Weeds of National Significance

Broom

Management Manual

Current management and control options for Scotch (*Cytisus scoparius*), Montpellier (*Genista monspessulana*) and flax-leaf (*G. linifolia*) brooms in Australia

Australian Government

NSW GOVERNMENT Office of Environment & Heritage
NSW National Parks & Wildlife Service

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2014

Published by:

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This manual was produced as part of the Weeds of National Significance Program, and is available for free download from the Weeds Australia website www.weeds.org.au/wons/brooms and the Office of Environment and Heritage website www.environment.nsw.gov.au/pestsweeds/brooms.

This publication should be cited as:

Office of Environment and Heritage (2014). Broom management manual: current management and control options for Scotch (*Cytisus scoparius*), Montpellier (*Genista monspessulana*) and flax-leaf (*G. linifolia*) brooms in Australia. Office of Environment and Heritage (NSW), Sydney.

This project was supported by the Office of Environment and Heritage (NSW) with funding from the Australian Government's Caring for our Country Program.

ISBN 978 1 74359 648 7

OEH 2014/0406

June 2014

Designed and typeset by Fiona Richardson, R.G. and F.J. Richardson, Melbourne, Victoria

Cover images
FRONT: *Cystisus scoparius* invasion, near Rossarden, Tasmania – M. Baker; flowering *Genista linifolia* – R. Richardson.
BACK: *Cystisus scoparius* invasion, Beechworth, Victoria – R. Richardson; flowering *Genista monspessulana* – R. Richardson; *Cystisus scoparius* seed pods – H. Cherry.

Acknowledgments

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WoNS management workshops

Workshops were held with weed managers and community volunteers in New South Wales, South Australia, Tasmania, Victoria and Western Australia in 2012 and 2013. Contributions from over 200 dedicated broom managers provided valuable information on current management and control practices, much of which forms the basis of this manual. Many thanks to all who contributed.

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As broom control is similar to gorse control, much of the information on control techniques in this manual was taken from the Gorse National Best Practice Manual www.weeds.org.au/wons/gorse.

Foreword

The naturalised and invasive brooms in Australia form a long list of very colourful and showy, but weedy shrubs, with white, yellow, pink or red flowers. This gives away the largely ornamental reasons for them being brought to Australia. The brooms are really the 'acacias of Europe', occupying the same niches and having showy flowers in early spring, with flowering seasons slightly separated between species. In parts of Europe and North Africa, Australian acacias invade broom territories! Both brooms and acacias are legumes, so they fix nitrogen and produce large, hard seeds that are often attractive to ants.

Two brooms, namely Scotch broom and Montpellier (or Cape) broom, are long overdue for being declared Weeds of National Significance (WoNS). They continue to increase in abundance and impact (particularly after fires) across Australia and their impacts are severe in both natural ecosystems and pastoral agriculture. They are also internationally important invasive plants, being problems in six continents including parts of their own home range. Flax-leaf broom is rapidly catching up in distribution and abundance across southern Australia. While it may seem odd that the three species are listed as weeds under the same WoNS entry, this reflects not only their similarities but also their ecological complementarities. Scotch broom is the temperate invader in frost prone areas. It does not grow through winter and is deciduous. Montpellier broom is the classic Mediterranean climate broom, benefiting from seasonal rain and growing whenever conditions are warm enough. Flax-leaf broom is more of an arid Mediterranean shrub, mostly from the southern Iberian Peninsula and North Africa, with better drought tolerance. They are all garden escapes, historically planted to adorn remote historical mining settlements and rural properties from which they spread, often down catchments.

Brooms present quite a challenge for management because they grow fast and produce so many seeds with the capacity for long dormancy. Plant nitrogen fixation means they can increase soil fertility, which favours broom germination rather than our native species that are adapted to more nutrient deficient soils. Few natural enemies of broom came with them from Europe. This means they can flourish and produce many seeds, swamping out native competitors. The brooms produce dense monocultures that shade out the ground flora, inhibit natural forest regeneration and restrict access to pasture. Such monocultures can also cause increased intensities of wild fires that burn through broom infestations. Post-fire broom seedling germination can come up like hair on a dog's back.

A lack of natural enemies is why most weedy brooms (except flax-leaf broom) have been considered as targets for biological control somewhere in the world. Finally, after more than 50 years of international effort, biological control agents, such as the Scotch broom gall mite and the Cape broom psyllid, are available that seem capable of providing long-term suppression of broom infestations. This is great news for broom control. But we must nonetheless continue to manage broom in many different ways for the different circumstances in which it is problematic in Australia, at least until we are sure biocontrol can contribute a widespread, long-term solution.

This best practice management guide is a vital manual for such endeavours and is a critical addition to the national efforts against these new WoNS. The manual provides the most up to date strategies for physical and chemical control of brooms, as well as a wealth of information on how to plan your broom control program to achieve the best results. It also provides information on identification and biology of brooms and, importantly, some great advice on how to follow up on and measure your achievements.

I highly commend the efforts of the WoNS broom activists who have put this manual together for broom-affected land managers. Make sure you have your copy in your ute!

Dr Andy Sheppard
Senior Principal Research Scientist in Weed Management, CSIRO, Canberra

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Contents

National management

Broom species are serious weeds of Australia's environment and primary production, including pastoral and forestry operations. The Brooms Strategic Plan 2012–2017 (AWC 2012) is a national plan developed under the Australian Weeds Strategy as part of the Weeds of National Significance initiative. Nationally coordinated implementation of the Broom Plan will allow for better protection of priority assets by providing tools and information, identifying management priorities and fostering partnerships that lead to more strategic, collaborative management.

The Plan aspires to three goals:

1. New broom infestations are prevented from establishing.
2. Established broom infestations are under strategic management.
3. There is greater capability and commitment to manage brooms.

Like the Australian Weeds Strategy, the Plan fosters a shared approach, and identifies efficiencies and collaborative actions that help to ensure existing resources can be allocated to achieve improved, strategic management outcomes. The Plan outlines measurable, targeted actions to ensure progress towards its vision that: **'Brooms are effectively managed to prevent further spread and to reduce their negative impacts on Australia's natural environment and primary production'**. The Plan is available at www.weeds.org.au/wons/brooms.

Using this manual

Who should use this manual?

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

Much of the management information in this manual is based on Scotch broom, as there is little information known about Montpellier and flax-leaf broom. Further information is also included from gorse management resources, as gorse requires similar management techniques.

S. Leighton

S. Leighton

Ulex europaeus (gorse) requires similar management techniques

This manual provides information on:

- Brooms and their impacts.
- Special management considerations for brooms.
- How to choose an appropriate control method.
- How to plan management.
- Restoration and repair of invaded habitats.
- Monitoring progress to ensure that intended outcomes are achieved.
- Case studies of first hand experiences with managing brooms.
- Legislation.
- Contacts and further resources.

Where is the information from?

This manual draws on the large amount of information and literature available for Scotch broom that has been compiled over many years of global research and management. Scotch broom has been recognised as a noxious weed and a serious pest in parts of Australia and other countries since the early 20th century. Extensive biological control programs commenced in North America in the 1960s, New Zealand in the 1980s and Australia in the 1990s.

Montpellier and flax-leaf broom, however, have not had such a high profile and relatively little is known about their ecology and management. As such, much of the information contained in this manual is based on Scotch broom, whilst highlighting known information on the ecology and management of the other two species. Further research on the ecology and management of Montpellier and flax-leaf broom is required.

R. Richardson

Genista linifolia (flax-leaf broom) – further research is required as little is known about its ecology and management

M. Baker

Landscape invasion of Cytisus scoparius (Scotch broom) in various coloured forms, near Rossarden, Tasmania

Section 1

Biology and threat

Biology and threat

Understanding brooms

Broom weeds in Australia

This manual focuses on the following three broom species, which are listed as Weeds of National Significance (WoNS) in Australia:

Scientific name	Common names	Also known as…
Cytisus scoparius (L.) Link	Scotch broom, English broom, common broom, broom	*Genista scoparius* Lam., *Spartium scoparium* L.
Genista monspessulana (L.) L.A.S. Johnson	Montpellier broom, Cape broom, French broom, Madeira broom, sweet broom	*Cytisus monspessulanaus* L., *Genista candicans* L.
Genista linifolia L.	flax-leaf broom, Mediterranean broom	*Cytisus linifolius* (L.) Lam., *Teline linifolia* (L.) Webb & Berthel

Throughout this manual, we use the common names Scotch broom for *Cytisus scoparius*, Montpellier broom for *Genista monspessulana* and flax-leaf broom for *G. linifolia*.

Several other brooms are also recognised as weeds in Australia, but are not specifically addressed in this manual. Many of the principles and techniques for their control, however, will be similar to those for the WoNS species above. Other broom weeds include:

- *Cytisus multiflorus* (L'Hér.) Sweet (white Spanish broom) and *Retama raetam* (Forssk.) Webb (white weeping broom), which are on the National Environmental Alert List, and are in the early stages of invasion, but have the potential to seriously degrade Australia's ecosystems (see pages 29–30 for further information).
- Hybrids and other forms of *Cytisus* and *Genista*, including the hybrid *Genista* × *spachiana* (found in Victoria and Tasmania), the pink flowering form of *C. scoparius* and the red and yellow flowering form, *C. scoparius* var. *andreanus*, which is naturalised in NSW, Victoria, Tasmania and South Australia.
- *Genista stenopetala* Webb & Berthel (Madeira broom); *G. canariensis* L. (Canary broom); *G. tinctoria* L. (Dyer's broom); *Calicotome spinosa* (L.) Link (spiny broom); *Spartium junceum* L. (Spanish broom); and *Chamaecytisus palmensis* (Christ) Bisby & Nicholls (tree lucerne or tagasaste).

None of these brooms are native to Australia.

P. Watton

P. Watton

Cytisus multiflorus (white Spanish broom): flowers (above), invasion (below). Note the upright nature of C. multiflorus versus the drooping nature of Retama raetam (see photos next page)


Biosecurity SA

Retama raetam (white weeping broom): flowers (left), whole shrub (right)



M. Baker (left); G. Keating (centre); R. Richardson (right)

Cytisus scoparius pink flowering form (left), C. scoparius red and yellow flowering form (centre), Calicotome spinosa (spiny broom) (right)


J. Miles (left); H. Cherry (right)

Spartium junceum (Spanish broom) (left), Chamaecytisus palmensis (tree lucerne or tagasaste) (right)

Biology and threat

While this manual focuses on the brooms listed as WoNS, many of the principles and techniques for their control will also be relevant to the other broom weeds in Australia.

The brooms listed as WoNS are native to Europe and North Africa and originate mainly from the Mediterranean areas of these continents. They were introduced to Australia mainly as ornamental plants, but have also been used for erosion control, particularly in highly disturbed areas such as former mine sites and quarries.

Brooms have now naturalised in all states and the Australian Capital Territory and are seriously impacting native ecosystems and primary production.

Brooms can:

- Transform native ecosystems by out-competing desirable plants, preventing native recruitment (including canopy species) and modifying habitat structure.
- Impact on primary production systems, by reducing available fodder in pasture and yields in forestry plantations.

G. Keating

Scotch broom invading a native ecosystem

H. Cherry

Scotch broom invading pasture, Kinglake, Victoria

Management note:
Site restoration and long-term follow-up management are essential elements of any broom management program because mature broom plants can:
1) produce thousands of seeds each year, which can remain dormant in the soil for decades and then rapidly germinate (see Case Study 3 on the sudden outbreak of broom seedlings following fires in the Victorian Alps); and
2) fix nitrogen in the soil and alter soil nutrient balance, causing impacts to natural regeneration.

P. Lennon

What do brooms look like?

Brooms are perennial leguminous shrubs in the Fabaceae (pea family), which have numerous, flexible, broom-like young branches that give rise to their common name. They commonly grow to 2–3 m tall, but can grow to 3–4 m and occasionally up to 6 m in Scotch broom. The brooms listed as WoNS all:

- lack thorns,
- have each leaf divided into three leaflets (termed 'trifoliate compound'),
- have bright yellow flowers,
- have pea-like pods,
- produce hard-coated seeds in pods, and
- have seeds that are light brown to very dark, almost black, around 2.5–3 mm long, with an edible growth on the end of the seed (called an aril) that is attractive to ants.

H. Cherry

Montpellier broom forms bright yellow flowers on long branches; note also trifoliate leaves and non-thorny stems

H. Cherry

Scotch broom is distinguished by having stems that are five-sided and green (photosynthetic) when young

M. Baker

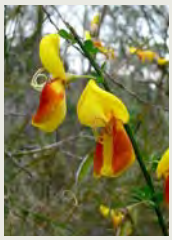
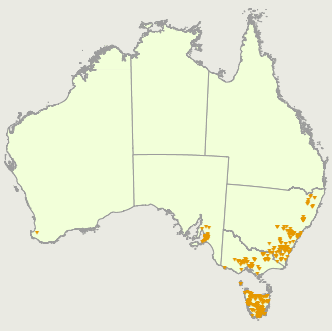
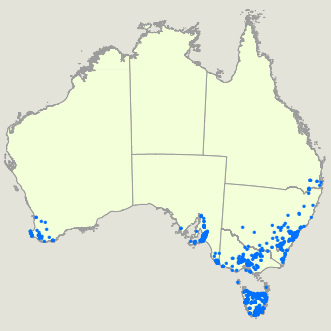
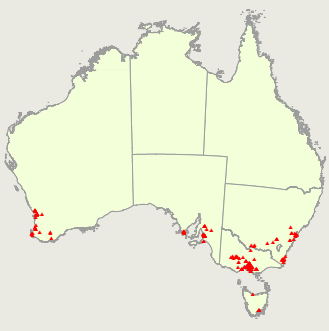
Scotch broom seed pods are flat and smooth, except for a distinct row of hairs along the pod margin

M. Baker

Flax-leaf broom can be identified at a distance by the young, hairy seed pods at the tips of branches

Distinguishing between the WoNS listed broom species in Australia

Species:	Scotch broom *Cytisus scoparius*	Montpellier broom *Genista monspessulana*	Flax-leaf broom *Genista linifolia*
Distinguishing features	Young, green stems are five-sided (or angled); yellow pea flowers to 25 mm long, are larger than the other two broom species; pods are 25–70 mm long and have a row of hairs on margins only	Young stems are green, hairy and ridged (but not five-sided as in Scotch broom); yellow pea flowers are to 13 mm long; mature pods are densely hairy, to 25 mm long and 5 mm wide	Similar to Montpellier broom but with a more sprawling habit and distinctively thin, lance-shaped leaflets that are dark green above and covered in silvery hairs underneath; the hairy seed pods in clusters at branch tips are distinct, and plants can have a 'silvery' appearance from a distance
Habit	Shrub 1–4 m tall  T. Inkson	Shrub 1–3 m tall  P. Watton	Shrub 1–3 m tall  M. Sheehan
Stems	Young stems five-sided, green with few leaves; can be deciduous when stressed, which can occur during winter in colder, frost prone areas and during summer in areas with low summer rainfall  H. Cherry	Usually one main stem with numerous branches, but can be multi-stemmed; young stems green, hairy, ribbed but not five-sided (as in Scotch broom), becoming grey to brown and woody with age  H. Cherry	Stems ribbed, with woolly grey hairs when young  H. Cherry
Leaves	Three leaflets on a short stalk or often simple and without a stalk on new growth; leaflets are narrow-elliptic to obovate, 5–20 mm long, 1.5–8 mm wide; hairs scattered on the upper side, numerous on the lower sides; deciduous when plants are stressed  H. Cherry	Three egg-shaped leaflets on a short stalk; leaflets are 5–25 mm long, 2–15 mm wide, broadly oval, broadest above the middle; lightly hairy on the lower surface, marginally hairy on upper surface; mid to dark green on the upper surface with a lighter underside; leaflets often have short point on the tip  R. Shepherd	Three narrow, lance-shaped leaflets; 10–25 mm long, 0.5–4.5 mm wide; margins rolled under; grey/silver hairs cover the undersides  H. Cherry

Species:	Scotch broom *Cytisus scoparius*	Montpellier broom *Genista monspessulana*	Flax-leaf broom *Genista linifolia*
Flowers and flowering time	Usually pure yellow but some naturalised hybrids have pink, red and yellow flowers with a red keel; 15–25 mm long (largest of the three species); single or in pairs; appear mostly from late winter to summer, but may be present at any time of the year in good seasons   P. Watton	Yellow, 8–13 mm long; usually in clusters of 3–9 arising from leaf axils and sometimes at tips of branchlets; appear mostly from late winter to spring, but sometimes again in late summer and autumn in favourable conditions  M. Baker	Yellow, 1–15 mm long; in clusters of 3–16 at branch tips, appearing in late winter or early spring; much shorter flowering period than the other two broom species – flowers over a few weeks, and rarely flowers again that year  M. Baker
Seed pods	Narrowly oblong, 25–70 mm long, about 10 mm wide, flattened and smooth but with distinct hairs along pod margin; up to 22 seeds (commonly 2–15 per pod). Seed pods initially green, then turn black on maturity, at which point they open and expel seeds explosively, particularly during warm and dry weather over the summer  M. Baker	Narrowly oblong, 10–30 mm long, 3–5 mm wide, flattened, densely hairy all over; 5–8 seeds. Mature seed pods are black to brown and coil distinctively once opened; usually mature over late spring to early summer, when they open and expel seeds explosively  M. Wisniewski	Narrowly oblong, 15–30 mm long, 4–8 mm wide, rounded, densely hairy all over; growing at branch tips; 2–6 seeds. Seed pods turn brown on maturity in late spring to early summer; pods open and eject seeds explosively as they dry out on warm, summer days  M. Baker
Current distribution	ACT, NSW, SA, Tas, Vic, WA (one recorded site only). Widespread in cool, wet areas 	ACT, NSW, Qld, SA, Tas, Vic, WA Widespread in south-eastern Australia 	NSW, SA, Tas, Vic, WA Scattered locations; locally widespread 

Biology and threat

Native look-a-likes

Several native plants, especially many native pea shrubs, can be misidentified as brooms. These native shrubs should be identified within broom control areas to prevent off-target damage and inefficient use of resources.

Scotch broom

Flowers and foliage of native pea shrubs such as *Viminaria juncea* (native broom or swiftbush), *Daviesia leptophylla* (narrow-leaf bitter-pea), and plants in the genera *Bossiaea* and *Jacksonia* can be mistaken for Scotch broom. Branches and stems of native plants such as *Exocarpus* spp. (ballarts), *Casuarina* spp. and *Allocasuarina* spp. (she oaks) also superficially resemble Scotch broom when it is not in flower.

J. Miles

Daviesia leptophylla (narrow-leaf bitter-pea)

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Viminaria juncea (native broom or swiftbush)

J. Miles

Jacksonia scoparia

J. Miles

Bossiaea foliosa

J. Miles

Exocarpus strictus

Montpellier broom

Goodia lotifolia (clover tree or clover-leaved poison) and *Pultenaea daphnoides* (large-leaf bitter-pea) are native pea shrubs that can resemble Montpellier broom although they can be distinguished easily by the red keel in the flowers of the native species. Montpellier broom is known to have only pure yellow flowers. *P. daphnoides* also has simple leaves versus the compound leaves of Montpellier broom.

J. Miles

J. Miles

Goodia lotifolia (clover tree or clover-leaved poison)

Flax-leaf broom

Flax-leaf broom foliage closely resembles that of *Westringia fruticosa* (coastal rosemary), however broom leaves are tri-foliate (with three leaflets) versus the simple leaves of coastal rosemary. The two shrubs are easily distinguished when in flower. *Gompholobium* spp. have large, pure yellow pea flowers but can be distinguished from both flax-leaf and Scotch brooms by hairless trifoliate leaves and short hairless seed pods.

P. Downey, B. Collier (inset)

Westringia fruticosa (coastal rosemary)

J. Miles

Gompholobium huegelii

Biology and threat

Where do brooms grow?

Brooms generally inhabit temperate regions, with Scotch broom commonly preferring cooler, higher rainfall areas. Brooms grow best in full sun in dry, sandy soils, but they are known to grow well in a variety of soil types and across a wide pH range (Leblanc 2001). Outside their native range, brooms have adapted well to a wide variety of climatic conditions.

Brooms readily colonise disturbed areas such as sand dunes, river beds, road sides, steep slopes, quarries and mine sites, but are also capable of gradually invading undisturbed areas once established nearby.

Brooms have invaded over one million hectares of Australia and have naturalised in many other parts of the world, including North and South America, Asia, and New Zealand.

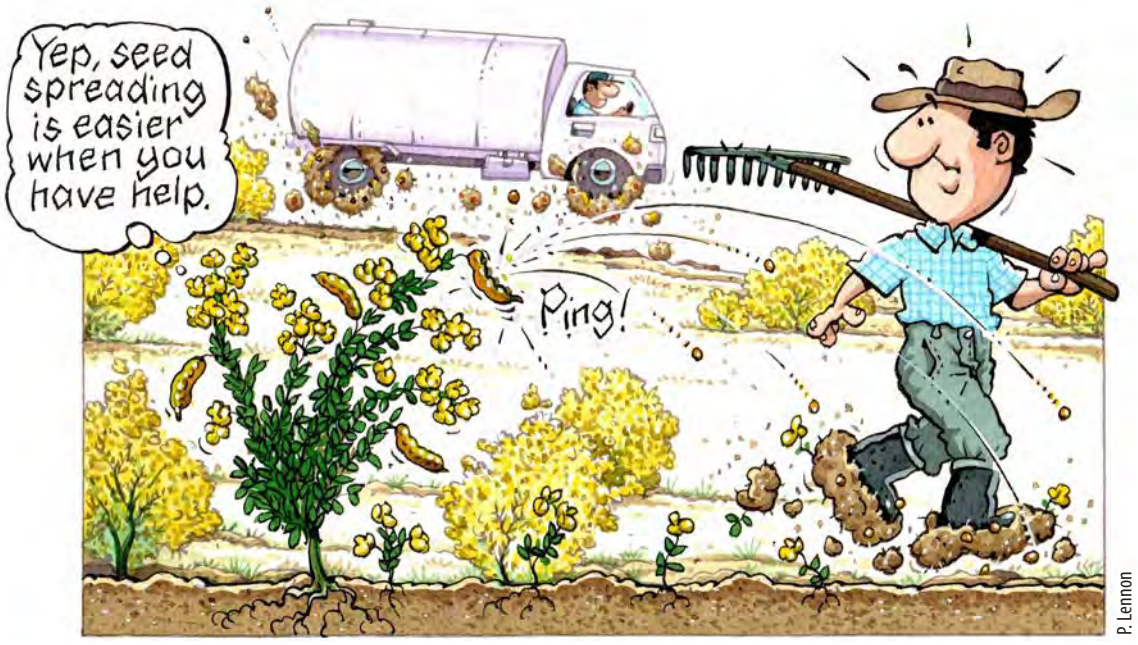
See pages 17–27 for specific information on the distribution and life cycle of each of the three broom species.

How do brooms spread?

Broom seeds are naturally dispersed from the plant by explosive pods that can flick seeds up to 3 m, though the majority of the seed lands within 1 m of the parent plant. Once on the ground, seeds are readily moved long distances by water, humans or animals.

DPIPWE Tas

Open pods of Scotch broom



P. Lennon

Spread by water

Seeds often move with sediments during flood events. They commonly germinate on open sand banks and alluvial deposits.

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Broom growing along the edge of a river in the alpine area of Kosciuszko National Park

Spread by humans

Humans frequently assist long distance dispersal of broom seeds. Examples include:

- moving them in soil on earthmoving machinery,
- through dumping garden refuse,
- by deliberate planting, or
- via grading of gravel roads or transportation of spoil from construction works.

N. Boyd, Orange City Council

Broom seeds can be spread by vehicles

Management note: Humans are a major vector for long distance seed dispersal (e.g. moving seeds accidentally in soil or on machinery). Good hygiene practices (see Section 3 page 47) are essential for all activities conducted on or near broom infestations, to prevent its further spread.

Spread by animals

Broom is also spread by:

- Animals such as cattle, sheep, wallabies and deer, via mud on their feet or by seeds lodging in their fur.

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WildCount OEH

Broom seeds can be spread by animals such as goats and kangaroos

- Ants moving seeds short distances to underground nests, where they remove the fleshy aril for food and then discard the seed. These seeds can be buried to depths of over 5 cm, where heat from fires may not trigger germination. Instead seeds may remain dormant for years, until they are brought to the surface by other disturbances such as erosion, animal diggings or earthworks.

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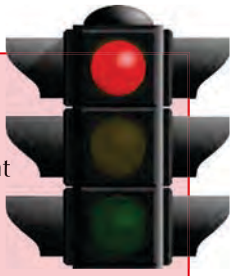


Management note: Containment of current broom infestations should be an essential component of broom management plans. This should be complemented by good hygiene practices and engagement of all relevant land managers across the local area in long-term management. Without satisfactory containment, brooms have great potential for spread.

Seed germination and growth

Mass seed germination

Mature broom plants can produce thousands of seeds each year, and these seeds can remain dormant in the soil for 30 years or more before germinating.

Mass germination of broom seeds can be stimulated by disturbance events such as:

- fire,
- cultivation,
- weed control works, or
- digging by animals.

Mass germination can rapidly transform a scattered population of mature broom plants into a dense infestation that can rapidly outgrow and exclude other vegetation. For example, fire can trigger germination of 70–80% of seeds in the soil, depending on how intense it is and how deep the heat penetrates into the soil.

For information on how you can use fire to help control broom, see ‘Reducing the soil seed bank’

Parks Victoria

Mass germination of Scotch broom seedlings after fire in the Victorian Alps

in Section 3 on page 57 and 'Fire and grazing' in Section 4 on page 95.

'Because there's so much Montpellier broom we need to prioritise the control work we do. We focus on disturbance activities because we know they will trigger growth.' John Hanel, Department of Parks and Wildlife Western Australia (see Case Study 2 on page 118).

Growth and flowering

Brooms generally flower in their third year following germination, though in good conditions flowering can occur earlier. Growth rates are dependent on soil fertility and rainfall, but growth is generally rapid for the first five years, peaking at around 3–5 years when it can exceed 1 m per year. This is followed by 6–8 years of slower growth and then a period of decline to senescence.

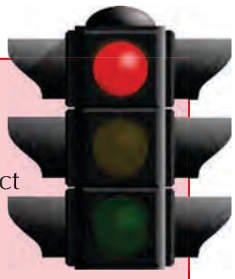
In areas where broom seedlings are regularly being suppressed by grazing or mowing, growth rates can accelerate once the root structure attains a robust size and the plant can quickly produce woody growth that is unpalatable to stock or difficult to mow. In these cases, what were apparently suppressed populations of broom can rapidly become dense and mature stands.

Flowering and seed production may be rapid following disturbance

Healthy and actively growing brooms reshoot (coppice) readily from their roots following a fire or other disturbance (e.g. mechanical clearing without herbicide), which removes the above ground portion of the plant. In favourable conditions, plants that reshoot are capable of flowering within 6–12 months of the event, due to an already well-established and robust root system. For example, a healthy plant up to 10 years of age that is burnt or cut in autumn can reshoot and flower the following spring in areas of higher rainfall. Plants over 10 years of age that are close to senescence, however, may not recover from such an event.

H. Cherry

Scotch broom resprouting and producing pods following clearing



FOLLOW-UP, FOLLOW-UP, FOLLOW-UP!

It is absolutely essential to conduct follow-up control and site restoration and maintenance for many years following initial weed control, given that:

- broom seeds can remain viable in the soil for more than 30 years,
- broom plants can grow and flower rapidly, once the root structure is established, and
- sudden mass germination events can be stimulated by major disturbances such as fire, cultivation or weed control works.

Without follow-up management, your initial control efforts could be wasted.

Biology and threat

Broom impacts

Brooms invade native vegetation, forestry and pastoral systems in Australia, where they cause significant environmental and economic impacts. Brooms establish rapidly after disturbance, such as fire, grazing or forestry harvesting, but can also invade relatively undisturbed areas.

Native ecosystem impacts

Broom weeds share similar characteristics that allow them to out-compete desirable plants, dominating and transforming native ecosystems. Robust growth allows brooms to dominate ground and shrub layers, eventually impacting the regeneration of canopy species. Brooms fix nitrogen in the soil, which in turn forms ideal conditions for broom regeneration and other weed growth, and may inhibit the growth of native species that are adapted to nutrient poor soils.

If not controlled, brooms can transform native habitats by:

- changing vegetation structure,
- preventing recruitment of native plants, including canopy species,
- changing fire frequency and intensity,
- altering soil chemistry, and
- increasing soil erosion by excluding grasses and groundcovers, thereby increasing the amount of bare ground underneath.

NP NPWS

Scotch broom in flower, Barrington Tops National Park, NSW

OEH

Scotch broom invasion in a remote, undisturbed area of Kosciuszko National Park, NSW

M. Sheehan

Montpellier broom invading native vegetation, Victoria

H. Cherry

Native Grevillea wilsonii overtopped by flax-leaf broom

Invasion by brooms can also impact native animals, contributing to changes in species diversity and density by:

- excluding native plants that are relied on for food,
- modifying habitat structure, and
- harbouring feral animals.

B. Collier

Threatened species such as Tasmannia glaucifolia (pictured) are directly impacted by Scotch broom

Scotch broom directly impacts several nationally-listed threatened species. For example, although young stands of Scotch broom can provide a temporary refuge for the threatened broad-toothed rat, as these broom stands age and exclude ground flora, the rat loses its refuge and food source. These areas are then more accessible to broad-tooth rat predators such as cats, dogs, foxes and pigs.

OEH

Broad-toothed rat (Mastacomys fuscus)

See Case Studies 2 (page 118) and 3 (page 121) for examples of how broom is being managed to reduce its impacts on native ecosystems.

Pastoral/grazing impacts

Mature broom stands will outcompete good pasture if left untreated. Mature plants are not preferred by stock because they are often unpalatable. Broom plants contain alkaloids that may be toxic to livestock and other animals, especially when grazed intensively, however there are no known records of stock poisoning from broom. Broom can also harbour feral animals such as foxes, pigs and rabbits. The costs of broom control can often exceed the value of the broom-infested land, making the need for containment of current populations critical, to avoid future expense.

See Case Study 4 on page 126 to discover how two primary producers have been managing broom on their property over the last 40 years, how they have maintained the effort and the important lessons they have learnt along the way.

G. Keating

Broom invading pasture, Omeo, NSW

N. Boyd, Orange City Council

Broom invading pasture, Orange, NSW

Biology and threat

Forestry impacts

Brooms are weeds of major concern to foresters. They grow quickly and outcompete native and plantation species, establishing rapidly or re-sprouting after forests are harvested or after other disturbances, such as fire. Scotch broom is known to significantly reduce yield in forestry plantations, particularly at the beginning of the rotation where it interferes with reforestation through competition for resources.

Impacts of Montpellier broom on forestry in South Australia

'Montpellier broom is a significant competitor for moisture and light, in particular during the plantation establishment phase, up until full canopy closure. It can significantly reduce plantation survival and stand productivity if not controlled. Post-thinning, broom successfully germinates under the standing trees – where it can form a dense understory severely reducing access for people and machinery. It also can increase the fine fuel loading and provide ladder fuels for fires, which can very significantly impact on wildfire behaviour, including contributing to the probability of the development of crown fires.' Kim Thomas, Forestry Officer, Research, Forestry SA.

Seed germination is stimulated by fire, with viable seed germinating up to three years after exposure. Montpellier broom will, however, germinate without fire as long as there is enough soil moisture.

Forestry SA staff have found that, in the post-thinning phase, Montpellier broom (or Cape broom) can compete effectively for the limited rainfall resource which penetrates the plantation canopy. As it is a prolific seed producer and is very shade tolerant under *Pinus radiata*, it thrives and utilises limited nutrient and soil moisture resources available. They have observed that, when not controlled, the impact of broom is on par with the worst competition effects of bracken fern on *Pinus radiata* productivity.

Forestry SA

Forestry SA

Montpellier broom causes significant impacts in forestry operations

Biology, ecology and distribution of the three WoNS brooms in Australia

Scotch broom

Origin and introduction

Scotch broom has a natural range extending from the British Isles in the west to Hungary and the Ukraine in the east, and from Sweden in the north to southern Spain and the Azores in the south. There are two subspecies recognised in its home range. *Cytisus scoparius* ssp. *scoparius*, the species naturalised in Australia, and *C. scoparius* ssp. *maritimus*, which is only found on exposed sea cliffs in the British Isles and north-west Europe.

Cytisus scoparius 'Andreanus' is a naturally occurring hybrid of Scotch broom that has flowers with a red keel. It was discovered in Normandy in 1844 and has been used to produce many cultivars with colour variants that are available in the retail nursery industry. This hybrid and one of its cultivars, *C. scoparius* 'Andreanus Aureus', are also recorded as naturalised in all Australian states.

The first record of Scotch broom in Australia was as early as 1800, when seeds were requested by Governor King as a substitute for hops. A plant called English broom (with no botanic name) was later recorded as growing 'luxuriantly' in Sydney in 1803. In Victoria, it was considered naturalised in 1887 and by 1901 it was regarded as a noxious weed. Many of the existing large and well-established populations in Australia today are associated with old and/or abandoned homesteads.

Habitat and distribution in Australia

Scotch broom will readily colonise grassland and open woodlands, making it problematic in pasture, woodland and alpine areas. In Victoria and Tasmania, Scotch broom grows at sea level, whereas in New South Wales (NSW) it is rarely found below 600 m elevation. In its native range, Scotch broom is known to prefer acidic soils and, in the southern extent of its range, is commonly found in heaths at higher, cooler altitudes (Smith 2000). In areas of low rainfall, Scotch broom seedlings rarely survive the summer, unless

K. Harvey

Cytisus scoparius 'Andreanus'

T. Inkson

K. Harvey

Scotch broom grows well in moist, fertile soils

protected by surrounding grasses. Under a dense canopy, seedling survival is very low. Scotch broom grows well in moist, fertile soils, while in sandy soils it is usually confined to drainage lines and disturbed areas (Hosking *et al.* 2000).

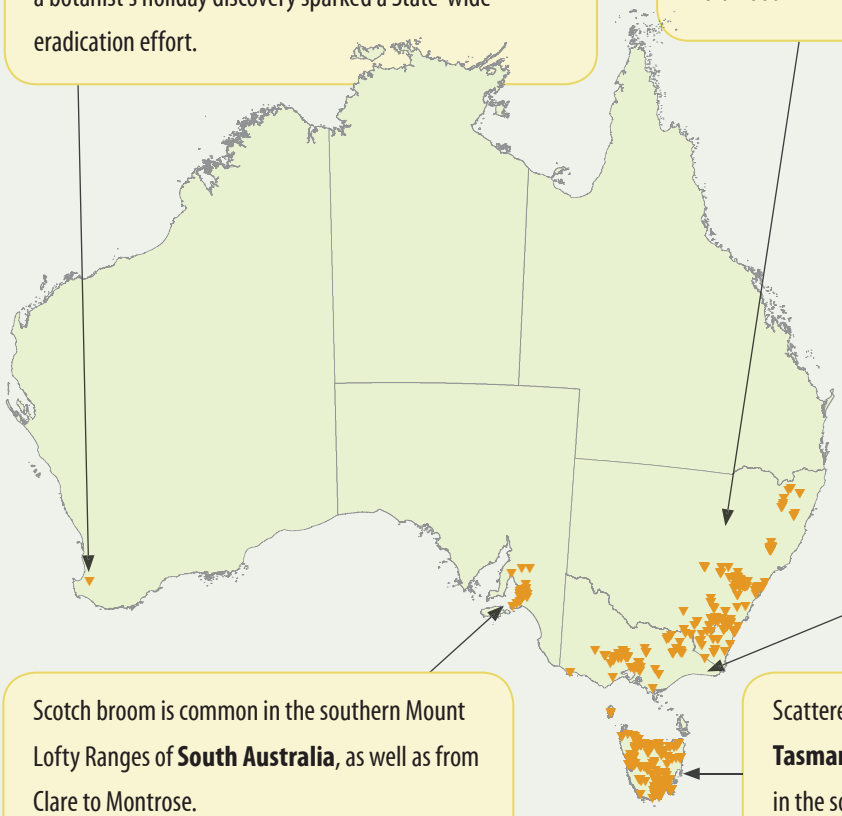
Over 230,000 ha across Australia are covered with Scotch broom (Hosking *et al.* 1998, Barnes and Holz 2000). It is widespread in NSW, Victoria, Tasmania and South Australia (see map) but is only known from one site in Western Australia.

Distribution models for Scotch broom indicate the potential for much further spread in Australia, including a significant area of southern Western Australia (Potter *et al.* 2009). These maps also indicate large areas of northern NSW and southern Queensland coastal plain as highly suitable for invasion.

Current distribution of Scotch broom (▼)

The first and only record in **Western Australia** is a small infestation that was discovered near the Collie River in 2010. This infestation is now the focus of an eradication program. See the Case Study on page 116 to learn how a botanist's holiday discovery sparked a State-wide eradication effort.

In **New South Wales**, Scotch broom mainly infests highland areas and is rarely found growing below 600 m above sea level. Barrington Tops has an extensive infestation of about 10,000 ha, but north and west of this region Scotch broom is scattered and often isolated in occurrence. Scattered populations are also found on the western slopes, with core infestations in the southern highlands, including in the Snowy Mountains and around Braidwood in the upper Shoalhaven River.



In **Victoria**, Scotch broom infests over 150,000 ha. It is widely naturalised in the cooler, wetter parts of the State, including dense populations in remote country in the Victorian Alps, in the central highlands between Ballarat, Daylesford and Mt Macedon, in regions east and north-east of Melbourne and near Corryong in eastern Victoria.

Scotch broom is common in the southern Mount Lofty Ranges of **South Australia**, as well as from Clare to Montrose.

Scattered populations exist throughout **Tasmania**, with core infestations around Hobart in the south-east and around Queenstown on the west coast.

