FUTURE FARMING

Weed Warriors Teacher Resource

State Government Victoria

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Cover picture: State prohibited weed, mequite (*Prosopis species*), M Hansford, 2009.

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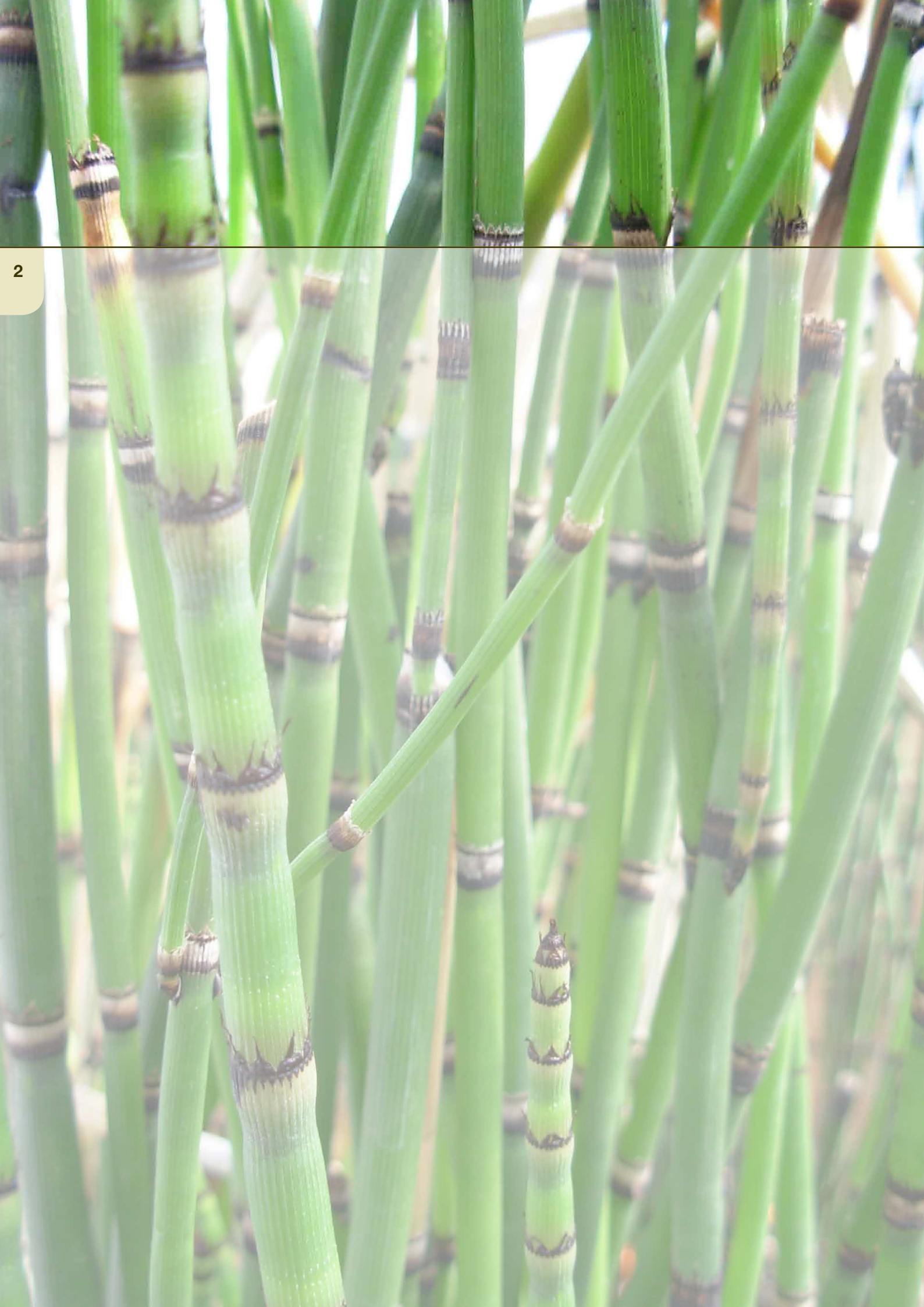


1. Weed Warrior program

1.1 Introduction

Weed Warriors is an innovative national community program that focuses on fostering increased awareness of, and involvement in, local weed issues.

Weed Warriors recognises students as the land managers of the future and seeks to involve them in weed issues through an on-going program of classroom and field based activities.

The activities are designed to move the program participants from knowledge to action, encouraging a sense of responsibility and connection with their natural environment.

The program also focuses on linking stakeholders involved in weed management with the community.

Weeds have a major negative impact on the Australian economy, environment and human health. Costs to the Australian agricultural economy from the impact of weeds are estimated to be around $4 billion per year. The impact of weeds on biodiversity, native conservation, tourism and landscapes is also substantial. Next to the problems caused by climate change, land clearing and salinity, weeds have been identified as a significant threat to biodiversity.

Weed Warriors brings the message of weed management to the future guardians of our land – our students. By making our students aware of weed issues we also raise these concerns within the local community. Local communities working together with natural resource management organisations: Parks Victoria, Landcare, local councils and other government departments, gives us the greatest opportunity to solve some of the problems that weeds present.

Weed Warriors teaches students how to manage weeds so as to reduce their harmful impacts on our environment.

1.2 What does the program involve?

Weed Warriors comprises three parts.

Program A provides information on weeds. It gives teachers the core knowledge needed to run a curriculum unit on weeds. It can also be used by teachers as a resource to supplement their own notes.

Program B is a weed curriculum program designed to build on the teacher notes provided in Program A. It includes classroom and school based activities which generally involve minimal set up, equipment and cost. Activities can be undertaken independently or as a whole unit of curriculum.

The information in Program B can be used as handout sheets or as part of other classroom activities.

Program C is a biological control program. Biological control is the management of weeds using natural enemies from the weed's country of origin. Through this program, students are given the chance to take part in real-life weed research. The students take on the role of weed scientists and their classroom becomes a mini research institute as they breed biological control agents to help control the target weed.

Program C generally lasts four to six weeks, schools can choose between the bridal creeper or gorse programs.

Teachers can choose which of the three programs they would like to run. As Program C requires more coordinated effort, support by the Victorian Department of Primary Industries is available to schools that want to take part in the full program.

1.3 Registering for Weed Warriors

Registration is essential for schools wanting to take part in Weed Warriors. Schools can register for free by contacting the Department of Primary Industries (DPI) on 136 186. The DPI Customer Service Centre will direct registration enquires to the Weed Warriors program coordinator for processing.

1.4 Weed Warriors and the Victorian Essential Learning Standards

Weed Warriors has been designed to meet and satisfy the requirements of the Victorian Essential Learning Standards (VELS) and associated domains for Levels three to six, as outlined in the tables on the following page.

Some components of the Weed Warriors program can be adapted to suit any level when accompanied by modified curriculum.

1.5 Accreditation

Weed Warriors is a component of the Australian Sustainable Schools Initiative (AuSSI). AuSSI is a partnership between the Australian Government, states and territories, which supports schools to work toward a sustainable future. Resource Smart AuSSI Vic is the local application of this national initiative, which involves a holistic approach to sustainability for primary and secondary schools by:

- involving the whole school
- providing students with real-life learning experiences
- improving management of the school's facilities and resource use including: energy, waste, water and increasing biodiversity.

The framework consists of a core module (ideally completed first) and four resource modules (waste, energy, biodiversity and water), which schools can complete over time in whichever sequence suits them. The Weed Warrior program falls within the biodiversity module.

ResourceSmart AuSSI Vic and 5 Star Sustainability Certification recognises and rewards best practices in sustainability. For further information visit the ResourceSmart website at http://www.resourcesmart.vic.gov.au/for_educators_3351.html.

Table 1 - Level three to six VELS requirements satisfied by Weed Warriors

Physical, personal and social learning

Domain	*Weed Warriors - general learning outcomes*
Health and physical education	Investigating weed problems in the environment encourages children to participate in physical activity in the local community.
Interpersonal development	Students are provided with experiences related to working in teams where collaboration and cooperation, sharing resources and completing agreed tasks on time are highlighted.
Personal learning	By giving students activities that have real and tangible relevance, the students have an emotional involvement and are encouraged to take responsibility for their learning.
Civics and citizenship	By participating in an event which is community based and extends beyond the school, the students are encouraged to think about the impact of their actions on the community.

Discipline-based learning

Domain	*Weed Warriors - general learning outcomes*
The arts	By including activities for project / poster work, students are encouraged to incorporate graphic representations of weeds and insects.
English	Students are required to read, undertake research, develop their own texts, communications and presentations.
The humanities – geography	Students study and investigate the geographical spread of introduced weeds in their local community and on a broader scale.
The humanities – history	By looking at how societies came to be established, the impact of these societies on the local environment is explored.
Mathematics	Students are required to record and monitor a range of data in a number of activities. They will learn how to measure and record data, how to display data graphically and how to interpret data.
Science	Students will be exposed to a significant number of new terms and definitions as well as scientific principles.

Interdisciplinary learning

Domain	*Weed Warriors - general learning outcomes*
Communication	Students are required to share their learnings from the program with the greater school community and also the local community.
Design, creativity and technology	Students combine an understanding of environmental issues with the practical skills involved in the design and implementation of an experiment / research project.
Information and communication technology	Students will be required to access, process, manage and present information and communicate with others using a range of different media.

2. Information on weeds - Program A

2.1 What are weeds?

A plant is commonly called a weed when it is out of place or growing in an area where it is not wanted.

Weeds can compete successfully for space, light, water and nutrients, which means that they can grow and reproduce rapidly. They often have protective features which prevent animals from grazing on them. Along with this most weeds often do not have native predators when they grow in areas where they have been introduced. People also sometimes provide favourable conditions for weeds to grow, without being aware that the weeds may grow out of control.

In some places, weeds can threaten agricultural productivity, have a negative effect on conservation values and have a harmful impact on human health.

2.2 Where do weeds come from?

Most of Australia's weeds have been introduced from other places including: Europe, South America, South Africa, North America, Asia and New Zealand.

Some weeds have arrived in Australia by accident in contaminated produce such as seed or soil, or through shipping and other transport. For example, in 1930 the African daisy was accidently introduced into South Australia from a ship's ballast at Port Lincoln.

However, most of the weeds from other countries have been deliberately introduced into Australia. Many were introduced to help establish successful primary industries when Europeans first settled in Australia. The plants were introduced for pasture improvement, cropping and horticulture or to support land management practices such as soil stabilisation and windbreaks. For example, willows were deliberately introduced in the 1800s and 1900s to stabilise streams and provide shelter for stock.

Primary industries are not the only group to have introduced plants into Australia. Public demand for exotic species for ornamental and cultural purposes has also contributed. At least 30% of the weed species currently found in Australia were originally introduced as garden plants. For example, bridal creeper was originally introduced as a garden plant in the 1870s.

It's important to note that a growing number of weeds are not introduced. These weeds are plants that occur naturally within Australia but have moved outside their natural range. For example, Cootamundra wattle, a native of New South Wales, has been planted throughout Australia as a streetscape and garden plant.

2.3 Weed characteristics

If weeds in Australia are not weeds in their home country, why do they become weeds here?

In Australia these weeds don't have natural predators or parasites that would attack the roots, seeds, leaves and stems of the plants, as would occur in their home country. Without these natural enemies, the plant population can grow more vigorously. If the plant also has features that allow it to colonise and out-compete other plants, it has a greater chance of becoming a weed.

The characteristics that can mean a plant is more likely to become a weed include the ability to:

- produce a large number of seeds
- produce seeds continuously
- produce seeds with long lives, which don't all germinate at the same time
- disperse seeds over long distances
- produce seedlings that grow quickly
- tolerate changes in the environment
- grow in different environments
- compete aggressively with other plants for light, water and nutrients
- produce protective features such as thorns, spines and poisons which stop animals from grazing on them
- respond well and adapt quickly to land disturbance.

Although a plant may exhibit some or all of these characteristics, it is not a weed until "found out of place or growing in an area where it is not wanted".

Introduced plants with 'weedy' characteristics that are not yet widespread are sometimes referred to as 'sleeper weeds'. This means that they're present in the environment but are not yet spreading rapidly. A change in environmental conditions such as adding fertiliser or removing a stand of vegetation, could help such plants establish and spread rapidly.

2.4 Types of weeds

Weeds are often divided into two broad groups: environmental weeds and agricultural weeds.

Some species can be both environmental and agricultural weeds, depending on where they are found. For example, blackberry is referred to as an environmental weed when it threatens native vegetation and as an agricultural weed when it threatens pasture production.

2.4.1 Environmental weeds

Environmental weeds are plants that threaten the conservation values of natural ecosystems. They include: bridal creeper, boneseed, willows, blackberry and English ivy.

They can be introduced species, or native Australian plants that are not endemic to the area in which they are growing. Coast wattle is an example of a native Australian plant that can be a weed in some environments.

Environmental weeds threaten conservation values in a range of ways:

Disturbing or reducing the biological diversity of natural ecosystems.
Weeds can eliminate or exclude native plant species preventing native plant regeneration. For example, sweet pittosporum reduces species diversity because the dense dark leaves that grow thickly on its branches cast heavy shade on the plants underneath. Weeds can also alter or destroy the habitat for native fauna. For example, wandering dew forms a dense mat over the forest floor preventing the lyrebird from scratching in the forest floor litter for food.

Bridal creeper invading native vegetation

Disrupting ecological processes and function.
Weeds can have a strong negative effect on systems such as hydrological cycles, soil chemistry, nutrient cycling patterns and dune configuration. For example, the thick root mat of willows can cause the flow and course of a stream to alter.

Competing with natural species.
Weeds can prevent native species from growing by out-competing with them for light, water and nutrients.

Reducing the aesthetic and recreational value of an area.
This can have an impact on industries such as tourism that depend upon the health of the natural environment. Weed invasion can reduce an area's appeal to tourists and threaten the area's income.

2.4.2 Agricultural weeds

Weeds can decrease agricultural yields by reducing the area available for grazing and by competing with pasture and crops. They can also cause livestock injury and even death. Weeds can also reduce the quality of produce through contamination and tainting.

These weeds are estimated to cost the Australian farming sector around $4 billion every year.

Agricultural weeds include: serrated tussock, Chilean needle grass, skeleton weed, ragwort, Paterson's curse and blackberry.

2.5 How weeds spread

Weeds can be spread in many different ways – and in fact are good at adapting to spread their seeds further. Some of the more common methods in which weeds may spread are described below.

2.5.1 Stock and feed

The spreading of hay and grains, contaminated with seed from weeds is one of the most common ways of spreading weeds into new areas.

Livestock can also spread weeds in their droppings because some ingested weed seeds can still grow after they've passed through an animal's digestive tract. Seeds that are sticky or spiny can also be spread on livestock for example, some seeds can get caught on a sheep's fleece.

Mexican feather grass planted in a garden

2.5.2 Machinery and disturbance

Soil that has been disturbed by machinery can be an ideal seedbed in which existing and introduced seeds from weeds can germinate. Seeds and plant parts can also get caught in tyres, slashers, graders and cultivators and be moved to new locations.

2.5.3 Humans and animals

Sticky or spiny seeds can get caught on clothing or shoes and can be carried to new places by humans after they walk through weed infested areas.

Domestic dogs, cats and wild animals can also distribute seeds in their coats, especially pest animals such as foxes and rabbits. Birds also transport seeds when they feed on the fruit and seeds of weeds such as blackberry and sweet pittosporum.

2.5.4 Garden escapees

Garden weeds can be spread when people dump their garden clippings, especially when they're dumped directly into bushland. Garden plants that have spread in this way include English ivy, wandering dew and agapanthus. Weeds are also sometimes mistakenly sold at nurseries. Government departments are therefore working with the industry to educate people about weed species.

2.5.5 Water, wind, explosive ejection and vegetative spread

The seeds and vegetative parts of weeds can enter waterways or drains and be carried downstream to new areas. Willows spread themselves along waterways in this way.

When plants are seeding, the wind can disperse seeds quite some distance. Many weed species have seeds that are adapted to be carried by the wind, such as the disc seed of ragwort, which has fine, white feathery hairs to aid wind dispersal.

Many legumes disperse their seeds through explosive ejection. The seeds are encased in pods which, when mature, burst open and eject the seeds. These seeds have been known to travel up to five metres from the parent plant.

2.5.6 Fire

Some weeds benefit from fire because it reduces competition and creates an environment in which the weed can spread rapidly. The new flush of weed growth after a fire can add to the available fuel load for future fires, potentially creating a cycle of high-fuel, intense burns followed by periods of immense weed growth.

