Section Three

Control methods

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Key points

Follow-up what you started

The key to successful boneseed control is sustained follow-up work over a number of years. Removal of mature plants promotes seedling germination from the long-lived seedbank, and these seedlings must be controlled before they establish and set seed. Seedlings will continue to emerge from the seedbank (perhaps for up to 10 years), or seeds may be dispersed into the area. Annual removal of these seedlings will be necessary for many years.

Integrate methods

Often the most successful and cost-effective way to control weeds is to combine or integrate different control methods (known as integrated weed management). An integrated approach does not need to be complicated. It may be as simple as using different techniques for initial and follow-up control – for example, mature plants might be treated by herbicide application, and the seedlings hand pulled in following years.

Choose methods based on the ecosystem, terrain, available resources and the size and density of the boneseed infestation. Target the timing of each treatment to coincide with the most vulnerable growth stage or season.

The following examples illustrate how methods can be integrated through the various stages of control in different situations. The control methods listed are the best options available for each situation. Detailed information on each of these control methods is presented later in this section.

Example 1 – Scattered boneseed plants in native bushland

Key points Use minimal disturbance techniques, and remove mature plants before they fruit (or you will have to dispose of the seeds). Many seedlings will die in their first summer, so follow-up seedling control should be done after summer to save unnecessary effort. If you wish to eradicate boneseed from the area, you will need to conduct annual surveys and remove all seedlings for many years.

Stages of control and appropriate methods:

- initial control to remove all boneseed plants by:
  ✔ hand pulling, cut-and-swab, or stem injection (for large plants)
- follow-up control of seedlings and any overlooked mature plants by:
  ✔ hand pulling, cut-and-swab
- natural native regeneration
- follow-up control of seedlings by:
  ✔ hand pulling

Example 2 – Dense boneseed infestation in native bushland

Key points Same as for Example 1. In addition, remove isolated plants first. Dense infestation can then be controlled in stages. Remove boneseed from small areas, or thin out the infestation, to allow native groundcovers to regenerate and resist further weed invasion. This approach also restricts herbivores from grazing on newly emerging native seedlings, and allows native animals to gradually adjust to changes in the habitat.

Stages of control and appropriate methods:

- initial control to remove isolated boneseed plants and thin out main infestation by:
  ✔ hand pulling, cut-and-swab, or stem injection (for large plants)
- natural native regeneration
- further control to remove all mature boneseed plants and new seedlings by:
  ✔ hand pulling, cut-and-swab, or stem injection (for large plants)
- natural native regeneration
- follow-up control of seedlings by:
  ✔ hand pulling

Example 3 – A planned hazard reduction burn by local fire authorities in an area containing boneseed

Key points Mature boneseed may not be killed by a low intensity prescribed burn, and soil temperatures may not be high enough to affect the seedbank. By slashing or hand pulling mature plants a few weeks or months prior to the burn you can increase boneseed mortality and fuel loads at ground level. The higher soil temperatures generated should also kill many seeds and stimulate mass seedling germination. Wait until just before the seedlings flower to control them, as they will thin out naturally through competition (they may flower in the first year after a fire).

Stages of control and appropriate methods:

- pre-treatment to dry out foliage before a hazard reduction burn by:
  ✔ hand pulling, slashing (with an axe or brush-cutter)
- hazard reduction burn
- follow-up control of post-burn seedlings just before they flower by:
  ✔ hand pulling or foliar spraying
- natural native regeneration
- follow-up control of seedlings by:
  ✔ hand pulling

Hillary Cherry

Grasp the stem close to the ground.

Manual control

Manual control is performed using no tools or hand tools only, and methods include hand pulling and cutting without herbicide (see box on page 26). Manual control methods cause minimal soil disturbance and minimal damage to desirable vegetation, thus reducing the risk of erosion and limiting the germination of weed seeds. Consequently, manual control is useful for tackling infestations in quality native bushland and in dunes or other areas prone to erosion.

Hand pulling

Because boneseed has a relatively shallow root system with no taproot, seedlings and young plants can be pulled out by hand. It is also possible to hand pull mature plants in sandy or moist soil, and hand tools are available that use leverage to help pull larger plants out of the ground (e.g. the 'Tree Popper'). Hand pulling mature plants is more difficult in heavier soils such as clay unless the soil is moist.

Method

For small seedlings, take hold of the stem at ground level and pull out vertically. Larger plants should be rocked backwards and forwards gently until they come away cleanly, or use a leverage tool. It's important to replace any disturbed soil and leaf litter as you go to reduce erosion and encourage regeneration of native seedlings.

Plants may be left to decay on site, provided the roots are not left in contact with the soil (otherwise they may re-establish).

Timing

This method can be used at any time of the year, but in areas with heavier soils you may need to wait until the soil is moist. Young plants must be removed before they first flower and set seed. Adult plants should ideally be removed when they are not in fruit in order to prevent the spread of seeds.

