weeds officer if you plan to redistribute bitou bush biological control agents so that a record can be kept of how far the insects have been transported.**

Weed Warriors

Weed Warriors is a program developed to engage school children in weed issues. Students rear biocontrol agents in the classroom and then release them on weed infestations in their community. Your local primary school can become involved in this program by contacting the *Weed Warriors* coordinator in your state (see Section 8). A *Weed Warriors* program has recently begun for bitou bush using the bitou leaf roller moth in New South Wales.



Centre for Learning Innovation



Centre for Learning Innovation

Weed Warriors is an extensive education program involving school children



Leaf roller (*Tortrix* sp.) caterpillar

In addition to *Weed Warriors*, an integrated educational resource called *Weeds Attack!* is available to teach children about biocontrol and other weed issues. See the case study on *Weed Warriors and Weeds Attack!* on page 80 for further details.



Comparison of control methods

Once you have identified appropriate methods for your habitat type (see page 33 and the specific control methods), use the summary table below to compare the advantages between methods to finalise your decision.

		Control method										
		Hand weeding	Crowning	Cut-and-paint	Stem injection / Scrape-and-paint	Foliar spraying	Splatter gun	Aerial boom spraying	Aerial spot spraying	Mechanical methods	Fire	Biological control
Page		34	35	42	43 / 44	45	47	48	50	51	52	55
Advantage / disadvantage	Easy to use (minimal training required)	✓	✓	✓	✓	○	✓	✗	✗	✗	✗	✓
	Minimal equipment required	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓
	Low or no off-target impacts	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓
	Low level of soil disturbance if done carefully	○	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
	Suitable for community groups	✓	✓	✓	✓	○	○	✗	✗	✗	✗	✓
	Covers large areas quickly	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	n/a
	Can be used in all weather	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓
	Follow-up required	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Enables access for follow-up control	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗
	No or limited growth if applied properly	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	n/a
	Applicable in inaccessible areas	✗	✗	✗	✗	○	○	✓	✓	✗	✗	✓
	Bitou bush dominance replaced gradually	○	✓	○	✓	○	○	✗	✗	✗	✗	✓

✓ Yes.

✗ No.

○ Dependant on situation and scale of infestation – see specific description of the method along with the advantages/disadvantages of the method in respective environments before using it.

n/a Not applicable.

Section Five

Linking control with restoration



Terry Inkison, Great Lakes Council



Jeff Thomas



Stephen Booth

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Follow-up control

Definitions

Bush regeneration

The practice of restoring bushland by focusing on re-instating and re-inforcing the system's ongoing natural regeneration processes (mainly via minimal impact control).

Control

The active treatment or management of weed species (to prevent or reduce their further impacts).

Natural regeneration

The germination of native plants from seeds or propagules without human intervention, leading to self-sustaining populations.

Rehabilitation

The returning of land to a pre-determined, stable condition which blends with the surrounding landscape, but not necessarily to its original form or land use, often requiring major works.

Resilience

The ability of the native vegetation to recover after disturbance events such as clearing, or long-term suppression (e.g. from weeds).

Restoration

The returning of degraded habitats to an approximation of the natural condition or an agreed condition.

Revegetation

The re-establishment of native vegetation through active human involvement (e.g. planting of tube-stock or direct seeding).

Control of bitou bush alone will rarely lead to achieving your goals and thus other management activities will be needed. These may include active restoration or accommodating natural regeneration. Information is presented in this section on restoration activities and the things to consider when choosing to implement them.

Control stages

There are three stages in achieving successful bitou bush control: stages 2 and 3 involve linking restoration with control.

1. **Primary weed control** – the initial removal of all weeds, for example, adults through to existing seedlings.
2. **Secondary treatment** (follow-up control) – intensive control of the seedlings that emerge after primary weed control, as well as any resprouting of existing plants. This part of the program could take several years.
3. **Maintenance weeding** (follow-up control) – the ongoing removal of all bitou bush seedlings that establish from the seed bank or from seeds spread into the area by birds or other sources, after primary and secondary control. The level of weeding required here is low, but the duration may be long.

Follow-up control (i.e. secondary treatment and maintenance weeding) is crucial because bitou bush seedlings can continue to germinate from the seed bank for many years. The extent of follow-up control required will decrease with time if all plants are treated annually. The rate of seed bank decline is dependent on the size of the seed bank and germination rate of seeds from that seed bank.

To achieve effective follow-up control you should:

- Inspect areas within six to 12 months of primary control. Remove all bitou bush seedlings by handweeding or foliar spraying before they flower and set seed. Also treat all regrowing plants or plants missed during the primary control.
- Inspect areas every 12 months (at least) for the next three years and remove new bitou bush seedlings by handweeding or foliar spraying before they flower and set seed.
- Maintain the area free of bitou bush plants by surveying regularly for new plants. Remove all plants detected. Pay close attention to areas where seeds might collect, such as under tree roosts and along fence lines where birds perch.



Terry Inkson, Great Lakes Council

Before primary weed control



Terry Inkson, Great Lakes Council

After primary weed control, under secondary treatment

- Monitor your progress in terms of number of plants treated, costs and time spent on control, time elapsed since primary control and date that plants were last treated.

 **Revisit the intended outcome/goal for your site regularly to gauge progress.**

Impact of bitou bush removal on plant succession

An understanding of native plant succession is also important following primary weed control. Some species are early successional species (e.g. the colonisers like wattles) and will germinate first and establish fast, even becoming dominant. Other species are later successional species and will germinate and

establish over time. Thus achieving a diverse community of native plant species may require a number of years following control.

Removing bitou bush as the dominant species in an ecosystem leaves a niche to be filled by the fastest, most easily established species (primary colonisers). Often the plant species that are most opportunistic in a disturbance situation (such as bitou bush removal) are other weed species.

Other weed species may be present in small numbers before bitou bush is treated or may invade after bitou bush is removed. Your management plan (see Section 2) must encompass the management of these other weed species. Some of these species may be more difficult to control than bitou bush; a list of weeds to look out for is on page 30 in Section 3. Your efforts in controlling bitou bush may be negated if another weed species becomes dominant and requires intensive control.

Weed dynamics after fire

A controlled burn at Illuka Bluff Nature Reserve on the Far North Coast of New South Wales was effective in controlling bitou bush, however the nature of the other weeds on the site changed after the fire. In the years following the burn and subsequent bitou bush control, a low native canopy developed in more protected locations from both plantings and natural revegetation. This allowed the establishment of bird/animal dispersed weeds such as *Lantana camara*, *Rivina humilis* and *Solanum seaforthianum*, which required ongoing management.

Nevertheless, growth of native species has been extensive on Illuka Bluff and the surrounding area, and the site has now been completely transformed to a thriving native plant community. This is an important example of how ongoing holistic management is essential to management of a site as a whole after bitou bush is contained.



Paul Downey

Bitou bush and lantana co-occurring on the North Coast of New South Wales

Restoring native vegetation

Returning degraded habitats to an approximation of the natural condition, or an agreed condition, may require active restoration (via revegetation) as well as relying on natural regeneration. Deciding on which process to undertake requires an understanding of the resilience of individual plant species and the vegetation community.

 **You may wish to wait and determine the level of natural regeneration at your site before beginning any revegetation activities.**

Natural regeneration

Natural regeneration is preferable to revegetation because:

- Locally present native plant species are adapted specifically to the site or environment. Such species are also known as 'local provenance' species,
- Local biodiversity is conserved,
- Natural regeneration is far more cost-effective than revegetation, and
- Natural regeneration may lead to greater establishment success than revegetation.

Also see the case study *Replacing bitou bush the natural way* on page 92.

Determining resilience across species

The level of resilience at your site will determine the need for revegetation. Resilience of native vegetation depends on the soil seed bank and propagule characteristics (e.g. some species store their seeds in cones or other structures) and the species' ability to re-establish – either directly on site (e.g. from the seed bank) or by spreading from nearby areas.

The composition of native species present at a site (above ground) is not always reflected in the composition of the soil seed bank (below ground) and vice versa. For example, propagules of some above ground species may not be present in the soil seed bank or may be present in low numbers. This is especially so for species that hold their seeds above ground (e.g. banksia seeds are stored in cones), and those that do not possess seed dormancy mechanisms. In long-invaded sites, native species seed may only be present below ground (in the soil seed bank). Therefore, the level and diversity of natural regeneration may not be what you expect.

Dispersal mechanisms are highly significant in assessing resilience. For example, in rainforest communities, the proportion of species which can be dispersed long distances (i.e. are wind or animal dispersed) is less than 50%, and as low as 20% in sclerophyll sites (Westoby *et al.* 1990).

Unless an adult plant exists within the immediate area, species with short distance dispersal vectors (e.g. ants or gravity) may never arrive at your site by natural means.

There are a range of management activities that can be used to promote the recruitment of native species from the seed bank. For example, burning piles of dead bitou bush may stimulate native seeds to germinate.

Below is a list of situations when natural regeneration should be used, in order of resilience potential of the site. Remember, resilience may be difficult to assess at a single point in time, so consider leaving a site to naturally regenerate if it is:

1. Newly invaded, hence still has a good level of resilience (e.g. there is a diverse native seed bank and many seeding adults are still present spanning a range of native plant species),
2. Recently invaded (i.e. <5 years) and still has a native seed bank and some seeding adults,
3. Invaded but has a viable native seed bank (apparent over time) and a few seeding adults, and
4. Long-invaded, with a decreasing seed bank and few seeding adults (reassess over time).

If natural regeneration is an option at your site then you should select control methods (primary through to maintenance) that either encourage native plants to regenerate from the existing seeds or soil seed bank, or disperse in from nearby areas.

Revegetation

Where a site has low resilience, restoration will require some kind of revegetation. It is important that you assess the site to determine



Stephen Booth

Native seedling growing up through mulched bitou bush canes

the level of resilience *before* planning any revegetation activities. Revegetation may also be required if key native species are missing from your site and are unlikely to return via natural recruitment or spread, or if there is an immediate risk of erosion following bitou bush removal (leaving the site to naturally regenerate without any revegetation activities in such instances is not advisable).

When developing a revegetation program, you will need to consider:

- What native plant species are you going to use? Consideration should be given to the rare (or cryptic) species, as they are seldom replaced during restoration programs.
- Where do you intend to plant them (i.e. their position at your site)?
- How many individuals of each are you going to use (the density of planting)?
- What is the likely survival rate, and does this influence the number you use?
- What revegetation methods will you use (e.g. direct seeding versus planting of seedlings)?
- Are the species locally occurring (e.g. local provenance)?
- What vegetation type or community are you trying to replace?
- How easily can you source the seeds or tube-stock seedlings?
- Are extra commitments needed (e.g. watering of planted tube-stock seedlings, or scarification of seed)?
- What is the cost?

“Weed control (by hand) provides probably the most ideal opportunity for workers to identify at close hand the emerging native seedlings amongst the weeds. We do this every three to six months after primary clearing and monitor the gradual emergence of native seedlings as the weeds are hand-culled.” – Lee Andresen, Angels Beach Landcare.



Steve McRae

Strip planting between protective barriers of bitou bush

When choosing native plant species to replant, it is preferable that you use locally indigenous species, preferably those propagated using material sourced from the local bushland (local provenance species) or a local nursery. If possible, include the rarer (more cryptic) species, as this will help to restore natural diversity. A permit may be required to collect seed from some species – see page 106 for further information.

For detailed information on revegetation see *Bush Regeneration: Recovering Australian Landscapes* by Robin Buchanan (1989).

Revegetating sand dunes

In sand dune environments, re-establishing native coastal vegetation should be both appropriate to the geographical area and position within the dune system, and able to sufficiently provide plant cover to protect fragile dunes against wind erosion. For details on revegetation succession see the *Coastal Dune Management Manual* (NSW DLWC 2001), or check the restoration resource information on page 70.

Ensure that you target revegetation activities in both the hind dune and foredune areas simultaneously to maximise restoration and promote dune stability. You may need to start with hardy pioneer plants such as beach birds eye (*Alectryon coriaceus*) or beach spinifex grass (*Spinifex sericeus*).

To ensure stability, such plantings can be done gradually by controlling small patches of

bitou bush and then waiting for the natives to establish before moving on to the next patch of bitou bush. Alternatively, if using manual control techniques in medium or low density bitou bush infestations, plantings can be undertaken before control activities start, with control occurring after native species have established.

Ensuring success of native seedlings

When using tube-stock seedlings you may need to undertake additional steps to ensure their survival. For example, protection such as tree guards may be necessary in areas where grazing or browsing pressure from native animals is high. Other activities may include watering seedlings until they establish in the field or using water crystals at the time of planting. Water crystals must be buried wet and below the plants, otherwise when they expand they may push the plants out of the ground. Alternatively, wide strips of torn up newspaper may be soaked in water and laid inside the holes before planting. Hydrolyzers may be used if there is a hydrophobic barrier in the soil.

Timing is important for successful revegetation for both direct seeding or tube-stock plantings. Try to schedule weed control activities in your weed management plan (see Section 2) to coincide with the best time to revegetate with native plant species, for example with respect to rainfall, season and the species ecology.



Jeff Thomas

Tree guards can help to protect tube-stock seedlings planted in the field

Direct seeding

Direct seeding is the act of broadly spreading seeds onto the ground either by hand or with a machine (including by air during aerial herbicide application), for the purpose of regeneration. Direct seeding is a useful technique when soil seed banks have been heavily depleted and large scale plantings are needed.

Direct seeding is expensive because of the large amount of effort required to collect seed. Many of the easy-to-collect species such as *Acacia longifolia* ssp. *sophorae* (coastal wattle) are likely to be readily present in the seed bank and easily germinable, and hence don't need to be direct seeded.

Native seeds can be collected on site or in the nearby area, or purchased from a supplier. If collecting seed you must ensure that you have a licence and appropriate permissions from landholders to collect such seed, regardless of how common or rare the species is. It is best to check with your local nursery or bushland officer for advice on which species to use, and when, where and how to collect their seeds. Use the resource information provided on page 70.

At your site, seeds from fruiting plants may be opportunistically sown by collecting and broadcasting them as you pass by. Consider brush matting (the laying of branches carrying ripe fruit on the ground) as another option. Check with your local council for any permit requirements.

Seeds may need to be treated (e.g. scarified) prior to direct seeding so that they can germinate readily. However, the time of direct seeding is important because treated seeds rely on rainfall within a few days for the results to be most effective. Therefore you should consider treating only half of the seeds to ensure some seed is available to respond to varied weather conditions. Pre-treatment can result in immediate germination, which can also help to avoid seed predation by ants or other animals.

Treatment of seeds may not be an option for all native plant species and you should



Stephen Booth

A banksia seedling germinated on site

seek advice from a botanist or horticulturist beforehand. It is also valuable to distribute seeds after herbicide application and bitou bush defoliation, when competition with adult bitou bush plants is limited.

 **Whether through natural regeneration or revegetation, bushland restoration is a long-term process that requires an extended commitment.**

Site rehabilitation

Rehabilitation activities are often a crucial component of any restoration program. They can determine the success or failure of the program. Thus, site rehabilitation needs to be considered during the planning stage of your weed control program (see Section 2). Rehabilitation activities include: erosion control, stabilising soils and reconstructing environments (e.g. reforming sand dunes). Rehabilitation activities also need to occur in combination with control and other restoration activities like revegetation.

Managing erosion and stabilising soils

Bitou bush often occurs in erosion prone areas such as on sea cliffs and sand dunes, where erosion can occur as a result of water or wind action. Water erosion in bitou bush infestations occurs from ocean forces (e.g. waves) or from run-off following rain. Managing ocean-driven erosion is very difficult and requires an understanding of such processes. It is best

SECTION 5: Linking control with restoration

achieved in conjunction with revegetation activities. The *Coastal Dune Management Manual* may be helpful for this; also see the table on page 70 for other information sources.

Managing wind erosion in bitou bush infested areas can be achieved using shade cloth or hessian fences to reduce the loss of wind blown sand/soil from the site. On-ground control of erosion is best done using mulched plant material or hessian laid along the ground. Bitou bush mulch can also be used. Staged control and revegetation activities may also limit soil erosion.



