



A community guide to
implementing

Biological Control



CARING
FOR
OUR
COUNTRY



Environment,
Climate Change & Water
National Parks & Wildlife Service



Industry &
Investment



Table of contents

The problem	3
Weed case study: Bitou bush (<i>Chrysanthemoides monilifera</i> ssp. <i>rotundata</i>)	3
Biological control	4
The biocontrol procedure & when it should be used	5
Creating a biocontrol program	6
Case study: Biological control of bitou bush using the leaf-roller moth	6
Rearing biocontrol agents: leaf-roller moth	7
Case study: How to collect and grow bitou bush plants to rear leaf-roller moths	7
Time of year	8
Setting up a nursery	8
Case study: How to harvest leaf-roller moth larvae from the field to establish a leaf-roller moth population	9
Monitoring agent development in the nursery	10
Release & distribution	11
Site selection	11
Case study: How to establish a leaf-roller moth colony in the field	12
Monitoring & evaluation – what is happening in the field?	12
Empowering school students in biocontrol: <i>Weed Warriors</i>	14
Who are the <i>Weed Warriors</i> ?	14
How to get involved	14
Biocontrol agent release information	15
Biocontrol agent monitoring information	16

This document should be referenced as: Jenner, J., Cherry, H., Postle, L., Holtkamp, R., and Sullivan, P. (eds). 2010. A community guide to implementing biological control. National Bitou bush and Boneseed Management Group, Sydney.

Front cover photographs: Hillary Cherry, Royce Holtkamp, HCRCMA.



The problem

Invasive weeds are a serious threat to the natural and economic environment of Australia. By overtaking and dominating areas, weeds significantly contribute to land degradation, a loss of native biodiversity, and decreased productivity of farm and forest land. Therefore, steps must be taken by land managers to control the spread of weeds and reduce their impact. Arguably, the best line of defence is preventing weeds entering Australia. However, once weeds are already well established, biological control has proven to be one of many successful weed management tools.

....weed case study

Bitou bush *Chrysanthemoides monilifera ssp. rotundata*



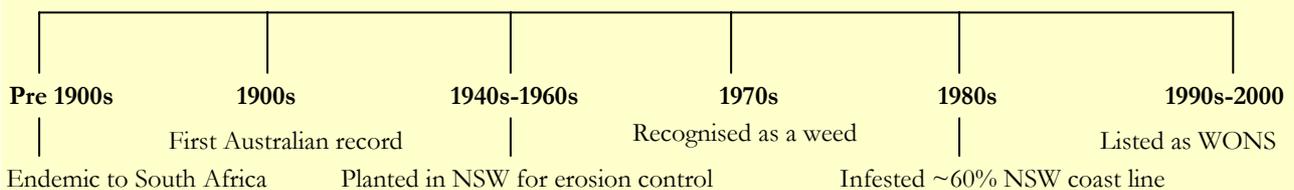
In Australia, the coastal shrub bitou bush is a Weed of National Significance (WONS). Bitou bush originates from South Africa and was first introduced accidentally into Australia by ship ballast waters in the early 1900s. In its native environment bitou bush grows in a controlled, non-weedy manner due in part to the presence of native South African insects and pathogens, which damage the plant and limit growth. However in Australia, the lack of natural predators, coupled with high growth rates and deliberate planting of bitou bush between 1940 and 1960 as a dune stabiliser, allowed this weed to overrun more than 80% of the New South Wales (NSW) coastline by the 1990s.

Bitou bush seed is widely distributed by birds and other animals. Where bitou bush invades, it can outcompete and suppress native flora, resulting in a decline in local plant and animal biodiversity. Furthermore, infestations create favourable environments for pest animals such as foxes and rabbits.