Scotch broom life cycle and growth patterns

Seasonal patterns for Scotch broom in areas of HIGH summer rainfall and COOL winter temperatures*

	Summer			Autumn			Winter			Spring		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Flowering		■	■	■	■	■	■	■	■			
Fruiting				■	■	■	■	■	■	■	■	■
Germination	■				■	■	■	■	■			
Foliage present					■	■	■	■	■	■		

■ Normally present
■ Present only in suitable conditions

Seasonal patterns for Scotch broom in areas of LOW summer rainfall and MODERATE winter temperatures*

	Summer			Autumn			Winter			Spring		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Flowering		■	■	■	■	■	■	■	■			
Fruiting				■	■	■	■	■	■	■	■	■
Germination	■				■	■	■	■	■			
Foliage present	■	■	■	■							■	■

■ Normally present
■ Present only in suitable conditions

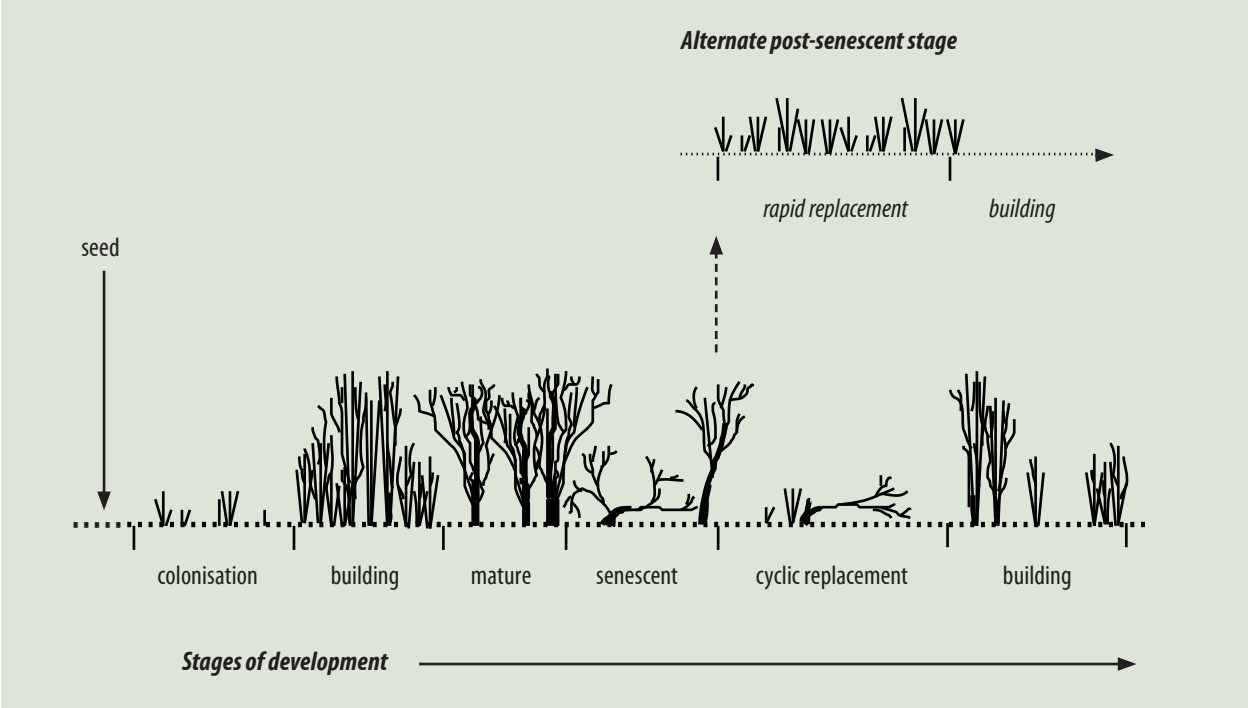
*These tables are a general guide. It is best to note the growth patterns at your site, as this will help determine the timing of your management practices.

In their native range, Scotch broom plants rarely survive for more than 12 years. However, in Australia, Scotch broom plants as old as 30 years are documented from Barrington Tops, NSW. Mature Scotch broom plants will often collapse and become prostrate (lie flat), with stems up to 6 m long lying on the ground and forming a thicket of limbs up to 2 m tall (Smith 2000). Seedling survival rates are very low, with sometimes as few as 2% of seedlings surviving to three years of age. However, given the massive number of seed produced by Scotch broom, a large number of plants still reach maturity.

The life cycle of Scotch broom can vary depending on seasonal weather conditions and disturbance events. Seeds typically germinate in spring and autumn in Australia, though can do so at any time of the year in favourable conditions, especially following a disturbance event. In areas with low summer rainfall, plants are most likely to lose their foliage in late spring and summer, whereas in areas

H. Cherry

Several stages in the Scotch broom life cycle (note seedlings in the foreground)



The life cycle of Scotch broom stands in Australia, showing each stage of development, including the two alternative post-senescent stages (Downey 2002)

with high summer rainfall plants are more likely to lose their foliage in autumn and winter.

Under dense canopies, Scotch broom seedlings do not survive. They will only establish and survive in such areas when there is a break in the canopy, which may occur when older plants naturally die or fall over, or when disturbances such as fires open up the canopy layer.

S. Garland

Fire or clearing will stimulate germination from the seed bank

H. Cherry

Under dense canopies, Scotch broom seedlings do not survive

Management note:
It is important to understand the growth patterns of Scotch broom in **your local area**, so you can use the control techniques best suited to the time of year and life stage of the plants.

For example, you can help prevent further spread by:

- Understanding when seed is being shed from plants and carefully managing access to infestations during this time.
- Reducing levels of disturbance to infested sites where possible, and being prepared to respond quickly following any major disturbances that do occur.

Parks Victoria

Mass broom seed germination can occur after fires

H. Cherry

Scotch broom plants can produce over 15,000 seeds annually

Scotch broom seed production and longevity

Mature Scotch broom plants can produce over 15,000 seeds annually (Bossard and Rejmanek 1994) and can generate soil seed banks of up to 50,000 seeds per square metre (Hosking *et al*. 1998). Some of these seeds will germinate within one to two years. For example, one study found 35% of seeds germinated within two years (Bossard 1993). But only small proportions of seed germinate at any one time, and many may remain dormant in the soil and not germinate unless exposed to heat or scarification, which may be needed to break the hard seed coat (Hosking *et al*. 1998).

In storage conditions, one study found 4 out of 636 seeds remained viable for 81 years (Turner 1933). In field conditions, seed predation and other factors such as fungal attack may cause seed bank decline of up to 50% per year. However, it is highly likely that some seeds may remain viable in the soil for decades, contributing to a large soil seed bank (Hosking *et al*. 1998).

P. Watton

Mass germination after clearing Scotch broom – many seeds may still remain dormant in the soil

Montpellier broom

Origin and introduction

Montpellier broom is native to much of the Mediterranean region, extending from Portugal and Spain in the west to Turkey in the east. British Isles populations are regarded as naturalised, having first been recorded in the wild in that region in 1915.

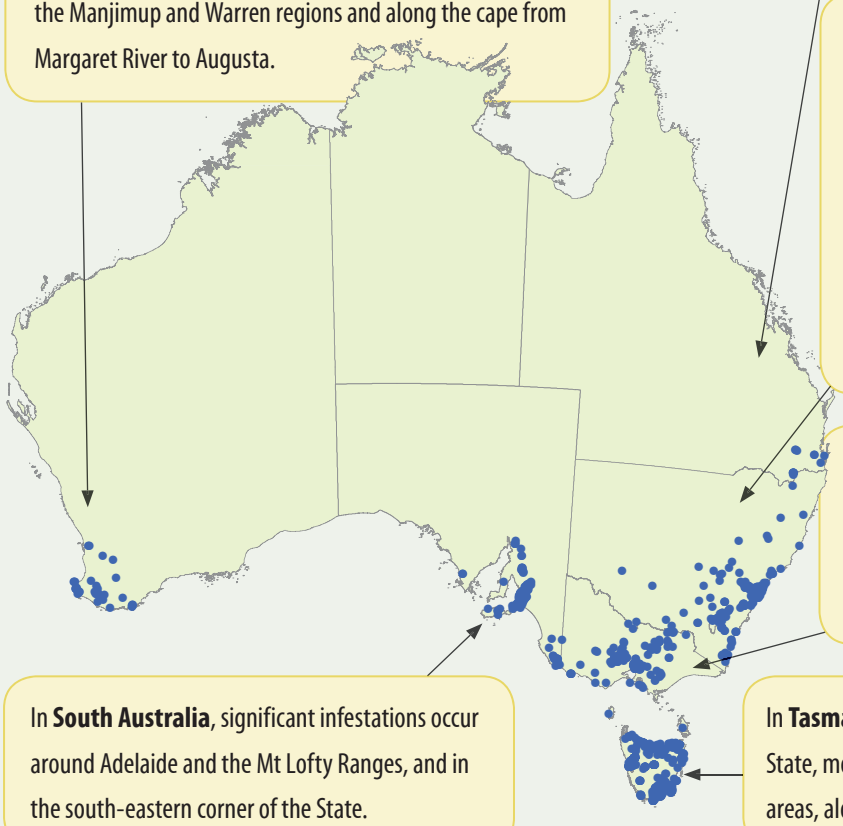
Montpellier broom was recorded in botanic gardens in the mid 19th century in Adelaide and Melbourne, and was commonly planted as a hedge plant in the late 19th century. Hybrids of Montpellier broom continue to be sold in Australia, such as cultivars of *Genista* × *spachiana* (a hybrid of *G. stenopetala* and *G. canariensis*).

Habitat and distribution in Australia

Montpellier broom can inhabit a broader range of habitats than Scotch broom, because it tolerates warmer and drier Mediterranean climates. It has also been found in wetlands. In many areas of Australia, Montpellier broom is found growing together with Scotch broom.

Montpellier broom is the most widespread of the brooms, having spread over 600,000 ha and occurring in all states of Australia and the Australian Capital Territory. It is most common and widespread in Victoria, Tasmania, the ACT, southern and central New South Wales, south-eastern South

Current distribution of Montpellier broom (•)



In south-west **Western Australia**, it is prevalent throughout the Manjimup and Warren regions and along the cape from Margaret River to Augusta.

In **Queensland** it is naturalised in the south-east and on Norfolk Island.

In **New South Wales**, there are large and well-established populations of broom in coastal and highland areas, in particular the Blue Mountains and Hawkesbury-Nepean catchment and many northern Sydney areas. Smaller infestations can be found in the New England and South Coast regions.

In **Victoria**, Montpellier broom occurs mainly in southern, central and north-eastern regions on grazing lands and in dry sclerophyll forests and woodlands.

In **South Australia**, significant infestations occur around Adelaide and the Mt Lofty Ranges, and in the south-eastern corner of the State.

In **Tasmania**, it is widely distributed across the State, mostly in disturbed bushland bordering urban areas, along roadsides and in neglected areas.

Australia and south-west Western Australia, but it is also naturalised in north-eastern New South Wales, in south-eastern Queensland and on Norfolk Island.

Potential distribution models for Montpellier broom indicate that it could become even more widespread, extending its current range and becoming denser in areas already invaded.

M. Sheehan

Montpellier broom

Life cycle and growth patterns

Seasonal patterns for Montpellier broom

	Summer			Autumn			Winter			Spring		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Flowering	■	■	■	■	■	■	■	■	■			
Fruiting				■	■	■	■	■	■	■	■	■
Germination	■	■	■				■	■	■			
Foliage present												

■ Normally present

■ Present only in suitable conditions

Montpellier broom is an evergreen plant that produces new growth each winter and spring. Its extensive root system allows it to withstand long periods of drought. The maximum recorded age for Montpellier broom plants in Australia is 13 years (Lloyd 2000). Seeds germinate from autumn to spring. An average of 790 seedlings per m^2 have been counted under dense broom stands (Adams and Simmons 1991).

Plant development is slow within the first year, and plants do not generally flower until they are at least two years old. Flowering then occurs in late winter to spring, with an occasional second period of flowering towards the end of summer. Seeds are generally shed in spring and summer. Seedling survival rates are much greater than those of Scotch broom, and even in dense stands there is continuous recruitment from the seed bank.

H. Cherry

Montpellier broom sapling and two seedlings

Biology and threat

L. Fontanini

Montpellier broom germinating in an oil spill – seedlings have the ability to grow in harsh environments

H. Cherry

Montpellier broom seedling (close up)

H. Cherry

Montpellier broom sprouting from the base, with seedlings underneath

Montpellier broom seed production and longevity

Montpellier broom produces large numbers of seeds. In Australia, seed productivity has been measured from 600–6000 seeds per mature plant (6–8 years old), and up to 12,000 seeds per plant have been recorded in its home range of France (Lloyd 2000). Soil seed banks in Australia can average up to 30,000 seeds per m^2 under mature plants, which is over 3000 times greater than soil seed banks measured in home range sites in Europe (Lloyd 2000). Mass seedling germination can occur after fire when seed dormancy is broken, but sufficient germination (enough to maintain and expand infestations) can also occur in the absence of fire (Adams and Simmons 1991).

Approximately 18% of annual seed production is able to germinate as soon as conditions are favourable, with the remaining seed requiring some form of treatment such as heat or scarification to germinate (Lloyd 2000). In lab experiments, 100% of scarified seeds successfully germinated at a constant 16°C, and seedlings had high growth rates with over 90% seedling survival after two years (González-Andrés and Ortiz 1996). Montpellier broom produces a long-lived seed bank from which seedlings can germinate whenever there is adequate light, rainfall and temperature (Sheppard and Henry 2012).

J. Miles

Montpellier broom produces a large number of flowers and pods per stem

Flax-leaf broom

Origin and introduction

Flax-leaf broom is predominantly found in the west Mediterranean, with its main range in coastal Spain and southern France, extending from Corsica in the east to the Canary Islands in the south-west.

In Australia, flax-leaf broom was listed as growing in Adelaide Botanic Gardens and in Victoria in the mid to late 19th century and was considered naturalised in Victoria by 1913.

Habitat and distribution in Australia

Like Montpellier broom, flax-leaf broom can inhabit a broader range of habitats than Scotch broom, because it tolerates warmer and drier Mediterranean climates. Like Scotch and Montpellier brooms, flax-leaf broom will readily colonise disturbed areas such as roadsides. Flax-leaf broom is also a weed of coastal areas, and in southern Australia it invades sand dunes.

M. Baker

Large infestation of flax-leaf broom with other 'garden escapes', Tasmania

M. Springall

Flax-leaf broom urban invasion (with lantana), New South Wales

M. Sheehan

Flax-leaf broom escaping from gardens down a road, near Castlemaine, central Victoria

H. Cherry

Flax-leaf broom invading native understorey in Perth Hills woodland, Western Australia

Biology and threat

Flax-leaf broom is the least widespread of the WoNS brooms, occurring mainly in Victoria around Melbourne and Port Phillip Bay, and extending into southern Gippsland and central Victoria. Elsewhere in Victoria, and in NSW and Tasmania, populations are scattered and isolated. Infestations occur in the Adelaide Hills in South Australia and the Perth Hills in Western Australia, with some scattered and isolated populations in other parts of these states.

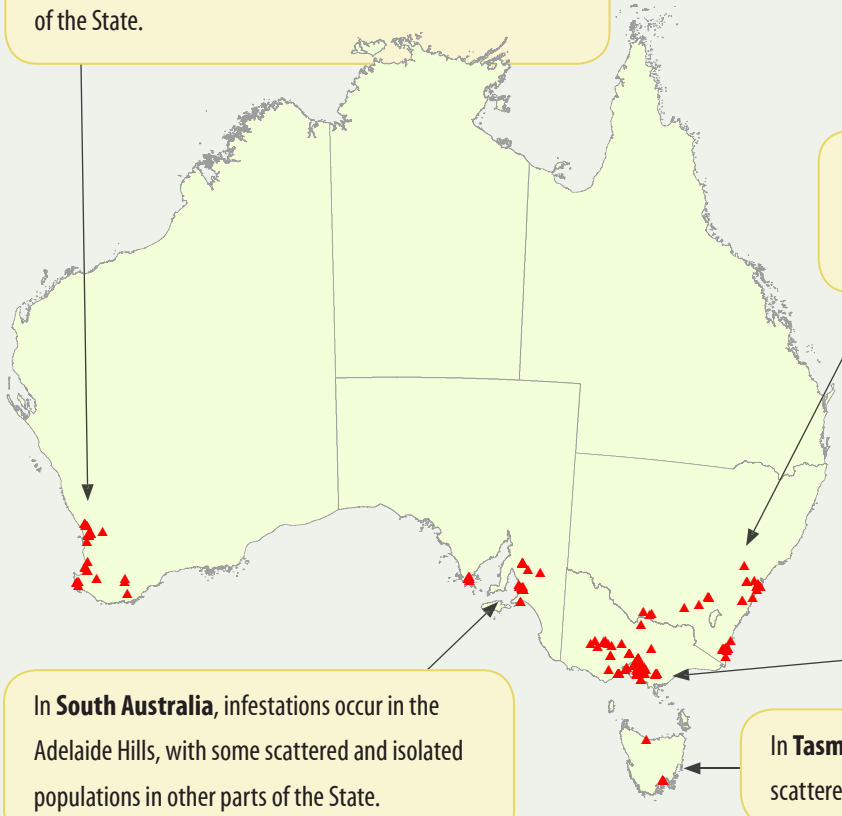
Modelling of its potential distribution indicates that flax-leaf broom could become more widespread in coastal Tasmania and Victoria, around Adelaide and the Fleurieu Peninsula to Kangaroo Island in South Australia, and across southern Western Australia.

H. Cherry

Flax-leaf broom, Perth Hills, Western Australia

Current distribution of flax-leaf broom (▲)

In **Western Australia**, infestations occur in the Perth Hills, with some scattered and isolated populations in other parts of the State.



In **New South Wales** populations of flax-leaf broom are scattered and isolated.

In **Victoria**, flax-leaf broom occurs mainly around Melbourne and Port Phillip Bay, extending into southern Gippsland and central Victoria. Elsewhere in the State, populations are scattered and isolated.

In **South Australia**, infestations occur in the Adelaide Hills, with some scattered and isolated populations in other parts of the State.

In **Tasmania** populations of flax-leaf broom are scattered and isolated.

Flax-leaf broom life cycle and growth patterns

Seasonal patterns for flax-leaf broom

	Summer			Autumn			Winter			Spring		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Flowering												
Fruiting												
Germination												
Foliage present												

Normally present
Present only in suitable conditions
Not present

Flax-leaf broom germinates from autumn to spring and development is slow within the first year (Parsons and Cuthbertson 1992). Like Montpellier broom, flax-leaf broom has a high germination (93%) and survival rates (100%) at the end of the first growing season (Gonzalez-Andres and Ortiz 1996). Flowering occurs in spring and plants generally do not flower until they are at least two years old. Seeds are generally shed in spring and summer and leaves are retained during winter.

H. Cherry

Flax-leaf broom immature plant (mature plant in background)

H. Cherry

Flax-leaf broom seedling

H. Cherry

Flax-leaf broom – lots of pods equals lots of seeds!

Flax leaf broom seed banks – there's a lot we don't know

A very limited amount of research has been done on flax leaf broom, relative to the other two WoNS species. Thus, little scientific data exists on seed production or persistence in this species. One study found flax leaf broom to have similar germination success and seedling survival rates to Montpellier broom (González-Andrés and Ortiz 1996). In addition, anecdotal observations from the field indicate that flax leaf broom produces similar amounts of seed to Montpellier broom. Given the rapid spread of current flax leaf broom infestations, and the fact that it is closely related to many species that have long-lived seeds, it is possible that flax leaf broom also produces a very large and persistent seed bank. Until further research can be done, it's best to 'err on the side of caution' and plan to manage flax leaf broom seed banks aggressively, and for many years in the future.

J. Miles

Flax-leaf broom mature pods – note seed on open pod right foreground

See Case Study 5 on page 129 for an example of how flax-leaf broom is being managed in Geelong, Victoria.

M. Sheehan

Flax-leaf broom roadside invasion

Other broom weeds

There are many shrubs in the tribe Genisteae that are commonly known as brooms, none of which are native to Australia (see pages 2–3). Some of these brooms have already become weeds, while others are in early stages of naturalising or have not yet 'jumped the garden fence'. These are high priorities for eradication or spread prevention.

White Spanish broom and white weeping broom: on the National Alert List for Environmental Weeds

The National Alert List for Environmental Weeds is a list of 28 non-native plants that threaten biodiversity and have the potential to cause other environmental damage. There are two broom species on this list. Although only in the early stages of establishment, if allowed to spread these weeds could seriously degrade Australia's ecosystems. Prevention and early intervention are the most cost-effective forms of weed control.

P. Watton

White Spanish broom flowers (above), stems (below)

Please report any new sightings of these species immediately to your state or territory weed management agency or local council.

For further information see:

- CRC for Australian Weed Management (2003a). White Spanish broom (*Cytisus multiflorus*) weed management guide. Available at nrmonline.nrm.gov.au/catalog/mql:1767.
- CRC for Australian Weed Management (2003b). White weeping broom (*Retama raetam*) weed management guide. Available at nrmonline.nrm.gov.au/catalog/mql:1702.

HELP STOP THESE WEEDS BEFORE THEY BOLT!

Become familiar with these brooms and, if you see them, alert your local weeds officer immediately. For further assistance with identification of these broom species or other weeds on the National Environmental Alert List, see www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/alert.html or contact your local weeds officer.

Biosecurity SA

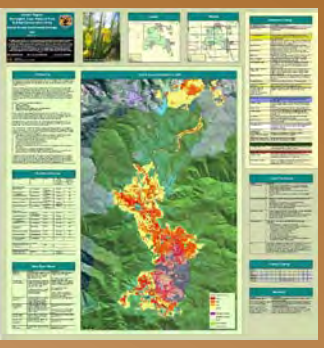
White weeping broom

Features of white Spanish broom and white weeping broom

Species:	White Spanish broom (also known as white broom or Portuguese broom) *Cytisus multiflorus*	White weeping broom (also known as white broom, bridal broom or ratamals) *Retama raetam*
Habit	Erect, deciduous shrub to 4 m high with numerous, striped stems and fine, greyish foliage  P. Watton	Erect, summer-deciduous shrub to 3 m tall and up to 6 m wide; plants are grey-green with slender, drooping branches  Biosecurity SA
Stems	Stems rounded in cross-section, longitudinally ribbed and covered with short, silvery hairs when young	Stems of young plants are covered with long soft hairs but become hairless with age; young plants are wispy with a single-stem and strong taproot
Flowers	White, pea flowers, with a pink streak at the base; approximately 8–12 mm long. It flowers prolifically between September and November  P. Watton	Small, white, pea flowers grow in clusters of 3–15 along stems; each flower is 8–10 mm long and forms a closed tube. Flowers are produced in late winter and early spring  Biosecurity SA
Leaves	Often leafless when in flower; leaves arranged in groups of three leaflets on the lower branches and single, stalkless leaflets on the higher branches; the silvery-silky leaflets are linear-lanceolate or narrow-oblong, to 12 mm long and 4 mm wide, with a pointed or blunt and rounded tip	Leaves are very small (about 5 mm long) and narrow (only 1 mm wide) and drop quickly; the plant remains leafless for most of the year
Seed pods	Covered in short hairs and linear-oblong, 20–30 mm long and 4–6 mm wide; turn black at maturity and release seeds explosively as the pods dry out on warm, sunny days during summer; mostly 3–6 ovoid to globose seeds in each pod, each about 2.5 mm long and olive-green to brown in colour	Seed pod is glabrous and 10–15 mm diameter, each with one or two kidney-shaped seeds, which are about 6.5 mm long and may be yellow, green, brown or black in colour. It can be distinguished from Scotch broom by having inflated pods (vs flat pods on Scotch broom)
Current distribution	Naturalised at three known sites in Victoria: Taradale near Castlemaine, St Georges Lake at Creswick, and at a cemetery in Ballarat. The Australian Virtual Herbarium also contains records from the Mount Lofty Ranges in South Australia and from a garden near Hobart, but the Mount Lofty Ranges populations have been eliminated (CRC 2003a). This species remains a serious environmental weed of native forest at Creswick, Victoria	Naturalised in South Australia, particularly around and to the east of Adelaide, and on the Yorke and Eyre Peninsulas; also on the Swan Coastal Plain around Perth and some areas of south-west Western Australia
Potential distribution	Currently, it is not known to impact on agriculture or forestry, but the potential for serious impacts is great. If not controlled, it may expand its range much further, threatening to invade a variety of natural ecosystems in the same way as the closely related Scotch broom	An aggressive invader, with each plant producing a large number of seeds, and very drought-tolerant, making it a particular threat in drier regions. It has the potential to become a significant threat to Australia's pastoral industry if not controlled
Control options	Control is difficult, but control methods similar to those for Scotch broom can be used	Control is difficult, but control methods similar to those for Scotch broom can be used (also see Bettink and Brown 2011)

Section 2

Planning



Make a plan before you manage brooms

Broom management is a long-term exercise. The most systematic and effective way to deal with brooms is to create and implement a plan. Developing and following a broom management plan is important because it will:

- be an essential information and communication tool,
- help you know what data to gather to inform decision making and adapt your management over time,
- help prioritise the use of limited resources,
- help identify the best means of control and, in turn,
- increase your chances of successfully managing broom in the most effective way.

This section discusses some of the main issues that should be considered when planning your broom management, including a check list of things to consider when developing your plan. These guidelines are based on the 'Introductory Weed Management Manual' (CRC 2004, available at nrmonline.nrm.gov.au/catalog/mql:582). Section 3 then provides more specific pre-control considerations, including hygiene protocols to prevent spread and management considerations in different habitats.

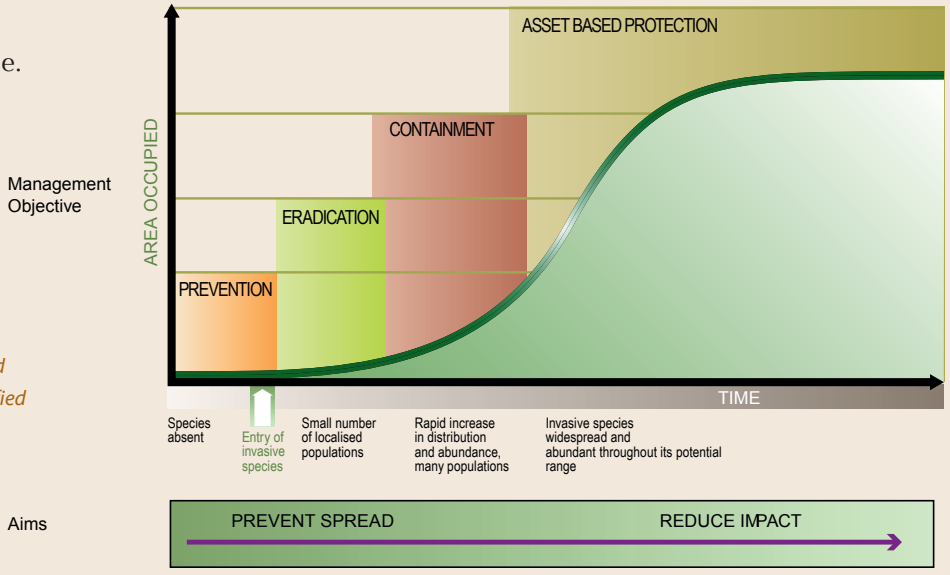
Please note that this manual will not necessarily provide you with all of the information you require for planning. Other texts should be referred to where appropriate.

What to aim for? Prevention, eradication, containment or asset-based protection

Setting realistic and attainable goals is important in directing how you go about control and how you communicate your management program to others. There are four possible management aims that will depend on factors such as:

- the size of the infestation,
- age of infestation (and approximate extent of seed bank),
- proximity to other infestations,
- site access, and
- resources available.

The goal you choose will shape the management plan you develop.



Stages of weed invasion with corresponding goals, management objectives and actions at each stage. Modified from Hobbs and Humphries (1995) and DEPI (2013).

PREVENTION: ***Aims to prevent new weeds from arriving at your site.***

At the site level, prevention of broom establishment is achieved through:

- ☑ raising awareness – educate the community on how to identify broom and, if found, consult an authorised officer for assistance with control options and mapping the infestation,
- ☑ assessing areas on a regular basis that are free from infestation but at a high risk of broom invasion (e.g. transport or stock corridors, vehicle tracks),
- ☑ controlling or monitoring potential vectors such as feral animals or stock,
- ☑ treating isolated plants, if found, before they set seed, and
- ☑ thoroughly inspecting machinery and vehicles if they have been used near known infestations.

A. Laird

Mobile washdown unit in the field

Prevention and early intervention provide a high return on investment. To achieve this, you will need to first understand how broom spreads (see 'How do brooms spread' in Section 1 on page 10 and 'Good hygiene can prevent broom spread' in Section 3 on page 47). Preventing spread and establishment of new infestations is the most cost effective way of managing broom.

ERADICATION: ***Aims to eliminate all plants and seeds from an area with limited or no potential for re-invasion.***

Eradication of a broom infestation should only be attempted after due consideration of whether the outcome is achievable. Generally, eradication is only possible when:

- ☑ the weed is in the very early stages of establishment,
- ☑ distribution and abundance is low across the general area,
- ☑ all infested areas are known,
- ☑ the chance of re-invasion from adjacent areas is unlikely,
- ☑ newly emerged plants are easily detected and controlled before seeds are released,
- ☑ there is low potential for a persistent soil-stored seed bank (a key issue with brooms), and
- ☑ resources are sufficient for regular survey, control and ongoing management.

Broom eradication is very difficult due to the highly persistent soil seed bank. High seed production and long seed viability can establish large soil-stored seed banks within a short time of broom establishment. Early detection of newly emerging broom plants is as important as post-control site monitoring. Once a mature broom population is established and has set seed, eradication may not be possible or will involve an extremely long-term commitment.

'Because we hit it so hard as soon as we knew about it, we only got about 12 seedlings coming up last spring. But don't give up. You have to keep watching and pull them out as soon as they germinate'*, says Christina Gilbert, Operations Officer, Nature Conservation Wellington District, Department of Parks and Wildlife, WA.*

Read Case Study 1 on page 116 to discover more about how the Department of Parks and Wildlife in Western Australia are attempting to eradicate the only known infestations of Scotch broom from the State.

H. Cherry

Montpellier broom seedling

CONTAINMENT: ***Aims to prevent the further spread of a high-risk weed that cannot be eradicated.***

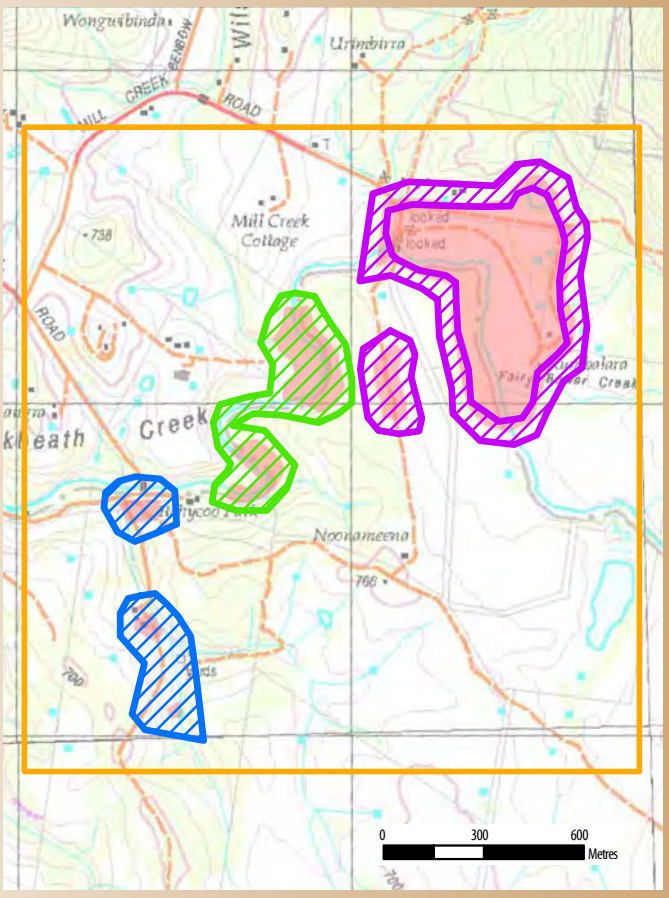
Containment involves controlling outlying or satellite infestations and preventing broom spread beyond core infestations that are too large and well established to eradicate. To successfully contain broom populations:

- ☑ Determine where to best focus your surveillance efforts by developing an accurate knowledge of the boundaries of current infestations and understanding the vectors and pathways of spread relevant to your site.
- ☑ Prevent broom spread by regularly controlling it along corridors such as roads, walking tracks, animal tracks, riparian areas and drainage lines.
- ☑ Where core infestations of broom occur, work from the edges of the infestation toward the middle, treating all outlier plants and allowing native plant establishment to determine the rate of weed removal.
- ☑ Work together with other land managers to maintain containment zones – collaboration is critical because broom seed disperses long distances via machinery, vehicles and water, and all partners must ensure good hygiene practices are adopted.
- ☑ Encourage regeneration of native plants in adjacent bushland – this is an integral part of containment efforts, as brooms thrive in more open sites and tend not to establish in areas with dense canopy and shrub cover.
- ☑ Plan for a very long-term investment of resources, as unlike eradication, the costs of containment will continue indefinitely.

T. Inkson

Montpellier broom along a road corridor

CONTAINMENT – continued on page 36



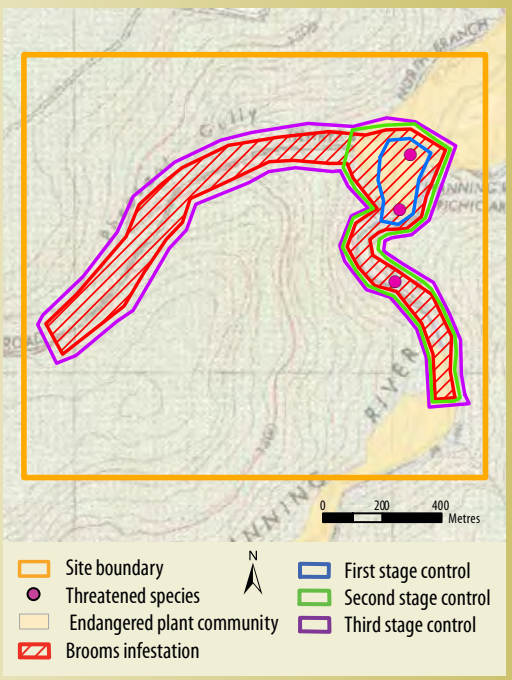
Site management map for containment-based control

Containment should focus on controlling small outlier populations of broom, and stopping its spread from the edges of large, core populations. Remember, a broom infestation may appear to not spread for many years, but a fire or other disturbance can promote mass seedling germination that will allow large populations to establish if not rapidly controlled.

Read Case Study 2 on page 118 to discover how a highly driven group of environmental professionals and community members have teamed up to contain Montpellier broom in the Shire of Manjimup, Western Australia. The Manjimup Weed Action Group have prioritised control of outlying or isolated infestations, where the size of the infestations is manageable and sufficient resources are available for the long-term follow-up needed for successful control.

ASSET-BASED PROTECTION: ***Aims to reduce the adverse impacts of widespread weeds on highly value assets by protecting and restoring those assets.***

Asset-based management should be the focus when broom has become so widespread that eradication or containment is not feasible. Assets may be defined as biophysical or physical elements of the area you are trying to protect (i.e. environment, primary production, human health or cultural). Assets can be prioritised at the state, regional or sub-regional level (e.g. threatened species populations, endangered ecological communities) or on a site or property level. To successfully protect assets:

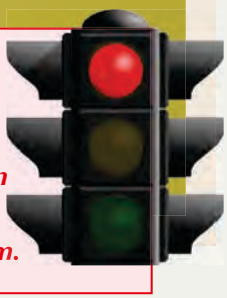


- ☑ focus control in areas of highest conservation value (those that contain threatened species) or other important assets at immediate risk, and where success is most likely to be achieved,
- ☑ select control techniques with a low risk of off-target damage,
- ☑ use a staged approach to control, guided by site-specific plans, where you work from the asset outwards (as opposed to working from outliers inwards),
- ☑ obtain a high degree of support from all affected stakeholders, and
- ☑ consult experts as needed.

In some situations, a two-pronged approach is required where aspects of both asset protection and containment strategies may be used. This is necessary when trying to contain large infestations to a particular area, while still protecting assets from broom impacts.

For more information on site planning and monitoring for asset protection approaches, see the *Monitoring Manual for bitou bush control and native plant recovery* at www.environment.nsw.gov.au/bitouTAP/monitoring.htm.

Obtaining a high degree of support from all affected stakeholders is a prerequisite to the success of any long-term eradication, containment or asset-based protection program.



Prevention, eradication, containment or asset protection can be in response to a specific or local situation, or used to implement strategic weed management at a regional, state or national scale. Different weed management strategies and legislation can be applied to each of these approaches, depending upon the situation. For example, see the WoNS strategic plan for brooms that is endorsed by all states and territories (available at www.weeds.org.au/WoNS/brooms).

Developing a management plan

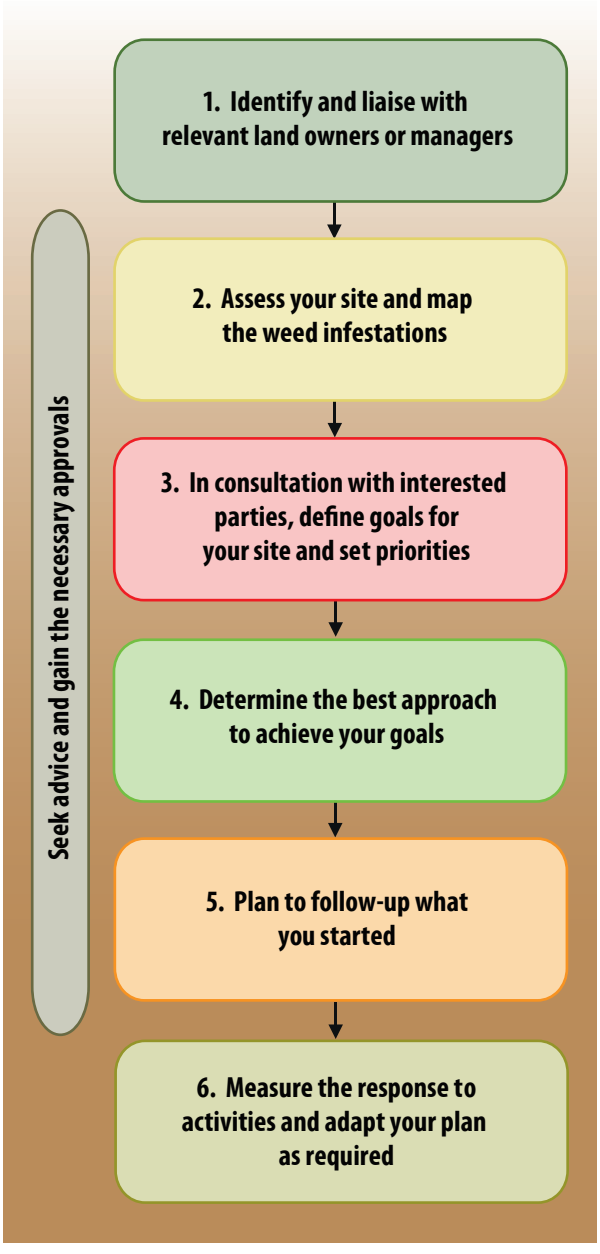
Broom management plans should be:

- ☑ targeted to achieve both long- and short-term objectives,
- ☑ able to respond to changes in the environment (e.g. fires and other disturbance events, other weeds),
- ☑ based on site conditions in the context of the broader landscape (e.g. neighbouring weed and native plant populations and how they may affect your program),
- ☑ consistent with existing strategies,
- ☑ aware of work already occurring in the community or region, and
- ☑ equipped with monitoring actions.