Jeff Thomas

Shade cloth fence tapered at the end to minimise sand build up



Steve McRae

Hessian staked into the ground can help minimise water erosion



Terry Inkson, Great Lakes Council

Timber and shade cloth fences can reduce wind erosion

Using dead bitou bush to limit soil erosion

Hand made 'eco-logs' can be built out of hessian wrapped around dead bitou bush plants. These logs are then pegged in place to provide a flexible structure that controls erosion and promotes litter accumulation.



Weed biomass is placed onto a length of hessian



The hessian is wrapped around the weed biomass and tied with string to form a flexible log structure



The eco-logs are secured using wooden stakes and shaped into arcs to create a pooling effect which then overflows to the next pool



Recently made eco-logs in 2005



Eco-logs in 2007 which have begun to decompose and collect sediments and organic material

All photographs provided by Trees in Newcastle

Advantages of hand made eco-logs

- Makes use of dead bitou bush plants,
- Uses decomposable materials for erosion control,
- Collects sediment and debris which allow for plant growth,
- Cheaper than buying pre-made eco-logs,
- Light and easy to manage when positioning into place, and
- Useful for disposing of bitou bush as it can't be transported, according to weeds legislation in all states.

Disadvantages of hand made eco-logs

- Requires more time and effort than buying pre-made eco-logs, and
- Not recommended for use when there are seeds on the dead bitou bush plants.

Mulching

Mulching dead (sprayed or handweeded) bitou bush plants by hand-lopping or machinery and spreading the mulched material over the ground will help control surface erosion and retain soil moisture. Mulching the standing bitou bush biomass can also improve the aesthetics of the site and reduce the risk of accidental or deliberate fire events.



Reece Luxton, Clarence Valley Shire Council

Mulching reduces fire hazard

Plants can be cut into small pieces (about 30 cm long) and spread evenly over the ground. Alternatively, mechanical mulchers can be used where vehicle access to the site is possible (see Section 4). Be careful, however, not to lay the mulch too thickly as this may prevent native regeneration.

Mulching will not completely suppress bitou bush germination, therefore follow-up control is essential. Also, bitou bush foliage is able to produce allelopathic chemicals which may suppress germination of native species for up to three months or more after control or mulching.

 **Note: In low nutrient environments, mulching bitou bush on site will increase nutrient levels in the soil. This can have adverse impacts on native vegetation adapted to low nutrient soils (such as heath), by favouring weeds that thrive on high nutrient loads. Be careful where you use bitou bush as mulch, so you don't provide a competitive advantage to the weeds!**



Lachlan Sims

Hand cut bitou bush mulch on site

Lake Cathie Mechanical Mulching – a disposal method for cleared bitou bush

Lake Cathie Landcare group have been handweeding extensive amounts of bitou bush since early 2007. Burning dead plants was not permitted and mulching by hand or carting plants away was not an option.

The quantities of dead plants were so large that the piles were causing a fire hazard (from accidental or deliberate lighting). Also, the piles were numerous and presenting a safety risk to volunteers working on further weeding.

The solution came with the purchase of a chipper/mulcher (driven by the power-take-off of the group’s small tractor) which can be moved into almost any work area.

One issue the group considered prior to mulching was what would happen to the bitou bush seed on the plants when mulched.

Lake Cathie Landcare coordinator, Rob Tate, said, “The seeds were not really a problem because we had an opportunity to control the seed from the removed plants”. The Landcare group found that if the mulch is heaped for about fourteen days after being processed, the vegetation begins composting which decomposes the seed. The group now

uses the composted mulch spread in a thin layer to protect native species germinating from the seed bank or after direct seeding, or to protect planted tube-stock. Regrowth from any remaining bitou bush seeds is easily controlled.

The group has witnessed positive results over the past twelve months using this technique, with only minimal regrowth of bitou bush. On the other hand, regrowth of natives from the seed bank and new plantings has been very encouraging.



Jack Jones



Jack Jones

Control and restoration considerations for native species

Broad scale control of bitou bush monocultures may create flow-on effects and alter native ecosystems. For example, removing large areas of bitou bush can deplete food and shelter for native animals which may rely on it as a primary source of food or habitat. Research has found that bird species which consume bitou bush fruit were less abundant following herbicide treatment of bitou bush, that suggests that the dramatic reduction in the amount of bitou bush fruit available caused them to forage elsewhere. Make sure you consider the requirements of native fauna when planning bitou bush control and restoration activities.



Marrion Winkler

Working around the needs of resident fauna may mean balancing the need for bitou bush control with habitat protection

Reconstructing environments – restoration of dunes under bitou bush hummocks

Bitou bush can form hummocks in sand dunes (see Section 3). Removing bitou bush from these hummocks and restoring them to natural habitats is a difficult task that may require substantial rehabilitation and restoration effort.

Fencing off these areas from public access is a good starting point to limit further erosion from 4WD traffic or from people walking on the dunes. However, this will not stop wind erosion which maybe exacerbated by the wind being channelled between the hummocks. The *Coastal Dune Management Manual* (NSW DLWC 2001) is an excellent resource covering various aspects of restoration in dune environments including rehabilitation of eroded dunes (see resources table on page 70).

Planting, brush matting and/or direct seeding can be used to fill in the gaps between hummocks (see the case study *Staged removal of bitou bush to protect Aboriginal sites and conserve biodiversity on the Yaccaba Peninsula*, page 90), however removing the bitou bush hummocks entirely may be the desired goal.

The process of dune reshaping is one way to rehabilitate the dunes after severe erosion events in areas with bitou bush hummocks. Heavy machinery may be used to uproot and bury bitou bush plants deep under the sand, clearing and reshaping the sand dunes entirely and preparing the site for revegetation. *Dune reconstruction is only suitable where bitou bush is the only remaining vegetation cover and erosion on the foredunes has become so extreme that natural regeneration is no longer a possibility.*

It is not suitable to use heavy machinery where threatened species of fauna or flora are present, or where long-term maintenance of the area is uncertain. Long-term commitment to site rehabilitation and restoration after dune reshaping is essential.

Before embarking on such reconstruction activities ensure that you:

- Consider all other options carefully,
- Set long-term commitments in place from the outset,
- Consider the revegetation options,
- Check for threatened species and nesting shore birds sites. Assess if they are/can be protected accordingly during your activities,
- Secure appropriate approvals. For example, a development application may need to be prepared for the project and approved by your local council, and
- Form appropriate communication networks and consult all relevant stakeholders.



Paul Marynissen, Wyong Shire Council

Heavy machinery being used to resculpt sand dunes



Paul Marynissen, Wyong Shire Council

A windrow of uprooted bitou bush plants on the dune crest

Restoration resource information

Resource	Information available
Florabank www.florabank.org.au	<ul style="list-style-type: none"> Information and guidelines (for download) on all stages of preparation, seed collection, seed cleaning, handling, storage, and native plant propagation Extensive web links
Greening Australia www.greeningaustralia.org.au	<ul style="list-style-type: none"> <i>Bush Tracks</i>: a database of high value vegetation management publications <i>Online Native Vegetation Guides</i>: directories of research and resources for vegetation management Facts sheets, conference proceedings and practical information on restoration, seed processing, etc. Extensive web links
CSIRO – Conservation Genetics www.csiro.au/science/psx8.html	<ul style="list-style-type: none"> Information on provenance and species selection Information on managing remnants
Coastal Plant Regeneration (NSW) www.lhccrems.nsw.gov.au/CPR/CPR/homeset.htm	<ul style="list-style-type: none"> Plant lists for revegetation, based on location Uses/values of specific species Propagation information
Growing Native Plants www.anbg.gov.au/gnp	<ul style="list-style-type: none"> Propagation information on hundreds of native plants
Beach and dune management Coastal Dune Management Manual www.shop.nsw.gov.au www.epa.qld.gov.au Click on Environmental management > Coast and oceans	<ul style="list-style-type: none"> Detailed information on dunes and the coastal zone, planning for working on dunes, dune reconstruction and protection, weeds and revegetation Detailed information about the formation, function, management and vegetation of Queensland's coastal sand dunes
Native plant alternatives to bird-dispersed weeds www.weedscrc.org.au Click on Publications > Factsheets and Guidelines > gardening and biodiversity	<ul style="list-style-type: none"> Guidelines for replacing weeds with native plants to support fruit-eating birds Alternative to bird-dispersed weeds for Weeds of National Significance Alternative to bird-dispersed weeds in North-East New South Wales and South-East Queensland
Seed collection permits You may need to apply for a licence/permit from the state authority, for example: www.dse.vic.gov.au www.environment.nsw.gov.au www.epa.qld.gov.au	<ul style="list-style-type: none"> When collecting seed, first ask the landholder for permission (consult your local council authority or national park office if intending to collect on public land) Information on seed collection and situations in which you are required to apply for seed collection permits

Section Six

Monitoring your progress



Mark Hamilton



Alana Burley

Monitoring your progress

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Monitoring can be easy

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Keeping a diary

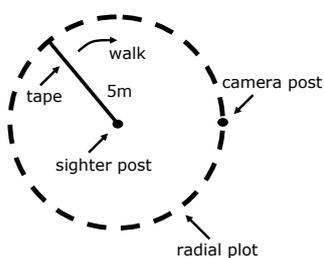
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Monitoring guidelines

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Distribution mapping of bitou bush

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Monitoring your progress

To evaluate how effective your control activities or programs have been in achieving your goal or proposed outcome, some kind of monitoring is needed. Thus monitoring is an essential part of your weed control program, as highlighted in Section 2.

Unfortunately, monitoring has not always received appropriate emphasis in the planning and assessment stages of weed control programs, where monitoring is most critical. Work is often put into collecting monitoring data that may not be useful for measuring success towards project goals. For instance, insufficient data or the wrong type of data may be gathered, data may be collected in a manner that is not robust enough to analyse, or data may be collected and never analysed. A recent survey of bitou bush control programs in New South Wales reported that, of the people who collected regular monitoring data, few analysed it.

Impediments to good monitoring can be due to many reasons, including:

- Lack of resources,
- Limited understanding about monitoring techniques,
- Absence of guidelines or professional guidance,
- Apprehension that monitoring may be too difficult or may take resources away from control efforts, and
- Lack of commitment.

But monitoring can be inexpensive and easy. Good monitoring techniques can be readily adapted to any situation and efficient monitoring can be achieved at many levels, from simple, straightforward data collection to rigorous scientific studies.

Monitoring can be easy

For many people monitoring is a daunting task – what to do, when to do it, how often, etc.? And then, what do you do with the data once you've collected it? This leads some

practitioners to avoid monitoring altogether. However, monitoring may be easier than you think. In fact, most of us do some form of monitoring every time we go to a site simply by observing changes over time or as a result of some event like weed control. The important thing is to convert these observations into something which can be objectively measured and analysed. If you can capture data which reflects your observations in a simple manner, these records can be analysed to inform on your progress towards the goals or objectives of your control program.

Keeping a diary

One of the easiest monitoring efforts involves keeping a diary. A site diary can be useful for documenting activities undertaken, as well as observations before and after such activities. For the site diary to be most effective, you need to make an entry every time you visit the site and record all activities and observations, as well as the date. Try to be as consistent as possible in your descriptions so they can be compared over time. Things to consider include: making observations from a standard location; describing the same patch (e.g. the south side of the headland); thinking about a measure of change, like percentage cover of bitou bush, and using it each time. The longer you can keep records of what is occurring at your site, the more robust your information will be.



Hilary Cherry

Tips for good monitoring

When monitoring always:

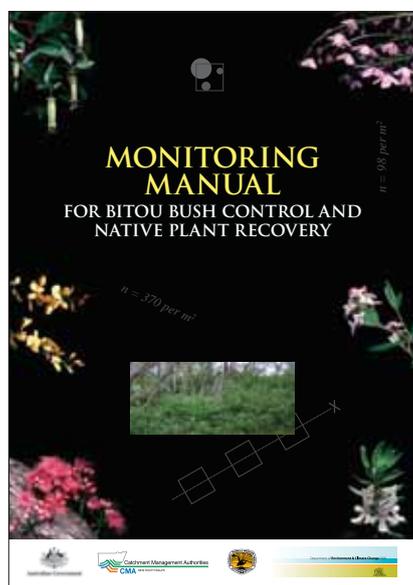
- Use the same methods (e.g. collect the data in a consistent manner),
- Undertake monitoring at the same or similar time every year,
- Monitor before and after control,
- Collect data from a non-invaded site for comparison/reference,
- Write down your methods,
- Make copies of your data,
- Use the same standard datasheets every time,
- Double check that you have collected all the necessary information before you leave the site,
- Avoid shortcuts,
- Try to have the same person/s collect the data each time,
- Incorporate monitoring into your yearly activity timetable,
- Collect data as you go (e.g. you can record the number of plants as you remove them during handweeding), and
- Enter your data into an electronic spread sheet (and make backup copies).

Monitoring guidelines

To help overcome monitoring challenges and encourage standardised data collection, monitoring protocols were developed in New South Wales as part of the *NSW Bitou Bush Threat Abatement Plan*. These protocols provide guidance on monitoring methods that assess the:

- Effectiveness of bitou bush control programs,
- Response of native species to control programs,
- Response of other weeds to control programs, and
- Cost of control activities.

Copies of the *Bitou Bush Monitoring Manual* can be obtained from www.environment.nsw.gov.au/bitoutap/monitoring.htm.



The *Bitou Bush Monitoring Manual* is also applicable to a wide range of users in terms of their skills and resources. This is achieved using a three-tiered monitoring system in which the standard monitoring methods are designed for all user levels, while the advanced methods are intended for those with previous monitoring experience or who wish to gain a better understanding of their site and efforts. Finally, the guidelines include a research tier that is aimed at high level monitoring to determine causality (i.e. if the control event was directly responsible for native species recovery), in a scientifically robust manner. The manual contains detailed descriptions of each monitoring method, as well as standardised data sheets and information on analysing data. The guidelines can be used by anyone, however if the data is collected from a priority bitou bush threat abatement site (TAP site) then the data should be submitted to the TAP coordinator, who will collate and analyse the data collectively.

Monitoring guidelines – standard monitoring

A brief overview of the standard monitoring protocols is presented here, outlining four basic monitoring components:

1. A map,
2. Photopoints,
3. Observational data (to support the photopoints), and
4. An economic assessment of the cost of the control effort.

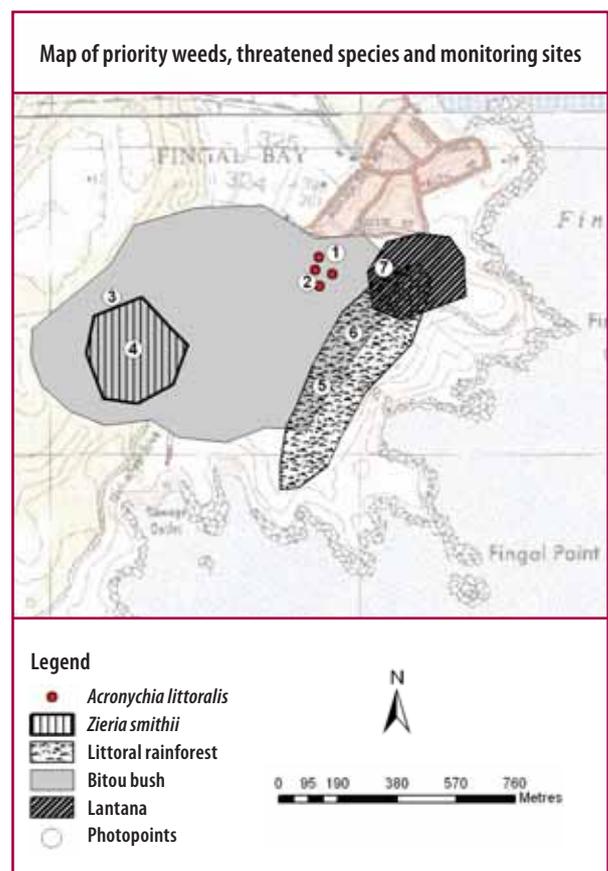
1. Monitoring with a map

Creating a map of your site is a critical component of your management program. This map, if made appropriately, can also be used to monitor the success of your control program. Below is a summary of the key points:

- Separate each aspect of your site and your control program/s onto different maps (layers). For example, a base map showing topography and key orientation objects (e.g. roads) of the site, a map of bitou bush only, a map of where you plan to control bitou bush, and maps showing locations of cultural heritage sites, threatened species, other weeds and monitoring programs such as photopoints.
- By creating each layer of information as a separate map, these layers or overlays can be compiled to produce a composite map. On each layer of your hard copy map, make two crosses of the same size, one at the top and one at the bottom of the page, in the same location, to line them up when forming the composite map. You can use clear plastic for the layers (e.g. overhead projector sheets) to help with viewing the final product. Alternatively, for electronic maps created with a geographical information system (GIS), attributes of each layer can be combined to produce the composite file.
- Each year, create an updated layer of where you undertook bitou bush control.
- Each year, create an updated layer of any other layers that may have changed. For example, if bitou bush or other weeds have

spread or changed their distribution on your site.