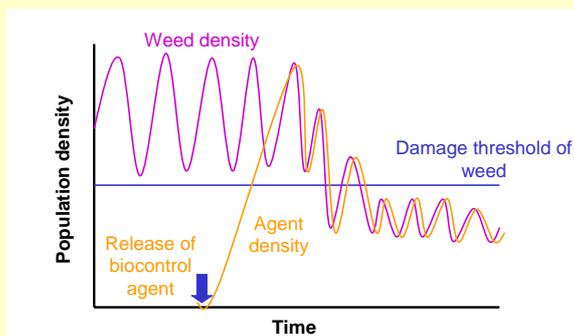
An example of a dense infestation of bitou bush

Bitou bush timeline



Biological control

Biological control, or biocontrol as it is also known, is the use of a weed's natural predators to suppress growth and/or reduce plant vigour. This is commonly done by introducing natural predators (biocontrol agents) from the home range of the weed species. One of the reasons introduced weeds



The relationship between weed and agent density



Examples of biocontrol agents for bitou bush including: the seed fly, tip moth, leaf-roller moth and tortoise beetle

can spread so successfully is because they usually have no natural predators in their new environment, e.g. bitou bush in Australia. By establishing biocontrol agents, this advantage can be reduced. This was the case when the cactoblastis moth was released into Australia in the 1920s. The moth dramatically reduced millions of hectares of prickly pear cactus infestations across NSW and Queensland (QLD). Now the level of damage from prickly pear to the environment and agricultural productivity is reduced to a manageable level.

The aim of biological control is not to eradicate the weed completely, but to reduce the abundance of a weed and to minimise its impact. Biological control offers complementary alternatives to traditional methods, such as mechanical removal and chemical control, and can be used alongside these techniques as part of an integrated management system.

The positive and negative aspects of biological control

Positive aspects	Negative aspects
<ul style="list-style-type: none"> • Specific (only target weed affected) • Environmentally sound (non polluting) • High cost-benefits - cheap in long term (small implementation & maintenance costs once agent established) • Low risk of missing weed control opportunity (agent's activity linked to weed's lifecycle) • Long-term solution to weed problem • Land tenure arrangements and terrain impose no problems • Continuous action 	<ul style="list-style-type: none"> • Not suitable for all weeds • Expensive in short term (need to find, test and mass distribute appropriate agent) • May take a long time for impact on target • May need to be used with other control methods • May be no suitable agents available • Release of biocontrol agents may raise unrealistic expectations



The biocontrol procedure & when it should be used

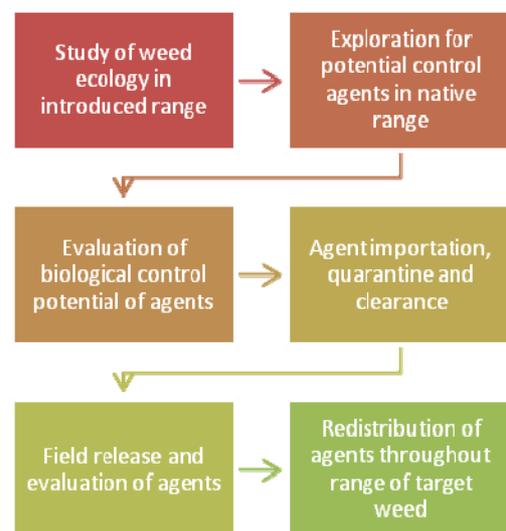


Biological control provides a low-risk solution to many weeds. Biocontrol agents often take a long time to establish, however when their populations are high and they are widespread, they can significantly reduce weed populations, decrease seed production and impede plant growth. Biological control has a number of advantages over other control options, being target-specific with continuous action and agents being able to disperse across the landscape irrespective of terrain. Unfortunately, the public perception of biological control may sometimes be negatively affected by past accidents, such as the cane toad, where a species introduced to control one pest has become the pest itself.

Cane toads were deliberately released in QLD in 1935 in an attempt to control pest beetles in sugarcane fields – but instead the toad spread and is now itself a target of a biocontrol program. The biocontrol approval process has changed dramatically since the 1930s. Now, the procedure to import and release an agent is lengthy and includes receiving the approval of several committees as well as meeting the requirements of the *Quarantine Act 1908* and the *Environment Protection and Biodiversity Conservation Act 1999*. If an agent meets these standards, it then undergoes rigorous and extensive host-specificity testing before it can be released into Australia. The aim is to ensure that the agent will only damage the ‘host’ (or target organism). In the case of weeds, it means the agent will only attack that particular species of plant and will not pose a threat to any other plants. Host specificity is very important to make sure that NO native plants or economically important plants are damaged.