Treatment	Advantages	Disadvantages
Hand pulling	• Low impact on natural environment • Whole plant removed (no regrowth) • Selective (boneseed can be removed when growing close to desirable vegetation) • No costly chemicals or equipment required • Low level of soil disturbance if done carefully	• Time-consuming and labour-intensive • Not practical for extensive infestations • Can be difficult in heavier soils or with large plants

Cutting without herbicide

Trees For Life in South Australia have had success killing boneseed with a technique they call 'cutting' – this involves simply cutting off the stem close to the ground, without applying herbicide. This method is used for boneseed plants that are too big to pull by hand, or when soil erosion is an issue, such as in steep areas and gullies.

Cutting is used successfully in the Adelaide Hills and around the Barossa Reservoir, although boneseed in the adjoining Para Wirra Recreation Park has been found to resprout. Success may depend on light availability, soil type, soil moisture or season. On the Eyre Peninsula, resprouting is minimal in late summer and autumn, when soil moisture is lowest.

For a successful kill, the stem needs to be cut very close to the ground, and preferably slightly below ground level if possible. If more than two centimetres of the trunk is left above the ground, boneseed is likely to resprout. After cutting, any exposed roots should be re-covered with soil to prevent resprouting.

Bush saws are ideal for larger plants, while smaller plants can be cut with long-handled loppers. Brush-cutters fitted with a steel blade are very useful for stems up to about 3 cm in diameter. Chainsaws are not suitable as it is not possible to obtain the very low cut required without blunting the equipment.

Cutting without herbicide must be trialled to test its suitability to your particular area before it is used on a large scale. If successful, cutting is a very ecologically sensitive approach to boneseed control, as it causes minimal soil disturbance and requires no chemicals.

Kym Smith

If stumps are cut too high when cutting without herbicide, regrowth may occur.

Chemical control

When used as part of an integrated management strategy, the use of chemicals (herbicides) can be a practical and efficient way of controlling boneseed. Four herbicide application methods are currently registered for use on boneseed:

- cut-and-swab (where herbicide is applied to the stump of a felled plant)
- stem injection (where herbicide is injected into the sapwood of the plant)
- foliar spraying (where the leaves of the plant are sprayed with a herbicide solution)
- splatter gun application (also spraying with herbicide).

These four methods are discussed in detail later in the section.

Herbicide labels and legislation

The Australian Pesticides and Veterinary Medicines Authority (APVMA; formerly known as the National Registrations Authority) controls and regulates the use of all pesticides, which includes herbicides. Herbicides are registered with the APVMA for specific applications as stated on the label. By law, only herbicides registered for boneseed control can be used on boneseed, and only in the manner specified on the label. APVMA also issues permits for herbicide applications that are not otherwise registered, and these are often referred to as 'Off-label' permits. See the APVMA website for more information <www.apvma.gov.au>.

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

Safety and training

Personal protective equipment (such as protective clothing, eye or face shields, and respiratory protection) must be used in accordance with the recommendations stated on the herbicide label or permit. Chemical use training is required for people using herbicides as part of their job or business. Training is recommended for community groups, and may be required if working on public land. Training courses are run by ChemCert and TAFE in each state. Other training courses may be available through state agencies (e.g. AgTrain in Victoria, SMARTtrain in New South Wales), local councils or non-government organisations. See Section 6 for contact information.

Registered herbicides

There are many different herbicide products registered for use on boneseed. It is important to check that each herbicide product is registered in *your* state or territory for the particular application method you are planning to use. The active ingredients in herbicide products registered for use on boneseed are glyphosate, metsulfuron-methyl, 2,4-D amine, picloram and bromoxynil, in various concentrations. The APVMA has issued permits for the use of triclopyr ester in some states.

Table 1 lists the herbicides registered for use on boneseed, and the states in which these registrations apply. Herbicides that are not registered for use on boneseed but which have Off-label permits covering their use are also shown. Check the APVMA website for current registration and permit information <www.apvma.gov.au>, and always check the label for the correct application rate.

Table 1.
Summary of registered herbicides for boneseed (as of June 2006). 'PERXXXX' denotes permit number.

Application method	Active ingredient	Commercial product examples[1]	State or Territory[2]	Rate	Situation in which the herbicide is registered	Comments
cut-and-swab	2,4-D amine[3] 500 g/L	Smash	VIC, SA	undiluted	pastures, rights of way and industrial areas.	Apply to cut stump at any time of year.
	picloram 75 g/L + 2,4-D 300 g/L	Tordon™ 75-D	QLD, NSW, VIC, SA, WA	1 L/10 L water	pastures, rights of way, commercial and industrial areas.	Apply to cut stump at any time of year.
	glyphosate[3] 360 g/L	Roundup®, Roundup® Biactive™, Weedmaster® Duo, Nuturf Razor, Biochoice™ 360	NSW	1:1.5 with water	urban bushland and forests, and coastal reserves.	PER9158
			SA	1:1 with water	nature reserves and other native vegetation, roadsides, urban open spaces and forests.	PER8865
			TAS	undiluted to 1:5 with water	bushland and non-cropping situations.	PER8949
			WA	undiluted to 1:5 with water	non-agricultural areas, bushland, forests and wetlands.	PER4984
	triclopyr 600 g/L	Garlon™ 600	TAS	1:60 with diesel	bushland and non-cropping situations.	PER8949
	triclopyr 240 g/L + picloram 120 g/L	Access™	TAS	1:60 with diesel	bushland and non-cropping situations.	PER8949
			WA	1:60 with diesel	non-agricultural areas, bushland, forests and wetlands.	PER4984
	triclopyr 300 g/L+ picloram 100 g/L	Grazon™ DS	SA	undiluted	non-cropping situations.	PER7869 – Persons under direction of Animal & Plant Control Commission in SA.
	picloram 43 g/kg	Vigilant®	All	undiluted (gel form)	native vegetation, conservation areas, gullies, reserves and parks.	Apply 3–5 mm layer of herbicide gel to cut stump from 'brushbottle' supplied.

