Managing weeds: eradication response guide

A guide for planning and undertaking an eradication response to weeds at the early stage of invasion on public land in Victoria



2nd Edition



Environment, Land, Water and Planning

Photo credit

Cover photo: White-spined Hudson Pear (Cylindropuntia pallida) at Ouyen State Forest, March 2014 (Photo by Bec James).

Other publications in this series:

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Victorian environmental weed risk database (2018), search online for 'early invader weeds'.

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About this guide

If eradicating a weed is a feasible aim (removing it completely from your patch), having a plan improves your chances of success. This guide will assist you plan and carry out eradication works.

Invasive species management is an integral component of any landscape or reserve scale conservation program. This includes weed management.

Increasingly around the world, the benefits of preventing and 'nipping new weeds in the bud' before they become widespread are being appreciated.

About WESI

The Weeds at the Early Stage of Invasion (WESI) Project was created to promote these benefits and enable Department of Environment, Land, Water and Planning (DELWP) and Parks Victoria public land managers adopt this approach.

The WESI project focuses on high risk invasive species at the early stage of invasion that threaten biodiversity. We work with DELWP and Parks Victoria staff looking after public land anywhere in Victoria.

WESI is funded through the Weeds and Pests on Public Land Program. Project information and tools are available at: www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders

Working within a framework

The WESI project has developed a decision making framework that guides public land managers through the process of dealing with invasive plants at the early stage of invasion (see Figure 1). This guide describes in detail a component of the larger framework.



Figure 1 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. There is an enlargement of the framework with scenarios in Appendix 1.

The guide series

Through research and trialling different approaches in the field, there is a growing amount of information about prevention and early intervention for weeds.

This document draws on that research and experience to offer a guide for public land managers, whether they do the work in the field, design the work or authorise the delivery of the work.

By using all of the guides in this series, public land managers can improve their decision making about what are the highest risk weeds, how to search for and identify them, determine where the infestation boundaries are, work out which management approach is best and, where feasible, respond with local eradication.

The early invader guide series is one of a number of tools available through the WESI project. The series provides step-by-step guides to plan and undertake the following work:

- Search and detect
- Name and notify
- Assess the risk
- Delimit the invasion (comprising all infestations present)
- Decide the response
- Implement eradication (if appropriate)

A summary of the guide series is available with all the blank templates in "Early invader manual: managing early invader environmental weeds in Victoria" (Blood *et al.* 2019). The tools are available at: www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders

Weed management including eradication

Weed activities fall into four broad categories: prevention, eradication, containment and assetbased protection. By better understanding these different management approaches, public land managers can make better decisions, invest resources more wisely, and have better biodiversity outcomes.

Eradication is the elimination of every single individual (including propagules e.g. seeds and buds) of a species from a defined area in which recolonisation is unlikely to occur (Panetta 2016).

There is no denying that eradication is hard to achieve, can take a long time and should only be undertaken for candidates that have a good probability of success. Using these guides will help you make better decisions.

Weed management should not simply be dismissed as 'too hard', but, through some careful planning and a continued and sustained response, can achieve great benefits for biodiversity.

What is 'in the early stage of invasion'?

There is ongoing debate about what area and number of infestations could be classified as eradicable. In reality, the answer depends on the weed and the situation because of the wide variation in the biology and ecology of weeds and the many different environments in which they grow. As a consequence, the relationship between the infestation area and the effort needed to achieve eradication will also vary (Panetta and Timmins 2004).

Through this guide series, we refer to 'weeds at or in the early stage of invasion'. The shortened term is 'early invaders'.

Early invaders are plants that have naturalised and have started to spread. Naturalised plants are non-indigenous species that sustain self-replacing populations for several life cycles without direct intervention by people, or despite human intervention. When spread has just begun, such plants are not at all widespread and are generally encountered only by chance, unless specifically targeted by search efforts. Co-ordinated management intervention, i.e. eradication or containment, is at its most feasible for plants at this stage of invasion, owing to their highly restricted distributions (Panetta 2016).

The aim of this guide

The aim of this guide is to help with the development and implementation of a 'park-scale' eradication response for invasive plants on public land. While eradication at state or national scale is advantageous, more localised eradication programs have considerable merit. Eradication is not easily achieved and needs to be undertaken with careful consideration of the risks, processes and costs that may be involved. Much has been written on the theory and practice of eradication in the last decade. This guide provides a summary of the important points that others have learnt in planning or undertaking eradication programs.

This guide supports the 'Eradication response' step in the framework shown in Figure 1. Use Figure 2 to help you navigate your way around this guide and the others in the series.

Before you start

These guides are full of different 'tools' and hints to help you through the weed management process. You may want to start at the beginning and work your way through step-by-step or browse for ideas in your topic of interest. Managing public land involves balancing many requirements, of which weeds are only one. Decisions about which weeds to manage have to be made in this broader context.

These guides lead you through the process to eradication of early invaders, but generally eradication will not be the aim for most weeds.

It is essential to be aware of the limitations of these guides, as well as the ongoing need for their modification in light of experience, intuition and local knowledge. Effective environmental weed management comes through long-term observations, learned skills and being able to make decisions based on the local conditions. These guides are to help, not substitute for, these important skills (Blood *et al.* 1996).

How do I undertake an eradication response?

I want to plan and undertake an eradication response to a weed at the early stage of invasion in my patch. Here is the process to follow.



Figure 2 - How to use this guide.

What is eradication?

Eradication is the elimination of every single individual (including propagules e.g. seeds and buds) of a species from a defined area in which recolonisation is unlikely to occur (Panetta 2016).

The term "extirpation" is often used in discussions concerned with the eradication of plants. Extirpation is the localised extinction of a species within a chosen geographic area. It is generally used when populations of a weed are completely removed, yet others exist elsewhere. Eradication in the broader sense refers to removal of all populations within a given geographical unit, usually a State or a country.

In this guide, the term extirpation will be referred to as localised eradication.

Why eradicate a weed?

There are many good reasons why eradication of invasive plants is worthwhile. Eradication has considerable benefits because of its potential to provide substantial and long-term ecological and economic benefits when an invading organism is eliminated (Harris *et al.* 2001; Wittenberg and Cock 2001; Simberloff 2003). Despite the benefits, eradication is often difficult to achieve and best applied to populations that are in the early stage of invasion and have limited extent. Choosing the target carefully is important, as are the operational procedures used to achieve eradication.

Plants are not well represented on the list of eradication successes (Simberloff 2003) and can be difficult targets owing to problems with detection and persistent seed banks (Panetta and Timmins 2004; Regan *et al.* 2006; Simberloff 2003; Panetta 2007). Generally, the success rate of weed eradication programs is low at around 10-20% (Howell 2012).

The intensity of effort and duration of effort required to achieve eradication is far greater than that required for ongoing control or management of invasive plants (Dodd *et al.* 2015). In many cases, eradication can take 10 years or more to achieve (Panetta 2007; Panetta and Lawes 2005). Eradication of even relatively small infestations can take decades to achieve, particularly if propagules are long-lived and it is difficult to prevent reproduction (Tomley and Panetta 2002).

By choosing eradication targets carefully using the earlier guides in this series, the likelihood of success should increase considerably.

Factors influencing eradication success

Generally, two groups of factors influence the eradication success of invasive plants. The first relates to site and species factors, which are beyond the control of a management agency, for example, the capacity of the target species to produce seeds or other propagules. The second group relate to organisational attributes, which can be influenced by management, for example, the allocation of sufficient resources to manage an eradication program (Dodd *et al.* 2015).

Retrospective reviews have identified several important factors that influence the success of eradication projects/programs, many of which occurred in Australia. This pool of knowledge is very helpful for guiding the design of eradication programs, and is summarised in Table 1.

Table 1 - Summary of the factors influencing eradication success.

| Factor | Explanation |
|------------------------------|--|
| Time present | Infestations at the early stage of invasion are more feasible to eradicate than those that have been present for long periods. |
| Propagule longevity | The shorter the life span of propagules (seeds, bulbs, buds etc.) the more feasible to eradicate. |
| Time to sexual maturity | The longer the time to sexual maturity, the more feasible to eradicate. |
| Detection distance | The longer the distance over which a species can be detected the more feasible to eradicate. |
| Previous eradication success | If the species has been eradicated elsewhere, the more likely it can be eradicated again. |
| Detectability period | The longer the species is detectable within its growth cycle, the more feasible to eradicate. |
| Infestation size | The smaller the infestation, the more feasible to eradicate. |
| Delimitation | The greater the searching effort, the more feasible to eradicate. |
| Monitoring rate | The more frequently eradication efforts are monitored, the more feasible to eradicate. |
| Public perception | Species that have no conflicting perceptions within the public forum are more feasible to eradicate. |

Time weed has been present

Biological invasions are often characterised by a lag phase followed by a rapid expansion in extent and density. Commencing eradication projects at the earliest possible stage in the invasion curve improves the chances of success (Rejmanek and Pitcairn 2002). Therefore, knowing how long an invasive plant has been present at a site is important.

Understanding of biological traits

The vulnerability of invasive plants to treatment methods and their ability to re-invade is strongly influenced by the biological traits of the target species, especially how quickly the species reproduces and for how long its seeds persist. Therefore, eradication programs require a good understanding of the species' biology, in particular the dispersal ability of the target species, its reproductive biology and its life history. This information needs to be collected and considered in the development of an eradication response plan (see template in Appendix 2). In some circumstances, when an early invader has been detected in a new environment, little information on the species' life history or biological attributes may be available, in which case, data from close relatives may have to be used.

Detection distance

Detection distance (distance from a plant at which it may be seen) has a large influence on the time to achieve eradication, which reflects the total search effort required to find all individuals.

Previous eradication success

Plants that have been eradicated elsewhere are likely to possess features that will increase the likelihood of success in further eradication efforts.

Detectability of target species

The detectability of the target species, comprising both the annual period of detectability and detection distance) have positive influence on rate of eradication (time taken to eradicate a population). Plants that are generally difficult to detect or are only detectable for a short period are more likely to escape control efforts.

Infestation size

The smaller the infestation, the more likely eradication will be achieved.

Delimitation

Delimitation is a critical component for successful eradication. Incorrectly assessing the extent of infestations is a major contributing factor to the need to switch from eradication to another management approach, highlighting the importance of exhaustive delimiting surveys (Howell 2012) (see "Looking for weeds: delimiting survey guide").

Monitoring rate

Infrequent monitoring is an important factor in the failure to eradicate (Howell 2012). Increasing monitoring intensity and thereby locating hard-to-find individuals can substantially decrease the time taken to achieve eradication (Dodd *et al.* 2015). Therefore, a long term plan with consistent treatment and regular monitoring of infestations is crucial. The frequency of monitoring should be determined by how quickly undetected plants could become reproductive.