A good example of ‘host-specificity’ in biocontrol agents can be found in the bitou bush and boneseed program. Both of these weeds are subspecies of *Chrysanthemoides monilifera* – and are therefore very closely related. However none of the agents introduced for bitou bush, such as the bitou seed fly or the leaf-roller moth (*Tortrix* sp.), will attack the very closely related boneseed.

When employed correctly, biological control is an environmentally friendly option that provides an effective, low risk, long-term solution to the problem of certain weeds. However, it is important to understand that not every weed is suitable for biological control and the success of a biocontrol agent can vary between geographic locations and from year to year. Furthermore, the process often takes substantial long term investment and may take many years to cause a significant reduction in the target weed. Biological control should always be considered as a long term commitment.



The biocontrol process

Creating a biocontrol program

After a biocontrol agent is found, tested and approved for release, it then needs to be reared, distributed and monitored in a way that provides the best possible chance of success. This booklet provides guidance on how the community can collect, rear and distribute a biocontrol agent by using the example of the leaf-roller moth. The leaf-roller moth is one of three agents that has contributed to the control of bitou bush introduced under the National Bitou Bush Biocontrol Program.

....case study

Biological control of bitou bush using the leaf-roller moth



The leaf-roller moth

Since 1989, six biocontrol agents have been introduced into Australia to combat bitou bush. The leaf-roller moth is the most recent introduction. Since its release in 2001, the leaf-roller moth has established at approximately six locations along the NSW coast. The moths only cause damage to bitou bush in their larval stage. The larvae feed directly on the foliage of the plant, focusing on new and developing leaves, buds and tips. This leads to the death of shoots and in summer, when larval populations are high, can result in severe defoliation and weakening of the plant.

Where the leaf-roller moth and other successful agents, such as the tip moth and the bitou seed fly, are all attacking bitou bush together, there is a noticeable decline in flowering. Spreading the leaf-roller moth throughout the core infestations of bitou bush has therefore been shown to positively aid in bitou bush control. However, the leaf-roller moth does not spread rapidly on its own accord, and as a result is now the subject of a community-based project that hopes to ensure rearing, release and monitoring of the leaf-roller moth along the NSW coast.

Successful bitou bush biocontrol agents. Table adapted from Downey, P., Holtkamp, R. Ireson, J., Kwong, R. and Swirepik, A. (2007). A review of the *Chrysanthemoides monilifera* biological control program in Australia: 1987-2005. *Plant Protection Quarterly* 22, 24-31.

Species	Date released	Establishment	Bitou bush damage
Bitou tip moth (<i>Comostolopsis germana</i>)	1989	All release sites and spread throughout range of bitou bush	Significant (50% reduction in seed production)
Bitou tortoise beetle (<i>Cassida</i> sp.)	1995	All release sites but minimal spread	Minimal (minor leaf chewing)
Bitou seed fly (<i>Mesoclanis polana</i>)	1996	All release sites and spread throughout range of bitou bush	Significant (27% reduction in seed production and up to 80% in some places)
Leaf-roller moth (<i>Tortrix</i> sp.)	2001	6 of the 45 release sites	Minimal at present but increasing

Rearing biocontrol agents: Leaf-roller moth

A number of factors significantly contribute to the success or failure of rearing a biocontrol agent. These include:

1. The time of year, as it relates to the agents' life cycle and also temperature;
2. The environment (nursery) created to rear the agent; and
3. Monitoring agent progress during development and after establishment.

....case study

How to collect and grow bitou bush plants to rear leaf-roller moths



Step 1: Collection

Small, healthy, bitou bush plants up to 20 cm high are ideal to pot up. Retain as much of the root system as possible by loosening the ground around the plant before gently pulling up the main stem close to ground level. Remove excess soil from the roots and wrap them in wet newspaper while transporting.