[1] Commercial products listed here are examples only, and many other products containing these active ingredients are registered for use on boneseed visit <www.apvma.gov.au>.

[2] Products may be registered for use on boneseed in all states and territories (shown as 'All') or only in the specific states and territories listed.

[3] Products containing different concentrations of the active ingredients 2,4-D amine and glyphosate are also registered for use on boneseed in various states, visit <www.apvma.gov.au>.

[4] Some manufacturers specify using a higher rate on plants over 1.5 m high.

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

Mick Richards, photo courtesy of DNRMW, QLD

Wear personal protective equipment when using herbicides.

Application method	Active ingredient	Commercial product examples[1]	State or Territory[2]	Rate	Situation in which the herbicide is registered	Comments
stem injection	glyphosate[3] 360 g/L	Roundup®, Roundup® Biactive™, Weedmaster® Duo, Nuturf Razor, Biochoice™ 360	TAS	2 mL undiluted per hole	bushland and non-cropping situations.	PER8949
			WA	2 mL undiluted per hole	non-agricultural areas, bushland, forests and wetlands.	PER4984
	triclopyr 300 g/L+ picloram 100 g/L	Grazon™ DS	SA	undiluted	non-crop situations.	PER7869 – Persons under direction of Animal & Plant Control Commission in SA.
foliar spray	glyphosate[3] 360 g/L	Roundup®, Roundup® Biactive™	QLD, NSW, VIC, TAS	5 or 10 mL/ 1 L water	all situations.	Best results achieved when treated at peak flowering during winter. Use higher rate on plants over 1.5 m high[4].
		Weedmaster® Duo, Nuturf Razor, Biochoice™ 360	All	5 or 10 mL/ 1 L water		
	2,4-D amine[3] 500 g/L	Smash	VIC, SA	100 mL/ 10 L water	pastures, rights of way and industrial areas.	Spot spray when in flower. Thoroughly wet all foliage.
	metsulfuron-methyl 600 g/kg	Brushmaster	All	10 g/ 100 L water	native pastures, rights of way, commercial and industrial areas.	Spray thoroughly to wet all foliage.
		Brushkiller™ 600, Brush-Off®	QLD, NSW, VIC, SA,	10 g/ 100 L water		
		All products	TAS	10 g/ 100 L water	bushland and non-cropping situations.	Permitted in TAS under PER8949. Spot spray using backpack.
	glyphosate 760.5 g/ kg + metsulfuron-methyl 63.2 g/kg	Cut-Out®	QLD, NSW, VIC, SA, ACT	95 g/ 100 L water	pastures, rights of way, commercial and industrial areas.	Spray thoroughly to wet all foliage.
			TAS	95 g/ 100 L water	bushland and non-cropping situations.	Permitted in TAS under PER8949. Spot spray using backpack.
	picloram 75 g/L + 2,4-D 300 g/L	Tordon™ 75-D	QLD, NSW, VIC, SA, WA	650 mL/ 100 L water	pastures, rights of way, commercial and industrial areas.	Spot spray when flowering or fruiting.
	bromoxynil 200 g/L	Bronco 200, Bromo 200	VIC, TAS	160 mL/ 100 L water	pastures, roadsides and rights of way.	Spot spray for young seedlings.
	triclopyr 300 g/L+ picloram 100 g/L	Grazon™ DS	TAS	350-500 mL/ 100 L water	bushland and non-cropping situations.	Permitted in TAS under PER8949. Spot spray using backpack.
	triclopyr 600 g/L	Garlon™ 600	TAS	170 mL/ 100 L water	bushland and non-cropping situations.	Permitted in TAS under PER8949. Spot spray using backpack.
splatter gun	glyphosate[3] 360 g/L	Roundup®, Roundup® Biactive™	QLD, NSW, VIC, TAS	1:29 or 1:19 with water	all situations.	Use higher rate (1:19) on bushes over 1.5 m high[4].
		Weedmaster® Duo	All	1:29 or 1:19 with water		

Cut-and-swab (cut-stump, cut-and-paint)

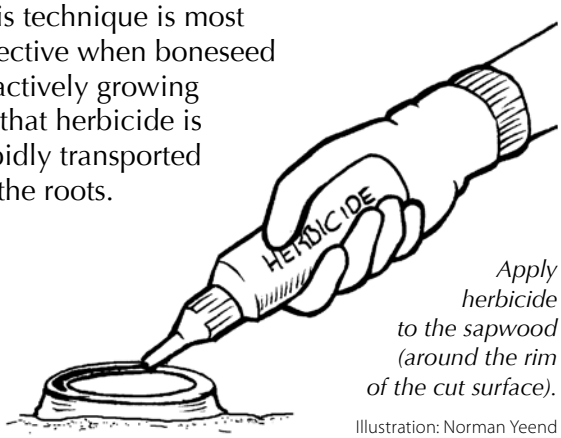
Also called cut-stump or cut-and-paint, the cut-and-swab method involves cutting the plant off at the base of the stem then immediately applying herbicide to the stump. Use this method for all boneseed plants that are too large to hand pull, or when soil disturbance should be avoided, such as in steep areas and gullies. Cut-and-swab is an ideal technique for use in native bushland, as there is little chance of off-target herbicide damage if done correctly.