Perennial weeds with well established, deep root systems survive fire very well. Weeds like flatweed, dock, sorrel and onion grass are among the first plants to recover and are often prominent after fires.

Many weeds are known to germinate more rapidly after fire than most native species and therefore can establish themselves in areas that native species may previously have dominated.

2.5.7 Climate change

Climate change results in a change in temperature and provides for more frequent weather extremes, such as flood and fire. Any factor that increases the stress on crops or native plants can make them more vulnerable to attack by insects and plant pathogens, which in turn means their ability to compete with weeds is reduced.

Weeds that respond rapidly to disturbances from climate change have a competitive advantage over less aggressive species.

Climate change, as well as the interactions between climate change and other processes (such as changes in land use and fire regimes) could turn some currently benign species into invasive species thus enabling sleeper weeds to become more active.

Climate change may favour weeds that are already established in limited areas in Australia. As climatic zones shift, weeds that are capable of rapid dispersal and establishment could potentially invade new areas and increase their spread.

2.6 Impact of weeds

There are a number of reasons why some plants are classed as weeds.

2.6.1 Stock injury, tainting and contamination

Weeds can cause injury to livestock. The seeds from saffron thistle and the burrs from spiny burr grass cause eye and mouth injuries in grazing animals. The fruit of the weed silver leaf nightshade can also poison and ultimately kill livestock.

Weeds can also reduce the quality of produce through tainting and contamination. The presence of weed vegetative matter, burrs or seeds in wool can lead to the downgrading of the value of a fleece. Horehound and Bathurst burr are common contaminants of wool.

Other weeds, such as wild garlic, can taint the milk and meat of livestock, lowering their value or making them unsaleable.

2.6.2 Competition

Weeds usually compete strongly with agricultural plants such as pasture and crops, for moisture, nutrients and light. This results in the reduced growth of the desired species, providing for a reduction in crop yields and a lower carrying capacity of pasture for livestock. Skeleton weed is an example of a weed that competes with cereal crops for nitrogen and when densely established can reduce wheat yields to almost nil. Thistles and Paterson's curse also compete and dominate pastures whilst boneseed competes with native vegetation.

2.6.3 Disease and pest animals

Some weeds, such as blackberry and gorse, can provide good harbour for rabbits, foxes and other pest animals. Other weeds may carry plant diseases for example, ox-eye daisy can host a virus that damages potatoes.

2.6.4 Interfering with agricultural practices

Some weeds make cultivation difficult when they are dispersed in the paddock as they become entangled in machinery and prevent efficient harvesting, as in the case of skeleton weed. They can also cause discomfort to workers when hand picking crops for example, thistles. Bridal creeper is an example of a weed that interferes with agricultural practices in citrus groves.

Some annual weeds such as Paterson's curse die off over summer leaving the ground bare and thus making the land more prone to erosion.

2.6.5 Interfering with transport, recreation and essential services

Weeds near railway lines can foul signal equipment and weeds near roads can block signs. Aquatic weeds such as water hyacinth can choke drains and irrigation channels. Weeds such as blackberry and gorse can form impenetrable barriers to livestock in paddocks and to bushwalkers in recreational areas.

2.6.6 Allergies and poisoning

Some weeds can cause allergies in humans. St John's wort and Bathurst burr can cause some people to develop skin reactions after being in contact with it, hemlock is also known to cause dermatitis.

Some plants are poisonous to livestock and humans. For example, ragwort contains alkaloids that damage the liver and St John's wort contains hypericin which makes animals sensitive to light.

3. Weeds in Australia

3.1 Weeds in Australia

Australia was the first country in the world to identify Weeds of National Significance (WONS). WONS are weeds defined as having a significant negative impact on agriculture, forestry and the environment.

In 1998 the Australian State and Territory Governments endorsed a framework to identify which species could be considered a WONS. The framework has four major criteria:

- the invasiveness of the weed species
- the impact of the weed
- the potential for spread of the weed
- socioeconomic and environmental aspects.

From a total of 3,000 non-native, naturalised plants, the states and territories nominated 71 weed species to be assessed and ranked under the framework. This process identified 21 WONS and a final list was endorsed by the Australian and state and territory governments in 1999.

This was the first attempt to identify and prioritise the impact of weeds across a range of land uses at the national level.

It was not a full scientific process but an attempt to draw together meaningful indicators as a base for future decision-making. It also provides a framework to prioritise weed management at the state, regional and local levels.

3.1.1 Threats posed by WONS

In Australia WONS threaten:

- human health and safety
- plant communities
- pastoral industries
- cultural values
- cropping industries
- tourism
- forestry management
- the community values
- water quality and supplies
- recreation and amenities
- infrastructure.

3.1.2 Managing WONS

Individual landowners and managers are responsible for managing WONS on their own land, according to the legislation in their own state. In Victoria, the state government is also responsible for eradication of a few WONS that are also State prohibited weeds (SPW).

The issues concerning WONS are serious enough to require coordination between all levels of government, organisations and individuals with weed management responsibilities.

A strategic plan, outlining strategies and actions needed to control the weed has been created for each WONS species.

There is also a Management Coordinator and a National Management Group/Steering Committee set up to oversee the implementation of the strategic plan for each species and to develop and coordinate priority actions.

The National Management Group is responsible for minimising the effects of the WONS on Australia's productive capacity and natural ecosystems and managing future threats to:

- primary industries
- land management
- human or animal welfare
- biodiversity
- conservation values.

3.1.3 Australia's Weeds of National Significance

alligator weed *Alternanthera philoxeroides*

- Found in Victoria, New South Wales and southeast Queensland.
- Grows on land or water.
- If found in Victoria call 136 186 immediately.

athel pine *Tamarix aphylla*

- Found in the Northern Territory, South Australia, New South Wales, Western Australia, Victoria and Queensland.

boneseed / bitou bush *Chrysanthemoides monilifera*

- These are different species from the same family and are very similar in appearance.
- Boneseed affects all states except Northern Territory and Queensland.
- Bitou bush is found along the east coast of New South Wales and Queensland and also found in Victoria.

blackberry *Rubus fruticosus*

- Occurs in southern parts of Australia, from Western Australia through to South Australia, Victoria, New South Wales, southeast Queensland and Tasmania.

bridal creeper *Asparagus asparagoides*

- Found in southern areas of Australia, especially in Victoria, South Australia, southwest Western Australia and some areas of New South Wales and Tasmania.

cabomba *Cabomba caroliniana*

- An aquatic plant infesting waterways along Australia's east coast in Queensland and New South Wales, also found in parts of Northern Territory.
- Prefers a warmer climate but has been found in central Victoria.

Chilean needle grass *Nassella neesiana*

- Large infestations in Victoria and New South Wales but also found in parts of South Australia, southeast Queensland and Tasmania.

gorse *Ulex europaeus*

- Mostly a problem in Victoria, Tasmania and New South Wales.
- Also found in South Australia and southwest Western Australia.

hymenachne *Hymenachne amplexicaulis*

- A wetlands plant which is found mainly in tropical coastal areas of Northern Territory, Queensland and northeast New South Wales.
- Not found in Victoria.

lantana *Lantana camara*

- Found mainly along the coast of New South Wales and Queensland.
- Some infestations in Northern Territory and Western Australia.

mesquite *Prosopis spp.*

- There are several different types of Mesquite in Australia.
- Found in all states except the Australian Capital Territory and Tasmania.
- If found in Victoria call 136 186 immediately.

mimosa *Mimosa pigra*

- Confined mainly to Northern Territory, with some infestations in Queensland.
- Not found in Victoria.

parkinsonia *Parkinsonia aculeata*

- Found in northern parts of Australia with some infestations in South Australia and New South Wales.
- Not found in Victoria.

parthenium weed *Parthenium hysterophorus*

- Mainly affects Queensland.
- Not found in Victoria.
- If found in Victoria call 136 186 immediately.

pond apple *Annona glabra*

- Small tree that mainly affects northern coastal areas of Queensland
- Not found in Victoria.

prickly acacia *Acacia nilotica*

- Mostly found in Queensland and Northern Territory with some infestations in South Australia and Western Australia.
- Not found in Victoria.

rubber vine *Cryptostegia grandiflora*

- Common throughout the river systems of Queensland and small infestations in Western Australia.
- Not found in Victoria.

salvinia *Salvinia molesta*

- An aquatic plant found in Queensland, NSW, Western Australia and Northern Territory.
- If found in Victoria call 136 186 immediately.

serrated tussock *Nassella trichotoma*

- Most infestations are in Victoria and New South Wales with some infestations in Tasmania.
- One of the worst weeds in Australia because of its invasiveness and potential for spread.

willow *Salix spp.* except *S. babylonica, S. x calodendron and S. reichardtii*

- There are many different types of willows found in Australia.
- Willows are predominantly in Victoria, New South Wales and Tasmania with some infestations in South Australia, Queensland and Western Australia.

For further information about the Weeds of National Significance go to the following website:
http://www.weeds.org.au/natsig.htm

3.2 Weeds in Victoria

3.2.1 Victorian noxious weed categories

Around 120 plants have been declared as noxious weeds in Victoria under the *Catchment and Land Protection (CaLP) Act 1994*. These plants cause environmental or economic harm or have the potential to cause harm and may also present risks to human health.

The CaLP Act defines four categories of noxious weeds:

State prohibited weeds (SPW)

These weeds either do not occur in Victoria but pose a significant threat if they invade or, if present, pose a serious threat and can reasonably be expected to be eradicated.

DPI is responsible for the eradication of State prohibited weeds from all land in Victoria. If you suspect you have seen a SPW please contact DPI immediately on 136 186.

Regionally prohibited weeds

These weeds are not widely distributed in a region but are capable of spreading further. The goal is to eradicate them from that region.

Regionally controlled weeds

These weeds are usually widespread and considered significant in a particular region. Land owners have the responsibility to apply control measures to these weeds to prevent the growth and spread.

Restricted weeds

These weeds include plants that pose an unacceptable risk of spreading in this State or to other parts of Australia if they were sold or traded in Victoria.

Plants in all four categories have the potential to cause harm and have environmental, economic and health impacts. It is illegal without permit to: buy, sell, possess for sale, deposit onto land, display, plant, propagate, bring into or transport around Victoria any of these declared noxious weeds. All schools registered with the Victorian Weed Warriors program are covered by a permit that allows students and teachers to undertake specific activities as a part of Program C.

A current list of declared noxious weeds is available on the Department of Primary Industries website at http://new.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/invasive-plants

3.2.2 Victoria's State prohibited weeds

alligator weed *Alternanthera philoxeroides*

- A perennial herb that can grow on both land and in water.
- Leaves are waxy, green, spear shaped and in opposite pairs along the hollow stem.
- Small ball-shaped white papery flowers grow on stalks.
- Spreads via runners or from fragmentation.
- Has been found in Melbourne backyards and along some waterways.

branched broomrape *Orobanche ramosa*

- A fleshy root parasite of broad-leaf plants lacking green parts (no chlorophyll).
- Stems are brown to straw yellow and branched.
- Flowers range from white to yellow, or mauve and with petals that form a tube.
- Grows upright (5-30 cm high), roots are thick, fleshy, short and attached to the host plant.

camel thorn *Alhagi maurorum*

- A spiny shrub growing up to 1.5 m tall.
- Leaves are smooth-edged, up to 2.5 cm long, arrow-head to oval shaped.
- Stems have sharp, yellow-tipped spines that are 1-2.5 cm long.
- Flowers are pea-like, brown to red or purple, in clusters of 1-8 near branch extremities, appearing in spring and summer.
- Seed pods are reddish-brown and strongly constricted between seeds.
- Roots of camel thorn can grow 2 m deep and up to 8 m laterally.

hawkweed *Hieracium species*

- A group of perennial daisies that can grow in a wide range of habitats, restricting the growth of neighbouring plants by releasing chemicals into the soil.
- Forms rosettes of leaves and stems, both of which are hairy.
- Flowers found in clusters of 5-30 flower heads and are either orange (orange hawkweed) or yellow (mouse-ear and king-devil hawkweed).
- Seeds are numerous and fluffy.
- Hawkweeds spread via seed or above ground runners (stolons).

horsetails *Equisetum species*

- A group of primitive spore bearing perennial fern allies, some preferring wetland habitats.
- Green, jointed hollow stems.
- Different species range in height (a few centimetres up to 2 m) and structure (straight stems to very branched).
- Does not produce flowers or seed. Horsetails spread via extensive underground root systems or from fragments.

karoo thorn *Vachellia karroo*

- A southern African wattle tree (up to 25 meters tall).
- Leaflets are small and opposite.
- Young branches are bright green, older branches are brown.
- White paired thorns (up to 25cm long) grow from branches.
- Ball-shaped flowers are yellow and appear over summer.
- Seed pods are smooth, sickle-shaped (up to 16 cm long).
- Has been removed from public gardens in Victoria.

knotweed *Fallopia japonica*, *F. sachalinensis* and *F. x bohemica*

- Fast growing semi-woody perennials that form dense, leafy thickets.
- Leaves of giant knotweed have a heart shaped leaf base, whereas Japanese knotweed leaves have a flat base.
- Stems are hollow and become woody with age.
- Small clusters of white, cream or greenish yellow flowers form in summer.
- Plants die back in autumn becoming dormant over winter, and regenerate from rhizomes in spring.

lagarosiphon *Lagarosiphon major*

- An aquatic plant that grows under the water surface either rooted to the floor of the water body or free-floating.
- Leaves (5-20 mm in length) are stiff, downward curving and arranged in alternate spirals along the stem.
- Stems grow 3-5 cm long.
- Flowers are very small, have 3 white petals and emerge above the water from December to April.
- It is currently not known to occur in Victoria.

lobed needle grass *Nassella charruana*

- Perennial tussock (80 cm – 1 m tall) invades open woodland and grassland habitats.
- Leaves are 20-60 cm long and rolled tightly inwards.
- Flowers emerge from the top 10–20 cm of unbranched stems (growing up to 1 m tall) during spring.
- Flowers/seeds are up to 6 mm long, with a distinctive off-white, two-lobed collar, at the base of the long awn (tail).
- Is rarely grazed as is unpalatable to stock.

mesquite *Prosopis species*

- A deciduous shrub or small tree (up to 15 m tall) with distinctive zig-zag shaped branches.
- Leaves are fern like (to 12 mm long).
- Stems are thick with dark, cracked bark.
- Pairs of spikes develop on the main stem or branches.
- Flowers are light yellow 'lamb's tails' (5-10 cm long) appearing over spring and summer.
- Can withstand drought conditions and produces abundant seed.

Mexican feather grass *Nassella tenuissima*

- A dense tussock (to 1 m high).
- Leaves are tightly rolled and serrated or rough.
- Flowers/seeds are fluffy and white to cream in colour, appearing mainly in spring and summer.
- Seeds have a long awn (tail) with one or more bends.
- May be found in gardens, particularly in metropolitan Melbourne.

parthenium weed *Parthenium hysterophorus*

- An annual herb (to 2 m tall) initially a flat rosette then grows upright to flower.
- Leaves are deeply divided (5-20 cm long) and covered in fine hairs.
- Flowers are creamy-white, star shaped and 4 mm across.
- Flowering can occur all year round in favourable conditions, but usually occurs in summer.
- Can cause skin irritations and is toxic to cattle.

perennial ragweed *Ambrosia psilostachya*

- A perennial herb growing to 30-150 cm.
- Leaves are grey-green, hairy and deeply lobed.
- Stems are branched in the top half, hairy, with lengthwise streaks and woody at the base.
- Male flowers are cream or pale green, arranged in 3-12 cm long spikes at the ends of branches.
- During summer - Autumn months single female flowers appear in the leaf axils.
- Creeping roots can form new plants and could be spread by cultivation.

poverty weed *Iva axillaris*

- A long-lived perennial herb (to 40 cm tall) that can restrict the growth of other plants due to chemicals it releases into the soil.
- It can also survive well in drought conditions.
- Leaves (10-30 mm long) are aromatic when crushed, hairy, grey-green, and grow directly from the main stem.
- Flower heads (5-7 mm) are green-yellow and drooping, appearing over summer.
- Reproduction is by a spreading root system or from root fragmentation.

salvinia *Salvinia molesta*

- A perennial aquatic fern, that floats on the water surface.
- Surface leaves are oval shaped (up to 2.5 cm long) and covered in waxy hairs that repel water.
- Submerged leaves act and look like roots.
- When plants are crowded the flat leaves become bunched up, oblong in shape and larger.