Step 2: Potting

Plants should be potted in deep pots as soon as possible after collection. One third of the pot should be filled with sand and supplemented with a well draining potting mix and a slow release fertiliser. Remove four or five of the lower stem leaves before placing the plant in the pot. Fill in the remainder of the pot with the potting mix, holding the plant straight. It is important to leave a couple of centimetres between the lip of the pot and the potting mix for watering the plant. The stem of the plant should be buried to the same depth as was found in the field. Press the mix down firmly, give the plants a good watering and add some slow release fertiliser pellets.

....case study continued



Step 3: Maintenance

It is vital that the plants stay in good condition to feed the leaf-roller moth larvae. They need to be at least 50 cm high before insects are released onto them. Larvae feed only on the healthy growing tips. Plants will originally need watering every second day, but when more foliage begins to appear they will need watering daily (this may vary depending on the potting mix and the situation). If possible, plants should be connected to a nursery watering system to maintain a regular water supply. Ensure that plants stay free from insect attack by growing them in screened enclosures. Pesticides are harmful to the agents and cannot be used later than two weeks before the agents are released onto the plants.



An example of a small screened bitou bush enclosure

Time of year

The success of rearing biocontrol agents can vary depending on the season. For example, leaf-roller moths are best raised during the hotter months of the year when they are most active. However, it is possible to keep agents growing all year, and this should be a goal when establishing a long-term nursery so that at least a minimal number of agents are present to keep the population going.

Setting up a nursery

A nursery needs to simulate the conditions that the agent would naturally experience. Because the leaf-roller moth feeds specifically on the growing tips of bitou bush, plants need to be collected and established at least ten to twelve weeks before attempting to rear the agent. The number of plants required will depend on the scale of the project and the facilities and resources available. Always grow more plants than are needed to allow for any stunted growth or plant mortalities. Grow as many plants as the nursery situation will allow - basically the more plants the better!



A successful nursery

Ideally, plants should be grown on an elevated bench in a sunny position, sheltered from the wind. Plants need to be placed within a screened enclosure to protect the agents from predators and to stop the agents migrating from the plants. Installing bitou plants in a screened off section of an existing community nursery would be a favourable option.

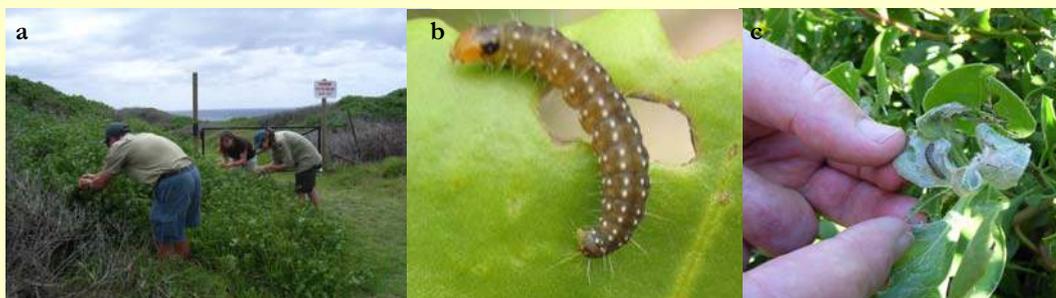
....case study

How to harvest leaf-roller moth larvae from the field to establish a leaf-roller moth population



Leaf-roller moth eggs will usually be available from your local project coordinator. However, leaf-roller moth larvae can easily be harvested from the field using the following method:

1. Select an infestation of bitou bush with a known leaf-roller population (check with the project coordinator or local council to determine where populations exist).



a) collecting larvae from the field; b) and c) examples of leaf-roller moth larvae

2. Identify the presence of the leaf-roller moth, making sure not to confuse it with the paler green or white tip moth. Look for leaf-roller moth caterpillars with dark bodies and orange heads in growing tips of plants where there is evidence of 'white webbing'. Leaf-roller moths are often very active when exposed and will wriggle vigorously, so it is important to have a container held underneath the leaves before attempting to extract the caterpillar, to catch them if they wriggle free. The most successful method is to gently pry open the white webbing and leaves, identify the leaf-roller caterpillar, close the webbing again and break off the tip of the branch, thus allowing the caterpillars to remain in the growing tip for transport.