Method

Cut through the stem horizontally as close to the ground as possible with a bush saw, secateurs, loppers, chainsaw or brush-cutter. Immediately (within 15 seconds) apply herbicide to the cut surface of the stump, before the plant cells close up and inhibit entry of the herbicide. This method works best when done by a two-person team – one person cutting and one person applying the herbicide. Herbicide can be applied using a squeeze bottle, sponge-tipped bottle or spray bottle. On larger stems, apply the herbicide to the outer sapwood (cambium layer) only, as only the sapwood will transport the herbicide to the roots.

Timing

This technique is most effective when boneseed is actively growing so that herbicide is rapidly transported to the roots.



Apply herbicide to the sapwood (around the rim of the cut surface).

Illustration: Norman Yeend

Peter Tucker

Use two people to cut-and-swab.

Kerry Brougham

Cut stem horizontally and as close to the ground as possible, to avoid leaving sharp stumps.

Read and follow all directions on the herbicide label. Usage restrictions are explained on the label (e.g. use is often restricted in wet weather).

Have you tried cutting without herbicide in your area? See box on page 26.

Left: Squirt bottle to apply herbicide. Below: Sponge-tipped bottle to apply herbicide.

Images: Trees For Life

Mick Richards, photo courtesy of DNRMW, QLD

Cut stem with loppers as close to the ground as possible.

Stem injection

Stem injection (also called drill-and-fill) delivers herbicide directly to the sapwood. Stem injection is an ideal technique for use in native bushland, as it causes minimal soil disturbance, and there is little chance of off-target herbicide damage if done correctly. This method is especially useful for large boneseed plants, as plants are left standing and can continue to provide shelter and habitat for native animals.

Kym Smith

Stem injection or drill-and-fill. Blue dye in herbicide shows that this plant has already been treated.

Method

Use a cordless drill to drill holes around the base of the trunk, no more than 50 mm apart. Holes do not need to go deeper than the sapwood layer, as the heartwood layer will not transport herbicide around the plant. Drilling holes at an angle of 45° will aid herbicide retention and increase absorption by the plant. Inject the herbicide within 15 seconds of drilling the hole, using a squeeze bottle or plastic syringe. Do not overfill the holes as excess herbicide is wasted and can contaminate the environment. Injection guns are available that can drill the hole and deliver a precise amount of herbicide.

Timing

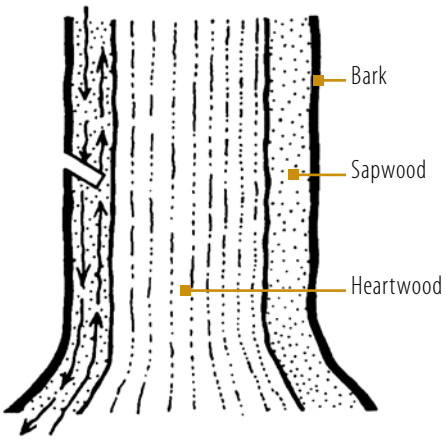
This technique is best used when boneseed is actively growing so that herbicide is rapidly transported around the plant.

Success using glyphosate

Trees For Life is a non-government organisation committed to the revegetation and protection of South Australia's native bushland. *Bush For Life* is its bushcare program, and volunteer bushcarers are trained in minimal disturbance bush regeneration techniques. Their preferred methods for controlling woody weeds in native bushland are hand pulling, cut-and-swab and stem injection.

They have had particular success in controlling boneseed using the cut-and-swab and stem injection methods with glyphosate herbicide. 'Many people don't realise that glyphosate is very effective on a range of woody weeds', says Peter Tucker, Technical Officer for Bush For Life. 'Glyphosate has few restrictions on its use, is cost-effective and requires less safety training, making it ideal for use by community bushcare groups'.

Peter has found that glyphosate is as good as any other herbicide at killing boneseed, with total mortality achieved when the cut-and-swab or stem injection methods are done properly.



Drill into sapwood not heartwood

Foliar spraying

Foliar spraying is the application of herbicide solution to leaves in the form of a fine spray. Foliar spraying can be used to treat plants of all ages. It is especially effective for treatment of dense 'carpets' of boneseed 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 boneseed-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 horticultural crops and vines.

Method

Foliar spraying of boneseed is usually done using a spray gun and backpack or vehicle-based spray unit; a small boom attachment is useful for spraying a dense cover of seedlings. Spray units connected to a tank and pump mounted on a vehicle are very useful when treating large areas. Plants must be sprayed thoroughly, wetting all foliage.