Public perception

Eradication feasibility is influenced not only by the species' biological factors, but also sociopolitical, economic and operational ones (Dodd *et al.* 2015). Eradication planning needs to consider conflicts that could arise in the removal of specific plants. An example might be the removal of early invaders at popular visiting sites on public land that attract the attention of the public.

In the eradication response plan template (Appendix 2), provision is made for analysis of the public perceptions involved in the presence and removal of the target species.

What's involved in an eradication response?

An eradication response plan guides the step-by-step procedure to stop the spread, to prevent reproduction, and to deplete viable propagules from areas occupied by the target species. Two operational phases define most response plans, consisting of the *active treatment* of established plants and new recruits, and *monitoring* to determine if further recruitment is occurring from the seedbank in the soil or budbanks (Panetta 2007) (see Figure 5).

Why prepare a response plan?

Developing a plan for your eradication response is a key step in moving towards eradication. Without it, operational activities can be poorly coordinated, lack project logic and be deficient in key information relevant to the target species. As eradication projects can run over long periods of time, an eradication response plan ensures that consistency is achieved if a change in personnel occurs. Achieving eradication of invasive plants requires a well-documented response plan that spans the expected life span of the project. Provision for project review is essential and the adaptive learning process is strongly advisable.

Planning phase - prepare a response plan

The theoretical concepts behind planning and running a successful eradication project are incorporated into the eradication response plan template in Appendix 2. Completing the template provides a firm basis for planning and scheduling your project. Information should be updated as it comes to hand or changes in approach are required through the adaptive learning process.

The eradication response plan template incorporates the following information:

- Weed name and identification features
- Site information (use a new template for each infestation)
- Project objectives
- Public perceptions
- Target weed biology and life history traits
- Growth calendar
- Hygiene requirements
- Treatment strategies (including budget)
- Monitoring phase
- Eradication assessment
- Budget
- Site works plan
- Attachments

A completed example of an eradication response plan is provided in Appendix 3.

Mapping

When including maps within a response plan, where possible:

- Show the gross and net infestations (see Figure 3); and
- Include the area to be covered for ongoing monitoring (see Figure 4) while the eradication response is underway.

Gross and net infestations: Net infested area is the area requiring treatment (Panetta and Timmins 2004; Dodd *et al.* 2015;), while gross infestation area is a larger area that includes the net areas that require treatment plus the surrounding area that must be searched in return trips following treatments (Panetta and Timmins 2004). See Figure 3 for an illustration of these terms and Figure 4 for an illustration of the different scales of site and the associated terminology.



Figure 3 - Illustration explaining the difference between net and gross infestations.



Figure 4 - An illustration of the different scales of site and the terminology assigned to them - the concept of public land, site, search area and targeted survey area.

Operational phases within an eradication response

There are two main operational phases associated with eradication projects: the active treatment phase, where a treatment is applied to an infestation; and the monitoring phase, where search effort is directed at locating any individuals of the species (Figure 5).



Figure 5 - Operational phases within an eradication response.

In both the active treatment phase and the monitoring phase, regular review is required to identify those projects that are on track and progressing, as well as projects that are unlikely to succeed and hence require consideration of a different management approach (i.e. containment or protection of biodiversity assets).

Active treatment phase

An eradication project remains in the active treatment phase while the target species has different life stages present in the treatment area. This will include adults, juveniles, seedlings, seeds and other reproductive organs e.g. underground bulbs. In order to assess whether the project should move to the monitoring phase, surveying (searching) is required and often on a regular basis. The extent, density and life stages present in a population are important measures of determining trends towards eradication.

Progress towards eradication will be shown by a declining area of extent, density and reduction in the number and age of adult plants. Effective searching is a critical element for weed eradication projects. Poor data can be expected if these are collected over limited areas or where there is limited likelihood of the weed occurring. Similarly, seasonal conditions influence search results and effort should be adjusted according to conditions at the time, with less effort expended if the target is unlikely to be detected (e.g. during drought) and more when conditions favour recruitment.

Even though it may be thought that the weed invasion was properly delimited prior to making a decision to pursue eradication, it is possible that some plants were missed during the delimitation survey. Moreover, further spread may occur from undetected plants within the area that has been delimited, so it is necessary to continue searching over a larger area. The adequacy of searching may be judged by plotting the area searched and infested area detected. Adequacy is achieved when there is no increase in the area infested with an increase in the area searched. If a lot of previously undetected infested area is found, then the effort required to achieve eradication will have to be recalculated; in the extreme it may be considered that eradication is no longer feasible. The absence of adequate mapping or delimitation data can be a major obstacle in estimating eradication feasibility (Rejmanek and Pitcairn 2002; Panetta and Timmins 2004; Panetta and Lawes 2005).

As mapping is a critical element, effective search and detection practices need to be determined, practised and perfected. Detection prior to the reproductive phase is one of the key determinants of eradication feasibility (Panetta and Timmins 2004; Panetta 2007). Regular site visits, in conjunction with effective search protocols, are required to give a high probability that any new recruits from the seed or bud bank are controlled before they can reproduce (Panetta 2007).

Additional information on how to improve walking surveys can be found in Appendix 4.

Where treatments are being applied the highest priority is to eradicate satellite infestations to reduce the extent of the gross infested area (Zamora *et al.* 1989; Robison *et al.* 2013; Shepherd 2013; Ensbey 2014). The next priority is the borders of large infestations, and the final priority is to control plants within core infestation areas.

Seed and other propagule production must be eliminated if eradication is to succeed. Difficulties with detection of juvenile and small adult plants can lead to reproductive escape, which prolongs the time taken to achieve eradication.

Hygiene, wellbeing and safety

Planning for hygiene to ensure weeds are not spread is very important. The wellbeing and safety of staff, contractors, site visitors and neighbours are crucial. Appendix 5 outlines some general points to incorporate into eradication response planning and activities.

Monitoring phase

The monitoring phase commences when no recruits or regrowth have been detected in the area subjected to active treatment. An arbitrary period of time is required to determine this transition point, which has been recommended to be at least 12 months (Panetta 2007). The monitoring phase reverts to the active treatment phase if plants are detected (refer to Figure 5).

How often a site is visited should be determined by how quickly the target species may become reproductive, an important piece of information for the eradication response plan (Panetta 2007). When determining how often to visit a site, keep in mind the possibility that sometimes small plants will escape detection and could possibly reach maturity before the next visit. Inconsistent site visitation has limited the progress of many eradication programs (Howell 2012).

Recording activity

Record treatment and monitoring activity in the Spatial, Temporal, Activity Recorder (STAR) and attach eradication response plans activities to STAR and save on Enterprise Content Management (ECM).

Assessing progress towards eradication

Because eradication efforts can be expensive and will potentially divert resources from other management activities, it is important to get a sense of whether eradication is likely, or whether the program might simply be evolving into an indefinite control effort. Regular searching and strong record keeping are required to properly evaluate an eradication program. If infested sites do not advance from the active to the monitoring phase within 3-5 years this should be a cause for concern, particularly if it hasn't been possible to prevent reproduction by the target.

Where there are multiple infestations, combining the times since detection of the target species for each site into frequency distributions (% of total infestations) is a useful way of demonstrating progress towards eradication (Panetta 2007). For example, 40% of the sites may be in the active phase, 30% may have been in the monitoring phase for 1 year, 20% in the monitoring phase for 2 years and 10% in the monitoring phase for 3 years. Progress towards eradication will be reflected by few (if any) sites remaining in the active phase and a shift towards longer times in the monitoring phase. Where seed persistence is likely, time without the appearance of seedlings may be viewed in relation to how long the seed bank would be expected to persist; this also provides an indication of progress towards eradication.

Reductions in target plant (including seedling) numbers over time will be favourable indicators, but remember that the aim is to achieve zero density of the target, and certainly to prevent reproduction by any new plants that appear.

Declaring eradication - How can we be sure?

A simple indicator that eradication has been achieved is when the target species has not been detected for a period equal to or greater than its seed longevity (Regan *et al.* 2006; Dodd *et al.* 2015). The longer the time, the more likely the weed has been eradicated (Bekker *et al.* 1998). Trends in seedling numbers provide some indication of the condition of the residual seed bank. However, caution is needed for species with deeply dormant seed or bud banks, and where variation in seed longevity occurs between environments.

What can go wrong when declaring eradication?

There are two ways that the decision to declare eradication can go wrong. The first is when a species has not been sighted for some time, eradication is declared and monitoring is stopped, but the species is still present and can escape, which may incur large economic and environmental costs. Alternatively, searching may continue when the species is already eradicated and therefore scarce economic resources are wasted (Regan *et al.* 2006).

Rather than rely on declaration of eradication based on an ad hoc criteria, such as after 3 or 5 years without detection (Rejmanek and Pitcairn 2002), ideas of seed bank longevity (Woldendorp and Bomford 2004), or by setting arbitrary thresholds of 1% or 5% confidence that the species is not present, an alternative economic consideration has been proposed. This suggests we stop looking for the target species when the expected search costs outweigh the expected benefits (Regan *et al.* 2006).

While this approach is practical for species with definable economic impacts (e.g. agricultural weeds), since a weed cost estimate is required, the approach is of limited use for environmental weeds, where economic impacts are notoriously difficult to estimate (Regan *et al.* 2006; Rout 2009). Despite this limitation for environmental weeds, taking into account the potential cost of damage to the environment should eradication fail versus the cost of the monitoring program can

assist managers to decide when to terminate weed eradication programs. Even when a program is declared successful, occasional visits to previously infested sites will pick up a resurgence in the weed population before much further spread has occurred. This was certainly the case with the eradication program targeting Bitterweed (*Helenium amarum*) in south-eastern Queensland (Tomley and Panetta 2002), where the weed was detected in one of its sites 5 years after eradication had been declared.

Communication

Develop and keep updated a simple communication plan concerning the stakeholders to be kept informed and how information about the eradication program will be communicated e.g. in the media and/or on social media. Seek advice from your agency communication staff.

Undertake treatment

Integrated management

Integrated management is the coordinated use of a range of suitable chemical and non-chemical treatment methods to reduce target density and extent (Ensbey 2014) of weeds. The best results will be achieved by combining treatment methods that take into account the weed's biology and ecology and site conditions.

At all times integrated management of weeds needs to be considered in the broader context of management for biodiversity, taking into consideration the ecology of the ecosystem being protected and the off-target impacts and consequences of the combination of weed treatment techniques used.

Although the aim of this series of guides is local eradication, some of these techniques will be more appropriate for treatment of weeds beyond the early stage of invasion. These techniques appear in this guide to assist public land managers that need to change management approach should local eradication no longer be feasible.

Each treatment will need to be tailored to the specific location for maximum efficacy and safety.

The best eradication strategy will probably combine cultural and chemical treatments, but should include alternative methods in case the primary treatments fail. An example is the use of fire to kill standing plants and reduce weed biomass. Regrowth after fire is treated with herbicides, with improved access and often with improved detectability.