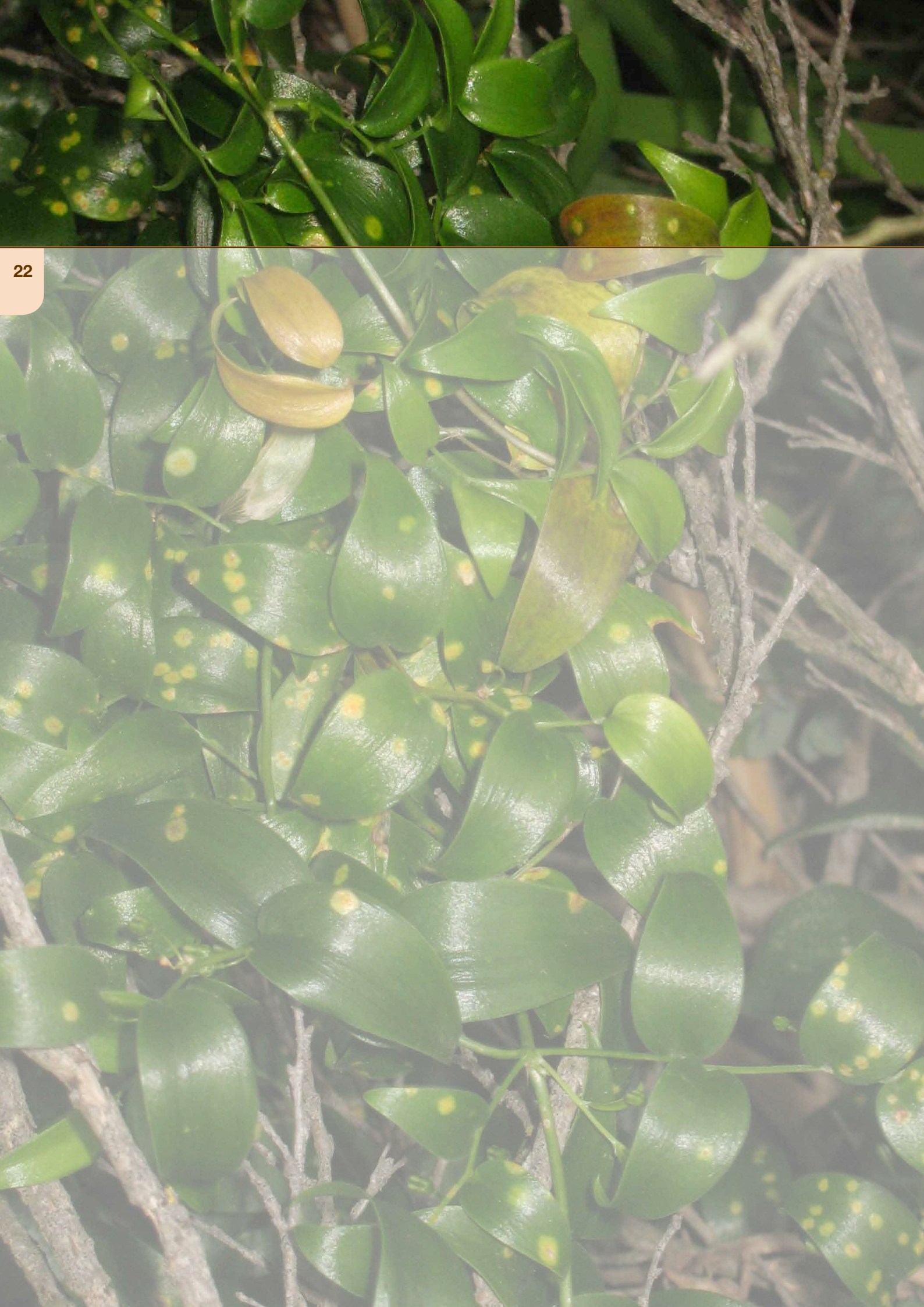
tangled hypericum *Hypericum triquetrifolium*

- A perennial herb to 45 cm that is very competitive and could invade open woodland and agricultural areas.
- Arrowhead-shaped leaves (5-15 mm long) arranged opposite.
- Stems are much branched and have numerous minute black glands.
- Over summer, short stalked, yellow flowers, with five petals, occur in clusters at the ends of branches.
- Fruit is a capsule with three compartments (3-4 mm long).
- Reproduces from rhizomes (underground stems) and seed.

water hyacinth *Eichhornia crassipes*

- An aquatic, free floating, plant which grows into dense mats.
- Stems are spongy and have a bulb-like swollen base that aids in flotation.
- Roots black to purple and appear feathery.
- Flowers are mauve with six petals, the upper most with a yellow spot in the centre.
- Has been found traded illegally at markets and garage sales.

If a State prohibited weed has been found in Victoria, please call 136 186 immediately.



4. Integrated weed management program

A number of methods are used to suppress, control and manage weeds. The invasion curve (see diagram below) outlines the four phases of weed management and their various levels of effectiveness.

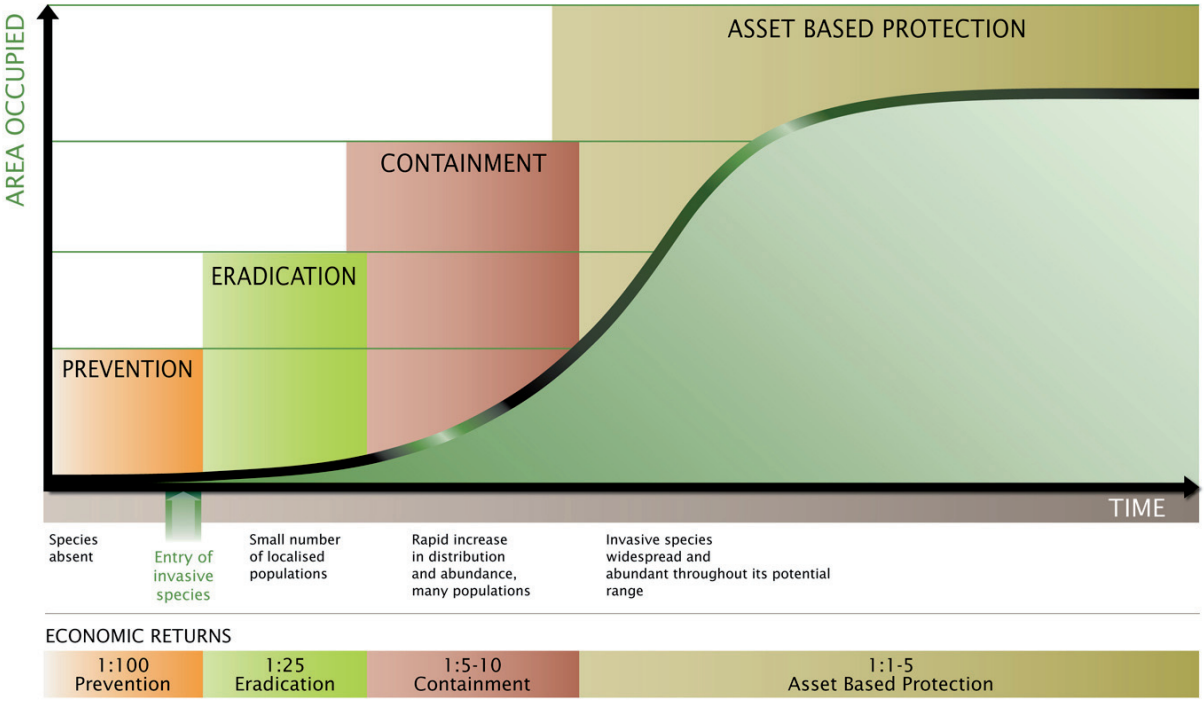
Prevention stops the weed species entering the area while eradication involves the complete removal of a weed species. These phases generally relate to new and emerging weeds that are either not present in Victoria or present in low numbers.

Containment involves identifying the boundary of a weed infestation and preventing the weed from spreading beyond that boundary.

Asset based protection involves managing invasive species that are so widespread it would be inefficient to control infestations everywhere it occurred and containment of these species would provide for a low return on investment. The asset based approach is to manage the species that would result in the reduction of its adverse effects. This approach provides the greatest benefits, by achieving protection and restoration outcomes, for specific highly valued assets.

Weeds can be managed using many different methods some of which are described below. Generally, weeds will be managed more effectively if combinations of these methods are used. This is known as integrated weed management.

The Weed Warrior program currently works with asset based protection species. Working on established species falls within the asset based protection phase of the curve and has a 1:1-5 return in investment. The Weed Warrior program however involves the biological control of established species which can have a 1:23 return on investment.



4.1 Prevention

This is the most effective means of weed control. Preventing weed spread is easier and cheaper than addressing established weed problems. The spread of weeds can be prevented by:

- ensuring that machinery used in a weed infested area is thoroughly cleaned before it is moved into a weed free area
- minimising soil and vegetation disturbance (disturbed ground often provides ideal conditions for the germination of seed from weeds)
- encouraging primary producers to buy shorn sheep as there is less chance of transporting weed seeds in their fleece
- confining livestock for a week when first brought onto a property, this will allow viable seed from weeds to be expelled from their digestive tract
- feeding livestock in a confined area if feed supplies have been brought in from outside the property
- purchasing fodder, hay and seed from local producers, which reduces the chance of new weeds being introduced into the district
- checking seed obtained from outside for any contaminants
- educating the community about weed prevention.

4.2 Containment, eradication and asset based protection

The following methods can be utilised to totally remove a weed or reduce weed abundance so that its impact is reduced. These techniques are therefore suitable for the control of weeds in all the stages of the invasion curve (containment, eradication and asset based protection).

4.2.1 Pasture and grazing management

Well-planned pasture and grazing management practices together with prudent fertiliser, sowing and soil aeration programs are essential to minimising weed infestations. Grazing at a range of different stocking rates can be a useful technique for weed control.

Heavy stocking rates force livestock to eat less desirable plants such as weeds, which reduces the weed's density and vigour. This should not be done when a weed is toxic to livestock.

Lighter stocking rates will lead to selective grazing and so weedy or less palatable plants remain uneaten. Mowing or slashing of pasture after light grazing ensures that weeds not eaten by livestock do not gain an advantage and crowd out the preferred plants.

The type of stock used in grazing can also assist in weed control. Sheep tend to graze close to the ground causing more damage to weeds than cattle. Goats preferentially select many weeds and can be very useful in controlling weeds such as thistle and blackberry.

4.2.2 Mulching

Mulching involves placing a layer of material on the ground so that the weeds cannot penetrate. The seed from the weeds are denied access to light and some are unable to germinate. Mulching also helps to preserve moisture in the soil for desired plants. Many different materials can be used as mulch including: bark, newspaper, plastic and crop stubble.

4.2.3 Plant competition

Growing more vigorous plants that will out-compete weeds can suppress their growth. For example, an early maturing cultivar of sub clover will help to out-compete capeweed and erodium.

4.2.4 Burning

Burning is a control method that must be carried out by experienced people.

Burning can control weeds in two ways. It kills the mature weed population and stimulates the weed seeds to germinate so they can be controlled while in the vulnerable seedling stage. Alternatively, the soil can be heated to a temperature that destroys the weed seeds and stimulates the germination of desirable plant seeds. This technique is used particularly for environmental weeds such as boneseed. Fire can also be used to remove weeds killed by chemical treatment providing access for follow-up control and may create better conditions for re-vegetation work.

4.2.5 Chemical

There are many herbicides available to control weeds. Some work on a wide variety of plants and others only affect certain types of plants; these are referred to as selective herbicides.

Choosing the most appropriate herbicide will depend on the weed and its life cycle characteristics. If a plant lives for one year (annual) it may only need a herbicide that kills the targeted section of the plant it will contact. However, a plant that lives for many years (perennial) may need a herbicide that kills all parts of the plant including the roots.

The growth stages of a weed determine when to apply the herbicide. As a general rule, all weeds should be treated before flowering and definitely before the seed sets. However, some weeds, such as Paterson's curse are best controlled during a rosette stage, which means that less herbicide is used.

How long a herbicide takes to work will depend on its mode of action. The results of some chemical control activities may not be seen for many months.

The label on the herbicide container will indicate its effectiveness for different weeds and how it should be applied. Herbicides should be strictly used according to the directions on the label and appropriate protective clothing should be worn.

Some herbicides may only be used by people who hold an Agricultural Chemical User Permit in Victoria. A list of herbicides and further information is available from the DPI website.

4.3 Biological control

Many of the weeds invading farms and bushland originally come from other countries. In their home country natural enemies such as insects, mites and plant diseases, kept these weeds under control. However, when introduced into Australia without these enemies these species are able to establish and spread.

Biological control involves the use of a living species (the agent) to suppress and reduce the occurrence of an unwanted pest species (the target). The aim is to restore the natural balance between a pest species and its environment by introducing its natural enemies.

This method is particularly suitable for controlling weeds and is also used to control insect or animal species such as the European wasp and the rabbit.

In Victoria, the Department of Primary Industries is responsible for research into the biological control of weeds.

4.3.1 The biological control process

The process of introducing and releasing a natural enemy of a weed into Australia is a lengthy one.

Firstly the benefit of controlling a weed is analysed against any possible benefits the weed may provide. This analysis is used to assess whether a biological control program is acceptable.

Next the weed is proposed as a candidate for biological control research to the Australian Weeds Committee and the Agriculture and Resource Management Council of Australia and New Zealand. Various industry groups are then given the opportunity to comment on the proposed target weed so that any possible objections can be determined. For example, Paterson's curse is considered a weed by graziers but is a useful plant to bee-keepers.

If the weed is approved for biological control research the taxonomy (naming), biology and ecology of the target weed is studied both in Australia and in its country of origin. The country of origin of the weed is then surveyed for natural enemies that could be potential biological control agents. When the most damaging agents are found their biology, distribution and the level of damage they cause is studied.

When promising agents are selected, permission is sought from the Australian Quarantine and Inspection Service (AQIS) and Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) to import them into an AQIS approved quarantine facility.

To ensure that the biological control agent does not become a pest itself it is thoroughly tested to determine its host specificity. Host specificity testing is defined as testing the range of plant species on which it will feed and reproduce.

This is a very important stage in the biological control process. Inadequate testing could result in agents that have an undesired effect (such as causing damage to horticultural industries or natural ecosystems) being introduced into Australia. The cane toad is a classic example of what can happen when proper consideration of risks does not occur prior to a species' introduction.

Host specificity testing involves allowing the biological control agent to feed on a range of plant species that are:

- economically important (vegetables)
- socially important (garden ornamentals)
- ecologically important (native plants).

Plants that are closely related to the weed species are also used in the testing.

If the agent feeds and successfully reproduces on any plants of economic, social or ecological importance it is not considered safe for release into Australia.

If testing indicates the agent is safe scientific experts from each Australian state and territory review both the test list and results of the host specificity testing. The test results are then submitted to AQIS and SEWPaC and permission to release the agent is sought.

If permission is granted, the agent must be bred under quarantine conditions for at least one generation to make sure it is free of parasites and diseases. The offspring of this initial generation can then be released into the Australian environment.

The best method for breeding large numbers of each agent is then determined. Widespread releases are made at the appropriate time of the year so that the agent will survive and become established.

Ideally locations where agents are released are closely monitored over many years. Their establishment, spread and the impact they exert on the target weed population are assessed and the program is reviewed.

Several species of agents and several strains of the same agent may have to be introduced to ensure that a weed is controlled, especially if it is distributed across different climatic zones.

4.3.2 Time required for biological control

Biological control programs are usually long-term because of the time it takes to find, test, breed and release potential agents. The time required for the agent to become sufficiently abundant so as to significantly affect the target also needs to be considered. A program for one weed may span more than a decade.

Even then, there are no guarantees either that the agents chosen and released will have an impact on the target weed. It is difficult to predict how well the agent will control the weed, even if it does become established. In fact, biological control agents may produce different results from year to year and place to place.

Agents that do become successful will help to suppress the target weed's vigour and restrict its spread into new areas. Biological control will never totally eradicate the target weed as a natural balance between the biological control agent and the weed will eventually be reached.

With luck, this happens at a level where the size of the weed population is reduced to a level where the weed's impact is no longer a problem. In some cases, further success can be achieved by introducing several agents to attack different parts of the weed such as the stem, root system, leaves and seeds.

It is sometimes possible for biological control to be so successful that no other control is necessary. More commonly other control methods will still be needed to achieve the desired control level, although these might not need to be so frequent or intensive.

For this reason, biological control should be considered as part of an integrated weed management program.

4.3.3 Biological control in Victoria

In Victoria, biological control programs have already been used, or are under way, on many important weeds.

Some of the programs are in the early stages of implementation and biological control agents are just being reared for release. Others already have agents well established in the field, which are collected and re-distributed to new infestations at the appropriate time of the year.

Weeds that have biological control agents established in Victoria include:

- blackberry
- dock
- skeleton weed
- St John's wort
- Paterson's curse
- common heliotrope
- slender thistle.