Timing

This technique must be used when boneseed plants are actively growing, and not stressed by hot, dry, cold, wet or other extreme conditions. It is during active growth that the herbicide is most readily absorbed through the leaves. Mature plants should ideally be treated either in winter or when in flower, depending on the herbicide used (see Table 1 on page 28). Scattered plants are also easiest to locate and identify when flowering.

Phil Maughan

Spot spraying from a backpack sprayer.

Rachel Melland

Spraying boneseed seedlings using a boom extension.

Foliar spraying should be avoided on windy days, to limit spray drift, and when rain is forecast. Read and follow all label directions regarding method and timing of application.

Splatter gun

Splatter guns administer large droplets of herbicide solution, and are used with more concentrated herbicide solutions than other foliar applications. Although splatter guns were developed over thirty years ago, they have not been used widely. Recent trials on lantana have shown splatter guns to be particularly effective in controlling this weed when the spray is applied in straight lines approximately one metre apart. This technique uses a much lower volume of spray mixture than standard foliar spraying, and the larger droplets are less likely to drift. While splatter guns are

not widely used on boneseed, they may be effective for mature boneseed control. They are not recommended for use on seedlings.

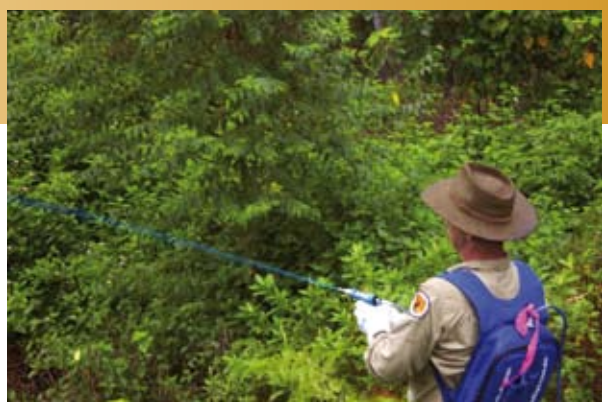
Method

Splatter guns are usually used with a backpack spray unit. Check the label to ensure the herbicide is registered for application by splatter gun, and read and follow all label directions.

Timing

As with foliar spraying, this technique must be used when boneseed is actively growing (and the plants are not stressed by extreme conditions) so that the herbicide is taken up by the plant. Mature plants should ideally be treated either in winter or when in flower, depending on the herbicide used (see Table 1 on page 28). Scattered plants are also easiest to locate and identify when flowering.

Splatter gun application should be avoided on windy days, to limit spray drift, and when rain is forecast. Read and follow all label directions regarding method and timing of application.



Daniel Stock, Photo courtesy of DNRMW, QLD

Applying herbicide with a splatter gun, using dye to mark areas already sprayed.

Treatment	*Advantages*	*Disadvantages*
Cut-and-swab, and Stem injection	• Very high kill rate • Selective • Uses less herbicide than foliar spraying • Minimal soil disturbance	• Labour-intensive and time-consuming when dealing with large infestations • Cannot be used in wet weather • May require training
Foliar spraying	• Very high kill rate • Large areas can be treated quickly • Can be used in steep terrain or erosion prone areas • Minimal soil disturbance	• High risk of off-target damage when treating large areas • Dense seedlings may cover one another leading to incomplete spray coverage • Cost may be prohibitive for large infestations • Cost of spray equipment • Cannot be used in wet weather • May require training
Splatter gun	• Very high kill rate for mature plants • Large areas can be treated quickly • Lower risk of off-target damage than with foliar spraying • Can be used in steep terrain or erosion prone areas • Minimal soil disturbance	• Cost may be prohibitive for large infestations • Cost of spray equipment • Cannot be used in wet weather • May require training

Mechanical control

Mechanical control involves the use of heavy machinery such as tractors and excavators. Fitted with a claw attachment, these machines can remove mature boneseed plants by pulling them from the ground. Tractors or excavators fitted with slashing or grooming attachments can be used to simultaneously fell and shred boneseed plants.

Due to the high level of disturbance caused to soil and desirable vegetation, mechanical control methods are not suitable in natural areas.

Mechanical pulling

Mechanical pulling can be used to clear large boneseed plants from degraded areas, pastures and grazing lands. Because of boneseed's shallow but extensive root mass, pulling large plants can lead to soil disturbance. This may promote the germination of boneseed and other weed seedlings. This method is performed successfully in areas of South Australia with fairly sandy soil, using a small excavator.

Method

Using a compact excavator or tractor with a modified claw attachment, it is possible to remove very large boneseed plants with the root mass intact. The claw grips the boneseed plant around the stem close to the ground, and the mechanical arm is lifted to pull the plant out of the ground.

Timing

This method can be used at any time of the year, but preferably before the plants set seed. This will prevent an increase in the boneseed seedbank; it also prevents machinery becoming contaminated with, and spreading boneseed seeds. On heavy soils such as clay, mechanical pulling may need to be done when the soil is moist.

Hillary Cherry

Boneseed has an extensive but shallow root system, with no tap root.

Tony Zwar

Mechanical puller - a claw attached to an excavator.

Hillary Cherry

The claw grasps the stem close to the base.

Craig Bray

Mechanically grooming boneseed monoculture, You Yangs, Vic.

