A GUIDE TO

Weed Biological Control

IN SOUTH AUSTRALIA

Helping to promote sustainable weed management

CARING FOR OUR COUNTRY

Government of South Australia

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

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Dock moth, *Pyropteron doryliformis* (Photo: Tasmanian Institute of Agriculture)

Section photograph, page 16:
Spear thistle gall fly, *Urophora stylata*, depositing eggs onto a flower head.

Back cover photographs:
Seed weevil, *Larinus latus*
Salvation Jane crown weevil, *Mogulones larvatus*
Cape broom psyllid, *Arytinnis hakani* (photo: Peter Crisp, SARDI)
Horehound plume moth larva, *Wheeleria spilodactylus*
Broom psyllid, *Arytainilla spartiophila* (photo: © D.Ouvrard/Psyl'list/NHM-London)
Bridal creeper rust fungus, *Puccinia myrsiphylli*
Mating spear thistle gall flies, *Urophora stylata*

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The weed problem

Weeds are a serious threat to the Australian environment and economy. The invasive and aggressive nature of many weeds enables them to dominate, and out-compete preferred plant species.

Weeds can form monocultures that inhibit regeneration of native plants or pasture species. They can transform ecosystems by altering soil nutrients to favour weed invasion, by adding dense shrub layers, and by outcompeting native grasses and other preferred species. The frequency and intensity of fires that threaten biodiversity, livestock and humans, can be increased through the accumulation of highly flammable weed debris. Pest animals, and detrimental insects and pathogens, are also known to be harboured by many weeds. Conventional weed control methods

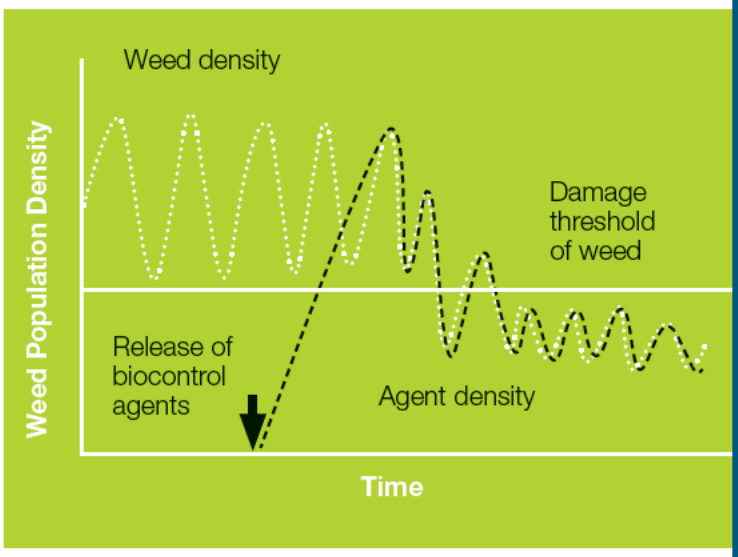
English broom and gorse invading grassy woodlands, Cudlee Creek, South Australia

can be very effective in the short term. However follow-up control may be required for years, and sometimes decades, to ensure weeds don't re-establish in previously controlled areas. As biological control (often shortened to biocontrol) can achieve long term results, it very effectively complements more immediate weed control methods. When applied as part of a landscape-scale, integrated weed management strategy, biocontrol is a valuable weed control method.

Weed biocontrol

Biocontrol uses a weed's natural enemies to reduce plant vigour and suppress growth. This limits the weed's capacity to reproduce and ultimately reduces the density of infestations.

In a weed's region of origin predators have co-evolved with it to create a relationship that keeps the plant in balance with its environment. When plants are introduced to new regions without their attendant predators as a natural check, there is great potential for them to become invasive. Natural predators can be sourced from a weed's region of origin and introduced retrospectively as biocontrol 'agents'. If successfully introduced, biocontrol agents can assist in reducing weed abundance, density and impact. Once established in an area biocontrol agents are not limited by boundaries or financial considerations. They provide a low-risk and sustainable method of long-term weed control.
It is important to remember that biocontrol utilises an ecological approach to weed control and as such, it will not lead to eradication. Instead, biocontrol aims for weed suppression and impact reduction. Biocontrol is regarded as a useful weed management tool that can complement other approaches to achieve an even greater level of control.