Wherever practicable, treat weeds on-site and aim to leave weed biomass there. Transporting removed weeds or contaminated soil is challenging: there is a risk that propagules will be spread, disposal of the material can be problematic, and it is more costly.

Integrated management requires long-term planning, knowledge of the weed's biology and ecology, and weed treatment methods (Ensbey 2014).

Note on seed banks and bud banks

Given that local eradication is the elimination of every single individual (including propagules) of a species from a defined area in which recolonisation is unlikely to occur, design response plans to take into account seed banks and bud banks. Under the ground, there may be long-lived seed and vegetative propagules e.g. root fragments, rhizomes, stolons, bulbils and tubers. Consider how long these propagules remain viable in the soil before ceasing monitoring for eradication.

In some situations, propagules in the soil can be stimulated to germinate/grow, exhausting the seed bank and bud bank and allowing the resulting new plants to be treated with a suitable technique.

Herbicides

Eradication programs will nearly always involve the use of herbicides at some stage in the project. When selected carefully they are:

- effective;
- efficient;
- cost effective;
- versatile a range of application methods;
- often selective;
- environmentally acceptable when applied skilfully and according to label; and
- enhanced when appropriate by the addition of adjuvants.

The use of herbicides in Australia is governed and regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Herbicide label information specifies where and how particular herbicides may be used to avoid off-target damage, unnecessary environmental damage and achieve satisfactory levels of control. Where a target species is not specified, off-label use may be required under permit from the APVMA (see Appendix 6).

The APVMA website is an excellent source of current information on agricultural and veterinary chemicals permitted for use in Australia. It is also available as a mobile application. See Public Chemical Registration Information System (PubCRIS) <u>https://portal.apvma.gov.au/pubcris</u>

Please be aware that formal accreditation is required for application of herbicides on public land. Protective clothing and equipment are always required for the safe application of herbicides (see Appendix 5). The Material Safety Data Sheet for herbicide products specifies what constitutes suitable protective clothing and equipment.

Foliar application

Foliar spraying applies herbicide to the foliage of the target plant, usually to the point of run-off (i.e. until each leaf is wet but not dripping).

Foliar spray application can be done in a number of ways depending on the nature of the weed, the size of the infestation and the presence of off-target plants.

High volume application is applied under pressure via a pump and hand-gun to the target species. While highly efficient at treating large infestations, off-target damage can be harder to control than with lower pressure systems, due to the rate of flow. This is a useful method for monocultures of hard-to-penetrate weeds e.g. blackberry (*Rubus* species), but is not so useful in diverse bushland situations.

Low volume application (e.g. spot spraying) uses low pressures to deliver herbicides, usually via hand-operated equipment such as backpacks or hand-held, small volumes sprayers (i.e. 8 L). This is suitable for small to medium sized infestations where non-target damage risks are high. Excellent control of spray direction and rate can be achieved. The limited capacity of spray units means frequent refilling is required. Battery operated pump systems (12 volts) are versatile, efficient and readily controllable methods of herbicide application under low pressure. High selectivity can be achieved with careful application and a range of tank sizes (up to 1000 L) reduces refill frequency. This is a useful method for spraying larger infestations in mixed plant associations.

Splatter guns apply a low volume of concentrated herbicide mix to foliage. A specialised nozzle produces a solid stream of large droplets that can be applied up to 6-10 m away. Only a small portion of the foliage needs to be sprayed, therefore non-target damage is reduced. This technique is particularly useful in areas of difficult access and where water supply is limited (Shepherd 2013).

Boom spraying applies herbicide via a horizontal boom and is used mostly within crops and pastures where the target is less than 1 m in height. This method has limited application in indigenous vegetation, but may find uses for managing weeds in grassland restoration projects.

Wiper application is used for control of weeds that grow taller than the non-target vegetation. It involves applying herbicide solution to an absorbent surface, such as a length of rope or wick. The herbicide saturated wick is attached to a boom set at a height that wipes the target and not the non-target species (Shepherd 2013). The use of drum rollers can be useful for taller weeds emerging above, for example, indigenous grassland species. Similarly, wipers can be sponges applied by hand, or attached to extendable handles and applied to individual target plants.

In some situations, applying herbicide can kill seeds carried on the target weed, which can be a useful short-term way of giving you breathing space while a more coordinated response plan is organised.

To maintain organic certification on private property, pine-oil based foliar sprays are particularly useful. Rapid dehydration follows treatment and can weaken, perhaps kill, perennial weeds with repeated application. Desiccants have a role in selectively removing annual plants from perennial plant communities. Although all species are affected, perennials recover with time.

Granular application

This method applies herbicide pellets evenly to the soil beneath the target weed's canopy. The herbicide acts by moving into the root zone of the weed following rain and is absorbed by the roots (Shepherd 2013). Depending on the product being used, weeds are killed at the pre-emergent stage (a germinating seed) or post-emergent (seedling or older) stage. Non-target species can be affected if their roots share the same soil space as that treated. This is a suitable method for some woody species where application of foliar herbicides is difficult. Many granular herbicides are persistent in the soil profile and can provide lasting control to mature plants and seedlings. The risk of persistent herbicides is that leaching and movement through the soil profile can occur in some situations, with impacts including preventing reestablishment of indigenous plants.

Application methods for woody weeds

Woody weeds (trees, shrubs, vines) are often less susceptible to foliar-applied herbicides than herbaceous or semi-woody species. A range of methods has been developed that suit the treatment of woody weeds and involve application to a cut surface or basal areas of the target plant. In general woody weed methods are:

- reliable require one-off or limited repeat applications;
- target specific;
- involve minimal soil disturbance; and
- simple.

Cut stump (cut and paint)

The main stem(s) or trunk(s) are cut horizontally and the exposed surface is sprayed or painted with herbicide to ensure the sapwood (located between the bark and drier heartwood) is covered. Concentrated herbicide is often used, although the addition of small volumes of water can improve uptake. The addition of dyes to the herbicide clearly identifies treated plants when large numbers of individuals require treatment. It is necessary to apply the herbicide promptly before the plant begins to seal the cut and prevents penetration of the herbicide into the sap stream. The stump should be cut as close to the ground as possible.

Scraping the bark below the cut and applying additional herbicide can help control difficult-to-kill species e.g. *Ligustrum* species (privets) (Shepherd 2013).

Some species will not reshoot from cut stumps providing the cut is made below the lowest green leaf or lateral branch (felling), therefore application of herbicides is unnecessary e.g. many acacias and pines. These species are also amenable to ringbarking (see over page).

Scrape and paint

Scrape and paint is used for some species of vines that are difficult to kill using other methods e.g. Madeira Vine (*Anredera cordifolia*). A sharp knife is used to scrape a thin layer of bark from a 15-30 cm section of stem. Herbicide is then applied immediately to the exposed sap tissue (Shepherd 2013). This is a time consuming method, but is needed for some species.

In many cases, the aerial part of the climbing plant can be left on the supporting vegetation to die and decompose. In some cases it may be necessary to remove the climbing weed but disposal can be problematic.

Stem injection (drill and fill)

Stem injection commonly uses the drill and fill method, which is applied to trees or tall shrubs. A power or hand drill with a drill bit 8 mm or larger is used to form holes on a 45-60 degree angle around the base of the target plant and below any branches. The holes should be angled so they can hold liquid or gel. Holes should avoid the heartwood and be spaced at 5-10 cm intervals around the trunk/stem. Herbicide is then immediately injected into the hole with a suitable applicator, such as a sheep drenching needle or spot gun. Exposed roots can also be treated using this method. Most species react quickly to this form of control. Deciduous species should not be treated while they are dormant.

Stem injection is used for the treatment of cacti, but rather than drilling holes, herbicides are injected using a lance device.

Frilling or chipping

Frilling (Figure 6) is used for woody trees and shrubs with a single large stem or trunk (greater than 10 cm diameter). The method involves cutting into the bark and injecting herbicide into the sap stream. Frills are made at 5-10 cm intervals with an axe, sharp knife, paint scraper, chisel, or machete to make a horizontal cut at an angle around 45 degrees. It is important not to make cuts too deep. The herbicide is then immediately applied into the cut (Shepherd 2013).



Figure 6 - Frilling a large Maple (*Acer* species) using a tomahawk, and spot gun to deliver herbicide into the wound. Source: Australis Biological.

Basal bark

This method is used to treat saplings, multi-stemmed shrubs, or trees providing they have thin smooth bark. The herbicide is mixed with diesel fuel at label rates and is applied to all sides of the basal stems or trunk from ground up to a height of around 30 cm. Stems should be dry, free of fire charring and not have debris (e.g. from floods) accumulated around them (Shepherd 2013). Treated plants die in situ and can then be removed or left to decay naturally. This is a very useful technique for species that may sucker following cut stump methods. Death is often rapid using this method but should not be applied to deciduous plants while they are dormant. Care needs to be taken with the application of the diesel/herbicide mixture and full protective clothing needs to be worn.

Soil fumigation (gas) and drenching (liquid)

Soil fumigation tends to be restricted to the preparation of soils for commercial production of some vegetables and fruits, particularly when problematic diseases are present. Gases or liquids are injected into the soil profile and then covered with plastic to prevent the escape of toxic products. Soil fumigation has not been commonly applied to the treatment of invasive plants but was a key method of control in the Branched Broomrape (*Orobanche ramosa*) eradication program in South Australia.

The method may also be applied to aquatic situations, where pesticides are contained beneath a sheet of anchored plastic. This method was used to eradicate the invasive marine alga *Caulerpa taxifolia* in California (Ensbey 2014).

The method is only suitable for small infestations but could have greater applicability than previously utilised. Underground parts such as roots and seeds are killed using this method. Seek further advice before using as it could be a high risk treatment technique. Treatment of weeds in aquatic systems is quite specialised and additional advice should be sought from practitioners in this field.

Physical treatment or removal

Mechanical

Mechanical control is the felling, removal or manipulation of weeds using power tools or machinery and is usually used for large, dense infestations. Commonly employed methods include:

- slashers, mowers or brush cutters to reduce weed biomass and restrict flowering;
- tractors to plough weeds and destroy their root system (cultivation);
- chippers to grind weeds into fine severed pieces; and
- mechanical weed pullers to wrench woody weeds out of the ground e.g. Boxthorn (*Lycium ferocissimum*).

Mechanical control can cause ground disturbance and may increase erosion, damage indigenous vegetation and promote weed seed germination. Contingency plans need to be in place to deal with these impacts. Cultivation is almost entirely restricted to arable land dedicated to agriculture.