Where to start

- **If you are concerned about broom on public land in your area,** contact the local council or 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 should follow the flow chart and checklist of steps below to develop a weed management plan.
- **If you are a private landholder or custodian of public lands and want to start work on broom,** you should also use the flow chart and checklist of steps below. In addition, it is important to talk with other landholders, custodians or groups working on brooms or other weeds in your area to see what they have done and if you can complement existing programs.
- **If you become involved with an existing broom 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 and steps shown.
- **If your site contains threatened species,** you should contact the relevant threatened species officer in your state or territory. Please refer to Section 7 page 136 for contact details.

Planning flow chart



Management plan checklist

The stages outlined in the planning flow chart on page 38 are expanded here to help guide you in the planning process and prepare a site management plan.

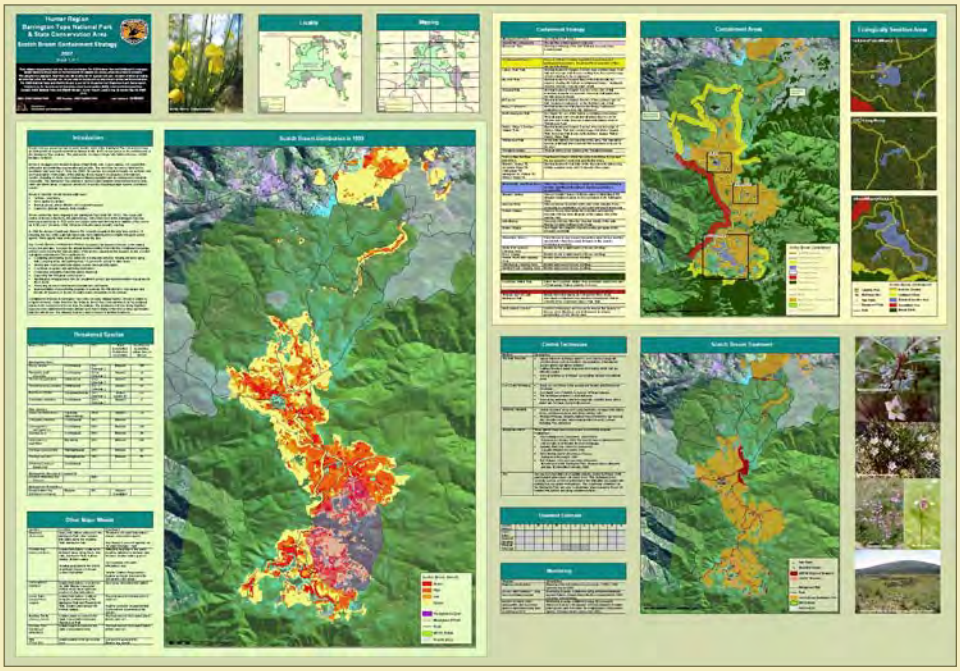
Steps in the planning process (as per flow chart page 38)	Short explanation about each step
1. Identify and liaise with relevant land owners or managers	Permission is required to undertake activities on other people's land, and with brooms it is likely that management across multiple tenures will be required. You should develop partnerships and cooperation across all areas needing management before commencing control efforts. This may be conducted in tandem with the next step, 'Assess your site'.

S. Cottrell

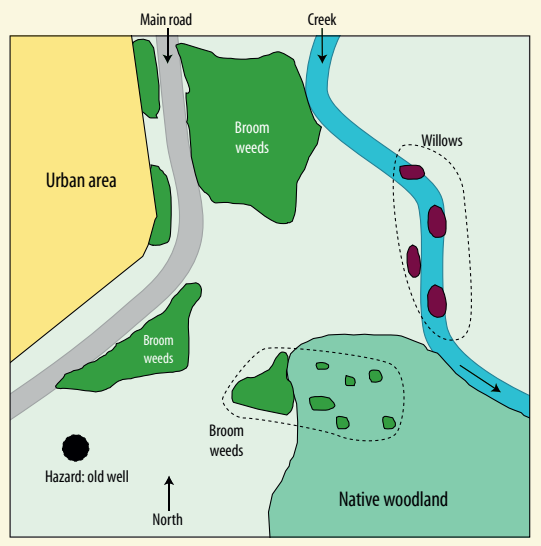
Liaise with the relevant landowners and community during the planning process and throughout your program

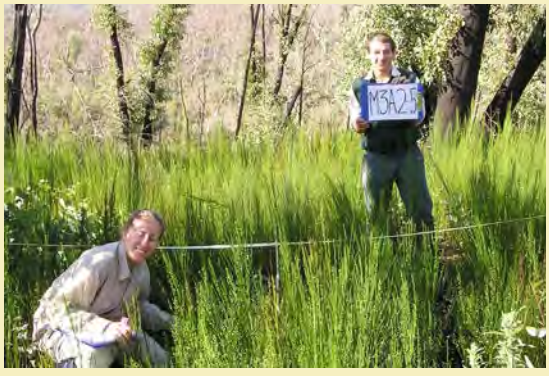
2. Assess your site and map the weed infestations

A primary step in any weed control project is to map infestations, identify areas for control and prioritise areas that require treatment first. To simplify this task, prepare a site information sheet (see the Appendix 'Site plan template'; Winkler *et al.* 2008) and weed management map.



Your whole plan can be as simple as a map with key areas outlined (e.g. this map shows strategic management actions for large broom infestations in Barrington Tops NP)

Steps in the planning process (as per flow chart page 38)	Short explanation about each step
[2. Assess your site… continued] ☑ **Prepare a site map**  	A local map of your site is a critical component of your plan. It forms the basis for recording information for your site assessment, and planning your control activities. It should: 1. set the boundaries for your site, 2. show location and extent of weed infestations, 3. show where significant environmental and cultural sites occur, 4. show where control areas are located, and 5. be able to demonstrate changes in weed location and density over time. Topographic maps or aerial photographs are useful for creating basic weed management maps. There are many mapping tools freely available on the Web. For example, the Atlas of Living Australia (www.ala.org.au) provides a free platform for interactive map making. Alternatively, for small sites, you can develop a mud map. Mapping broom in the spring while in flower makes plants easier to spot amongst vegetation.
☑ **Identify and prioritise weeds on site**	Often there are multiple weeds to deal with and it is important to assess their likely levels of impact and risk. Some weeds may not warrant control in the short-term, while others may require urgent attention.
☑ **Determine the extent of weed invasion**	This will help assess whether you can eradicate, contain or reduce impacts.
☑ **Identify risks – deal with geomorphology for long-term site stability**  J. Cohen  P. Vale *Scotch broom commonly invades steep and inaccessible areas*	This extends to dealing with risks associated with safety and access (steep or uneven terrain). Consider risks around waterways, such as difficulty of access and control limitations in aquatic situations. Perform a safety assessment for your group and neighbouring residents.  S. Bower

Steps in the planning process (as per flow chart page 38)	Short explanation about each step
☑ **Identify and record assets** 	For example, the presence of animals and threatened plant species, sites consisting of geological and biological features that are highly sensitive to change (e.g. wetlands) and/or cultural heritage sites. A valuable resource to consider is *Ask First: a guide to respecting Indigenous heritage places and values* (available at www.environment.gov.au/resource/ask-first-guide-respecting-indigenous-heritage-places-and-values). Also see the table on page 137 in Section 7 – Further information.
☑ **Determine land-use and/or management history**	Who are the stakeholders involved? How long have weeds been present on the site? Are there historical factors that may influence management (e.g. recent fire, disturbance events, any recent revegetation or restoration works)? Mark these sites on your maps.
☑ **Consider future fire events**	Fire plays an integral role in the functioning of many natural ecosystems in Australia. Bushfires and planned prescribed burns should be considered when formulating a broom management plan. Prescribed burns are carried out for either hazard (fuel) reduction purposes or for ecological purposes to trigger the regeneration of native vegetation, or both (see Section 3). They can also trigger mass germination of broom seedlings.
☑ **Research the target weed/s**	. . .to understand why weeds are present, when they flower and set seed in your particular area, and what other weeds may become problematic.
☑ **Allocate time and funds**	. . .extending to and including follow-up management. If it is unlikely that there will be sufficient funds in future to conduct follow-up work, your initial investment could be completely wasted.
☑ **Monitor the effectiveness of control outcomes**  Parks Victoria	In your initial site assessment, ensure that you have considered what factors you want to measure to demonstrate the success of your control program. This ensures that you have adequate baseline information to compare with future changes, which allows you to easily communicate your successes and adapt your program in response to any changes that occur.  Parks Victoria

Steps in the planning process (as per flow chart page 38)	Short explanation about each step
3. In consultation with interested parties, define goals for your site and set priorities	Using your site assessment, you can now determine your priorities and develop objectives and actions to address them. For example, what do you want to achieve? Do you want to restore the vegetation to its original condition, eradicate a weed, contain a weed infestation or determine whether a site is worth investing in? Refer to page 32 'What to aim for?' for further information on setting realistic goals.

Who should I talk to? People that you can consult or talk to about your site include:

- Community Support or Regional Landcare Officers (CMA / LLS / NRM).
- Local council officers (weeds, bushland, biodiversity or environmental).
- Local Aboriginal communities.
- Local and regional community groups including Landcare groups.
- Local weed authority or biosecurity officers.
- National Parks rangers.

For your reference, a collection of relevant contacts is provided in Section 7– Further information.

4. Determine the best approach to achieve your goals

To determine the best broom control methods for your site, you should consider:

☑ **The need to integrate control methods**	Often the most successful and cost-effective approach to controlling weeds is to combine or integrate several control methods over time (integrated management). A variety of methods can be used to target vulnerable aspects of a weed, its life cycle, or its environment. For example, mature plants may be treated with herbicide while subsequent seedling germination may be controlled by hand pulling. By using several techniques to control weeds, you can reduce the chance of that weed species developing resistance to a particular herbicide. Also, some control methods will apply to multiple weeds, allowing you to control a range of weed threats together. It is important to note that biological control takes many years and must be integrated with other management techniques to control infestations.
☑ **What 'assets' are found at your site?**	To protect important assets, you should choose a control method that will have minimal adverse impacts on that asset (e.g. minimal off-target damage).
☑ **The impact of weed removal**	Is native plant regeneration likely or is there a possibility of invasion by other high impact weeds, or both? If revegetation is required, planning at the outset is essential to ensure resources will be available to meet long-term objectives.
☑ **The need for cooperation from adjoining landholders**	Weeds do not recognise property boundaries. There may be socio-economic factors that affect the ability of land owners to manage weeds. Communication with adjacent landholders will help align landscape priorities and garner commitment.

A. Shackleton

Steps in the planning process (as per flow chart page 38)	Short explanation about each step
☑ **What is causing the problem and can you manage this cause?**	For example, broom can be spread by humans using machinery or dumping garden material, in water flowing from broom infestations, or by seeds sticking in the fur or feet of animals. How can these pathways be managed to reduce spread? See 'Preventing broom spread' on page 46 for further information on this.
☑ **What resources do you have?**	Do you have skilled personnel, funds or a financial plan and equipment available to complete the work? Making contact with local government or regional groups may allow you to access additional resources or combine your efforts with others who are managing brooms and other weeds (see Section 7 – Further information for a list of relevant contacts).
☑ **Establishing a long-term plan**	Schedule a control plan that is ongoing and includes follow-up control and monitoring activities at appropriate times (see Section 4 – Control methods and Section 5 – Follow-up, restoration and monitoring).
5. Plan to follow-up what you started	The key to successful control is commitment to an appropriate ongoing control program. Often initial control is done across too large an area for follow-up control to occur, or initial efforts are not maintained over time to allow a successful outcome. Exhausting the broom seed bank will take many years, thus ongoing monitoring and control activities will need to be conducted. Because broom seed is very long-lived, it is essential to prevent further seed set and not allow replenishment of the soil seed bank. Broom control activities can be reduced in frequency once all mature (reproductive) plants are controlled and are no longer producing seed (i.e. contributing to the seed bank). The rate of germination observed at your site should be used to inform the frequency of follow-up treatments.

M. Sheehan

Montpellier broom resprouting from the base

P. Watton

Montpellier broom regenerating after a prescribed burn

Steps in the planning process (as per flow chart page 38)	Short explanation about each step

[5. Plan to follow-up what you started… continued]

Brooms 'fight back' swiftly after control, so…

Plan to manage regrowth and seedlings – or you may end up with a bigger problem than you started with!

After initial control of mature broom, plants that do not die will resprout and/or seedlings will emerge. Your follow-up control plan should consider the differences between regrowth and seedlings, because they are each managed in different ways.

☑ **Plan to follow-up monitor and control any regrowth within 3–6 months following initial control**

Mature and actively growing broom plants will resprout from well-established root systems if burnt, ineffectively sprayed or cleared without using herbicides. Regrowth will usually be multi-stemmed and vigorous and is capable of producing seed within 6–12 months after initial control, due an already well established and robust root system. You should therefore plan to control any regrowth within 3–6 months after control.

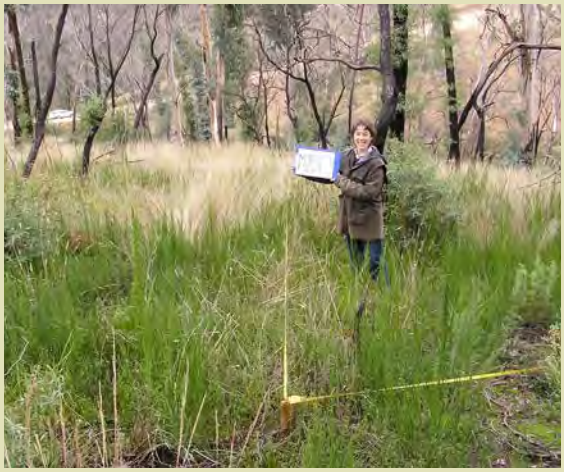
☑ **Plan to follow-up monitor and control seedlings approximately 12 months following initial control**

Seedlings germinate from seeds in the soil. New seedlings are soft, single stemmed and have three leaflets. In contrast to regrowth, seedlings are spindly and weak in the first year or two and are vulnerable to competition and to hot and dry weather, so follow-up control of seedlings can easily be delayed until 12 months following initial control. This will allow natural mortality to take place and new seedlings to emerge.

☑ **Plan to continue to follow-up and control regrowth and seedlings at regular intervals for many years!**

Due to the enormous seed bank and ability of seeds to remain dormant in the soil for a long time, long-term follow-up management will be needed. Only a very small percentage of seedlings need to survive to then become a dense stand of mature plants.

6. Measure the response to activities and adapt your plan as required


Parks Victoria

Are your management actions achieving your priorities and goals? Some simple monitoring and evaluation will help you answer this question. Monitoring is an essential component of any weed management program and sufficient resources should be allocated to monitoring.

Monitoring allows you to:

- assess the effectiveness of your control program,
- adapt your control program if it is not achieving desired outcomes,
- assess the rate of establishment of native regeneration, if applicable,
- identify any new weed infestations or issues that may affect the success of your control program,
- demonstrate progress to your group or funding body, and
- raise awareness for group momentum and general public education.

See Section 5 for more information on monitoring.

Section 3

Pre-control considerations

Pre-control considerations

Important pre-control considerations for broom management

Before commencing broom control activities, you should consider the following:

- ☑ **Do you have commitment and/or resources to conduct follow-up management?**
  Follow-up management is critical given the long-lived seed banks and ability for broom seeds to suddenly germinate *en masse* following disturbance.
- ☑ **Do you have plans for site restoration?**
  Site restoration can be particularly challenging on conservation land because brooms can fix high levels of nitrogen in the soil, which can alter soil properties and affect regrowth of native plants and weeds.
- ☑ **How accessible is the site?**
  Your best control options may depend on easy site access.
- ☑ **How will you ensure that seeds are not moved to other sites during or after control?**
  What time of year will you conduct works? Who else uses this site and have you engaged them? To prevent seed spread from a control site, it is important that all people with access to the site follow good hygiene practices.

Preventing broom spread

Preventing the spread of broom to other areas is critical to all management plans, and should be a major consideration in planning your control.

Long distance spread of broom commonly occurs along easily identified pathways such as roadsides, railways, animal paths, bushwalking tracks and watercourses. It is typical for brooms to establish along these pathways and gradually spread into surrounding areas over time. Remember that seeds are easily spread by:

- moving machinery along roadsides, where seeds can get stuck in tyres in mud,
- bushwalkers, where seeds can get stuck on muddy boots or caught in clothing,
- livestock or native animals, where seeds attach to fur or muddy feet, and
- heavy rains, which can create fast-moving streams that push seeds quickly down slopes

A. Shackleton

Seed spreads along culverts and road edges

and along tracks, or carry seeds further into creeks and rivers (often via flooding) and then into remote and difficult to access locations.

Keeping mature broom away from these potential spread pathways will go a long way towards preventing spread to other areas.

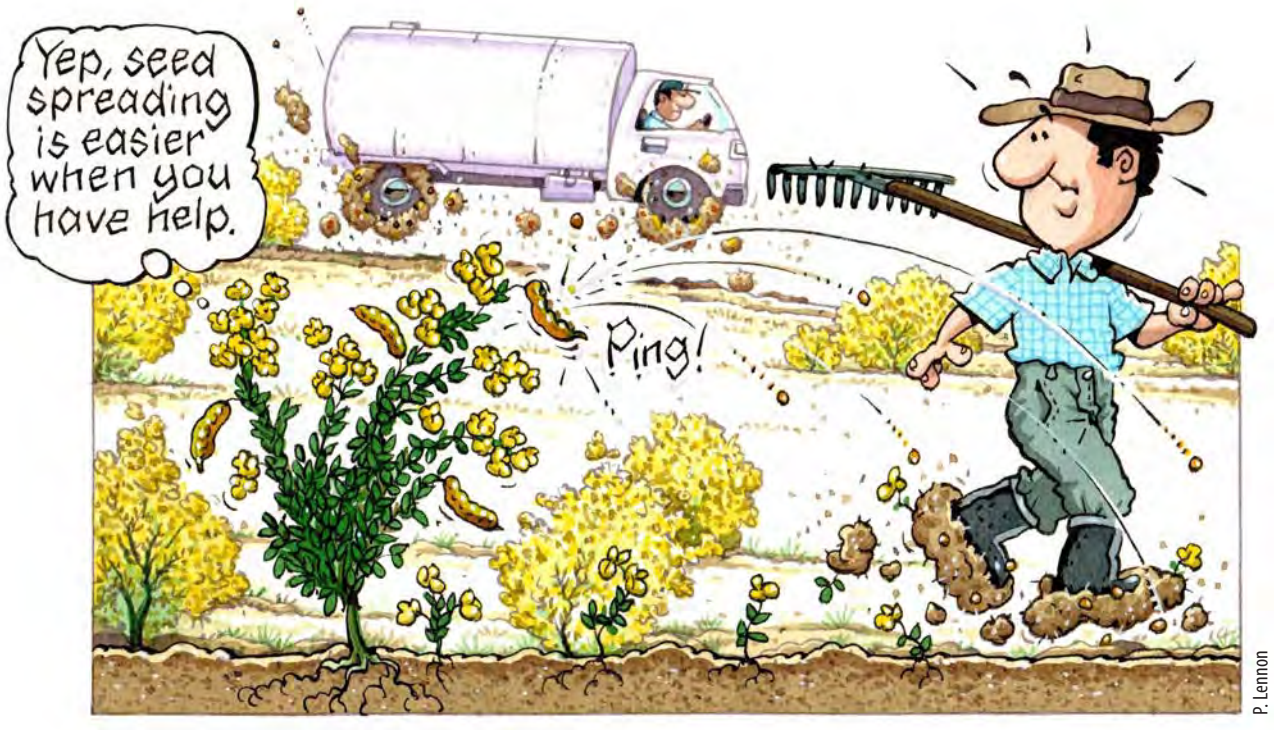
See Section 1 for further details on how brooms spread.

Manjimup Weed Action Group, in Western Australia, has found that seed transported on graders and heavy equipment used in road maintenance seems to be a major factor in the spread of Montpellier broom and, in areas where timber harvesting is active, isolated outbreaks have been associated with harvesting coupes and vehicle parking bays (see Case Study 2 on page 118).

Good hygiene can prevent broom spread

Good hygiene practice is important as long distance broom spread is usually assisted, albeit inadvertently, by human activities such as movement of machinery and soil.

It is crucial that you establish protocols for good hygiene practices and have them adopted by anyone who works in and around broom infestations in your area.



P. Lennon

Case study

Preventing broom spread along roadsides and other corridors – developing machinery hygiene protocols

Andrew Matthews, Weeds Officer, Shire of Bridgetown-Greenbushes

This work was supported by the Western Australia Natural Resource Managment Office. The complete project summary is available at www.nrm.wa.gov.au/projects/10060.aspx.

The Shire of Bridgetown-Greenbushes has developed a set of guidelines for Montpellier broom management on roadsides as part of a larger project titled '*Strategic washdown bays, equipment and procedures to minimise soil-stored Cape [Montpellier] broom seed dispersal*'. These guidelines are relevant to all broom weeds, and are also useful to help prevent the spread of other weeds and diseases. The following information is adapted from these guidelines.

Roadsides and corridors as vectors for broom spread

Brooms thrive on roadsides and corridors, such as utility easements, which represent high-risk reservoirs for further spread of this weed. By their nature, road reserves and corridors are highly accessible, frequented by many and susceptible to regular soil disturbance. These factors make broom-infested roadsides a high-risk source of seed that can cause new infestations. Thus, strategic planning and implementation of good hygiene to prevent spread in these corridors is critical to managing broom on a landscape scale.

Broom can easily spread along roadsides as:

- broom seeds are numerous, hard and long lived, making them highly suited to transport by machinery,
- the explosive release of seeds (which can be expelled up to 3 m from plants) enables seeds to be deposited in roadside drains and shoulders, and on vehicles and machinery,
- broom seeds readily spread along roadsides by run-off and during grading or drainage maintenance,
- other road verge works such as installing signage and removing fallen trees can also spread seeds,
- slashing throws seed from parent plants and contaminated slashing machinery or vehicles move seed between sites,
- seed travels long distances in soil on contaminated earthmoving equipment, and
- contaminated soil is hard to identify and is often transported by grading.

A. Matthews

Seeds can easily spread on soil trapped on machinery, as on this grader

Any work where contaminated soil becomes trapped and transported by machinery can spread seeds.

To limit the spread of broom seeds by machinery, trapped soil must be removed from equipment and machinery before moving from an infested area. This can be difficult to achieve in practice, as the task of checking for and removing soil from machinery and vehicles can be time consuming and costly; worse, it can be overlooked or forgotten, if not correctly included in standard procedures.

When good maps of weed locations are available, and for major works such as road construction where planning occurs well in advance of the actual works, prevention and hygiene activities can be included in the planning and costing of proposed works. Such forward planning, however, is not always possible because work crews are often deployed on short notice for incidents such as storm or fire recovery.

Achieving a workable 'day to day' biosecurity outcome depends on work crews having the right knowledge and resources when situations arise. Prior planning and training are important to ensure that crews have:

1. An understanding of how machines spread broom seeds (further information page 49).
2. The ability to identify high risk spread zones (further information page 50).
3. The ability to assess the risks of machinery contamination (further information page 52).
4. Suitable alternative work practices that minimise contamination risks (further information page 53).
5. Simple hygiene procedures and suitable facilities/equipment to clean machinery (page 54).

Further information on each of these points is provided below.

1. How machines spread broom seeds

Any machinery that comes into contact with contaminated soil can spread seeds. However, backhoes and graders are the most common vectors, as:

- they are the most frequently used machines on roads,
- both cause significant soil disturbance, and
- they are highly mobile.

The way these machines spread seeds differs however, and is reflective of the individual function of each machine in road maintenance.

Backhoes are more likely to relocate seeds to new areas, thereby creating new infestations, by transferring soil from one culvert/drain to the next.

A. Matthews

Washing down a backhoe

Case study continued/…

Graders are more likely to extend existing stands by dragging contaminated gravel along the road. However, like backhoes, they can also relocate seeds to new areas when used for cutting offshoot drains, as soil is more likely to accumulate and fall off the top of the blade assembly when the grader crosses the shoulder and digs into the soil in the verge.

A. Matthews

Grader and broom

Machinery such as **excavators**, **trenching machines** and **truck mounted augers** are also highly likely to spread broom seeds when workers are maintaining infrastructure such as water mains, telecommunication cables and electricity supplies.

A. Matthews

Truck mounted auger

2. Identifying infestations and high-risk spread zones

Work crews need specific knowledge and skills to identify high-risk spread zones and to assess the risk of machinery contamination. Only then can effective hygiene procedures be incorporated into daily work practices.

Observation and recording of living (or dead) broom is valuable for identifying infestations and soil seed banks that occur in works areas, as are weed maps with accurate broom data points.

In field situations, there may be no live broom plants or other visible evidence of a seed bank. This 'hidden contamination' represents a high risk for machinery contamination and seed spread. Thus, other methods should be used to indicate infestations (or seed banks) to anyone who uses these areas.

Using signs to mark infestations

In the Shire of Bridgetown-Greenbushes, most roadside Montpellier broom infestations have been mapped, but are also delineated in the field by highly visible, bright orange weed marker signs. These signs are placed in the middle of isolated infestations, or at regular intervals along extended infestations or areas that may be contaminated with seed. As the signs are often placed in the middle of seed banks, crews are asked to consider the contamination risk to their machines if they are operating within sight of a sign, not just in the 10–20 m radius around the sign itself.

Weed marker sign indicating dead broom plant

A. Matthews

Similar signage is used elsewhere in Australia, for example:

- '**Red guide posts**', which are being installed along roadsides throughout the Riverina and western NSW (see www.riverinaweeds.org.au/Documents/images/WAP_2.1.1.9_Vehicle_Hygiene_Protocol_040613.pdf), and
- **Enviromark**, a national program marketed by Greening Australia, where coded field markers can be purchased and placed along roadside areas and roadside managers are then provided with a specification sheet to cross-reference the code and carry out the appropriate action/s (see www.greeningaustralia.org.au/our-projects/land/enviromark-targets-roadside-weeds).

Riverina Noxious Weeds Advisory Groups

Red guide posts are used along roadsides in the Riverina and western NSW to alert road workers and others to keep clear of weed infested areas

Case study continued/…

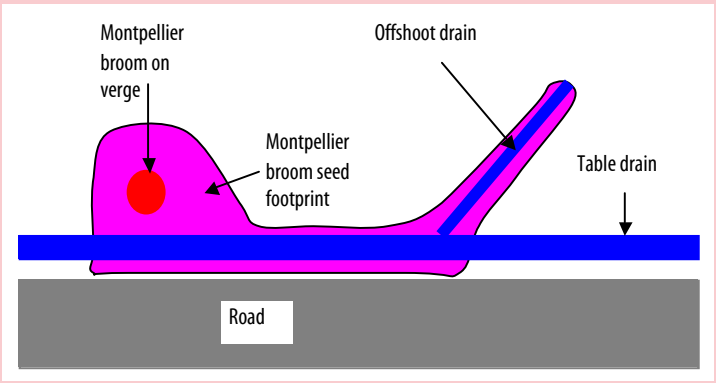
3. Assessing the risks of machinery contamination

Assessing the contamination risk at a particular site is a dynamic process and involves multiple factors, including knowledge of the work area, the biology and ecology of the weed and the extent and history of nearby infestations. Such knowledge can help works crews make an informed judgement, enabling them to optimise both their work output and biosecurity goals.

Prior to conducting works, workers on site should consider the risk factors outlined in the table below.

A seed footprint assessment can be conducted to help identify the areas at high risk of contamination, by considering where vehicles are most likely to travel and the order in which works are conducted on site. This then enables consideration of how you can minimise any risks of machine contamination.

Conceptual diagram of a roadside Montpellier broom seed footprint



Risk factors for machine contamination by Montpellier broom seed on roadsides

Risk factor	Highest risk	High risk	Medium risk
Proximity	▪ Less than 10 m from an infestation boundary	▪ Within 10–20 m of an infestation boundary	▪ Greater than 20 m from an infestation boundary
Soil type and moisture content	▪ Top 10 cm of soil ▪ Wet or sticky soils, e.g. clays and heavy loams with humus and leaf litter ▪ Soil and leaf litter from washouts	▪ Dry friable loams, clays and gravels	▪ Soil from 10 cm below surface ▪ Dry sandy or highly friable soil
Drain/culvert frequency and steepness of hills	▪ Table drains downhill from infestations, up to and including 1st downhill offshoot or culvert and discharge area ▪ Bottom of steep hills with long table drains and few offshoots/culverts	▪ Table drains between 1st and 3rd downhill offshoot or culvert	▪ Drains beyond 3rd downhill offshoot or culvert ▪ More than 10 m uphill from infestation
Age and size of infestations or soil seed banks	▪ Old actively or recently controlled infestations with plants older than two years ▪ Seed banks less than 30 years old	▪ New infestations less than 1.5 years old (prior to first flowering)	▪ Controlled infestations that have had no new seed production for 30–50 years
Season and prevailing weather conditions	▪ During winter and spring or after storms that cause heavy run-off, erosion and uprooting of trees ▪ During early summer when seeds are explosively released from seed pods	▪ Late summer and autumn, during dry, hot conditions	

4. Alternative work practices that minimise contamination risk

Weed marker signs that delineate Montpellier broom infestations, such as the orange markers used in Shire of Bridgetown-Greenbushes, enable works crews to identify the exact location of infestations and seed banks. After assessing the risks of machinery contamination, crews can reduce or prevent contamination by making an informed decision about how they undertake the job. A key aim should be to reduce the number of times crews need to clean their machinery. These decisions can include:

- the order of jobs e.g. leaving contaminated areas until last,
- working from weed free areas towards infested areas,
- choosing a lower risk practice, e.g. chainsaw to remove a fallen tree instead of a backhoe, or
- being more aware and careful not to disturb and/or pick-up soil.

If contamination of machinery is unavoidable, crews can then:

- use hand tools to remove accumulated soil and associated weed seed from machinery,
- request on-site washdown with mobile washdown equipment for larger contaminations, or
- travel directly to nearest washdown bay or a shire depot for thorough decontamination.

A. Matthews

Orange weed markers are used to designate broom sites to warn those working along roadsides to avoid the areas

A. Matthews

Mobile washdown trailers can be used to clean machinery on site, preventing further spread of seed

Case study continued/…

5. Simple hygiene procedures and suitable facilities/equipment to clean machinery

The document 'Managing Phytophthora Dieback – guidelines for local governments' (www.dieback.org.au/index.cfm?objectid=72055B2C-A0CC-3C8C-D9DC7E33E2D4F9AD) provides guidelines for preventing the spread of weeds and diseases. Although these guidelines are designed to help people remove the microscopic fungal spores of *Phytophthora cinnamomi* (root rot) from machinery, a task more difficult than removing weed seeds, adopting hygiene procedures of this standard will ensure your efforts reduce the spread of most weeds and diseases.

> **In general,** removing all mud and soil from vehicles, machinery, tools and equipment is usually sufficient to minimise the risk of spreading weeds and diseases.

Cleaning footwear

- ☑ Before leaving infested site, remove as much mud and soil as possible with a brush or stick, and minimise the amount of water used.
- ☑ If you have left the infested site, collect all mud and soil removed in a bag or bucket. Dispose of this material at a deep burial tip or with household garbage.

> **Work crews should carry a small brush and plastic bag in their vehicles, where possible.**

Cleaning vehicles and machinery

Cleaning will be easier and more effective if it is completed at a depot or a permanent/designated cleaning area.

A. Matthews

> **Engaging all groups who move machinery and vehicles is critical to preventing spread.**

If cleaning is to occur in the field:

- ☑ select a site with a hard, well-drained surface (e.g. a road) that is well away from remnant vegetation,
- ☑ if possible, wash down in an area that is close to the area you have been operating in,
- ☑ minimise the amount of water used,
- ☑ try to remove soil and mud as soon as possible (a stiff brush may assist this process), and use a brush or stick to remove compacted soil,
- ☑ wash down on ramps if possible,
- ☑ do not allow mud and wash-down effluent to drain into bushland or enter a watercourse,
- ☑ do not drive through wash-down effluent, and
- ☑ pay particular attention to mudflaps and tyres.

Washdown sites should be preferably in the field:

- ☑ Wash down near the infestation.
- ☑ Don't wash down where run-off can enter a watercourse.
- ☑ Avoid native vegetation.
- ☑ Select a site with grass, gravel, bark or timber cording.
- ☑ Allow enough space to move tracked machinery.
- ☑ Avoid hazards e.g. powerlines.

A. Matthews

Washdown bay in the field

The following table (see page 56) describes some typical machinery used on roads and verges and, for each, identifies:

- actions with high risk of contamination,
- where seeds will most likely accumulate on the machine, and
- recommended washdown procedures.

This information is based on the Tasmanian Washdown Guidelines for Weed and Disease Control, Machinery, Vehicles and Equipment (see dpipwe.tas.gov.au/invasive-species/weeds/weed-hygiene/washdown-guidelines).

Machinery types and associated contamination risks from broom seed

Vehicle/ machine	High risk actions	Major points of soil accumulation	Washdown procedure
Grader	▪ Gravel road grading where infestations are within 5 m of the shoulder ▪ Cutting drains within 15 m of an infestation or up to 100 m downhill from infested areas ▪ Road construction/widening with any verge infestation	▪ Blade assembly ▪ Grills/guards/steps around cab ▪ Wheels and axle housings ▪ Rippers	▪ Remove as much soil as possible from top of blade assembly and rippers using a brush/scraper ▪ Wash off remaining soil from blade, rippers, wheels and grills
Back-hoe	▪ Installing or digging out sediment from culverts and drains within 10 m of an infestation or downhill from infestations ▪ Digging/moving/loading soil from infested areas using the bucket ▪ Pushing up/removing fallen trees	▪ Bucket ▪ Backhoe assembly ▪ Stabiliser legs ▪ Wheels and rims ▪ Top of axles/housings ▪ Grills/guards	▪ Remove any clumps of soil from buckets and stabiliser legs with brush/scraper ▪ Wash buckets, wheels, grills and stabiliser legs to remove remaining soil
Loader	▪ Pushing up/removing fallen trees ▪ Carting/moving/loading soil from infested areas using the bucket	▪ Bucket ▪ Wheels and rims ▪ Axle housings	▪ Remove any clumps of soil from bucket and wheels with brush/scraper ▪ Wash bucket and wheels and to remove remaining soil
Skid steer	▪ Use of auger, or ▪ Bucket to move soil	▪ Tracks ▪ Around hydraulics, grills/guards ▪ Bucket ▪ Auger	▪ Remove any clumps of soil from bucket/auger and tracks with brush/scraper ▪ Wash bucket, auger and tracks and to remove remaining soil
Auger (truck mounted)	▪ Digging holes to install signs etc. within 10 m of an infestation	▪ Auger ▪ Stabiliser legs	▪ Remove any clumps of soil from auger and stabilising legs with brush/scraper. ▪ Wash auger and stabiliser legs to remove remaining soil
Tip-trucks	▪ Transporting soil from infested sites ▪ Transporting fallen trees with attached root mass and soil	▪ Inside back of truck ▪ In recesses along the sides and rear – especially the side it was loaded from	▪ Wash out any caught soil in back of tray and tailgate ▪ Wash off any soil trapped on wheel arches and guards
Tractor with slasher/ scarifier	▪ Slashing verges with seed bearing plants ▪ Installing/maintaining fire-breaks	▪ Any grills or guards, wheels and axles ▪ PTO assembly ▪ Top of slasher and around blades ▪ Entire scarifier assembly	▪ Remove all accumulated plant material from wheel mounts, grills, PTO, slasher deck and around blades ▪ Brush/wash off any accumulated soil from slasher or scarifier
Fire control vehicles	▪ Fire control activities where vehicles drive or hoses are dragged over seed banks or over/around seed bearing plants ▪ Pushing out fire control tracks/ containment lines near or through infestations	▪ In tyre tread, rims and axles ▪ Around hose reels ▪ Fire crews' boots and foot wells ▪ Soil on hand tools ▪ Entire machine, especially tracks/wheels, buckets, blades and scarifiers	▪ Wash ash/soil from wheels and arches ▪ Wash hose and around reel ▪ Kick tyre several times to dislodge ash/soil from footwear ▪ Wash down entire lower section of machine to remove ash/soil/mud ▪ Clean all hand tools used in area before using elsewhere
Any vehicle	▪ Parking within 5 m of or driving through mature seed bearing plants from mid December to February (when spring loaded seed pods eject seeds into air)	▪ Ute trays and any upward facing crevice where seeds ejected from pods could land	▪ Sweep out crevices and trays using brush or compressed air

Reducing the soil seed bank

Dense infestations of broom have large and persistent seed banks, even without any additional seed input from mature plants. Generally, the deeper the seed is buried, the longer it will remain dormant.

Management that aims to stimulate germination of the seed bank and control seedlings before they flower can effectively reduce the amount of time and resources needed for long-term broom control. Germination can be stimulated by fire or by cultivation and other mechanical control techniques. It is important to note, however, that cultivation may also bury some seeds deeper into the soil, allowing them to remain dormant for longer.