Leaf-roller moth damage and larva

Vs



Tip moth larva and damage

3. Collect as many larvae as possible and place them into a container either in the branch tips or with leaf tips for them to feed on. The most effective containers are polystyrene boxes as they have some insulation. Keep the container in a cool place during transport to the nursery. If larvae are to be in transit for longer than a few hours, secure an ice brick to the floor inside the container and put some wet newspaper or kitchen roll in with them. Release larvae onto nursery plants by inserting the branch tip collected in the field onto a healthy bitou bush nursery plant, near a growing tip. The caterpillars will move onto the nursery plant by themselves.



Monitoring agent development in the nursery

Raising an agent is an ongoing process that requires time and attention. The eggs of the leaf-roller moth need to be carefully monitored after they are attached to the plants. When hatched the larvae may defoliate a plant before they are ready to pupate, leaving them without a food source.



Fresh plants need to be installed before this occurs – therefore extra plants should always be readily available. To introduce a new food source, simply place a fresh plant in contact with the defoliated plant. Wait at least a week for the larvae to move themselves across to the new plant and then remove the old plant. Ensure that the old plant is disposed of properly, so as not to spread bitou bush.

Approximately four to five weeks after the egg batches have hatched, the larvae will start to pupate. When this occurs the pupae will need to be removed from the plants and placed in cardboard containers using the following method:

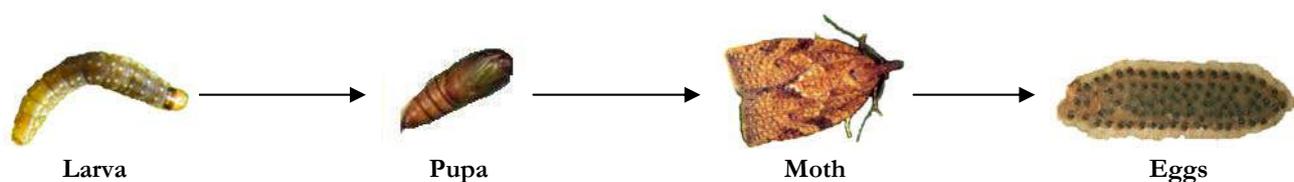
Step 1: Check the whole plant for pupae, focusing search efforts on the white webbing created by the larvae as a feeding shelter (usually at growing tips or between two leaves). Pupae can also be found hidden under the lips of pots so it is important to do a thorough inspection. Gently remove all the pupae from the plant using forceps held parallel to the pupa, and place them into a container.



Step 2: Sort the pupae into males (< 10 mm) and females (> 10 mm), and place approximately three of each sex into a cardboard container (such as milkshake cups) with a paper tissue installed at the bottom. Record the date on the side of the container before sealing the top with a piece of breathable gauze held in place by an elastic band.

Step 3: Repeat steps 1 & 2 three times a week until all the pupae have been collected.

After seven to ten days, moths will hatch and mate and the female will deposit batches of eggs on the side of the container. The moths will then die, leaving the eggs ready for release and distribution.



To distribute eggs, cut around the egg batches, leaving enough room to staple the cardboard to a bitou bush plant in the field, and place them into a container (such as an esky). Store the container in a cool place while transporting it to the field release site. Distribute eggs as soon as possible.



Release & distribution

As with every other stage of the biocontrol process, careful planning and consideration needs to be put into the release and distribution of the agent. Issues like site selection, storage and transport of the agent, release numbers and supplying insects to other land managers, should all be considered when planning egg release.



Site selection

Not all sites are suitable for biological control. Sites may already have other control methods in place or may be difficult to access. In general, a site will be suitable for releasing biocontrol agents if:

- The infestation is prolific and widespread (there are lots of healthy plants and fresh growth for the agent to feed on);
- There is a long time frame for control (the infestation is likely to be there for a long time);
- The infestation has a low priority for control by other methods (no one is planning to control the infestation in the near future);
- Chemical control will not be used on the infestation in the near future; and
- The land manager/owner agrees to have a biocontrol release site on their land.

Land manager approval must be formally obtained before the release of the agent. Land managers must understand that biological control does not replace the need for controlling weed infestations and therefore does not relieve them of their responsibilities of actively controlling weeds by other integrated methods. Further information on integrated control methods can be obtained from www.weeds.org.au.