- Make notes on the causes for these changes. For example, ‘other weed populations were reduced as a result of spraying for bitou bush control’.
- By comparing the initial layers with the updated layers, measures of success can be made, for example by assessing the area treated, or by assessing the distance you have moved bitou bush away from a threatened species.



Example composite map showing multiple layers including locations of weeds, threatened native species, areas for control and monitoring/photopoint sites

2. Photopoints

Photopoints are a photographic record of changes occurring over time at your site, taken consistently from the same locations. They are an excellent tool for demonstrating progress to members of community groups, the public, and funding bodies.

To assist with monitoring, photos can be taken of:

- Patches of bitou bush, before and after control,
- Other weeds that invade after bitou bush control, and
- Other aspects of your site which are important to your goal (e.g. threatened species).

As soon as each photo has been taken, record the details of the photograph in your site diary, or on the photopoint monitoring field sheet (available in the *Bitou Bush Monitoring Manual*). Include the time and date, the location of the photo, the subject of the photo, and the photo number. Also record the location of where the photos are to be stored and the file name if the photos are taken with a digital camera.



Stephen Booth



Stephen Booth

Photos taken from the same point over time clearly show visual changes before (above) and after (below) bitou bush control (note the headland in the background has been included as a point of reference)

Tips for taking good photopoints

- Always take photos from the same place. Either permanently mark the location with a post or star-picket or use a fixed object (e.g. fencepost).
- Include some prominent, long-lasting features in the photo such as large rocks or trees. You can also record a compass bearing to prominent land marks.
- Use the same camera and zoom setting for each photo. It is easier to match the photos if no zoom is used.
- Take the photos at the same time of the day (preferably not in the middle of the day).
- Take previous photos into the field to help replicate the shots.
- A tripod helps standardise the height of the photo.
- Include an object of known size in the photo for scale. Examples include a person, a clipboard, or a measuring rod.
- If possible, include the horizon in the photo.
- If possible, include an identification label for the site, for example an A3 piece of cardboard clearly identifying the site name, date of photo and subject of photo which will be easily recorded in the photo. Try to position the label about 5 m from the camera position.
- Take several photos, as the first one may not be the best.

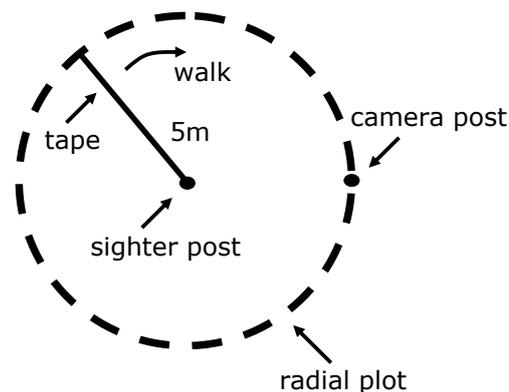
3. Observational data (to support photopoints)

While photopoints can be a very valuable monitoring tool to illustrate the changes in vegetation over time, they have limitations with respect to reporting your progress to other people or for inclusion in reports (e.g. in many instances the photos show a change from one green plant to another green plant). The *Bitou Bush Monitoring Manual* outlines a series of observational data collection methods to describe the changes observed between

photos taken using the photopoint monitoring method.

Methods for collecting observational data are summarised below:

- Using the permanent marker for your photopoint site and a tape measure, create either a circular or rectangular plot covering the immediate area in the photo (i.e. the first 5 m (see figure opposite)).
- Create a list of key species to observe (both native and weedy – including bitou bush). The number of key species will depend on what you want to show over time. Think about their likely response before selecting your key species (e.g. are they likely to change? Increase? Decrease?). *Use the same key species every time.* If you add new species later, record which ones and why you added them (e.g. they may suddenly become dominant).
- Within the plot, make observations on the presence or absence of your key plant species (both native and bitou bush/weeds).
- You can combine this presence/absence data with observations on the coverage of each species (e.g. bitou bush covered 60% of the area). If using cover estimates use standard percentage classes (e.g. 0%, 1–5%, 6–25%, 26–50%, 51–75%, and >75%).
- Alternatively you may wish to assess the density of your key species by counting the number of individuals of each within each area sampled. Note: if you use this method you will need to permanently mark out the area sampled so you count the same individuals each time. You will also need to work out the area sampled. For example a circle with a 5 m radius around your marker equates to an area of 78.5 m². The number of plants should then be converted into an individual metre squared value (e.g. 23 plants would convert to 0.29 plants per m²).
- Lastly, you might want to break down the number of key plant species into age classes (e.g. adults and seedlings) to show the level of recruitment and the success of that recruitment over time.



Circular photopoint and monitoring plot

4. An economic assessment of the cost of the control effort

Recording the cost of control (both in terms of labour and dollars spent) is important for evaluating the cost-effectiveness of different methods and helps you stay within budget. You should record in a diary the time spent on each day, the number of people involved and costs incurred (e.g. contractors or tools) or partial costs (e.g. 100 mL of herbicide). Where possible, record individual activities such as bitou bush control, other weed control, monitoring etc., either as separate activities (e.g. bitou bush control took three hours) or as a proportion of the total (e.g. bitou bush control took 50% of the time).

Distribution mapping of bitou bush

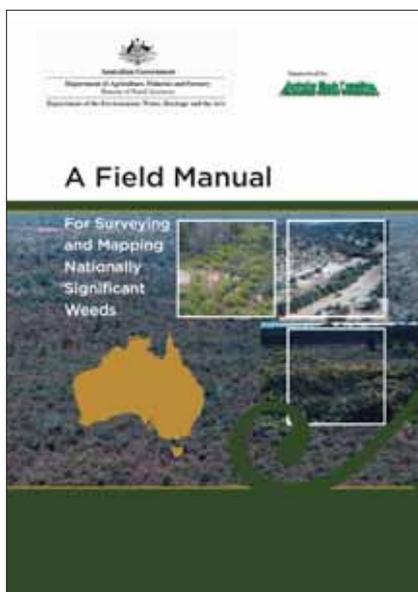
A fine scale of bitou bush distribution is a critical component for your site map and it provides essential information for your management plan and future decision making. Surveying and recording bitou bush distribution can also be performed over a wide area of the landscape either on the ground or from the air (e.g. helicopter surveying using video recording or using aerial photography).

Information on the distribution of bitou bush at any scale is extremely important to a range of stakeholders outside of your site, (e.g. see 'Bitou bush network in Australia' on page vii). It can feed into regional, state and national distribution maps. If you think you have identified a new or previously unknown bitou

bush infestation, report it to your local weeds officer (contactable through your local council or shire) and provide them with your map. The information can then be passed on to state agencies, and be added to maps at state and national levels.

 **Recording the absence of bitou bush in an area is also important to ensure the area is known to have been surveyed and is free of bitou bush. Be sure to pass the results of your survey on to the relevant weed authorities.**

Standard protocols for mapping the density of bitou bush and other Weeds of National Significance (WoNS) in Australia have been developed by the Australian Government (McNaught *et al.* 2006). Where possible you should use these so that your distribution map is consistent with and can feed into other broader maps. Copies are available from www.weeds.org.au.



Recording control history is also worthwhile as this can indicate the reasons for changes in density or distribution over time. Mark the areas treated by various control methods (e.g. handweeding, aerial spraying etc.) on your distribution map. Chance natural events such

as fire or flooding can also affect bitou bush distribution, therefore mark affected areas as a reference for future assessment.

 **A problem may arise when trying to classify recently controlled infestations. For example, a heavy infestation (100% cover) may reduce to less than 10% cover immediately after control, and may be 40% by the time of next control. For consistency, always record the density pre-treatment.**

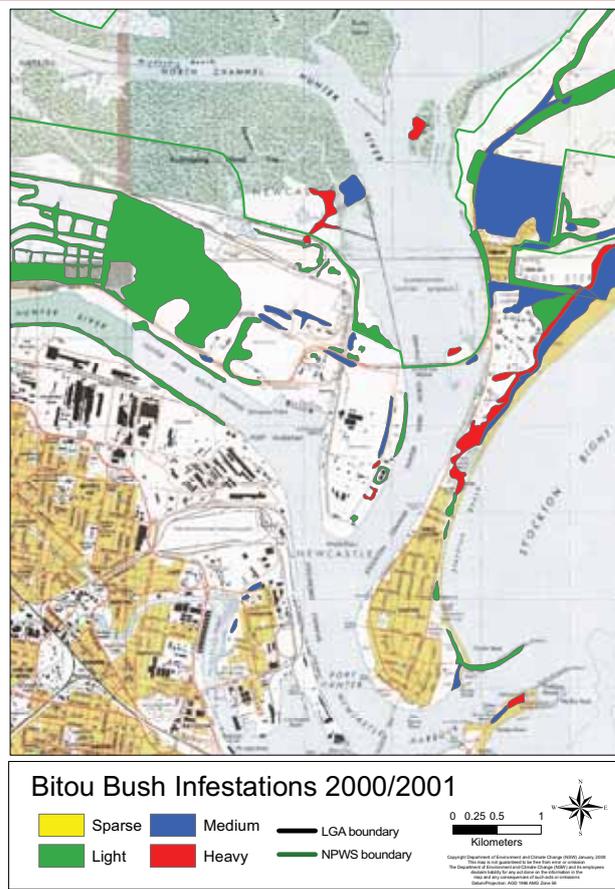
National bitou bush mapping program

Prior to 2007, individual states and regions had been collating their bitou bush distribution maps independently and not necessarily in the same format. For example, comprehensive mapping was carried out in New South Wales in 1984 and 2001, while in Queensland bitou bush has been surveyed annually since the late 1990s using slightly different density classes. The national WoNS program provided an opportunity to map bitou bush in 2008 on a national scale.

Density classes were adopted to enable appropriate comparisons between historic bitou bush data and newly collected data in 2008, on a national scale. While the density classes provided on page 78 are slightly different to the WoNS standard density classes, they can be suitably fed into the WoNS classes and may therefore be used for future bitou bush distribution mapping, enabling further comparisons with historical data.

Density classes for bitou bush mapping*

Standard colour scheme	Bitou bush density class	Description	Standard WoNS density class**
Grey	Absent	No plants found during survey	Class 1
Yellow	Sparse	One or two plants only	Class 2
Green	Light	<10% cover, infrequently dispersed seedlings, small or large plants and small clumps	Class 3
Blue	Medium	10–40% cover, plants and small clumps readily located, generally uniformly dispersed throughout the site; occasional clumps	Class 4 equivalent
Red	Heavy	40–70% cover, dense clumps forming continuous infestations in patches, with native flora still present in patches	Class 5 equivalent
Black	Very heavy	>70% cover, bitou bush plants essentially forming monocultures	
White	Not surveyed	Not surveyed	Class 8



* The methods adopted for bitou bush mapping were based on previous mapping methods bitou bush in New South Wales (Thomas (2002), originally defined by Williams and Gerrand (1999)).

** McNaught *et al.* 2006.

Class 6 (present, density unknown) and Class 7 (not known, or uncertain) are not shown as they have not been used in previous bitou bush mapping.

Section Seven

Case studies

Case studies: Eleven firsthand experiences



Graham Harding, Eurobodalla Shire Council



Daintry Gerrand

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Weed Warriors and Weeds Attack! – Educating school children about bitou bush

Raising weed awareness among young people is important for the future of weed management because children are the natural resource managers of tomorrow. *Weeds Attack!* and *Weed Warriors* are innovative educational programs designed to increase weed awareness among young Australians by educating them about the impact of weeds on the environment and what they can do to help reduce those impacts.

Weeds Attack! is a web-based, multimedia resource with interactive learning activities, aimed at preparing primary school students to investigate a local Weed of National Significance. Using a games-based approach with extensive use of video, it stimulates students in and out of the classroom to think more about weed issues, prevention and management, while at the same time learning cognitive and practical skills as set out in the school curriculum. Features specific to weed management include matching the weeds to their country of origin, building a superweed through knowledge of plant biology and memory games based on weed identification.

Students make their way through 16 activities gaining code words along the way. At the end of the adventure they use the code words to gain access to a certificate of success. The activities are suitable for individual or group learning, homework, whole class discussions, demonstrations or investigations. Many of the activities work well on interactive whiteboards.



Leaf roller
(*Tortrix* sp.)
moth



Through participation, school children learn about collecting and rearing biocontrols, and monitoring weeds

The *Weeds Attack!* resource, which focuses on bitou bush and other Weeds of National Significance (WoNS), was designed by education experts at the NSW Department of Education and Training's Centre for Learning Innovation to address the New South Wales science curriculum and can easily be adapted to other States and Territories, thus giving it national relevance.

Weed Warriors is a national program that empowers students to act on weed issues using biological control agents. During the 'hands on' part of *Weeds Attack!*, students learn how to become *Weed Warriors* and actively reduce the impact of weeds by rearing, releasing and monitoring biocontrol agents at sites in their community. For bitou bush, the *Weed Warriors* program uses the *Tortrix* leaf roller moth biocontrol agent. Students involved in the program are redistributing a successful biocontrol agent for bitou bush, thus supporting this important biological control program and helping control bitou bush.

More information and free copies of the *Weeds Attack!* multimedia resource are available from NSW Department of Primary Industries (www.dpi.nsw.gov.au/weeds) or by contacting the bitou bush national coordinator (www.weeds.org.au/WoNS/bitoubush). 



Moving the National Southern Containment Line northward

Kerry Thompson, Shoalhaven City Council, New South Wales and **David Pomery**, Illawarra District Noxious Weeds Authority, New South Wales

Bitou bush and boneseed cover 38%, or 9400 hectares, of the southern coastline of New South Wales (Wollongong to Bega), and threaten rare and endangered flora such as *Pimelea spicata*, *Cynanchum elegans* and *Thesium australe*. On the Far South Coast, the habitat of the white footed dunnart, *Sminthopsis leucopus*, is also threatened by bitou bush infestations.

Successful control of south coast bitou bush populations has been achieved through the actions of the South Coast Bitou Bush and Boneseed Taskforce (SCBBBT) and their implementation of the South Coast Regional Bitou Bush Strategy and Five-year Management Plan. The northern movement of the National Southern Containment Line is one of their most outstanding successes.

Regional Strategy and Five Year Plan

The South Coast Regional Bitou Bush Strategy (Broese van Groenou and Wolfenden 2002) and Five-year Management Plan (SCBBBT 2002) emphasise and encourage coordinated approaches to bitou bush and boneseed management and control by all stakeholders throughout the region. An updated plan was recently prepared (SCBBBT 2007) and was endorsed by all stakeholders for a further five years until 2012. The plan includes regional containment strategies and regional priority sites for control of bitou bush for biodiversity conservation, as identified in the *NSW Bitou Bush Threat Abatement Plan* (DEC 2006). All members of the Taskforce had input into its preparation through progressive workshops.

Who are the South Coast Bitou Bush and Boneseed Taskforce?

SCBBBT is an advisory and working group comprised of regional weed experts from local and state government agencies and the community. The Southern Tablelands and South Coast Noxious Plants Committee established the Taskforce in 2000 to oversee

the implementation and continuation of the Regional Strategy and the Five-year Management Plan.

The initial role of the taskforce was to develop and implement bitou bush and boneseed management strategies. Continuing results include:

1. The implementation, review and updating of the Regional Bitou Bush and Boneseed Strategy and Management Plan,
2. The implementation of public awareness programs, and
3. Provision of a coordination role and funding body for regional weeds projects.