When combined as part of an integrated approach with other control techniques, deliberate stimulation of broom seed germination can help reduce the seed bank. But ensure resources are available to control seedlings, which cannot be allowed to set seed.

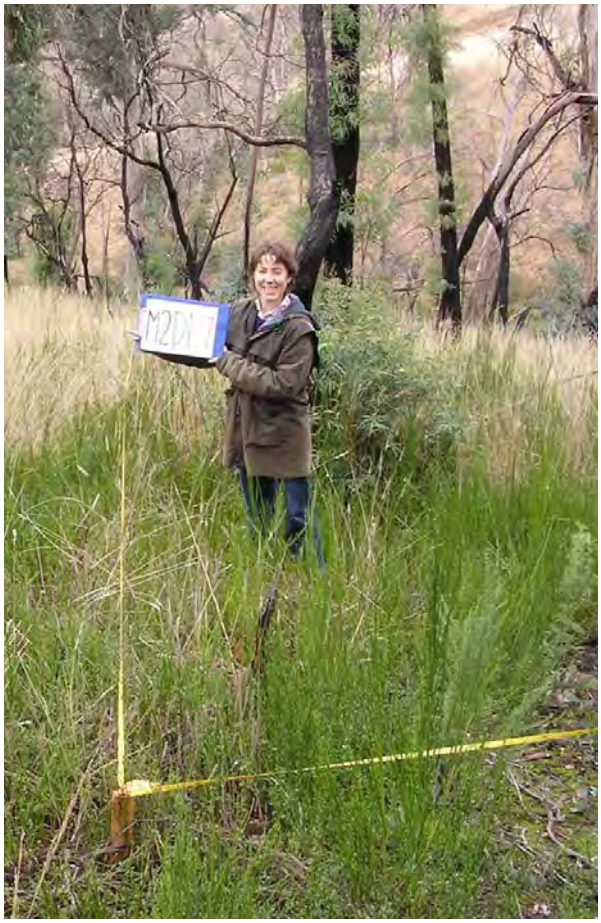
Parks Victoria

Mass broom seed germination can occur after fires, but seedlings must be controlled to prevent broom invasion

Fire and broom management

Fire can trigger 70–80% of the seed bank to germinate, depleting the number of seeds in the soil. This can encourage growth of seedlings that are easy to control during follow-up management. Because it stimulates the mass germination of broom seeds, fire should only be used as part of an integrated control strategy, which must include follow-up seedling control.

On high fire risk days, broom can increase fire risk and intensity, so extreme caution is needed!



Parks Victoria

Fire can be used as part of an integrated control program that includes monitoring and seedling/seed bank management

Pre-control considerations

As a general rule, controlled (prescribed) burns are of a low to medium fire intensity; however weed infested areas may not burn well because weeds often contain too much moisture or may not provide good fuel structure. This can be especially true of dense stands of broom, where shade and competition can exclude a grassy understorey, leaving the ground bare of fuel. Thus, controlled burning of broom infestations requires careful planning to ensure a fire of sufficient intensity. Alternatively, in times of severe fire weather, such as low humidity, high temperatures and strong winds, dense broom stands will carry a fire very well and can actually increase the fire risk and fire intensity, even allowing fire to carry into the canopy.

S. Garland

Dense broom stands can contribute to reducing the intensity of fire in benign weather or act as a fire hazard in dangerous fire weather.

H. Cherry

Dense old broom stands can be a fire hazard

Site preparation, timing and technique play a critical role in the successful use of fire for weed management and for aiding restoration of degraded ecosystems. Important considerations in using fire include:

- ☑ Talk to the land manager and relevant fire authorities. Public lands that are fire prone will usually be covered under a fire management strategy and this should be consulted to determine if and when the next prescribed burn will occur.
- ☑ To prepare for prescribed burns, you may need to treat broom and other weeds to ensure they will burn properly. You can do this by either:
  - cutting plants down and leaving them on site to dry out, adding to the fuel load,
  - spraying plants with herbicide to kill them and reduce their moisture content, or
  - cutting down plants without herbicide, allowing them to resprout and then spot spraying regrowth a few months prior to burning. As the regrowth dries out from the foliar spray, it also adds to the fuel load, which may increase the intensity of the fire. A hot enough fire may kill small broom plants and seedlings.
- ☑ Be sure to treat the large number of seedlings that germinate after the burn. This should be done before they flower or set seed set to prevent further recruitment to the seed bank. Growth rates of reshooting plants and seedlings will be dictated by rainfall. Monitoring of sites at 3, 6 and 12 months following the burn will allow you to determine when best to conduct follow-up control.
- ☑ Where dense seedling growth occurs, treat the seedlings while they are still small. If using a foliar spray for broad-scale seedling control, it can be difficult to get complete herbicide coverage of foliage in dense stands of waist high plants. Observations of Montpellier broom in Western Australia following fire indicate that broom seedlings emerge before many native seedlings, giving a brief window where off-target damage may be reduced. Because each burn is different, post-burn monitoring is critical to assessing opportunities at each specific site.

Rapid response after fire can turn devastation into opportunity!

When wildfires and back-burning operations triggered mass germination of over 6 million Scotch broom seeds in the Blue Mountains in 2002, a collaborative effort by a network of skilled volunteers, contractors, and environmental agencies ensured a swift response. Within just 12 months, a grant was secured to provide resources, and control was undertaken in all burnt areas before broom was able to flower or seed. For more on this story, see Case Study 3 page 121 'Call to action after fire: community groups shaping the on-ground response to Scotch broom in a World Heritage area'.

P. Vale

Treatment of seedlings post-fire must be swift to prevent flowering and seed set

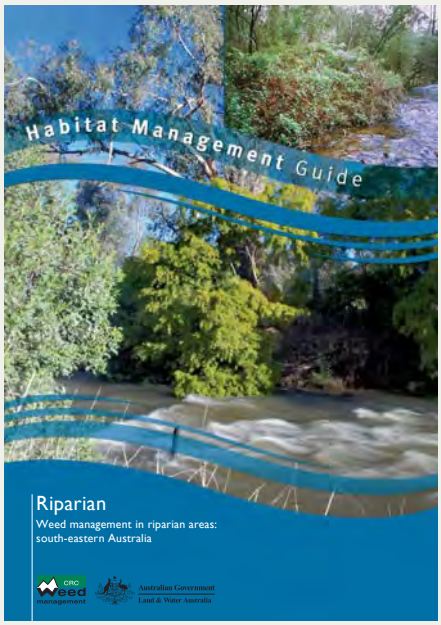
Management considerations within specific habitats

Habitat	Considerations for management
Broom as a refuge for native animals  WildCount OEH	While broom infestations can provide harbour for feral animals, they can also provide habitat and refuge for native animals. In areas where habitat is fragmented by urban development or cleared for production, these refuges may be important for the survival of native species. If you think that broom is important for birds or mammals at your site, consider the following before taking control measures: ▪ Survey sites to assess their importance for native fauna. ▪ Retain dead broom *in situ* and allow native understorey to re-establish. ▪ Remove broom over a number of seasons, and replant or revegetate with native shrubs. ▪ Chemical control (e.g. foliar spraying) can offer better habitat protection than mechanical clearing or burning. ▪ Mechanical control/burning is more effective in autumn than spring for habitat protection.
Natural ecosystems  H. Cherry  S. Ruming  R. Cleary	Brooms invade many types of native habitats, including grasslands, heath, riparian vegetation, woodland including sub-alpine woodland, dry and wet sclerophyll forest, and wetlands such as alpine bogs. Flax-leaf broom can also be a weed in coastal dunes. Many of these areas are sensitive and may include threatened species, endangered ecological communities and regionally significant native vegetation remnants. Control measures adopted in all these natural ecosystems must minimise damage to desirable vegetation, minimise soil disturbance and encourage native regeneration. While native systems vary, there are some general management principles that apply to all conservation areas. The selection of control techniques is very important, as some control methods may further reduce the ability of the vegetation community to recover and make restoration efforts more costly and less successful. An understanding of native plant species and vegetation on site will help to minimise off-target damage. See 'Riparian areas' on the next page for information specific to riparian habitats and Section 4 for details of the control methods discussed below. **Take care when planning and choosing control techniques to minimise impacts to native vegetation.** **In particularly sensitive areas, the use of more costly or resource-intensive control methods may be warranted.** **Contact your state/territory environment department for more information (for a contact list, see Section 7).**

Habitat	Considerations for management
Natural ecosystems continued/. . .  *Scotch broom (flowering in background) is often found with other weeds such as gorse (foreground)*	**Choose your control method carefully** Inappropriate control techniques can potentially cause more long-term impacts on native vegetation than broom invasion. Hand removal and chemical control are generally the best choice in natural areas. Low impact techniques, such as hand pulling, cutting (without herbicide), cut-and-paint, and stem injection are preferred over foliar spraying. Although foliar spraying may be a more efficient initial herbicide treatment than cut-and-paint or stem injection, off-target damage can have significant impacts on native vegetation. Native ground cover species can be killed by off-target spraying, which will open up areas to further invasion by broom and other weeds. Where spraying is required to effectively manage large areas, herbicide selection and foliar spraying techniques should be chosen to minimise short- and long-term off-target damage. The City of Greater Geelong has developed methods for managing flax-leaf broom in sensitive grasslands and grassy woodlands. Read Case Study 5 on page 129 for their story. **Watch out for other weeds** Clearing a dense broom infestation can allow other weeds, such as blackberry or invasive grasses, to spread rapidly by reducing competition for light, water, nutrients and space. Before removing broom, take note of what other weed species are growing under and around the broom infestation. Other weeds may need to be treated at the same time to prevent scattered weed populations expanding after broom is removed.
Riparian areas   	Brooms readily establish in open areas such as on sand and gravel banks, and in intermittently dry creeks and river beds. Many Australian creeks and rivers have a 'chain of ponds' system in the upper reaches that provides suitable areas for broom to colonise and establish. **Minimising bank erosion and excess nutrient input to the water** When controlling weeds along watercourses: ☑ select control methods that minimise bank erosion, ☑ treat small areas to allow native plants to regenerate and stabilise the bank, and ☑ try to prevent large amounts of plant material falling into pooled water, as the breakdown of organic matter can deplete oxygen levels, which can negatively impact aquatic systems. For these reasons, mechanical control methods should be avoided in riparian areas. Cut-and-paint is the most appropriate method to use, especially when the cut stems and foliage are removed from the water's edge. The cut-and-paint technique also decreases the chance of bank erosion because broom root systems are left in the ground. continued on page 62/. . .

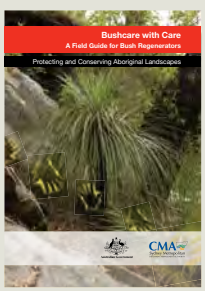
Management considerations within specific habitats …/continued from page 61

Habitat	Considerations for management
Riparian areas continued/…	**Using herbicides in riparian zones** It is important to consider the risks associated with the use of herbicides in and around riparian and aquatic zones. Guidelines for herbicide use in and around water can be found at: pandora.nla.gov.au/pan/64168/20080620-0000/www.weeds.crc.org.au/documents/gl01_herbicides_water.pdf. Another useful resource is Ede, F.J. and Hunt, T.D. (2008). *Habitat management guide—Riparian: Weed management in riparian areas: south-eastern Australia.* CRC for Australian Weed Management, Adelaide, which can be found at: www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/319448/ahmg_riparian.pdf. **Some herbicides contain surfactants that are toxic to aquatic organisms such as frogs. Use only herbicides registered for use in aquatic environments, and follow all label or permit directions. See Section 4 for information on herbicides.** **Accessing remote areas** Often broom seed is carried into remote and inaccessible areas by water, especially during flood events. Gaining access to these areas for monitoring and control work can be very time consuming and costly. Control techniques are restricted by the ability to transport equipment and limitations on herbicide use around water. The use of chest waders, canoes, kayaks and lilos can help with access to these areas by using the waterway to avoid walking through thick riparian vegetation and/or on steep banks. Scattered and isolated plants can be easily treated using cut-and-paint or hand removal techniques. Larger patches may be mapped for later spraying. Aerial spot spraying using glyphosate registered for aquatic use is undertaken in remote riparian areas in Kosciuszko National Park in NSW, where sudden flows from hydro-electricity generation are hazardous for operators on the water or on foot. See Case Study 3 on page 121 for an example of where broom is being successfully managed in remote areas in the Blue Mountains.



Accessing thick riparian vegetation in the Blue Mountains

Scotch broom transforming ecosystems in a remote and inaccessible area of Kosciuszko National Park (above and opposite)

Habitat	Considerations for management
Pastures and grazing lands  K. Harvey *Scotch broom infestation along a creekline in grazing land, Braidwood NSW*	Integrating pasture maintenance and/or improvement with broom control is important because: ▪ broom seedlings compete poorly with grasses, so well-managed pasture reduces recruitment of new broom seedlings, ▪ broom that has been fertilised, especially with nitrogen, is more attractive to sheep, and ▪ lime suppresses broom seedlings. See Case Study 4 on page 126 for an example where primary producers have been successfully managing large-scale Scotch broom infestations in their pastures near Braidwood NSW for over 40 years.
Forestry  Forestry SA *Spraying broom with herbicide is an issue near plantation species*  D. Tucker *Hygiene is important to prevent seed spread in forestry operations*	Broom easily spreads by seed along access tracks in soil attached to machinery or on vehicles used in maintenance, harvesting and other forestry operations. Good machinery hygiene practices can help to protect clean areas (see hygiene information on pages 47–56). Preventing broom from setting seed within 10 m of access roads will also help reduce spread along corridors. Follow-up control of broom after fire should be prioritised and, if resources for post-fire control are not available, consideration should be given to excluding broom infested areas from prescribed burns. Annual monitoring and control of known broom sites and surveillance for new incursions should be a part of regular forest maintenance programs. The Manjimup Weed Action Group in Western Australia have found that, in active timber harvesting areas, isolated broom outbreaks are associated with harvesting coupes and vehicle parking bays, implicating forestry machinery in broom seed dispersal (see Case Study 2 on page 118 for their story).
Cultural heritage sites  	Weed control around Indigenous and historic heritage sites needs to be managed carefully. Before starting any activities at your site, find out if the site holds any historical or cultural significance. Asking locals is a good place to start. All stakeholders who have an association with, or interest in the site need to be involved in planning the weed management program. Many states and territories require that assessments be done before beginning work in areas of cultural significance. Initially, contact your local government, public land manager or natural resource management authority, as they will be able to inform you of any issues and advise you on how to proceed. For further information and contact details, see the table 'Cultural heritage legislation and information' on page 137. continued on page 64/. . .

Management considerations within specific habitats …/continued from page 63

Habitat	Considerations for management
Road, utility and railway corridors, and vacant land  M. Sheehan  J. Mitchell	Broom often occurs along road, utility and railway corridors, which are managed by local councils, state governments, utility providers and transport operators. Although these areas are often degraded, roadsides and utility corridors can contain significant remnants of native bushland. If this is the case, these areas have conservation value, and weed control methods should be chosen that minimise disturbance to desirable vegetation and soil (e.g. hand pulling or cut-and-paint). Management of broom in these corridors is important in containment programs as they are key areas along which further spread can readily occur (see 'Preventing broom spread along roadsides and other corridors – developing machinery hygiene protocols' on page 48). Vacant land, such as land awaiting development, is often unmanaged. Weed infestations on such land can easily spread to neighbouring properties and native bushland. At a minimum, broom infestations should be managed to prevent spread to other areas. On heavily degraded land, this can be achieved by slashing (mechanical slashing or with a brush-cutter) at least once a year before flowering. Alternatively, foliar spraying from a vehicle-based spray unit at least once a year will also prevent seeding, and should kill all broom plants. Land managers or contractors can carry out these control methods cost effectively. Use caution when clearing broom by any method, as resprouting broom can set flower and produce new seed rapidly after disturbance. **Cooperation between all landholders in an area is essential for successful control, as broom can easily spread from an unmanaged property and invade neighbouring properties.**
Steep and inaccessible sites  S. Bower	Terrain can greatly influence the choice of control methods, and in some circumstances even prevent control. Broom on cliff faces, steep slopes, remote areas, or at the water's edge may be inaccessible. It is important to identify inaccessible and difficult-to-access areas in your management plan, as you may need to engage trained contractors or government agency staff to control broom in such areas. People with the appropriate training and experience can control broom on cliff faces and steep slopes using safety equipment such as harnesses and ropes. You should always consider workplace health and safety guidelines when planning to control broom in difficult to access areas. **Managing erosion on steep slopes** Dense broom stands provide very poor erosion control because they exclude grasses and groundcovers, leaving the ground bare under the broom canopy. In addition, broom control on steep slopes can also result in erosion, so control methods that limit soil disturbance should be chosen to minimise areas of bare ground. Chemical control methods are the most suitable as the roots are left in the ground and soil is not disturbed. Manual control may be used on small infestations, although hand pulling should only be performed when the soil is moist or loose to prevent erosion (see Section 4 for details on each control method).

Section 4

Control methods

Control methods

Integrated weed management

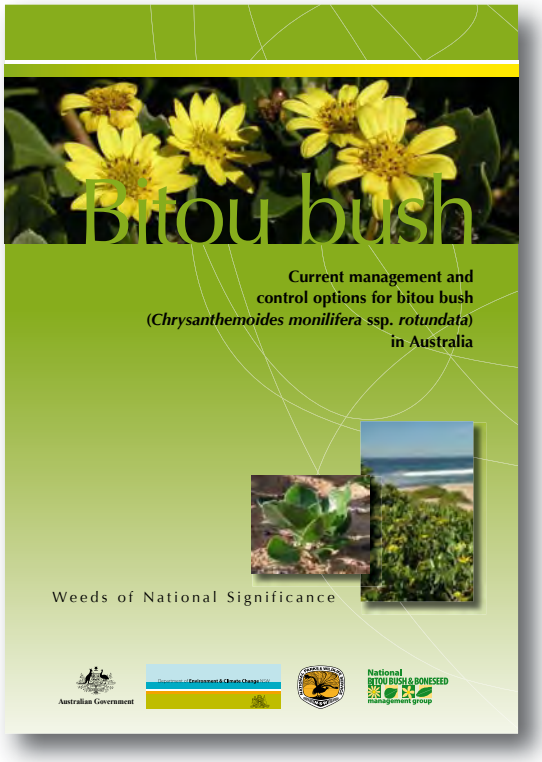
Best practice broom management requires an integrated approach that combines prevention activities, such as good hygiene practices, a variety of control techniques and long-term, follow-up management. Preventing further spread should be a key consideration in your overall management plan, and when choosing your specific control techniques.

Using one control technique alone will rarely produce satisfactory long-term control. For example, once mature plants are controlled, different techniques are often required to deal with regrowth from seedlings. The best range of control techniques to choose will depend on:

- the life cycle stage of the plants,
- the situation in which plants are growing,
- site accessibility and assets on the site,
- time of year,
- available time and resources, and
- the stage of your control program.

Controlling individual broom plants is a relatively straightforward task. The challenge lies in gaining access to infestations, especially in steep and remote country, and maintaining a consistent effort over many years to deal with regrowth from the highly persistent seed bank. Left untreated, broom will quickly grow and dominate the vegetation community. Efforts to control large infestations of broom across vast landscapes are best prioritised to target outlier plants and populations first, before treating well established core infestations. Within core populations, particular assets may be identified, such as a threatened species, where asset protection should be undertaken using techniques that have a low risk of off-target damage.

Methods for undertaking broom control are detailed in this chapter. Much of this information is based on other WoNS National Best Practice Management Manuals, in particular for gorse, lantana and bitou bush. These are available for download at www.weeds.org.au/WoNS. Gorse is a leguminous invasive shrub, closely related to brooms, that occurs in similar environments and causes comparable impacts. The similarity in response to control techniques, as well as issues around gorse seed longevity and seed bank persistence means that many of the same management considerations are needed. Lantana and bitou bush are weedy shrubs that can invade similar environments to Montpellier and flax-leaf broom and also share some common control techniques and considerations.

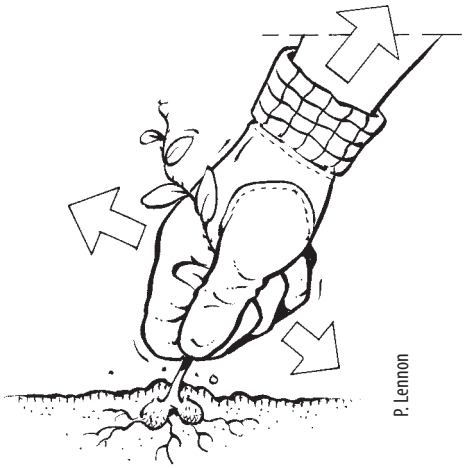


See Case Study 5 on page 129 to learn how City of Greater Geelong has matched flax-leaf broom control methods with different sites and conditions.

Mechanical and physical options

Hand pulling

Young seedlings and small plants can usually be pulled out easily from softer and moist soils. In harder, compacted and/or rocky ground, plants may break at the roots and reshoot. There is also a risk of back strain when hand pulling larger plants. If you can't pull the plant out easily, it is better to use the cut stump method or leverage hand tools, such as Tree Poppers™, Pullerbears™, Weed Wrenches™ or similar devices, which can remove larger plants that are not easily removed by hand pulling.



Hand pulling – grasp the stem close to the ground

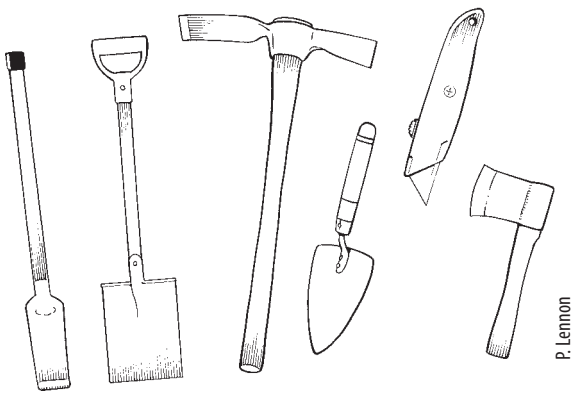
Hand pulling

Timing	Suitability of method	Advantages	Disadvantages
Use this method at any time of the year, but in areas with heavier soils you may need to wait until the soil is moist. Young plants should be removed before they first flower and set seed. Adult plants should ideally be removed before seed set to prevent the spread of seeds.	**Plant age** – smaller plants **Habitat type** – any **Size of infestation** – isolated infestations, scattered plants or infestations that cover a small area	▪ Causes no or minimal damage to desirable vegetation ▪ High kill rate ▪ Selective (i.e. only broom is removed) ▪ Whole plants are removed preventing regrowth ▪ Provides easy access for follow-up works ▪ No chemicals and minimal equipment required ▪ Low cost ▪ Applicable for use in areas containing sensitive habitats or threatened species	▪ Causes soil disturbance ▪ Labour intensive and time consuming ▪ Not suitable for most plants, other than seedlings ▪ Risk of back injury or strain injury if done incorrectly

Hand cutting without herbicide

Older, senescent broom plants can be cut at or below ground level without the subsequent use of herbicide, as they usually do not resprout or coppice at that stage of their life cycle. In California, Scotch broom plants cut off at or below ground level during the dry season were significantly less likely to resprout, regardless of shrub size or height of the cut (Bossard and Rejmanek 1994). Similar results could be expected in Australia during times when plants are stressed, such as drought.

Removal of above ground plant parts will open up the canopy and may stimulate germination from an existing broom seed bank. Follow-up control of seedlings and resprouting mature plants will be necessary.



Tools for manual control

Hand cutting without herbicide

Timing	Suitability of method	Advantages	Disadvantages
This method is ideally used when older broom plants are stressed from drought or frost.	**Plant age** – older, senescent plants **Habitat type** – any **Size of infestation** – older infestations that cover a small area	▪ Causes no or minimal damage to desirable vegetation ▪ Selective (i.e. only broom is killed) ▪ Provides better access for follow-up works ▪ No chemicals and minimal equipment required ▪ Low cost ▪ Applicable for use in areas containing sensitive habitat or threatened species	▪ Method only trialled for Scotch broom ▪ Labour intensive and time consuming ▪ Some plants may resprout ▪ Limited use, as only applicable at specific times, and with older plants

Mechanical clearing

Mechanical clearing aims to reduce the above ground biomass of broom to provide easier access for follow-up treatments. Clearing will not kill mature, actively growing broom, so it must be integrated with other control methods (e.g. spraying with herbicides, restoring pasture, grazing or cultivation) to achieve long-term broom control. It can be an effective primary control method in situations, such as pastures, forestry and some more accessible, less sensitive natural areas. However, some broom may grow back from stumps and roots left behind after clearing. Older broom plants approaching senescence often don't reshoot after mechanical clearing.

Spraying regrowth after mechanical clearing typically requires only 20–25% of the amount of herbicide needed for spraying uncleared broom, and the infestation is much easier to access, reducing the risk of spray drift. This is particularly effective in pastures where a combination of over-sowing with fodder crops, followed by grazing and spot spraying, can lead to productive land in a short period of time.

If you clear broom infestations, remember that:

- the use of heavy machinery can:
  1) increase the risk of erosion and soil structure degradation,
  2) may seriously impede regeneration of other species, and
  3) may contribute to further degradation of natural areas by removing or damaging the native seed bank,
- a permit may be necessary to do earthworks on river banks or to clear vegetation,
- broom seed that is buried deeper than 8 cm is likely to stay dormant for many years or decades until being exposed by erosion, digging or other earthworks, and
- removal of above ground plants will open up the canopy and may stimulate germination from an existing broom seed bank. Follow-up control of seedlings and resprouting mature plants will be necessary. See page 44 'Brooms 'fight back' swiftly after control, so…'.

Applying the method

A variety of mechanical clearing techniques are effective on brooms.

Dozing with a bulldozer, tractor with blade, or similar machine. The aim of using a bladed machine is to break broom stems off at soil level, or to push plants over and trample them to provide easier access for spraying and/or a fuel structure suitable for burning. Avoid scalping the surface soil.

Grubbing with an excavator, tractor with bucket, front-end loader, bobcat or similar machine. The aim is to break the broom off at soil level. This is most effective on old, hard broom and least effective on young, soft and actively growing broom. Avoid scalping the surface soil.

Root raking or **stick raking** with an excavator or bulldozer fitted with a root rake or stick rake. The aim is to pull bushes and larger roots out of the ground. This method results in less regrowth than dozing, but creates more soil disturbance and buries seed.

Mulching or **grooming** with a tractor or excavator-mounted mulcher, hammer mill, groomer or similar. This method cuts bushes off at ground level and processes them to fine mulch. The mulch provides some suppression of seedling growth. This method leaves a 'cleaner' site after control than some other mechanical methods. Excavator mounted groomers can be used to access creek banks and steep sites, but must be kept away from streambeds. Some operators have found that broom is too flexible for top down mulchers to be used effectively.

S. Cummings

Groomers can be used on weeds such as gorse and brooms

S. Welsh

Tractor-mounted mulcher

Crushing with a tractor-mounted 'Meri Crusher' or similar. This method breaks bushes, including the root crown, into pieces and incorporates broken material within the top 10 cm of the soil profile. With gorse, this method has resulted in less regrowth than other mechanical methods because the leaves and green stems are buried, however it can also lead to deep burial of seeds.

A. Laird

Meri Crusher

Slashing with roadside or grass slashing equipment can be used to reduce the height of broom. Slashing will not kill broom and broom subject to repeat slashing may flower and set seed at a height of only 10–15 cm. It may also develop an extensive root system. The reduced stem and leaf growth means that there may not be enough foliage surface area to absorb sufficient herbicide for effective follow-up spraying. Plants should be allowed to regrow to a height of around 1 m to avoid this problem. The deep mulch layer left after slashing broom may also limit effective herbicide coverage when spraying regrowth or seedlings.

With all mechanical removal methods that involve machinery, good hygiene to prevent seed spread is critical. See pages 47–56 in Section 3 for tips on simple hygiene procedures that can make a big difference!

Control methods

J. Gouldthorpe

Machinery hygiene – the blower is carried on slasher deck for cleaning in field

B. Jepson

Cultivation tractor with disc plough

Pulling with a tractor and chain or other tools (see page 67 for hand tool examples) is effective at reducing above ground biomass. Pulling should not be used where soil disturbance is unacceptable, such as in riparian or conservation areas.

Cultivation or **tillage** with disc or mouldboard ploughs is useful for breaking established roots and for follow-up treatment of seedlings and regrowth in large infestations. Due to the flexible nature of broom stems, cultivation of living, mature bushes can create a tangle of stems and may damage equipment. Cultivation as part of a cropping regime or for pasture maintenance is very effective at killing broom seedlings or promoting germination prior to other follow-up methods. While rarely used for broom control, many land managers believe that three to four years of cultivation and cropping will control gorse effectively on arable land, and the same may apply to broom.

Mechanical clearing

Timing	Suitability of method	Advantages	Disadvantages
Any time of year – but avoid when broom is in seed, as seed can spread on machinery.	**Plant age** – any, but may depend on type of machinery and method used **Habitat type** – pastures, fire-breaks, roadsides, flat and open country **Size of infestation** – large, dense infestations	▪ Can treat large plants across a large area ▪ Provides improved access for follow-up work ▪ No chemicals in initial works ▪ Reduced amount of herbicide needed for follow-up	▪ Soil disturbance and compaction from heavy machinery ▪ Plants may resprout ▪ May increase soil erosion ▪ Machinery may spread seed or bury seed into the soil ▪ Broom seeds may be buried deeper and remain dormant longer ▪ Can damage native plant regeneration potential ▪ Heavy machinery may damage tree roots ▪ Not appropriate for use in conservation areas

Chemical options

Chemicals (herbicides) can be a practical and efficient way of controlling brooms when used as part of an integrated management strategy. Seven herbicide application methods are currently registered and/or permitted for use on brooms (Note: these herbicides and their application methods are specific to each state/territory, and all label and permit directions and conditions should be followed).

Herbicide application methods are:

- cut-and-paint,
- basal barking,
- stem injection (drill-and-fill),
- scrape-and-paint,
- foliar spraying,
- splatter or gas gun, and
- aerial spot spraying.

The information below can assist you to use herbicides in a safe manner and in accordance with the relevant legislation. However, this information is only a guide and should be used in conjunction with advice from weed management professionals and applied following all relevant legislation and regulations.

Herbicide labels and legislation

Registration of all pesticides, including herbicides is controlled by the Australian Pesticides and Veterinary Medicines Authority (APVMA). In Australia, by law, only herbicides registered by the APVMA for broom control can be used on broom, and only in the manner specified on the label or permit (but for Victoria, see box page 74). Chemical use is regulated by relevant state or territory legislation, and by the relevant state or territory agencies.

Safe herbicide use is your responsibility

All herbicides come with a label, which is a legal document. You must read the label. You are breaking the law by using a herbicide in a manner other than that stated on the label, unless covered by an off-label permit (but see information on page 74 for Victoria).

The label tells you how to use the herbicide:

- safely,
- effectively, and
- in a way that reduces the risk of off-target impacts.

The same applies to off-label permits.

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 following the most updated information (www.apvma.gov.au). The PUBCRIS search engine for registered herbicides is also available at portal.apvma.gov.au/pubcris.

The APVMA also issues 'off-label' permits for herbicide applications that are not otherwise registered. A variety of off-label permits for broom control are held by government departments and individuals and can be used by other individuals or groups as directed in the permit. Current off-label permits (at the time of writing) relating to the use of herbicides for brooms are included in the table on pages 75–84 for each state/territory. See the APVMA website (portal.apvma.gov.au/permits) to search for current off-label permits relating to herbicide treatments for brooms in your state/territory and situation.

Be aware of legislation in your state/territory regarding herbicide use. For example, a written record of herbicide use may be required. In addition, some chemicals are restricted in certain states/territories or in specific areas of the state/territory, and you may require a licence or permit to use these chemicals

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 waterways, and all prohibitive statements (e.g. 'Do Not' statements) must be observed.

Safety and training

Personal protective equipment (PPE), 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 and/or licences may be required for people using herbicides as part of their job or business, and the requirements vary for each state. Training is recommended for community groups and may be required if working on public land. Training courses are run by registered training organisations (RTO) and Technical and Further Education (TAFE) colleges in each state/territory. Other training courses may be available through agencies (e.g. AusChem in Victoria, SMARTtrain in NSW and AgForce in Queensland), local councils or non-government organisations (see the 'Funding, organisational and training resources for volunteer groups' table in Section 7 on page 139).

Registered herbicides

The table on pages 75–84 lists the herbicides registered for use on brooms and the states/territories in which these registrations apply. Herbicides that are not registered for use on brooms 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 rates and methods.

M. Richards

Wearing personal protective equipment (PPE)

Choosing herbicides that can treat multiple weed species at one time may be beneficial. For information on which herbicide is most appropriate at your site, contact your local agronomist, weeds or biosecurity officer, or chemical reseller.

The active ingredients in herbicides currently registered for use on brooms are glyphosate, metsulfuron-methyl, fluroxypyr, picloram, aminopyralid and triclopyr; some of these are used in combination. The characteristics of the most

commonly used herbicides are described on pages 73–74.

This information does not imply any recommendation of a specific herbicide, and individual site and user requirements must be considered when choosing a herbicide.

In natural areas, both short- and long-term off-target damage should be considered and minimised. Non-selective herbicides, such as glyphosate, may have a risk of larger off-target damage in the short term, but have a low residual effect. Glyphosate is also available in formulations that can be used in aquatic situations, such as wetlands and riparian areas. Selective herbicides, such as those based on picloram and aminopyralid, can have lower immediate off-target damage but, due to their residual nature, may have delayed off-target impacts due to root uptake by adjacent plants.

Note: Herbicides in the pyridine carboxylic acid group, which include fluroxypyr, picloram, aminopyralid and triclopyr, can remain active in stock manure even after composting. Apply caution when using potentially affected stock manure as fertiliser.

These herbicides are moderately residual and can also remain active in the soil for an extended period. Some practitioners have reported severe impacts to the tree canopy in areas that have received several years of herbicide treatment due to uptake of these herbicides through tree roots. Alternating treatments between herbicide groups can minimise these impacts and also reduce the risk of herbicide resistance.

Glyphosate

Glyphosate is a non-selective herbicide used on grasses, broad-leaf and woody plants. It is absorbed through leaves and green stems and rapidly transported to actively growing parts of the plant. The herbicide interferes with the formation of amino acids that are essential for the growth of plant cells. The 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 (but markedly less so in sandy soils, as it binds only to the clay fraction). It is broken down in the soil by microbial activity. The average half-life of glyphosate in soil is 47 days, with a range 3–130 days, depending on temperature, soil moisture and soil type.

Metsulfuron-methyl

Metsulfuron-methyl is a broad-spectrum, selective herbicide for use on broad-leaf plants and some annual grasses. It is also effective on most geophytes (perennial plants that reproduce by buds on underground bulbs, tubers, or corms), including orchids. It is absorbed through the roots and leaves and moves rapidly through the plant, but can be slow acting. It inhibits an enzyme required for the production of amino acids necessary for plant cell division. The residual activity varies with soil type, soil pH and organic matter. High carbon levels in the soil following fires may reduce residual activity of metsulfuron-methyl. 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. Leaching of metsulfuron-methyl may be greater in alkaline soils and sands.

Picloram

Picloram is a selective herbicide for use on broad-leaf and woody plants. Grasses tolerate picloram at label rates. It is absorbed through roots, leaves and cut stems, and translocates throughout the

plant. Picloram affects the synthesis of proteins and disrupts plant cell growth. It is relatively slow-acting: signs of severe damage may take 2–3 months to show and total plant death up to six months after application. Picloram is residual and can persist in the soil for more than a year, and for up to two years within the plant. It does not bind strongly with soil: it is water-soluble and can move vertically and horizontally in the environment. The chemical can suppress seed germination and plant growth for some time after treatment. Picloram is degraded in soil and water mainly by microbial activity.

Triclopyr

Triclopyr is a selective herbicide used for control of woody weeds and broad-leaf plants, but does not affect conifers or grasses. It is absorbed through leaves or roots, and translocates throughout the plant. Triclopyr disrupts hormone balance and protein synthesis, resulting in abnormal plant growth followed by death. This herbicide breaks down in soil with a half-life of between 30 and 90 days, depending on soil type and environmental conditions.

Herbicides for use on brooms

The herbicides listed in the table below are currently (at the time of writing) permitted for use according to the relevant label or permit instructions. Before using any herbicide, always read the label or permit carefully. All herbicides must be applied strictly in accordance with the directions on the label and the conditions in the APVMA permit (but see box below for Victoria).

This table is only a guide. Do not rely solely on this table. You should only rely on current label or permit directions, so check the permit or label before application to ensure it is still valid. Commercial products listed here are examples only, and many other products containing these active ingredients may be registered, for example, visit portal.apvma.gov.au/permits. To search registered chemical products visit portal.apvma.gov.au/pubcris.

Herbicide use in Victoria

The use of some chemicals off-label is allowed without a permit in specific circumstances in Victoria, as explained in 'A guide to using agricultural chemicals in Victoria', which can be found at www.depi.vic.gov.au/agriculture-and-food/farm-management/chemical-use/publications/a-guide-to-using-agricultural-chemicals-in-victoria.