Damage caused to bitou bush by biocontrol agents

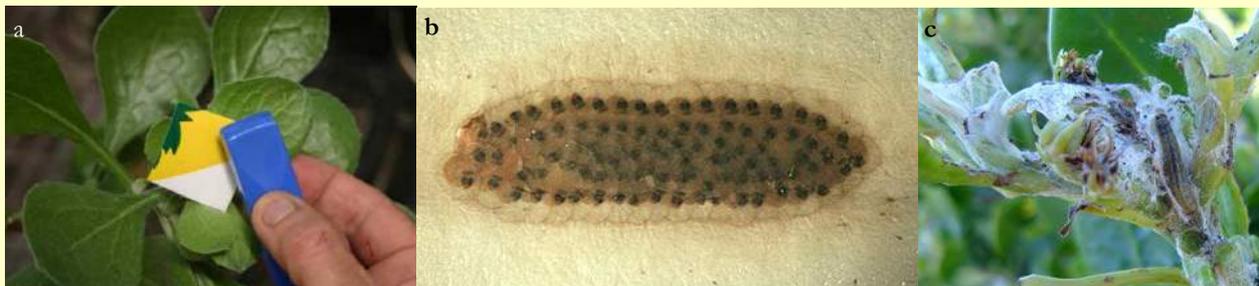
....case study



How to establish a leaf-roller moth colony in the field

The best time of year to release leaf-roller moth eggs is during the warmer months when they are most active. This will increase chances of establishment and hence their ability to control the bitou bush infestation. First, an appropriate site must be selected and land managers must be consulted. Egg batches should be prepared as described on page 10.

When transporting the leaf-roller moth eggs to the chosen site, the eggs must be kept in a cool place out of direct sunlight. All eggs should be released in a single area of bitou bush (approximately 1 m x 1 m) to increase their chance of establishment. It is important that the bitou bush plants chosen are dense, healthy and green.



a) stapling leaf-roller moth eggs on to new leaves; b) moth eggs; c) an established moth larva.

Carefully staple the egg batches (eggs face down) to the newer sections of plant growth, such as the leaf tips. Clearly (and permanently) mark the release site in a way that it can be easily located for future monitoring, for example with star pickets or wire around the base of the bush, and note down the GPS location. Finally, fill out a 'Biocontrol agent release information' data sheet (see page 15). Once the sheet has been completed, provide a copy to the land manager of the site as well as biocontrol supervisors.

Monitoring & evaluation: what is happening in the field?

The release site needs to be monitored regularly throughout the year so that important information, such as the agent's establishment, spread and impact, can be collated and assessed. Sites can be monitored by qualitative methods such as estimates of plant damage and agent spread. To record data visually take photographs. The type of information gathered should cover questions such as:

- Is the agent still present at the site?
- Is the agents' population increasing?
- Is the damage to the infestation detectable? If so, what is the total area affected?
- How far has the agent spread from the original release point and in which direction?
- Are there any factors that may be affecting the survival of the agent (such as drought, chemicals, disturbance etc.)?

When monitoring you should also fill in information such as:



- Name of the observer
- Location including GPS point
- Date and time of day
- Environmental conditions
- Number of observations
- General comments



A number of factors may affect the assessment of a site. For example, the weed and insect life cycle vary throughout the year, as does the climate. If a leaf-roller moth site is assessed during the winter months, when the agent is less active, the effect of the biocontrol agent will be less noticeable than during the summer months. Biological control is a long-term control method; it may take five to ten years for the numbers to build up enough to have an impact. The initial goal is to get the agents established so that they reproduce successfully on their own at the site. It may take multiple releases over time to do this, as often the agents need to build up a large population to overcome the effects of predation. For example, the leaf-roller moth and larvae are relatively large insects and are subject to predation by birds, other insects and animals. After several releases populations should increase and become self-sustaining. **Biological control is a long-term process!**



a) and b) an example of using a quadrat method to monitor leaf-roller moth sites; **c)** agent damage (photo: CSIRO)

All data should be collated and shared with biocontrol supervisors, collaborators and/or community groups. The success of the program can be determined by the spread and density of the agent and by the damage visible on the plants. If leaf-roller moths have survived, even only in small numbers, the program should be considered a success.