Weeds with biological control programs in progress include boneseed, bridal creeper, gorse, cape and English broom and blackberry.

4.4 Revegetation

Revegetation is important whenever large stands of a weed have been removed, most often in the asset based protection phase of weed management.

Weed control programs need to be coupled with a replacement or revegetation program. This involves filling the gap with more desirable species to prevent weeds reinvading the space.

Replacement can involve: pasture improvement or renovation, the planting of a crop, or revegetation with indigenous species (that is, plants native to the local area).

Revegetated areas should also be checked regularly for weed reinvasion. Any weeds that are detected must be dealt with immediately to control the infestation before it spreads further.

5. Weed curriculum - Program B

5.1 Classroom program

A number of practical activities have been developed to support the theory component of this program, and enhance and extend the students' understanding and knowledge of weeds and weed management.

They range from activities that can be completed in a class session to ongoing projects. These activities are provided in the following pages of this section:

- 5.2 Weeds – what do you know?
- 5.3 Meet the weeds
- 5.4 Weed dictionary
- 5.5 Weed parts
- 5.6 Flying seeds
- 5.7 Weeds of National Significance
- 5.8 Weed management
- 5.9 Biological control
- 5.10 Bugs and weeds
- 5.11 Weeds – what do you know now?

The activities have been designed for Weed Warriors to satisfy the requirements of the Victorian Essential Learning Standards (levels three to six).

All worksheets can be copied and distributed to students as part of an overall unit of curriculum.

A table to help you identify activities that focus on specific skills and knowledge has been provided in Section 5.12

5.2 Activity: Weeds - what do you know?

Welcome to Weed Warriors. You and your school are going to be working on an important project to reduce the weed problem in your local community. First, let's see what you know about weeds already.

1. What is a weed?

2. Where do weeds come from?

3. How do weeds spread to other areas?

4. Can you name any weeds?

5. Why do you think weeds are a problem in the community?

6. How can we get rid of weeds?

7. Most weeds can be eaten by living things that are their natural enemies. Can you list any living things that eat weeds?

TRUE or FALSE (Circle the correct answer)

Weeds are able to grow quickly.	TRUE	FALSE
Weeds can have a bad effect on human health and safety.	TRUE	FALSE
Weeds only grow in gardens and lawns.	TRUE	FALSE
Some weeds can grow in water.	TRUE	FALSE
Only farmers and Landcare are responsible for managing weeds.	TRUE	FALSE
A weed's natural enemy comes from the same country from which the weed originated.	TRUE	FALSE
Biological control utilises a natural enemy of the weed to reduce its spread.	TRUE	FALSE
Weeds are not dangerous to animals or humans.	TRUE	FALSE
Cows and sheep can eat any weeds that grow in their environment.	TRUE	FALSE

*Answers can be found by reviewing the information contained in Program A.

5.3 Activity: Meet the weeds

Weeds can look like just any other plant. They can sometimes look very attractive. Remember though, a weed is a plant that grows where it is not wanted.

Aim:

To explore the school environment and examine the presence of weeds.

Equipment:

A copy of this worksheet and a sunhat.

Method:

Visit three different outdoor areas around your school, for example, garden bed, play area, pathway. Complete this worksheet and discuss back in the classroom.

Area 1:

1. Can you see weeds? YES / NO
2. How many different kinds of weeds can you see? _____
3. Draw the most common weed you can see:

4. I think there are weeds in Area 1 because:

_____

_____

_____

Area 2:

1. Can you see weeds? YES / NO
2. How many different kinds of weeds can you see? _____
3. Draw the most common weed you can see:

4. I think there are weeds in Area 2 because:

_____

_____

_____

Area 3:

1. Can you see weeds? YES / NO
2. How many different kinds of weeds can you see? _____
3. Draw the most common weed you can see:

4. I think there are weeds in Area 3 because:

_____

_____

_____

5.4 Activity: Weed dictionary

Aim:

To become familiar with words used in the study of weeds.

Equipment:

Sheet of poster paper.

Coloured pens.

Dictionary (or other internet reference material).

Method:

Students can work individually or in pairs.

Starting with the list of words and terms below, find out what each one means and write it on your poster. As you continue to learn about weeds, make sure you add all new terms to your poster. You can also include drawings or pictures on your poster.

Here's a list to start you off – see how many more you can add.

- Weed
- Environmental weed
- Agricultural weed
- Ecosystem
- Biodiversity
- Habitat
- Biological control
- Native plant
- Introduced plant
- Invasive species

5.5 Activity: Weed parts

Aim:

To become familiar with the different parts of weed plants.

Equipment:

A copy of this worksheet.

Examples of weeds collected from within the school grounds before the activity.

Method:

With a partner, choose two different types of weeds from the samples collected. Describe your weeds in detail by completing the table on the next page. You can use drawings as well as descriptions.

Compare the two weeds and give a one minute presentation to the class describing the weeds and how they spread.

Name of weed 1:

Part	Present (Yes/No)	Shape	Size (mm)	Colour	Smell	Texture
Leaf						
Stem						
Root						
Seed						
Flower						
Fruit						
Prickles / thorns						
Tuber						
Other part						

Name of weed 2:

Part	Present (Yes/No)	Shape	Size (mm)	Colour	Smell	Texture
Leaf						
Stem						
Root						
Seed						
Flower						
Fruit						
Prickles / thorns						
Tuber						
Other part						

5.6 Activity: Flying seeds

Background:

Weeds can be spread (dispersed) by many natural means. Seeds (or other parts of the weed plant) can be moved to other places by wind, water and animals.

Aim:

To look at weeds that produce seeds that are spread by the wind.

Equipment:

A copy of this worksheet.

Seeds collected from a number of different weeds found on the school grounds (at least four) .

Paper or plastic bags.

Magnifying glass.

Large book.

Measuring tape.

Vacuum cleaner.

Method:

Part 1 – weed collection

There are a few different ways you can collect seeds:

- Put large woolen socks over the shoes of students and have them walk through weedy areas on the school grounds. Pick the seeds from the woolen socks.
- Collect directly from the weed plant.
- Place a stocking over a weed flower and tie the bottom of the stocking around the stem. This will collect the mature seed of some weeds.

For this activity, you will need a large number of seeds from four different weed plants.

Part 2 – seed dispersal

- Make a sketch of each of the different seeds.
- Use a hard floor surface to make a row of four different seeds. Use a book to create a wind current, by standing it up so it can flop down. Make sure that the book will not land on the seeds. Let the book go so it makes a fast current of air.
- Watch as the seeds move and come to rest. Measure the distance that each of the seeds travelled and record it in the table (in centimetres). Observe also how the seeds travelled, for example, did they float (stay aloft) or glide (move in a straight line)?
- Collect the seeds and repeat the process twice more. Calculate the average distance travelled by each of the seeds over the three trials.
- Make up a graph to show the results.

Seed	Sketch	Round 1	Round 2	Round 3	Average

Questions:

1. Which seed travelled the furthest?

2. Which seed floated the longest?

3. Did any seeds have features that might help the seed to glide (fly through the air quickly), such as wings? Use a magnifying glass to help you get a closer look.

4. Did any seeds have features that might help them to float (catch the air like a parachute) eg hairs?

Use a vacuum cleaner to remove ALL the seeds and make sure you dispose of the vacuum bag in landfill rubbish.

5.7 Activity: Weeds of National Significance (WONS)

Aim:

To familiarise students with the names and diversity of the WONS that affect Australia.

Equipment:

A copy of this worksheet.

Computers with internet access.

World map & pins.

Method:

Students work in pairs and select two weeds from the WONS list below. Prepare a poster, word document or Powerpoint presentation covering the questions below.

For further information about the WONS go to the following website:
http://www.weeds.gov.au/weeds/lists/wons.html

Weed Management Guides for each WONS species can be found at:
http://www.weeds.gov.au/publications/guidelines/wons

Weeds of National Significance:

- alligator weed
- athel pine
- boneseed/ bitou bush
- blackberry
- bridal creeper
- cabomba
- Chilean needle grass
- gorse
- hymenachne
- lantana
- mesquite
- mimosa
- parkinsonia
- parthenium weed
- pond apple
- prickly acacia
- rubber vine
- salvinia
- serrated tussock
- willow

Questions:

1. Where did the weed come from?
2. How do you think the weed came to Australia?
3. Where is it found in Australia?
4. How does this weed spread?
5. What climatic and soil conditions does it like?
6. Discuss the weed's impact on bushland / farms / waterways /communities.
7. How is this weed being controlled in Australia?
8. Are there any natural enemies of this weed?
9. Why do you think this weed has been classified a Weed of National Significance?

Presentation:

Give a presentation to your class on your weed, showing its country of origin on the world map with a coloured pin or other marker.

5.8 Activity: Weed management

Aim:

To explore and understand the different methods of weed management to prevent weed spread.

Equipment:

A copy of this worksheet.

Library for reference materials.

Access to internet sites.

Method:

Using reference materials (books, brochures, websites etc) complete the table on the next page investigating different methods for managing the spread of weeds.

Method	Description	Advantages	Disadvantages
Prevention			
Mechanical			
Chemical			
Fire			
Biological control			

5.9 Activity: Biological control of weeds

Aim:

To develop an understanding of biological control and its impact on invasive weeds.

Equipment:

A copy of this worksheet.

Method:

Read the following text and answer the questions in your workbook.

Biological control of weeds:

Plants that have become weeds in Australia are rarely invasive and troublesome in their home country or area. This is often because populations in the home country are controlled by natural enemies such as insects and pathogens (disease-causing organisms like fungi and bacteria) which attack the seeds, leaves, stems and roots of the plant.

If plants are introduced to a new country or area that doesn't have these natural enemies, their populations may grow unchecked to the point where they become so common that they are regarded as weeds. A weed becomes a problem when its population increases so much that it starts to affect the economic or ecological sustainability of the ecosystem.

What is biological control?

Biological control makes use of the weed's naturally occurring enemies (found in their country of origin) to help reduce its impact on agriculture and the environment. It aims to reunite weeds with their natural enemies and achieve sustainable weed control.

The natural enemies of the weed are often called biological control agents.

It is critical that the biological control agents do not become pests themselves. Considerable host-specificity testing is done before biological control agents are released, to ensure they will not pose a threat to non-target species such as native and agricultural plants.

Not all weeds are suitable for biological control. Developing a biological control project requires a major investment, sometimes costing millions of dollars.

Biological control agents are generally only used when the cost of conventional control methods such as herbicides, mechanical control or fire is too great, either in dollar terms or in terms of their impact on the environment.

Australia has been working on the biological control of weeds since the 1920s, starting with the biological control of prickly pear. There are now many active biological control projects underway for many of the Weeds of National Significance (WONS), which cause problems in bushland, agricultural and waterway ecosystems.

Biological control is not a magic solution and not all weeds have biological control agents that would be safe to introduce into Australia.

The process

It can take up to 10 years to find, test, breed and release potential agents. It is difficult to predict how successful an agent will be in controlling a weed in any specific situation.

If the agent does establish itself on the weed it will help to suppress the target weed's vigour and restrict its spread into new areas.

Biological control does not kill the target weed completely but establishes a natural balance between the agent and the weed. If that point is one at which the ecosystem can tolerate the weed, the biological control has been successful.

Biological control is a long-term solution which is most effective as part of an integrated weed management approach.

Questions:

1. What is biological control?
2. Explain what is meant by "host –specificity".
3. Give three reasons why all weed problems cannot be treated with biological control.
4. What does "vigour" mean?
5. What is a "pathogen"?
6. Why do you think it can take up to 10 years before a release agent is ready for use?
7. What might happen if proper testing was not done prior to the release of a biological control agent?
8. Why do you think it is important that the biological control agent does not kill the target weed?
9. Name five effects that weeds can have on an environmental or agricultural ecosystem.
10. What other methods could be used in an integrated weed management approach?

5.10 Activity: Bugs and weeds

Aim:

To study a selected weed in detail and explore the effectiveness of biological control agents for this weed.

Equipment:

A copy of this worksheet.

Access to the internet.

Library reference material.

Copies of the Weed Management Guides for gorse, boneseed, blackberry and bridal creeper. These can be found at: http://www.weeds.gov.au/publications/guidelines/wons/index.html

Method:

Students work in small groups and select a weed such as gorse, boneseed, bridal creeper or blackberry.

In part 1 of this activity students are to undertake research on their chosen weed and display the results on a poster, PowerPoint, website/blog or through the use of a three-dimensional model.

In part 2 students are required to produce a news article raising awareness on the use of biological control for weed management.

Students are to list reference details of at least two websites and two text books.

Part 1:

1. Describe the weed, its country of origin and how it came to Australia.
2. Why has it been classified as a Weed of National Significance?
3. How widespread is the weed throughout Australia?
4. What methods have been used to control this weed?
5. What biological control methods are being used to manage this weed?
6. Hint: include the name and details of the agent.
7. Has biological control of this weed been successful – why / why not?
8. Give specific examples.

Part 2:

Write an article for your school newsletter (or website) to help raise the awareness of biological control of weeds in the local community.

Each paragraph should focus on a particular point – such as what the weed is, how the agent is used to control it, advantages, disadvantages. Make sure you come up with an attention grabbing headline!

5.11 Activity: Weeds - what do you know now?

This activity is best used after participation in Program C.

You have been working hard and doing a great job to reduce the weed problem in your local community. What else do you know about weeds now?

School: _____

Year: _____

Name: _____

Date: ____ /____ /____

1. What is the name of the weed you have been growing and what country is it native to?

2. Draw a diagram of what this weed looks like.

3. What is the natural enemy of this weed and what country does it come from originally?

4. Draw a diagram of what this insect looks like.

5. What affects do weeds have on local plants and animals?

6. What does biological control of weeds mean?

7. In the community, who has the responsibility to reduce the weed problem?

8. What are some of the challenges to starting a biological control program?

9. How will you know if your biological control program has been successful?

10. What part of the program did you enjoy the most?

11. Was there a part of the program that you think could be improved?

12. Would you recommend this program to other students? YES NO

5.12 Activity Idenfication Chart

LEVEL 5 (Years 7 & 8)			5.2 Weeds - what do you know	5.3 Meet the weeds	5.4 Weed dictionary	5.5 Weed parts	5.6 Flying seeds	5.7 WONS	5.8 Weed management	5.9 Biological control	5.10 Bugs and weeds	5.11 Weeds - what do you know now?
Strand	**Domain**	**Learning outcomes**										
Physical, personal and social learning	Health and physical education	Participate in outdoor activities promoting a healthy lifestyle.		√			√					
	Interpersonal development	Provide support to other members of the team to ensure team success.				√		√			√	√
		Review team performance and suggest ways to improve performance.				√	√	√			√	
	Personal learning	Recognise personal strengths and weaknesses and take actions to address weaknesses.	√		√	√					√	
		Respond positively to feedback from others.	√		√	√		√			√	√
		Complete work within set timeframes.		√		√	√	√		√	√	
	Civics and citizenship	Explain different perspectives on contemporary issues.						√	√	√	√	
		Propose solutions to problems in societies.	√							√	√	√
		Participate in school and community events that contribute to environmental sustainability.									√	