Herbicides for use on brooms

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
All states	High volume spraying	Triclopyr 600 g/L	Garlon 600	170 mL per 100 L	Agricultural non-crop areas, commercial and industrial areas, forests, pastures, and rights of way	*C. scoparius* *G. monspessulana* *G. linifolia*	As per label instructions	
	High volume spraying	Triclopyr 300 g/L + picloram 100 g/L	Grazon DS	250 mL per 100 L 350 mL per 100 L	Agricultural non-crop areas, commercial and industrial areas, forests, pastures, and rights of way	*C. scoparius* *G. monspessulana* *G. linifolia*	As per label instructions	Apply as a thorough foliage spray ▪ 250 mL per 100 L spring to mid-summer prior to pod formation ▪ 350 mL per 100 L autumn to winter
	High volume spraying	Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8 g/L	Grazon Extra	250 mL per 100 L 350 mL per 100 L	Agricultural non-crop areas, commercial and industrial areas, forests, pastures, and rights of way	*C. scoparius* *G. monspessulana* *G. linifolia*	As per label instructions	Apply as a thorough foliage spray ▪ 250 mL per 100 L spring to mid-summer prior to pod formation ▪ 350 mL per 100 L autumn to winter
	Cut-and-paint	Picloram 43 g/kg	Vigilant gel	Neat herbicide gel	Native vegetation, conservation areas, gullies, reserves and parks	*C. scoparius* *G. monspessulana* *G. linifolia*	As per label instructions	Cut stems horizontally and preferably no higher than 1 cm above ground level. Use and squeeze the brush bottle to apply a 3–5 mm thick layer of gel over the cut surface of the plant. In the case of multi-stem plants treat at least 80% of stems including all main stems.
	Foliar application: high volume (knapsack or handgun)	Glyphosate 360 g/L	Roundup Biactive	10–13 mL per 1 L	For general weed control in domestic areas (home gardens), commercial and industrial areas, public service areas, agricultural buildings and other farm situations, forests, pasture	*C. scoparius*	As per label instructions	Spray to wet foliage. When using the low rate add Pulse (2 mL/L spray solution) to improve coverage. At full leaf only the high rate can be used without Pulse.
New South Wales	Cut stump/ drill/ axe cut/ inject	Glyphosate 360 g/L	All registered products	Undiluted to 1 L per 6 L water	Urban bushland and forests, coastal reserves	*C. scoparius*	PER11916 expires 31/3/2020 Glyphosate and metsulfuron / Various weeds	Use higher rate for plants with stem diameter >5 cm

continued on page 76/...

Herbicides for use on brooms.../continued from page 75

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
New South Wales continued	Spot spray	Glyphosate 360 g/L	All registered products	Up to 1 L per 50 L water	Areas of native vegetation (e.g. subtropical rainforest remnants, littoral rainforest and other bush land reserves); Lands controlled by the Botanic Gardens Trust; Non cropland areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 Glyphosate, metsulfuron methyl and fluroxypyr / Areas of native vegetation and non crop areas / A range of environmental and noxious weeds	
	Cut stump, basal bark spray or cut/scrape and paint, drill, frill, axe or injection	Glyphosate 360 g/L	All registered products	1 L per 1.5 L water to undiluted herbicide	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Splatter gun	Glyphosate 360 g/L	All registered products	Rate of up to 1 L per 9 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Spot spray	Metsulfuron-methyl 600 g/kg	Brush-off plus other registered products	10–20 g per 100 L water plus surfactant	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Spot spray	Glyphosate 360 g/L and metsulfuron-methyl 600 g/kg	All registered products	Tank mix of up to 2 L glyphosate + 15 g metsulfuron methyl per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Cut-and-paint, stem injection	Glyphosate 360 g/L and metsulfuron-methyl 600 g/kg	All registered products	Tank mixes of 1: 1.5 glyphosate + 1 g metsulfuron-methyl per 1 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Spot spray	Glyphosate 835 g/kg + metsulfuron-methyl 10 g/kg	Trounce Brush-Pack Herbicide plus other registered products	173 g pack per 100 L water plus surfactant	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
New South Wales continued	Spot spray	Glyphosate 760.5 g/kg + metsulfuron-methyl 63.2 g/kg	Cut-out Brush Controller plus other registered products	95 g pack per 100 L water plus surfactant	Areas of native vegetation (e.g. subtropical rainforest remnants, littoral rainforest and other bush land reserves); Lands controlled by the Botanic Gardens Trust; Non cropland areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 Glyphosate, metsulfuron methyl and fluroxypyr / Areas of native vegetation and non crop areas / A range of environmental and noxious weeds	
	Spot spray	Fluroxypyr 333 g/L	Starane Advanced plus other registered products	300 mL to 600 ml per 100 L water; or 3–6 L per ha; or label rate for specific weed	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Basal bark spray	Fluroxypyr 333 g/L	Starane Advanced plus other registered products	21 mL per 1 L diesel/kerosene	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Spot spray	Fluroxypyr 200 g/L	Nufarm Comet 200 Herbicide plus other registered products	500 mL to 1 L per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Basal bark spray	Fluroxypyr 200 g/L	Nufarm Comet 200 Herbicide plus other registered products	35 mL per 1 L diesel/kerosene	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER9907 expires 31/3/2020 as above	
	Helicopter spot spray	Glyphosate 360 g/L	All registered products	1–1.3 L per 100 L water	Natural ecosystems (non-agricultural)	*C. scoparius*	PER12363 expires 31/12/2015 Glyphosate and metsulfuron methyl / Areas of native vegetation / A range of environmental and noxious weeds	Apply using helicopter mounted spot spraying equipment only. Spray to wet foliage. Surfactant approved for aquatic situation ONLY is used with lower rate otherwise use higher rate

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Herbicides for use on brooms.../continued from page 77

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Australian Capital Territory	Cut stump	Glyphosate 360 g/L	All registered products	Undiluted to diluted product at 1 L per 1 L to 1 L per 5 L water	Urban open space, national parks, reserves, non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 Glyphosate, metsulfuron, triclopyr and picloram / Various situations / Environmental weeds	Treat stump IMMEDIATELY after cutting. The higher cut-stump glyphosate concentration (1:1) is needed for brooms
	Cut stump and basal bark	Triclopyr 600 g/L	Garlon	Diluted at 1 L per 30 L diesel	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 as above	
	High volume spray	Metsulfuron-methyl 600 g/kg	Brush-off, Ally	10 g per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 as above	
	High volume spray	Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8 g/L	Grazon Extra	250 mL to 500 mL per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 as above	
		Triclopyr 600 g/L	Garlon	170 mL per 100 L water				
	Stem injection (Stem drilling)	Triclopyr 600 g/L	Garlon	Diluted at 1 L per 12 L diesel. 2 mL per drill hole	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 as above	Drill holes are to be spaced at 10 cm apart around the tree trunk
	Cut stump	Glyphosate 360 g/L	All registered products	Undiluted to diluted product at 1 L per 1 L to 1 L per 5 L water	Domestic (home garden)	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13420 expires 31/3/2017 as above	Treat stump IMMEDIATELY after cutting. The higher cut-stump glyphosate concentration (1:1) is needed for brooms

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Queensland	Drill, frill, axe or stem injection	Glyphosate 360 g/L	Roundup	Undiluted to 1 L per 2 L water at 1 mL per 2 cm of hole or cut	Non-agricultural areas, bushland, forests, wetlands, coastal and adjacent areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 Various products and chemicals / Non-Agricultural areas / Environmental weeds	
	Cut stump	Glyphosate 360 g/L	Roundup	Undiluted to 1 part product to 2 parts water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Paint stump immediately after cutting; or paint basal green bark and/or crown
	Spot spray	Metsulfuron-methyl 600 g/Kg	Brush-off, Ally	10 g per 100 L water plus wetting agent; or 100 g per ha plus wetting agent	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	
	Spot spray	Fluroxypyr 200 g/L	Starane 200	500 mL to 1 L per 100 L water; or 5 L to 10 L per ha; or label rate for specific weed	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	
	Basal bark spray	Fluroxypyr 200 g/L	Starane 200	35 mL per 1 L diesel/kerosene	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	
	High volume spray	Fluroxypyr 333 g/L	Starane Advanced	45 mL to 900 mL per 100 L water. Label rate for specific weed.	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Dilute with water as per label instructions
	Basal bark application	Fluroxypyr 333 g/L	Starane Advanced	900 mL to 3 L per 100 L diesel; or 6 mL undiluted per plant for specific weed application as per label; or label rate for specific weed.	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	As per label instructions
	Cut stump/ brush-cutter application	Fluroxypyr 333 g/L	Starane Advanced	900 mL to 3 L per 100 L diesel; or label rate for specific weed.	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	As per label instructions

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Herbicides for use on brooms.../continued from page 79

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Queensland	Low volume/ high concentrate drench or gas powered gun (splatter gun)	Fluroxypyr 333 g/L	Starane Advanced	300 mL to 600 mL per 10 L water; or label rate for specific weed	Non-agricultural areas, bushland, forests, wetlands, coastal and adjacent areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 Various products and chemicals / Non-Agricultural areas / Environmental weed	As per label instructions
	Spot spray	Triclopyr 200 g/L + picloram 100 g/L	Tordon Double Strength [DS] Herbicide	500 mL per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Spot spray where residual weed control is required away from waterways
	Drill, frill, axe or stem injection.	Triclopyr 200 g/L + picloram 100 g/L	Tordon Double Strength [DS] Herbicide	1 L per 4 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	
	Cut stump	Triclopyr 200 g/L + picloram 100 g/L	Tordon Double Strength [DS] Herbicide	50 mL per 1 L	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Cut stumps to less than 10 cm above the ground and immediately paint stump after cutting or spot spray cut stump
	Cut stump/ basal bark	Triclopyr 240 g/L + picloram 120 g/L	Access	1 L per 60 L diesel	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Either paint stump immediately after cutting or paint or spray basal bark
	Spot spray	Triclopyr 300 g/L + picloram 100 g/L	Grazon DS	350 mL to 500 mL per 100 L water plus wetting agent or spray oil; or label rate for specific weed	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Spot spraying where residual weed control is required
	Spot spray	Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8 g/L	Grazon Extra	350 mL to 500 mL per 100 L water plus wetting agent or spray oil; or label rate for specific weed	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER11463, expires 30/6/2015 as above	Spot spraying where residual weed control is required

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Western Australia	Spot spray	Glyphosate 360 g/L	Roundup Biactive	1 L per 100 L water; or 10 L per ha; or label rate for specific weed	Non-agricultural areas bushland and forests, wetlands, roadsides, industrial areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13333 expires 31/3/2017 Various products and chemicals / Non-Agricultural areas / Environmental Weeds	Spot spraying in dry land areas
	Cut stump	Glyphosate 360 g/L	Roundup Biactive	Undiluted to 1 L per 5 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13333 expires 31/3/2017 as above	Paint stump immediately after cutting or paint basal bark
	Drill, frill, axe or injection	Glyphosate 360 g/L	Roundup Biactive	2 mL per hole or cut	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13333 expires 31/3/2017 as above	
	Spot spray	Clopyralid 300 g/L	Lontrel	500 mL per 100 L water plus wetting agent; or 5 L per ha; or label rate for specific weed	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13333 expires 31/3/2017 as above	
	Cut stump/ basal bark	Triclopyr 240 g/L + picloram 120 g/L	Access	1 L per 60 L diesel	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13333 expires 31/3/2017 as above	Paint stump immediately after cutting or paint or spray basal bark
South Australia	Spot spray	Metsulfuron-methyl 600 g/kg	Brush-off	15 g per 100 L water + surfactant	Non-crop areas, rights of way, roadsides and easements, forest and conservation areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 Glyphosate and/or metsulfuron-methyl / Nature reserves and other native vegetation / Environmental weeds	
	Spot spray	Glyphosate 360 g/L and metsulfuron-methyl 600 g/ kg	Weedmaster Duo, Roundup Biactive, Brush-off	(Roundup 1 L + Brushoff 3 g) per 100 L water + surfactant	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Spot spray	Glyphosate 360 g/L and metsulfuron-methyl 600 g/ kg	Weedmaster Duo, Roundup Biactive, Brush-off	(Roundup 200 mL + Brushoff 10 g) per 100 L water + surfactant	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Spot spray	Glyphosate 360 g/L and metsulfuron-methyl 600 g/ kg	Weedmaster Duo, Roundup Biactive, Brush-off	(Roundup 1 L + Brushoff 10 g) per 100 L water + surfactant	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Cut stump	Glyphosate 360 g/L	Roundup, Roundup Biactive, Nufarm Weedmaster Duo	1 L per 1 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	

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Herbicides for use on brooms.../continued from page 81

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
South Australia continued	Stem injection by drill	Glyphosate 360 g/L	Roundup, Roundup Biactive, Nufarm Weedmaster Duo	1 L per 1 L water	Non-crop areas, rights of way, roadsides and easements, forest and conservation areas	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 Glyphosate and/or metsulfuron-methyl / Nature reserves and other native vegetation / Environmental weeds	
	Cut stump	Glyphosate 450 g/L	Roundup CT, Roundup ProBiactive 450	Undiluted	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Cut stump	Glyphosate 450 g/L	Roundup CT, Roundup ProBiactive 450	1 L per 1 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Stem injection by drill	Glyphosate 450 g/L	Roundup CT, Roundup ProBiactive 450	Undiluted	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Spot spray	Glyphosate 450 g/L	Roundup CT, Roundup ProBiactive 450	1 L per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13371 expires 31/3/2017 as above	
	Cut stump/ basal bark	Triclopyr 600 g/L	Garlon 600	1 L per 30 L diesel oil	Nature reserves and other native vegetation, roadsides, urban open space and forests	*C. scoparius* *G. monspessulana* *G. linifolia*	PER12932 expires 31/8/16 Triclopyr (Garlon 600) / Nature reserves and other native vegetation / Environmental weeds	
	High volume spot spray	Triclopyr 600 g/L	Garlon 600	170 mL per 100 L water	as above	*G. monspessulana*	PER12932 expires 31/8/16 as above	
Tasmania	Spot spray, knapsack	Glyphosate 360 g/L where product has an aquatic registration	Roundup Biactive	10–13 mL per 1 L plus adjuvants ONLY in accordance with label as required	Non-cropping and bushland (native vegetation both forested and non forest, including urban bushland reserves)	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 Various actives / Non-crop and bushland / Environmental weeds	Only those specific glyphosate products which have label approvals currently in place for aquatic use may be used in or near aquatic areas
	Drill, axe	Glyphosate 360 g/L where product has an aquatic registration	Roundup Biactive	Undiluted per hole/cut	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	as above

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Tasmania continued	Cut stump	Glyphosate 360 g/L where product has an aquatic registration	Roundup Biactive	1 L per 5 L water to undiluted. Trees and shrubs generally. Undiluted for blackberry, bulbs and hard to kill weeds	Non-cropping and bushland (native vegetation both forested and non forest, including urban bushland reserves)	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 Various actives / Non-crop and bushland / Environmental weeds	Only those specific glyphosate products which have label approvals currently in place for aquatic use may be used in or near aquatic areas
	Spot spray, knapsack, wiper	Glyphosate 540 g/L (where product has an aquatic registration)	Sickle	As per existing registrations or if weed not recorded on label: 7 mL per L plus adjuvants ONLY in accordance with label as required	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	as above
	Drill, axe	Glyphosate 540 g/L where product has an aquatic registration	Sickle	Undiluted per hole/cut	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	as above
	Cut stump	Glyphosate 540 g/L where product has an aquatic registration)	Sickle	1 L per 5 L water to undiluted. Trees and shrubs generally. Undiluted for blackberry, bulbs and hard to kill weeds	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	as above
	Cut-and-paint	Triclopyr 240 g/L + picloram 120 g/L	Access	As per existing registrations or if weed not recorded on label: 1 L per 60 L diesel	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	
	Spot spray, knapsack	Triclopyr 300 g/L + picloram 100 g/L	Grazon DS	At label rate or 250–350 mL per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	
	Spot spray, knapsack	Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8 g/L	Grazon Extra	At label rate or 250–350 mL per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	
	Spot spray, knapsack	Metsulfuron-methyl 600 g/kg	Brush-off	As per existing registrations or if weed not recorded on label: 10–15 g per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	

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Herbicides for use on brooms.../continued from page 83

	Application method	Active ingredient	Examples of commercial products	Rate	Situation as per label / permit	Species	Label / Permit (APVMA) requirements	Comments
Tasmania continued	Gas gun	Metsulfuron-methyl 600 g/kg	Brush-off	As per existing registrations or if weed not recorded on label: 1 g/L + Pulse penetrant (2 mL/L)	Non-cropping and bushland (native vegetation both forested and non forest, including urban bushland reserves)	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 Various actives / Non-crop and bushland / Environmental weeds	
	Spot spray, knapsack	Triclopyr 600 g/L	Garlon 600	As per existing registrations or if weed not recorded on label: 170 mL per 100 L water	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	
	Cut stump	Triclopyr 600 g/L	Garlon 600	At label rate or 1.25 L per 60 L diesel	as above	*C. scoparius* *G. monspessulana* *G. linifolia*	PER13160 expires 31/3/2017 as above	

Products may be registered for use on brooms in all states and territories (shown as 'All') or only in the specific states and territories listed.
Please note that this is not a full list of herbicides and applications for use on brooms. Seek further advice from APVMA or your local weed authority.

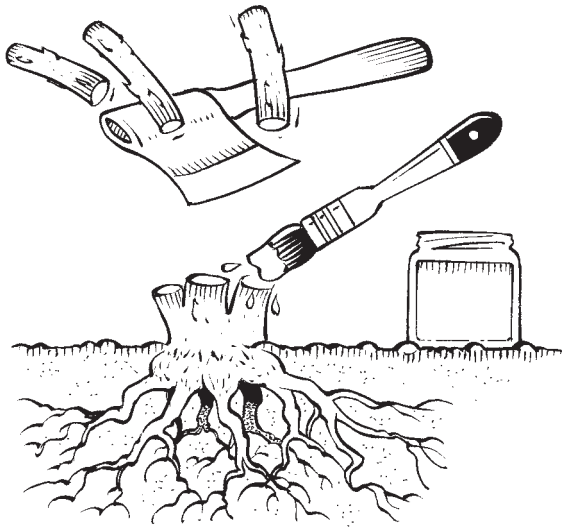
Stem treatments – chemical control

Cut-and-paint

Also known as 'cut stump' or 'cut-and-swab', the cut-and-paint technique involves cutting the plant stems off as close as possible to ground level and then immediately (within 15 seconds) applying herbicide to the stump. This can be used on any broom plant but is generally used where:

- plants are too large to hand pull,
- off-target damage from foliar spraying or mechanical removal is unacceptable, and/or
- soil disturbance needs to be minimised to prevent erosion and/or reduce germination of broom seedlings.

Cut-and-paint is an ideal technique for use in native vegetation and sensitive areas, as there is little chance of off-target herbicide damage if it is done correctly. It is a labour intensive technique but is relatively safe and simple to use.



P. Lennon

Cut-and-paint application

This control technique is the most likely to kill the plant on the first treatment. Glyphosate herbicides are the most commonly used for cut-and-paint, as they have few restrictions on their use and require less safety training, making them ideal for use by community groups.

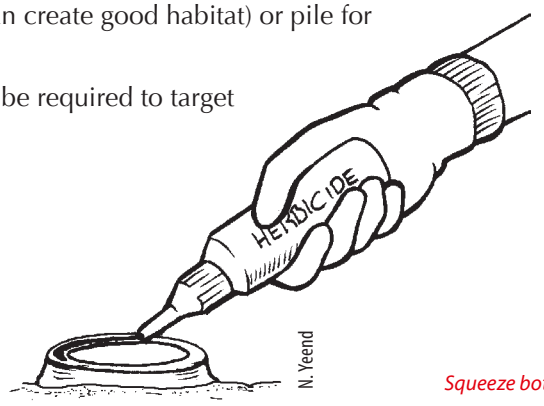
P. Tucker

Cut-and-paint technique is commonly used by community groups

Applying the method

- Cut through the stem horizontally as close to the ground as possible using a bush saw, secateurs, loppers, chainsaw or brush-cutter. A horizontal cut is important to prevent herbicide run-off.
- Immediately (within 15 seconds) apply herbicide to the cut surface of the stump. On large stems, apply the herbicide to the outer sapwood (cambium layer) only. Sapwood will transport the herbicide to the roots.
- Herbicide is most commonly applied using a squeeze bottle. A paint brush, or a sponge-tipped bottle (such as a shoe polish bottle) may be used, but these can get clogged very quickly. Atomiser spray bottles set on stream can also be used however some do not stand up well to continuous use. Some herbicide products come with a special sponge-tipped attachment.
- Leave plants on site to decay (small piles of dead broom can create good habitat) or pile for burning.
- Follow-up will be required to target seedlings.

Stumps cut too high are a trip hazard, and have the potential to resprout due to reduced herbicide translocation to roots. It is important to cut stumps as low as possible and parallel to the ground. The effectiveness of cut-and-paint is reduced the higher the stump is cut above the ground, and angled cuts can lead to herbicide run-off.



N. Yeend

P. Tucker

Squeeze bottles can be used to apply herbicide to cut stems

Cut-and-paint

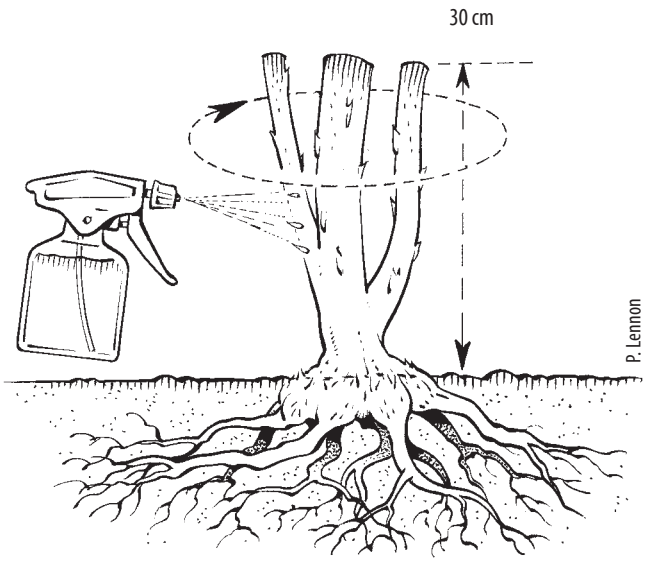
Timing	Suitability of method	Advantages	Disadvantages
Any time of the year (weather permitting), as long as broom plants are actively growing, so that herbicide is rapidly transported to the roots. Also refer to label directions for specific herbicides.	**Plant age** – all plants with hard stems; useful for plants that are too large to hand pull **Habitat type** – any; ideal for use in conservation areas 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	▪ High certainty of plant kill if applied correctly ▪ Selective (i.e. only broom is controlled) ▪ No soil disturbance ▪ Improved safety for operators; very suitable for volunteers ▪ Limited, or no off-target damage (no drift) ▪ Increased ability to recognise treated or untreated plants, so unlikely to treat twice or miss plants ▪ Small quantities of herbicide used ▪ Ideal when working in high-quality vegetation	▪ Labour intensive ▪ Time consuming when dealing with large infestations ▪ May need to dispose of broom waste material (especially if presenting a fire hazard) ▪ May require training ▪ Not applicable in some situations (e.g. on steep slopes or near cliffs without trained personnel)

Basal barking

This method involves applying herbicide mixed with an adjuvant such as diesel or kerosene to the lower trunk or stem of woody plants. The adjuvant helps move the herbicide through the bark and into the cambium, allowing the herbicide to enter the root system.

Applying the method

- Spray or paint the whole circumference of the stem or trunk with herbicide solution from ground level to a height of 30 cm.
- The herbicide solution is best applied using a hand held pump sprayer, as it avoids the need to bend over. The pump also does not get as dirty as a paint brush, and there is less chance of spilling the herbicide. The sprayer need not be pressurised as the herbicide will gravity feed from the spray nozzle. If pressurised, use low pressure to reduce splashing and off-target damage.



Basal bark application

The Nature Conservancy in Nebraska has developed a tool called a kill stick, similar to a weed wand, which can be used for basal barking. Detailed instructions on making and using a kill stick can be found at prairienebraska.org and click on downloadable guides.

Basal barking

Timing	Suitability of method	Advantages	Disadvantages
Any time of the year (weather permitting), and when broom is actively growing so that herbicide is rapidly transported to the roots and foliage. Do not apply when the bark is wet, as it will repel the herbicide and adjuvant mix.	**Plant age** – all plants with woody stems **up to** approximately 10 cm in diameter (but check label or permit directions); useful for plants that are too large to hand pull **Habitat type** – any, though consider the potential for contamination of soil from run-off **Size of infestation** – isolated infestations, scattered plants or infestations that cover a small area	▪ High kill rate ▪ Selective (i.e. only broom is controlled) ▪ No soil disturbance ▪ Gradual defoliation of the plant *in situ* may offer habitat or cover for native species ▪ Suitable for targeted control over a small area, when other methods are unacceptable (e.g. around threatened species) ▪ No waste material to remove ▪ Possible reduced germination of broom seedlings due to minimal disturbance	▪ Labour intensive ▪ Time consuming when dealing with large infestations ▪ Difficult to apply when plants are densely clustered, or when plants have numerous stems ▪ Dead broom vegetation remains *in situ* which may become a fire hazard ▪ May require training

Stem injection

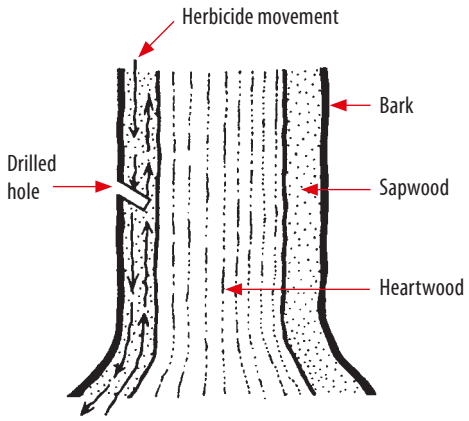
Also called 'drill-and-fill', stem injection delivers herbicide directly to the sapwood. It is rarely used on brooms, but could be an effective technique if appropriate to the situation or if operators are already using this technique on other woody weeds in the vicinity (such as willows in riparian areas). This method is most appropriate in well-established, large broom infestations, as it is only applicable to mature plants (with stems over 5 cm in circumference).

Note that trials on white weeping broom (*Retama raetam*, see page 29) in Western Australia using 50% glyphosate only achieved 50% plant mortality 12 months after treatment (Bettink and Brown 2011). Thus, small-scale trials in your local area with specific broom species may be useful before applying this method on a large scale.

Applying the method

For use on plants with stems over 5 cm in circumference.

- 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 (just under the surface of the bark; approximately 5 mm depending on stem size) as the heartwood (inner) layer will not transport herbicide around the plant. Drill holes at a 45 degree angle (downwards) to aid herbicide retention by creating a reservoir. This will increase opportunity for herbicide uptake by the plant and reduce run-off.
- Alternatively, a chisel and hammer, a tomahawk or machete can be used to make 45 degree angled incisions down into the sapwood. 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 mixture can contaminate the environment. Using a drill to make the holes will minimise spillage. Drills are also more manoeuvrable in dense infestations, where it can be difficult to swing a mallet or axe. Injection guns are also available that can drill the hole and deliver a precise amount of herbicide at the same time.



Stem injection

Timing	Suitability of method	Advantages	Disadvantages
Any time of the year (weather permitting). Most effective when broom is actively growing so that herbicide is rapidly transported to the roots.	**Plant age** – mature plants with woody stems over 5 cm in circumference **Habitat type** – any; particularly useful for remote and hard to access areas as tools and amount of herbicide are minimal and easy to carry **Size of infestation** – isolated infestations, scattered plants or infestations that cover a small area	▪ High kill rate ▪ Selective (i.e. only broom is controlled) ▪ No soil disturbance ▪ Gradual defoliation of the plant *in situ* may offer habitat or cover for native species ▪ Suitable for targeted control over a small area, when other methods are unacceptable (e.g. around threatened species) ▪ No waste material to remove ▪ Possible reduced germination of broom seedlings due to minimal disturbance	▪ Labour intensive ▪ Time consuming when dealing with large infestations ▪ Difficult to apply when plants are densely clustered, or when plants have numerous stems ▪ Dead broom vegetation remains *in situ* which may become a fire hazard ▪ May require training

Scrape-and-paint

This method involves scraping away a small section of the bark and applying herbicide directly onto the sapwood. It is an effective, but rarely used technique for broom control.

Applying the method

- Using a knife, chisel or sharp axe, scrape a 15 cm long length of bark off the base of the main trunk, running vertically along the trunk and getting as close to the ground as possible. 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 are useful to show treated plants.
- Depending on the diameter of the stem, multiple scrapes may be required around the circumference of the stem.
- Place each scrape a few centimetres apart to ensure maximum herbicide uptake without ringbarking (removing a complete ring of bark and conductive tissue from the stem, which prevents herbicide transport to stems and roots).

S. Booth

Scrape-and-paint involves removing the outer bark from the base of the main trunk and immediately applying herbicide

Scrape-and-paint

Timing	Suitability of method	Advantages	Disadvantages
Any time of the year (weather permitting). Most effective when broom is actively growing so that herbicide is rapidly transported to the foliage and roots.	**Plant age** – saplings or mature plants with woody stems **Habitat type** – any, access permitting **Size of infestation** – isolated infestations, scattered plants that cover a small area	▪ Moderate to high kill rate ▪ Selective (i.e. only broom is controlled) ▪ No soil disturbance ▪ 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 provide some continued cover or habitat for native species ▪ Good for use in remote areas (limited tools or herbicide needed)	▪ Labour intensive ▪ Uses more herbicide with a lower kill rate when compared to cut-and-paint or stem injection ▪ Time consuming when dealing with large infestations ▪ Difficult to apply when plants are densely clustered, or when plants are multi-stemmed; may be hard to access stems of plants in dense infestations ▪ Dead broom vegetation remains *in situ* which may become a fire hazard ▪ May require training

Foliar treatments – chemical control

Foliar spraying

Foliar spraying is the application of herbicide solution to weed foliage in the form of a fine spray. A range of other chemicals may also be added (e.g. penetrants, adjuvants, surfactants, wetting agents). The application rate, volume and concentration of herbicide vary with the application technique used.

Foliar spraying can be used to treat plants of all ages, but can be less effective on older plants. It is especially effective for treatment of dense 'carpets' of broom seedlings because large areas can be treated quickly. Foliar spraying is useful for treating infestations in steep terrain where erosion is an issue. It is also practical when few workers are available, because it can be done relatively quickly by one person. 'Spot spraying' refers to the foliar spraying of individual plants or clumps of plants, and is used on small infestations or isolated plants.

No broom-selective herbicide currently exists, so care needs to be taken not to damage desirable vegetation by off-target spraying, over-spraying or spray drift. Desirable vegetation includes both native vegetation and that on productive lands. Herbicides commonly used for foliar spraying of brooms include glyphosate, triclopyr and triclopyr/picloram based products. Triclopyr and picloram based products are considered more selective than glyphosate as, while they can damage many broadleaf species, they are generally tolerated by grasses.

There are several techniques available, including back-pack and vehicle-mounted sprayers, splatter guns and aerial spot spraying. The technique selected will depend on:

- the size of the infestation,
- site access and specifications,

D. Stock

Hand held spray equipment, such as a splatter gun, is useful for small infestations

- habitat (e.g. native vegetation, pasture, roadside),
- access to equipment and chemicals, and
- the availability of resources, including trained staff and contractors.

Applying the method

Foliar spraying of broom is usually done using a spray gun and backpack or vehicle-based spray unit (see later in this section for splatter gun and aerial spot spray applications). Spray units connected to

B. Rayner

Vehicle-mounted spray rig suitable for high volume spraying

a tank and pump mounted on a vehicle are very useful when treating large areas, but are restricted by vehicle access.

- Back-pack/knapsack/hand held pump spraying – for low pressure spraying using a low concentration of herbicide and high volume of liquid (e.g. 1:100 for glyphosate 360 g/L). This can be used for spot spraying large or small infestations.
- Vehicle-mounted spray rigs – for high pressure, high volume spraying using a hose with a hand-gun. A low concentration of herbicide and high volume of liquid is sprayed on broom over larger areas accessible by vehicles. A small boom attachment is useful for spraying a dense cover of seedlings. The registered application volumes and rates are the same as for knapsack foliar spraying.

Successful control requires plants to be free from salt-spray, water, dust or other vegetation (e.g. vines). Plants must be sprayed thoroughly, wetting all foliage to the point of run-off. Plants that are not completely covered or that are under stress will often survive. Surviving plants may take more than 12 months before they reshoot, so treated areas should be inspected annually.

Foliar spraying

Timing	Suitability of method	Advantages	Disadvantages
Use this technique when broom plants are actively growing, and not stressed by hot, dry, cold, wet or other extreme conditions. Herbicide is most readily absorbed through the leaves during periods of active growth. Herbicides can also be absorbed by photosynthetic stems, but less so than the leaves. For this reason, Scotch broom can be harder to kill using foliar sprays when it has lost its leaves. Spraying when Scotch broom has very few leaves can cause more off-target damage than normal, as less herbicide is retained on the plant. Treatments should ideally be scheduled for autumn or early winter. A second treatment for missed plants should be applied later in winter or spring when plants are in flower, to prevent seed set. Scattered plants are also easier to locate and identify when flowering. **When to spray to avoid spray drift?** Before you spray with herbicides, it is important to understand the best weather conditions for spraying and to take steps to avoid spray drift. Check your state/territory weed management agency website for information on spray drift specific to each jurisdiction. Useful information can also be found on the APVMA website www.apvma.gov.au/use_safely/spray_drift.	**Plant age** – all plants, but can be less effective on older plants **Habitat type** – any except where prohibited by legislation; caution is needed around water and high value vegetation **Size of infestation** – the area treated should be matched to the appropriate 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. on a quad bike or tractor). Do not treat large areas unless resources are available for follow-up control ***Protecting native species*** *Make sure you thoroughly check the area for native plants prior to spraying, particularly for threatened or at-risk species. If native plants occur in the area to be sprayed, clear an area (buffer) of broom away from native plants using hand weeding 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. Although this may protect native plants when spraying, please refer to the herbicide label for any soil residual impacts. In these cases, leaving a buffer around certain native species may be more appropriate.*	▪ Large areas can be treated quickly. ▪ Not labour intensive; can be done by one person. ▪ Cost effective. ▪ Can be used in steep or erosion prone areas. ▪ No soil disturbance, as plants are left to die *in situ*	▪ Risk of off-target damage ▪ Kill rates can be variable ▪ Cost of spray equipment and herbicide ▪ Weather conditions and site location (e.g. near water) limit when it can be used ▪ May require training ▪ Herbicide can be washed off by rainfall; check forecast before spraying ▪ Double-spraying or off-target spraying may occur if marker dye is not used ▪ Limitations 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)

OEH

Vehicle based Quick Spray® unit

OEH

Broom control in the alpine area of Kosciuszko National Park – red dye is evident. Use dye in the herbicide mixture to indicate coverage

Best practice spraying

Remember these points when spraying herbicides on broom to get the best results:

1. **Follow the label or permit directions and read the critical comments section.**
2. **Complete coverage of foliage is essential.**
3. **Only use a wetting agent/penetrant/adjuvant/surfactant as directed by the label.**
4. **Only spray actively growing broom plants.**
5. **Regrowth of cleared or previously sprayed plants (not seedling growth) should be at least 40 cm tall – and preferably around 1 m tall – before spraying.**
6. **Leave sprayed broom plants undisturbed for at least 12 months after treatment.**
7. **Use clean water. 'If you wouldn't drink it, don't use it'. Water quality can mean the difference between a poor result and a total kill. Trucking clean water to a site may actually save money.**
8. **Do not spray stressed broom plants (during extremes of heat, cold and/or drought).**
9. **Calibrate spraying equipment and clean and replace nozzles/jets regularly. Worn nozzles or poor calibration can deliver four to 20 times the required amount of herbicide. This increases herbicide costs and increases the chances of off-target damage.**
10. **Spray in suitable weather and at the most appropriate time of day. Labels can provide guidance or ask an expert. Avoid wet, very cold, very hot or windy weather. Spraying in these conditions reduces effectiveness and/or increases off-target damage.**
11. **Use dye in the herbicide mixture to indicate coverage.**

Splatter gun (or gas gun)

Splatter guns were developed over thirty years ago for sheep drenching. They have recently been adapted for weed spraying and are proving increasingly useful in the treatment of weeds such as lantana, blackberry, pampas grass and bitou bush. The splatter gun (or gas gun) control technique uses a pressurised gun to deliver a low volume, high concentration application of herbicide to broom foliage. The splatter gun administers large droplets of herbicide solution in one direct stream, and thus is used with more concentrated herbicide solutions than other foliar applications. This application technique uses a much lower volume of spray mixture than standard foliar spraying and the larger droplets are less likely to drift. Due to the high concentration, complete coverage of all foliage is not required.

This technique is particularly useful in areas that are difficult to access or have sensitive vegetation because the tool is easily portable and targeted application in one direct stream causes limited off-target damage. Splatter gun application can also be less expensive than traditional foliar spray methods, as it uses less herbicide. While splatter guns are not commonly used on brooms, they may be effective for mature broom control, particularly for *Genista* spp. They are not recommended for use on seedlings or immature plants, or for leafless Scotch broom.

Applying the method

Splatter guns are usually used with a small backpack spray unit and may be hand or gas powered (gas gun). While there are no herbicides currently registered for splatter gun application on brooms, New South Wales, Queensland and Tasmania have off-label permits for using splatter or gas guns that may be applicable for use on brooms (see table on pages 75–84).

Splatter gun spraying involves applying a low volume of concentrated herbicide mix to small portions of foliage. Because the herbicide is so concentrated, it is only applied in a few 'strips' (or squirt lines) to limited areas of total plant leaf cover (e.g. approximately 16 mL of mixed herbicide in total for a 2 m bush). The following recommendations have been adapted from the lantana control manual and provide a guide for use on brooms. **This method should only be used when broom plants have a dense cover of leaves.**

H. Cherry

Splatter gun equipment

M. Winkler

Hand powered splatter gun equipment

M. Winkler

M. Winkler

Gas powered splatter gun equipment

- To apply the herbicide, angle the spray gun at 45 degrees (to the ground) and arc the stream of herbicide over the top of the bush and down the front face.
- If treating dense thickets of broom, apply one vertical spray line every two strides, with an occasional horizontal pass low across the front edge of the bushes to treat any low growth.
- Ensure you only apply the recommended volume of herbicide (for glyphosate 360 g/L that is two squirt lines of 2 mL chemical mix per half meter of plant height ~ approximately 16 mL of mixed herbicide in total for a 2 m bush).
- It is vital with this technique that you do not spray to the point of run-off as you would with conventional foliar spray techniques. Application of too much chemical at this concentration will put the plant into shock and inhibit herbicide uptake.
- Always use clean water for mixing and cleaning as dirty/heavy water can bind the herbicide and dramatically reduce the kill rate.
- A specialised nozzle that produces large droplets of herbicide mix must be used to achieve the desired low volume, high concentration application. A fine spray or mist will not be effective.
- The commercial gas powered devices enable the application of a stream of herbicide from a distance of 6–10 m allowing the delivery of herbicide from an elevated position into gullies or hard to reach areas.
- The splatter gun technique does not work well on spindly or thin bushes as it is difficult to apply the total volume of required herbicide to the leaves in this situation.
- Apply only to actively growing plants with full foliage and ensure leaves are not wet from rain or dew.
- A marker dye is recommended to identify splattered bushes.
- Manual drench guns or gas powered guns are commercially available. The gas powered option will allow a longer day's work compared to the manual option but costs more to buy and operate.
- Follow-up treatments are critical to control seedlings and/or regrowth.