Further information:

www.weeds.org.au/WONS/bitoubush

www.dpi.nsw.gov.au/agriculture/pest-weeds/weeds/profiles/bitou-bush

Empowering school students in biocontrol: Weed Warriors

Who are the *Weed Warriors*?

Children are the natural resource managers of the future. The *Weed Warriors* program gives schools the opportunity to involve students in the management of local weed issues, while learning important scientific principles. Students and teachers have the chance to learn about invasive pest plants and become part of the solution to the problem by rearing and releasing a biological control agent for a local priority weed species.



Throughout the program, school children work closely with local weed officers, land managers and community groups to carry out a biocontrol program for a local weed. This creates a real world experience for the students and encourages a sense of connection to, and a responsibility for, their local environment. In each program the children are taught the skills needed to breed a biological control agent in the classroom and release and monitor the agents in an infestation local to the school.

Weeds Attack! is an interactive, electronic resource developed by NSW Department of Education and Training that complements the *Weed Warriors* program. Students and teachers can use this exciting, games-based resource to lead them through the *Weed Warriors* program – from videos showing how to pot up bitou plants, right through to monitoring agent release sites. The resource is free and can be downloaded or used on the web at www.weeds.org.au/WoNS/bitoubush/resources.htm (it is also available on DET internal websites).

The roles of *Weed Warrior* participants include:

State/Territory Coordinators

- provide support and assistance to the *Weed Warriors* Key Contacts, mentors and community groups
- provide resources and educational materials to Key Contacts



Key Contact

- organise, coordinate and implement the *Weed Warriors* program within a local area
- support the continuation and expansion of the program within the region



Mentors/community groups

- help in connecting participating students to environmental issues within their local community
- maintain this connection with students within, and beyond, the program
- strive to engage the participating students in addressing other local environmental challenges



How to get involved

Weed Warriors is a national program administered and supported by state/territory coordinators. It also relies on support from a network of community members.

For further information, please contact:

lesley.postle@industry.nsw.gov.au



Biocontrol agent release information

<p>Target weed</p> <p>Biocontrol agent released</p> <p>Number and stage released e.g. eggs, larvae, adults</p> <p>Date of release</p> <p>Name of person releasing agent</p>	
<p>Site information</p> <p>Is the site public or private land?</p> <p>Land tenure</p> <p>Land use</p> <p>Infestation size (ha)</p> <p>Density of infestation (% in 5 m sq at the release point)</p> <p>Surrounding vegetation</p> <p>Current control methods</p>	
<p>Release site location</p> <p>Map sheet #</p> <p>Longitude</p> <p>Latitude</p>	
<p>Land manager contact details</p> <p>Land manager name</p> <p>Agency (if applicable)</p> <p>Postal address</p> <p>Site location</p> <p>Phone</p> <p>Email</p>	<p>Mobile</p>



Biocontrol agent basic monitoring

Search for approximately ten minutes in the release site area for evidence of damage caused by the biocontrol agent. Start at the release point and work out from there.

1. Are the biocontrol agents still present at the release site?
 - Yes
 - No

If no, check the surrounding area for signs of the agent.
2. Which of the following best describes the level of damage caused by the biocontrol agent at the release site?
 - No damage
 - Damage just detectable
 - Low damage
 - Medium damage
 - Severe damage
3. Which of the following best describes the population level of the biocontrol agent at the release site?
 - Low
 - Medium
 - High
4. What is the maximum distance the biocontrol agents have moved from the original release point (in metres):
5. From the original release point, in which direction have the biocontrol agents moved?
 - North
 - East
 - South
 - West
6. What is the total area of the target weed affected by the biocontrol agent?
Length (m) x Width (m) = m²
7. In what condition is the target weed, where the biocontrol agents are present?
 - Excellent condition (green and growing vigorously)
 - Good condition (mostly green, but with some paleness)
 - Poor condition (mostly yellow/bleached)
 - Stressed
 - Other
8. Please comment on any event or process that may have affected the biocontrol agents or the release site. For example flood, fire, drought, herbicides, insecticides, vandalism etc.