Slashing or mowing

This method is perhaps most amenable to indigenous vegetation where access is possible. This method will not eradicate weeds but will certainly help provide access by reducing biomass, and the reproductive potential of weeds. When integrated with herbicide application or fire, greater control potential occurs. Hygiene of this equipment is paramount to prevent further spread (see Appendix 5). Mowing has these features (Muyt 2001; Shepherd 2013):

- The scale will determine the equipment to be used.
- It can be used to contain infestations.
- Catchers can be used to gather seed heads and propagules.
- Slash can be collected, reducing soil nutrient levels.
- Propagules are easily spread by equipment.
- It should be undertaken before propagules ripen.
- It is useful for suppression of annual species
- Repeat mows may be required over the growing season.
- Indigenous species can be adversely affected, including fauna habitat.

Grubbing out and hand pulling

This method involves digging weeds out using a mattock, spade, and hoe or by hand (handpulling) and is suitable when there is a small number of plants. Grubbing and digging out can be useful for weeds that have their growing points at ground level or below the surface of the ground (corms, bulbs, rhizomes, clumped or fibrous root systems, grasses). Some soil disturbance can result from this method and follow-up monitoring for regrowth is required (Shepherd 2013).

Alternatively, disturbance is minimised by pressing disturbed soil back into shape and covering with local leaf litter. Fertile plants i.e. with propagules attached, need to be removed off-site, particularly within an eradication project, and the material disposed of following quarantine measures. For small quantities requiring disposal, plant material can be placed in a sealed heavy duty plastic bag, inside another sealed plastic bag (i.e. double bagged).

Plants that lack seeds or other viable propagules can be left on site, providing they cannot take root. Stacking or hanging off the ground in other vegetation is a good way of preventing this from happening. The method is labour intensive and slow, but useful in better quality vegetation where other techniques may cause even greater disruption. Grubbing is highly selective and suited to small or scattered infestations.

Cutting and felling

Some weeds can be killed by the simple cutting of the stem(s) near ground level. The species susceptible to this treatment method do not reshoot either from the cut stump or roots e.g. *Pinus radiata*. The felled part of the weed can be left on-site to decompose.

Ringbarking

Ringbarking involves stripping the bark and sapwood off the entire circumference of the main trunk or stem. The ring is made with an axe, knife, machete or chainsaw, and is generally at least several centimetres wide. The cut is made as close as possible to ground level. The host then dies from dehydration.

Scalping

Scalping involves removal of the top layers of soil that contain weed propagules. Mechanical equipment is used in most cases, but for very small infestations this can be done by hand. It is a drastic, high disturbance method of weed control and often used as a last resort method. Scalping also removes indigenous plants and propagules, soil microbes, and a high proportion of soil nutrients, reducing soil fertility. The method has become useful for restoring indigenous plant communities, particularly by direct seeding, in areas that were previously dominated by invasive species.

Scalping has some application for eradication as it addresses residual soil seed and bud banks. Strict quarantine measures need to be in place when using scalping for eradication projects to prevent accidental spread through the movement of equipment or soil. Contingency plans need to be in place for the treatment and safe disposal of removed soil and vegetation.

This is a high risk and expensive treatment technique and should not be used lightly.

Grazing

Although grazing may not be an eradication treatment per se, it may be a component of maintaining an ecosystem in which an eradication response is occurring. Grazing by domestic stock is a common method of weed suppression in agricultural areas and has been used by pastoralists for centuries. Of course, palatable species are consumed in preference to unpalatable weedy species under normal conditions. Palatability can be changed by the use of spraying a solution of molasses or some herbicides e.g. 2, 4-D, which alters dietary preferences by some domestic stock (spray-grazing).

While grazing by domestic stock is useful in agricultural habitats, it is of very limited value in indigenous vegetation, as stock cause ground disturbance, graze non-selectively, disperse weed seeds and elevate soil nutrients. Therefore, weed problems can be aggravated by grazing from domestic stock. However, where indigenous vegetation has a history of regular grazing and is in a stable condition, grazing may need to be continued, as rapid removal can lead to weed outbreaks e.g. some indigenous grasslands.

Little is known about the value of indigenous herbivores for the suppression of weeds, but like introduced grazing animals, they are probably of little value for eradication projects.

Heat

Fire

Fire has been used for centuries as a form of vegetation management and weed control as it reduces weed biomass, clears for follow-up chemical control and, for some fire-sensitive species, destroys the plant altogether, or stimulates seed germination of weeds that can then be treated. Exotic plants vary in their response to fire, just as Australian indigenous plants do. Therefore, fire is a complex management tool (e.g. Figure 7), as weed responses will depend not only on the biology of the target species, but those of other weeds and indigenous species present at the site.

Success as a weed management tool is also influenced by the speed, intensity, and seasonality of fire (Ensbey 2014).



Figure 7 - Heathy Woodland that was rolled with machinery and then burnt. The high fuel loads near ground level created an excellent ash bed with high continuity. The post-fire vegetation was species rich with low weed abundance. Image by Robin Adair, Australis Biological.

Fire has considerable potential as a tool for eradication programs because it:

- destroys mature plants and seedlings;
- exhausts weed seed banks;
- improves access and encourages regrowth for follow-up;
- removes dried material that can impede herbicide uptake; and
- promotes competitive desirable species.

Careful planning is required for the use of fire in any weed management program as it can:

- favour weeds and have detrimental impacts on indigenous vegetation e.g. rare or threatened species;
- be unsuitable in some ecological vegetation communities e.g. rainforests, salt marsh;
- demand high intensity management in the early recovery period, putting stress on resource availability; and
- introduce new weeds and pathogens to the site if appropriate hygiene protocols are not followed.

Therefore, fire as an eradication tool needs to:

- consider how both indigenous and introduced species respond to fire;
- consider fire frequency, seasonality and intensity to achieve desired targets (add to treatment plan);
- consider if pre-burn treatments are required to carry the burn or achieve target intensities. This
 may involve the use of herbicides or rolling vegetation in order to dry it and increase biomass on
 the ground layer;

- take into account grazing impacts. Grazing from introduced and indigenous animals can increase following fire. Exclusion of grazing animals by fencing or control (rabbits) may be required to avoid detrimental impacts; and
- incorporate integrated management actions to achieve eradication targets.

Before any planned burn on public land, authorisation must be obtained in consultation with DELWP, Parks Victoria and the Country Fire Authority (CFA) (if required).

Flame weeding

Flame weeding uses liquid propane gas (LPG) or propane as a fuel to burn targeted weeds. Gasfired burners are useful, as heat is applied to localised areas. Flaming doesn't require the weed to be burnt but raises the moisture level to above 100 degrees Celsius at which point steam ruptures plant cells. Seedlings are more susceptible than large plants. There is considerable variation is susceptibility to flaming. Weeds with thick leaves or protected stems require more heat than thinleaved or smooth-barked species. Upright plants are easier to treat than prostrate species, where branches and growing points may be protected. Weeds with growth points located beneath the soil surface will recover quickly from flaming treatments. The technique is useful for localised infestations of seedlings or adult plants. Flaming regrowth can be targeted for herbicide treatment, often without affecting nearby desirable species.

Hot water/steaming

This is a similar method to flame weeding except steam or hot water is used as the treatment medium. Steam breaks down the waxy coating on the leaf surface, thereby increasing moisture loss and dehydration. The impact on roots is minimal.

Solarisation

Solarisation uses heat from the sun to destroy above ground and below ground populations of weeds. Heavy duty black plastic sheeting (or sometimes clear) is used to cover the infestation. The absence of light inhibits photosynthesis and temperatures are raised to lethal levels on sunny days. Heat from solarisation can penetrate the soil profile and destroy propagules in the surface layers (to 1 cm depth). It is also a useful method for weeds with rhizomes or stolons.

Solarisation is non-selective and acts as a vegetation sterilant. Therefore, it has potential for eradication programs, but mostly for small infestations, or where little or no indigenous vegetation remains. It is an underutilised method for the treatment of weeds and in preparation for restoration of indigenous vegetation, particularly in areas that are difficult to treat with herbicides. Regular maintenance checks on treated areas are required to ensure plastic sheeting remains secured. Cord Grass (*Spartina* species) has been successfully treated by solarisation in some Tasmanian estuaries (Muyt 2001).

Other treatment techniques

Mulching, smothering

Mulches work by smothering weed infestations and tend to be temporary solutions to weed management problems, as weed recovery usually occurs with time as mulches break down, or weeds penetrate through the surface materials. Mulching has a very limited role in the eradication of weeds. However, smothering using human-made plastics or fabrics can be useful in some situations e.g. when used in conjunction with drawdown of an aquatic system for an aquatic weed. Mulches can be used in site restoration works following declaration of eradication. In summary mulching:

- has a limited role in natural ecosystems, but may be effective in restoration projects;
- requires on-going care;
- can reduce maintenance costs (through pre-mulching treatments);
- is detrimental to indigenous plant recruitment; and
- can introduce materials into the landscape that have other consequences e.g. black plastic litter, introduced seeds brought in with organic mulch.

Water or nutrient manipulation

In some situations, manipulating water levels (by drought or flood) can be a valuable technique, especially in wetland systems and standing water bodies for the treatment of aquatic weeds. Either drowning a plant or draining a water body (full drawdown) may be useful methods. Manipulating pH or nutrient levels can also be useful e.g. removing artificial nutrient sources in drainage lines that encourage a target weed. Treatment of weeds in aquatic systems is quite specialised and additional advice should be sought from practitioners in this field.

Competition through regeneration or revegetation

Competition uses planted or regenerating indigenous plants to suppress the growth, reproduction or recruitment of weeds by reducing access to sunlight, nutrients and moisture. It is generally used in integrated and long-term weed management programs (Shepherd 2013). Regenerating indigenous communities can suppress weeds to some degree but will not be particularly useful in an eradication program, unless for site restoration following declaration of eradication. Developing an overhead canopy for weed control can reduce shade intolerant weeds, but conversely may favour shade tolerant species. Integrated planning is important to prepare for likely changes, monitor and act (Shepherd 2013; Ensbey 2014).

Biological control

Classical biological control involves the use of natural enemies from the country of origin to suppress the health and vigour of target weeds. The method is economical, effective and environmentally sound but requires extensive development and establishment phases. Importantly, biological control will not eradicate the weed target, but may reduce infestations to an acceptable level where it can be controlled by other means. Therefore, biological control should not be relied on in any eradication project but could be useful if a different management approach is required.

Seed and bud bank treatments

In some situations, it will be advantageous to harvest and remove above-ground seeds and vegetative propagules such as aerial tubers or bulbils. For seeds and buds situated underground there are a number of ways to promote germination or growth if it is necessary to accelerate seed and bud bank exhaustion. These include disturbance and exposure to light, inoculating the soil with bacteria that may increase decomposition, or the use of smoke stimulants such as 'smoke water' to stimulate germination of fire sensitive species. This may also be useful to stimulate growth of indigenous species that may outcompete weeds.