Splatter gun

Timing	Suitability of method	Advantages	Disadvantages
As with foliar spraying, this technique must be used when broom is actively growing (and the plants are not stressed by extreme conditions) so that the herbicide is taken up by the plant. The best times to spray are typically before 10 am and after 3 pm, when there is reduced evaporation and the plant will be more susceptible to herbicides (but check the label or permit). Splatter gun application should be avoided on windy days or when rain is forecast.	**Plant age** – medium to large plants; not suitable for seedlings or plants with limited leaf area **Habitat type** – any; particularly useful in dense infestations that are difficult to access with vehicles, or on steep slopes and cliffs **Size of infestation** – heavy infestations or dense, scattered clumps	▪ Large areas can be treated quickly ▪ Cost effective and equipment costs are relatively low ▪ Easy to operate and useful in steep terrain, erosion prone areas, and remote and difficult to access areas ▪ Minimal soil disturbance ▪ Can treat plants long distances (up to 10 m) away ▪ Splatter gun herbicide mix requires minimal water, and thus is easier to transport in a backpack and will allow more plants to be treated	▪ Not trialled comprehensively on brooms ▪ Not effective for Scotch broom when leaves are absent ▪ Off-target damage can be amplified due to high concentration of herbicide ▪ Cost may be prohibitive for large infestations ▪ Cannot be used in wet weather ▪ May require training

Aerial spot spraying in New South Wales

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

Aerial spot spraying is only currently permitted for use in NSW with glyphosate on Scotch broom, and requires a specially trained pilot. For more information on this technique, see the Bitou Bush Management Manual at www.weeds.org.au/wons/bitoubush and/or the 'Best practice guidelines for aerial spraying of bitou bush in New South Wales' (www.environment.nsw.gov.au/resources/pestsweeds/bestPracticeAerialSprayGuidelines.pdf).

Many aspects from the bitou bush aerial spraying guidelines will apply to brooms (e.g. techniques, notifications, helipads, limiting public access, etc.). Follow-up will be required to target recruitment of broom seedlings which may require repeated aerial or ground-based herbicide applications.

OEH

Fire and grazing

Fire

Fire, as a control technique, can only be employed successfully in broom infestations as part of a holistic and integrated management program. While fire can kill broom plants, it will also stimulate a mass germination of broom seeds and can create a worse situation if follow-up control measures are not taken. Herbicide or mechanical control of broom may be required prior to burning to ensure the fire burns appropriately (i.e. broom plants are dry enough to carry fire). For more information on managing broom with fire see Section 3 page 57.

Grazing

Stock availability, adequate fencing and the establishment of strong pasture grasses are the keys to using grazing to improve broom management. These methods should always be used as part of an integrated approach with other control methods and pasture management techniques.

Livestock such as goats, sheep and cattle will graze brooms, and can be used to manage broom in pastures. While toxic alkaloids are known to occur in broom, there are no known records of livestock poisoning. Goats are more effective at controlling mature stands of broom than sheep and cattle, which only graze on small plants up to head height. Broom plants that are suppressed by continual grazing over several years will eventually develop a large root system, with relatively small biomass above ground. At this point, growth rates can then quickly exceed the rates of grazing by sheep and cattle, and plants may escape grazing to flower and set seed. Broom plants that are along fences or are outside the paddock will not be grazed and will need another form of control.

To learn more about how primary producers James and Mandy O'Brien have managed large-scale Scotch broom infestations in their pastures since the 1970s, see Case Study 4 on page 126.

Biological control

Weed biological control (biocontrol) has been successfully used as part of integrated weed management in Australia for over 100 years. The agents used in biocontrol programs include insects such as psyllids, moths and beetles, as well as mites and pathogens, such as rust fungi. They are selected through a rigorous process, using internationally recognised protocols, formal government approvals and risk assessment processes. The agents are sourced from the home range of the weeds, in the case of brooms, from Europe and North Africa. Once an agent is selected, it undergoes rigorous host specificity testing to ensure there is no risk of non-target impacts to native species.

Biocontrol has the potential to be a cost effective way of suppressing large infestations of broom. In Europe, brooms host many natural enemies that are not present in Australia. These natural enemies make brooms significantly less vigorous in their home range than in Australia. The selection and introduction of some of these highly specific natural enemies for use as biocontrol agents has the potential to limit broom spread and reduce their ability to dominate Australian landscapes.

In Australia, biocontrol programs began for Scotch broom in 1989 and for Montpellier broom in 1999, led by the CSIRO (Commonwealth Scientific and Industrial Research Organisation) and state government agencies, in collaboration with New

Parks Victoria

Gall mite monitoring

Zealand and the USA. To date, four agents have been tested and released for Scotch broom, and one for Montpellier broom. Only one of the Scotch broom agents (the broom gall mite) is showing clear levels of impact and so is being actively distributed. The one agent for Montpellier broom (the Cape broom psyllid) is also being distributed to sites around south-eastern Australia in order to maximise agent effectiveness. Although flax leaf broom is an approved candidate for biological control in Australia, no agents have yet been tested.

There are also a number of exotic pathogens and accidentally introduced insects that damage brooms to varying degrees. Detailed information on the history and research of broom biocontrol agents can be found in the Biological Control of Weeds in Australia (Julien *et al.* 2012).

Management note:
Biological control takes many years and must be integrated with other management techniques to control infestations.

Research and Action in Partnership:
The Atlas of Living Australia Weed Biological Control website gets everyone involved

A new national website for information on the locations, availability and redistribution of weed biocontrol agents can be found at root.ala.org.au/bdrs-core/wbiocont/home.htm or simply enter 'weed biological control ALA' into an internet search engine. This Atlas of Living Australia (ALA) based website provides a single location to 1) find out what agents are available for major weeds (including brooms), 2) find places to source agents for redistribution, and 3) document releases of biocontrol agents for some of Australia's most damaging weeds. It is a key online resource for researchers, the public, or anyone who wants to assist biocontrol efforts in their region. Check it out today and get involved!

Broom biological control agents in Australia

Key agents for broom in Australia

Cape broom psyllid (*Arytinnis hakani*)
Target: Montpellier (Cape) broom
Currently in NSW, SA, Vic, Tas

Description The Cape broom psyllid is a small, sap sucking insect that can complete four to five generations in a year. Adults are approximately 2–3 mm long, and are green with clear wings that make them highly mobile. Up to 200 eggs per female are laid in fresh leaves and buds. Eggs are laid in the growing terminal and are very difficult to detect with the naked eye. The five nymph stages vary in size from 1 mm to just over 2 mm depending on the growth stage. The nymphs are wingless but can be quite mobile on the plant. The colour of the nymphs varies from orange in the early stages to bright green in the later stages. Psyllids are generally found in the growing tips of Montpellier broom and their presence can be indicated by white deposits that look like sugar crystals. Psyllid numbers decline during hot dry summer months and over winter. During this time they are usually found as nymphs or adults sheltering in young shoots.

Impacts The Cape broom psyllid feeds on the sap of the host plant, reducing plant health, vigour and seed set. Plant damage can be severe in Australia,

P. Crisp

Cape broom psyllid nymph

P. Crisp

Cape broom psyllid adult

P. Sullivan

Montpellier broom killed by Cape broom psyllid, Captains Flat, NSW

A. Sheppard

Cape broom psyllid impacts in New Zealand

with large sections of plants dying back, and occasionally resulting in complete plant death. This contrasts with the native range, where these levels of damage have not been observed.

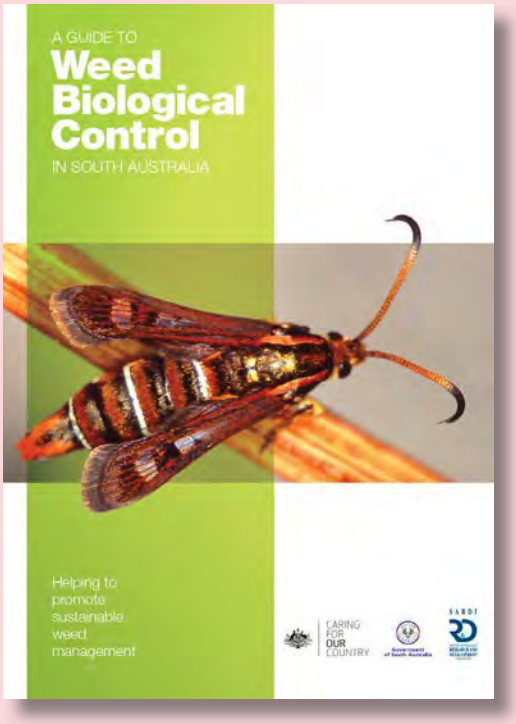
Redistribution The Cape broom psyllid can easily be redistributed from sites where it has formed well-established populations. To locate the psyllids, look for the white, sugary crystals in growing tips of plants and check broom plants for the small green insects. Adult psyllids can be easily located by lightly beating or shaking the foliage over a tray or any other suitable receptacle and looking for green winged adults. Cape broom psyllids can be collected by pruning off infested branches. These should then be placed in a suitable container for transport, such as a plastic food container that should be placed in a cooler. The release should be made within 24 hours of collection. This is done by tying the psyllid-infested branches to the branches and foliage of broom plants at the new sites. The psyllids will move on to the new plants to establish new colonies. This can be done at any time of the year when broom is actively growing, but hot, dry summer weather should be avoided as the adults and nymphs are very sensitive to temperatures over 26°C.

S. Ivory

Cape broom psyllid nymphs – note sugary residue

A GUIDE TO WEED BIOLOGICAL CONTROL IN SOUTH AUSTRALIA

This excellent guide contains more photos and information on the key broom biological control agents, as well as other significant weed biological control agents in Australia (e.g. for gorse, blackberry, St John's wort and other weeds). It has in-depth information on how to collect and redistribute agents, as well as how to monitor their establishment and success. The Guide can be found at: www.sardi.sa.gov.au/pestsdiseases/publications.



Broom gall mite (*Aceria genistae*)
Target: Scotch broom
Currently in NSW, Vic, SA and Tas

Description The broom gall mite is a microscopic mite that lives in colonies within galls established on the stem buds of Scotch broom. The mites themselves are less than a quarter of a millimetre in length making them best viewed under a microscope. The galls are much more distinctive, being an abnormal, rounded and hairy growth up to 1 cm in diameter on stem buds. One gall can contain hundreds of mites. The galls also attract other small insects and larger predatory mites. Female mites will lay eggs in the gall, or will leave the gall to find new stem buds on the same plant. They can also move to other plants on the wind. The broom gall mite has four stages to its life cycle, and there can be several overlapping mite generations in a gall over spring and summer. At the end of summer and in autumn, the galls dry out and the mites crawl to dormant stem buds where they spend the winter.

Impacts The mites suck sap from the plant and trigger the growth of galls. These galls limit the allocation of resources to normal plant growth and reduce plant health and vigour. As galls form on successive years of stem growth, they can induce stunting, reduced flowering and even plant death.

Redistribution Plants infected with the broom gall mite are distinguished by the presence of furry galls on the stems. In late summer, autumn or spring, branches infested with galls can be cut and tied to the branches of broom plants at new sites. When being transported, the branches should be kept cool by placing them in a cooler. The release should take place within 24 hours of collection. As the transported gall and branches dry out, the mites will emerge and colonise the buds of the live plants. A minimum of 50 galls should be collected and released to enable mite establishment at the new site.

Other broom agents in Australia

Broom seed bruchid (*Bruchidius villosus*)
Target: Scotch broom, but will attack other broom weeds
Currently in NSW, Vic and SA

The broom seed bruchid is a small black beetle that eats pollen and lays its eggs on the developing seed pods of brooms. While the introduced population


Parks Victoria


Parks Victoria

Galls on Scotch broom stems


Parks Victoria

Gall mite monitoring

was sourced from Scotch broom, the beetle can feed in the pods of other broom weeds, including Montpellier broom. The adults are around 2–4 mm in length with clubbed antennae. The beetle larvae feed on the developing seeds. They pupate within the outer shell of the seed and are expelled with the seed itself, overwintering in the seed husk. Adults emerge from the leaf litter in late winter and spring and congregate around early flowers for feeding and mating. In late summer and autumn, mature beetles may be found sheltering in seed pods. In New Zealand, this agent is reported to have seed predation rates of over 80% at some sites. In Australia, there are currently no redistribution programs being conducted as, since its release in Australia, the beetle has been found to feed on the pods of tagasaste (a fodder crop) in New Zealand. The beetle has established at several sites in NSW, Victoria and South Australia and appears to be spreading.

Broom twig mining moth (*Leucoptera spartifoliella*)
Target: Scotch broom
Currently present (but in decline) in SA, Tas, Vic, NSW

The broom twig mining moth is a small silvery white moth whose larvae burrow along stems of previous years' growth of Scotch broom plants. The adults are 2–4 mm long with a small dark, silver patch and fringing on the end of each forewing. Over summer, moths lay around 100 eggs in the furrow of broom stems. Upon hatching, the larvae bore into the stem where they live and feed until they pupate in the spring. During development, the larvae may burrow through a 30–50 cm length of stem. In mid to late spring, the larvae emerge and form cocoons made of silk where they pupate for a month. The cocoon stage is the most easily detected of any of the life stages of the twig mining moth, as they are exposed on the lower branches. Broom plants heavily infested with twig mining moth larvae will have considerable areas of dead wood, stunted growth and reduced flowering. In Australia, recent surveys indicate that numbers of twig mining moths may be declining at release sites. Research suggests that this agent will not provide effective suppression of broom.

Scotch broom psyllid (*Arytainilla spartiophila*)
Target: Scotch broom
Currently not established in Australia

The Scotch broom psyllid is similar to the Cape broom psyllid but the adults are light brown to light red brown in colour and have only one generation per year. The psyllid sucks plant sap, and in Europe can occur in large populations that cause significant plant damage. Several releases of the Scotch broom psyllid were made in Australia from 1999. However, recent surveys of release sites have failed to locate any surviving populations. It is possible that another concerted effort to import and release this agent could be successful. However, with only one generation a year, this psyllid is unlikely to be as effective as the Cape broom psyllid.

Other insects and diseases found to damage Scotch brooms
There are a number of other enemies of Scotch broom present in Australia that are either native or were not deliberately introduced. These include:

- *Parthenolecanium rufulum* – a scale insect at the Barrington Tops and in southern NSW which sucks sap and has been credited with a 33% reduction in broom seed production in some years.
- *Etiella behrii* (lucerne seed-web moth) – a native moth in southern NSW, the larvae of which eats broom seeds. This can be a pest of lentils so should not be redistributed.
- Cerambycid beetles – borers found in southern NSW, the larvae of which can cause stem girdling, particularly in older mature plants.
- *Uromyces pisi-sativi* – a rust fungus first discovered in Canberra in 2003 but was subsequently found to be widespread throughout the distribution of Scotch broom in Australia.

Section 5

Follow-up, restoration and monitoring

Follow-up, restoration and monitoring

Follow-up weeding, maintenance, restoration and monitoring are critical to the success of weed management efforts. Provision for these activities should be integrated in your broom management plan (see Section 2) from its inception.

Follow-up, follow-up, follow-up!

Good planning and the allocation of sufficient time and resources to follow-up management activities are very important. Follow-up weed control needs to be ongoing for brooms due to their long-lived seed bank. Even when seedlings do not germinate and the seed bank may appear depleted, sites should still be checked every two years at a minimum, preferably during the flowering season, and especially after disturbance events such as fire.

Understanding the ecology of your site will help you plan and manage follow-up control and restoration. It will also help you utilise processes such as natural regeneration, not only to save time and effort, but also achieve more complete restoration.

Careful monitoring is the key to successful and systematic follow-up:

- Plan your monitoring program and determine exactly what changes you want to monitor.
- Visit sites at appropriate times of the year, for example after rain, during the active growing season or at flowering times.
- Visit sites regularly.
- Monitor for regrowth of target weeds as well as new and emerging weeds.
- Monitor the natural regeneration of desired plant species.
- Treat regrowth of target weeds using appropriate control methods (see Section 4).

No such thing as a 'clean sweep' with brooms

BEWARE! Brooms will leave their mark below the soil long after plants are gone.

After controlling old, well-established broom infestations, it may seem like the bulk of the work is done, but threats may still linger below the surface.

1. **Brooms leave a large, long-lived seed bank**
   - Seeds can germinate for many years and quickly re-establish infestations.
   - Soil moved from infested sites can start new infestations in far away places, and often will go unnoticed on machinery or vehicles. Hygiene is important at infested sites (see pages 47–56).
2. **Brooms can alter the level and type of nutrients in the soil**
   - Increased nutrients from decaying broom foliage and nitrogen fixation by brooms can foster weeds at the expense of native plants, which may not thrive in high nutrient conditions.

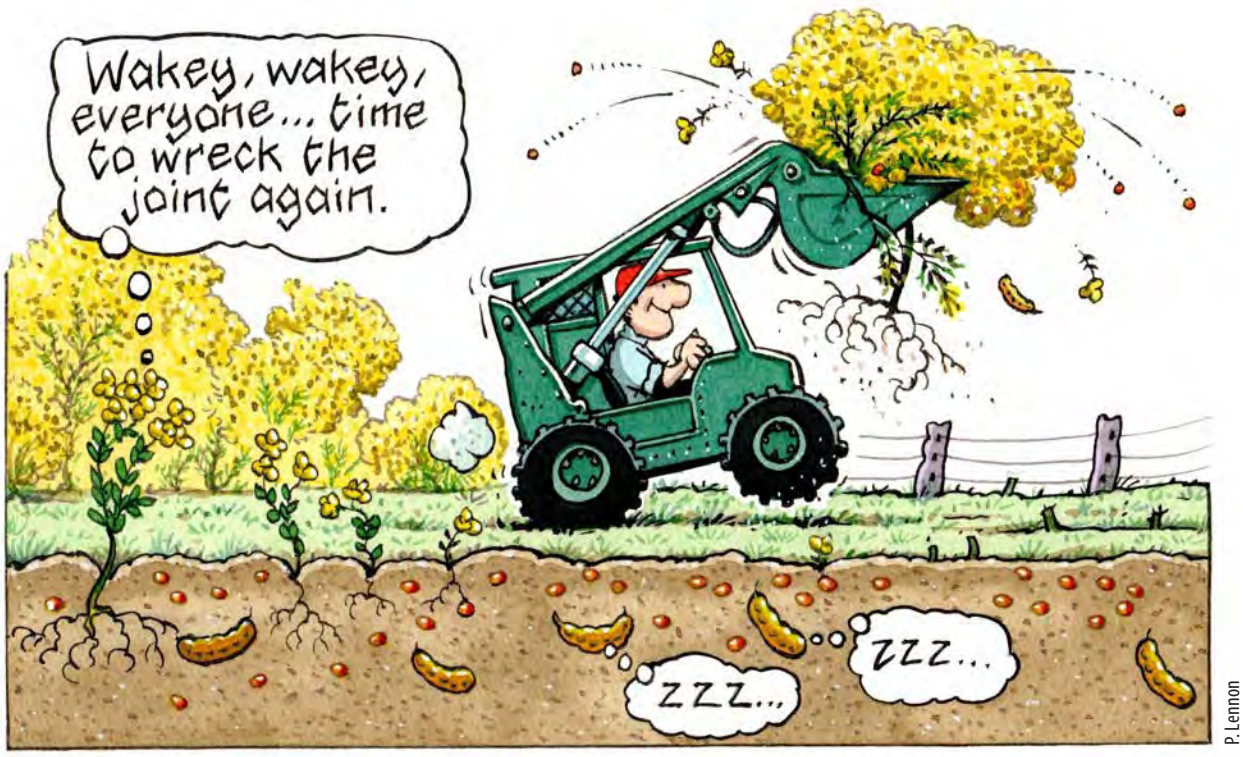
FOLLOW-UP…
keep out new weeds and control seedlings

RESTORE…
where necessary, to encourage desired plants

MONITOR…
make sure brooms don't re-establish and seeds are not spread in soil

AND

MANAGE NEW INFESTATIONS QUICKLY
BEFORE **they can get a foothold and cause impacts!**



P. Lennon

Things to watch out for with brooms

- The long seed dormancy of brooms requires sites to be regularly inspected and treated over the long-term. It is likely that this will need to be continued for several decades.
- Plants resprouting from the roots after fire, cutting, slashing or grazing have the potential to flower and set seed within 6–12 months, unless re-treated.
- Seedlings can flower in their first or second year in ideal conditions but are more likely to flower at three years. In more extreme environments, brooms may not flower until four or five years. Check your site and keep records to inform management and control decisions.
- Fire and other major site disturbance can be both an opportunity and a threat (see Case Study 3 'Call to action after fire' on page 121). If you are able to control all seedlings after fire, there is opportunity to greatly reduce the soil seed bank. On the other hand, if resources are not available to treat mass germination of seedlings, there is an imminent threat that the broom problem will get worse.
- One plant is capable of producing up to 20,000 seeds in a good season. Follow-up control should target **all** flowering plants to prevent seed set.
- Follow-up control in natural ecosystems should not impact on existing and regenerating native plants. Use caution, as repeated use of some herbicides commonly used on brooms can have large residual and off-target effects on canopy trees.
- Disturbance events that trigger germination of broom seed can also trigger germination of seeds of native plants.

Identifying new broom outbreaks and acting quickly to control them ensures that large, long-lived seed banks do not establish. Prevention is better than cure!

Follow-up

Learn from other people's mistakes, instead of making your own

'The biggest mistake people make is taking on larger areas than they can afford to control and not following up every second year. You must have the money to keep spraying out the continuing germination, otherwise you've wasted your initial outlay. If you get a few dry years there's minimal germination and you think you've got rid of it. You're lulled into a false sense of security. Then you have a wet year and it comes up thick as hairs on a cat's back. Follow-up, follow-up, follow-up!'
Mandy O'Brien, primary producer.

Site restoration

Restoration of native ecosystems

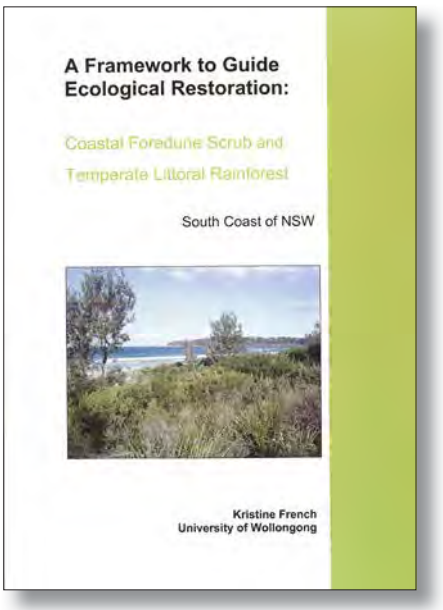
Restoring ecosystem health and function is a difficult task, not only because the impact of weeds might be extensive, but also because natural ecosystems are very complex.

Healthy, functioning ecosystems are dynamic and can have a high level of resistance to invasion by weeds. Restoring species diversity and structure may help to restore resilience and reduce the need for intensive ongoing management. It may also contribute to restoring a healthy self-sustaining plant community.

'Like any weed control, it is a process, not an event. We need to look not only to the short term gains, but also ensure that sites have the best possible chance for regeneration in the long term.'
Alex Shackleton, City of Greater Geelong (see Case Study 5 on page 129 for her story).

Because brooms can form large, dense stands, removal of infestations can leave a 'gap' in vegetation structure. This gap will be filled naturally with either opportunistic indigenous species or another suite of weeds. It is often advisable to wait and see what naturally fills the gaps before proceeding with revegetation. In the interim, any new weeds must be controlled, including broom regrowth.

Planting to reduce erosion



A five-step approach to ecological restoration following weed management has been developed for coastal foredune shrub and temperate littoral rainforest (French 2010) available at www.weeds.org.au/WoNS/bitoubush. This approach can be used as a template for many vegetation types and many of the techniques will be useful when restoring natural areas following broom control.

Five-step approach to ecological restoration

Step 1	Make a species list containing all the plants that would have historically been present at the site; define your project goal based on this.
Step 2	Commence weed management according to your site management plan.
Step 3	Allow natural regeneration to occur and monitor regrowth; noting that soil nutrients may have changed, so a different mix of species may occur.
Step 4	Reassess the site and make a species list of plants that are now growing there; compare this list with the pre-disturbance list to determine which species are missing.
Step 5	Propagate and plant missing species that do not return from seed bank or via natural dispersal. Allow sufficient time for natural regeneration.

Wait before commencing replanting activities unless urgently required. Natural regeneration of some species can occur, saving resources. Some native species can take up to two years to emerge after disturbance. Due to the difficulty in propagating many common native species, natural regeneration may be the only chance for their recovery.

Natural regeneration

The ability of a site to regenerate naturally depends on multiple factors, including its resilience, the remaining seed bank, and the duration and extent of weed invasion. In many sites, at least some of the plant species present before disturbance will regenerate naturally. In many plant communities, natural regeneration takes place in successional stages. The cycle of natural succession begins after a major disturbance event, such as weed control. The first plants to appear are generally fast growing plants that can quickly germinate, grow and produce a new crop of seeds. A successional process will then occur, sometimes over many years, whereby these early coloniser plants thin out and are replaced by other plant species.

It can pay to wait and see what emerges over several years of natural regeneration, but be prepared to closely monitor and control any new weeds that emerge.

Natural regeneration can make a number of important contributions to site restoration:

- It ensures plants of local provenance regenerate.
- Success rates of naturally regenerated plants are generally higher than planted seedlings.
- It is the most economical form of restoration.
- It saves time and effort planting species that are going to regenerate anyway, allowing targeting of *missing* species for propagation and replanting.
- It allows important ecosystem processes to occur, for example the mass germination of seedlings followed by natural thinning out until just a few strong individual plants remain to grow to maturity.

Follow-up

Site resilience

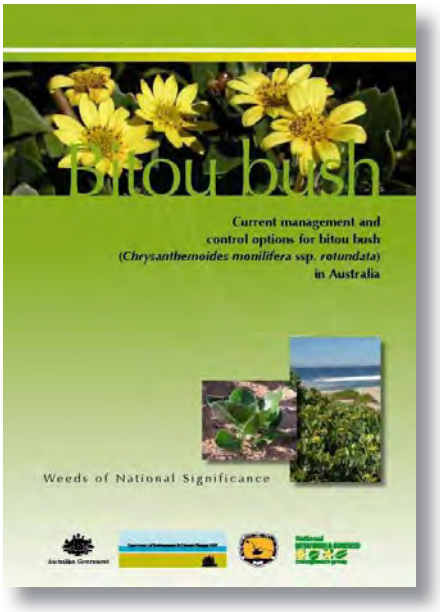
Assessing the resilience of your site will help you understand how much natural regeneration is likely to occur. On most sites, resilience will be determined by:

- The seed bank in the soil and in surrounding remnant native vegetation.
- The amount and quality of surviving remnant vegetation.
- Distance from less disturbed sites that can act as native seed source.
- The severity and time span of disturbance (including the severity and length of time of the weed invasion), and associated changes in soil nutrients.
- The presence of other degrading factors such as feral animals, erosion and nutrient enriched stormwater.
- The presence of ecosystem elements, such as native animals, that disperse seed or help cycle nutrients through the soil.

The composition of native species in some habitats is not always reflected in the soil-borne seed bank; the seed bank may also be held in surrounding plants. For instance, seventy four percent of plant species growing on undisturbed secondary dunes along the NSW south coast are not present in the soil seed bank (French 2010). For example, *Banksia* species that store their seeds in cones have no propagules in the soil-stored seed bank. Sites that are heavily infested with weeds for many years are likely to have severely depleted and less diverse native seed banks. Even if seeds are present, some species require a fire or other disturbance event for germination to occur. Understanding the ecology of the vegetation type you are working in is very important.

Indicative guide to site resilience based on age of weed infestation (adapted from the Bitou Bush Management Manual 2008)

LOW | resilience | HIGH
Newly colonised by weeds; rich native seed bank; broad range of native plant species growing; many adult native plants available to flower and seed.
Weed infestation for up to five years; strong native seed bank; some native plants growing; some adult plants available for flowering and seeding.
Established weed infestation; native seed bank persisting and viable but likely to only be apparent over time; few native plants growing and available for flowering and seeding (monitor and assess).
Long established weed infestation; denuded seed bank and few seeding adults (monitor and assess); elevated soil nutrients.



Seed dispersal

Seed dispersal is a natural mechanism that contributes to site resilience. Seeds disperse in a variety of ways.

Seeds can:

- fall at the base of the parent plant or be propelled to adjacent areas,
- be carried short distances by insects or overland flow,
- be carried longer distances by birds or mammals, or
- be blown by the wind or transported within watercourses, sometimes over great distances.

Seeds that arrive at your site from long distances are particularly important. They enable natural regeneration of plant species that disperse from vegetation remnants nearby.

For this reason, isolated sites that do not have good quality remnant vegetation nearby are disadvantaged and may require more intensive revegetation works.

Many of our most invasive weed species disperse seeds over long distances. Regular monitoring is important to identify any new weeds that disperse into your site and to control them promptly and appropriately.

S. Booth

A banksia naturally germinating from seed

Propagation, replanting and seeding

Once weeds have been removed, it is important that they are replaced with native species; otherwise more weeds may emerge to fill the gap. It is possible that natural regeneration will not result in plant diversity equivalent to that present before disturbance, even in sites that have high levels of resilience. It is also highly unlikely that revegetation will replicate the same complexity and diversity. Many native plants, even common species, can be difficult to propagate, or not available due to inability to collect or germinate seed in large enough quantities.

If natural regeneration does not occur at a sufficient rate (e.g. in sites prone to erosion) or some of the desired species are not able to regenerate naturally (e.g. from seed bank or via dispersal) and native plants are still missing from the site, some level of revegetation may be needed. Planting and seeding activities should be carefully integrated into your overall weeding and restoration plan. Most revegetation projects can be divided into a six-step process.

Six-step approach to revegetation

Step 1	Develop a revegetation plan; incorporate into your weed management plan – see Section 2.
Step 2	Select a revegetation method.
Step 3	Undertake site preparation; e.g. spot spraying, safety assessment.
Step 4	Order seeds or seedlings and other supplies well in advance of planting time, organise labour, contractors, volunteers etc.
Step 5	Undertake revegetation activity; plant seedlings, broadcast seed.
Step 6	Monitor revegetation and undertake maintenance activities such as watering and weed control.

Follow-up

Considerations when developing a revegetation plan

- **Which native plant species are you going to use?** Comparing the pre-disturbance and actual plant lists from your sites is a good starting point, but establishing a comprehensive pre-disturbance list is difficult. The final list of plants will be dictated by what is available. Consult your suppliers and be realistic about what plant species can be sourced. Contact your natural resource management agency or local council bushcare officer for guidance. Plant lists and guides to plant communities may be available for your area. Useful resources are listed in Section 7.
- **What is the availability of seed or tube-stock seedlings for the species you chose to plant?** Can the local native nursery be engaged to propagate species they do not currently stock or does your group have the ability to do so? Many species of native plants will not be available due to issues in collecting or propagating from seed. What is the time lag between placing an order with the nursery and availability of viable seedlings? This can easily take over 12 months depending on the species.
- **How important is local provenance to your project or site?** Local provenance is generally less important for species with seed that is naturally dispersed long distances. With very rare or localised plants, local provenance may be more important. Advice should be sought from local plant experts or natural resource management officer.
- **Do you have the relevant permits, knowledge and skills to collect seed and propagate seedlings?** If you decide to gather seed and propagate seedlings, this requires appropriate permits and knowledge of native plant species, as well as knowledge of when and where to gather seed and propagation techniques such as seed scarifying. See the Florabank guidelines for more information www.florabank.org.au/default.asp?V_DOC_ID=755.
- **Have you considered rare and cryptic species?** Rare and cryptic species are often overlooked in restoration programs. It is important to promote recovery of these species to improve plant community resilience. If you decide to include these species in revegetation efforts, be aware that they are often difficult to propagate, probably occur naturally at low densities, and may require specific habitat of very high quality to survive. If working with threatened plant species, always contact the relevant natural resource management or conservation agency to obtain permits and find out who is working on that species' recovery. You may be able to help each other.

When choosing native plant species to replant, it is preferable to use locally endemic species. You can ensure local provenance by sourcing seeds from nearby bushland. Try to include rare and cryptic species in your list to restore healthy biodiversity. Seed collection will usually require a permit and should be collected according to Florabank or other recognised guidelines.

Note: Many local councils run community nurseries that can be a good source of advice and local provenance plant material.

WildCount OEH

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

Monitoring

Monitoring is the repeated collection and analysis of observations with the aim of providing information to answer a specific management question.

One of the first activities to conduct at your site is monitoring.

It will establish an historical summary of the *before*, against which you can compare the *after*. In other words, it will provide a benchmark to assess progress at the site.

To ensure that sufficient time and resources are allocated, monitoring should be included in your broom management plan (see Section 2). Many funding bodies require that some form of monitoring be incorporated into your project. Monitoring will inform project reports and provide quality information for promoting your activities and allowing adaptive management.

Monitoring is used to evaluate the progress and effectiveness of your project by comparing data in light of your goals and objectives. If done regularly, it will help keep track of progress, show what is working and what is not, help you fine-tune your methods and motivate you as it highlights successes.

If you set out clear, achievable and quantifiable goals at the beginning of your project, monitoring will be a relatively straightforward and rewarding activity.

Monitoring made easy

Monitoring can be simple and achievable. Monitoring can be as easy as taking photos from set points, to assessing vegetation cover and counting numbers of individuals, or measuring health of individual plants. The trick is to record these observations in a systematic and consistent way that enables measurements and comparisons to be made.

Some tips for good monitoring

- Seek technical advice before you begin monitoring.
- Keep a site diary to record your observations.
- Use simple, consistent methods and document these.
- Use standardised datasheets for data collection.
- Record observations at monitoring points at similar times of year.
- Pick appropriate times for monitoring. For example, brooms are easier to locate when in flower, so time photo points or at least one monitoring visit when plants are flowering. Conversely, Scotch broom is difficult to monitor when it is leafless, so consider this in planning monitoring timelines.
- Monitor before and after weed control and restoration activities.
- If resources allow, collect additional data from similar, but less degraded, sites nearby for comparison and reference.
- Keep copies of the data and enter it electronically for ease of analysis.
- If monitoring methods are simple and clearly documented, it should not matter who does the monitoring. However, if one person is usually responsible for monitoring, consider doing it with another person or mentoring another person for long-term continuity.

Designing your monitoring questions

Deciding what changes you want to monitor and what questions you want to answer is the first essential step of any monitoring program. It will determine what data to collect, how to collect it and how often. Monitoring questions need not be

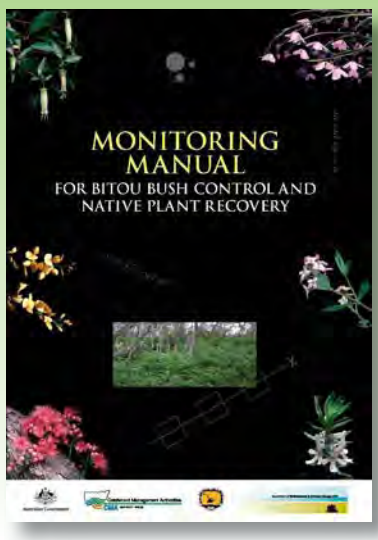
complex but they must be specific, measurable and clearly defined.

Some possible monitoring questions include:

- **Has the density of the broom reduced?** This could be monitored by measuring the density of the broom at specific points at the same time over several years.
- **Has the abundance of native vegetation increased?** This could be measured by estimating cover or assessing density over time.
- **Which control method is most effective?** To answer this question, monitor areas where different control methods are used and compare results over time. Make sure your monitoring method is consistent across the different sites.

BITOU BUSH MONITORING MANUAL

The bitou bush monitoring manual (Hughes *et al.* 2009) outlines a three-tiered approach to monitoring with techniques ranging from simple qualitative assessments to robust research studies, allowing managers to adopt the level most suitable to their objectives and desired outcomes, skills and resources. The manual is appropriate for use on most weeds, including broom species. Available at www.environment.nsw.gov.au/bitouTAP/monitoring.htm.



Site diary

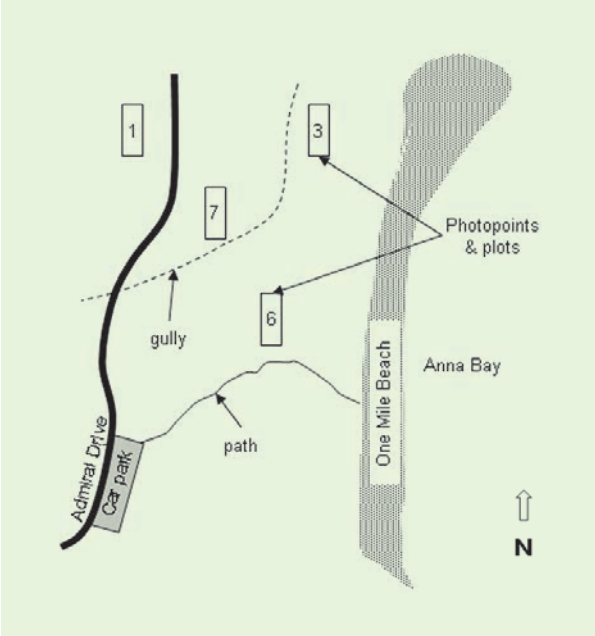
A site diary is indispensable for recording details about activities conducted at your site, and observations before and after each activity. It can include species lists, animal sightings, observations about seasonal changes, fire, floods and climatic conditions. To be most effective, ensure that all site and weed management activities are recorded. Make your observations and descriptions as consistent as possible, so they can be compared across the site and over time. A site diary can comprise a range of methods for recording information: written, audio, graphic and photographic. Monitoring points, photopoints and sampling areas can be recorded on maps. As an alternative to a site diary, the bitou bush monitoring manual has datasheets to capture the above information and also includes an area for a mud map.