The above diagram demonstrates how biocontrol works over time. The weed displays its normal variation in population density in response to the environment, seasons and climate. Biocontrol agents are introduced and as the agent establishes, it increasingly impacts on the weed. Over time this impact reduces the weed's density below a threshold level where it is no longer having a significant economic, social or environmental impact.

The biocontrol procedure

Phase1 **Finding a biocontrol agent**

Study of weed ecology in introduced range

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Weed declared a candidate for biocontrol

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Exploration for potential agents in native range

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Evaluation of biological control potential of agents

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Agent importation, quarantine and clearance

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Field release and evaluation of agents

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Redistribution of the agent throughout the target weed's range

Importing, testing and releasing a natural enemy of a pest species into Australia is a lengthy process requiring considerable investment.

The process usually starts with an assessment of the economic, environmental and social impacts of the target weed, and a study of the associated costs.
This information is used to support a submission to have a weed declared as a candidate for biological control.
The submission follows a series of steps through various federal committees, and industry and community consultation, before biocontrol candidacy is approved.
If biocontrol candidancy is approved, native range surveys look for promising biocontrol agents and a pool of potential agents is prioritised for host specificity testing. Selected agents are tested on a range of plants related to the target weed that are economically, environmentally or socially important.
It is critical that biocontrol agents have no effect on these test plants. Additional studies assess the effectiveness of agents against the target weed.
Testing may be undertaken in Australia or overseas, and quarantine regulations apply to any testing done within Australia.

If a suitable agent is conclusively shown to be host specific then approval will be sought for its introduction into the Australian environment. The requirements of the *Quarantine Act 1908* and the *Environment Protection and Biodiversity Conservation Act 1999* must be met before approval is given to introduce an agent into the Australian environment.
To inform this assessment Biosecurity Australia undertakes an Import Risk Analysis and a draft report is made available for public comment.
Approval leads to an agent being reared and tested in quarantine facilities, to ensure no associated parasites, pathogens or other insects are inadvertently released in Australia with the agent.
Following this comprehensive process the program moves into a second phase, of agent distribution and evaluation across the introduced range.

Phase 2
Distribution programs

Once release from quarantine is approved, a distribution program is established and mass rearing of agents begins.

Building up a quantity of agents sufficient to undertake field releases can be slow and expensive. Field sites must be established well enough to allow for sustainable harvesting before accelerated distribution is initiated. Redistribution spreads biocontrol agents across the target weed's range faster than unassisted self-distribution. Participants in a redistribution program can be landowners/managers, community groups, and various government organisations. Good support from varied groups improves the potential for a successful biocontrol program. Effective coordination assists program development, record keeping, and mapping and monitoring of release sites.

Researchers refine techniques to improve the effectiveness of biocontrol distribution methods based on early evaluation of field releases. Early impact, and integrated pest management studies that combine the use of biocontrol with other control techniques, are often undertaken to provide an indication of the agent's potential in Australian conditions.

Left: Host specificity testing for the Cape broom psyllid, CSIRO Montpellier laboratories, France (photo: Thierry Thomann, CSIRO)

Right: Mass rearing of Salvation Jane flea beetles, Waite, Adelaide

Community members distributing bridal creeper rust fungus, Meningie, South Australia

Biocontrol takes time

Biocontrol programs are long term projects. It can take several years to a decade to select and test agents, and then five to twenty years for the introduced agents to have a significant impact on the target weed.

Also, the degree of control that can be achieved at a given location is difficult to predict, as weeds occur as part of complex ecosystems which vary according to many contributing factors.
In some cases the agent fails to establish, or to have effective impact, due to a range of reasons. There could be genetic incompatibility where the target weed has a slight, but significant, genetic difference to the plant in the country where surveys for biocontrol agents occurred. In other cases poor, or lack of, establishment can be caused by excessive predation on the agent by Australia's indigenous and introduced insects. In addition an agent may show variable effectiveness under differing climatic conditions, such as in sub-tropical compared to temperate areas of Australia. Biocontrol cannot eradicate a weed, however it can be a critical part of an integrated control program that reduces weed density and slows spread into new areas.

Pollen beetle resting on Salvation Jane leaf

Where can weed biocontrol be used?

Biocontrol is particularly useful in situations where other weed control methods are difficult, or there are insufficient resources available to apply other methods.