National Southern Containment Line

The National Bitou Bush and Boneseed Strategy (ARMCANZ *et al.* 2000) identified the need for a national southern containment line between Merimbula and Narooma. The NSW Bitou Bush Strategy (NPWS 2001) accordingly designated this containment line to be positioned at Tuross Head, delineating the southern containment boundary for bitou bush in Australia. In 2002, the South Coast Regional Strategy proposed that this control line be shifted from Tuross Head to Sussex Inlet (over 100 km north) by September 2004 and



Kerry Thompson, Shoalhaven City Council

Community members at Culburra Beach, New South Wales contributing to the South Coast Regional Bitou Bush Strategy

that all bitou bush south of the line should be under control by September 2007.

The Containment Line was successfully moved north to Sussex Inlet after only five years of coordinated control. All bitou bush south of the Containment Line is now being controlled as per regional, state and national management plan initiatives, with the specific objective to prevent further seed production each year. This highlights how local action can contribute to regional, state and national targets.

The Containment Line now sits just south of a large infestation of bitou bush in Booderee National Park. This infestation is too large to control with current resources and thus prevents continued northward movement of the line. The Taskforce chose to implement a buffer zone around this infestation and continue to strategically control all bitou bush infestations north of the Park as they were not as large. The buffer zone will contain the infestation within Booderee National Park, preventing spread to nearby areas that are bitou bush free. Recent fires in the park have provided a substantial opportunity to control outlier infestations and resprouting bitou bush seedlings, as well as reduce the seed bank in the buffer zone.

North of the Containment Line, the control process is being implemented strategically.



Kerry Thompson, Shoalhaven City Council

Volunteers are integral to the project's success. Conjola Bushcare members at work controlling bitou bush



Kerry Thompson, Shoalhaven City Council

Volunteers propagating plants for a revegetation project

The 2007–2012 Five-year Management Plan sets out that all populations, excluding those at Booderee National Park and Wollongong, will be targeted in a staged fashion, such that all sparse and light infestations will be targeted by September 2009, and 100% of medium density and core infestations will be treated or contained by 2012.

In addition to bitou bush, all boneseed plants (*Chrysanthemoides monilifera* ssp. *monilifera*) throughout the region are being controlled annually. Boneseed, the other subspecies of *Chrysanthemoides monilifera*, is included in the Five-year Management Plan because it also poses a serious threat to southern New South Wales. The objective is eradication of all boneseed plants by 2012. Continual targeting of new seedlings will lead to depletion of the seed bank.

The movement of the Containment Line from Tuross Head to Sussex Inlet is a distance of over 100 km. This is a substantial achievement in only five years and is testament to the effective working partnerships between all Taskforce constituents. Volunteers are fundamental to the integrated on-ground works and more than 24 environmental 'Care' groups working throughout the region have contributed significantly to the success of the project. These groups will continue to be involved into the future. ☀️



Bitou bush eradication opportunities at a regional level in Queensland

Lyn Willsher and Barry Whyte, Department of Primary Industries and Fisheries, Queensland

It is very important to realise the gains Queensland has made in bitou bush eradication over 20 years and remember the potential areas of risk of bitou bush invasion.

The 'first environmental weed' in Queensland

Bitou bush was the first weed to be declared noxious in Queensland for purely environmental reasons. Since it was declared in 1981, **eradication** from the entire state has been the ultimate goal. Because of the nature of the infestations, surveillance and control efforts are to remain (as described below).



Barry Sullivan, Qld DPI&F



Barry Sullivan, Qld DPI&F

Aerial surveying for bitou bush occurs every three years

Coordinated, multi-agency control efforts have already produced notable economic and environmental benefits.

Invasion history

From 1966 to 1972 areas of Inskip Point and South Stradbroke Island were mined for mineral sands (Anderson 1991). Bitou bush may have been used to revegetate and stabilise dunes following mining, but this is uncertain. The plant was first documented in Queensland in 1970 with a herbarium specimen collected from Coolangatta (Sandencoe 1984). A decade later, there were approximately 700 hectares of bitou bush scattered along the coast of South-East Queensland which raised the concern of the Queensland Environmental Protection Agency (EPA).

The weed was then recognised as having the potential to destroy Queensland coastal dune communities of high conservation, recreational and tourism value, and it became targeted for eradication in accordance with its noxious weed listing.



Barry Sullivan, Qld DPI&F

Areas under immediate threat include the World Heritage listed Great Sandy Region (comprised of Fraser Island, Great Sandy Straights and Cooloola)

How and when did the eradication program begin?

Control trials were set up in 1980 at the request of the Queensland EPA. Bitou bush control work began at Inskip Point in 1982, by which time the infestation covered approximately 200 hectares.

In 1986, control work began on South Stradbroke Island using aerial herbicide application because it was cost-effective and more accurate at that location. Fifty three hectares of bitou bush were aerially sprayed using glyphosate at a rate of 8 L/ha. On-ground follow-up work was also carried out. Control work began on infestations on North Stradbroke Island and other coastal areas in South-East Queensland in 1992.

Initial treatments occurred in winter months with low volume herbicide applications using backpacks with 3 m sprinkler spray wands. Plants treated with this equipment only required a few large drops of solution on each leaf meaning that a reduced amount of herbicide mixture was required. This was favoured over high volume applications due to the lightweight nature of equipment that can be easily carried by workers through rough terrain (Anderson 1984).

Establishment of a buffer zone

A buffer zone was proposed and established in 1995 for the area north of the Tweed River. Significant populations of bitou bush existed in this area and seed dispersal by means of birds eating and spreading fruits was contributing to seedling establishment along Gold Coast beaches. A designated National Northern Containment Line was established on the Tweed River to keep bitou bush infestations in New South Wales from spreading into the eradication zone of Queensland.

The buffer zone and north of the Containment Line is a joint project between Queensland Department of Primary Industries and Fisheries

(DPI&F) and NSW Far North Coast Weeds Advisory Committee. It is maintained annually with input from both parties and very little bitou bush occurs in the area today.

How is the current eradication program functioning?

Under the current treatment program, all known areas of bitou bush in Queensland are physically surveyed and treated annually, with some more densely populated areas such as North Stradbroke Island being treated twice annually. When the eradication project commenced, 90% of plants found were large adults that had to be treated with herbicides, now the majority of plants found are seedlings and can be removed by hand.

Annual herbicide usage on South Stradbroke Island to control bitou bush



Evidence of success: A decrease in bitou bush infestations on South Stradbroke Island over time is best illustrated by the decreased amount of herbicide required to treat the infestation

Aerial surveys were introduced to the eradication program in the late 1990s as a means of monitoring progress, mapping infestations and surveying difficult-to-access areas. The aerial surveys have proved an invaluable tool as large plants can be spotted from the air that would otherwise be very difficult to locate in the rugged terrain. The aerial surveys are carried out every three years in late autumn when plants are flowering. Individual bitou bush plants are mapped with a GPS and locations are recorded on the DPI&F database which is later used to relocate them for control.



Looking for flowering bitou bush plants from the air

The eradication project has evolved into a multi-agency program with input from Far North Coast Weeds, Gold Coast City Council, Redland City Council, Brisbane City Council, Sunshine Coast Regional Council, Fraser Coast Regional Council, Gympie Regional Council, EPA, DPI&F, Department of Natural Resources and Water and Consolidated Rutile (a private landholder). The DPI&F coordinates the annual eradication program and aerial surveys.

It is difficult to put an accurate cost figure on the annual program as many different agencies contribute. However, it is estimated that the DPI&F contributes approximately \$30,000 annually with the combined input of other key stakeholders being roughly \$50,000. Given that in Queensland, the area considered to be



A team of committed staff from Queensland Parks and Wildlife Service, Gympie Regional Council staff and Queensland DPI&F work together towards eradication

climatically suitable for bitou bush extends over 500 km further north than its current distribution, making the investment in the eradication program is a sound one.

As one measure of success, in 2007 only 36 individual bitou bush plants were found growing on South Stradbroke Island. The majority were physically removed with only a couple requiring spot spraying.

Why the program is so successful

The following factors are major reasons for program success:

- The project was initiated when infestations were still relatively small and bitou bush had a limited distribution in Queensland.
- Staff members working on the eradication project from the outset have been very motivated and committed to the eradication of bitou bush. Often work conditions are difficult, uncomfortable and work is strenuous. The commitment of staff members is very important in such circumstances.
- All agencies involved have been committed to the long-term goal of eradication.
- Staff from different agencies are able to work together in a coordinated team across several different land tenures. This is important as there are often no discernable land boundaries in the field.

With the same areas of land requiring survey and treatment annually, the cost of controlling *individual* plants has risen considerably. It is very important to realise the gains Queensland has made in bitou bush eradication over 20 years and remember the potential areas at risk of bitou bush invasion. With the large size of the area to be surveyed annually, it is likely that scattered bitou bush plants will be found for years to come primarily due to re-invasion from New South Wales infestations. In the future, the eradication program might best be viewed as a long-term surveillance and removal program to prevent bitou bush from gaining a foothold in Queensland. Regardless, ongoing support and commitment of all agencies involved must be maintained to ensure continued success. 🌻



Biodiversity in focus on the Manning coastline

Daintry Gerrand, Manning Coastcare Group, New South Wales

“Our goal is to restore the coastal corridor and maintain biodiversity, as opposed to conserving a small number of specific sites.” – Daintry Gerrand, Manning Coastcare Group Coordinator (volunteer).

The Manning Coastcare Group (MCCG) is a community group that works to protect native biodiversity along the Greater Taree Local Government Area (LGA) coastline on the New South Wales Mid-North Coast. Their goal is to restore the coastal corridor and maintain the biodiversity within it, rather than aiming for a ‘weed free’ state at every site.

Group members initially came from existing Landcare and Dunecare groups on the Manning Coast. In 1996, they combined their efforts towards regional biodiversity conservation, as opposed to working across a small number of specific sites. Together they expanded from eight core sites to achieve holistic rehabilitation across a 40 km coastal strip, providing a vital link between the many pockets of rainforest along the coast. The group now actively manages over 80% of this 40 km coastline, including the original areas of endangered littoral rainforest.

“As a community organisation, we recognised the need to take an holistic approach on a regional scale. Our aim is to restore native vegetation along the coastal wildlife and habitat corridor, working towards a state where natural regenerative processes are ‘winning the battle’ against weed infestations.” – Daintry Gerrand, MCCG Coordinator.

Manning Coastcare’s work focus

Work efforts focus on priority biodiversity areas such as littoral rainforest and *Themeda* grasslands and incorporate integrated weed management practices to reduce pressure from target weed species like bitou bush. Control is focused on weeds, many of which are Weeds



Manning Coastcare

of National Significance, that prevent the natural regeneration of coastal scrublands and littoral rainforests. The group looks objectively at each site’s history and scale of weed infestation, then prioritises weed species and allocates work priorities according to the funds and resources available.

Top priority weeds are bitou bush and the ‘asparagus weeds’: ground asparagus (*Asparagus aethiopicus*), climbing asparagus (*A. plumosus*) and bridal creeper (*A. asparagoides*).

The group now targets priority weeds across 200 hectares of the coastal corridor under funding from the Hunter-Central Rivers Catchment Management Authority. The secondary weed focus is on willow wattle (*Acacia saligna*), cassia (*Senna floribunda*), prickly pear (*Opuntia* spp.), glory lily (*Gloriosa superba*), morning glories (*Ipomoea* spp.), moth vine (*Araujia sericifera*), Madeira vine (*Anredera cordifolia*), Brazilian nightshade (*Solanum seaforthianum*) and spike rush (*Juncus acutus*).

In the beginning, this was hard work due to extensive tracts of bitou bush between rainforest remnants and dense understorey infestations of asparagus in the rainforests. The group knew community goodwill would not be enough to manage the massive problem. To assist, they contracted bush regenerators and spray professionals and began a regular volunteer workers program. Weed control is carried out by hand and chemical control methods. Seed collection, plant propagation, planting and fencing are also undertaken.

Group members and functioning

Key members have practical common sense, tertiary training in environmental management and a strong desire to achieve productive on-ground outcomes. Restoration occurs with volunteers and specialist regeneration teams integrating on-ground control, in some cases with aerial spraying of bitou bush.

In 1998, contract bush regenerators were employed and a project officer was hired to manage and organise volunteer teams. Spraying by contract regenerators could then be followed up by weeding, planting and site maintenance by the dependable workforce of volunteers. This support gave the group confidence to tackle weed infestations that were previously beyond the resources of the individual groups.

While conservation of the biodiversity of the coastal corridor was a central focus, the MCCG has also concentrated on developing skills and providing social and employment opportunities for the local community. The group has developed a mechanism for harnessing community contribution on a regular basis through an 'over 50's volunteer worker' program, in association with Centrelink. Over 30 local volunteers contribute 15 hours per week every week of the year under this scheme. This in-kind contribution, coupled with the group's other voluntary time, has allowed MCCG to contribute over \$3 million in labour since 1996.

In addition, a council nursery facility was restored and is now being managed by dedicated members of the 'over 50's volunteer worker' program. The nursery team now collects seed locally and supplies local provenance tube-stock to complement all regeneration and restoration efforts. Council also benefits from a supply of tube-stock for their own planting projects.

Manning Coastcare Group was awarded the National Coastcare Award (2006) in recognition of their achievement in employing a systematic approach to bitou bush control and successful 'coastal corridor' restoration.

Foundations for success

Strategic project development and long-term persistence was essential in reducing weed infestations along the Manning coastline. Initial site assessment, clear objectives, strategic plans, available skills, professional implementation of works and council support have all contributed to successful regional and local rehabilitation. Monitoring and evaluation of priority work areas is underway. Coastcare and NSW Environmental Trust funding was obtained in 1998 to undertake surveys and develop restoration guidelines. In 2008 the Hunter-Central Rivers Catchment Management Authority is funding a re-survey of weed infestations as part of the group's monitoring and evaluation program.

Funding has been sought and obtained consistently by MCCG, which aids their success. Most importantly, it is the people who are passionate and enthusiastic about the work that they do that make Manning Coastcare Group such an outstanding success. 🌻

"These people are dedication itself. They feel they own the area and they have a lot of pride. They are a classic example of what is so amazing about Coastcare. It's people who make all the difference." – Brian Scarsbrick, Landcare Australia's Chief Executive.



Members of MCCG receiving a Landcare Award in 2006, left to right: Warwick Dyson – Volunteer Workers Project Officer, Alana Parkins – Publicity Officer, Daintry Gerrand – Coordinator, Jim Love – Contract Regenerator



Community spirit drives the Regional Eradication Program in Tathra

Jim Kelly, Tathra Landcare, New South Wales

The Tathra Landcare group has fostered a sense of community spirit that sustains a three-pronged bitou bush eradication program in the south coast town. Ongoing working bees, community awareness programs and herbicide spray programs have been strategically integrated to produce immense reductions in bitou bush infestations. After 15 years of sustained control, the seed bank finally appears to be exhausted on the beach front and monoculture stands of bitou bush have been eliminated. As is commonly the case for Landcare groups, the community's dedication and strategic direction are vital components of their success.

Bitou bush in Tathra

Originally introduced to Tathra in the late 1960s, bitou bush was used to control sand drift on a small section of degraded dune at the southern end of Tathra Beach. By the 1990s, approximately 300 ha of the surrounding area was infested by bitou bush including the dune system, headlands, cliff areas and nearby bushland, private land and public reserves.

Various agencies and organisations were committed to bitou bush control around Tathra since the 1970s, but bitou bush outpaced the small bands of volunteers and council initiatives and continued to re-invade.



Jim Kelly

A band of volunteers at a monthly working bee

Between 1991 and 1994, resources from organisations and government agencies at all levels were applied to integrated eradication projects. Bega Valley Shire Council undertook rehabilitation works at the south end of Tathra Beach in 1991 and physically removed and buried all bitou bush plants along a 200 m long stretch. Spinifex, marram grass, coastal wattle and bottle brush replaced the mass of bitou bush in this area, but hundreds of bitou bush seedlings continued to emerge.



Alan Smith, Bega Valley Shire Council

The local council assists with herbicide control on cliffs

Tathra Landcare eradicates bitou bush

Tathra Landcare (TLC) was established in June 1993 as a response to the need for something further to be done. One community group member said, "Tathra's a nice bushy place, and in the last 10 years or so, bitou bush has been taking over – it's just destroying the character of Tathra. That's why I like to get out and try to eradicate it, because it's a problem and we've gotta start somewhere."