Non-target damage

Weed control programs invariably aim to reduce non-target impacts caused by the use of suppression methods and generally considerable effort and care is allocated to this end. While this practice needs to continue and is endorsed, eradication programs may sometimes need to adopt a more flexible attitude to non-target damage. There will be cases where protecting non-targets will interfere with achieving eradication objectives by limiting control options. If a weed has been justified as a target for eradication it is because of its highly destructive potential impacts to the economy, environment or social values. Unnecessarily handicapping an eradication program to reduce non-target damage could be counterproductive, and convincing justification should apply. This may certainly occur when interesting, rare, threatened or endangered species or communities occur in infested areas. If not, then accepting there will be damage and undertaking vegetation restoration after declaration of eradication may be a more cost effective and safe option to pursue. In this situation, well developed communication plans will be required.

Repair the site and rehabilitation

Rehabilitation of weed treatment sites may be required in some situations, particularly where natural re-establishment of non-invasive or useful species is unlikely to occur quickly. Where intervention is required, the methods used will depend on the extent of disturbance, environmental risks, land use requirements and reconstruction objectives i.e. what do we want the restored site to look like in the future?

At sites where indigenous species are abundant and the vegetation community has a high level of resilience e.g. fertile and montane soils, mediated rehabilitation may not be required. However, as a general rule, disturbed sites are less prone to invasion by other weeds if they are quickly revegetated with competitive and compatible species suitable for the site. Provisions for fencing and signage may be required to facilitate rehabilitation. They may also be useful in the earlier stages of eradication where public access could interfere with eradication objectives, or may involve risks to unauthorised personnel.

Rehabilitation is a specialist undertaking and is not directly described in this guide. However, during the implementation of an eradication response plan (specifically active treatment) broad consideration should be given to the next stage i.e. what will be the after effects of herbicide use to remove a specific weed e.g. regrowth of another weed, bare earth exposure etc.

Review

This document is very focussed on the eradication response. This decision to commence an eradication response is based on the information available at the time and as an eradication response proceeds it is frequently found that new information emerges e.g. additional infestations are found, or treatments work better or worse than expected etc. A decision to run an eradication response is subject to review and it is normal that some attempts will need to be halted after a short time – be prepared for this possibility.

Review an eradication response plan regularly through the active treatment and monitoring phases and adapt your management as appropriate.

What next?

Celebrate and share your successes including with the WESI project team (Appendix 7).

Case study: eradication of Hawthorn at Aranda Bushland

Hawthorn (*Crataegus monogyna*) is a problematic tree or tall shrub in bushland areas across the State. The species is a declared noxious weed but was permitted in the past as a hedge row, where it forms spiny barriers to stock.

At the Aranda Bushland Reserve in the ACT, Hawthorn invades Box Woodland vegetation and forms dense impenetrable thickets. A local friends group (Friends of Aranda Bushland) recognised the threat Hawthorn presented to the reserve and commenced a control program (Geue 2012). Dedicated and persistent action over 20 years saw a gradual reduction in Hawthorn density and extent. A range of treatment methods were used, but most plants were removed using felling with chainsaw or hand saws and followed up with either cut and paint methods or hand pulling.

The core infestation was tackled, as were satellite infestations within the reserve. Regeneration after the initial control efforts was strong, but persistent effort saw the number of Hawthorn plants decline, until finally the species was considered to be locally eradicated. During the course of the management program other weeds presented but these were also controlled if they posed a high risk.

The friends of Aranda Bushland learned that eradication can take time and is a long-term commitment. They persisted and achieved results by incorporating several key approaches to their program. Firstly, the infestation was defined by delimitation; they knew exactly where the population they were attempting to eradicate was located.

Secondly, they visited the infestation regularly over a long period of time to ensure that all plants and new seedlings were treated. Monitoring after the control program gave them the confidence that the species had been eradicated from the reserve. Natural regeneration was encouraged following the control program, which provided some resistance to future weed invasions.

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Appendix 1 - Decision making framework (with scenarios)



* consider conducting a structured field search if insufficient existing weed records exist

Figure 8 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. This version illustrates three typical scenarios faced by public land managers.

Appendix 2 - Eradication response plan template

Attach eradication response plans to STAR and save on ECM.

| General weed information | | | | |
|--------------------------|--|--|--|--|
| Photo | | | | |
| | | | | |
| Source: | | | | |
| | | | | |
| | | | | |
| | | | | |

| Site information | |
|--------------------|-------------------------------------|
| Site address/name: | Contact person & mobile phone: |
| Project Easting: | Reference number: |
| Project Northing: | Land manager: |
| Zone reference: | DELWP Region/Parks Victoria Region: |

Project Approval

By endorsing this Eradication Response Plan, signatories are agreeing to deliver the plan as described to the required standards and levels of resourcing outlined in this plan.

| Project Manager: | |
|---------------------|--|
| Position: | |
| Signature and date: | |

| Project Owner: | |
|---------------------|--|
| Position: | |
| Signature and date: | |

Objectives (site specific)

(e.g.) Treat infestations, ensuring whole removal of infestation. Quarantine area and sign post appropriately. Ensure vehicle hygiene is practised for all vehicles. Establish and implement monitoring activities. Undertake any post control follow up required. Monitor infestations and surrounding areas for any new plants. Undertake searches in neighbouring areas.

Year 1:

Year 2:

Year 3:

Year XX:

Public perceptions

Are there stakeholders or interest groups that may object to eradication of the target weed? If so, what is the communication plan?

| Target weed biology and life traits (include source information where possible) | | | | |
|--|---|--|--|--|
| Method of reproduction (e.g. seed, vegetative, suckering) | • | | | |
| Seed longevity (e.g. seeds can remain dormant in the soil up to x years) | • | | | |
| Bud bank longevity (e.g. bulbs, rhizomes etc.) | • | | | |
| Time to sexual maturity (e.g. time from seedling to first seeds produced) | • | | | |
| Time between flowering and seed set | • | | | |
| Spread by (e.g. wind, water, garden dumping, humans, animals) | • | | | |
| Propagule dispersal range | • | | | |

| Growth calendar | | | | | | | | | | | | |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Detection | | | | | | | | | | | | |
| Germination | | | | | | | | | | | | |
| Flowering | | | | | | | | | | | | |
| Seeding | | | | | | | | | | | | |
| Ideal | | | | | | | | | | | | |
| treatment | | | | | | | | | | | | |

| Hygiene req | uirements | | | |
|---|--|---|--------------------|--|
| Site | • | | | |
| (e.g. avoid mo | ovement | | | |
| through infest | ed site) | | | |
| Transport | • | | | |
| (e.g. wash dov | wn vehicle and | | | |
| equipment pri | or to entering | | | |
| and leaving in | fested site) | | | |
| Disposal | • | | | |
| (e.g. deen bur | ial) | | | |
| (0.g. 000p bui | | | | |
| | | | | |
| Treatment s | trategies | | | |
| Method e.g. Chemical control, mechanical control | Method detail List all possible treatments and consider all life stages and follow up treatments | Situation e.g. a dense infestation, sensitive area (threatened species, EVCs), along watercourse | Timing (months) | Comments (record observations on target response) |
| Chemical* | • | | | • |
| | | | | • |

| Mechanical | | | • | |
|----------------------------|--|-----------|---|--|
| control • | | | | |
| | | | | |
| | | | | |
| Source: | | | | |
| | | | | |
| *Off-label permit | | Comments: | | |
| required? | | | | |
| Refer to Appendix 6 for a | | | | |
| guide to choosing an | | | | |
| appropriate chemical for | | | | |
| control of invasive plants | | | | |

•

Treatment budget

(What are expenditure items for the treatment program?)

•

2018/19 2019/20 2020/21

Monitoring phase

Monitoring phase life span

(Tip: The length of the monitoring phase should be equal to or greater than the length of time the target species seeds and/or buds remain viable in the soil.)

| Monitoring search method (i.e. What search methods will be used and how?) | • |
|---|--------|
| Monitoring area (i.e. What is the monitoring area?) | • |
| Optimum timing of monitoring (i.e. The months of the year when the plant is most detectable) | • |
| Frequency of monitoring (e.g. Once or twice a year) | • |
| Budget | |
| Monitoring budget (What are expenditure items for the monitoring/eradication assessment program?) | • |
| Eradication assessment | |
| What eradication criteria will be used? (i.e. choose appropriate criteria from below that will be used to assess the progress towards eradication) | |
| 1. Time since target weed was last observed over time (in relation to bud bank or seed bank longevity) | Yes/No |
| 2. Monitoring costs vs cost of the target weed to the environment | Yes/No |
| 3. Trends in seedling numbers | Yes/No |
| 4. Reduction in infested area newly detected through searching | Yes/No |

Yes/No

5. Other (specify)

| Site works | s plan | | | | | | | | | | | | | |
|-----------------------------------|---|----------------------------|-----------|---|---|---|--|--|---|-------------------|----------|--|----------|---|
| Works plan | 1 | | | | | Annual wo | orks plan | | | Proposed works | | Actual works completed | | |
| Map/Works ID (Infestations) | Location i.e. description of where infestations is | Eastings Zone: 54/55 | Northings | Area (hectares) (for polygon data only) | Pattern of infestation i.e. scattered, individual or continuous | Operational Phase i.e. active treatment phase or monitoring phase | Control method (for active treatment phase only) e.g. spot spray, mechanical, fire | Activity (for monitoring phase only) e.g. monitoring for re- invasion | Total Budget for the site (\$) | Timing | Comments | Actual cost (\$) or Staff time (days) | Comments | Contract reference (DELWP or PV specify which) |
| Year 1 – 2 | 018/19 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 2– 20 |)19/20 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 3 – 2 | 020/21 | | | | | | | | | | | | | · |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 4 – 2 | 021/22 | <u>.</u> | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 5 – 2022/23 | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Add rows and edit as required. Enlarge table (to A3) and text for readability.

Attachments

Items that could be included as an attachment to the plan (and attached to STAR and saved in ECM):

- Locality map
- A3 site maps (for more detail about where the infestation is located, delimiting survey results etc.)
- Request for Quote documentation
- Copy of contracts
- Photographs of seedlings etc. to assist identification during treatment and monitoring

Appendix 3 - Completed example (fictitious) of an eradication response plan for White-spined Hudson Pear

This is a made-up example, based on a real situation.