Craig Bray

Results of mechanical grooming. Regrowth and seedlings will require treatment.

Mechanical slashing and grooming

Mechanical slashing and grooming can be used to stop flowering boneseed plants setting seed and increasing the size of the seedbank. This method is usually only appropriate in non-natural areas, such as vacant land awaiting development. Many stumps will resprout, although the regrowth can be treated by spraying. This is more economical than spraying an entire large infestation, and therefore the high machinery costs may be balanced against reduced herbicide costs.

Method

Heavy duty slashing (mowing) attachments simultaneously fell boneseed plants and cut them into pieces, while grooming heads fell plants and shred them into a fine mulch. Either attachment can be attached to a tractor, which is driven over the infestation. Alternatively, grooming heads can be attached to excavator arms to treat infestations in hard to access areas, as they can reach around objects to fell and shred boneseed.

Timing

This method can be used at any time of the year, but preferably before the plants set seed. This will prevent an increase in the boneseed seedbank; it also prevents machinery becoming contaminated with, and spreading boneseed seeds.

Treatment	*Advantages*	*Disadvantages*
Mechanical pulling	• Whole plant removed (no regrowth) • Targeted – minimal damage to surrounding trees • Less labour intensive than manual or chemical control methods • Can treat large infestations relatively quickly	• Potentially high levels of soil disturbance and compaction • Risk of damage (crushing) to desirable shrubs and grasses • Disturbance may promote germination of weed seeds • Weed seeds can be spread on machinery • Requires access for machinery • High machinery costs • Training required for machinery operator
Mechanical slashing and grooming	• Less labour-intensive than manual or chemical control for large infestations • Can be cost-effective for large infestations • If foliar spraying regrowth, less chemicals are required than if spraying entire plants	• Many plants resprout • Damages desirable vegetation • Potentially high levels of soil compaction • Weed seeds can be spread on machinery • Requires access for machinery • High machinery costs • Training required for machinery operator

Boneseed and fire

Fire plays an integral role in the functioning of many natural ecosystems in Australia, and bushfires and prescribed burns should therefore be taken into account when formulating a weed management plan. Prescribed burns are carried out for either hazard (fuel) reduction purposes or to trigger the regeneration of native vegetation. The main consideration with boneseed is the need for follow-up seedling control after fire, as fire stimulates the germination of boneseed seeds.

Effect of fire on boneseed

If boneseed plants are entirely scorched in a fire they are unlikely to survive (unlike bitou bush which will often resprout after fire). Fire kills many seeds and stimulates mass germination from the seedbank, resulting in a dense 'carpet' of boneseed seedlings. If seedlings are controlled before they set seed, a fire can effectively reduce the number of years required for follow-up control by depleting the seedbank (see case study on page 60). If seedlings are not controlled they will out-compete native seedlings, exhausting the native soil seedbank. The boneseed population can then expand and quickly re-establish a massive seedbank (see case study on page 65). Although boneseed plants are usually at least 18 months old before first seeding, post-fire seedlings grow rapidly and can often set seed around 12 months after a fire, depending on climate conditions (Melland in prep).

Boneseed does not burn as easily as many native shrubs, in part due to the fleshy nature of the leaves. Dense boneseed infestations can shade out native grasses and herbs that would otherwise provide ground-level fuel for a fire, so a low intensity fire will not carry well through a boneseed monoculture (Melland in prep).

Rachel Melland

Prescribed burn in boneseed infestation, You Yangs, Vic.

To increase boneseed mortality during a prescribed burn, mature plants should be slashed or pulled out prior to the burn. The plant material should be left to dry on the ground where felled (not in piles). This fuel at ground level will help to carry a fire, and thus heat the soil, stimulating the boneseed seedbank to germinate. Ideally, plant material should be left to dry for several months, depending on weather conditions (Melland in prep). However, this extra fuel can increase the risk of bushfires. Consult local fire authorities regarding the suitability of this technique for your area.

High intensity fires (such as bushfires) can heat the soil to extreme temperatures, which can destroy the boneseed seedbank. However, follow-up control is still needed as fires are usually patchy, and it is unlikely that all seeds will be killed over large areas. Follow-up seedling control will be necessary in areas of

Rachel Melland

No boneseed seed was found in the soil three days after the January 1997 wildfire, Arthurs Seat, Vic.

low intensity, near water sources, and where seeds have dispersed into the burnt area from unburnt sections of the population (Melland in prep).

If you are in a bushfire-prone area make sure you have an 'emergency' follow-up control plan in place. This way you can respond quickly after a bushfire and take advantage of the opportunity to control the boneseed infestation, by eliminating any seedlings before they flower and replenish the seedbank. The massive seedling recruitment is advantageous if you have the resources to control the seedlings, because it rapidly depletes the seedbank. A concerted effort after a fire can reduce the intensity and duration of your boneseed control program (Melland in prep).

Rachel Melland

No boneseed emerged in areas burned by intense wildfires in Arthurs Seat, Vic.

Boneseed in the You Yangs Regional Park

Fire triggers mass boneseed germination and if seedlings are not controlled they will out-compete native seedlings, exhausting the native seedbank. The boneseed population can expand as it quickly re-establishes a massive seedbank.