The strategy of the TLC group has been, and continues to be, to systematically weed out bitou bush from around Tathra and the surrounding environment on a biennial cycle. Originally, TLC adopted a Small Area Contract Scheme where volunteers accepted a

'contract' to clear bitou bush over time from a small patch, which filled the gaps left between areas treated during the biennial sweep.

Prior to the TLC group's efforts, 3 km of Tathra Beach foreshore had extensive infestations of bitou bush. In 2007, the TLC group (the mainstay in bitou bush management in the area for the past 15 years) reached a benchmark of no regenerating bitou bush seedlings on the 200 m of dunes north of the surf club, an area which was originally planted with bitou bush in the 1960s. This success indicates that long-term commitment is needed to control bitou bush, but that localised eradication is possible. Such achievements are due to the ongoing strategic commitment of the 40 member-strong community group, who now conduct systematic annual searches of infested areas and ensure all sites are visited every two years.

Three-pronged success

The function of TLC is founded in a three-pronged approach. The three equally important stages are:

1. Monthly working bees from April to December attended by connected, committed community members. Communication is via a newsletter and a monthly phone-tree, in keeping with the bottom heavy organisation structure. Whole areas are walked systematically by the group and plants are treated by hand-weeding or cut-and-paint with glyphosate from an eye dropper. Bitou bush working bees capitalise on group momentum and provide robust bitou bush control.
2. A targeted spraying program. Spraying was started in 1993 by TLC to treat the large bitou bush infestations and to access bitou bush on the cliffs. Three to four volunteers used a large, truck-mounted sprayer borrowed from the local council to spray in the winter months. This was extremely successful in 'breaking the back' of the bitou bush problem by 1996. The council took over spraying in 2002. Today it is limited to a small spray program that targets cliffs or steep areas.

3. A strong public awareness program publicises the need for weed control and creates awareness of bitou bush in the community. This is achieved by publicity in the local paper and radio, by permanent interpretive signage and large scale photo displays rotated through schools, council chambers and shops, market days and field days throughout the district. TLC has won awards every two years since its inception and this also has helped to maintain its profile. The strong community network within TLC ensures awareness campaigns are successful. Community participation extends beyond the group itself; even the Tathra postman will tip off the Landcare group on any new bitou bush incursions he sees while delivering the post!



Hilary Cherry

Tathra Beach after control: 40 years after the original bitou bush plantings and years of subsequent control

TLC remains a grassroots organisation. Numerous community members have been in the group for many years and new members join every year. The group has a high community profile which wins public respect and ensures council involvement, even though the group is independent of council. Personal interaction between members helps to sustain TLC and the social aspect is a significant feature of the group's success. Tathra is a small town where most people know each other and the group's work is very well recognised and supported. The three-pronged, structured approach has produced notable results and ensured successful bitou bush management in this community. 🌻



Staged removal of bitou bush to protect Aboriginal sites and conserve biodiversity on the Yaccaba Peninsula

Andrew Staniland, Great Lakes Council, New South Wales



Kerry Simmons, Great Lakes Council

Yaccaba Peninsula

The Great Lakes region, located on the Mid-North Coast of New South Wales about 300 km north of Sydney, contains approximately 725 km² of land affected by bitou bush. A majority of these infestations are a result of disturbance by humans, mainly through sand mining that has occurred in many areas. Bitou bush and other coastal species, such as coastal wattle (*Acacia longifolia* ssp. *sophorae*) and coastal tea tree (*Leptospermum laevigatum*), were introduced to stabilise sand mined sites and then spread as weeds. It is suspected that bitou bush was introduced to this area during the sand mining period, although no records exist to confirm this. While the problem is widespread throughout the region, one of the core areas of infestation lies on an extremely vulnerable sand spit on the Yaccaba Peninsula.

The Yaccaba Peninsula supports a range of different vegetation communities such as coastal dunes, remnant littoral rainforest and wet sclerophyll eucalypt forests. Yaccaba Peninsula is of high importance to the Aboriginal people of the area. Several significant sites were uncovered that indicate the Peninsula was frequently used throughout history. In more recent years, sections of the site have been sand mined and recent

urbanisation has encroached on the western fringe.

The area of primary concern, approximately 79 hectares, lies on the sand spit. Due to the high level of anthropogenic and natural disturbance, the site is highly susceptible to weed invasion. Bitou bush is currently out-competing native species and forming large hummocks that promote sand blowouts. This, in turn, is encouraging four wheel drive (4WD) enthusiasts to create new tracks through the blowouts, which adds to site degradation. Furthermore, the hummocks are a threat to sacred Aboriginal sites because the sand erosion exposes and degrades the sites.



Great Lakes Council

Aerial view of Yaccaba Peninsula. Fences used to limit access and aid restoration are shown in black

To begin work aimed at controlling and hopefully eradicating bitou bush on the Peninsula, the following key stakeholders were identified:

- Worrimi and Karuah Local Aboriginal Lands Council,
- DECC Northern Aboriginal Heritage Board,
- National Parks and Wildlife Service,
- Recreational fishermen,
- Professional fishermen,
- General community,
- Hunter-Central Rivers Catchment Management Authority (CMA),
- Department of Lands, and
- Great Lakes Council.

All stakeholders were consulted and their ideas for long-term sustainability of the site were recorded. The views of all stakeholders were collaborated into a Work Plan designed to be implemented in three stages.

The project, directed by the Work Plan, commenced with funding from the Natural Heritage Trust and Hunter-Central Rivers CMA, through the *NSW Bitou Bush Threat Abatement Plan* (Bitou TAP).

Implementing the Work Plan

The plan lays out three stages.

Stage 1 – The redirection and definition of 4WD movement on the Peninsula. Great Lakes Council and Aboriginal Lands Council members worked together to erect fencing to define beach access and a designated peninsula crossing point (see map on page 90). Pine and bacco fencing was used for several reasons: minimal cost, ease of installation, ease of repair in cases of vandalism or storm damage, and the style of fencing has proven successful on other beaches in the Great Lakes area for traffic control. To date two cases of vandalism have occurred, both minor, and damages were repaired on the same day. The formalisation of 4WD tracks has allowed for significant Aboriginal sites, as well as native vegetation, to be conserved.

Stage 2 – Conservation and regeneration of remnant littoral rainforest. Bitou bush will be treated manually with the cut-and-paint method, with cut material being used as mulch on site, thus promoting littoral rainforest regeneration. Gas gun (splatter gun) herbicide application will be used to reduce the large bitou bush stands currently threatening the littoral rainforest. Several maintenance visits will be undertaken targeting emerging bitou bush seedlings. Erosion fences will also be erected where necessary.



Andrew Staniland, Great Lakes Council

Yaccaba Peninsula – southern end containing littoral rainforest

Stage 3 – Conservation of *Stackhousia spathulata*. *Stackhousia spathulata* is a significant native ground cover growing in a restricted habitat within the foredune area on the Peninsula. Given its narrow growing region and limited population, works are being undertaken to reduce the threat of bitou bush out-competing and smothering this rare native plant. Bitou bush will be handweeded from above *Stackhousia* plants and backpack spray techniques will be used adjacent to known *Stackhousia* populations.

Grant funding received through the Hunter-Central Rivers CMA under the Bitou TAP will allow all three stages of the Work Plan to be undertaken. Stage 1 was successfully completed in 2007/08 and Stage 2 is scheduled to commence shortly, with Stage 3 closely following. This work will protect the important Aboriginal heritage and biodiversity values of the Yaccaba Peninsula. 🌻



Replacing bitou bush the natural way – working with the resilience of nature and the element of time

Stephen Booth, Technical Officer, Cape Byron Trust, New South Wales



Stephen Booth

Cosy Corner – nestled behind Tallows Beach at the base of Cape Byron

Cosy Corner, a littoral rainforest site on the Far North Coast of New South Wales, is being restored using natural resilience and rapid weed removal as the foundation for rehabilitation. Management practices implemented at Cosy Corner demonstrate how working with the regenerative capacity of nature can produce potentially more sustainable and affordable results for biodiversity, site restoration and rehabilitation than the use of active revegetation over a long period of time.

“During initial site assessment and then after each stage of weed treatment, it is a primary focus to identify natural resilience before a commitment to planting is made. There are quantifiable environmental and cost benefits of utilising nature.” – Steve Booth, Technical Officer, Cape Byron Trust.

A biodiverse environment under threat

Cosy Corner is located west of Tallow Beach within Cape Byron Headland Reserve. As part of the NSW National Parks and Wildlife estate, the reserve is managed by the Cape Byron Trust. Over 150 native plant and 50 weed species have been recorded on the 10 ha Cosy Corner site, including numerous

threatened plant species and littoral rainforest, an endangered ecological community.

Bitou bush was planted to stabilise the dune complex following sand mining in the 1960s, which followed mineral sand extraction in the 1930s and gold mining in the 1880s. By the 1990s, bitou bush had invaded the dunes and littoral rainforest (12.5% of the 5 ha western littoral rainforest section, and approximately 60% of the 5 ha eastern coastal dune complex section).



Stephen Booth



Stephen Booth

*The invaded coastal dune complex includes areas of coastal wattle, (*Acacia longifolia* ssp. *sophorae*) (above), horsetail she-oak (*Casuarina equisetifolia*) woodland (planted, shown below), and coastal banksia (*Banksia integrifolia*) open forest (planted, not shown)*

Project aims

The objectives of best practice management are to maximise environmental benefits, while using the least amount of resources and minimising negative impacts. With this in mind, the current site managers at Cosy Corner selected a nature-led approach to restore the littoral rainforest community following bitou bush control to protect and enhance biodiversity.

Objectives were to:

- Remove weeds from littoral rainforest and coastal dune plant communities, and
- Increase structural and floristic diversity via natural regeneration over five years following control.

To achieve effective bitou bush management within the project aims and objectives, priorities were to secure five years of funding, engage a restoration practitioner with specialised local knowledge and experience in coastal ecosystem dynamics, and produce a five year Management Plan with built in cycles of review to reassess the significance of changing site conditions over time.

From March 2006 to January 2007, the NSW Environmental Trust provided \$21,700 for littoral rainforest restoration. Cape Byron Trust, with the support of Department of Environment and Climate Change, has an ongoing commitment to contributing human, financial and material resources to restore the Cosy Corner site. Funding from the Natural Heritage Trust was also received in 2007 to carry out work under the *NSW Bitou Bush Threat Abatement Plan*.

Underpinning approach for restoring the rainforest

The underpinning knowledge used to rehabilitate the long-invaded rainforest community was:

- Bitou bush has prevailed on the site for 40 years, and
- Bitou bush seed persists in the soil for at least five years or more.

Long-term accumulation of bitou bush seed in the seed bank, along with its capacity to seed twice each year, gives clear indication that bitou bush at Cosy Corner will require intensive and frequent management for at least the first three, if not five years. Because of this, using natural processes to restore the site (rather than planting) is seen as highly advantageous, as funds can be solely directed to weed management.

The abundance and diversity of surrounding native flora at Cosy Corner provides a rich seed source to re-establish native rainforest communities through natural regeneration. Allowing time for natural processes to trigger the seed bank and for native local species to re-establish is the key to rehabilitation of this site.

Bitou bush removal

The technique for removing bitou bush at Cosy Corner is best simply stated as '*Remove mature bitou bush as quickly and on as large a scale as funds allow, to maximise environmental benefits with the least environmental impact*'. The intent of rapid and broad scale reduction in the mature (seed bearing) weed load is to remove the seed source and to expose the ground. This provides conditions that can trigger the native seed bank or prompt native seed to germinate. Exposure of ground at such a scale will increase costs in the short-term (the first 1–2 years), due to management of the inevitable secondary weed invaders. In the medium-term however (3–5 years), costs will be significantly reduced. Using a rapid removal approach across a large area will significantly reduce potential for re-infestation and facilitate natural regeneration processes across the entire site over the shortest possible period of time.

Alternatively, a smaller scale, slower operation would leave the adjoining weed seed source intact. This would facilitate continual re-infestation of the original site and, thus, a continuous need for weed control until the seed source is removed. These areas would remain arrested by weed invasion and be excluded from potential natural regeneration. Costs will therefore not be reduced and

could increase over time, depending on site conditions and project scale. On the Cosy Corner site, the added cost of leaving the eastern section of mature bitou bush intact was calculated at around \$10,000 per year.



Rainforest before bitou bush treatment



Rainforest after bitou bush treatment

Environmental benefits against costs

It is acknowledged that there are potential risks in a rapid weed removal process. There may be effects on native flora resulting from rapid change in both structure and microclimate, and effects on fauna resulting from rapid structural change in plant communities. However, the she-oak woodland and open banksia forest canopies on the site are considered sufficient to shelter both existing and recolonising rainforest species, even if all bitou bush is rapidly treated. Treated bitou bush skeletons in all areas will be left intact to reduce the impact of habitat change, and the canes will be manually broken down over 3–5 years. The risk of potential damage to individual native plants, or the short-term loss of habitat from rapid structural and microclimate change, is seen as acceptable when compared to the environmental benefits derived from rapid bitou bush removal.

Broad scale weed removal may be considered risky if native resilience is perceived to be absent or is overlooked. Lack of natural regeneration over time will result in large open areas requiring perpetual weed control. Fear of this outcome may result in an over-cautious approach to weed control or lead to the anthropocentric desire to undertake the ‘feel

good’ activity of planting. But before planting, natural resilience (or regenerative capacity) should be assessed. Planting too soon may interfere with or prevent natural regeneration. Indeed, planting may not be necessary at all, as demonstrated in the Cosy Corner rainforest example.

“Learn by experience over time – there is no substitute for observation and interpretation, and you simply can’t interpret nature unless you understand its processes.” – Steve Booth, Technical Officer, Cape Byron Trust.

What has happened

The primary focus of restoration should be to assess and then constantly review *any* resilience potential *before* planting is considered. This will allow land managers to capitalise on the economic and environmental benefits of using natural resilience.

At the time of writing, effective and thorough weed control has resulted in no known mature bitou bush within the 10 ha management area. Rainfall events have exposed multiple generations of bitou bush seed in the area first sprayed in 2005. Local observations indicate bitou bush typically has seven germination cycles over five years before the seed bank is all but exhausted, although it is still unknown exactly how long bitou bush seed is viable. Given the pace at which nature is responding, by 2010 a native canopy cover should be present that reduces potential for bitou bush re-invasion on any significant scale.

As for the natives, a wetter than average summer and autumn 2008 resulted in prolific flowering and fruiting of rainforest species. Examples include the ROTAP (Rare or Threatened Australian Plants) listed saw-leaved palm lily (*Cordyline congesta*), and one individual of the endangered scented acronychia (*Acronychia littoralis*) which produced an estimated 5000 seeds. It is hoped these works will provide opportunity for these and other native species to thrive. 🌻



Developing aerial spraying techniques in natural ecosystems

John Toth, Management of Environmental Weeds Pty Ltd, New South Wales

The aerial spraying program for bitou bush in New South Wales was developed following trials undertaken by NSW Agriculture (now Department of Primary Industries) in the late 1980s and early 1990s around Jervis Bay. The aim was to investigate whether extensive bitou bush control using aerial spraying within native vegetation could be effective. The results were favourable and aerial spraying has been used to control bitou bush along the New South Wales coastline between Narooma and Tweed Heads since 1992.

Initial trials focused on ground spraying techniques to determine which herbicides were most effective in controlling bitou bush. Six herbicides were trialled on bitou bush at different rates. At the same time, a permit was granted to deliberately apply the herbicides to seven native plant species: *Acacia longifolia* ssp. *sophorae*, *Banksia integrifolia*, *Casuarina glauca*, *Leptospermum laevigatum*, *Leucopogon parviflorus*, *Monotoca elliptica* and *Lomandra longifolia*, to determine the impact of over-spray. Herbicides that either failed to control bitou bush or caused severe damage to native plants were excluded from further testing. Only glyphosate and metsulfuron methyl were effective for controlling bitou bush in this study (Toth *et al.* 1996). Notably, low rates of glyphosate produced no measurable damage to native species, and low rates of metsulfuron methyl resulted in only ephemeral damage to *L. laevigatum* and *L. parviflorus*. Hence these two herbicides proved sufficiently appropriate for use on bitou bush in native vegetation (Toth *et al.* 1993).