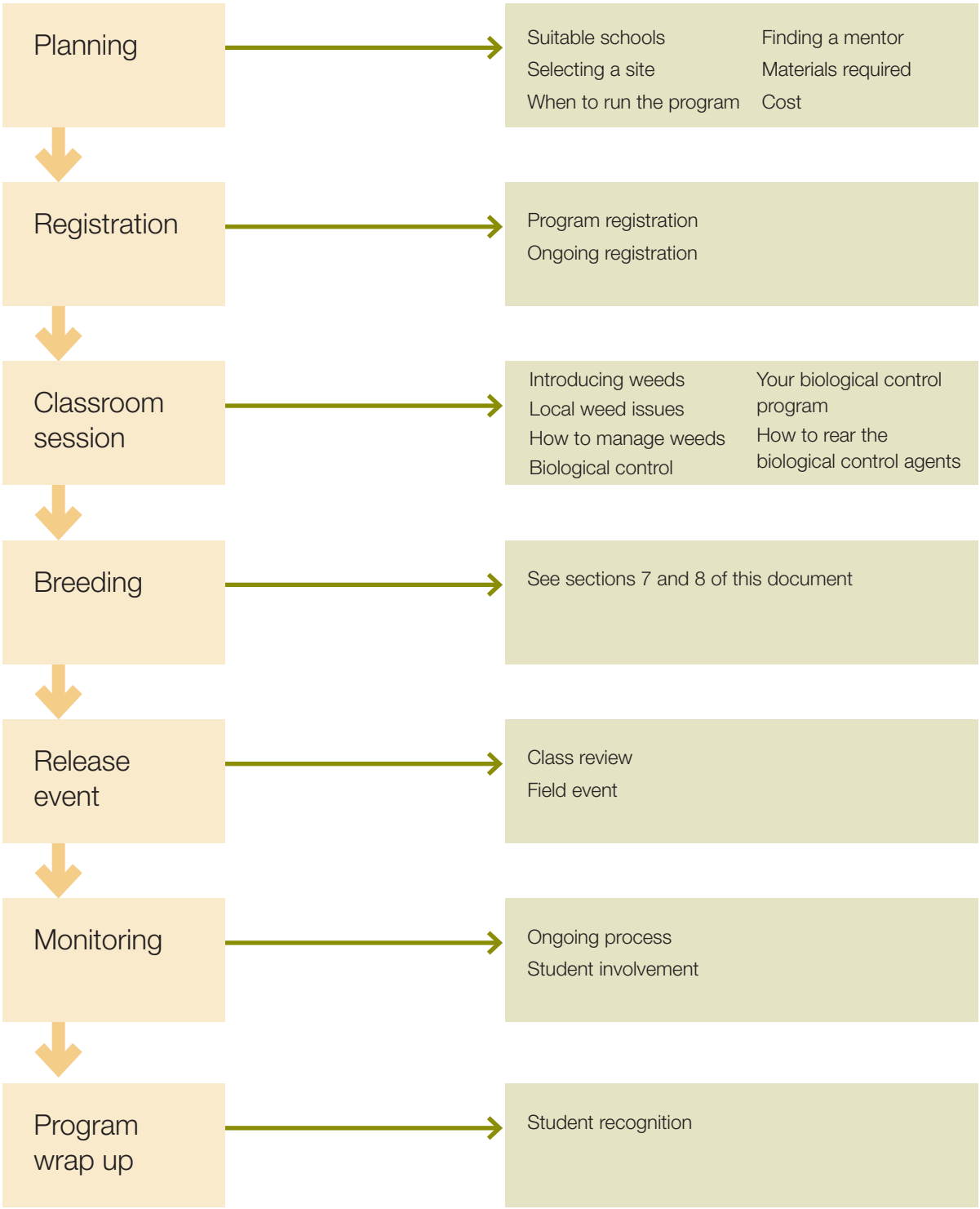
LEVEL 5 (Years 7 & 8)			5.2 Weeds - what do you know	5.3 Meet the weeds	5.4 Weed dictionary	5.5 Weed parts	5.6 Flying seeds	5.7 WONS	5.8 Weed management	5.9 Biological control	5.10 Bugs and weeds	5.11 Weeds - what do you know now?
Strand	**Domain**	**Learning outcomes**										
Discipline based learning	The arts	Plan, design, make and present art works that represent and communicate ideas and purpose.		√				√			√	√
	English	Read, analyse and interpret text a variety of different texts.	√		√			√	√	√	√	√
		Produce a variety of texts in print and electronic forms for different purposes.			√			√			√	
		Plan, rehearse and make presentations.				√		√			√	
	The humanities - geography	Explain, using examples, how human activities have affected geographical and environmental conditions.						√	√		√	
		Collect and interpret geographical information from a number of sources.									√	
	The humanities - history	Identify how societies came to be established and the impact of these on the environment.						√			√	
	Mathematics	Measure and record data.				√	√					
		Display data graphically.					√					

LEVEL 5 (Years 7 & 8)			5.2 Weeds - what do you know	5.3 Meet the weeds	5.4 Weed dictionary	5.5 Weed parts	5.6 Flying seeds	5.7 WONS	5.8 Weed management	5.9 Biological control	5.10 Bugs and weeds	5.11 Weeds - what do you know now?
Strand	**Domain**	**Learning outcomes**										
	Science	Describe the impact of human societies on identified ecosystems.						√			√	
		Design investigations that include measurement and the recording of observations and data.		√		√						
		Interpret data and make conclusions according to the aims of the study.		√		√	√					
		Conduct field /lab work in accordance with correct testing protocols.		√			√					
		Use simulations to predict the effect of changes on an ecosystem.										
		Explain scientific terms and principles.			√	√	√		√	√	√	
Interdisciplinary learning	Communication	Modify verbal responses to suit different audiences.				√		√			√	
		Interpret verbal presentations and evaluate the effectiveness of a presentation.				√		√			√	
		Convey a clear message through presentation to meet the needs of context, purpose and audience.			√	√		√			√	

LEVEL 5 (Years 7 & 8)			5.2 Weeds - what do you know	5.3 Meet the weeds	5.4 Weed dictionary	5.5 Weed parts	5.6 Flying seeds	5.7 WONS	5.8 Weed management	5.9 Biological control	5.10 Bugs and weeds	5.11 Weeds - what do you know now?
Strand	**Domain**	**Learning outcomes**										
	Design, creativity and technology	Work safely with a range of tools and equipment and manage components and processes to produce a desired outcome.										
	Information and communications technology	Select appropriate search engines to locate information on websites.			√			√	√		√	
		Share learnings through blog, website or public forums, complying with ICT conventions.									√	
		Apply ICT tools that best support the organisation and representation of concepts and information.						√				
	Thinking processes	Generate a range of strategies of reasoning and analysis to evaluate evidence and points of view.						√		√	√	
		Resolve problems which have a large number of variables and solutions.								√	√	
		Demonstrate creativity in the way ideas are generated and explored.		√			√	√	√	√	√	

6. Biological control program - Program C

Weed Warriors biocontrol program



6.1 Planning

This section is designed to guide you in planning for your biological control program.

We strongly recommend that you read through this resource before committing to the program, so you are aware of the level of involvement required and can consider whether the program will meet the needs of your curriculum and students.

6.1.1 Is your school suitable?

The program is suited to primary and secondary schools, with activities and class sessions based on specific learning outcomes for Levels three to six.

Schools that will benefit most will:

- have teachers who are motivated to work with students on a community project
- be environmentally active or seeking Resource Smart accreditation
- have a gorse or bridal creeper infestation nearby, preferably within walking distance.

6.1.2 Selecting a site

You will need to consider a number of factors when deciding whether a weed infestation site will be suitable for biological control. (A more detailed checklist for selecting a suitable biological control release site can be found at Appendix 2). A release site will ideally be:

- sites with dense, persistent weed infestations
- sites where other methods such as chemical management, are physically or financially impractical
- easily accessible for you and your students, preferably within walking distance from the school
- safe, avoiding areas with hazards such as hidden gullies, mine-shafts or cliffs
- adequate for long-term control (if the infestation needs to be eliminated immediately the site is probably not suitable)
- a site where no herbicides or insecticides are used within 20 meters
- sites that wont be disturbed by stock, slashing, burning or cultivating
- an existing biocontrol site in your area
- agreed upon by the land manager.

Please also remember that while biological control can reduce the density and spread of weeds, it does not eradicate them.

In some cases, the weed can be controlled by biological agents so that is no longer a problem. However, if eradication of the infestation is the desired long-term outcome, other control methods will still be required (although not so frequently or intensively).

6.1.3 When to run the program

When to start your program will partly depend on your other curriculum activities and the time it takes to locate a suitable site and mentor. More importantly, the life cycle of the weed being targeted and the biological control agent being reared need to be considered.

Bridal creeper, one of the target weeds for this program, dies down over summer and actively grows throughout the cooler months. This means that the program could only be conducted in terms two and three.

The agent for gorse, the other target weed for the program, is most active between September and April, thus the program is better suited to terms one and four.

A Weed Warrior program generally runs for four to six weeks, although this is just a guide. It's safest to plan to run the program over at least four weeks.

You will need to set aside time for the initial classroom sessions (ideally one 80 minute or two 40 minute sessions) at the start of the program. You'll need to set aside at least one or two hours around four weeks later for the students to release their classroom reared biological control agents.

You should also plan to encourage students to do follow up visits over the term (or year) to track the status of the weed infestation at the release site.

Weed Warriors Program B includes a number of related activities that can be conducted with the students. You may wish to incorporate some of these activities before the classroom session or as ongoing projects.

6.1.4 Finding a mentor

Successful Weed Warrior programs identify people to be mentors to the students and link the students with active local community groups.

Anyone with expertise, experience, passion or an interest in environmental management in the local area can make an excellent Weed Warrior mentor. You will probably already know of individuals or groups that are active in your local area that would be suitable.

If you can't think of anyone, contact your regional Landcare coordinator or DPI. An invitation to possible mentors can be found at Appendix 1.

6.1.5 Materials required

The resources and materials you'll need to run a biological control program will be supplied by the Victorian DPI. A detailed list of what's required for bridal creeper leaphoppers can be found in Section 7 and the list for gorse spider mites is included in Section 8 of this manual.

6.1.6 Cost

The Weed Warrior program is provided free of charge to all Victorian schools.

All the materials needed to establish the weed supply and breeding colony are provided through the program however you may need to think about the cost of the mentor's time and any costs associated with transporting students to and from the release site.

6.2 Registration

Once you have read through this manual and decided that the program is suitable for your school and students, you need to register.

6.2.1 Initial registration

Registration is very important because it's the only way to access the resources and information you'll need to run the program. Registration is also a requirement of the accreditation scheme for Resource Smart schools.

Registration is essential for schools wanting to take part in Weed Warriors. It is recommended that you register at least one month before you plan to begin the program.

Schools can register for free by contacting the Department of Primary Industries (DPI) on 136 186. The DPI Customer Service Centre will direct registration enquires to the Weed Warriors program coordinator.

We recommend that you read through this resource before committing to the program, so you are aware of the level of involvement required and can consider whether the program will meet the needs of your curriculum and students.

The Department of Primary Industries must have full records of areas that are being used as release sites and who in the community will be monitoring them. You will need to have this information available when you register.

6.2.2 On-going registration

Weed Warrior schools are encouraged to create sustainable, on-going programs. We encourage you to make sure you re-register your school every year.

6.3 Classroom session

This section provides a suggested format for the Weed Warrior initial classroom sessions and outlines the basic content of each topic. More detailed information on each topic can be found in Program A.

Ideally your classroom sessions should be interactive, with the students encouraged to answer questions. You may wish to have your students complete some of the activities in Section 5 of this manual (Program B) before you hold this session.

We recommend that you use props and presentation aides to help you illustrate this session. Where possible, photos or samples of the weeds should be provided for the students to examine. If the weeds contain prickles or thorns, you will need to ensure that the students have access to gardening gloves. Magnifying glasses and microscopes can also be useful tools in the classroom session.

You may also wish to invite the mentor to take an active role in this session, perhaps to present the section on local weed issues.

The following lesson plan is 80 minutes long. It could be delivered over one session, or two 40 minute sessions. If run over two periods, the first session should focus on a general introduction to weeds and the second on running the biological control program on the school's target weed – gorse and/or bridal creeper.

Outline

1	Introducing weeds	• What is a weed? • Why are weeds not wanted? • What is the impact of weeds? • Where do we find weeds? • How do weeds spread?	5-10 mins
2	Local weed issues (mentor or other invited guest may speak)	• What weeds are found in this area? • Where they are found? • How did they get here?	10-15 mins
3	How to manage weeds	• How can weeds be managed? • What are the positive/negative effects of these methods?	2-5 mins
4	Biological control	• What is biological control? • How does it work?	3-5 mins
5	Your biological control program	• Target weed – details • Target biological control agent – details	5 mins
6	How to rear the biological control agents	• Demonstration on how to prepare and establish weed cuttings • Explain and demonstrate how to establish the breeding colony	10-15 mins
7	Wrap up	• Summarise the students' role in managing weeds in the community generally • Discuss any questions • Discuss the students' role in rearing the biological control agents • Discuss the release event	5 mins

Detailed information about each section of the lesson plan is included on the following pages.

6.3.1 Introducing weeds

What is a weed?

- A weed is a plant out of place or a plant growing in an area where it is not wanted.

Why are weeds not wanted? What is the impact of weeds?

- Impact on agricultural productivity by injuring or poisoning livestock; becoming entangled in machinery; contaminating wool; competing with crops/pasture; carrying plant diseases; and preventing access to water/pasture.
- Impact on conservation values by eliminating or excluding native plants; preventing plant regeneration; or altering or destroying fauna habitat.
- Impact on human health by causing allergies or poisoning.

Where do we find weeds?

- On farms; in natural environments, such as bushland; in waterways; along rivers; in the garden; and along foreshores.

How do weeds spread to these areas?

- Stock feed; animals; soil disturbance; humans; garden waste; water; machinery and vehicles (boats, cars); wind; and bursting seed pods.

6.3.2 Local weed issues

This content will be specific to the area where the school is located. It will be most effective if the Weed Warrior mentor and/or other invited guests from within the local community are given the opportunity to contribute. If this is not possible, you should adjust the following notes accordingly.

Presentation to students by mentor /invited guests will involve around 10 minutes on:

- their interest and experience with weed management
- the organisation or group or agency they represent (if applicable)
- weeds that occur in the local area
- the impact those weeds are having
- what is being done to control those weeds
- background on the weed issues at the site where the biological control agents are to be released (if known).

If representatives of a community group or government agency are also in attendance, you may wish to give them a minute to introduce themselves and to discuss the role of the groups they represent.

6.3.3 How to manage weeds

What are the different ways of controlling weeds?

- There are many different methods, and a combination of methods (integrated weed management) is most effective. Methods include: prevention strategies, pasture and grazing management, mulching, plant competition, burning, chemical control, biological control, physical control and follow up control.

6.3.4 Biological control

What is biological control?

- Biological control aims to suppress the spread of a weed, not eradicate it.
- Biological control involves using a natural enemy of the weed to suppress and reduce the numbers of that weed. It aims to restore the natural balance between the weed and its environment. Natural enemies (or biological control agents) come from the weed's country of origin. For example, bridal creeper is native to South Africa, so its natural enemies are also native to South Africa.

Consider the use of enlarged photographs of the agents for display on a screen.

How does biological control work?

- Deliberately introducing the natural enemies of a weed can help to control it by reducing their vigour, growth and spread. Testing is done to ensure these natural enemies will only affect the target weed and not impact on any other species of plant or animal in Australia.

- NB: For primary students, it may be easiest to summarise the information presented in Sections 2, 3 and 4 of this manual. Secondary students may benefit from a more in-depth discussion of the biological control process.
- All biological control agents approved for release into Australia are thoroughly tested to prove that they only feed or have an impact on the target weed and nothing else (ie. they are host-specific).
- During this lengthy and thorough scientific process, Australian native plants and plants of economic importance to Australia (such as crops, fruit and vegetables) are tested to ensure that the biological control agent does not damage them.
- This is done to avoid what happened with the cane toad which is an example of what can happen if species are introduced without specific testing. In fact, cane toads were never tested at all.
- It is not uncommon for the testing process to take ten years for one weed, and the effects of biological control agents will vary from year to year and place to place. There will not be any guarantees that the agent selected and released will even be successful.

6.3.5 Your biological control program

This section should cover the specifics of your school's target weed and biological control agent. Detailed information about the bridal creeper and gorse can be found in Sections 7 and 8 of this manual.

Consider the use of photographs of infestations and a map of the world showing the target weed's origin and spread.

Consider the use of photographs of the biological control agent and their damage to a weed population.

6.3.6 Rearing the biological control agents

Again, please see Sections 7 and 8 of this manual for detailed information.

6.3.7 Wrap up

Recapping the important points from the session gives the students a summary of what they have learnt. Your wrap up may include:

- what weeds are, why they are a problem, where they are found and how they are affecting your local area
- biological control using the target weed as the example
- how to rear the biological control agent for the target weed and in particular, how to maintain their food supply.

It's also important to emphasise the importance of the activity the students will be engaged in throughout the next four to six weeks. Summarise the field-based activity in which they will release their classroom reared biological control agents at the end of the program.

Weed Warriors aim to ensure that students understand that this is more than just a fun learning experience, it's also a way of:

- contributing to the stewardship of local places
- helping provide a solution to a serious local weed problem
- providing an important community service by providing local land managers with a valuable integrated weed control technique they may not otherwise have access to
- spreading the knowledge of biocontrol and weed management in the community.

6.4 Breeding

The breeding phase is the time that it takes to rear a substantial quantity of control agents in the classroom. The actual length of time will depend upon the control agent chosen, the time of year and rearing conditions. Generally though, you should allow at least four weeks.

We recommend that you allow around half an hour a week to supervise the students as they maintain their biological control agents.

Details of how to breed and raise the selected control agents can be found in Sections 7 and 8 of this manual.

6.5 The release event

Up to two hours should be set aside for the release event, depending on how close it is to the school. The session can be conducted by the mentor or the teacher.