Updating the site map

Creating a series of maps of your site is an effective way to help you understand your site and your project and is a useful adjunct to the site diary. Visual representations summarise complex information in a meaningful, accessible format. If done systematically, maps can chart the dynamics of your site and successes of your control program. When working in a community group, mapping can be an appealing way to employ the more creative members of your group and engage with young people.

For detailed instructions on how to create and update your site map, see the bitou bush monitoring manual (Hughes *et al.* 2009) here: www.environment.nsw.gov.au/bitouTAP/monitoring.htm. Maps (or layers) can be redrawn and dated regularly or at important stages of your project, then presented in series to show changes.

A set of national core attributes to collect when mapping weeds can be accessed online at www.weeds.org.au/docs/National_Core_Attributes_for_Weed_Mapping.pdf.



Site mud maps can be redrawn and dated regularly

At a minimum, information should be collected for each of these national core attributes when monitoring and reporting at regional, state or national levels. This will allow your data collection to be consistent and feed into other monitoring efforts.

Selecting monitoring locations

Here are some basic principles for choosing locations to make observations:

- Monitoring locations should be easy and safe to access.
- Establish permanent monitoring points so that you can return to make your observations from exactly the same spot year after year.
- Mark your monitoring points using GPS or map coordinates and a physical marker such as a stake, or flagging tape tied around a tree. It pays to also mark your location on a mud map and enter it in your site diary.
- You may want to select monitoring sites based on where you have used certain control methods.

Photopoints

This is a very simple but effective method of documenting change and progress. Photopoints are a series of photographs recording any activity or feature of your site taken from fixed locations over time. A picture will indeed speak a thousand words to members of your group, the wider community and funding bodies. However, there are limitations to photographic records of vegetation. Not all sites are suitable for photopoint monitoring and it is often difficult to interpret images of green on green, so photopoints should ideally be accompanied by observational data or detailed monitoring data, such as measures of plant density. Photopoints are particularly useful for recording the results of weed control on a large weed infestation over time.

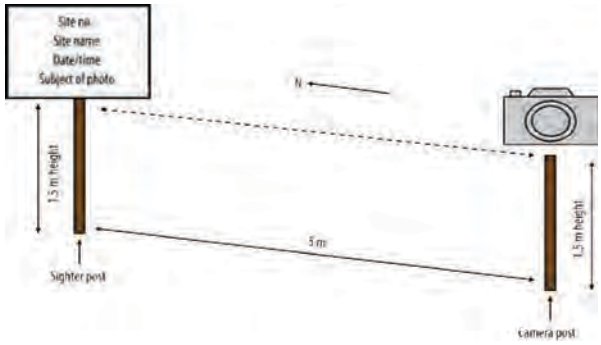
Using photopoints requires preparation and a systematic method, supported by meticulous documentation:

- Establish and record your photopoint locations; GPS coordinates, compass bearings, post markers (see *selecting monitoring* locations). Give each photopoint a unique number or name.
- Return to the same photopoints to record changes over time. It is important to use exactly the same location, face the same direction with the camera at the same height, at the same time of day, so that images are comparable. If possible, use the same camera and lens. Always consider where the sun is and try not to take a photo into the sun.
- A simplified photopoint method is to use two permanently installed posts. Rest your camera on top of one post and place the other post in the centre of the frame. Include an object of known size in the photo for scale. If possible include an identification label for the site. By repeating the same method each time, your photograph will always be taken from the same spot at the same height in the same direction with the post for reference.

Follow-up

A. Meiklejohn

Install a permanent monitoring marker



Suggested photo point marker specifications

Take lots of photos; digital files are cheap – the moment is lost forever. Make sure you have a digital filing system that matches your field notes so you can easily locate and cross-reference images for years to come. Make backups and make sure others have access to this priceless archive.

Parks Victoria

Include a site label in your photographs

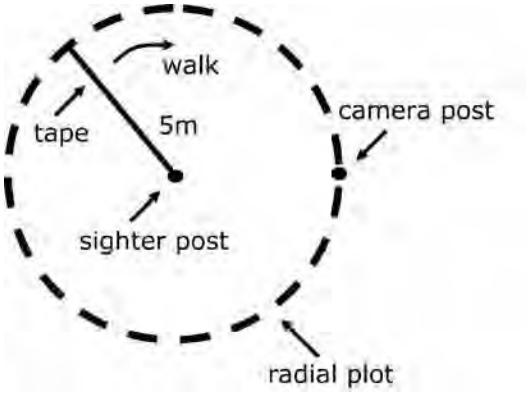
Things to consider with photopoints

- Ideally, include a reference point (or several) in the camera frame for orientation and scale; a rocky outcrop, the horizon, a tree, or one of your marker posts.
- Select a location that dissects the subject vegetation to show its profile; a cutting, a creek, a path. But remember, vegetation develops unique characteristics along fringes.
- For detail shots, remember your subject will grow and change over time, so think about multiple close, middle and distant points.
- Observe which direction gives the best lighting conditions and note the time of day; hint: low sunlight angles in early morning or late afternoon can offer ideal lighting conditions.
- Standard datasheets are available in the bitou bush monitoring manual www.environment.nsw.gov.au/bitouTAP/monitoring.htm.

Supporting photopoints with observational data

The locations you chose for photopoints can also be used as plots for collecting observational data that can help interpret the images and add new and useful information.

- At a photopoint location marker, use a tape measure and stakes to permanently mark a circular or rectangular plot (quadrat).
- Identify and measure all species or select key species to observe, including weeds.
- Note density, plant cover or other features from the list on the following page.
- A useful feature to note is the age of plants (e.g. seedlings, juveniles, adults) to record recruitment over time.



Circular photopoint and monitoring plot

The bitou bush monitoring manual has instructions on how to set up and collect supporting data on plant species abundance. See www.environment.nsw.gov.au/bitouTAP/monitoring.htm.

Observational data collection methods

There are a variety of other methods you can use to monitor changes at your site. Collecting quantitative data requires more effort, but can provide data that will enable you to answer monitoring questions with much greater certainty.

Some sampling methods include:

- **Quadrats:** a square or rectangular plot often used to sample vegetation. Quadrats are a sampling unit where plant abundance or the number of species can be assessed.
- **Transects:** single dimensional plots or 'lines' along which plant abundance can be measured or points or quadrats are established. The trick with transects is to avoid following natural feature lines, which could introduce bias to your observations. To avoid bias, follow a compass bearing when establishing transect lines.

Parks Victoria

Transect monitoring

Follow-up

Gathering statistically robust data requires a systematic approach to establishing sampling units (e.g. quadrats or transects). These should be permanent, randomly or systematically selected and numerous enough to be representative of your site. See the bitou bush monitoring manual (www.environment.nsw.gov.au/bitouTAP/monitoring.htm) for instructions on how to employ these methods in the field and important considerations necessary before starting your monitoring program. In addition, enlist the advice of someone versed in environmental survey methods, receive training and give careful thought to your monitoring program prior to commencing weed management.

Some suggested features to record when measuring vegetation and habitat

- Presence or absence of species (i.e. dated species lists).
- Density – number of individuals of a species in a defined area.
- Cover – percentage foliage cover of one or all species in a defined area.
- Frequency – usually expressed as the percentage of sampling units a species occurs at.
- Reproduction – flowering and seeding rates.
- Growth stage – density of seedlings, juveniles, and adults.
- Trunk or stem diameter.
- Plant height.
- Individual plant health for key species.
- Success rate of planted seedling (from Buchanan 2009, p. 148).

Section 6

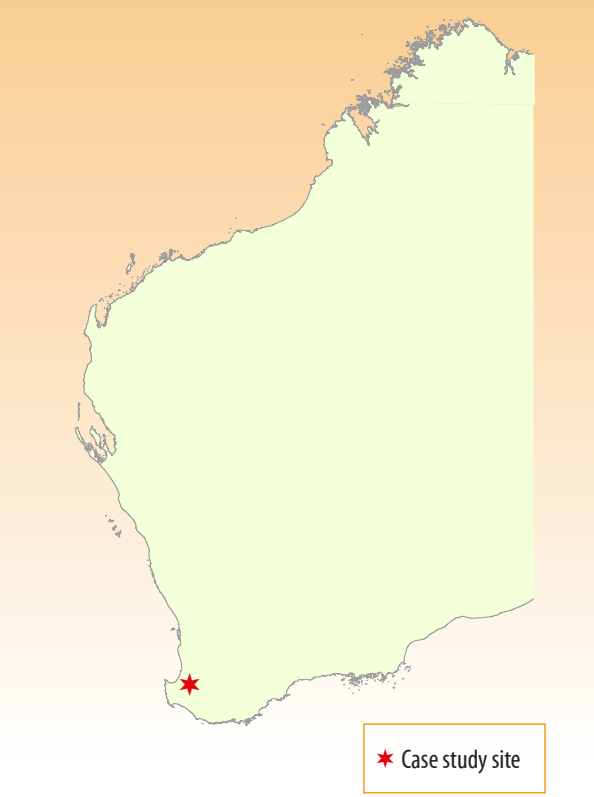
Case studies

First hand experiences of broom management

Case study 1

Managing Western Australia's first recorded Scotch broom outbreak

***Christina Gilbert**, Operations Officer, Wellington District, Department of Parks and Wildlife, Western Australia*



When a biologist on holiday noticed an unusual plant growing along the Collie River, in Western Australia and reported it, this turned out to be the State's first reported case of naturalised Scotch broom.

Located on the Darling Scarp 20 km inland from Bunbury, Wellington National Park is centred on a large dam in the Collie River Valley. Open bushland of jarrah, marri and yarri trees with an understorey of *Banksia*, *Casuarina* and *Xanthorrhoea* grows on gravelly loam watered by an annual rainfall of approximately 800 mm. Below the dam wall is a landscaped tourist precinct known as The Quarry, comprising scenic lookouts, a kiosk, car parks and toilet block.

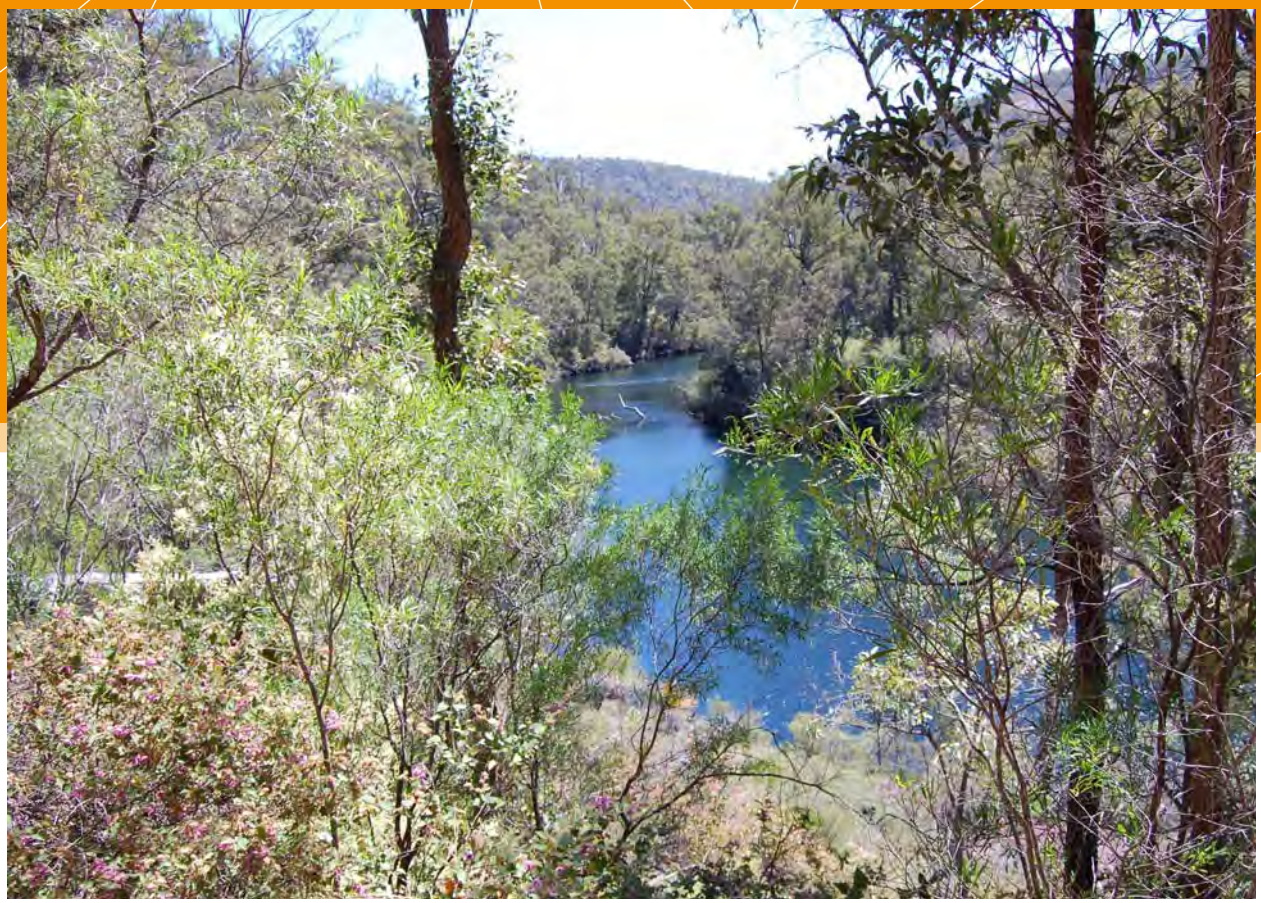
In 2010, the biologist noticed the plant growing along the river below the dam and followed the trail of specimens upstream to The Quarry. He took samples, identified them as Scotch broom (*Cytisus scoparius*), and alerted the then Department of Environment and Conservation. This was the first reported case of naturalised Scotch broom in Western Australia, this occurrence having escaped notice for some time and not appearing in any local plant lists.

Research suggested the weed originated as a planting during refurbishment of a rock garden above The Quarry sometime between 1970 and 1990. From there it had escaped and spread through the landscaped recreational area then downhill into the river valley below.

The confirmed outbreak of Scotch broom prompted an immediate response and a crew set about controlling it.

Christina Gilbert, Operations Officer, Nature Conservation Wellington District, Department of Parks and Wildlife recalls, ***'I'd noticed it when I was Parks Ranger there, but hadn't picked it up'***. When the removal of *Acacia melanoxylon* disturbed the soil and opened up the canopy, ***'Cytisus really seemed to take off'***. The main infestation of mature plants with ***'trunks on them like small trees'*** was 2 m high and covered an area of 30 m^2. Outlying plants were found as far away as 300 m downstream along the Collie River.

Mature plants were cut down with chainsaws or clippers then stumps were painted with 50% glyphosate. Smaller plants were hand pulled. As the weed was not seeding at the time, all material was left lying on the ground. After initial control work



C. Gilbert

Collie River Valley

removed 90% of the plants, intense follow-up work continued for two seasons. Every remaining plant was cut-and-painted and new growth reaching about 15 cm was hand pulled. The area is now carefully monitored each spring with only an occasional plant being found and pulled.

The next stage is to survey riverbanks further downstream. Access is difficult because the bank is rocky and a high rate of water flow is maintained year round for downstream irrigation. The plan is to survey in spring when the plant is in flower and readily identifiable.

Christina is confident that isolated outbreaks of Scotch broom can be successfully controlled. ***'Because we hit it so hard as soon as we knew about it, we only got about 12 seedlings coming up last spring. But don't give up. You have to keep watching and pull them out as soon as they germinate'***.

C. Gilbert

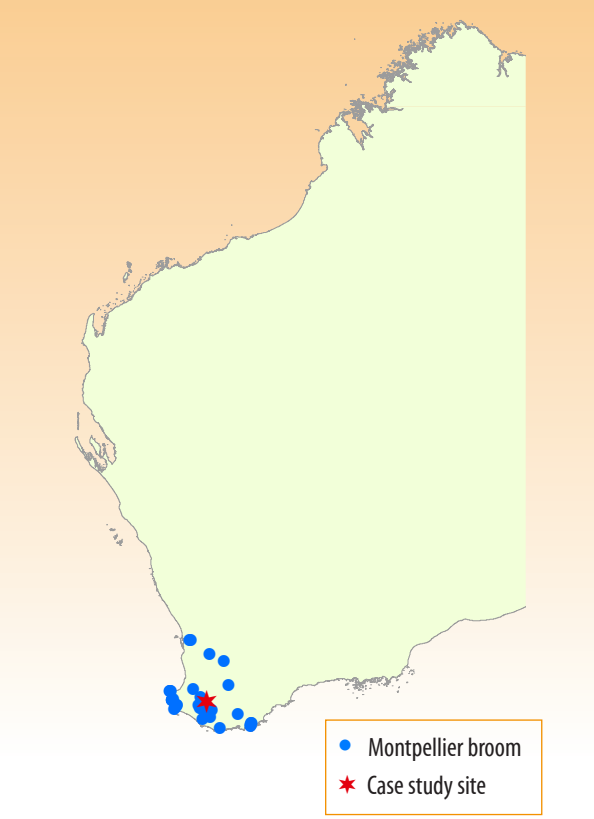
C. Gilbert

Below Wellington Dam is a landscaped tourist precinct known as The Quarry

Case study 2

Stakeholders working together to contain Montpellier broom at a regional scale

***Ian Wilson**, Nature Conservation Coordinator, and **John Hanel**, Ranger, Department of Parks and Wildlife, Western Australia*



A highly driven group of environmental professionals and community members are working together to prioritise the control of Montpellier broom in outlying or isolated pockets across the Shire of Manjimup, Western Australia. By prioritising management of outlying or isolated infestations, the group are ensuring that sufficient resources are then available for the long-term follow-up needed for successful control.

The Shire of Manjimup is in the Warren Blackwood Region of south-west Western Australia. Located at the southern extremity of the Darling Plateau, it is Southern Forests country well known for its timber industry and prolific native flora. One of only five Mediterranean-type ecosystems in the world, it features relatively high rainfall and a long growing season. Unfortunately, these favourable conditions and the long history of settlement, farming and forestry have contributed to what National Parks Ranger John Hanel describes as 'weed heaven'.

A collaborative approach

In 1998, representatives from the then Department of Conservation and Land Management, Department of Agriculture, Landcare and Shire of Manjimup began meeting on a regular basis to discuss weed control across the district. With increased community involvement, this group evolved into the Manjimup Weed Action Group (MWAG). Now chaired by a member of the community, it retains strong government representation and support, enabling a coordinated approach to weed control over the district and across jurisdictional boundaries. It oversees approximately 1600 sites where over 60 species of invasive weeds are subject to control activities. The group has established strong working relationships with Warren Catchments Council and CSIRO, who are experimenting with biological weed control. One of MWAG's strengths is its ability to share information and work collaboratively across projects. The multi-agency representation also facilitates community engagement. As Ian Wilson, a Nature Conservation Coordinator for the Department of Parks and Wildlife, points out, ***'MWAG strongly brings us together and drives everyone to achieve something'***.

Rare and threatened species

Woody weeds are identified as a major threat to the natural biodiversity in the region. Critically endangered flora such as the majestic spider orchid (*Caladenia winfieldii*) is vulnerable to mid-storey weeds that significantly reduce the amount of sunlight reaching the forest floor. In addition, because some woody weeds grow higher than most native shrubs, they are able to cast their

M. Sheehan

Montpellier broom

seeds wider. Woody weeds establish dense belts of significantly reduced biodiversity, changing shrub and ground cover layers in a way that is considered a threat to rare marsupials found in the more open forest habitats to the east of Manjimup. These species include woylie, numbat, southern brown bandicoot, western quoll and phascogale.

M. Pot (Wikimedia Commons)

Numbat

Land use and patterns of weed infestation

Well-established infestations of Montpellier broom are associated with disturbance that has occurred in the older settled areas and along farmland boundaries. Montpellier broom is patchy among the open jarrah and marri forest that grows on gravelly soils in the uplands to the east and north of Manjimup. It is also patchy in the higher rainfall areas to the south and west, where karri forest with dense understorey grows on rich loams in deeply incised valleys, and jarrah and marri grow on the mid to upper slopes. In the more established pockets of Montpellier broom, estimated densities of five to six mature seed producing plants per square metre have been reported by Department of Parks and Wildlife teams.

The extent of invasive weeds in the district, and limited resources to draw on, means that control projects need to be prioritised. Since 2000, woody weed control has focussed on *Acacia dealbata* and *A. melanoxylon*. Treatment of Montpellier broom has so far been restricted to outlying or isolated pockets, where the size of the infestations is manageable and sufficient resources are available for the long-term follow-up needed for successful control.

The search for effective responses

Initially, there was little information available for controlling Montpellier broom. Experience with *Acacia* species was used as a starting point to formulate a control strategy. Mapping was the first key task so that a known point or line could be chosen and the weed pushed back from there. Assessment plots were then established to monitor the effectiveness of different control methods.

One assessment plot was established where a dense weed outbreak had resulted from disturbance by timber harvesting. It was found that although mulching worked well with *Acacia* species, the flexible stems of Montpellier broom meant the

B. Rayner

Spraying Montpellier broom

type of head commonly used on excavators for top-down mulching did not work. So either brush cutters or a forestry mower was used. Felled Montpellier broom dries within 2–3 months, so it is ready to burn in spring and early summer. As the plant does not produce large amounts of leaf litter it is not always possible to generate the hot fire needed to stimulate seed germination. Assessment of prescribed fuel reduction burns suggests that cooler fires have limited results. Once mature plants have been cut down, another method is to remove the over storey during autumn or spring to trigger germination. Ian Wilson notes that, ***'It responds well to disturbance, either mechanical or fire'***.

The optimal time to spray Montpellier broom is during its flowering season from late September to December. Plants are blanket sprayed with a glyphosate mixture and wetting agent using vehicle-mounted spray units. A burn is put through 3–4 years later to trigger further germination. In areas that have been controlled for many years and regrowth is down to 10–20 plants, these are then hand pulled.

Although off-target damage has to be carefully managed, Montpellier broom dominates when it gets a hold, so in many cases spray operators are dealing with concentrated outbreaks that include few or no native plants. National Parks Ranger John Hanel stresses that, ***'the first priority is to get rid of the weeds'***. The approach is to remove as much weed growth as possible then rehabilitate the site afterwards. In sites where natural regeneration is poor, once it is assessed as controlled, the site will be ripped and seeded with appropriate native species.

A policy of containment

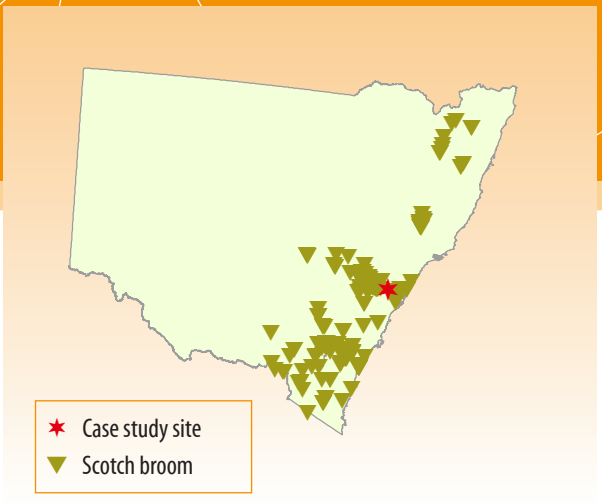
Efforts are continuing to build understanding to assist in controlling the further spread of Montpellier broom. A major factor seems to be seed transported on graders and heavy equipment used in road maintenance. John Hanel warns that, ***'you've got to be so careful with what you do'***. In areas where timber harvesting is active, isolated outbreaks associated with harvesting coupes and vehicle parking bays implicate seed dispersion by forestry machinery. Establishing the link between disturbance and new outbreaks of Montpellier broom is important for prioritising weed control across the landscape.

Ian Wilson concludes that, ***'Because there's so much Montpellier broom we need to prioritise the control work we do. We focus on disturbance activities because we know they will trigger growth. The key to tackling this species at a regional scale is a good understanding of where it occurs, having some tried and proven control methods, a community capacity to make a difference and getting out and doing it. It is extremely rewarding to see the increased biodiversity after weed control'***.

Case study 3

Call to action after fire: community groups shaping the on-ground response to Scotch broom in a World Heritage area

***Vanessa Richardson**, National Parks and Wildlife Service NSW, and **Lyndal Sullivan**, Katoomba Creek Bushcare Group volunteer, bush regenerator and Blue Mountains City Council Bushcare Officer*



When wildfire and back-burning operations in the Blue Mountains National Park triggered a massive germination of Scotch broom seeds that had lain dormant in the soil for many years, an active network of skilled volunteers, contractors and environmental agencies quickly responded, turning disaster into opportunity.

As Blue Mountains National Park comes under increasing pressure from the growth of nearby Sydney, Vanessa Richardson, National Parks and Wildlife Service (NPWS) Ranger, believes, ***'It's important that we deal with negative impacts and try to maintain biodiversity in the World Heritage Area'***. To help achieve this, NPWS has established a long-term working partnership with Blue Mountains City Council (BMCC) and in particular the Bushcare Team. Lyndal Sullivan has been active in local environmental projects since the 1980s, as a bushcare volunteer and a bush regenerator and, more recently, as a Bushcare Officer with BMCC. Together, and with others, they have nurtured a dynamic network of highly skilled and motivated community volunteers and established a track record of effective weed control projects in the Grose River catchment, both in the park and surrounding it.

A high-profile landscape

The Grose River flows east along a valley deeply incised through uplifted sandstone tablelands in the heart of the World Heritage listed Blue Mountains National Park. Tributaries rise on the ridges and plateaus where 70,000 residents live in towns and bushland dwellings linked by a network of roads. Originating as garden escapees, most of the Grose Valley weeds have been dispersed by birds or in run-off which carries seeds down creek lines into inaccessible valley floors below. Hidden from the populated areas above, weeds can and do cause a lot of damage if left unmanaged.

The community calls for action

The Grose Valley has a long and proactive history when it comes to community calling for action, which officially started in the 1930s with the bushwalking fraternity beginning its fight to conserve blue gum forest. This community concern rose again in the early 1990s to address the threat of weeds in the Grose Valley, particularly with regards to gorse (*Ulex europaeus*). With the support of the community, the NPWS and BMCC joined forces and started the Great Gorse Weed Walk (GGWW) in 1992, which has led to a massive reduction in gorse and other woody weeds within the catchment, including Scotch broom.

The lead taken by local community groups in shaping on-ground responses has been vital. Volunteers lobby, contribute to planning, and offer a range of specialised skills. This has enabled a

L. Sullivan

A section of Govetts Creek – one of the more remote sections in the project area that was worked by contractors with skills in bushwalking (and swimming!)… and it is less than 6 km from Katoomba Post Office

P. Vale

P. Vale

Scotch broom site: taken from about 3 m down the slope, looking down and across with the Three Sisters in the background, towards the south-west – note the burnt (dead) Banksia trees

coordinated response to weeds on a large scale in rugged and remote areas over a long period. The group of dedicated and long-term skilled volunteers have ownership over their sites and their work and commitment gives them a stake in how it's managed.

A landscape strategy to control weeds

Because BMCC and NPWS work together, a catchment-wide approach across jurisdictional boundaries is possible. The traditional bush regeneration approach has been used – which is to start working in the good areas and work towards the worst. As weed infestations follow riparian zones down along the creeks, the strategy has been to start at the lower end of a weed plume coming from the urban edge and work back up stream to the source. When undertaking work in more remote locations down in the valleys, all high priority weeds are targeted when located.

Wildfire in Yosemite, Katoomba and Govetts Creeks – disaster and opportunity

Having a close-knit weed-fighting network in place ensures a swift response and the ability to turn disaster into opportunity.

Yosemite, Katoomba and Govetts Creeks wind through canyon-like valleys just north of Katoomba township. In December 2002, wildfire and back-burning operations triggered massive germination of Scotch broom seeds, which had lain dormant in the soil for many years.

'We were devastated after the fire when we started to see dense carpets of Scotch broom seedlings

J. Cohen

Volunteers working along Katoomba Creek – a full day's effort to get all the broom before its first seeding after the fire

N. Summers

Volunteers working along Katoomba Creek, in rugged terrain with difficult access – note the fire blackened trees and shrubs

emerge all along the banks of these creeks. We wondered how on earth we could remove them all before they produced seed and multiplied the problem. We had no other choice than to harness all the resources we could.' The Katoomba Creek and Minnehaha Bushcare groups initiated the action. They had worked for 10 years to protect their creeks (Katoomba and Yosemite), and its threatened species in the upper catchment as well as the integrity of the Grose River Wilderness Area downstream. The initial assessment was that the fire had caused over 6 million Scotch broom plants to germinate.

It was soon realised that the fire had created a golden opportunity to remove Scotch broom from these areas if enough resources could be harnessed, otherwise it would create a huge problem that may never be controlled as it continued to multiply. It was initially thought that $259,700 would be needed to deal with this over the first three years. In fact, this was a serious underestimation.

Rapid reaction

The track record of successful projects, the active network of skilled volunteers, contractors, and the close partnership between environmental agencies enabled some funding to be quickly secured and an on-ground response to commence. However, the exact scope and cost of the project would not be known for some time and there was no obvious or secure source of funding available to address this emergency.

In spite of these challenges a good response (at a frantic pace) was developed within 12 months. The gaining of an Environmental Trust grant was the cornerstone of the project. This enabled control measures to be undertaken in all burnt areas before most of the broom was able to flower and seed which was a major strategy to address long-term control.

The planning of the operation was a very complex task because some areas required considerable bushwalking as well as bush regeneration skills, and could only be undertaken at certain limited times of the year because of the need to swim through sections of the creek carrying tools, among other things, and the limited number of access and exit points.

Comprehensive response

Katoomba Creek and Minnehaha Bushcare groups were the key to this effort. They approached BMCC, NPWS and other catchment bushcare groups to develop a coordinated strategy. Grants were obtained to supplement funds from BMCC and NPWS to implement the four year weed management plan. Resources were pooled to

R. Ley

A volunteer working at Minnehaha Falls reserve in January 2006, just two years into our major Broom Blitz effort

employ bush regenerators, organise special volunteer 'Broom Blitz' events and to seek support from other agencies. ***'It was a great opportunity to get in other community members, bushwalkers and members of other bushcare groups who responded well to the emergency'***, recalls Lyndal.

The plan developed called for a four-stage strategy to encourage natural bush regeneration along 15 km of creek line and its benched banks by removing all target weeds, with Scotch broom as a major target. This covered a length of over 11 km that had been burned, plus almost 1 km upstream of each tributary to serve as a weed free buffer.

Typically, weeding Scotch broom was done by cutting and painting with glyphosate, or hand pulling. Foliar spraying was rarely used because it damages native vegetation, hinders its ability to regenerate and the equipment is difficult to carry into many sites. It is also not effective on juvenile or mature plants because of the small amount of leaf cover on most plants.

- **Stage 1** – cut-and-paint with glyphosate, or hand-pull weeds in burned areas along creek lines and banks; Scotch broom 200 mm high or more were targeted to prevent maturity and seed forming.
- **Stage 2** – all weeds targeted, both those left from the first round plus newly germinated plants in burned and unburned areas were treated.
- **Stage 3** – with still a significant amount of fresh germination of Scotch broom (mainly through disturbance from previous weeding), woody weeds were targeted in all areas and all weeds were comprehensively treated within sections that were in the best condition. These were the most remote and furthest downstream.
- **Stage 4** – with a reduction in the numbers of weeds; the sections being comprehensively weeded were extended further upstream.

Over the four years, 19,335 volunteer and contractor hours were contributed with $478,312 spent on bush regeneration works, bringing the total value of the work bush regeneration works to $581,652 (at 2006–7 costs) when volunteer times were included. This represents $60,000 for each kilometre of creek length including banks. By 2008, in all burned areas (from the most remote to those closest to the urban edge):

- all woody weeds had been treated,
- only newly germinated woody weed seedlings or the occasional missed plant were expected to need treatment in future years, and
- treatment of herbaceous weeds was well advanced in all burned areas and in some unburned 'buffer' areas.

Ongoing works

Work has continued since 2008 to ensure that all woody weeds are removed from the riparian zone along the identified tributaries:

- weeding has pushed into new areas upstream into the urban area,

L. Sullivan

Photos of a remote location where the 2004 photo (left) shows a typical high density area where an average of 270 broom plants per square metre were found and weeded during the primary treatment. The 2013 photo (right) is the same location taken after four years of intense work and maintenance follow-up

- private landholders have been involved with on-ground works, linked to funds, training and Landcare groups, and
- stormwater and erosion control, creek-bank stabilisation and wetland rehydration is underway.

The plan now relies heavily on volunteers with only limited funding for professional bush regenerators. ***'When you go down and you see how the bushland is recovering and it's not being threatened by weeds, that's a big win… it is very satisfying after five years of intense effort'***.

When asked about future directions, Vanessa advises, ***'Working with volunteers takes a lot of time and commitment. We would benefit from a local dedicated volunteer coordinator'***. Lyndal recommends that funds be made available specifically for bushland rehabilitation after fires. ***'Instead of chasing funding, most volunteers would rather be out there and doing the real job of weeding.'***

Fire management is a major issue. Because wildfires, back-burning and fuel reduction stimulate mass germination of woody weeds, NPWS and BMCC have started to look at how resources can be made available for pre-weeding (where burns are planned) and also follow-up rehabilitation. Increasing community awareness of weeds remains a priority for BMCC and NPWS. According to Vanessa, ***'We were able to broaden the scope of the Great Grose program, add value to the park, still engage the community as well as educating them about what weeds do once they get out of back yards. Hopefully people take those messages with them and talk over the back fence to their neighbours'***.

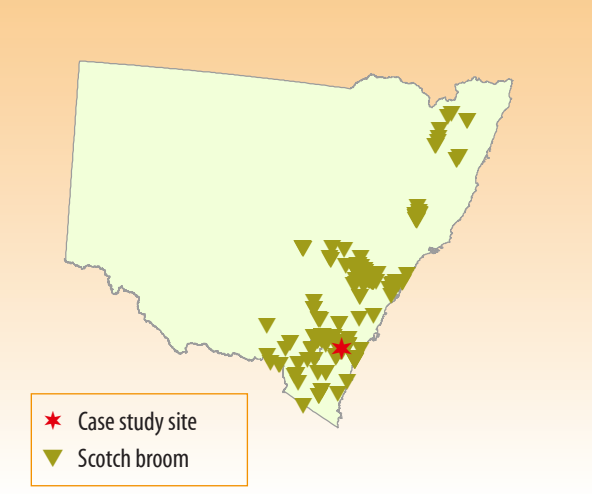
Although Lyndal cautiously acknowledges that Scotch broom control programs have been very effective, careful monitoring and maintenance needs to continue for a long time given the long-term viability of some seeds.

'When we walk a remote section of Katoomba Creek now, we might find one broom plant every 10 square metres or so. Back 3–5 years ago, we'd find 200–300 plants in a square metre in some places. The more remote sections of Katoomba Creek are down to maintenance visits once every year or two. We only expect to find scattered weeds and enjoy the beautiful sandstone escarpments'.

Case study 4

Primary producers' life-long experiences with Scotch broom point to long-term control rather than eradication

***James and Mandy O'Brien**, Krawarree property, Braidwood NSW*



Primary producers James and Mandy O'Brien have managed large-scale Scotch broom infestations in their pastures since the 1970s. As the property cycled through good years and bad, weed control was maximised when the budget was generous. Maintaining follow-up control in leaner years has been the biggest challenge.

The weed problem escalated when farming methods changed

The O'Briens run approximately 1300 head of beef cattle on a 2200 ha property near Braidwood in the Southern Tablelands of NSW. Nestled among rolling hills and granite outcrops at the head of the Shoalhaven River valley, the family has farmed here since clearing it from forest in the 1860s. Scotch broom (*Cytisus scoparius*) has been present on *Krawarree* for as long as James can remember. ***'I heard from my grandfather that it started as a garden plant and it took off from there.'***

Up until the late 1960s, sheep and cattle were grazed on native kangaroo grass and poa tussock, which was regularly burned. Sheep, particularly wethers, ate immature Scotch broom as soon as it produced foliage. This regime kept the weed under control, restricting it to watercourses and some rocky outcrops. A program of pasture improvement in the late 1960s saw paddocks ploughed and planted with pasture grasses including cocksfoot, phalaris, fescue, ryegrass and clovers. This coincided with a period of mild wet seasons and the phasing out of sheep due to increasing feral dog and dingo attacks. By 1971, there was a massive Scotch broom infestation covering 400 acres.

According to James, ***'The broom infestation was so bad that my Dad got helicopters in to spray 2,4,5-T. The problem was we took out so much that we could not physically keep up hand spraying the whole 400 acres. To make matters worse, after 2,4,5-T was banned the only available chemical was Garlon (triclopyr), which was twenty-five times more expensive. This was a huge lesson in managing both broom and our finances. We spent that initial amount then couldn't follow it up. We learned to take out small blocks after that.'***

Because Scotch broom produces such large quantities of seed, the infestation established a massive seed bank in the soil. In the early 1990s, the CSIRO took a soil sample one metre square by 30 cm deep that produced 30,000 seeds. Forty-two years after initial treatment, hand spraying continues every second year in these paddocks.

The search for an effective control method

Fire is no longer a control option at *Krawarree*. The ideal time to burn the Scotch broom is mid-summer, but fire permits are not easily obtained as the property is bordered by National Park and State forest.

DPI Victoria

Mature stand of Scotch broom with sprayed broom in foreground

J. O'Brien

Scotch broom infestation on Krawarree property

J. O'Brien

Krawarree property after mulching was trialled and found to be ineffective

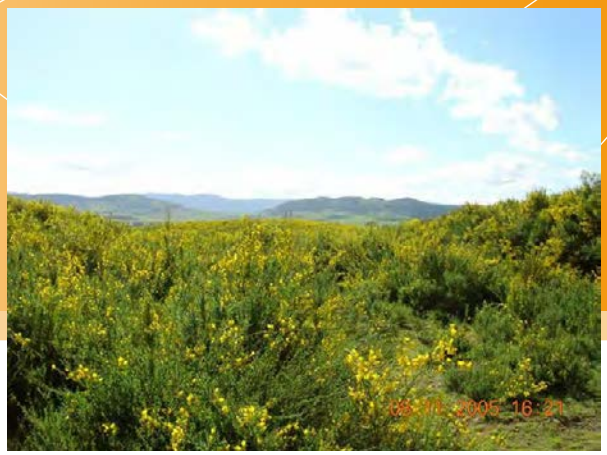
Mulching was trialled but found to be ineffective. The thick layer of mulch was supposed to inhibit regrowth, but a massive germination ensued. It was impossible to get in to spray seedlings because a flail mulcher fitted with hammers left sharp stumps that punctured vehicle tyres. A bulldozer was used to clear the area.