Biocontrol is most beneficial in the following situations:

- In difficult to access areas such as steep slopes or remote locations
- In areas where the weed appears unmanageable due to infestation size and density
- When other control methods are focused on outliers and a level of control in the core area is required
- When other control methods are unsatisfactory (e.g. too costly, or not effective in reducing the target weed)
- When minimal vegetation and soil disturbance is a priority
- When conventional options cannot be used

Biocontrol of wheel cactus with cochineal in remote South Australia

Participating in a biocontrol distribution program

Site selection

Selection of suitable release sites is an important step in ensuring a biocontrol agent establishes well. The ideal site will be densely covered in the target weed and located within a broader infested area. This ensures there is ample opportunity for the agent to establish and spread beyond the release site. A good release site will be fenced to exclude grazing and trampling by livestock. Ironically, the target weed should also be allowed to grow at the release site without being subjected to other control methods for at least five years.

Do

- Make sure the landowner/manager has agreed to the release site being established
- Consider the climatic requirements of the agent
- Make arrangements to ensure the agent can be monitored and harvested in the long term
- Make sure the initial release point is accessible for monitoring
- Release onto dense, healthy weeds and consider the likelihood of the agent spreading to nearby areas

Don't

- Release where other weed control methods are likely to be used in the next 5 years
- Release into heavily grazed areas or high stock traffic areas without protecting an area from livestock
- Release onto stressed plants
- Release into areas without sufficient target weed population.

Right: Stemless thistle growing in a fenced release site for the rosette weevil, Burra, South Australia (photo: Wayne Mitchell)

Collecting and distributing biocontrol agents

Most biocontrol agents can be collected and redistributed from established field sites, though some have complex lifecycles that make collection and redistribution difficult - these agents are not recommended for field collection without researcher assistance.

Rearing of agents to produce eggs for release is not discussed here. This information can be obtained from *A Community Guide to Implementing Biological Control,* produced by the National Bitou bush and Boneseed Management Group.

The minimum number of agents to release at each site is determined through testing. It is inadvisable to release fewer agents as this will impact on the agent's ability to establish. At an individual release site agents should not be spread widely but released in close proximity to each other.

Releasing an agent at multiple sites reduces the risk of complete agent loss due to site destruction or localised adverse conditions. It also increases the range of the agent's potential impact on the target weed. The multiple release strategy additionally contributes in-field information to improve knowledge of situations most suited to a particular agent.

There are several methods for collecting biocontrol agents depending on the weed and the agent. It is important to have an understanding of the lifecycle of the agent involved to be sure of the best time and method for collection and distribution. Collected agents should be kept cool, dry and out of the sun while being transported to new sites. An overview of the most common collection and distribution methods is provided over page.

Right: Buckets, watering cans, spray bottles, containers of rainwater and bags of bridal creeper infected with bridal creeper rust fungus gathered in preparation for making and distributing spore water.

Collecting and distributing techniques

Spore water

Spore water is used to distribute agents that are fungal pathogens, such as bridal creeper rust fungus and blackberry leaf rust fungus. Infected weed leaves are harvested and washed in rainwater to dislodge the rust spores. The solution is then sieved to remove pieces of leaf and any other large particles before being decanted into a distribution device such as a spray bottle, or into watering cans. The spore-laden water can then be applied to the target weed, preferably onto the underside of leaves and late in the afternoon. This is a good time to apply rust fungi because conditions are cooling and potential evaporation is reduced. Covering inoculated plants with a plastic bag can assist the agent however the bags should be removed the following day or overheating may occur. Do not apply rust fungi during rain events as spore solution may be washed off the leaves.

Cuttings

Distributing cuttings of infested plant material is a useful way to spread microscopic or very small insects and mites. It is also recommended for distributing the exposed larval stage of some agents. Cuttings should preferably be collected on the day of, and not more than one day before, distribution to a new site. Cuttings are secured to the new host plant and as the cutting dries out the agents will move onto the new host plant and begin creating new colonies. The agent needs to be mobile for this method to work. Note that this method will also transport any predators of the agent that may be present as well. For the gorse spider mite it is recommended that only 5 cm lengths of branch tips from an infested plant are used, since predators are more likely to be further down the stem targeting spider mite eggs and juveniles.

Beating or tapping

Tapping or beating branches over a tray will dislodge insects including any biocontrol agents that may be present. Using an aspirator (pooter), biocontrol agents can be sucked from the tray into a receiving container. A benefit of this method is that it allows the operator to exclude other insects including predators. Suitable aspirators can be constructed from a keyboard vacuum cleaner or they can be a manual device with suction applied by a person. Collected agents can be transferred into larger containers and transported to new sites.