It is important that permission has been granted by the land owner / manager for the release event well in advance of the proposed release date.

The school should consider inviting other guests to the event such as the landowner, parents, representatives of Landcare or other environmental groups, media, local members of parliament or council.

Of course, check with the land owner or manager before inviting guests.

Remember also to be vigilant about safety when working outside especially on extreme weather days. In fact, if the release is scheduled for a day of extreme heat or cold it is better to postpone.

The release event is divided into two parts: a class based review session and the field based release.

6.5.1 Class-based review session

Here are some general ideas about what you might cover in this session:

Ask students to describe what they've been doing, including:

- the target weed and the biological control agent
- the tasks involved in rearing the biological control agents
- their observations and learnings about biological control agents throughout the program
- the impact the biological control agent had on the weed throughout the program
- what they enjoyed the most
- what they would like others to know about what they have been doing.

You may also like to briefly re-visit some of the topics you introduced to the students in the initial classroom session, including:

- what weeds are and why they need to be controlled
- what biological control is and how it works.

This session will give you useful feedback about how effective Weed Warriors has been in educating students about weed-related issues. These questions and answers also help educate and raise awareness with invited guests.

Finally, before leaving for the release site, hand out copies of the "Release Form" to all students (see Appendix 4) and run through it quickly. Make it clear that the data sheet will:

- help locate the biological control release site in the future
- record who is responsible for the biological control release site

- record how bad the weed infestation was before the biological control agents were released thus providing a good reference point for future comparisons of the condition of the attacked infestation
- record details of the biological control agents being released for future reference.

Ensure that the students understand that the sheet is not just for their benefit, it also provides vital information to the Department of Primary Industries, to help them monitor the release sites.

6.5.2 Field event

As students arrive at the release site encourage them to take photos and draw sketches of the infestation, showing its impact on the environment and associated ecology. They should also start completing the details required on the Release Form (Appendix 4).

Demonstrate the best methods for the release of the biological control agents (see Sections 7 and 8 for detailed information about the best release methods).

Divide the students into pairs or small groups and ensure that each group has a container of biological control agents to release. If possible, students should count or estimate the number of agents that they are about to release and record this information on the data sheet.

Allow the students to release their biological control agents at various points within the infestation and assist them practically or by answering any questions that may arise.

While you're at the site, it might also be useful to have the mentor address the class and guests about:

- the values of the release site and why they should be protected or restored. This would include natural values (e.g. biodiversity); productive values (e.g. crop yields); historic, cultural and aesthetic values; recreational values; or catchment care
- specific weed issues at the site including identifying the target weed
- how the program will contribute to the management of the site
- why biological control is the right method to use at the site and how to identify other suitable sites (see Appendix 2)
- why monitoring is important
- how students can stay involved in the site's management – perhaps by continuing with Weed Warriors, or joining or forming junior Landcare, Bushcare or a "Friends of" group, or by starting a nature club at the school.

The cuttings and foliage of the target weed will remain at the release site. The potted weed plants should be returned to the Department of Primary Industries.

6.6 Monitoring

Discuss the future monitoring requirements of the biological control release site with the students.

6.6.1 Ongoing process

Although specific requirements will depend on the target weed and the biological control agent, the site is generally required to be reviewed around 6-12 months after the release event to see whether the biological control agent is still present. Detailed information about the monitoring requirements for the bridal creeper leafhopper and the gorse spider mite programs can be found in Sections 7 and 8 of this manual.

6.6.2 Maintaining student involvement in monitoring

Student 'ownership' of the site and the program will be stronger if they maintain their involvement in the monitoring phase. This could be done by:

- arranging for the same students to revisit the site for monitoring
- organising for the person responsible for monitoring the site (often the land manager) to take photographs and to present their findings to the students.

Data collected through ongoing monitoring is important for students to see the impact their efforts have made and is also useful information for the Department of Primary Industries.

A Release Site Monitoring Form for each target weed is included at Appendix 4. The students can use this form to gather information on monitoring visits.

6.7 Program wrap up

Although monitoring activities will continue well into the future, the Weed Warrior program does need to be brought to a conclusion.

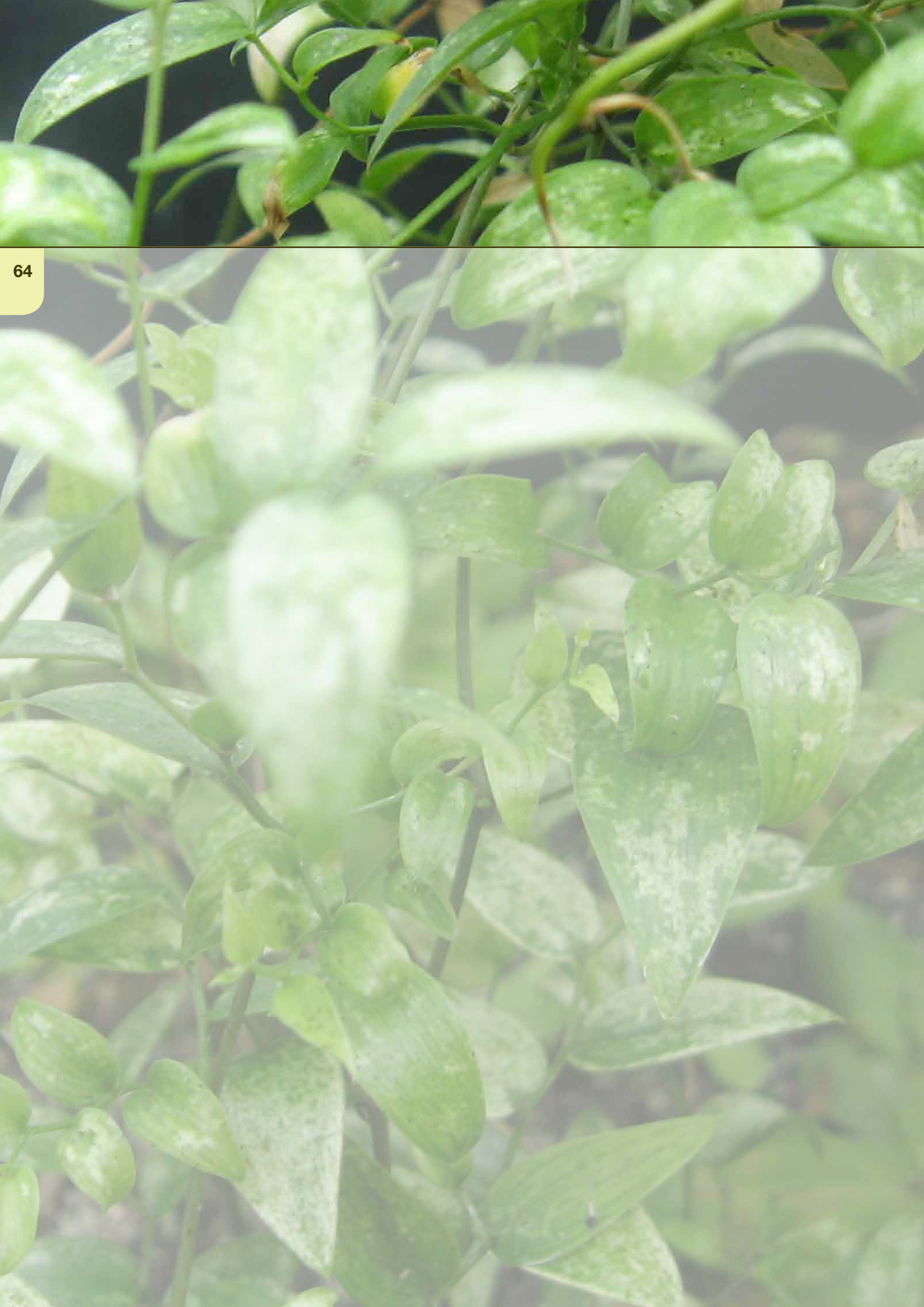
This activity should involve an effort to recap the important points covered throughout the activity. It should also create an opportunity for students to give and receive feedback on their participation.

Ideally, students should finish with a sense of pride in the contribution they've made to solving serious local weed problems.

You may also wish to gauge the students' interest in continuing with the program and/or help others to become involved with Weed Warriors.

The wrap-up is also a great opportunity to remind students that they can continue their involvement in weed management and other conservation by joining local community groups or environmental programs such as Landcare, Land Learn, Bug Blitz and Water Watch.

We would recommend that you ask your students to complete Activity 5.11 of this manual.



7. Bridal creeper module - Biological control program

This module contains specific information on bridal creeper and its biological control using leafhoppers.

Schools that want to conduct a biological control program on bridal creeper should refer to the notes in this module in addition to the notes in the overview in Section 6.

7.1 Background

Bridal creeper (*Asparagus asparagoides*) is a native of South Africa. It was first recorded in Australia in 1857 in a nursery catalogue and by the 1870s was a common garden plant.

Bridal creeper is now one of Australia's Weeds of National Significance. It is an extremely damaging plant which invades a wide range of habitats including bushland areas, creeks and riverbanks, citrus orchards and shrublands.

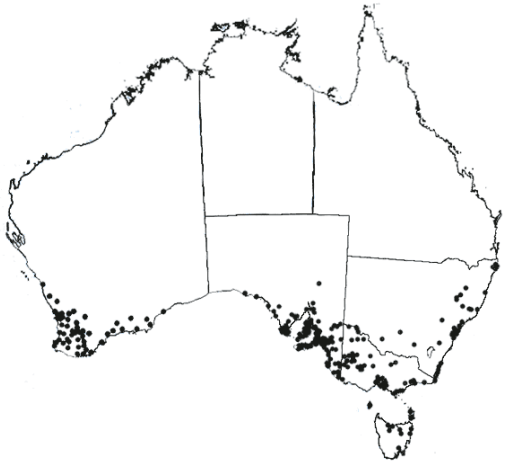
Its climbing stems form a dense canopy, smothering other vegetation, and its masses of underground roots can extend to form a thick mat which destroys understorey plants.

Bridal creeper smothering native vegetation

Bridal creeper is distributed through southern Western Australia, South Australia, Victoria, parts of New South Wales and Tasmania and the cooler areas of southeast Queensland.

The successful and rapid spread of bridal creeper in Australia is partly due to the lack of natural enemies to limit its population density and vigour. Some of its infestations are in very inaccessible locations, making them difficult to control thus contributing further to the spread of the species.

As a result, biological control is the desirable management option for bridal creeper. Reintroducing bridal creeper to its natural enemies helps control its spread and reduce plant growth in situations where other control measures are not practical.



Distribution of bridal creeper throughout southern Australia

Bridal creeper's delicate white flowers

7.2 Biological control agents

Three natural enemies of bridal creeper have been released in Australia: the leafhopper (*Zygina sp*), the rust fungus (*Puccinia myrsiphylli*) and the leaf beetle (*Crioceris sp*).

Leaf hoppers on bridal creeper leaf

Leaf beetle on bridal creeper leaf

Rust fungus on bridal creeper leaves

Each agent works differently: the leafhopper sucks out the contents of the plant leaf tissue; rust fungus destroys leaf tissue; and the leaf beetle strips young stems of shoots and leaves.

Using all three of these agents will have a greater impact on the growth and vigour of bridal creeper than any one would have on its own. All of these agents have been released at carefully selected sites throughout southern Australia.

Once established at a selected site, the agents are harvested and used to establish new colonies. Active re-distribution of these agents will establish them more quickly through bridal creeper infestations compared to leaving them to disperse naturally.

Schools can use the leafhopper as their biological control agent.

To conduct a biological control program you will need bridal creeper plants. These will be supplied by the Department of Primary Industries.

This manual also outlines the procedures for rearing leafhoppers (see Section 7.4).

7.3 Bridal creeper leafhopper

The leafhopper was the first biocontrol agent to be released in Australia in June 1999. It weakens and damages bridal creeper by sucking out the contents of the plant's leaf tissue. Dense populations of the leafhopper defoliate the plant, which reduces flowering, seed production and tuber development.

Adult bridal creeper leafhoppers are yellowish-white in colour and are around 2.5 mm long. The females are slightly longer than the males and can be identified by the dark brown egg tube seen on their abdomen before they lay eggs.

Juvenile bridal creeper leafhoppers have five nymphal (growth) stages. The nymphs grow and become paler with each stage. The fragile first nymph is only 0.8 mm long and it has a soft yellow body. Wing buds appear on the third nymph and sex identification is possible on the fifth nymph. The growth stages are very difficult to see without a magnifying glass.

Adult leafhopper viewed under the microscope

Adult leafhopper (left) and the five nymphal stages

The bridal creeper leafhopper's eggs are transparent and oblong and around 0.5 mm long by 0.1 mm wide. Older eggs turn deep yellow and red eye-spots become visible when the nymphs are ready to hatch.

7.3.1 Life cycle

Bridal creeper leafhoppers spend most of their time feeding or resting on the underside of bridal creeper leaves.

The females lay their eggs into the underside of mature bridal creeper leaves at the base of a plant. However, if the population is high or damage to the bridal creeper's leaves is severe, the laying will occur in younger leaves.

Adult leafhoppers will live for six to eight weeks. A female will lay an average of 186 eggs during her existence. These eggs take around two weeks to hatch and the nymphs will reach adulthood around two weeks later. The nymphs will remain on the same leaf from egg to adult, only moving if disturbed or if they're running out of food.

Bridal creeper leafhoppers have several generations each year, breeding more quickly in warmer temperatures. In summer rainfall areas or near watercourses where bridal creeper grows all year round, the leafhopper will remain on the host and continue to breed. However, in most areas, bridal creeper foliage dies back during summer and the populations of leafhoppers go into decline until new growth appears in autumn. It is not known where the bridal creeper leafhopper retreats during the summer months as extensive surveys of foliage and leaf litter during this period have failed to find them.

The damage caused by the bridal creeper leafhoppers, three years after their initial release

7.3.2 Impact

Bridal creeper leafhoppers have sucking mouthparts that pierce the individual cell walls of bridal creeper leaves, extracting the cell contents of the leaf tissue. The cells that are damaged are the photosynthesising cells, which the plants depend on to survive.

Although the leafhoppers live on and feed from the underside of the leaves, they eat the contents of the upper layer of cells in the leaf, so their damage is usually obvious on the upper surface. The feeding damage will appear as white spots, often in a zig-zag pattern. Heavily damaged leaves appear variegated and dense populations of leafhoppers can remove all the cell contents of bridal creeper leaves, leaving them completely white.

Damaged bridal creeper leaves can appear variegated (as in the left photo) or completely white (as in the right photo)

If the bridal creeper leafhoppers establish self sustaining populations they are expected to considerably reduce the number of fruits produced on bridal creeper in a season, helping to slow the further spread of the weed. When present in high numbers over several years the leafhoppers deplete underground reserves in the extensive tuber mats, reducing the competitiveness of the weed.

7.4 Rearing leafhoppers

The best time to rear bridal creeper leafhoppers is from April to October, which fits in well with the program being conducted in terms two or three. This timing ensures that, after being released, the leafhoppers have time to breed for several generations before they begin their summer resting phase.

7.4.1 Materials required

Materials will be supplied by the Department of Primary Industries, to be arranged when registering for the program. If you wish to collect your own plants a permit is required, call the DPI on 136 186 for more information.

The materials required to run the program include:

- rearing cage
- supply of potted bridal creeper plants
- pot saucers
- mesh bag to cover plants
- ventilated container
- adult leafhopper colony.

7.4.2 Setting up the leafhopper colony

1. Select a position in the classroom for the rearing cage. The area selected will need to be one metre square and should be elevated and have access to natural light.
2. Make sure that the sleeve on the door is big enough so that fresh potted plants can be added through it without tearing it.
3. Place a potted bridal creeper plant through the sleeve.
4. Carefully place the mesh bag containing adult leafhoppers and bridal creeper foliage infested with eggs and nymphs through the sleeve.
5. Remove the infested bridal creeper foliage from the mesh bag and drape it around the potted bridal creeper plant, making sure they are touching. This is to encourage the nymphs to walk across onto the healthy bridal creeper.
6. Gently turn the mesh bag inside out and give it a little shake to disperse any leafhoppers that are resting on it.
7. Carefully remove the bag from the cage. Retie the sleeve securely to ensure that the leafhoppers will not escape.

7.4.3 Adding new bridal creeper plants to the leafhopper colony

Keep a watchful eye on the foliage of the potted bridal creeper plants in the rearing cage. When between 60 and 80 per cent of the plant has turned white, a healthy bridal creeper plant will need to be added.

Healthy bridal creeper plants are placed in the rearing cage to cater for the growing number of adult leafhoppers in the breeding colony. If too many adults live on the plant they will consume all available plant material before the next generation of eggs hatch and the nymphs will starve.