Biocontrol has also been trialled. First the twig mining moth *Leucoptera spartifoliella* was released in 1993, subsequently the Scotch broom psyllid *Arytainilla spartiophila*, the seed feeding beetle *Bruchidius villosus* and most recently the gall mite *Aceria genistae*. Of the four, the beetle is thriving in its test area, but as yet there is little evidence of lasting damage to the weeds.

A range of herbicides has been applied. According to James, ***'Glyphosates won't kill it at all. We've had Graslan (tebuthiuron) trialled, but that didn't kill it. We've tried Brush Off and Ally (metsulfuron-methyl) with minimal results. The only thing that will kill it effectively is Grazon and Conqueror (picloram plus triclopyr).'***

A method to match the scale of the problem

After years of trial and error, James has developed the following method for controlling Scotch broom in his pasture. Where there are large stands of broom in arable country, a bulldozer with blade plough followed by a heavyweight offset disc plough lays the plants down then cuts them up. The paddock is then cropped, grazed and ploughed annually. Turnips, oats and ryegrass are used alternately over five to seven years until Scotch broom germination diminishes. Tetila ryegrass is a particularly useful recovery crop because it out competes weeds and provides early feed. Cattle are kept out of heavily infested areas to control seed spread on hooves, but are let back into treated paddocks as soon as recovery crops mature. This returns the land to productivity and recoups some of the cost of weed control. To support the control work, isolated plants in *clean* paddocks, rocky knobs, watercourses and uncultivated country are hand sprayed using a vehicle mounted reel sprayer every second year.



DPI Victoria

Scotch broom in flower – seeds can remain fertile in the ground for many years

DPI Victoria

Pasture improved paddock where large stand of broom had been but is now clean, with major Scotch broom infestation in background

Adopting a practical long-term approach

Krawarree's weed control budget is $20–30,000 per annum. ***'With the cost of chemicals and labour, it's an expensive operation.'*** It is important to keep initial weed control to practical proportions and remember that follow-up will be required for many years.

According to Mandy, ***'The biggest mistake people make is taking on larger areas than they can afford to control and not following up every second year. You must have the money to keep spraying out the continuing germination, otherwise you've wasted your initial outlay. If you get a few dry years there's minimal germination and you think you've got rid of it. You're lulled into a false sense of security. Then you have a wet year and it comes up thick as hairs on a cat's back. Follow-up, follow-up, follow-up!'***

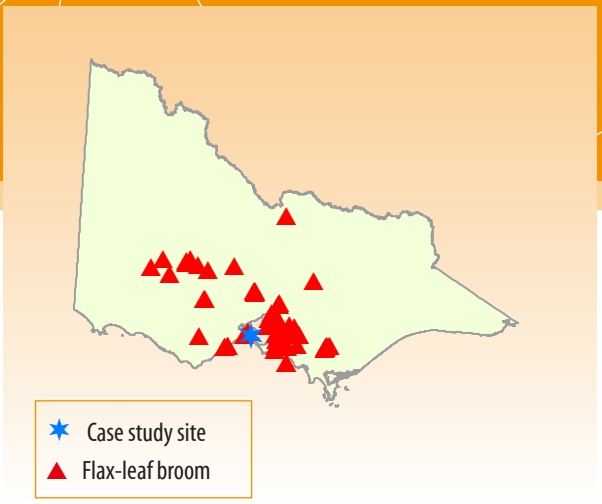
As there is little or no financial assistance available for weed control on the property, the biggest challenge is maintaining continuity of weed control over the long-term. When funds are plentiful, maximise weed control operations. As the budget tightens, still find ways to continue some level of weed control follow-up, to ensure farm productivity is maintained and improved.

As James observes, ***'It's hard to put money into a weed control program when you're dealing with tough seasons. When the property's doing well, production's good and you're making heaps of money, spend heaps of money back at it. But when things are bad, production is down and you're not getting enough money for your products, you just don't get the cash flows to spend. That's the big problem. But you've got to keep prioritising weed control because you've already put so much in and you don't want to let it get away on you again. You've got to look after the land. If you look after the land, the land will look after you.'***

Case study 5

Managing flax-leaf broom across the City of Greater Geelong

***Alex Shackleton**, Conservation Reserves Team, City of Greater Geelong, Victoria*



Alex Shackleton is Supervisor, Conservation Reserves Team (CRT) for the City of Greater Geelong (CoGG). Among other broom species in the district, either well established like Scotch broom, or threatening to spread like *Spartium junceum*, Alex considers flax-leaf broom ***'by far the worst problem'***.

A regional city in a heavily-impacted landscape

The City of Greater Geelong has 220,000 residents mostly concentrated in a rapidly developing urban area. This contrasts markedly with low-density farming communities in the surrounding country and holiday and resort facilities along the coastal fringe. Volcanic plains, rolling hills and uplands, sheltered Port Phillip and exposed Bass Straight coast, estuaries, wetlands and extensive saltmarshes comprise the varied landscape.

Remnant vegetation is scarce. **'It is conservatively estimated that only about 5% of former pre-European indigenous vegetation exists in the City of Greater Geelong… often severely degraded.'** (CoGG Biodiversity Strategy 2001).

The City of Greater Geelong is responsible for managing conservation reserves on freehold land owned by council or on Crown Land. The CRT is an on-ground crew that delivers, amongst other things, weed control for the purposes of biodiversity rehabilitation in CoGG-managed reserves and selected roadsides. It works as part of the Environment and Waste Services Unit of the CoGG. The unit also uses contractors to provide broader-scale weed control on reserves and roadsides and strong working relationships with several environmental consultants have been developed. Program objectives include reducing fuel load along strategic fire-break roads, meeting statutory obligations and improving biodiversity values.

Prioritising weed control

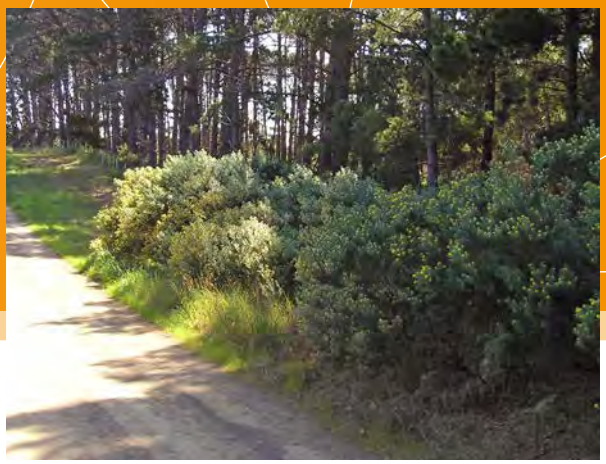
Flax-leaf broom is widespread throughout the region, where it out-competes remnant native plants and harbours feral animals. It is also considered a serious fire hazard. Broom control projects are strategically prioritised (as one of several woody weeds), especially along roadsides designated as strategic firebreaks.

According to Alex, flax-leaf broom proliferates ***'under the wire, where farmers can't plough it and roadside maintenance teams can't mow it. It's generally worst on properties with absentee landowners, or properties falling out of production waiting for subdivision.'***

Salt Lagoon is a site once used as a tip and council depot. It contains remnant woodland with sheoak and moonah fringing a saltmarsh. Flax-leaf broom forms a dense impenetrable barrier over three metres high on disturbed ground and is spreading into adjacent areas. The plan is to weed within the

A. Shackleton

Flax-leaf broom spreading along an urban roadside in a new subdivision, St Leonards



A. Shackleton

Head-high flax-leaf broom can dominate roadsides, creating visual hazards and greatly increased fuel loads, Indented Head

surviving remnant first, which is in a good position to recover, and then progressively eliminate the core weed infestation on the disturbed ground.

In other sites, flax-leaf broom is less well established, so the CRT is targeting these areas. ***'It's getting into the dunes so we're responding and keeping infestations down,'*** says Alex. In addition, ***'we're prioritising the northern area of the municipality where it is still controllable and has not yet spread into wooded areas.'***

In order to initiate projects of sufficient scale and longevity, the CoGG applies for sizeable grants from federal and state sources, such as the federally-funded Corangamite Catchment Management Authority Coast Tender Program.

Working with the community

Flax-leaf broom is considered desirable by some landowners, who utilise it as animal fodder.

To raise community awareness in targeted areas of new or low-infestation, and gain support from landowners, mail outs are undertaken and selected properties are visited to encourage engagement or provide direct site-advice. Neighbours were also notified of large-scale roadside works such as those on Old St Leonards Road. This is aimed at encouraging them to 'join in' at an opportune time, and reduce the chances of cross-seeding to and from differing land tenures.

Conservation Volunteers Australia works with the CRT primarily on manual weed removal in places inaccessible to machinery. ***'They're great to work with. They've got their own OH&S controls and they're not tied to particular reserves, which allows for flexibility in responding to outbreaks of broom, along with other woody weeds.'*** Regular teams of locally based volunteers also provide levels of knowledge and skills needed for sensitive hand weeding. Friends groups focus on selected reserves and raise funds to enable works.

Matching control methods with different sites and conditions

Research and management information about flax-leaf broom is scarce, so the CRT has adapted methods used successfully with other weeds. Typically, control is a three-stage process:

1. Tall, dense infestations are cut and burned, or cut and removed and the stumps painted with herbicide.
2. Burning produces mass germination of broom seedlings, which are sprayed or burnt using a gas gun. The burn option gives better long-term management results but is not possible on

A. Shackleton

A handweeded strip on a roadside adjacent to an uncontrolled patch of flax-leaf broom on adjoining private property – sensitive handweeding reveals indigenous groundflora and lowers fuel loads

A. Shackleton

Burning either through the use of gas guns (above) or a larger planned burn (below) can allow for easier follow-up spraying, as well as triggering germination of desirable local species

some sites. Cutting and painting gives rise to both seedlings and resprouts, especially if not done properly. Germination following cut and paint control is not as prolific as after a burn, so follow up is required over a longer period to ensure all seedlings are controlled.

3. After three to five years, the site enters a regular maintenance cycle.

The CRT has developed methods for working in sensitive grasslands and grassy woodlands. ***'Initially, spray with half-strength glyphosate. This doesn't kill the plant, but dries off foliage to provide fuel. Burn it then wait for the mass germination event. Either respray or burn again and repeat over two or three years, by which stage you should be down to about 5–10% of original coverage. Then maintain weed control and allow remnant vegetation to recover.'***

The target weed, its physical setting and the presence of remnant vegetation determine the choice of treatment, both in terms of herbicide choice and if /how/when a site can be burnt. Alex stresses that, ***'Weed spraying, or any treatment for that matter, that eliminates remnant vegetation is counterproductive. One of the merits of the spray-burn-spray method is that it removes biomass build-up. This in turn frees up space for regeneration, as well as improving future spraying efforts by allowing better targeting of weeds while avoiding collateral damage. As some indigenous species are fire-dependent, burning can germinate plants that were not initially evident.'*** The CoGG works closely with the County Fire Authority to coordinate larger site burns.

Experience suggests that forestry mowers are not suited to clearing flax-leaf broom in bushland settings. According to Alex, ***'Because it's flexible and stringy, broom tends to leave a dense mulch mat on the ground, creating an intense nutrient load and a smothering effect. Without triggering a mass germination through fire, which you can easily re-treat, you set yourself up for a much more protracted period of follow-up work. You miss the opportunity for a cleared deck that you get with fire'*** which provides remnant vegetation a better opportunity to recover. ***'The remaining high nutrient load, in turn, favours the return of weed species, rather than tilting the balance towards indigenous regeneration. Like any weed control, it is a process, not an event. We need to look not only to the short term gains, but also set ourselves up so that the sites have the best possible chance for regeneration in the longer term. This also***

A. Shackleton

Using forestry mowers on flax-leaf broom is problematic as a thick, stringy mulch is left behind which adds to nutrient levels, as well as obstructing spraying of new germinants

usually works out cheaper for us over the longer term as well.'

Among remnant grasslands, the CRT employs hand weeding or broadleaf spraying, applied very carefully from backpacks, and adhering to specialist bushland rather than agricultural methods. Cautious about replanting treated sites, the CRT adopts a wait-and-see approach to limit further disturbance and observe regeneration of remnant native vegetation or pasture grasses.

Sites require a commitment spanning decades and a coordinated approach. Portarlington Recreational Reserve hosts substantial gorse, blackberry and broom infestations. Most upper and middle storey flora is lost and only ***'a smattering of wattles remains'***. The CRT adopted a 20-year time frame and targeted gorse and blackberries first. Flax-leaf broom will be left in situ and contained for the moment, providing habitat while regeneration from nearby remnant bushland is closely monitored.

A $60,000 program was started five years ago along 11 km of St Leonards Road, from Drysdale to St Leonards with 600 m sections totally dominated by flax-leaf broom 3 m high. As the road is a strategic firebreak, weed control was incorporated into fuel reduction works. Initially, treatment comprised cutting by toothed disc on brush cutters and painting with glyphosate. This reduced the fire hazard and made the site more easily workable, but the ten-second herbicide application limit (after cutting stems) was missed, so there were many reshoots. Dense low-level broom regeneration will be sprayed, gas gunned and mowed for three seasons, before being placed on the regular maintenance schedule. Traffic management is the single biggest expense of this project, totalling about 60–70% of the project cost.

Monitoring, evaluation and review

The CRT has developed resourceful ways to make the most of a very limited budget. Alex points out that, ***'We have only recently been supplied with a GPS and most of the historical work relied on a compass and a 60 m tape. We're really good at mud-mapping!'***

Monitoring is kept simple and regular. ***'I drive up the road and check my sites, and anything that shouldn't be there gets clobbered, sprayed, chipped, pulled, mowed or burned.'***

Alex and her crew might only number five, but low staff-turnover ensures local knowledge and expertise is developed and retained, and is key to achieving successful weed control: ***'When you're driving along St Leonard's Road, it's not a broom woodland anymore. In Buckley Park Foreshore Reserve, we've got a coastal grassland mosaic that is holding its own after 11 years effort. Yes, it gets maintenance, but it's functioning. It's gone from four native species to at least 40. At Anakie, we've stopped it getting into the forest and have negligible growth on the roadside, literally a handful of plants instead of wall-to-wall broom.'***

Optimistic about managing flax-leaf broom, Alex warns it is ultimately a matter of money and calls for more research: ***'It's not a one-or-the-other approach. It's both keeping it out of areas it hasn't got into, and it's about tackling the heavy infestations in a strategic manner. It can be done. We know how to kill it.'***

Section 7

Further information

Further information

Legislation relevant to broom weeds

Scotch broom, Montpellier broom and flax-leaf broom are prohibited entry into Australia. All three species are declared weeds in some states or territories and may be restricted from sale and/or require control. Invasion and establishment of Scotch broom is a key threatening process under the NSW *Threatened Species Conservation Act 1995*. Broom control that may cause damage to native vegetation may also be subject to legislation.

Declared status of WoNS broom species in each state/territory of Australia (June 2014)

	Relevant legislation	Scotch broom	Montpellier broom	Flax-leaf broom
ACT	*Pest Plants and Animals Act 2005*	Must be suppressed Prohibited	Must be suppressed Prohibited	Prohibited
NSW	*Noxious Weeds Act 1993*	The plant must not be sold, propagated or knowingly distributed across NSW, And: Control Class 3 (regionally controlled) weed = 11 LCAs And: Control Class 4 (Locally controlled) weed = 38 LCAs	As a notifiable weed in parts of NSW, the plant is banned from sale or from being knowingly distributed across NSW, And: Control Class 2 (Regionally prohibited) weed = Lord Howe Island And: Control Class 3 (regionally controlled) weed = 98 LCAs And: Control Class 4 (Locally controlled) weed = 11 LCAs	The plant must not be sold, propagated or knowingly distributed across NSW, And: Control Class 3 (regionally controlled) weed = 5 LCAs And: Control Class 4 (Locally controlled) weed = 1 LCA
NT	*Weeds Management Act 2001*	Not declared	Not declared	Not declared
QLD	*Land Protection (Pest and Stock Route Management) Act 2002*	Not declared Note: Qld Parliament approved the Biosecurity Bill in March 2014, which will come into effect no later than July 2016	Not declared Note: Qld Parliament approved the Biosecurity Bill in March 2014, which will come into effect no later than July 2016	Not declared Note: Qld Parliament approved the Biosecurity Bill in March 2014, which will come into effect no later than July 2016
SA	*Natural Resources Management Act 2004*	Movement and sale prohibited in whole of State Control required in areas at risk	Movement and sale prohibited in whole of State Control required in areas at risk	Declaration pending, in line with national strategy (as at June 2014)
TAS	*Weed Management Act 1999*	Importation, movement and sale prohibited. Landholders may be required to control. Zone A municipalities required to eradicate	Importation, movement and sale prohibited. Landholders may be required to control. Zone A municipalities required to eradicate	Not declared
	Plant Quarantine Act 1997	Declared List B The importation of this species into Tasmania is restricted	Declared List B The importation of this species into Tasmania is restricted	Not declared
VIC	*Catchment and Land Protection Act 1994*	Declared. Regionally prohibited in 2 CMAs. Regionally controlled in 5 CMAs. Restricted in 3 CMAs	Declared. Regionally controlled in 7 CMAs. Restricted in 3 CMAs	Declared. Regionally prohibited in 2 CMAs. Regionally controlled in 4 CMAs. Restricted in 4 CMAs
WA	*Biosecurity and Agriculture Management Act 2007*	Prohibited	Unassessed	Permitted

Relevant legislation and regulating authority for the use of pesticides in each state/ territory of Australia

	Relevant legislation	Regulating authority
ACT	*Environment Protection Act 1997*	Environment Protection Authority
NSW	*NSW Pesticides Act 1999*	Environment Protection Authority
NT	*Agricultural and Veterinary Chemicals (Control of Use) Act*	Department of Primary Industries and Fisheries
QLD	*Queensland Chemical Usage (Agricultural and Veterinary) Control Act 1988*	Qld Department of Agriculture, Fisheries and Forestry
SA	*Agricultural and Veterinary Products (Control of Use) Act 2002 and Regulations 2004*	Primary Industries & Regions South Australia, by Biosecurity SA
TAS	*Agricultural and Veterinary Chemicals (Control of Use Act) 1995*	Department of Primary Industries, Parks, Water and Environment
VIC	*Agricultural and Veterinary Chemicals (Control of Use) Act 1992*	Department of Environment and Primary Industries
WA	*Agricultural and Veterinary Chemicals (Western Australia) Act 1995*	Department of Agriculture and Food Western Australia

Threatened species legislation relevant to brooms

	Relevant legislation	Declaration details
Federal	*Environment Protection and Biodiversity Conservation Act 1999*	Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants is listed as a KEY THREATENING PROCESS
NSW	*Threatened Species Conservation Act 1995*	Invasion and establishment of Scotch broom (*Cytisus scoparius*) as a KEY THREATENING PROCESS in Schedule 3 of the Act Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants as a KEY THREATENING PROCESS in Schedule 3 of the Act
VIC	*Flora and Fauna Guarantee Act 1988*	Invasion of native vegetation by 'environmental weeds'

Safety

All weed control activities involve risk, so personal safety must be prioritised. Regulations regarding the safe use of herbicides and machinery must be followed and personal protective equipment such as gloves, respiratory equipment, eye and ear protection worn as appropriate. Training may also be required for handling herbicides and operating machinery (see Section 4 – Chemical options).

New Commonwealth Occupational Health and Safety (OH&S) legislation, regulations and codes of practice were introduced in 2011. The ACT, NSW, Qld and NT revised their Work Health and Safety (WHS) regulations in 2012. Other states have updated their own workplace safety structures accordingly. Check with your state or territory for the latest information.

In some states, areas where restoration work is carried out are classified *work places*. Here, participating volunteers are classified as *workers* subject to the same health and safety regulations as managing agency employees.

Guidance, information and fact sheets for working with volunteers are available from Safe Work Australia at www.safeworkaustralia.gov.au, and relevant authority websites in each state.

A risk management tool called *Running the Risk?* is available from Volunteering Australia at volunteeringaustralia.org/wp-content/files_mf/1377053059VAManagersrunningtherisk.pdf. Contact your local council or natural resource management agency for current information about safety and weed management.

Further information

Protection of native vegetation and threatened species

Restoration works can impact on native vegetation and threatened species. Remember this includes herbs and grasses as well as trees and shrubs. Before commencing works, familiarity with relevant legislation governing weed control activities in your state is essential. Working near threatened species, impacting threatened species or propagating threatened species may require a permit.

Contact your local or state government authority for advice on state and federal legislation and any local laws governing weed control activities in natural areas or near waterways, before commencing any weed control activities.

Native vegetation and threatened species contacts

	Native vegetation contacts	Threatened species contacts
ACT	Dept. of Territory and Municipal Services 132 281 www.tams.act.gov.au/parks-recreation/plants_and_animals *Nature Conservation Act 1980*	Dept. of Territory and Municipal Services 132 281 www.tams.act.gov.au/parks-recreation/plants_and_animals *Nature Conservation Act 1980*
NSW	Office of Environment and Heritage 131 555 www.environment.nsw.gov.au/vegetation *The Native Vegetation Act 2003* and *Native Vegetation Regulation 2005*	Office of Environment and Heritage 131 555 www.environment.nsw.gov.au/threatenedspecies *Threatened Species Conservation Act 1995*
NT	Dept. of Land Resource Management (08) 8995 5001 www.lrm.nt.gov.au/natveg *Planning Act 2009* and *Pastoral Lands Act 1992*	Dept. of Land Resource Management (08) 8995 5001 www.lrm.nt.gov.au/plants-and-animals/threatened-species *Territory Parks and Wildlife Conservation Act 2000*
QLD	Dept. of Natural Resources and Mines phone numbers for each region at: www.dnrm.qld.gov.au/land/vegetation-management/contacts *Vegetation Management Framework Amendment Bill 2013*	Dept. of Environment and Heritage Protection 137 468 www.ehp.qld.gov.au/wildlife/threatened-species/endangered/index.html *Nature Conservation Act 1992 (NCA)* *Nature Conservation (Wildlife) Regulation 2006*
SA	Dept. of Water, Land and Natural Resources (08) 8204 1910 www.environment.sa.gov.au/Conservation/Native_vegetation *Native Vegetation Act 1991* *Native Vegetation Regulations 2003*	Dept. of Water, Land and Natural Resources (08) 8204 1910 www.environment.sa.gov.au/Plants_Animals/Threatened_species_ecological_communities *South Australia's National Parks and Wildlife Act 1972*
TAS	Dept. of Primary Industries, Parks, Water and Environment 1300 368 550 or (03) 6233 3295 dpipwe.tas.gov.au/conservation *Forest Practices Act 1985* and *Land Use Planning and Approvals Act 1993*	Dept. of Primary Industries, Parks, Water and Environment 1300 368 550 or (03) 6233 8759 dpipwe.tas.gov.au/conservation/threatened-species *Threatened Species Protection Act 1995*
VIC	Dept. of Environment and Primary Industries 136 186 www.depi.vic.gov.au/environment-and-wildlife/biodiversity/native-vegetation *Catchment and Land Protection Act 1994*	Dept. of Environment and Primary Industries 136 186 www.depi.vic.gov.au/environment-and-wildlife/threatened-species-and-communities *The Flora and Fauna Guarantee Act 1988*
WA	Dept. of Environmental Regulation Native Vegetation Conservation (08) 6467 5020 http://www.der.wa.gov.au/your-environment/native-vegetation *Environmental Protection Act 1986*	Dept. of Parks and Wildlife (08) 9334 0455 www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities *Wildlife Conservation Act 1950*
Federal	Dept. of the Environment (02) 6274 1111 www.environment.gov.au/land/vegetation/index.html *Environment Protection and Biodiversity Conservation Act 1999*	Dept. of the Environment (02) 6274 1111 www.environment.gov.au/biodiversity/threatened *Environment Protection and Biodiversity Conservation Act 1999*

Rare or threatened species and vegetation of conservation significance should be identified at your site and in your broom management plan (see Section 2).

Cultural heritage

Before beginning restoration work in areas that may hold cultural significance, it is appropriate and respectful to assess all issues, and this may be required by state or territory legislation. Contact your local government or natural resource management authority for information about appropriate procedures. Copies of the laws summarised in the table below are available online from Australasian Legal Information Institute at www.austlii.edu.au.

Note that the databases listed in the following table may not be comprehensive registers of culturally significant places. Previously unknown sites of Indigenous cultural significance are frequently revealed during the course of on-ground works. A useful introduction to identification, consultation and management of new sites titled *Ask First: A guide to respecting Indigenous heritage places and values* is available online from the Australian Heritage Council at www.environment.gov.au/heritage/ahc/publications/commission/books/ask-first.html.

Cultural heritage legislation and information

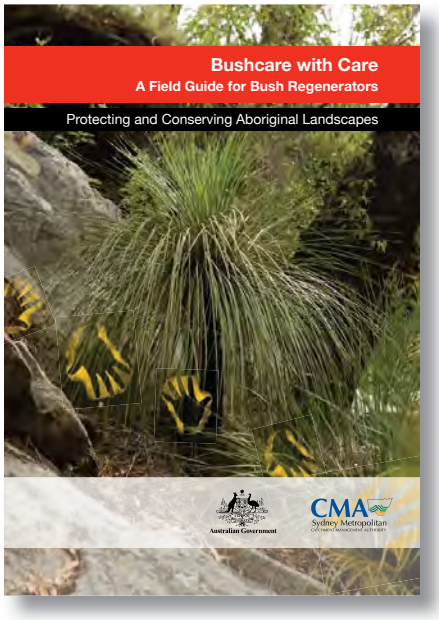
	Act	Register and managing agency	Website
ACT	*Heritage Act 2004* *Heritage Objects Act 1991*	Heritage Register; Environment and Sustainable Development Directorate	www.environment.act.gov.au/heritage/heritage_register
NSW	*Heritage Act 1977* *National Parks and Wildlife Amendment (Aboriginal Ownership) Act 1996*	State Heritage Register; Office of Environment and Heritage	www.environment.nsw.gov.au/heritageapp/heritagesearch.aspx
NT	*Aboriginal Sacred Sites Act 1989* *Heritage Conservation Act 1991*	Register of Sacred Sites; Aboriginal Areas Protection Authority	www.aapant.org.au
QLD	*Aboriginal Cultural Heritage Act 2003* *Torres Strait Islander Cultural Heritage Act 2003* *Queensland Heritage Act 1992*	Aboriginal and Torres Strait Islander Cultural Heritage Register; Dept. of Aboriginal and Torres Strait Islander and Multicultural Affairs	www.datsima.qld.gov.au/atsis/aboriginal-torres-strait-islander-peoples/indigenous-cultural-heritage
SA	*Aboriginal Heritage Act 1988* *Heritage Act 1994*	Heritage Sites Database; Dept. of Water, Environment and Natural Resources	www.environment.sa.gov.au/our-places/Heritage/SA_Heritage_Register
TAS	*Aboriginal Relics Act 1975* *Historic Cultural Heritage Act 1995*	Tasmanian Aboriginal Site Index; Dept. of Primary Industries, Parks, Water and Environment	www.aboriginalheritage.tas.gov.au/tasmanian-aboriginal-site-index-(tasi)
VIC	*Aboriginal Heritage Act 2006* *Heritage Act 1994*	Victorian Aboriginal Cultural Heritage Register; Dept. of Premier and Cabinet	http://www.dpc.vic.gov.au/index.php/aboriginal-affairs/heritage-tools
WA	*Aboriginal Heritage Act 1972* *Heritage of Western Australia Act 1990*	Register of Aboriginal Sites; Dept. of Aboriginal Affairs	www.daa.wa.gov.au/en/Site-Search/
Federal	*Aboriginal and Torres Strait Islander Heritage Protection Act 1984* *Environment Protection and Biodiversity Conservation Act 1999* *Australian Heritage Commission Act 1975*	The Australian Heritage Database contains information for over 20,000 natural, historic and indigenous places. Searching by local government area provides a list of heritage places in each locality; Dept. of the Environment	www.environment.gov.au/topics/heritage/publications-and-resources/australian-heritage-database

Further information

A guide for protecting and conserving Aboriginal landscapes called *Bushcare With Care* is available online from the former Sydney Metropolitan CMA at www.sydney.cma.nsw.gov.au/index.php?option=com_remository&Itemid=51&func=startdown&id=218.

Government appointed natural resource management officers can help with questions about Aboriginal heritage. State, territory and regional contacts are available online from Caring for our Country at www.nrm.gov.au/contact/officers.html.

Most states and territories maintain Indigenous heritage site registers. Because of the sensitive and vulnerable nature of many sites, access to some information may be restricted and require an application process. As well as accessing information, it is equally important to report previously unknown sites for entry into the databases. For more information, contact the government agency responsible for managing each register.



The Bushcare with Care guide is available online

Information for community volunteers

Incorporating a volunteer group is a straightforward and inexpensive process that is highly recommended. Incorporation is required for independent government grant and funding applications. An alternative is for your group to join a large organisation that acts as an *umbrella body*. Regional Landcare groups often have multiple member groups covered by their incorporation and provide funds management and insurance cover.

There are many funding opportunities for weed management. These may be included in applications that have wider scope than just weeding activities, such as projects for restoration of native vegetation. Grants may be available from federal and state government sources, natural resource management boards, local councils and non-government organisations. Information about government grants is available from the Commonwealth Department of Environment (see table on page 139).

NSW Government Environment and Heritage website http://www.environment.nsw.gov.au/

Funding, organisational and training resources for volunteer groups

Entity	Information	Website
Australian Association of Bush Regenerators	Bushcare Volunteer Training and Professional Support materials – VCN Manual 2012 and 'Bushcare Booster' Training Modules	http://www.aabr.org.au/learn/professional-practice/manuals/
Central Coast (NSW) Community Environment Networks	Workshops and events	www.cen.org.au
Coast Care	Community coast care groups	www.coastcare.com.au
Commonwealth Department of the Environment	Government grants	www.environment.gov.au/biodiversity/invasive/weeds/government/index.html
Landcare Australia	Community land care groups	www.landcareonline.com.au
Landcare Tasmania	Volunteer recruitment, training, incorporation and insurance	www.landcaretas.org.au
Natural Resource Management knowledge online	Digital online archive for information about natural resource management activities	nrmonline.nrm.gov.au
School of Volunteer Management	Volunteer management education and training activities	www.svm.edu.au
The Centre for Volunteering	Skills, training and education resources for volunteers, managers of volunteers, trainers and not-for-profit organisations	http://www.volunteering.com.au/tools_and_research/useful_links.asp
Training.gov.au (TGA)	Vocational education and training in Australia; formerly The National Training Information Service and Australian National Training Authority	training.gov.au
Victorian Landcare Gateway	Volunteer recruitment, training, incorporation and insurance	www.landcarevic.net.au
Volunteering Australia	National standards and best practice information and materials for volunteers and volunteer managers	http://www.volunteeringaustralia.org/policy-and-best-practise/best-practise/
Volunteering WA	Useful range of volunteering resources	www.volunteeringwa.org.au/resources.aspx

Further information

Useful contacts and information

	Organisation	Website	Information available
National	**Weeds Australia**	www.weeds.org.au/WoNS www.weeds.org.au/WoNS/brooms	Weed ID Legislation Contacts and web links
	Dept. of Agriculture	www.daff.gov.au	Web links Funding Biosecurity
	Dept. of Agriculture's import conditions database	http://www.daff.gov.au/biosecurity/import/icon-icd	Import conditions for foreign plants and other commodities
	Dept. of the Environment	www.environment.gov.au/topics/biodiversity/invasive-species	Invasive species Legislation Biosecurity Funding
	Australian Association of Bush Regenerators	www.aabr.org.au	Bush regeneration
	Australian Pesticides and Veterinary Medicines Authority	www.apvma.gov.au portal.apvma.gov.au/permits portal.apvma.gov.au/pubcris	Herbicide permits / labels, registrations Safe herbicide use
	ChemCert Australia	www.chemcert.com.au	Chemical handling, training and certification
	Smart Train	www.smarttrain.com.au	Herbicide training and manuals
	Safe Work Australia	www.safeworkaustralia.gov.au	OH&S
	Drum Muster	www.drummuster.com.au	Recycling chemical containers
ACT	**Environment and Sustainable Development Directorate Territory and Municipal Services**	www.environment.act.gov.au/environment www.tams.act.gov.au/parks-recreation/plants_and_animals	Weed control Natural resource management Environmental protection
New South Wales	**Dept. of Primary Industries**	www.dpi.nsw.gov.au www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/123317/Noxious-and-environmental-weed-control-handbook.pdf www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/links	Noxious weeds Funding opportunities Legislation Education / awareness Control handbook
	Office of Environment and Heritage, NSW National Parks and Wildlife Service	www.environment.nsw.gov.au www.environment.nsw.gov.au/pestsweeds www.environment.nsw.gov.au/cpp/ConservationPartners.htm	Weed management legislation Conservation partners program Cultural awareness
	Local Land Services (former CMAs)	www.lls.nsw.gov.au	Regional community support officers Regional weed plans

	Organisation	Website	Information available
NT	**Dept. of Land Resource Management**	www.lrm.nt.gov.au/weeds	Noxious weeds Weed risk management
Queensland	**Dept. of Agriculture, Fisheries and Forestry (Biosecurity Queensland)**	www.daff.qld.gov.au	Control methods Declared plants legislation
	SEQ Fire and Biodiversity Consortium	www.fireandbiodiversity.org.au	Fire management for biodiversity
	Advancing Rural Queensland	www.agforceqld.org.au	Land management chemical accreditation
	Qld Regional NRM Groups Collective	www.rgc.org.au	Resource management
South Australia	**Biosecurity SA** **Dept. of Primary Industries and Regions SA (PIRSA)**	www.pir.sa.gov.au/biosecuritysa/nrm_biosecurity/weeds	Noxious weeds Biological control Weed risk management
	Natural Resources Management	www.nrm.sa.gov.au	Catchment management
	Adelaide and Mt Lofty Ranges NRM Board	www.youtube.com/watch?v=Gudl7cDyxf0&feature=player_embedded	YouTube video 'How to control broom'
Tasmania	**Dept. of Primary Industries, Parks, Water and Environment**	www.dpipwe.tas.gov.au/weeds	Noxious weeds Legislation Management plans
Victoria	**Dept. of Environment and Primary Industries, Parks Victoria**	www.depi.vic.gov.au parkweb.vic.gov.au	Noxious weeds Chemical use Biological control Legislation Catchment management
Western Australia	**Dept. of Agriculture and Food**	www.agric.wa.gov.au	Declared plants Weed control Legislation/Biosecurity
	Dept. of Parks and Wildlife	www.dpaw.wa.gov.au	Natural resource management Conservation
	Environmental Weeds Action Network	www.environmentalweedsactionnetwork.org.au/projects.html	Bushland Weeds Manual
	Natural Resource Management	www.nrm.wa.gov.au	Natural resource management

Further information

Glossary

Adjuvant	A substance added to a herbicide mixture to aid or modify the action of the herbicide
Alkaloid	A chemical substance of plant origin composed of carbon, hydrogen, nitrogen, and (usually) oxygen; can have physiological effects on animals
Alluvial	Pertaining to the sediment deposited by creeks and rivers
Annual	A plant that germinates, flowers and dies in one year or less
Aril	A fleshy appendage to a seed
Cambium	The thin layer of cells between the phloem and xylem; the area in the plant stem that derives the cells that transport sap and water around the plant
Coppice	To reshoot, resprout or regrow from the base of an existing main trunk or stem
Cryptic	Difficult to distinguish; hidden or camouflaged in the natural environment
Deciduous	A plant that seasonally loses its leaves for part of the year
Elliptic	Oval in shape, broadest around the middle
Gall	An abnormal swelling or growth of plant tissue as a response to attack from organisms such as insects or a virus
Geomorphology	The scientific study of landforms and the processes that shape them
Heartwood	The older non-living central wood of tree trunks
Leguminous	Belonging to the pea (Fabaceae) family, with seeds in pods
Naturalised	Originating elsewhere but established and reproducing itself in a new area without assistance
Nymph	The immature form of some invertebrates that undergoes metamorphosis before reaching adult stage.
Obovate	An oval shape with the length 1–3 times the width, but broadest above the middle
Penetrant	An adjuvant mixed with a herbicide spray mix to help the herbicide enter the plant (e.g. through waxy leaves or woody plant material)
Perennial	A plant whose life span extends over more than one growing season
Propagule	Any part of a plant that can become detached to produce a new plant; e.g. bud, corm, seed, spore
Provenance	The geographical and genetic source of a particular plant or seed
Pupate	To go through the metamorphic state of an insect developing from a larva to adult, usually enclosed in a cocoon or protective covering
Sapwood	The soft outer layers of recently formed wood between the heartwood and the bark, containing the functioning vascular tissue (xylem and phloem)
Scarify	To scratch or abrade the protective coating of a seed to provoke germination
Senesce/senescence/ senescent	Process of drying and withering in period between maturity and death of a plant, or part of a plant. The natural end of a plant's lifespan
Surfactant	An additive (adjuvant) to a herbicide spray mix that increases spray coverage on the leaf and helps the herbicide stick to the plant, increasing herbicide uptake
Vector	A thing or process that helps transport seeds
Vegetative growth	New individuals arise without process of sexual reproduction when viable propagules become detached from parent plants and establish new independent plants
Wetting agent	A surfactant

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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.

List all relevant weed strategies (e.g. state weed strategy, regional weed 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:

☐	Target weed density	☐	Ecological communities
☐	Other weeds	☐	Cultural heritage
☐	Natural features	☐	Map legend
☐	Built amenities	☐	North orientation
☐	Threatened species	☐	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).

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

G. Control methods

- **Identify the stages (initial or follow-up) of the 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 target weed present and the stage of control identified above.
- **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.
- **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 target weed control or the response of native species to target weed 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

Broom

Management Manual