Boneseed expanded its range rapidly after bushfires in 1985 in the You Yangs Regional Park, south-west of Melbourne. Before the fires, boneseed was scattered throughout the park. The fires were widespread, burning 85 per cent of the park, and they triggered the mass germination of huge numbers of boneseed seedlings. Within three years of the fire, the boneseed infestation became dense and widespread in the You Yangs, and now impacts upon 1300 hectares of the 2000 hectare park. Boneseed now dominates the middle-storey vegetation in the areas that were burned.

The park is now missing a lot of indigenous middle-storey plants, as they were out-competed by fast-growing boneseed seedlings after the fire. The loss of native plants has had a huge detrimental impact on the numbers of native birds and animals that relied upon them for food and shelter.

There are simply not enough resources to control all the boneseed in the park, so management is strategically targeted to some 40 hectares where boneseed threatens high conservation values, such as around the rare brittle greenhood orchid. For more details on boneseed in the You Yangs see the case study on page 65.

Boneseed seedbank and fire

Laboratory experiments by Lane and Shaw (1978) showed that exposing boneseed seeds with cracked seed coats to temperatures of 100 °C for 30 seconds induced the seeds to germinate. They also showed that temperatures over 250 °C killed the seeds after two minutes. Seeds with uncracked seed coats would not germinate at all.

Field experiments by Melland (in prep) revealed that peak soil surface temperatures of 250 to 300 °C are required to substantially deplete the boneseed seedbank. During a controlled burn at Arthurs Seat State Park, the soil surface temperature remained over 100 °C for just over 5 minutes, and the temperature 2 cm below the soil surface remained over 50 °C for more than 30 minutes. This burn eliminated the boneseed seedbank at this site via seed death and stimulation of germination.

An even burn is required to eliminate as many boneseed seeds from the seedbank as possible. A patchy burn will lead to an increase in weed control time and labour costs in the post-burn years, as seeds surviving the fire continue to germinate. Brush-cutting boneseed and leaving it to dry on the ground prior to burning will increase the fuel load and enable fires to be carried throughout the boneseed infestations (Melland in prep). For more details of these experiments see the case study on page 60.

Talk to local fire authorities

Keep in contact with local fire authorities and the land managers of your site. Alert them to the effect fire can have on boneseed populations and its implications for control. By having input into fire management plans, you can better plan your weed control activities. For instance, before a prescribed hazard reduction burn, you can pull or slash mature boneseed to improve mortality rates during the fire; you can also arrange follow-up seedling control for after the fire.

Community input into fire management plans

In the Meehan Ranges outside of Hobart, the Flagstaff Gully Landcare Group was concerned about the rapid spread of boneseed after fire – particularly when the fire was hot enough to remove the native understorey plants, and good rain followed the fire. The group and other members of the community encouraged the Clarence City Council in south-east Tasmania to include boneseed in the local fire management plan. The council has now introduced a simple notification process to advise when they will carry out hazard reduction burns in their bushland reserves. The council writes to landcare groups and land owners in spring to notify them of burns planned for autumn. This gives all stakeholders an opportunity to raise concerns and provide input into the fire management process, as well as plan for post-burn weed control.

Last spring, the council fire crew hand pulled around 1500 boneseed plants from the area cared for by the Flagstaff Gully Landcare Group, prior to a planned burn. This improved mature boneseed mortality rates, and helped promote an even burn, stimulating seed germination. The landcare group then focused its efforts on the burnt areas in winter, where they removed the mass of seedlings that emerged after the fire. Thus, the planned hazard reduction burn assisted the landcare group's boneseed removal program by rapidly depleting the seedbank.

Tom Morely

Lacy-winged seed fly pupa and maggot in boneseed fruit.

Biological control

Biological control (biocontrol) is the use of a weed's natural enemies (biocontrol agents) to suppress a weed population. The agents used on boneseed come from its native range in South Africa. The aim of biological control is to:

- suppress plant vigour
- reduce seed production
- slow plant growth
- reduce the density of the weed infestation.

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

Brief history

A biological control program to combat boneseed and bitou bush was established in 1987. To date, four of the six insect species released on bitou bush have established, with the bitou tip moth (*Comostolopsis germana*) and bitou seed fly (*Mesoclanis polana*) now widely distributed in New South Wales. In contrast, none of the six insect species released for boneseed control has established. The reasons for the failure of these agents to establish in the field are not known, although they are thought to be related to the predation of the biocontrol insects by ants, mites and spiders.

Tom Morely

Adam Magennis, Parks Victoria ranger releasing the lacy-winged seed fly onto boneseed, Arthurs Seat, Vic.

Tom Morely

Lacy-winged seed fly.

The lacy-winged seed fly, first released in 1998, has so far failed to establish on boneseed, probably due to boneseed's flowering period being too short to sustain seed fly populations from one season to the next. In an effort to establish a self-sustaining population, the seed fly was released onto bitou bush (which flowers year-round) on the south coast of New South Wales in August 2005. If establishment is successful, large quantities of seed flies will then be released onto boneseed. The seed fly was also re-released onto boneseed at two sites at Arthurs Seat in Victoria.

For a detailed review of the *Chrysanthemoides monilifera* biological control program see Downey *et al*. (in press).