As a guide, one healthy plant will probably be required to be added to the cage each week. Students should be encouraged to monitor this time and note any changes.

Data about how often new plants are added should be recorded and can be graphed using the worksheet on page 70.

1. Take a healthy bridal creeper plant and mark the pot with a number and the date it is added to the cage (the original plant in the cage will be plant one, the next plant two, and so on).
2. Untie the sleeve on the cage. Carefully place a saucer for the pot to rest on through the sleeve. Take the new plant through the sleeve. Make sure the bamboo stake is clear of the mesh before it is tilted upright. Place the new plant onto the saucer.
3. Move the new plant so that it touches the damaged plant in the cage. This will allow leafhoppers to move easily from plant to plant.
4. Remove your arm from the cage and retie the sleeve securely to ensure that the leafhoppers will not escape.
5. When around 60 to 80 per cent of the newly added bridal creeper plant has turned white, add another new plant.

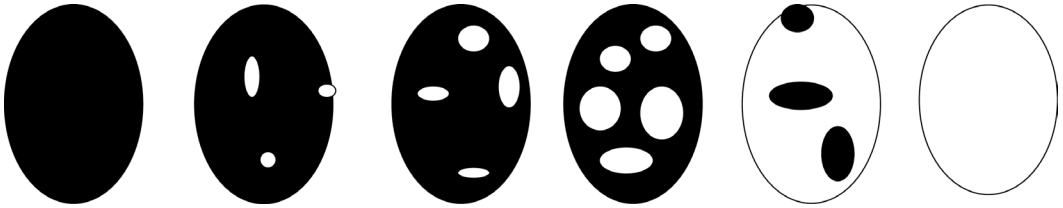
Adding leafhoppers and infested bridal creeper plant into the cage

Adding a bridal creeper plant into the cage

Innoculated plant is positioned next to the healthy bridal creeper plant so the leafhopper nymphs will transfer across to the fresh feeding material

7.4.4 Leafhopper colony assessment form

Leaf damage score chart



(Black area represents green leaf colour, White area indicates amount of Leafhopper damage)

Date of Assessment: _____ **Number of plants in colony:** _____

Record the date that each new plant was added to the colony.

Plant 1 ……/…../…..		**Plant 2** …../…../…..		**Plant 3** …../…../…..		**Plant 4** …../…../…..		**Plant 5** …../…../…..		**Plant 6** …../…../…..		**Plant 7** …./…./….	
Leaf	Score	Leaf	Score	Leaf	Score	Leaf	Score	Leaf	Score	Leaf	Score	Leaf	Score
1		1		1		1		1		1		1	
2		2		2		2		2		2		2	
3		3		3		3		3		3		3	
4		4		4		4		4		4		4	
5		5		5		5		5		5		5	
6		6		6		6		6		6		6	
7		7		7		7		7		7		7	
8		8		8		8		8		8		8	
9		9		9		9		9		9		9	
10		10		10		10		10		10		10	
TOTAL													
Average													

7.4.5 Maintaining the bridal creeper plants

Bridal creeper plants must be kept healthy if they are to feed the leafhopper colony. Healthy bridal creeper plants that are not being used in the cage should be kept in a sheltered area outside.

It is very important that healthy bridal creeper plants are maintained to feed the leafhopper colony. Fresh bridal creeper plants that are being grown should be kept in a sheltered area outside.

All bridal creeper plants will need watering three times a week – on Monday, Wednesday and Friday.

When watering the pots in the cage, water directly into the saucer to avoid getting the leaves wet, which may disturb or even drown the leafhoppers.

Watering the bridal creeper plant

Only give plants in the cage half a cup of water, as they are being attacked by the leafhoppers and are under stress. They will not grow as quickly as the healthy plants, so do not need as much water.

It would be a good idea to draw up a roster so that the students can take turns watering the healthy bridal creeper plants and the bridal creeper in the rearing cage.

7.4.6 Dealing with escapees

While all attempts should be made to ensure that the leafhoppers are kept secure (for instance, by always making sure that the sleeve on the cage is secure), some leafhoppers are bound to escape.

To trap escapees, it is a good idea to have a 'trap plant' set up on the outside of the cage. Any leafhoppers that do escape from the cage will be attracted to the trap plant. These leafhoppers will settle and feed on this plant, which can be left here until the end of the program.

7.5 Releasing bridal creeper leafhoppers

7.5.1 Capturing the leafhoppers for release

The leafhoppers will need to be captured for transporting to the site the day before they are to be released. This is best done early in the morning when the leafhoppers are less active.

To capture the leafhoppers follow these simple steps:

1. Untie the sleeve on the cage and slip a mesh bag in.
2. Place the bag on the cage floor and arrange it so that a plant can be placed gently onto it.
3. Place one of the damaged plants onto the arranged bag.
4. Carefully pull the sides of the bag up to surround the plant and close off the top with your finger to prevent the leafhoppers flying out. The leafhoppers will be very active, flying back and forth when disturbed.
5. The quicker the bag can be pulled up, the fewer leafhoppers will fly out.
6. Secure the top of the mesh bag with a rubber band.
7. Repeat this process with all of the damaged plants in the cage and also the 'trap plant' that is on the outside of the cage.

Mesh bag placed around bridal creeper (left) innoculated plant covered with mesh bag (right)

7.5.2 Trapping leafhoppers in a ventilated container

Place a ventilated container in the cage with some freshly cut bridal creeper foliage inside it.

The leafhoppers that were not captured in the mesh bags will settle down onto the foliage in this container. Leave the container open in the rearing cage all day and overnight.

By the next day (the morning of the release), the remaining leafhoppers will have settled on the bridal creeper foliage in the container.

Put the lid through the sleeve and place it on the container. This should be done quickly so as to not disturb the leafhoppers. To prevent overheating of the leafhoppers when in transit, the plants should be placed in a position both out of direct sunlight and excessive heat.

The bridal creeper leafhoppers are now ready to be released at the selected site.

Foliage in container trapping the remaining leafhoppers

7.5.3 Releasing the leafhopper colony

Bridal creeper leafhoppers can be released whenever there is healthy green bridal creeper foliage present. Ideally, they should be released after the plant has started growing again – generally April until October.

Releasing during this period will allow the maximum number of generations to occur before the bridal creeper dies off in late summer.

It is imperative that great care is taken to ensure that the weeds are not further distributed. A permit under the *Catchment and Land Protection Act 1994* is available to cover registered schools in the transport of plants to the release site. A copy of the permit conditions will be provided to mentors and school contacts when registering for the program.

Follow the steps below to release the leafhoppers:

1. Choose an area at the release site where the bridal creeper is very dense, green and healthy. It should be an area that is not likely to be disturbed, so not too close to walking tracks or roads. Leafhoppers like a shady position and will do best in a swampy area where the bridal creeper lives long into the summer.
2. Once an area is chosen the leafhoppers can be released over an area no bigger than 1m by 1m. Spreading the leaf hoppers over a larger area can reduce their chances of establishing, as they need to be able to find each other to mate and lay eggs.
3. Carefully remove the mesh bag from one of the potted plants and place the bag on the ground.
4. Using secateurs or scissors, cut the foliage off at the base of the plant near the pot. This foliage should be placed onto the growing bridal creeper infestation so that any nymphs can move easily onto the fresh foliage.
5. Gently turn the mesh bag inside out and shake it close to the bridal creeper infestation to disperse any leafhoppers that are still resting on it.
6. Finally, place the foliage from the ventilated container onto the bridal creeper infestation, turn the container upside down and tap the base to shake out any remaining leafhoppers.
7. Fill in the Release Form (Appendix 4) and return it to the Department of Primary Industries.
8. Contact the Department of Primary Industries to arrange collection of used pots and materials.

7.6 Monitoring bridal creeper leafhoppers

After the initial release of the bridal creeper leafhoppers, the release site should be monitored.

By monitoring the release site, you can assess whether the bridal creeper leafhoppers have established, how far they have spread and what impact they are having on the bridal creeper infestation.

You will need to think about:

- whether the leafhoppers are still present at the site
- whether adults are present – gently tap the foliage and watch for fast moving whitish insects making flights of about 20 cm before returning to the foliage
- whether nymphs are present – look at the underside of damaged leaves for small non-moving insects (a magnifying glass will assist with making them visible)
- what leafhopper life stages can be observed (egg, nymph or adult)
- how much leafhopper damage can be seen at the site
- how far the leafhoppers have spread from the original release point
- the total area affected by the leafhoppers
- the furthest location from the release point at which leafhoppers or feeding damage can be seen
- the estimated coverage of bridal creeper at the site
- the maximum height of the bridal creeper at the site
- whether the bridal creeper infestation has increased, decreased or remained the same since the leafhoppers were released
- other factors that may be affecting the survival of the leafhoppers such as drought, chemicals, vandalism etc.

The bridal creeper leafhopper Monitoring Form (Appendix 4) should be completed each time the site is monitored. This should only take 30 minutes. Copies of the completed form should be given to the land manager of the site and to the Department of Primary Industries.

7.6.1 What to expect

In the first season after release damage to bridal creeper by the leafhoppers will be very minor and very hard to find without thorough searching.

Don't be dismayed if signs of leafhopper activity can't be seen as they can be hard to find. It is not unusual for sites to seem to have failed and for the leafhoppers to 'reappear' after two or three seasons once the population has built up.

Remember that biological control is a long-term control method: it may take five to ten years for the numbers to build up enough to start having an impact.

If the leafhoppers have survived their first summer, even if only in small numbers, your efforts have been a great success. Their numbers will steadily increase over the next few years.

8. Gorse module - Biological control program

This module contains specific information on gorse, and its biological control using gorse spider mites.

Schools that want to conduct a biological control program on gorse should refer to the notes in this module in addition to the notes in the overview in Section 6.

8.1 Background

Gorse or furze (*Ulex europaeus*), is a native of central and western Europe. It was introduced into Australia in the mid 1800s as a hedge plant and has spread throughout all states except the Northern Territory.

Gorse is both an environmental and agricultural weed. It invades bushland, reducing conservation values and threatening the survival of endangered plant species.

On pastoral land, gorse significantly reduces pasture and animal productivity. Gorse also provides habitat and shelter for pest animals such as rabbits and foxes and increases fire hazards.

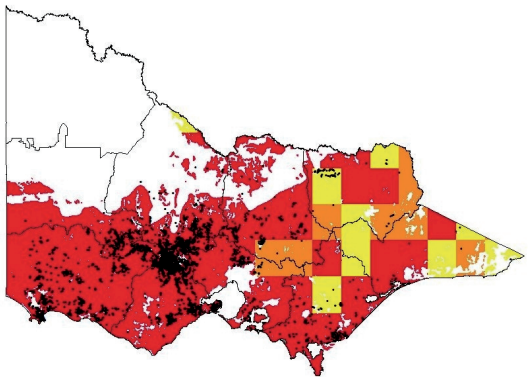
In Victoria, gorse is common in the central highlands, the south west and parts of Gippsland. A 1980 survey of gorse in Victoria estimated that it occupied a total area of 948,000 hectares.

The successful and rapid spread of gorse in Australia has been partly attributed to the lack of natural predators to limit its population density and vigour.

Distribution of gorse in a paddock.

While gorse may be here to stay, the use of biological control will help to reduce its impact and spread in Victoria.

Over the years, several biological control agents have been released for gorse. Different insects attacking different stages of the gorse life cycle, throughout the year, will have a greater impact on plant growth and vigour than one insect acting alone.



Colours indicate the possibility of gorse infesting these areas

Red	= Very high	Yellow	= High
Orange	= Medium	Green	= Likely

- Sites where gorse has been recorded

Present and potential distribution of gorse in Victoria (2010)

8.2 Biological control agents

8.2.1 Past agents

During the 1940s, the gorse seed weevil, *Exapion ulicis*, was introduced into Australia from Europe. It has successfully established throughout most areas in Australia. In spring, seed weevil larvae feed on the developing seeds within the gorse pod. As a result most gorse seed produced in spring is destroyed.

Though the weevil is now widespread, it has not had a significant impact on seed production. This is because gorse in Australia produces viable seed not only in spring but also in autumn and winter when the weevil is not active.

Gorse seed weevil under the microscope

Gorse thrip under the microscope

8.2.2 Present agents

The gorse spider mite, *Tetranychus lintearius* and gorse thrips, *Sericothrips staphylinus*, have been introduced into Australia to further disadvantage gorse. The spider mites and thrips feed directly on gorse foliage throughout the year. Spider mites prefer mature foliage, while the thrips can be seen on newer growth.

Six strains of the spider mites were introduced from the United Kingdom, Spain and Portugal in 1998 and have been released at over 120 sites throughout Victoria. The thrips were introduced from Portugal in 2000 and have been released at many sites in Victoria.

Once established, these agents are harvested from the release sites and used to establish new sites. Actively redistributing the agents ensures that they become established across the infestation of gorse more quickly than if they were left to disperse naturally.

Adult spider mites moving up the stem of the gorse plant

8.2.3 Future agents

Another natural enemy of gorse, the soft shoot moth, *Agonopterix ulicitella*, has been approved for release in Australia. The moth was reared through a mandatory one generation in the quarantine facility at DPI, Frankston and is currently being released at sites across Victoria to complement the impact of the gorse seed weevil, spider mites and thrips.

8.3 Gorse spider mite

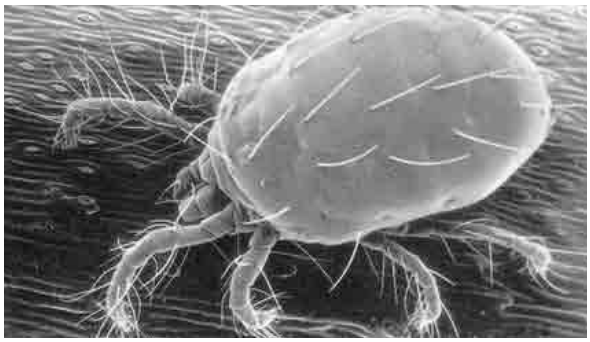
Adult gorse spider mites are brick red in colour with eight legs and are smaller than the size of a pinhead. The females are oval and about 0.56 mm long and the males are smaller (0.36 mm long) and more triangular in shape.

Juvenile gorse spider mites are initially bright orange, turning green to dark green after their first feeding. Newly hatched mites are similar to adults but have only six legs and are much smaller. Gorse spider mite eggs are translucent, spherical, 0.13 mm in diameter and turn bright orange when ready to hatch. They are laid in clusters tucked in close to the gorse stems.

8.3.1 Life cycle

Gorse spider mites live in communal webs on gorse bushes. Females congregate in a ‘feeding colony’ and move slowly in their colonies as they feed along gorse shoots. Both eggs and inactive larvae are left behind in the webbing as the colony moves.

Most mature males do not move with the feeding colony but stay behind to guard and eventually mate with the juvenile females as they reach maturity.



Adult spider mite viewed under a microscope

Gorse spider mite eggs (indicated by white arrows) and adults (by black arrows)

Gorse spider mites in their communal web

Female gorse spider mites live for two to four weeks and each female produces up to 40 eggs during her life, usually at a rate of one per day.

The eggs take around two weeks to hatch and the juveniles moult (shed skin to allow growth) through six stages. There is a resting stage after each of the active larval stages. Once the juveniles become adults they will feed for two weeks before they begin to breed.

Gorse spider mites have several generations per year and breed more quickly at higher temperatures. The entire life cycle, from egg to adult takes around six weeks at 15ºC but can take only three weeks at 23ºC.

In warmer weather the mites move busily throughout the web, but tend to cluster together in the centre of the web in colder weather, often on the leeward side of stems where they are protected from wind and rain.

When a gorse spider mite colony becomes too large some will migrate to a new gorse bush. They do this by grouping together on the ends of branches. They may even drip from them like icicles from where they are blown by the wind and land on gorse further away.

Gorse spider mites ready to migrate may congregate in an icicle like drip

8.3.2 Impact

Gorse spider mites have sucking mouthparts that pierce the individual cell walls of gorse foliage so they can extract the cell contents. This causes the foliage to look bleached or brown.

When present in large enough numbers gorse spider mites can cause considerable damage to gorse plants. Extensive feeding pressure can kill shoots, reduce plant growth and overall plant biomass, causing the plant to stop producing flowers.

In New Zealand, where gorse spider mites have been established since 1989, studies have shown that when spider mites attack a gorse bush for one year, growth of the bush is stunted during the year but it is able to recover and grow normally the following year. However, if a spider mite colony remains on the gorse bush in large enough numbers for several years then the damage is more permanent and the gorse bush is unable to recover once the spider mites leave.