Left: Harvesting cochineal infested cactus pads for redistribution to a new release site

Right: Salvation Jane flea beetles collected with a "pooter", then roughly counted and separated into containers for transport to a new release site

Using a sweep net

Sweep nets or butterfly nets can be used to collect agents that are in flight, or found on the surface of plants, or where plants are reasonably flexible. This method is especially good for flying and jumping insects. The contents of the net can be deposited into a sealed container; a zipped, collapsible laundry basket is good. Agents can be sucked out with an aspirator (as described previously) and transferred into a suitable container for transport to a new site.

Above: Collecting Salvation Flea beetles with a sweep net (photo: Phil Cramond)
Below: Releasing Salvation Jane pollen beetles (photo: Gemma Lindschau, EP NRM)

At the release site

All release sites should be clearly marked to ensure they can be easily relocated for monitoring.

Wooden stakes or star-droppers are useful markers, especially if painted in bright colours, as is flagging tape.

Many biocontrol agents will benefit from being released into a confined space such as a release cage. This reduces immediate dispersal and increases the likelihood of agents locating a mate. Release cages should have an open base and cover a small area of host weeds. The cage should be made of breathable material such as shade cloth that will limit the build-up of heat and condensation inside. Caging released agents is often very important in the early stages of a distribution program when the quantity of agent available for release is limited.

Uncaged releases can also be successful, and are a suitable method for community groups involved in large distribution programs, such as for bridal creeper and horehound biocontrol programs. Uncaged release sites should ideally be permanently marked, for example with a brightly painted stake, to assist ongoing monitoring.

Biocontrol agents released into pastures should be fenced off from livestock to prevent trampling and ingestion. Alternatively, sites can be located adjacent to pasture paddocks, in fenced native vegetation or tree lines. Biocontrol agents will be able to move from these refuges onto weeds in the pasture.

While different species of biocontrol agents for a weed will often not compete with each other directly, it is advisable to make the releases at different locations. This increases the likelihood of each agent establishing. Over time, as the agent populations expand, they will eventually spread to occupy the same location, maximising the impact on the weed population.

Release tent for the Salvation Jane pollen beetle, Mt Bold, South Australia.

Recording release site information

It is essential to keep complete records of all biocontrol releases.

Release information should be passed on to state and/or national researchers, and to regional and/or state biocontrol coordinators. This ensures that sites can be monitored over the long term. A sample release form is provided at the back of this booklet.

Critical information to record includes:

- Release date
- Agent being released and host plant (weed)
- Number or quantity of agents being released and life stage if possible
- Life stage and number of plants being inoculated (if relevant)
- Release method e.g. caged, spray solution
- Location of release with GPS coordinates
- Size of weed infestation, i.e. area infested
- Names of all people present at release
- Name and contact details of landowner/manager
- Name and contact details of release site manager if not the landowner
- Details of any photo points being established including GPS coordinates, compass heading to release site and distance to release site.

Monitoring and recording data on Salvation Jane biocontrol agents

Monitoring & evaluation: What is happening in the field?

Monitoring and evaluating release sites provides the primary source of information on the success of a biocontrol program.

Monitoring will provide information on presence or absence of agents over time as well as agent spread and impact. If there is a national, state or regional biocontrol program in place there may be a data sheet available to guide the monitoring method and information to collect.

In general, the type of information gathered should cover questions such as:

- Is the agent present at the site?
- Can agent damage be detected? If so can the area affected be quantified? Is damage affecting flower and fruit/seed production? Is the target weed becoming less dense?
- What is the spread of the agent from the original release site? What is the direction of spread?
- Are there any factors that may be affecting the success of the release site?

Before beginning to monitor a site, be familiar with the agent's lifecycle and damage so that the timing of monitoring is appropriate. A visual cue of agent presence is needed; such as larval or adult feeding damage, gall development, tunnelling or mining of stems or roots, bleaching, webbing etc. In some cases the weeds may need to be destructively sampled by breaking open stems or roots to see the relevant stage of the agent.

Other essential information to record includes:

- Name of observer
- Location of site with GPS coordinates
- Date of monitoring and time
- Environmental conditions, such as rain, cloud cover, temperature
- Number of observation points
- Impact at each observation point
- General comments on impact and spread and any contributing factors such as fire scars, recent weed control events, changes in land use etc.