Attach eradication response plans to STAR and save on ECM.

| General weed information | |
|--|---|
| Scientific name: Cylindropuntia pallida | Photo |
| (formerly known as <i>Cylindropuntia rosea</i>) Common name: White-spined Hudson Pear | |
| | |
| | Source: Bec James' photo. Ouyen State Forest 1.5.2012 |

Site information

Site address/name: Ouyen State Forest, north east corner, Victoria

Project Easting: 620234

Project Northing: 6115909

Zone reference: 54

Contact person & mobile phone: B. Weedy (DELWP)

Reference number: 01_C.pallida_Ouyen State Forest

Land manager: Department of Environment, Land, Water and Planning (DELWP)

DELWP Region/Parks Victoria Region: Loddon Mallee (DELWP)

Project Approval

By endorsing this Eradication Response Plan, signatories are agreeing to deliver the plan as described to the required standards and levels of resourcing outlined in this plan.

| Project Manager: | Joe Bloggs |
|---------------------|------------------------|
| Position: | Project Officer |
| Signature and date: | Loe Bloggs 1 Sept 2015 |

| Project Owner: | Mary Sproggs | | | | | | |
|---------------------|--------------------------|--|--|--|--|--|--|
| Position: | District Manager | | | | | | |
| Signature and date: | Mary Sproggs 1 Sept 2015 | | | | | | |

Objectives (site specific)

(e.g.) Treat infestations, ensuring whole removal of infestation. Quarantine area and sign post appropriately. Ensure vehicle hygiene is practised by all vehicles. Establish and implement monitoring activities. Undertake any post control follow up required. Monitor infestations and surrounding areas for new plants. Undertake searches in neighbouring areas.

Year 1: Treat infestations 1 and 2 (refer to map), ensuring entire removal (for mechanical control) of individual infestations and full coverage of spot spray of multiple infestations. Quarantine the work area and sign post appropriately. Ensure vehicle hygiene is practised by all vehicles. Establish and implement monitoring activities.

Year 2: Undertake any post control follow up required. Monitor infestations and surrounding areas for new plants. Undertake surveillance in neighbouring areas. Ensure vehicle hygiene is practised by all vehicles. Implement monitoring activities.

Years 3 and subsequent: Undertake any post control follow up required. Monitor infestations and surrounding areas for new plants. Undertake surveillance in neighbouring areas. Ensure vehicle hygiene is practised by all vehicles. Implement monitoring activities.

Following eradication: Rehabilitate the site, manage the pathways of spread into and out of the site. Prevent future infestations of *C. pallida* occurring at the site.

Public perceptions

Are there stakeholders or interest groups that may object to eradication of the target weed?

If so, what is the communication plan?

None. If any stakeholders do become concerned about the control of White-spined Hudson Pear, then they will be directed to speak to Joe Bloggs, Project Officer, who will deal with concerns accordingly.

| Target weed biology and life traits (include source information where possible) | | | | | | | | | | |
|---|--|--|--|--|--|--|--|--|--|--|
| Method of reproduction • (e.g. seed, vegetative, suckering) | Vegetative is the most common form of dispersal. This can occur year round when segments, immature fruit or flowers detach and make ground contact Rarely forms seeds (seed appear to be sterile) | | | | | | | | | |
| • (e.g. seeds can remain dormant in the soil up to x years) | It is believed that <i>C. pallida</i> does not produce viable seed | | | | | | | | | |
| • (e.g. bulbs, rhizomes etc.) | n/a | | | | | | | | | |
| Time to sexual maturity•(e.g. time from seedling to firstseeds produced) | Unknown | | | | | | | | | |
| Time between flowering and • seed set | Unknown | | | | | | | | | |
| Spread by (e.g. wind, water, garden dumping, humans, animals) | Most spread in Australia has been by people Vehicles Equipment Rubbish dumping (tips, bushland) Water (along drainage lines, water courses) | | | | | | | | | |
| Propagule dispersal range • | For vegetative dispersal, depends on the level of disturbance associated with the plant (i.e. vehicle drives over the top). | | | | | | | | | |

| Growth calendar | | | | | | | | | | | | |
|-----------------|-----------------------|--------------|--------------|--------------|--------------|-----|-----|--------------|--------------|--------------|-----|--------------|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Detection | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 1 | ✓ | ✓ | ✓ | ✓ | ✓ |
| Germination | ✓ | \checkmark | ✓ | 1 | 1 | 1 | 1 | \checkmark | \checkmark | 1 | 1 | ✓ |
| Flowering | ✓ | \checkmark | | | | | | | | \checkmark | 1 | \checkmark |
| Seeding* | | | \checkmark | \checkmark | \checkmark | | | | | | | |
| Ideal | | | | | | | | \checkmark | \checkmark | \checkmark | 1 | \checkmark |
| treatment | | | | | | | | | | | | |
| *not verified | | | | | | | | | | | | |

| Hygiene reg | uirements | - | | | | | | |
|---|--|---|-----------------------------------|---|--|--|--|--|
| Site (e.g. avoid mo through infest | ovement • | Avoid movement throughout the infested site Stick to establish roads/tracks | | | | | | |
| Transport (e.g. wash do equipment pri and leaving in | wn vehicle and or to entering ifested site) | Check vehicle tyres segments Check shoes, socks | and under the , pants, gaiters | chassis for any attached for any attached segments | | | | |
| Disposal (e.g. deep bui | • ial) | Dispose of segment to ensure no regrow | s in a deep bur th | ial (e.g. at least 1 m deep) | | | | |
| Treatment s | strategies | | | | | | | |
| Method e.g. Chemical control, mechanical control | Method detail List all possible treatments and consider all life stages and follow up treatments | Situation e.g. a dense infestation, sensitive area (threatened species, EVCs), along watercourse | Timing (months) | Comments (record observations on target response) | | | | |
| Chemical* | Spot spray using: MSMA Triclopyr | Suits large infestations and roadsides | Sept - Nov? | Ensure adequate coverage of the plant (all sides of the segment) to prevent regrowth Plants may die more quickly as a result of warm weather spraying | | | | |
| | Stem injection using: | Suits isolated, small infestations or difficult to access sites | Sept - Nov? | Not suitable for large or dense infestations | | | | |
| Mechanical control | Physical removal • Dispose of appropriately via deep burial | Small isolated plants | Sept - Nov? | Care must be taken when mechanically or physically removing <i>C. pallida</i> due to its spiny nature. Plants can pose significant risk of injury when handled. Small segments can easily be broken off when being removed | | | | |

| FireBurn the whole plant e.g. using a drip torchWhen access is required to an area and to remove the bulk of the plant so less herbicide is requiredSept - Nov? end within standardsPractise burning within standardsFireBurn the whole plant e.g. using a drip torchWhen access is required to an area and to remove the bulk of the plant so less herbicide is requiredSept - Nov? endPractise burning within standardsFollow-up herbicide may be requiredFollow-up herbicide may be required | | | | | | |
|--|------|---|---|-------------|---|--|
| | Fire | Burn the whole plant e.g. using a drip torch | When access is required to an area and to remove the bulk of the plant so less herbicide is required | Sept - Nov? | • | Practise burning within standards Hot fires can kill plants, although regrowth can occur Follow-up herbicide may be required |

Source: Potter, S. (2011) Weed Management Guide, Weed of National Significance: Opuntioid cacti, including *Austrocylindropuntia*, *Cylindropuntia* and *Opuntia* species.

*Off-label permit required?

Yes 🗹 No 🗵

Comments: Off-label Chemical advisor (Mr X) provided information 7.1.2014

Refer to Appendix 6 for a guide to choosing an appropriate chemical for control of invasive plants in Victoria

| Treatment | t budget | | |
|---|--|------|---|
| (What are e | expenditure items for the treatment progr | am?) | |
| 2015/16 | \$1,500.00 | | |
| 2016/17 | \$1,500.00 | | |
| 2017/18 | etc. | | |
| Monitorin | g phase | | |
| Monitoring (Tip: The let be equal to target speci in the soil.) | phase life span ngth of the monitoring phase should or greater than the length of time the ies seeds and/or buds remain viable | • | 5 years |
| Monitoring (i.e. What so how?) | search method earch methods will be used and | • | Annual search will be conducted in spring of each year. Two people in a vehicle checking all the tracks/roads and checking on foot around the proximity of known current and pre-existing infestations. |
| Monitoring (i.e. What is | area s the monitoring area?) | ٠ | Ouyen State Forest as a whole and specifically around known existing and pre-existing infestations |
| Optimum t i (i.e. The mo most visible | iming of monitoring onths of the year when germination is e) | • | Any time of the year, but spring is a good time to have a look, especially when the sun is shining on the plant (easier to see in the field). |
| Frequency (e.g. Once o | of monitoring or twice a year) | ٠ | Annual |

| Budget | |
|---|--|
| Monitoring budget (What are expenditure items for the monitoring/eradication assessment program?) | Staff time – 1-2 days annually |
| Eradication assessment | |
| What eradication criteria will be used? (i.e. choose appropriate criteria from below that will be used to assess the progress towards eradication) | |
| 1. Time since target weed was last observed over time (in relation to seed bank longevity) | No |
| 2. Monitoring costs vs cost of the target weed to the environment | No |
| 3. Trends in seedling numbers | No |
| 4. Reduction in infested area newly detected through searching | Yes |
| 5. Other (specify) | n/a |

| Site work | s plan | | | | | | | | | | | | | |
|---------------------------------------|---|----------------------------|-----------|--|---|--|---|---|---|------------------|--|---|---|---|
| Works pla | n | | | | | Annual w | orks plan | | | Propos | ed works | Actual w | orks compl | eted |
| Map/Works ID (Infestations) | Location i.e. description of where infestation s is | Eastings Zone:54/5 5 | Northings | Area (hectare s) (for polygon data only) | Pattern of infestation i.e. scattered, individual or continuou s | Operationa I Phase i.e. active treatment phase or monitoring phase | Control method (for active treatment phase only) | Activity (for monitoring phase only) e.g. monitoring for re- invasion | Total Budget for the site (\$) | Timing | Comments | Actual Cost (\$) or Staff time (days) | Comments | Contract referenc e (DELWP or PV specify which) |
| Year 1 – 2 | 2015/16 | | | | | | | | | | | | | |
| 01 | Western section of Search area D. Northern side of the road, 600 m from Boulka Rd | 619591 | 6115694 | n/a | Individual | Active control phase | Mechanica I (hand pull) | n/a | \$1,500.0 0 | Sept 2015 | 1-3 m off the track to the north | \$1,000.0 0 | Single plant removed | 217164 |
| 02 | Western section of Search area D. Approx 10 -15 m off track on either side | 619621 | 6115672 | n/a | Scattered | Active control phase | Spot spray | n/a | | Sept 2015 | Approximatel y 6 plants located 10-15 m off track on either side of track. All infestations are flagged with pink tape | | All 6 plants were treated | 217164 |
| Year 2- 2 | 016/17 | | | | | | | | | | | | | |
| 01 | Western section of Search area D. Northern side of the road, 600 m from Boulka Rd | 619591 | 6115694 | n/a | Individual | Monitor phase | n/a | Surveillanc e for re- invasion | x1 staff, in the field for a day | Octobe r 2016 | Undertake surveillance on previous infestation site. Record any signs of new infestations | x1 staff, half a day in the field | x4 new infestations were located and GPS points taken. Removed mechanicall y on the day. | n/a |
| 02 | Western section of Search area D. Approx 10 | 619621 | 6115672 | n/a | Scattered | Active control phase | Spot spray | | \$1,500.0 0 | Octobe r 2016 | An additional 2 plants located from original infestation. | \$750.00 | All plants treated | 345678 |

| Site work | ite works plan | | | | | | | | | | | | | |
|---------------------------------------|--|----------------------------|-----------|--|---|--|---|---|---|----------------|--|---|----------|---|
| Works pla | n | | | | | Annual works plan | | | | Proposed works | | Actual works completed | | |
| Map/Works ID (Infestations) | Location i.e. description of where infestation s is | Eastings Zone:54/5 5 | Northings | Area (hectare s) (for polygon data only) | Pattern of infestation i.e. scattered, individual or continuou s | Operationa I Phase i.e. active treatment phase or monitoring phase | Control method (for active treatment phase only) | Activity (for monitoring phase only) e.g. monitoring for re- invasion | Total Budget for the site (\$) | Timing | Comments | Actual Cost (\$) or Staff time (days) | Comments | Contract referenc e (DELWP or PV specify which) |
| | -15 m off track on either side | | | | | | | | | | Includes the 1 plant missed last season | | | |
| Year 3 – 2 | 2017/18 | | | | | | | | | | | | | |
| etc | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 4 – 2 | 2018/19 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Year 5 – 2 | 2019/20 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Add rows and edit as required. Enlarge table (to A3) and text for readability.