Hillary Cherry

Park rangers are raising biocontrol agents for boneseed in this greenhouse. School students will release these agents in the You Yangs as part of a weed awareness program.

Engaging the community in biological control

Parks Victoria staff at the You Yangs Regional Park have been running their own biological control program for boneseed since 2004. This is an innovative community engagement program aimed at increasing awareness and involvement in local weed issues. The program engages school students in weed management through a series of practical hands-on experiences based on biological control.

Park rangers, with the assistance of Norlane High School, northern Geelong, have been breeding the boneseed leaf-rolling moth (*Tortrix* sp.) in specially constructed greenhouses. Norlane High School has also constructed a greenhouse on the school grounds where students monitor the breeding success of the moths. The students then release the moths in the You Yangs Regional Park. Students have also been studying the effects of different control methods on boneseed in trial plots at the park.

Recently, North Shore Primary School (also in northern Geelong) built a greenhouse to breed the boneseed leaf-rolling moth. The school also has plans to incorporate observations of the moth's life cycle and results from post-release distribution surveys at the park into their science curriculum.

As well as making a valuable contribution to on-ground weed control, this program allows students to gain knowledge and awareness of environmental issues, and a sense of empowerment because they are actually contributing to weed control.

Similar work on other weeds is being done through the *Weed Warriors* program, a joint initiative between the CRC for Australian Weed Management and state agencies <www.weedwarriors.net.au>.

Future directions in biological control

Despite the lack of success in establishing biocontrol agents on boneseed to date, there are still promising agents yet to be released.

The boneseed leaf buckle mite (*Aceria sp.*) has been approved for release in Australia, and mass-rearing techniques are currently being developed to ensure large numbers of mites are available for release. A distribution network is also being formed, with releases planned for Victoria, South Australia and Tasmania. The leaf buckle mite induces the formation of felt-like leaf galls (or erinea). The photosynthetic efficiency of boneseed plants is reduced, resulting in less vigorous growth and reduced reproductive capacity.

Another promising biocontrol agent for boneseed (and potentially bitou bush) is the boneseed rust fungus (*Endophyllum osteospermi*). The rust affects the entire plant, and the infection is retained until the death of the plant. Host-specificity testing is partially completed.

Two undescribed insects have been identified as possible agents – the tip wilt pyralid moth (family Pyralidae), and the stem-galling cecidomyiid (family Cecidomyiidae) – but are yet to be formally identified or tested for suitability.

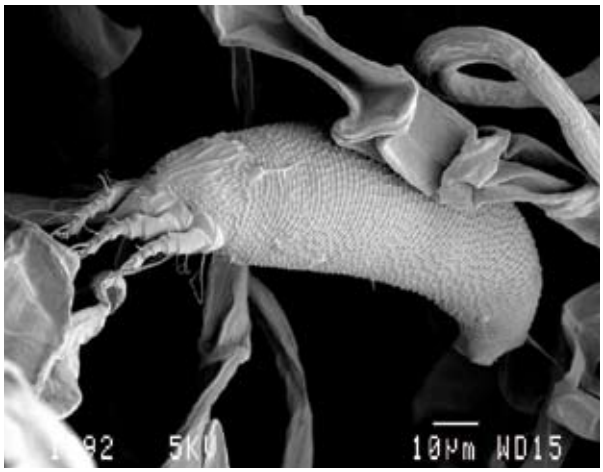
Table 2, on page 42, lists biocontrol agents that have been released for boneseed control, and those that are being considered for future releases.

Tom Morely

Rust-affected boneseed, Cape Town, South Africa.

Tom Morely

Damage caused by boneseed leaf buckle mite.



Charnie Craemer

Scanning electron micrograph of boneseed leaf buckle mite.

Table 2 – Boneseed biological control history

Biological control agent	Years released	Establishment summary	Current status
bitou tip moth *Comostolopsis germana*	1989–1998	Did not establish – possibly due to predation.	
black boneseed leaf beetle *Chrysolina scotti*	1989–1996	Did not establish – possibly due to predation.	
blotched boneseed leaf beetle *Chrysolina picturata*	1992–1995	Did not establish – possibly due to predation.	
painted boneseed beetle *Chrysolina oberprieleri*	1994–1995	Did not establish – possibly due to predation.	
lacy-winged seed fly *Mesoclanis magnipalpis*	1998–2000 2005 (onto bitou bush and boneseed)	Did not establish – short flowering period of boneseed may not allow fly to survive from one season to the next.	Released onto bitou bush (which flowers year-round). If it establishes, will then release large quantities of seed flies onto boneseed.
boneseed leaf-rolling moth *Tortrix* sp.	2000–2004	Did not establish – possibly due to predation.	The bitou leaf-rolling moth (a different *Tortrix* sp.) to be released onto boneseed in Victoria.
leaf buckle mite *Aceria* sp.	Approval for release granted in March 2005		Mass-rearing techniques being developed.
boneseed rust fungus *Endophyllum osteospermi*	Host-specificity testing underway		Host-specificity testing under way.
tip wilt pyralid moth Pyralidae family	Untested		
stem-galling cecidomyiid Cecidomyiidae family	Untested		