A subsequent trial was undertaken to examine the seasonal sensitivity of bitou bush to glyphosate and metsulfuron methyl and an effective application rate for bitou bush control amongst native species. The two-year trial revealed that spraying in winter reduced the impact on native vegetation while delivering effective control of bitou bush; bitou bush was at least twice as sensitive to glyphosate

in winter than during summer, especially following peak winter flowering (Toth 1997). There was no apparent trend with metsulfuron methyl.

Subsequently, similar seasonal and rate trials were carried out on five of the native plant species: *A. longifolia* ssp. *sophorae*, *B. integrifolia*, *L. laevigatum*, *L. parviflorus* and *L. longifolia*, to determine seasonal and application rate tolerances. The results showed a seasonal tolerance of these native plants to low rates of herbicides applied during winter. However, seedlings of *A. longifolia* ssp. *sophorae* showed some sensitivity to glyphosate (Toth *et al.* 1996).



Terry Inkson, Great Lakes Council

Aerial boom spraying bitou bush



John Toth

Initial aerial spray trials at Jervis Bay in the late 1980s and early 1990s. Treatments involved glyphosate and metsulfuron methyl on bitou bush and native plants



John Toth



John Toth



John Toth



John Toth

Coastal heath (*Leptospermum laevigatum*) before (above) and after (below) glyphosate spray in winter

Bitou bush before (above) and after (below) glyphosate spray in winter

Further trials were undertaken using aerial techniques at four sites along the New South Wales coast from Jervis Bay to Yamba. This work supported the ground spraying trials, suggesting that effective control of bitou bush could be achieved using aerial spraying, with minimal off-target damage to native species. Very low rates of glyphosate [2 L/ha of Roundup® (360 g/L glyphosate)], and metsulfuron methyl [30 g/L of Brushoff® (600 g/kg metsulfuron methyl)] were proven effective and applied. Penetrants were also trialled but based on unfavourable results were not recommended further (Toth *et al.* 1996, Toth and Winkler 2008).

Based on these trials, permits for helicopter boom spraying of bitou bush using glyphosate products, and more recently for metsulfuron methyl, have been approved by the Australian Pesticide and Veterinary Medicines Authority (APVMA). The response of 220 plants species

(natives and weeds) to glyphosate and 83 species to metsulfuron methyl has been collected (Broese van Groenou and Downey 2006) and observational data continues to be collected on the response of native species to aerial spraying. Further research on biodiversity changes after aerial spraying can be found in Mason and French (2007).

The outcome of 15 years of aerial spraying to control bitou bush in New South Wales has revealed that while large areas can be treated effectively, follow-up control is essential to managing bitou bush recruitment, as well as secondary weed invasion, after each aerial spraying operation. And, more importantly, that aerial spraying should only be undertaken when resources are available to undertake such follow-up control work. See page 49 for *Best practice guidelines for aerial spraying of bitou bush in New South Wales*. 



Six years of bitou bush control at the Sea Acres demonstration site

Jeff Thomas, Parks and Wildlife Group, Department of Environment and Climate Change, New South Wales

The NSW National Parks and Wildlife Service established a bitou bush control demonstration site at the Sea Acres Nature Reserve, in Port Macquarie on the Mid-North Coast of New South Wales, in 2001. The demonstration site was established to study effectiveness of control programs on bitou bush and the response of native species to different control programs, as well as the effort required for treatment. The following are results of three combinations of herbicide treatment and handweeding undertaken over six years at this site.

The demonstration site

The site was located on the northern slope of a headland adjacent to a high conservation value littoral rainforest and remnant *Themeda* grassland. The site was heavily infested with bitou bush ($\geq 40\%$ cover) in 2001 and only minor bitou bush control works had previously occurred. Remnant vegetation within the site consisted mostly of hardier rainforest trees, with few taller than the bitou bush canopy. Minor infestations of other weeds (*Senna pendula* var. *glabrata* and *Lantana camara*) were also present.

Bitou bush control programs

The site was separated into three blocks that were each treated with a different control method. All blocks were treated annually over the next six years (with an initial biannual treatment in the first two years). At 18 months and subsequently, the bitou bush in all blocks was controlled using a combined glyphosate spraying/handweeding/cut-and-paint treatment.

Block 1 – the initial treatment was foliar backpack spraying with glyphosate (360 g/L) at a rate of 1:200.

Block 2 – initial treatment was foliar backpack spraying with metsulfuron methyl (600 g/kg) at a rate of 1 g/10 L plus Pulse®.

Block 3 – initial treatment was handweeding combined with cutting and painting stumps using glyphosate (360 g/L) at a rate of 1:10.

Several wildfires occurred at the site, including one in block 1 in 2006, which led to increased bitou bush germination from the soil seed bank and damage to rainforest canopy species. Management needs to be able to respond to disturbances, such as fire, that favour the re-establishment of bitou bush.

Changes in vegetation cover after six years of control showed a decrease in bitou bush cover across the entire site and all treatments, and a corresponding increase in native vegetation cover. There was also an increase in the diversity of native species.

Bitou bush re-infestation varied depending on the methods of control used (physical removal versus spraying). Physical removal (block 3) caused disturbance of the ground



Jeff Thomas



Jeff Thomas

Demonstration site before bitou bush treatment, 2001 (above) and after treatment, 2007 (below)

and exposed ground surfaces, giving rise to increased bitou bush seedling germination and re-infestation compared with foliar spray plots, where dead bitou bush plants and recovering native vegetation helped suppress bitou bush germination. There was a lower cover of bitou bush in the metsulfuron methyl block (block 2) following control, which may be due to dense growth of blady grass (*Imperata cylindrica*) suppressing germination and/or reduced germination due to a residual effect of metsulfuron methyl.

In the glyphosate and handweeding blocks (1 and 3), there was over 50% cover of bitou bush prior to the second control application, which demonstrates the importance of follow-up treatment.

Effort required to treat the site has also changed over time. After two years, control in the sprayed blocks (1 and 2) was reduced to a fraction of the initial effort. The physical removal block (3) required substantially more effort for initial control and follow-up control (at 12 months) than the sprayed blocks. Increases in effort were also needed to control other weeds, principally *L. camara* and *S. pendula* var. *glabrata*.

Conclusions

1. Information collected from this site demonstrated that control of bitou bush

and restoration of natural vegetation is achievable within a reasonable time frame (i.e. <5 years). However, continual but reduced levels of maintenance must be undertaken and control of other weed species must be considered if native vegetation restoration is a priority.

2. Selective foliar spray treatments of either glyphosate or metsulfuron methyl reduce cover of bitou bush and allow native species density and numbers to increase.
3. Six-monthly (biannual) control is not recommended because it did not lead to more effective long-term control. In addition the effort expended in implementing biannual control was greater than simply increasing the effort during annual control. However, annual control must be thorough.
4. The information collected in these trials suggests that physical removal is only economically practical when bitou bush infestations are small or at very low densities. The cost of physical removal over a large area does not compare favourably with other methods of control. However, where access is limited and/or where avoiding impacts to native species and maximising return of native vegetation are high priorities, then intensive, careful physical control is the preferred option. 🌻



Block 1 changes over time
Clockwise from top right:
2001, 2002, 2004 and 2007
Photos: Jeff Thomas



Protecting native plants from bitou bush invasions – the NSW Bitou Bush Threat Abatement Plan

Paul Downey and Alana Burley, Department of Environment and Climate Change, New South Wales



Paul Downey

Bitou bush engulfing the habitat of Pandanus tectorius var. australianus

In 1984, Dodkin and Gilmore outlined the extent to which bitou bush was posing a serious threat to native plant communities in New South Wales. It was not, however, until 1999 that the threat was formally recognised when the invasion of native plant communities by bitou bush and the closely related boneseed was listed as a Key Threatening Process (KTP) under the NSW *Threatened Species Conservation Act 1995 (TSC Act)*. A year later bitou bush was listed as a Weed of National Significance (WoNS). The KTP listing led to the development of a Threat Abatement Plan (TAP) under the Act to reduce, abate or ameliorate the threat posed by bitou bush to native plant communities (DEC 2006).

In order to prepare the TAP, an assessment of the native plant species and ecological communities at risk was needed. A systematic evaluation of the available information on the native plants and ecological communities threatened (both formally listed and those not listed) by bitou bush in New South Wales was undertaken. This process identified 157 plant species, three threatened plant populations and 24 ecological communities as being at risk from bitou bush invasions; approximately 65% of these plant species were not listed

as threatened. Of the identified biota, 19 plants, two populations and eight ecological communities were deemed to be the highest priority for conservation.

The next step in the TAP development was to identify priority sites for control of bitou bush irrespective of land tenure (i.e. public and/or private). This process identified almost 350 sites in New South Wales, from which 169 were deemed to be the highest priority for control because control at these sites was likely to have the greatest benefit to threatened biodiversity. This assessment was based on three site attributes: (1) the impact present, (2) the ability to achieve effective control, and (3) the condition of the native species at risk.

The draft TAP was overwhelmingly supported following public exhibition in 2004 and a final TAP was released in 2006 under the *TSC Act*. The TAP is now being implemented across New South Wales.

Work at many of the high priority TAP sites has now commenced, with 93 site-specific management plans approved. A steady influx of new site-plans is continuing. This has seen engagement of a wide range of stakeholders, spanning government agency staff, council workers, community groups and volunteers. Approximately 30 different land managers are currently involved with the implementation of the TAP in New South Wales.

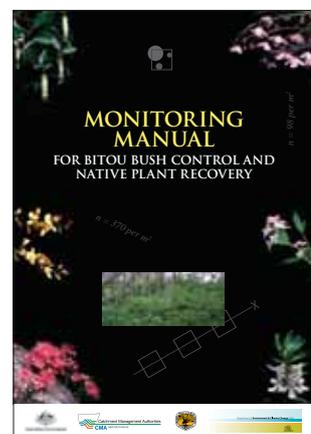
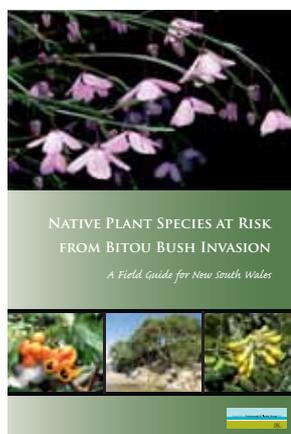
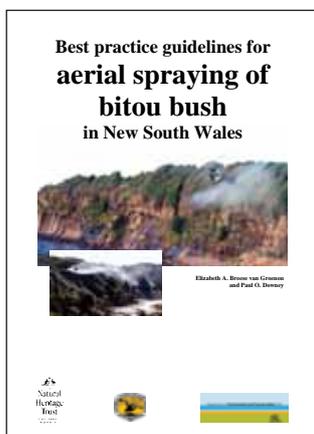
To help land managers and community groups protect the native species identified in the TAP, a range of tools are available as part of the TAP implementation including: (1) a Bitou TAP website, (2) a field guide to the native species at risk, (3) a monitoring manual, (4) best practice information, (5) a site-specific management plan pro-forma, (6) a generic scientific licence, and (7) a dedicated coordinator (see page 100).

TAP tools

Bitou TAP tools are:

- 1. TAP implementation website** – www.environment.nsw.gov.au/bitoutap.
- 2. Field guide to the native species at risk** – information on the species at risk from bitou bush was insufficient for land managers to identify them, thus a photographic identification guide was produced. Copies of this field guide are available free of charge.
- 3. Monitoring manual** – a monitoring manual is being produced to help land managers collect sufficient data to show how bitou bush control leads to the recovery of the native plant species at risk. This manual outlines a series of standardised monitoring techniques, spanning three different levels of complexity. Copies will be available in early 2009.
- 4. Best practice information** – a range of best practice information has been developed in conjunction with the WoNS program which include aerial spraying guidelines, the boneseed management manual and this bitou bush manual. Copies of aerial spraying guidelines are available from the website, and copies of the boneseed manual are available for download from www.weeds.org.au/WoNS/bitoubush or contact the national bitou bush and boneseed coordinator (see website for contact details).
- 5. Site-specific management plans** – help to ensure that bitou bush control is focused on protecting native species. Management plans connect individual land managers with their site, and enable them to account for their site conditions, limitations, skills and resources.
- 6. Scientific licence** – once a site-plan has been approved by the TAP coordinator, a copy of the generic TAP scientific licence is then provided to the relevant land manager. This allows them to work with threatened species provided they follow the site-plan, the TAP, and all other conditions on the licence.
- 7. TAP coordinator** – implementation of the TAP is highly dependent on the coordinator. This position assesses site-plans, updates the website, applies for funding, liaises with stakeholders, collates information on each site and the progress made and reports back to funding bodies on the TAP.

Copies of the Bitou TAP and other products can be obtained from the website (www.environment.nsw.gov.au/BitouTAP) or the TAP email address (bitou.tap@environment.nsw.gov.au) or by contacting the TAP coordinator at: Pest Management Unit, Department of Environment and Climate Change, PO Box 1967, Hurstville, New South Wales 1481. 🌻





Economic evaluation of the *NSW Bitou Bush Threat Abatement Plan*

Susie Hester and Jack Sinden, University of New England, Armidale, New South Wales

The *NSW Bitou Bush Threat Abatement Plan* (TAP) aims to reduce the impacts of bitou bush on biodiversity in New South Wales. This is the first weed TAP in Australia and so its effectiveness in conserving threatened biodiversity, as well as its cost of implementation, must be examined to determine if this new approach should be adopted as the template for managing the biodiversity impacts of other major weed species. We therefore consider the question "is the TAP a good investment in relation to protecting biodiversity?".

The steps for evaluating the TAP follow the standard procedures of benefit-cost analysis (see Sinden and Thampapillai (1999) for further details). These are:

- Define the problem and the management strategy,
- Define the nature and value of the costs,
- Define the nature of the benefits,
- Measure the gain in quantity of benefits,
- Value the increase in benefits, and finally
- Calculate the benefit-cost ratios.

Sinden *et al.* (2008) give full details of how benefit-cost ratios for the TAP were calculated and their method and results are only briefly detailed here.

The problem is the threat posed by bitou bush to native plant communities in New South Wales. The TAP is a management strategy to address the problem, which aims to protect 157 plant species, three populations and 24 ecological communities at over 350 sites along the entire New South Wales coastline. The TAP comprises various actions including on-ground control, monitoring the response of bitou bush and native species to control, and coordination of on-site and between-site management to implement the plan. The analysis must answer the question, "do the benefits of the TAP exceed the costs?". The benefit is the value gained from the protection

of biodiversity from bitou bush, and the costs are the resources invested to achieve this benefit.

The costs of implementing the TAP include cash expenditure, external grants and in-kind contributions. The costs include expenditure by the Department of Environment and Climate Change, Department of Lands, five coastal catchment management authorities, the Lord Howe Island Board, numerous coastal councils and the University of Wollongong. The external grants are income from other state and Commonwealth agencies such as the Natural Heritage Trust and the in-kind costs include volunteer labour costed as the number of volunteer hours multiplied by an hourly wage rate, government agency and other staff time and the associated on-costs. The total cost of implementing the plan in 2005–06 was \$2,845,500, which is estimated to remain at a similar level for each of the following five years of the TAP (DEC 2006).

There are two kinds of benefit derived from the TAP, namely (i) the increase in amenity from the improved access to the beaches (and the associated social values), and (ii) the increase in environmental services from the extra biodiversity that is protected. To identify the increase in environmental and social services due to the TAP, consider an area where native species are being protected by the TAP for their biodiversity benefits. This can be compared to the situation if the TAP is not implemented, where the environmental services will decline.

To measure the increase in the quantity of benefits from implementing the TAP, we need to know how this decline in biodiversity would occur without the TAP, and how much biodiversity exists at the end of the time horizon if bitou bush were allowed to spread.

The next step in the process is to value a unit of the benefits that would flow from implementing the TAP. There are many different techniques available for valuing

biodiversity and in this study a defensive expenditure approach is used. In this approach, the amount of money spent on protecting native species from a bitou bush invasion is taken as the minimum value to society of those species protected. An example of this type of study is provided by Sinden and Griffith (2007), who derived the value for biodiversity services provided by sites that were protected from 35 weeds in Australia. Their value for the benefit was \$5864 per site per year and this value is used as a starting point to determine the benefits from protecting biodiversity by controlling bitou bush over time.