Attachments

Items that could be included as an attachment to the plan (and attached to STAR and saved in ECM):

- Locality map
- A3 site maps (for more detail about where the infestation is located, delimiting survey results etc.)
- Request for Quote documentation
- Copy of contracts
- Photographs of seedlings etc. to assist identification during treatment and monitoring

Appendix 4 - Tips on how to improve walking surveys for monitoring

These simple practices can be used to improve the effectiveness of walking surveys to find invading species and monitor treatment programs:

- Survey speed should not be increased as plants become either more or less visible, as more attention is given to walking than to looking for the plant.
- "Contouring" involves walking parallel to imaginary elevation contour lines and by using landmarks to prevent overlapping or creating gaps on successive sweeps, helping to ensure complete coverage.
- GPS units are highly effective at ensuring complete coverage is achieved (see "Looking for weeds: search and detect guide" and "Looking for weeds: delimiting survey guide").
- Shifting positions in the sequence of surveyors in sweeps alleviates monotony and maintains concentration. Using several survey methods will also increase accuracy and dependability (Zamora *et al.* 1989).
- Initial searching should involve systematic and intensive surveys in the local vicinity of known occurrences (see "Looking for weeds: search and detect guide"), and other areas selected, based on dispersal behaviour of the weed and potential pathways of spread.
- Presence and absence data should be collected which can be used to improve future survey design (Lawes and Panetta 2004).
- Surveys usually work progressively outward from the centre of the infestation and along dispersal pathways (Robison *et al.* 2013). The search area can be narrowed by identifying the invading plant's habitat type and plant associations.
- Thorough surveys require pessimism and training. Pessimism is assuming that an infestation is larger than expected and expanding the search area around the initial sighting.
- The amount to expand the survey depends on the plant's potential dispersal distance. A useful rule of thumb is to expand the survey to a geographical border or the limits of the habitat.
- Using multiple search images of the same plant in a survey improves concentration by preventing the surveyors from fixating on one image. Use multiple images of the plant's various forms, distinctive characteristics such as colours or silhouettes, habitat(s), and plant associations (Zamora *et al.* 1989).
- Trained sniffer dogs are proving to be highly effective at locating hard to locate plants. Dogs are more accurate than humans, especially for detection of small plants, and from greater distances. Invasive plant monitoring using detection dogs can provide greater overall accuracy of plant detection (Goodwin *et al.* 2010).

Appendix 5 - Wellbeing, safety and hygiene for field work

Wellbeing and safety

Refer to your agency's Occupational Health and Safety (OH&S) requirements for personal protective equipment and safety requirements. Items that should be considered include:

- first-aid kit and snake bite kit;
- personal protective equipment; and
- satellite phone and emergency position-indicating radio beacon (EPIRB) if in remote locations.

Consider these points when you are planning and conducting field work:

- Avoid sun damage to skin wear appropriate clothing, broad-brimmed hat, gloves, sunscreen, and sunglasses.
- Avoid field work on days of extreme fire danger.
- Be aware of flood and other emergency and weather warnings for the area and take appropriate precautions.
- Have a safety plan and reporting procedure in place for working remotely (refer to your agency's OH&S guidelines).
- When working near roadsides, park safely and wear high visibility clothing such as a reflective vest.
- Wear gaiters and carry a snake bite kit and know how to use it.
- Wear appropriate protective clothing when handling weeds. Be aware of plants which have:
 - spines or barbs that may have sheaths, toxins or irritants. Avoid stick injuries and treat punctures immediately.
 - o sap that can cause skin irritation immediately or after exposure to sunlight.
 - o fine hairs that can cause skin irritation and become lodged in clothing.
 - pollen and perfumes that can cause allergic reactions including respiratory irritation and hayfever.
- If working with cacti, carry pliers to remove cacti spines from footwear. Always check the back of boots before crouching down. Some cacti have spines with sheaths that remain in the body when the spine is removed. The "Managing Opuntioid cacti in Australia" manual has a chapter on safety and welfare (Sheehan and Potter 2017).
- Seek prompt medical advice if reactions, injuries or infections occur.

Hygiene

It is very important not to spread weeds, pests, wildlife diseases, soil-borne and plant-borne diseases between and within sites. Examples of things that may spread other than weeds include soil and plant-borne pathogens such as Phytophthora, Myrtle Rust, Chytrid fungus of frogs, and crazy ants. Consider these hygiene points when you are planning and conducting field work and check your agency's hygiene protocols:

- Carry a hygiene cleaning kit with instructions in vehicles, and a sealable container (e.g. plastic bottle with screw-top lid) in which to place loose or seeds removed from clothing for later safe disposal.
- Wear cotton clothing that seeds do not readily adhere to and avoid cuffs on trousers and shorts.

- Wear gaiters over socks and boots.
- Clean footwear and clothing including seeds in laces and socks, and soil on soles before and immediately after a site visit.
- Avoid placing carry bags and packs on weeds that are in seed.
- Regularly check camera bags and clothing pockets for seeds.
- Plastic sample bags can build up static electricity to which weed seeds can readily adhere.
- Avoid driving vehicles into weed infestations and check and clean the vehicle regularly, including within the cabin and boot or tray.
- Consider undertaking WeedStop training to maintain suitable vehicle hygiene standards.
- Ensure other staff and contractors conducting field work are following appropriate hygiene standards.
- Be aware that the transportation of plant propagules of declared noxious weeds without a permit is prohibited. If collection of a sample or herbarium specimen is required for identification purposes, contact 136 186 for further advice.
- Companion and conservation working dogs readily pick up and spread weed seeds on their coat and between their toes.
- Consider using a footbath before entering and leaving wetland areas to reduce the risk of spreading Root Rot (*Phytophthora cinnamomi*) or frog disease, Chytrid fungus (*Batrachochytrium dendrobatidis*).

Support

Working with invasive species can be overwhelming at times. Seek help if you are feeling down or overwhelmed. Check in with your local workplace peer support person, OH&S person or contact:

Beyond Blue: www.beyondblue.org.au 1300 224 636

Lifeline Australia: www.lifeline.org.au 13 11 14

Appendix 6 - Flowchart for choosing an appropriate chemical for the control of invasive plants in Victoria



Figure 9 - A guide to choosing an appropriate chemical for the control of invasive plants in Victoria (based on Nigel Ainsworth 5/3/2014).

Appendix 7 - Further contacts

Contact the WESI project team

The WESI project team can assist with planning and undertaking eradication responses and working out what to do next.

Having some information ready when making contact will make it easier for the WESI project team to help you:

- Your name and contact details (email, mobile phone etc.)
- The botanical name of the target weed(s)
- Where and when the weed was detected (location name, land tenure, directions, and GPS reading)
- Any notes on what it looks like and the situation it is growing in e.g. growing in sand or clay or in a water body
- Observations about how the weed may have got there, what is spreading it and how far it has spread. An estimate of how many plants there are and the area covered
- What are its impacts and what are the biodiversity values under threat?
- Its risk rating and completed feasibility of eradication score sheet

Have you taken photographs of plant features and landscape that can be emailed? Electronic images can be emailed to the WESI project team to assist with identification (if images are large, only one image should be attached to each email). Alternatively, let WESI know that you have placed images in the WESI folder on the DELWP corporate drive statewide: L:\Department Business Share\WESI early invaders

For assistance with a possible weed at the early stage of invasion contact the WESI project team.

 Bianca Gold
 Kate Blood

 bianca.gold@delwp.vic.gov.au
 kate.blood@delwp.vic.gov.au

 Phone via the Customer Service Centre 136

Phone via the Customer Service Centre 136 186.

The WESI project has a seasonal newsletter "Early invader update" that you can receive for free. Contact us to subscribe.

The project team is active on social media. Search for handle @weedyk8 and hashtags #WESIProj #weedID #invasivespecies

Agency contacts

Victorian Government Customer Service Centre: 136 186 (for DELWP; and Agriculture Victoria biosecurity staff at Department of Economic Development, Jobs, Transport and Resources (DEDJTR) (to be replaced by Department of Jobs, Precincts and Regions (DJPR) on 1 January 2019).

https://www.environment.vic.gov.au/

https://economicdevelopment.vic.gov.au/

Parks Victoria: 13 1963

http://parkweb.vic.gov.au/

Glossary and abbreviations

Glossary

Absent, absence data - Locations searched where the weed was not observed (Sheehan *et al.* 2016). These data provide a record of effort expended on searching, help in the planning of future searches, and are useful in quantifying the spread of an infestation over time (MacKenzie *et al.* 2002).

Active treatment phase - Occurs while the target species has different life stages present in the treatment area. This will include adults, juveniles, seedlings, seeds and other reproductive organs e.g. underground bulbs. In order to assess whether the project should move to the monitoring phase, surveying (searching) is required, often on a regular basis.

Adjuvants - Materials added, in this case, to herbicides to improve the herbicide's effectiveness.

Asset-based approach - Involves prioritising control actions for a number of threats, based on the relative value of identified assets that will be protected by the actions. The aim of prioritisation is to maintain the viability of important environmental assets and optimise outcomes for asset protection and management (Victorian Government 2010).

Biodiversity - The variety of life forms: the different plants, animals and microorganisms, the genes they contain and the ecosystems they form (Victorian Government 2010).

Biodiversity asset - The area (e.g. nature reserve or park) that is being managed to preserve biodiversity values (Panetta 2016).

Biomass – Biological material derived from living or recently living organisms, in this case plants (Panetta 2016).