Bleaching of gorse caused by gorse spider mites

Unfortunately, gorse spider mites rarely remain on the same gorse bush for several years. The whole colony moves to new gorse most years. That means that successful biological control of gorse must rely on the combined impact of all the gorse agents.

The gorse spider mite obtains its nutrients and water from the living plant cells of gorse leaves and stems. The mite's constant absorption and removal of nutrients is detrimental for the development and reproduction of the plant, and its stem, flowers and seedling production.

In large numbers, the gorse spider mites reduce plant growth, causing foliage to look bleached or brown and reducing the impact of the weed

8.4 Rearing spider mites

Ideally, spider mites should be released once gorse has started growing, from spring until late autumn, or between September and March/April. Releasing during this period of time will allow the maximum number of generations to reproduce. Rearing the colony for release will take around four to six weeks.

8.4.1 Materials required

Materials will be supplied by the Department of Primary Industries, to be arranged when registering for the program. If you wish to collect your own plants a permit is required, call the DPI on 136 186 for more information.

The materials required to run the program include:

- rearing cage
- fluorescent lamp with stand
- timer for lamp
- supply of gorse cuttings or potted gorse plants
- trays for adults and nursery
- adult colony and nursery tray labels
- gro wool blocks and cubes
- plastic containers and saucers
- adult spider mite colony.

8.4.2 Setting up the spider mite colony

1. Find a place in the classroom for the rearing cage. The cage should be in an elevated area around 1m by 1m, near a power point and away from direct sunlight.
2. Set up a fluorescent light in the front corner of the cage and plug it into the timer. Plug the timer into a power point. Set the timer to come on at 9am and go off at 3.30pm.
3. Place two trays inside the cage, with the adult colony label on one and the nursery colony label on the other. On the adult colony tray, place the gorse cutting with the supplied spider mites.

Rearing cage set up

8.4.3 Observation period

The colony of spider mites will be attracted to the light and will begin to move together as a colony towards the tip of the gorse, laying eggs all the way up the stem.

Once the colony begins gathering at the top of the cutting in large numbers, transfer the spider mite colony onto a fresh supply of gorse. The original gorse cutting with eggs and juvenile mites should be kept for the nursery.

How fast the spider mites move up the cutting and cluster at the ends of the spines will depend on how warm the cage is and the freshness of their food supply.

Gorse tip containing adult spider mite colony

8.4.4 Adding new gorse cuttings to the spider mite colony

1. Place two gro wool blocks into a plastic container and squash them down. Put a gro wool cube in the hole in the centre of the top gro wool block.
2. Fill the container with water until the gro wool is completely wet. Tip out any excess water. The gro wool must be kept completely wet at all times – the spider mite colony will die if it dries out.
3. Take a freshly prepared cutting of gorse and rinse it thoroughly in water. This will help ensure that the cutting is free from insects and spiders that can destroy the spider mite colony. Shake the water off the cutting.
4. Remove the lower spines of the washed gorse cutting by pulling them downwards. Be careful as the spines are very sharp – it's a good idea to wear thick gloves. Make sure there is about 15cm of clear stem to hold.

Gorse cutting inserted into gro wool

5. Now insert the clear stem of the fresh gorse cutting into the centre of the gro wool, through the gro wool cube, until it almost touches the bottom.
6. Take the gorse cutting that is home to the adult spider mite colony and cut off the tip of the gorse where the colony is congregating. Keep the rest of the cutting and put it in the nursery tray.
7. Gently place the tip with the adult spider mite colony on it into the lower spines of the base of the freshly prepared gorse cutting. In time, the spider mite colony will transfer itself onto the new food supply to feed. Place this newly prepared container onto the adult colony tray in the rearing cage.
8. There should now be two containers in the rearing cage – one in the adult tray (containing the transferred adult spider mite colony) and one in the nursery tray (containing the original cutting with the eggs and juvenile mites).
9. Repeat this process when the mites in the adult tray begin clustering at the top of the gorse cutting again.
10. Remember to watch the nursery tray. When the larvae emerge hatch and start to mature, they will begin to cluster at the top of the gorse cutting. They should then be transferred to a new cutting, using the same process as that used for the adults.

11. Once the colony of juvenile mites has been transferred to the new gorse cutting, transfer them to the adult tray and throw away the original gorse cuttings*.

12. Remember, all gorse cuttings in both the adult and nursery trays in the rearing cage will need regular watering. It may be a good idea to set up a roster and have the students take turns at checking the gro wool (and the growing medium in the original container), watering them when necessary.

Adult and nursery trays

***To dispose of the unwanted gorse material.**

1. Wrap gorse in newspaper.
2. Double bag material in heavy duty tie-able garbage bags.
3. Organise for DPI to collect.

8.5 Releasing spider mites

8.5.1 Before release

1. Identify a release site appropriate for students to walk to, or organise another mode of transport if needed.
2. Ensure the site is safe for students to attend. (Checklist in Appendix 2 will help you identify an appropriate release site).
3. Get a signed consent form to visit the site from the land manager (Appendix 3) and, if necessary, consent forms and photo release forms for the students.

8.5.2 Releasing the spider mite colony

It is imperative that great care is taken to ensure that the weeds are not further distributed. A permit under the *Catchment and Land Protection Act 1994* is available to cover registered schools in the transport of plants to the release site. A copy of the permit conditions will be provided to mentors and school contacts when registering for the program.

To release the spider mites follow the steps below:

1. Spider mite can be released whenever there is healthy green gorse.
2. Remember to use gloves as the gorse is very prickly!
3. Place the infested plants into a container, avoiding contact with the mites.
4. At the release site, choose an area where the gorse is very dense, green and healthy. It should be an area that is not likely to be disturbed, so not too close to walking tracks or roads. Spider mites will do best in an area with plenty of light.
5. Once an area is chosen the spider mites can be released over an area no bigger than 1m by 1m. Spreading them over a larger area can reduce their chances of establishing, as they need to be able to find each other to mate and lay eggs.
6. Fill in the Release Form (at Appendix 4) for each release site and give copies to the land manager and to the Department of Primary Industries.
7. Contact the Department of Primary Industries to arrange collection of used pots and materials.

Placing spider mite amongst gorse infestation

8.6 Monitoring the gorse spider mites

Once released, the spider mites should be monitored at the release site throughout the year. It's a good idea to visit when the spider mites will be breeding and visible, at the beginning and end of the season. Monitoring should be conducted at the same time each year.

By monitoring the release site, you can assess whether the spider mites have established, how far they have spread and what impact they are having on the infestation.

You will need to think about:

- whether the spider mites are still present at the site – red clusters throughout the foliage and webbing indicate that they're still there
- what spider mite life stages can be observed (egg or juvenile/adult)
- how much spider mite damage can be seen at the site
- how far the spider mites have spread from the original release point
- the total area affected by the spider mites
- the furthest location from the release point at which spider mites or feeding damage can be seen
- the estimated coverage of spider mites at the site
- whether the spider mite infestation has increased, decreased or remained the same since the spider mites were released
- other factors that may be affecting the survival of the spider mites such as drought, chemicals, vandalism etc.

The spider mite Monitoring Form (Appendix 4) should be completed each time the site is monitored. This should only take 30 minutes. Copies of the completed form should be given to the land manager of the site and to the Department of Primary Industries.

8.6.1 What to expect

In the first season after release damage to gorse by the spider mite will be very minor and hard to find with thorough searching.

Don't be dismayed if signs of spider mite activity cannot be seen: they can be hard to find. It is not unusual for sites to seem to have failed and for spider mites to 'reappear' after two or three seasons once their population has grown.

Remember biological control is a long-term control method: it may take five to ten years for the numbers to build up enough to start having an impact.

If the spider mites have survived their first summer, even if only in small numbers, your efforts have been a great success. Their numbers will then steadily increase over the next few years.

Appendix 1 - Invitation to mentors

This template is a formal invitation to mentors, community groups and other potential Weed Warrior program participants, to participate in the Weed Warrior Program.

<Mentors organisation /group>

<Postal address>

<Suburb VIC Postcode>

<Date>

Dear <Mentor's name>

Weed Warriors Program

Students from <school> are ready to become Weed Warriors to help make a difference in the fight against weeds and I thought <you or your organisation> might be interested in being a mentor for these students.

Weed Warriors is a national community education and engagement program that is focused on fostering increased community awareness of and involvement in local weed issues. Through the program, students, with the assistance of land managers and community groups, are given the unique opportunity to undertake real-life weed research at school by breeding biological control agents for a target weed, and then releasing them at local infestations.

The role of the Weed Warrior mentor in the program is to help increase the quality of the learning experience and to develop in the students a sense of connection to, and responsibility for weed issues in their local area. Your involvement in the program will help to create a real-world experience for the students and to help them develop a thirst for environmental knowledge.

If you are interested in becoming the Weed Warriors mentor for the <school> students, please contact me on <phone> or <email>.

Yours sincerely,

<Name>

<Position>

Appendix 2 - Checklist for selection of a suitable release site

Use this checklist to ensure that the infestation you have in mind is suitable.

- Biological control will achieve the expected outcome for the infestation.
- The infestation is dense, widespread and persistent.
- The infestation has a low priority for control by other methods.
- The land manager is cooperative and fully aware and will sign / has signed an agreement of co-operation form.
- The infestation has a long-term time frame for control.
- No chemicals will be used at the infestation within the agreement period.
- Disturbance of the infestation can be kept to a minimum.
- Utilise existing biological control release sites (if possible).
- Infestation is easily accessible and not hazardous.
- The site is preferably adjacent to or within walking distance of the school.

Appendix 3 - Biological control release site – Land Manager agreement of cooperation form

School: _____

Contact teacher: _____

Contact number: _____

Mentor: _____

Contact number: _____

Release Site details (School to complete)

- Release site location (Melways reference or GPS coordinates):

  _____

  _____

  _____

- Target weed: _____
- Biological control agent to be released: _____
- Planned date of release: _____
- Land Manager / Owner Name: _____
- Agency (if applicable): _____
- Phone: _____
- Mobile: _____
- Email: _____

To be signed by Land owner / manager

I (name), _____

agree to allow the stated school onto the stated property to release biocontrol agents for the target weed. By signing this form I accept that I am not excluded from any responsibilities for weed management and control as stated in the *Catchment and Land Protection Act 1994* or as directed by the Department of Primary Industries.

Signed _____ Date _____

To be signed by mentor or teacher

Name: _____

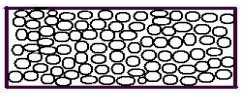
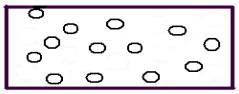
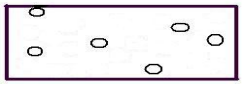
Signed _____ Date _____

A signed copy of this document needs to be sent to the Department of Primary Industries at least one month before the planned release date. Copies should also be retained by the teacher, mentor and land owner /manager.

Appendix 4 - Forms

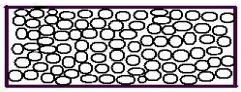
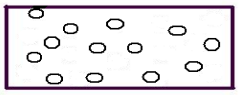
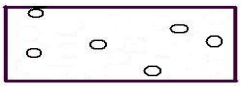
Release form for bridal creeper (BC) leafhopper

Participant information					
Contact details:					
Organisation:					
Address:					
Email:					
Telephone:					
Weed Warriors school:					
School address:					
Class:					
Number of students:					
Release information					
Date of release:					
Site address:					
Land manager:					
GPS coordinates or Australian Map Grid Reference (if available):					
Photo ID at release site: 1. Select site and hammer 45cm stake into ground leaving approx 4cm above ground. 2. Mark GPS co-ordinate and place results above in data sheet. Then identify best aspect for photo providing best indication of spread of infestation, move 5-10 m from GPS site, centre original GPS site in photo. Take photo at head height and identify the GPS site of photo point and record below on data sheet. GPS site MODE GDA UTM 7 digits					
Time of release:					
Weather conditions:	Hot	Mild	Cold	Wet	Dry
State of the agent;	Excellent	Good	Poor		
Weed Information					
BC infestation size :					
Density of BC (%):					
Plant condition (you may circle more than one):	Growing vigorously	Good condition	Poor condition		
In the case of re-release					
Is the site clearly marked with a stake	Yes	No			
If not install a stake as directed above and collect the corresponding information					

At the Re-release site		
Adults seen:	Yes	No
Nymphs:	Yes	No
Eggs seen:	Yes	No
Extent of damage: (Mark X if appropriate)		
Dense (leaf hoppers everywhere bleached bridal creeper)		
Medium (medium leaf hoppers with variegated bridal creeper)		
Scattered (sporadic leaf hopper, minimal effect on bridal creeper)		
Maximum distance travelled by leafhoppers from original release point:		
Density of damage at original leafhoppers release point (1m x 1m area):		
Other comments:		

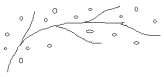
Monitoring form for bridal creeper leafhopper

Participant information			
Contact details:			
Organisation:			
Address:			
Email:			
Telephone:			
Weed Warriors school:			
School address:			
Class:			
Number of students:			
Release information			
Date of release:			
Site address:			
Land manager:			
Weed Information			
BC infestation size :			
Density of BC (%):			
Plant condition (you may circle more than one):	Growing vigorously	Good condition	Poor condition
Other: (please comment)			
Is the site clearly marked with a stake:	Yes	No	

Monitoring observations							
Date monitored:							
Adults seen:	Yes	No					
Nymphs seen:	Yes	No					
Eggs seen:	Yes	No					
Extent of damage: (Please circle appropriate level)							
Dense (leaf hoppers everywhere bleached bridal creeper)							
Medium (medium leaf hoppers with variegated bridal creeper)							
Scattered (sporadic leaf hopper, minimal effect on bridal creeper)							
Maximum distance travelled by leafhoppers from original release point:							
Average density of damage within the leafhopper infected area:							
Density of damage at original leafhopper release point (1m x 1m area):							
Direction leafhoppers have travelled in:	N	NE	E	SE	S	SW	W
Comments: **(factors affecting leaf hopper survival)**							

Release form for gorse spider mite

Participant information					
Contact details:					
Organisation:					
Address:					
Email:					
Telephone:					
Weed Warriors school:					
School address:					
Class:					
Number of students:					
Release information					
Date of release:					
Site address:					
Land manager:					
GPS coordinates or Australian Map Grid Reference (if available):					
Photo ID at release site: 1. Select site and hammer 45cm stake into ground leaving approx 4cm above ground. 2. Mark GPS co-ordinate and place results above in data sheet. Then identify best aspect for photo providing best indication of spread of infestation, move 5-10 m from GPS site, centre original GPS site in photo. Take photo at head height and identify the GPS site of photo point and record below on data sheet. GPS site MODE GDA UTM 7 digits					
Time of release:					
Weather conditions:	Hot	Mild	Cold	Wet	Dry
State of the agent;	Excellent	Good	Poor		
Weed Information					
Gorse infestation size :					
Density of gorse (%):					
Plant condition (you may circle more than one):	Growing vigorously	Good condition	Poor condition		
In the case of re-release					
Is the site clearly marked with a stake	Yes	No			
If not install a stake as directed above and collect the corresponding information					

At the Re-release site		
Adults seen:	Yes	No
Eggs seen:	Yes	No
Extent of damage: (Please circle appropriate level)		
Dense (spider mites everywhere forming a peak, lots of webbing)		
Medium (medium spider mites in patches, little webbing)		
Scattered (sporadic mites just detected, minimal webbing)		
Maximum distance travelled by mites from original release point:		
Density of damage at original mite release point (1m x 1m area):		
Other comments:		

Monitoring form for gorse spider mite

Participant information			
Contact details:			
Organisation:			
Address:			
Email:			
Telephone:			
Weed Warriors school:			
School address:			
Class:			
Number of students:			
Release information			
Date of release:			
Site address:			
Land manager:			
Weed Information			
Gorse infestation size :			
Density of gorse (%):			
Plant condition (you may circle more than one):	Growing vigorously	Good condition	Poor condition
Other: (please comment)			
Is the site clearly marked with a stake:	Yes	No	

Monitoring observations							
Date monitored:							
Adults seen:	Yes	No					
Eggs seen:	Yes	No					
Extent of damage: (Please circle appropriate level)							
Dense (spider mites everywhere forming a peak, lots of webbing)							
Medium (medium spider mites in patches, little webbing)							
Scattered (sporadic mites just detected, minimal webbing)							
Maximum distance travelled by mites from original release point:							
Average density of damage within this mite infected area:							
Density of damage at original mite release point (1m x 1m area):							
Direction mites have travelled in:	N	NE	E	SE	S	SW	W
Comments: **(factors affecting mite survival)**							