Once calculated, the gains and losses from the TAP can be readily compared using the following benefit-cost ratio (BCR) formula:

$$\text{BCR} = \frac{\text{Present value of the flow of annual benefits for all sites for } t \text{ years}}{\text{Present value of the flow of TAP costs for 5 years}}$$

A present value is the value today of a flow of future benefits, or costs, discounted at an appropriate rate. This analysis is undertaken from the viewpoint of the community, as opposed to that of the private firm, so a discount rate of 5% is appropriate and year one is taken as 2005–2006. When the BCR exceeds 1.0, benefits exceed costs, when it equals 1.0 benefits equal costs, and when it is less than 1.0, costs exceed benefits. A BCR of 2.4, for example, reflects \$2.40 worth of benefits for every dollar invested.

Benefit-cost ratios to assess the desirability of implementing the NSW *Bitou Bush Threat Abatement Plan* with standard deviations shown in parentheses

Years of benefit flow (time)	Benefit-cost ratios	
	On-ground TAP costs	Total TAP costs
20	2.22 (0.28)	1.94 (0.25)
50	2.92 (0.38)	2.56 (0.33)

The mean BCR of the TAP for two time periods and the two kinds of cost are shown in the table above (see Sinden *et al.* 2008 for details of how these were derived). The most relevant scenario comprises the total costs and a 50-year benefit flow because these attributes best model the implementation of the TAP across its range of actions and reflect the long-term benefits of these management activities. This scenario has a mean BCR of 2.56. Thus, every dollar invested in the implementation of the TAP yields \$2.56 in return. So the annual benefit from the TAP, or its total annual economic worth, is \$7.28m (2.56 × \$2.845m). The benefits from the TAP therefore appear to exceed the costs under a wide variety of economic conditions. 

Section Eight

Further information

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Declaration details of bitou bush in Australia

The importation of bitou bush (and all subspecies of *Chrysanthemoides monilifera*) into Australia is illegal, as determined by the Australian Quarantine Inspection Service (AQIS). See the import conditions database (ICON) on the AQIS website for details (www.aqis.gov.au).

Management of bitou bush at a state/territory level varies across Australia. The table below outlines the agencies responsible and the relevant legislation in each jurisdiction.

State/Territory and agency	Relevant legislation	Declaration details for bitou bush	Area to which the declaration applies
Australian Capital Territory Department of Urban Services	<i>Pest Plants and Animals Act 2005</i>	Prohibited pest plant Bitou bush is a pest plant whose propagation and supply is prohibited	Whole of territory
New South Wales Department of Primary Industries	<i>Noxious Weeds Act 1993</i>	Declared noxious weed Bitou bush (or material containing bitou bush) may not be imported into New South Wales, sold, bought or otherwise distributed	Whole of state
		Class 2 Regionally prohibited weed The plant must be eradicated from the land and the land must be kept free of the plant	1 LCA: Lord Howe Island
		Class 3 Regionally controlled weed The plant must be fully and continuously suppressed and destroyed	33 LCAs: Ashfield, Albury, Bankstown, Bega Valley, Blue Mountains, Botany Bay, Burwood, Canada Bay, Canterbury, Fairfield, Holroyd, Hornsby, Hunters Hill, Hurstville, Kogarah, Ku-ring-gai, Lane Cove, Leichhardt, Liverpool, Marrickville, Mosman, North Sydney, Parramatta, Pittwater, Randwick, Rockdale, Ryde, Strathfield, Sydney, Warringah, Waverley, Willoughby, Woollahra
		Class 4 Locally controlled weed The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority	24 LCAs: Bellingen, Cessnock, Clarence Valley, Coffs Harbour, Eurobodalla, Far North Coast County Council, Gosford, Great Lakes, Greater Taree, Kempsey, Kiama, Lake Macquarie, Maitland, Nambucca, Newcastle, Port Macquarie-Hastings, Port Stephens, Shellharbour, Shoalhaven, Sutherland, Wollongong, Wyong
Department of Environment and Climate Change	<i>Threatened Species Conservation Act 1995</i>	Key threatening process 1999 Preparation of a threat abatement plan was required at the time of listing so as to abate, ameliorate or eliminate the adverse effects of bitou bush on threatened (or potentially threatened) species, populations or ecological communities	Whole of state

State/Territory and agency	Relevant legislation	Declaration details for bitou bush	Area to which the declaration applies
Queensland Department of Primary Industries and Fisheries	<i>Land Protection (Pest and Stock Route Management) Act 2002</i>	Bitou bush – declared as a Class 1 pest. It may not be introduced or supplied, and is subject to eradication from the state. Landowners must take reasonable steps to keep land free of bitou bush	Whole of state
Victoria Department of Primary Industries	<i>Catchment and Land Protection Act 1994</i>	Declared noxious weed Bitou bush (or material containing bitou bush propagules) may not be imported into Victoria, and must not be sold, bought or otherwise distributed or moved	Whole of state
		Regionally prohibited weed Landholders and public authorities must eradicate or control these weeds on their lands	3 of 10 CMAs: North Central, North East, East Gippsland
		Regionally controlled weed Landholders are responsible to take all reasonable steps to control the growth and spread of these weeds on their land	7 of 10 CMAs: Mallee, Wimmera, Glenelg-Hopkins, Corangamite, Port Phillip, Goulbourn Broken, West Gippsland
Northern Territory Department of Natural Resources, Environment, the Arts and Sport	<i>Weeds Management Act 2001</i>	Declared weed Class A To be eradicated Class C Not to be introduced to the Territory Bitou bush may not be bought, sold or moved within the Territory. Owners and occupiers of land are required to control bitou bush, comply with weed management plans, and notify authorities of new occurrences of bitou bush	Whole of territory
South Australia Department of Water, Land and Biodiversity Conservation	<i>Natural Resources Management Act 2004</i>	Class 4 Control required throughout the state (trade and movement usually restricted throughout the state)	Whole of state
Tasmania Department of Primary Industries and Water	<i>Weed Management Act 1999</i>	Declared weed Bitou bush may not be imported into Tasmania, and must not be sold or otherwise distributed	Whole of state
Western Australia Department of Agriculture and Food	<i>Agriculture and Related Resources Protection Act 1976</i>	Declared plant P1 The trade, sale or movement of plants or their seeds is prohibited within Western Australia P2 Any bitou bush found is to be eradicated	Whole of state

Safety and other legal requirements

Safety

All weed control activities involve some form of risk, so personal safety must be a top priority. Regulations regarding the safe use of herbicides and machinery must be followed and personal protective equipment such as gloves, respiratory equipment and eye and ear protection must be worn when required. Training is necessary in certain situations when using herbicides and machinery.

Legislation regarding Occupational Health and Safety (OH&S) is available from the Australian Safety and Compensation Council www.ascc.gov.au. Volunteering Australia has a good OH&S management tool for organisations involving volunteers called *Running the Risk?* which can be downloaded free of charge from www.volunteeringaustralia.org. You can also talk to your local council or NRM agency for more information on safety in weed management.

Protection of native vegetation and threatened species (including licensing)

Weed control can impact on native vegetation. You may need permits if you work with threatened species or if your activities are likely to impact native vegetation. Contact the relevant native vegetation or threatened species authority in your area for details (see page 107).

 **Rare or threatened species, or vegetation of conservation significance, should be identified in your bitou bush management plan (see Section 2).**

Cultural heritage

 **Many states require that assessments be done before beginning restoration work in areas that may hold cultural significance.**

Commonwealth legislation governing indigenous and historic heritage sites includes the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*, *Environment Protection and Biodiversity Conservation Act 1999* and the *Australian Heritage Commission Act 1975*. State and local government legislation may also apply. Initially, contact your local government or NRM authority; they will be able to inform you of any issues and advise you on how to proceed.

More often than not, the location of culturally significant sites are not known until work in these areas uncovers them. A valuable resource to consider before beginning any work is *Ask First: a guide to respecting Indigenous heritage places and values*, a document which can be downloaded from the Australian Government Heritage Council website <http://www.environment.gov.au/heritage/ahc/publications/index.html>.

The Australian Heritage Database contains information on over 20,000 natural, historic and indigenous places, and searching by local government area will provide a list of heritage places in a locality. The database can be found on the Department of the Environment, Water, Heritage and the Arts website www.environment.gov.au/heritage. Indigenous Land Management Facilitators can help with questions about Aboriginal heritage. For a list of these Indigenous Land Management Facilitator contacts, see the Australian Government Caring for our Country website www.nrm.gov.au/contacts.

Native vegetation and threatened species contacts

Jurisdiction	Native vegetation contacts (and relevant legislation)	Threatened species contacts (and relevant legislation)
Australia	Department of the Environment, Water, Heritage and the Arts 02 6274 1111 www.environment.gov.au <i>Environment Protection and Biodiversity Conservation Act 1999</i>	Department of the Environment, Water, Heritage and the Arts 2 6274 1111 www.environment.gov.au <i>Environment Protection and Biodiversity Conservation Act 1999</i>
Australian Capital Territory	Department of Territory and Municipal Services 13 22 81 <i>Nature Conservation Act 1980</i>	Department of Territory and Municipal Services 13 22 81 <i>Nature Conservation Act 1980</i>
New South Wales	Department of Environment and Climate Change 131 555 www.nativevegetation.nsw.gov.au <i>Native Vegetation Act 2003</i>	Department of Environment and Climate Change 131 555 www.threatenedspecies.environment.nsw.gov.au <i>Threatened Species Conservation Act 1995</i>
Queensland	Department of Natural Resources and Water 13 13 04 www.nrw.qld.gov.au <i>Vegetation Management Act 1999</i> <i>Integrated Planning Act 1997</i>	Environmental Protection Agency 1300 130 372 www.epa.qld.gov.au <i>Nature Conservation Act 1992</i>
Victoria	Department of Environment and Sustainability 136 186 www.dse.vic.gov.au <i>Catchment and Land Protection Act 1994</i>	Department of Environment and Sustainability 136 186 www.dse.vic.gov.au <i>Flora and Fauna Guarantee Act 1988</i>
Northern Territory	Department of Natural Resources, Environment, the Arts and Sport 08 8999 5511 <i>Planning Act 2008</i> <i>Pastoral Land Act 2007</i>	Department of Natural Resources, Environment, the Arts and Sport 08 8999 5511 <i>Territory Parks and Wildlife Conservation Act 2007</i>
South Australia	Department of Water, Land and Biodiversity Conservation 08 8463 6800 www.dwlbc.sa.gov.au/native/ <i>Native Vegetation Act 1991</i>	Department for Environment and Heritage 08 8222 9311 www.deh.sa.gov.au/biodiversity/threatened.html <i>National Parks and Wildlife Act 1972</i>
Tasmania	Department of Primary Industries and Water 03 6233 3295 or 1300 368 550 www.dpiw.tas.gov.au <i>Forest Practices Act 1985</i> <i>Land Use Planning and Approvals Act 1993</i>	Department of Primary Industries and Water 03 6233 8759 or 1300 368 550 www.dpiw.tas.gov.au <i>Threatened Species Protection Act 1995</i>
Western Australia	Department of Environment and Conservation 1800 061 025 www.dec.wa.gov.au <i>Environmental Protection Act 1986</i>	Department of Environment and Conservation 08 9334 0333 www.dec.wa.gov.au <i>Wildlife Conservation Act 1950</i>

Useful weed contacts and resources

This table includes additional contacts to those in the table on page 107.

Organisation	Web address or contact details	Information available
National		
Weeds Australia – bitou bush and boneseed – other Weeds of National Significance (WoNS)	www.weeds.org.au – www.weeds.org.au/WoNS/bitoubush	<ul style="list-style-type: none"> • Legislation • Funding • Weed ID • Contacts and web links
Cooperative Research Centre for Australian Weed Management	www.weedsrcr.org.au	<ul style="list-style-type: none"> • Weed management guides • Research information
Department of the Environment, Water, Heritage and the Arts – weeds – indigenous heritage protection	www.weeds.gov.au – www.environment.gov.au – www.environment.gov.au/biodiversity/invasive	<ul style="list-style-type: none"> • Legislation • Funding opportunities • Heritage protection • Weed identification
Australian Heritage Commission – indigenous heritage protection	www.environment.gov.au/heritage/ahc	<ul style="list-style-type: none"> • Heritage protection
Department of Agriculture, Fisheries and Forestry – NRM funding	www.daff.gov.au – www.daff.gov.au/nrm	<ul style="list-style-type: none"> • Web links • Funding • NRM programs
Australian Government Caring for our Country	www.nrm.gov.au	<ul style="list-style-type: none"> • Funding opportunities • Contacts and web links
Australian Quarantine and Inspection Service	www.aqis.gov.au	<ul style="list-style-type: none"> • Import conditions database (ICON)
Australian Pesticides and Veterinary Medicines Authority – search for herbicides – search for permits	www.apvma.gov.au – services.apvma.gov.au/PubcrisWebClient – www.apvma.gov.au/permits/permits.shtml	<ul style="list-style-type: none"> • Current herbicide registrations and permits • Safe herbicide use
Australian Safety and Compensation Council	www.nohsc.gov.au	<ul style="list-style-type: none"> • OH&S legislation
ChemCert Australia	www.chemcert.com.au	<ul style="list-style-type: none"> • Chemical use training
drumMUSTER	www.drummuster.com.au	<ul style="list-style-type: none"> • Collection and recycling of chemical containers
Volunteering Australia	www.volunteeringaustralia.org	<ul style="list-style-type: none"> • Risk management tool
Landcare Australia	www.landcareonline.com	<ul style="list-style-type: none"> • National Landcare site • Web links
Coastcare	www.coastcare.com.au	<ul style="list-style-type: none"> • National Coastcare site • Contacts and web links

Organisation	Web address or contact details	Information available
National continued/...		
Weedbusters Australia	www.weedbusterweek.info.au	<ul style="list-style-type: none"> • Community weed awareness
<i>Weed Warriors</i>	www.weedwarriors.net.au	<ul style="list-style-type: none"> • Community biological control
Australian Association of Bush Regenerators	www.aabr.org.au	<ul style="list-style-type: none"> • Bush regeneration
Queensland		
Department of Primary Industries and Fisheries	www.dpi.qld.gov.au	<ul style="list-style-type: none"> • Legislation • Declared plant lists • Control methods
Landcare Queensland	www.landcare.org.au	<ul style="list-style-type: none"> • Funding opportunities • Resources
Regional Natural Resource Management (SEQ Catchments, Burnett Mary Regional Group)	www.regionalnrm.qld.gov.au	<ul style="list-style-type: none"> • Regional natural resource management bodies
AgForce Queensland	www.agforceqld.org.au	<ul style="list-style-type: none"> • Chemical use training
New South Wales		
Department of Primary Industries – weed management – noxious weed declarations	www.dpi.nsw.gov.au – www.agric.nsw.gov.au/reader/weeds – www.agric.nsw.gov.au/noxweed	<ul style="list-style-type: none"> • Legislation • Noxious weeds list • Funding opportunities • Education/awareness
Department of Environment and Climate Change	www.environment.nsw.gov.au/pestsweeds	<ul style="list-style-type: none"> • Legislation • Weed management • Web links • Pesticide legislation • Pesticide use
SMARTtrain	www.smarttrain-publications.com	<ul style="list-style-type: none"> • Chemical use training
Catchment Management Authorities	www.cma.nsw.gov.au	<ul style="list-style-type: none"> • NSW CMAs • Regional community support officers • Regional weed plans
Local Government Portal	www.nsw.gov.au	<ul style="list-style-type: none"> • Web links • Contacts
Landcare NSW	www.landcarensw.org	<ul style="list-style-type: none"> • Landcare group resources • CMA contacts

SECTION 8: Further information

Organisation	Web address or contact details	Information available
New South Wales continued/. . .		
Far North Coast Weeds Advisory Committee (Nambucca Shire north to Queensland border)	www.northcoastweeds.org.au	<ul style="list-style-type: none"> • Weed declarations • Strategies, management and control plans • Web links
Community Environment Network (Lake Macquarie, Wyong, Gosford)	www.cccen.org.au	<ul style="list-style-type: none"> • Workshops and events information • Web links
Manning Coastcare (Greater Taree City Council area)	www.manningcoastcare.org	<ul style="list-style-type: none"> • Volunteer work • Community nursery
Lake Macquarie Landcare	www.lakemacquarielandcare.org	<ul style="list-style-type: none"> • Group contacts
Hastings Landcare	Ph: 02 6586 4465	<ul style="list-style-type: none"> • Group contacts • Liaison officer for funding
Wycare (Wyong Shire Landcare network)	www.wycare.com.au	<ul style="list-style-type: none"> • Contacts • Annual Landcare forum
Trees in Newcastle	www.treesinnewcastle.org.au	<ul style="list-style-type: none"> • Native plant nursery • Revegetation and restoration information
South Coast Bitou bush and Boneseed Taskforce	www.southerncouncils.nsw.gov.au – Click on > Programs > Noxious Weeds (IDNWA) > South Coast Bitou Bush Project	<ul style="list-style-type: none"> • Management • Reports • Strategies • Contact information
Victoria		
Department of Primary Industries – weeds – agricultural chemical use	www.dpi.vic.gov.au – Click on > Agriculture and Food > Crops, pastures and weeds > Weeds – Click on > Agriculture and Food > General farming > Chemical use	<ul style="list-style-type: none"> • Legislation • Noxious weeds list • Chemical use • Biological control information • Information on weeds on public land
Department of Sustainability and Environment – CMAs	www.dse.vic.gov.au – Click on > Land management > Catchments	<ul style="list-style-type: none"> • Victorian CMAs
AgTrain	www.dpi.vic.gov.au/agtrain	<ul style="list-style-type: none"> • Chemical use training
Landcare Victoria	www.landcarevic.net.au	<ul style="list-style-type: none"> • Landcare group resources • Contacts • Insurance

Information for community volunteers

Incorporation, insurance and liability

It is recommended that all volunteer groups be incorporated. In most cases, the liability of any legal actions brought against an incorporated group are limited to only the group's assets. Without incorporation, individuals and their assets are liable. Groups must also be incorporated to directly receive any government grants or funding, otherwise they must use an incorporated sponsor to manage the funding money on their behalf.

All volunteer groups should have insurance that covers them for public liability and personal accidents. Groups should also consider associations liability insurance (provides protection for officers of the group from legal actions). Insurance policies for Landcare, Bushcare and Coastcare groups can be obtained for around \$300. Good general information on incorporation and insurance is available from the Tasmanian Landcare Association's website www.taslandcare.org.au.

An alternative to obtaining incorporation and insurance is for your group to join a large organisation that acts as an 'umbrella body'. Organisations such as regional Landcare groups may encompass member groups within their corporation and provide insurance.

Groups working on council or state land (e.g. national parks and reserves or land managed by CMAs, or NRM boards) may also be covered for insurance – contact the relevant authority for details.

Funding for weed management

There are many funding opportunities for weed management, which are often part of a broader natural resource management program, such as the restoration of native vegetation. Grants are available from federal and state governments, CMAs and NRM boards, councils, and private entities. The Australian Government Weeds in Australia website www.weeds.gov.au contains information on funding

opportunities or see the Weeds Australia website www.weeds.org.au.

When applying for funding, involve the land manager of your site and seek help from your council and CMA or NRM board in the early stages of planning. For state-wide or national projects involving bitou bush or other Weeds of National Significance (WoNS), you can enlist the help and support of the relevant WoNS coordinator – see www.weeds.org.au/natsig.htm for contact details. Having a well prepared management plan (see Section 2) will help you to fill out funding applications.

Attracting new community volunteers

A large amount of bitou bush control along the coast is performed by community groups. Expanding your community group is advantageous for group longevity and to perpetuate the good work invested. The Tasmanian Landcare Association has initiated a program that links volunteers to working groups via 'a dating agency for sustainability' known as Extrahands – see www.taslandcare.org.au for more information.

Awareness raising is one good way of attracting new community volunteers. Your community group may choose to report good news in the local paper or radio, or present an information display at a local field day, as shown in the photograph below. Events that foster community participation and



Bitou bush display at Florafest community event, Lake Macquarie, New South Wales

Kim Hignell, City of Lake Macquarie Council

demonstrate the significance and benefits of your group's work tend to encourage involvement from additional community members. Regular electronic newsletters are also valuable in sharing progress and keeping people involved. This can also make it easy to report on your results through the bitou bush network (see page vii).

Community groups that continually gather new members may couple a social focus along with the environmental focus. Examples of actively growing community groups are presented in two case studies on Manning Coastcare and Tathra Landcare in Section 7. Often the impetus for growth is stimulated by an individual, or small groups of individuals, who are committed to drive the direction of the whole community group.

Education and awareness materials

Education and awareness materials for bitou bush are available free from the National Bitou Bush and Boneseed Coordinator. Available for distribution are: national bitou bush flyers; *Native Plant Species at Risk from Bitou Bush Invasion – a Field Guide for New South Wales*; bookmarks of high priority species at risk from bitou bush in New South Wales; the *NSW Bitou Bush Threat Abatement Plan* (Bitou TAP); and *Best practice guidelines for aerial spraying of bitou bush in New South Wales*. Available for loan for field days and educational displays are: a national bitou bush banner (around 2 m tall); a Bitou TAP banner for New South Wales; and a Bitou TAP tools banner.

For contact details for the national coordinator, and to download this manual, flyers, and weed management guides, see the Weeds Australia website www.weeds.org.au/WoNS/bitoubush.



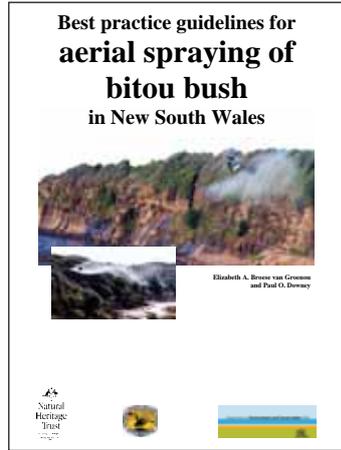
National bitou bush banner



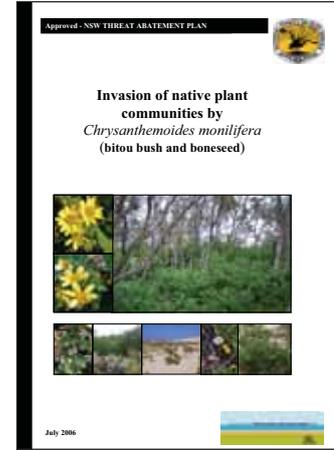
National bitou bush flyer



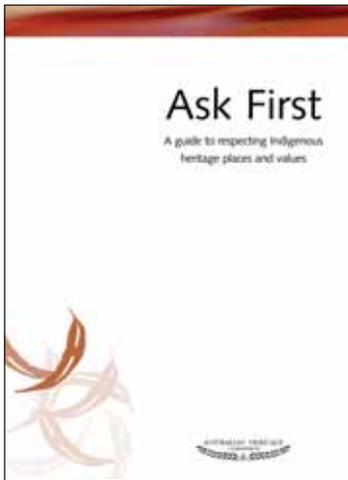
Weeds CRC bitou bush management guide



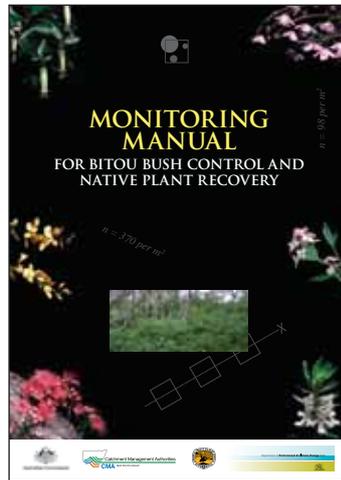
Aerial spraying guidelines



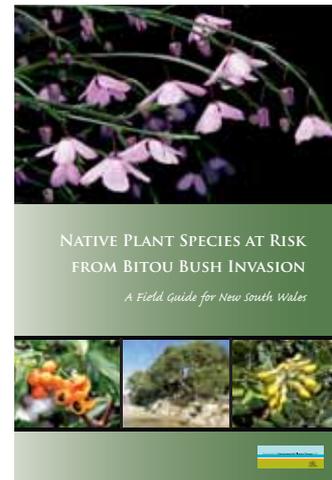
NSW Threat Abatement Plan



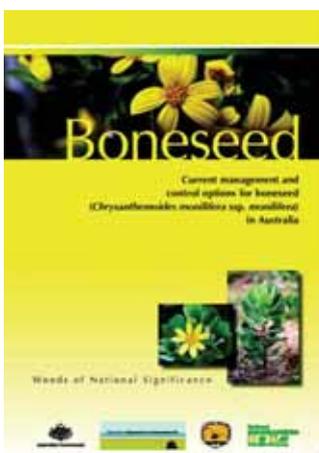
Ask First: a guide to respecting Indigenous heritage places and values



Monitoring guidelines



Field guide to the native plants at risk in New South Wales



Boneseed management manual



National Bitou Bush and Boneseed Forum proceedings



Priority native species bookmarks

Glossary

Achene	A dry one-seeded fruit that does not open at maturity to release the seed
Allelopathy	The inhibition of growth of a plant due to biomolecules released by another plant
Corm	A swollen stem-base containing food material and bearing buds; an organ of vegetative reproduction
Core infestation	A situation where a weed has a well-established self-regenerating population, the risk of further establishment is high, and wide-scale eradication is neither practical nor possible
Disc floret	A small flower formed in the centre of an Asteraceae inflorescence, with small equal sized lobes (which form the 'petal' structures)
Floret	A small flower, one of a dense cluster that makes up a compound inflorescence
Hydrolyzer	A soil wetting agent used to overcome water resistance of the soil and allow water to penetrate into the pore spaces between soil particles
Inflorescence	The flower-bearing structure of a plant – the bitou bush 'flower' is actually an inflorescence made up of multiple flowers (disc and ray florets)
Outlier infestation	An isolated infestation or clump of a weed, separate from the core infestation
Propagules	A structure with the capacity to give rise to a new plant (e.g. a seed)
Ray floret	A small flower formed at the outer edge of an Asteraceae inflorescence, with one large strap-shaped lobe (which forms the 'petal' structure)
Seed bank	Dormant, viable seeds of a species (refers specifically to seeds in the soil, or 'soil seed bank')
Strandline plant	Plants that grow on the beach strand, i.e. the sandy shoreline area between the land and the ocean, including intertidal zone and dunes
Succession	More-or-less predictable and orderly changes in the composition or structure of an ecological community over time
Swale	A long, narrow, usually shallow trough between ridges of sand (e.g. on a beach, running parallel to the coastline)
Threatened species	Any plant or animal species likely to become endangered within the foreseeable future if the factors affecting its vulnerability do not become reversed

Acronyms

APVMA	Australian Pesticides and Veterinary Medicine Authority
AQIS	Australian Quarantine and Inspection Service
CMA	Catchment Management Authority
CRC	Cooperative Research Centre
DECC	Department of Environment and Climate Change (NSW)
GIS	Geographical information system
LCA	Local control area or local control authority
NBBBMG	National Bitou Bush and Boneseed Management Group
NPWS	NSW National Parks and Wildlife Service (part of DECC)
NRM	Natural resource management
TAFE	Technical and Further Education
TAP	Threat Abatement Plan
WoNS	Weed(s) of National Significance

Abbreviations

cm	Centimetre
et al.	Latin <i>et alii</i> , meaning 'and others'
g	Gram
ha	Hectare
L	Litre
km	Kilometre
m	Metre
mm	Millimetre
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
syn.	Synonym

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Appendix

Site-plan template

This is a suggested template that can be used to prepare a site management plan at any site. If you are managing your site specifically for biodiversity conservation there is an example site management plan specifically for biodiversity conservation at: www.environment.nsw.gov.au/bitoutap/siteplans.htm

A. Site assessment details

Site name		
Local Government Area or National Park name (if applicable)		
Site location details:	Coordinates (i.e. one of these three)	Where reading was taken from? (e.g. centre point of site)
Latitude / longitude		
AMG (Australian Map Grid)		
GDA (Geodetic Datum of Australia)		
Landowner		
Site manager(s)		
Phone number		
Mobile		
Email		
Plan prepared by (name/ organisation)		
Address		
Phone number		
Mobile		
Email		

B. Goals and actions

Define goal	Specific action	Priority (i.e. high, medium or low)

C. Consult others and establish network

Identify and consult with community groups or agencies with respect to work currently occurring in the area (e.g. at nearby sites) on weed control programs, threatened species or other sites of significance, including the likely interactions of each group/agency at your site.

Name of person contacted	Organisation	Current work of interest	Outcomes of consultation e.g. partnerships

D. Relevant strategies

List all existing weed strategies relevant to the site, and state whether the strategies are addressed in this plan. Also check the objectives of each relevant strategy to ensure that all actions are accounted for. **Note:** if your site contains species listed in the NSW Bitou TAP, you should prepare a site management plan in accordance with the TAP.

List all relevant weed strategies (e.g. State weed strategy, regional weed strategy, regional bitou bush strategy, etc.)	Action required	Action addressed in this plan?

E. Site history

Record history of the site regarding management projects (e.g. weed control, restoration), disturbance and natural changes (e.g. fire) over the last five years, if possible. Include the year each activity took place and the stakeholders and costs involved. Also include information on any other weed control undertaken at the site.

Year	Control measure undertaken or natural occurrence (e.g. fire)	List problems addressed by this control measure (e.g. protecting threatened species, erosion control)	Stakeholders (community group and contractor)	Cost (\$ and in-kind)

F. Site attributes

Map – add a map on a separate sheet, including features listed below:

<input type="checkbox"/>	Bitou bush density	<input type="checkbox"/>	Ecological communities
<input type="checkbox"/>	Other weeds	<input type="checkbox"/>	Cultural heritage
<input type="checkbox"/>	Natural features	<input type="checkbox"/>	Map legend
<input type="checkbox"/>	Built amenities	<input type="checkbox"/>	North orientation
<input type="checkbox"/>	Threatened species	<input type="checkbox"/>	Scale bar or other

Attributes that affect control

List the site attributes that may influence delivery of your control program and how they affect control (e.g. physical – terrain, erosion potential; biological – threatened species, habitat type, other weeds; cultural heritage). If your site contains native species, populations or ecological communities listed in the NSW Bitou TAP, see <http://www.environment.nsw.gov.au/pestsweeds/BitouPageg.htm> for a site specific management plan template to use instead.

Attributes that affect control (e.g. terrain, threatened species, cultural heritage sites)	Effect

G. Control methods

- **Identify the stages (initial or follow-up) of bitou bush control required** and the proposed timetable for each stage e.g. over a five year period, based on your goals.
- **Identify the most appropriate management technique required** for the level of bitou bush present and the stage of control identified above, see Section 4 of the management manual. Note: aerial spraying must be consistent with the best practice guidelines (Broese van Groenou and Downey 2006).
- **Outline the follow-up control required in each stage** to prevent re-invasion/re-infestation of the site after initial control.

Year	Stages of control	Area/location to be treated (also mark on map in Part F)	Initial control technique to be used (e.g. cut-and-paint, ground spraying, etc.)	Follow-up control technique to be used (e.g. for recruitment and resprouting plants)	Estimated cost (\$) (for initial and follow-up control)	
					Initial	Follow-up

Identify any likely non-target effects of the control program outlined in previous table.

Non-target effects of control	Specifics (i.e. the species affected)

H. Restoration

- **Define the conditions you would like to restore at your site**, where restoration refers to returning existing habitats to an approximation of their natural condition.
- **Assess natural resilience** *check this box when assessment is performed.*
- **Identify the restoration methods required to re-establish the pre-defined conditions above** and the proposed timetable for each method e.g. over a five year period, based on your goals. See Section 5 of this manual.
- **Outline the maintenance required and the estimated costs.**

Year	Area/location to be restored (also mark on map in Part F)	Restoration method to be used (e.g. planting, natural regeneration, dune reconstruction)	Maintenance required (e.g. watering plants, maintenance of fencing)	Estimated cost (\$) (for restoration and maintenance)	
				Restoration	Maintenance

I. Monitoring

Outline any monitoring programs being undertaken to evaluate the effectiveness of bitou bush control or the response of native species to bitou bush control.

Monitoring method undertaken (e.g. photopoints, quadrats)	Measures collected (i.e. what is being measured or recorded, e.g. seedling counts)	Interval of collection (frequency at which data is collected)	Where the data is stored and who collected the data

Who do you report your results to?

Name	Organisation	Contact phone number or email address	Date to report results