Budbank, bud bank - The viable growing points underground (other than seeds) that can grow into new plants e.g. bulbs, rhizomes (Blood and James 2016b).

Bulbil - A small bulb produced on a plant stem above ground that can grow into a new plant. A detachable propagule (Blood and James 2016b).

Containment - The aim of preventing or reducing the spread of invasive species, e.g. by preventing invasions into new areas and eradicating any species that are found outside a defined area or beyond a defined line (Panetta 2016).

Control - To implement actions that reduce the effects of a pest organism where it occurs. For weeds, a wide range of treatment methods are used for control, generally falling into the categories of mechanical, chemical and biological control (Panetta 2016).

Core infestation - An established population of a pest animal or weed from which satellite infestations may arise (Victorian Government 2010).

Decision making framework - Information organised in such a way to lead the user through a logical step-by-step process to make decisions (Blood and James 2016a).

Delimit, delimiting survey, delimitation - The process of determining the full extent of an invasion. This usually involves intensive surveys of areas in which the species is considered likely to be present (Panetta 2016).

Desiccant - A material that is used to dry out something.

Detectability period - The time during which something is likely to be found i.e. because it is more visible during this time (Blood and James 2016b).

Detection distance, search distance - The distance over which a weed is detectable prior to reproduction, when a search is undertaken in particular terrains and vegetation types (Blood and James 2016b).

Early intervention - The timely action to prevent a small problem becoming a large one.

Early invaders, early weed invaders - These are plants that have naturalised and that have started to spread. Since spread has just begun, such plants are not at all widespread and are generally encountered only by chance, unless specifically targeted by search efforts. Co-ordinated management intervention, i.e. eradication or containment, is at its most feasible for plants at this stage of invasion, owing to their highly restricted distributions (Panetta 2016).

Early stage of invasion - See 'early invader'.

Ecosystem - An ecosystem consists of a diverse and changing set of living organisms that form a community, interacting with each other and with the physical elements of the environment in which they are found (DSE 2009).

Environmental weed - Exotic or Australian native plant growing beyond its natural range that has, or has the potential to cause, a detrimental effect on natural values (DSE 2009).

Eradication - The elimination of every single individual (including propagules) of a species from a defined area in which recolonisation is unlikely to occur (Panetta 2016).

Eradication assessment - The process of determining when eradication has been achieved.

Eradication response plan - A plan detailing the steps to undertake and achieve eradication.

Extirpation - Denotes local, as opposed to global, elimination of a species (Panetta 2007). For this guide series 'park-scale eradication' is used instead.

Feasibility of eradication - The probability that eradication will be achieved (Blood and James 2016b). All other factors being equal, a potential target that has a low feasibility of eradication will require considerably more effort to eradicate than one having a high eradication feasibility. Ultimately, the assessment of eradication feasibility must take into account the amount of resources that is likely to be available (Panetta 2009).

Gross infestation area - The larger infested area including the net areas that require treatment plus the surrounding area that must be searched in return trips following treatments (Panetta and Timmins 2004).

Habitat - The kind of place in which a plant grows (FloraOnline 2010).

Hygiene - For weed practitioners, hygiene relates to the cleaning of equipment, machinery, vehicles, personal clothing and footwear etc. to avoid spreading weed propagules, pests, wildlife diseases, soil-borne and plant-borne diseases within and between sites (Blood and James 2016a).

Identification - The process of naming a plant, if not instantly from your knowledge, then through a more structured process, either by using a botanical key or other reference. Until a plant identification has been verified through the collection and submission of a specimen to the National Herbarium of Victoria (Herbarium), a proposed or preliminary name can be called a 'provisional' identification (Blood and James 2016a).

Indigenous - Native to the area; not introduced (FloraOnline 2010).

Integrated management - Using a number of treatment techniques in combination to achieve the best management outcome for a situation.

Invasion curve, biosecurity curve - A graphical representation illustrating the phases a weed goes through as it arrives and invades an area (Blood and James 2016b).

Invasive plants - Naturalised plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (approximate scales: greater than 100 m; under 50 years for plants spreading by seeds and other propagules; greater than 6 m in 3 years for plants spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over a considerable area (Richardson *et al.* 2000).

Monitor - To observe and check the local performance of a plant species over a period of time, in order to detect increases in invasiveness and impact should these occur. If practicable, monitoring at yearly intervals is recommended (Panetta 2016).

Monitoring phase - Commences when no recruits or regrowth have been detected in the area subjected to active treatment. An arbitrary period of time is required to determine this transition

point, which has been recommended to be at least 12 months (Panetta 2007). The monitoring phase reverts to the active treatment phase if plants are detected.

Monoculture - Growing a single crop species.

Naturalised plants - Non-indigenous species that sustain self-replacing populations for several life cycles without direct intervention by people, or despite human intervention. Naturalised species are not necessarily invasive, that is they have not (yet) spread any significant distance (Panetta 2016).

Net infested area, net infestation - The area requiring actual treatment (Panetta and Timmins 2004).

Noxious weed - In Victoria, a weed declared under the *Catchment and Land Protection Act* 1994, and there are four categories of noxious weed.

Operational phases - Active treatment phase and monitoring phase.

Pathogen - An infectious agent such as a virus, bacterium, prion, fungus, viroid, or parasite that causes disease in its host (Reference viewed online 3/9/2015: https://en.wikipedia.org/wiki/Pathogen).

Present, presence data - Information collected to indicate that, in this case, a weed exists at a location (Sheehan *et al.* 2016).

Prevention - Is the act of preventing, to keep from occurring (Delbridge et al. 1998).

Propagule - An independent part of a plant (i.e. a seed or other vegetative structure) that is capable of being dispersed and growing into a new plant (Panetta 2016).

Public land - Land set aside for the use and benefit of the community/public e.g. State forest, national park, public park.

Rehabilitation and restoration - Active intervention and management of degraded communities and landscapes (usually caused by clearing, fire damage, forest road works, landings and mining) in order to restore biological character, ecological and physical processes and their cultural and visual qualities (DSE 2009).

Reproductive escape - The production of seeds or other propagules by the target species during the course of an eradication program (Panetta 2007).

Resilience - The capacity of a system to experience shocks while essentially retaining the same function, structure and feedbacks, and therefore its identity. The more resilient a system the larger the disturbance it can absorb without shifting it to an alternative state (DSE 2009).

Revegetation - To replant or regrow vegetation in an area following the loss of original cover (DSE 2009).

Rhizome - An underground stem, usually growing horizontally (FloraOnline 2010). A rhizome is an example of a joined vegetative propagule.

Risk - The chance of something happening that will have an impact on objectives. NOTE: The level of risk (e.g. high, medium or low) is defined by the particular method being used. Estimating the level of risk requires an objective, evidence-based consideration of the likelihood and consequences of a particular set of circumstances (Victorian Government 2010).

Satellite infestation - A potentially eradicable population of a weed arising as a result of spread from an established population (Hester *et al.* 2010).

Search, searching - The act of looking for something.

Seedbank, seed bank - The accumulated viable seed buried in the soil or in the leaf litter on top of the soil.

Site - The boundary of the area of interest for the search, survey or treatment within the broader reserve, State forest, or national park etc. It may be defined by vegetation communities, land type most susceptible to invasion, roads or river boundaries that divide the land parcel into more manageable areas (Sheehan *et al.* 2016).

Stolon - A stem that is usually growing horizontally above the ground, roots forming at the nodes and a new plant forming at the tip. Stolons are a joined vegetative structure propagule.

Treatment - Is a technique applied to a weed to kill or reduce the vigour of the weed and/or its propagules.

Weed - Plants (not necessarily alien) that grow in sites where they are not wanted and which usually have detectable economic or environmental effects (synonyms: plant pests, harmful species, problem plants) (Richardson *et al.* 2000).

Weeds at the early stage of invasion - See 'early invaders'.

Woody weeds - Plants containing thickened stems, including trees, shrubs, some vines and creepers.

Abbreviations

| ACUP | Agricultural Chemicals Users Permit |
|-----------|--|
| ALA | Atlas of Living Australia |
| APC | Australian Plant Census |
| APNI | Australian Plant Names Index |
| арр | application |
| APVMA | Australian Pesticides and Veterinary Medicines Authority |
| AVH | Australia's Virtual Herbarium |
| CaLP | Catchment and Land Protection |
| CFA | Country Fire Authority |
| CLM | Crown Land Manager |
| CSC | Customer Service Centre |
| DEDJTR | Department of Economic Development, Jobs, Transport and Resources (to be replaced by DJPR on 1 January 2019) |
| DELWP | Department of Environment, Land, Water and Planning |
| DJPR | Department of Jobs, Precincts and Regions (to replace DEDJTR 1 January 2019) |
| DMF | decision making framework |
| ECM | Enterprise Content Management |
| Ecodev | URL abbreviation for DEDJTR |
| EIS | Environmental Information System |
| EPIRB | Emergency Position Indicating Radio Beacon |
| et al. | et alia |
| FIS | Flora Information System |
| GBIF | Global Biodiversity Information Facility |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| ha | hectare |
| id, ID | identification |
| IPNI | International Plant Names Index |
| I-SPEI | Invasive Species Prevention and Early Intervention |
| ISSG | Invasive Species Specialist Group |
| IUCN | International Union for Conservation of Nature |
| LPG | liquid petroleum gas, liquefied petroleum gas |
| OH&S, OHS | Occupational Health and Safety |
| PubCRIS | Public Chemical Registration Information System |
| | |

| STAR | Spatial, Temporal, Activity Recorder |
|--------------|--|
| URL | Uniform Resource Locator |
| VBA | Victorian Biodiversity Atlas |
| VRO | Victorian Resources Online |
| Weeds CRC | Cooperative Research Centre for Australian Weed Management |
| WESI Project | Weeds at the Early Stage of Invasion Project |
| WONS | Weed of National Significance |
| | |

List of figures and tables

Figure 1 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. There is an enlargement of the framework with scenarios in Appendix 1.

Figure 2 - How to use this guide.

Figure 3 - Illustration explaining the difference between net and gross infestations.

Figure 4 - An illustration of the different scales of site and the terminology assigned to them - the concept of public land, site, search area and targeted survey area.

Figure 5 - Operational phases within an eradication response.

Figure 6 - Frilling a large Maple (*Acer* species) using a tomahawk, and spot gun to deliver herbicide into the wound. Image: Australis Biological.

Figure 7 - Heathy Woodland that was rolled with machinery and then burnt. The high fuel loads near ground level created an excellent ash bed with high continuity. The post-fire vegetation was species rich with low weed abundance. Image by Robin Adair, Australis Biological.

Figure 8 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. This version illustrates three typical scenarios faced by public land managers.

Figure 9 - A guide to choosing an appropriate chemical for the control of invasive plants in Victoria (based on Nigel Ainsworth 5/3/2014).

Table 1 - Summary of the factors influencing eradication success.

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www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders