

Early invader manual

Managing early invader environmental weeds in
Victoria

Kate Blood, Bec James, F. Dane Panetta,
Matt Sheehan, Robin Adair, and Bianca Gold

February 2019



Photo credit

Learning how to identify Opuntoid cacti in the Rushworth State Forest, September 2018. Photo by Kate Blood, DELWP.

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Weeds at the Early Stage of Invasion (WESI) Project

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Documents and tools in this series

Early invader tools available at: <https://www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders> :

- Blood, K., James, R., Panetta, F. D., Sheehan, M., Adair, R., and Gold, B. (2019) Early invader manual: managing early invader environmental weeds in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-317-5 (Print); ISBN 978-1-76077-318-2 (pdf/online/MS word).
- Sheehan, M., James, R. and Blood, K. (2018) Looking for weeds: search and detect guide (2nd Edition). A guide for searching and detecting weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-039-6 (Print); ISBN 978-1-76077-040-2 (pdf/online/MS word).
- Blood, K. and James, R. (2018) Looking for weeds: name and notify guide (2nd Edition). A guide for identifying weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-041-9 (Print); ISBN 978-1-76077-042-6 (pdf/online/MS word).
- Blood, K., James, R. and Panetta, F. D. (2018) Managing weeds: assess the risk guide (2nd Edition). A guide for assessing the risk for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-043-3 (Print); ISBN 978-1-76077-044-0 (pdf/online/MS word).
- James, R. and Blood, K. (2018) Looking for weeds: delimiting survey guide (2nd Edition). A guide for planning and undertaking delimiting surveys for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-045-7 (Print); ISBN 978-1-76077-046-4 (pdf/online/MS word).
- Blood, K. and James, R. (2018) Managing weeds: decide the response guide (2nd Edition). A guide for determining the appropriate response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-047-1 (Print); ISBN 978-1-76077-048-8 (pdf/online/MS word).
- Adair, R., James, R. and Blood, K. (2018) Managing weeds: eradication response guide (2nd Edition). A guide for planning and undertaking an eradication response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-049-5 (Print); ISBN 978-1-76077-050-1 (pdf/online/MS word).

Risk rating tools available at: <https://www.environment.vic.gov.au/invasive-plants-and-animals/weed-risk-ratings> :

- White, M., Cheal, D., Carr, G. W., Adair, R., Blood, K. and Meagher, D. (2018) Advisory list of environmental weeds in Victoria. Arthur Rylah Institute for Environmental Research Technical Report Series No. 287. Department of Environment, Land, Water and Planning, Heidelberg, Victoria. ISBN 978-1-76077-001-3 (pdf/online).
- Panetta, F. D. (2016) Environmental weed risk screen for Victoria: background and development. A report prepared for the Department of Environment, Land, Water and Planning, Vic. ISBN 978-1-76047-017-3 (Print); ISBN 978-1-76047-018-0 (pdf/online).
- Victorian environmental weed risk database (2018), search online for 'early invader weeds'. The Victorian environmental weed risk database is an *Excel* spreadsheet that contains a summary of the scores from the Victorian Weed Risk Assessments.

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1. About this manual

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.

1.1 About WESI

The Weeds at the Early Stage of Invasion (WESI) Project focuses on high risk invasive species at the early stage of invasion (early invaders) that threaten biodiversity.

The WESI project works mainly with Department of Environment, Land, Water and Planning (DELWP) and Parks Victoria staff looking after public land and biodiversity anywhere in Victoria.

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

1.2 Early invader tools

A range of tools (Figure 1) have been developed to help with the management of early invaders. The tools have been designed to help public land and biodiversity managers, whether they do the work in the field, design the work or authorise the delivery of the work. Other tools are in development.

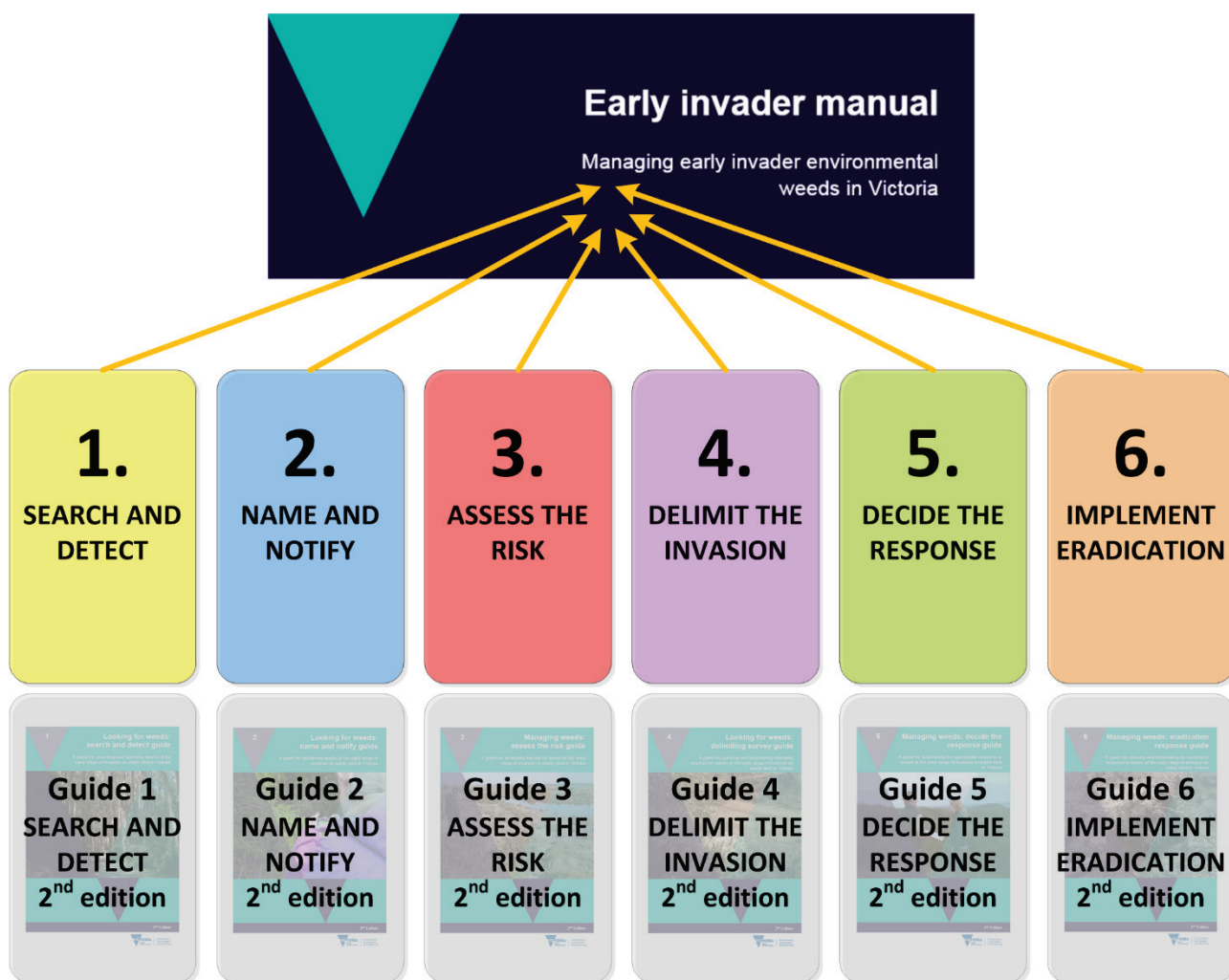


Figure 1: This early invader manual contains six main sections and each of these sections is supported in more detail by a separate guide (see the document list on the back of the title page).

This “Early invader manual: managing early invader environmental weeds in Victoria” (manual) is a summary of a set of six detailed guides about early invader management. They can help improve 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.

Risk rating information for environmental weed species and several management templates are available. The early invader tools are available at: www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders

1.3 Working within a framework

The WESI project has developed a decision making framework that guides public land and biodiversity managers through the process of dealing with invasive plants at the early stage of invasion (see Figure 2). An enlarged version of the decision making framework including scenarios that public land and biodiversity managers typically face is in Appendix A.

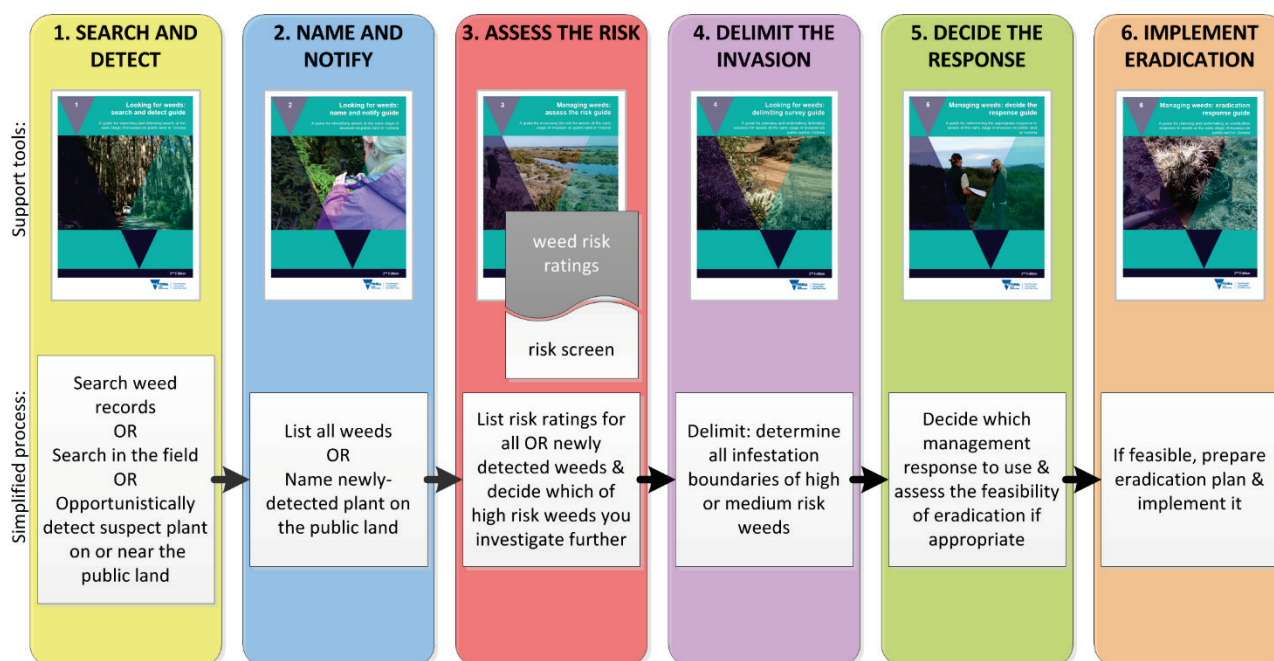


Figure 2: This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. There is an enlargement of the framework with scenarios in Appendix A.

The decision making framework is available as a case summary template (see Appendix B) to record progress with weed cases.

1.4 Weed management including eradication

Weed activities fall into four broad categories: prevention, eradication, containment and asset-based 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 the early invader tools will help you make better decisions about where and when to undertake localised eradication.

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.

1.5 What is 'in the early stage of invasion'?

There is ongoing debate about what area and number of infestations could be classified as eradicable. 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 manual, 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).

1.6 Before you start

Managing public land involves balancing many requirements of which weeds are only one. Decisions about which weeds to manage must be made in this broader context. This manual leads 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 manual's limitations, as well as the ongoing need for its 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. This manual is to help, not substitute for, these important skills (Blood *et al.* 1996).

1.7 Need help?

The WESI Project team can be contacted directly in various ways for assistance (see Appendix C). The team is active on social media and this is a great way to ask for help with weed identification.

The WESI team hold regular training events. Events are promoted on social media, through the 'Friends of WESI' email list and in the "Early invader update" newsletter. Contact the team to subscribe.

2. How to use this manual

This manual contains 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 (see Figure 3).

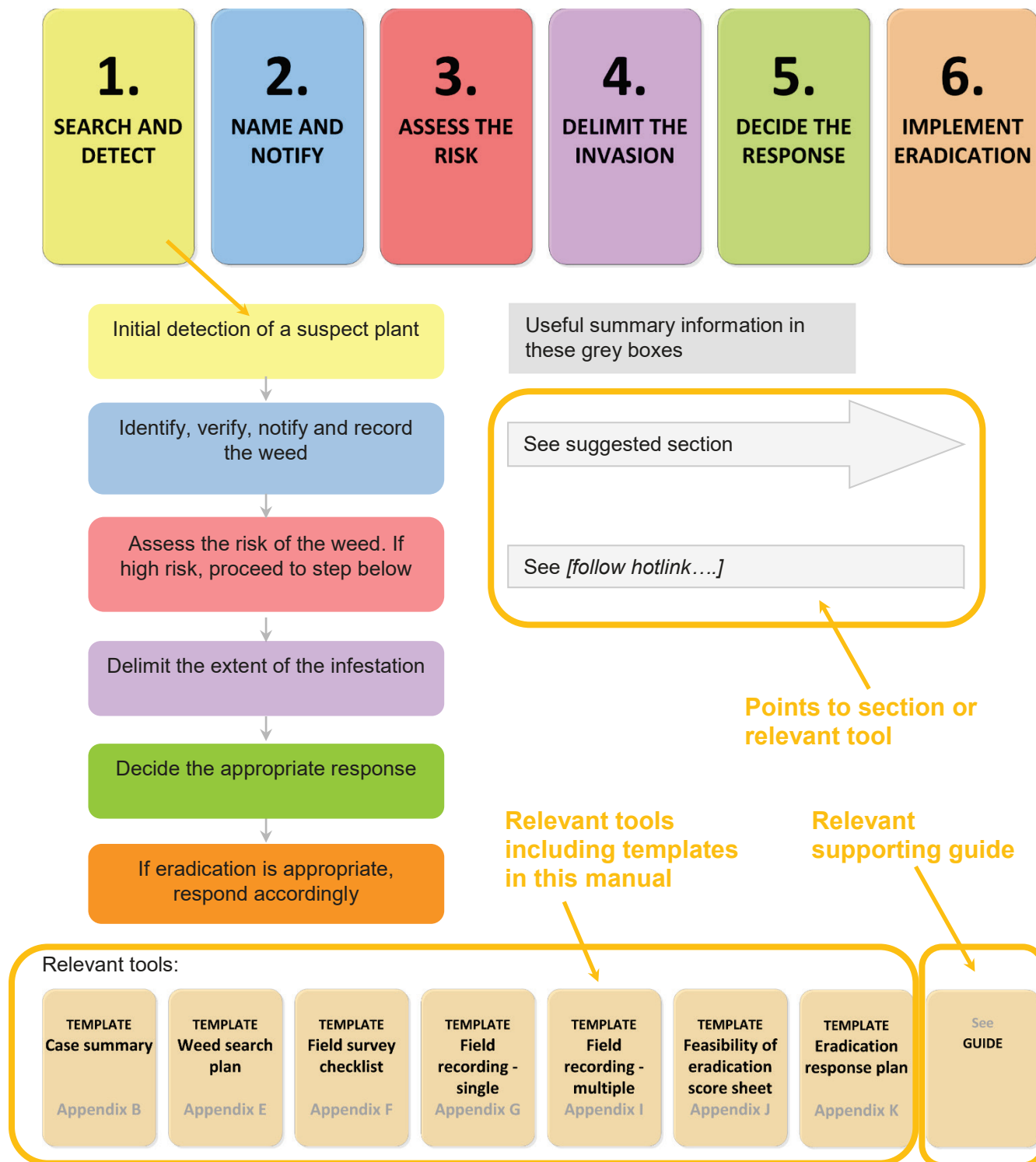


Figure 3: How to use this manual.

3. Tips and tricks

Useful information for managing early invader weeds.

3.1 Build a weed list for public land

A weed list for public land is a very useful tool for effective management planning. It goes together with flora and fauna lists of indigenous species and an invasive animal list (often vectors or spreaders of weeds). A weed list is particularly useful when working out the highest priority early invaders on or outside the public land (scenarios A and C in the decision making framework in Appendix A).

To build a weed list for a piece of public land create an *Excel* spreadsheet or other database. Separate tabs can be opened to hold information from different sources before combining them into one list in a new tab. There are many sources of distribution information in Appendix D. Another option is to copy the *Excel* spreadsheet of the “Advisory list of environmental weeds in Victoria” (White *et al.* 2018) (see Section 6) and remove the species that are not present.

If you have spatial mapping skills, draw a line around the public land boundary. Then interrogate the spatial layers to determine species records for the area within the boundary.

These are called ‘**desk-top**’ searches because they typically are carried out on computer or through publications while at a desk. With mobile technology, these searches can increasingly be conducted anywhere.

Field activities and searches supplement the information in the list. While undertaking search and detect surveys, delimiting surveys and other activities, additional weed records can be added to the list.

Weeds around public land - If you are working out the weeds around your public land try these techniques:

- Look at distribution data sources (Appendix D) and scenario C in Appendix A.
- Using spatial mapping skills, draw a buffer around the public land boundary. Generally, larger buffers are suitable for large areas of uniform vegetation, and smaller buffers for small blocks of variable vegetation. Then interrogate the spatial layers to determine species records for the area within the buffer strip.
- Don't forget to consider the islands of private land within larger areas of public land.

3.2 What and where to record information

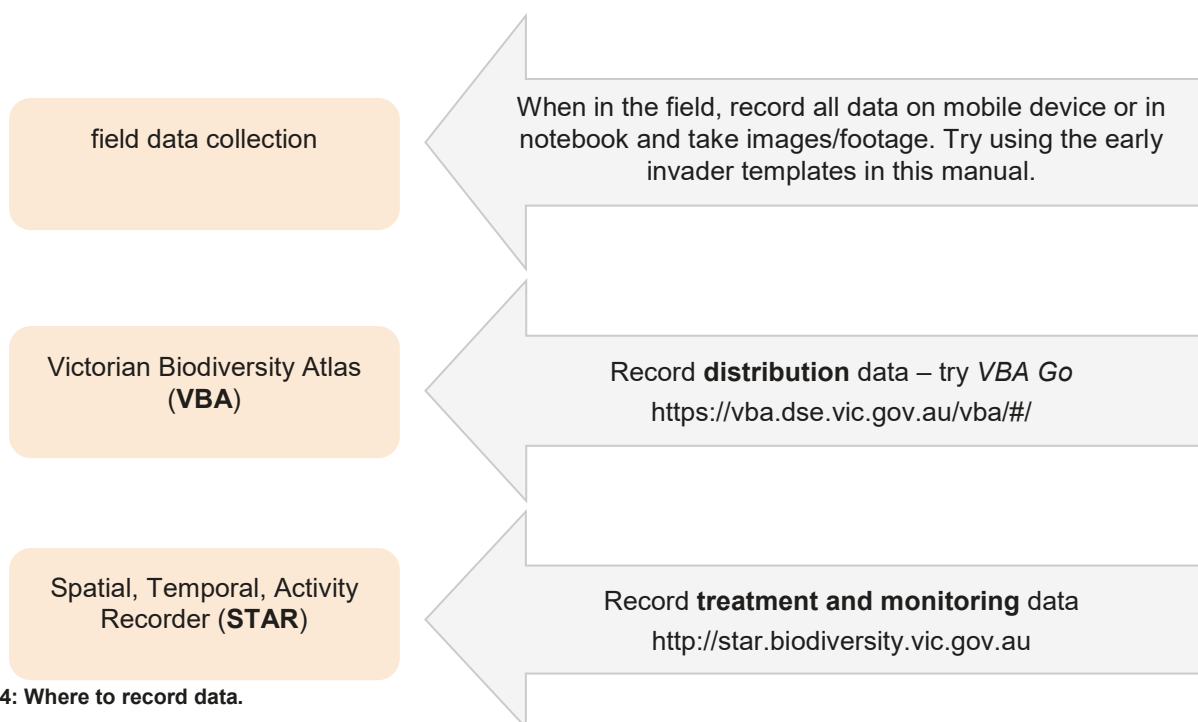


Figure 4: Where to record data.

Information to collect - If at first the identity of the plant is unknown, it is important to record the location (preferably with a Global Positioning System (GPS)) and date as a minimum so the location can be found again.

The sooner information is entered into a digital format the better (see Figure 4). Enter it once when you find the plant so information processing is not delayed.

Try using the ArcGIS Collector app on your mobile device (iOS) developed for field data collection for early invaders. It has been successfully used to survey Buffel Grass (*Cenchrus ciliaris*) on roadsides in the Mallee. Contact the WESI team (Appendix C) for the user name and password.

Another option is to enter distribution data and images straight into the Victorian Biodiversity Atlas (VBA) using the VBA Go application (app) or use the VBA data recording template for bulk uploads and follow its data entry protocol to input the survey data. Citizen Science projects are increasingly using the Atlas of Living Australia and iNaturalist for recording.

Try using the provided templates in this manual's appendices that incorporate minimum data standards.

Remember for any contractors undertaking survey work and collecting data, these data recording requirements need to be built into contractor job specifications (i.e. Request for Quote documentation).

Store the treatment and monitoring information where future staff can access it in the Spatial, Temporal, Activity Recorder (STAR).



Figure 5: “Spot, stop and take a shot”. Finding White-spined Hudson Pear (*Cylindropuntia pallida*) near Ouyen in the Victorian Mallee, January 2018.

Credit: Kate Blood, DELWP

Images and video footage - Photos and videos are very useful to assist with weed identification and for recording points in time that can be looked at in sequence to see change, for example during monitoring. See the information on taking photographs and video footage including geotagging in Guide 2 ‘Name and notify’. Taking a number of photographs can assist with both identification and relocating the plant. A useful phrase to remember particularly for opportunistic detections is “Spot, stop and take a shot” (see Figure 5).

Why record absence data? Absence data, that is, locations searched where the weed was not observed is just as useful as presence data. In the case of weed focused searching, it is equally important to record where it is not i.e. where it is absent.

It provides a record of effort expended on searching, helps in the planning of future searches, and is useful in quantifying the spread of an infestation over time. When recording absence data, it is also important to record the confidence you have in the absence observation. Not detecting a weed does not mean that it is not there (MacKenzie *et al.* 2002). A way to collect absence data is to turn the tracking function on a GPS and record where you have been.

3.3 Mapping and spatial information

Weeds are mapped during search and detect surveys, the identification and reporting process, when delimiting an infestation (i.e. determining its boundaries), during treatment activities and when monitoring the success of treatment works.

Global Positioning System (GPS) coordinates are the most accurate way to record both presence and absence data, either as:

- a point location or series of point locations (defined by a pair of coordinates);
- a polygon representing an area; or
- a linear feature (e.g. roadside), defined by start and end coordinates.

It is always useful to complement this data with site photos and reference to landmarks.

When creating a map with the points, polygons or lines you have collected, it is important to be aware that there are certain **standards** that need to be followed. DELWP has produced a “Map style guide” (available on DELWP’s intranet – search for ‘GIS Help Desk’ on Ada/intranet) that has been developed to provide guidelines and tools to assist staff in creating well designed map products which meet map accessibility standards.

The **Geographic Information System (GIS) Help desk** on the DELWP intranet provides a wealth of information on GIS software, spatial information and ‘how to’ guides.

Other useful **mapping guides** include “A field manual for surveying and mapping nationally significant weeds” (McNaught *et al.* 2008) and the “Tasmanian weed mapping guidelines” (Welsh 2000).

Collect spatial information using a GPS (Figure 6), since this will ensure the most accurate recording of the location of infestations, points of interest etc. Applications (apps) are available for mobile devices that record accurate points, lines and polygons.



Figure 6: Record geographic information with a GPS or other device in the field.

Credit: Kate Blood, DELWP

Create maps to take out in the field - Creating a variety of maps to take out in the field (digitally on devices and printed paper) will greatly assist in orientating yourself at the site, identifying areas that may need to have a targeted survey undertaken and identifying any correlations between the presence of the target weed and factors such as vegetation type, land use etc.

A list of useful maps to take out in the field includes:

- location of the search areas within your site;
- locations of previously recorded infestations of the target species;

- the land status of the site, including its boundaries and adjoining land use; and
- an aerial photograph of the site to draw on in the field.

Pre-load data onto a GPS or device - It is a good idea to load the road network, property/ parcel boundaries and any previous recording of your target weed onto your GPS or mobile device. This will make it a lot easier when orientating yourself in the field, and in relocating previous infestations of your target weed. The ArcGIS Collector app developed for field data collection for early invaders works well for this purpose and for data collection in the field.

3.4 Defining search sites, search areas and targeted survey areas

A site needs to be described at various scales and the approach used throughout this manual is illustrated in Figure 7. At the largest scale is the public land parcel in which the search is conducted. For example, State forest or a national park. The 'site' is the area of interest for the search and may be defined by considerations such as vegetation community or land type most susceptible to invasion. Sites can also be defined by logistical or geographical considerations or constraints, such as roads or river boundaries that divide the land parcel into more manageable areas.

The 'search area' is the specific area(s) within the site that is the focus of the search. Again, these may be vegetation communities, or high risk locations such as roadsides. Finally, the 'targeted survey area' is an area within the search area that is intensively surveyed. Note that this level of surveying may not be necessary or possible for the initial detection survey. It is more relevant to delimiting surveys and is therefore discussed in detail in Guide 4 'Delimit the invasion'.

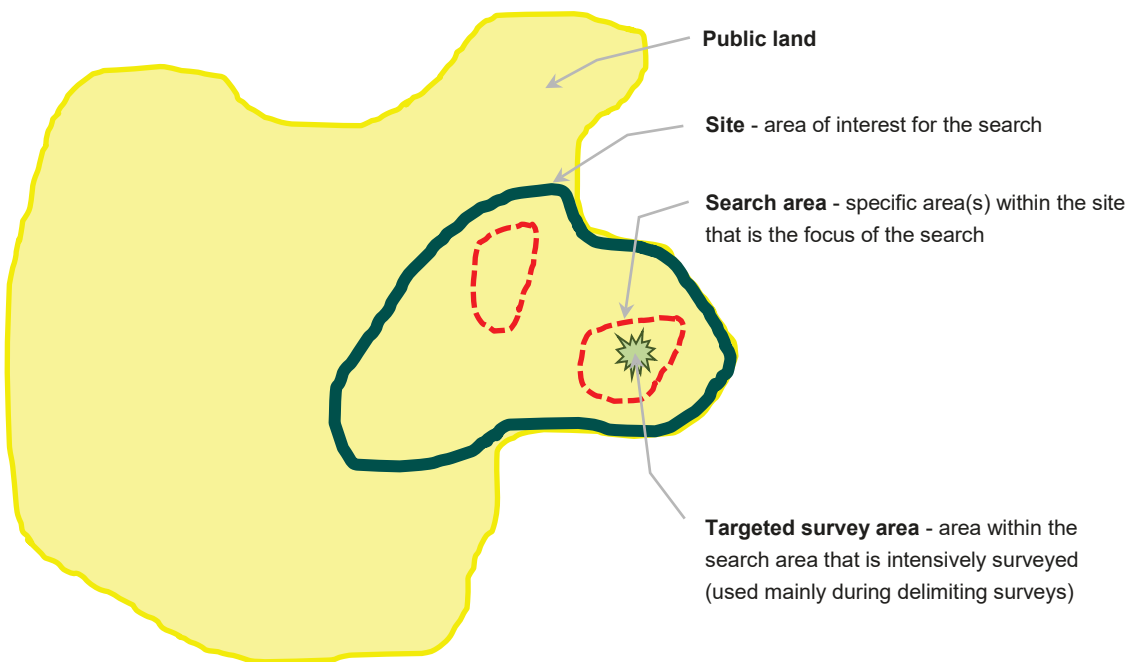


Figure 7: An illustration of the different scales of site and the terminology assigned to them - the concept of public land, site, search area and targeted survey area.

3.5 Marking locations in the field and digital tagging

Tagging the site using a marker/tag - Physically tagging survey sites in the field makes it easier to find them when returning to the site. One option is to tag sites with a marker. Remember to choose tags/markers that will be able to survive all weather conditions (McMaugh 2005) and are of sufficient visibility to be found again but not so visible as to attract vandalism or removal. Also consider tag design to reduce the chance of removal by animals, including foxes and some birds. Options for marking include:

- placing a marker in the ground i.e. a star picket or peg (termites may eat timber pegs);
- spray painting a mark (remember that tree bark often peels off annually);
- attaching a bright coloured tag to a tree, branch etc. (nails can damage living tree tissue); and
- establishing photopoints.

As the tags may be lost in the future due to deliberate removal or disintegration, it is important to take a GPS recording of the site. Take photos to help find sites, including prominent land marks.

Tagging a site using a GPS - A quick and effective way of relocating yourself back in a site is to load locational information (i.e. road, watercourse, and land use datasets) into your GPS, along with any data points from previous surveys that can assist you in returning to a site.

Geotagging images - Geotagged photographs and video allow images to be associated with a geographical location by geotagging (reference accessed on-line 31/12/2013:

http://en.wikipedia.org/wiki/Geocoded_photo). This is especially useful for weeds at the early stage of invasion, where they may be difficult to locate. It is as simple as turning on the GPS feature on your camera equipment, including mobile devices. Spatial data are automatically attached to the image.

3.6 Communication and engagement

Communication and engagement are very important components of all management approaches.

Effectively engaging with staff, volunteers, community and other stakeholders is essential for the success of weed management. Agencies have communication officers who can assist with the planning and carrying out of engagement. DELWP has a series of useful engagement guides (Riches 2005: book 1, 2, 3), and Kruger *et al.* (2010) is also useful.

Keep a log of your engagement activities using the template available on STAR and seek assistance from communication support officers in each region if required.

4. (1) Search and detect

Regularly searching for weeds at the early stage of invasion is a good way to prevent the next widespread weed. How do you organise a search, where do you look and what do you look for? This section (Figure 8) is designed to assist with searching for and detecting weeds at the early stage of invasion.

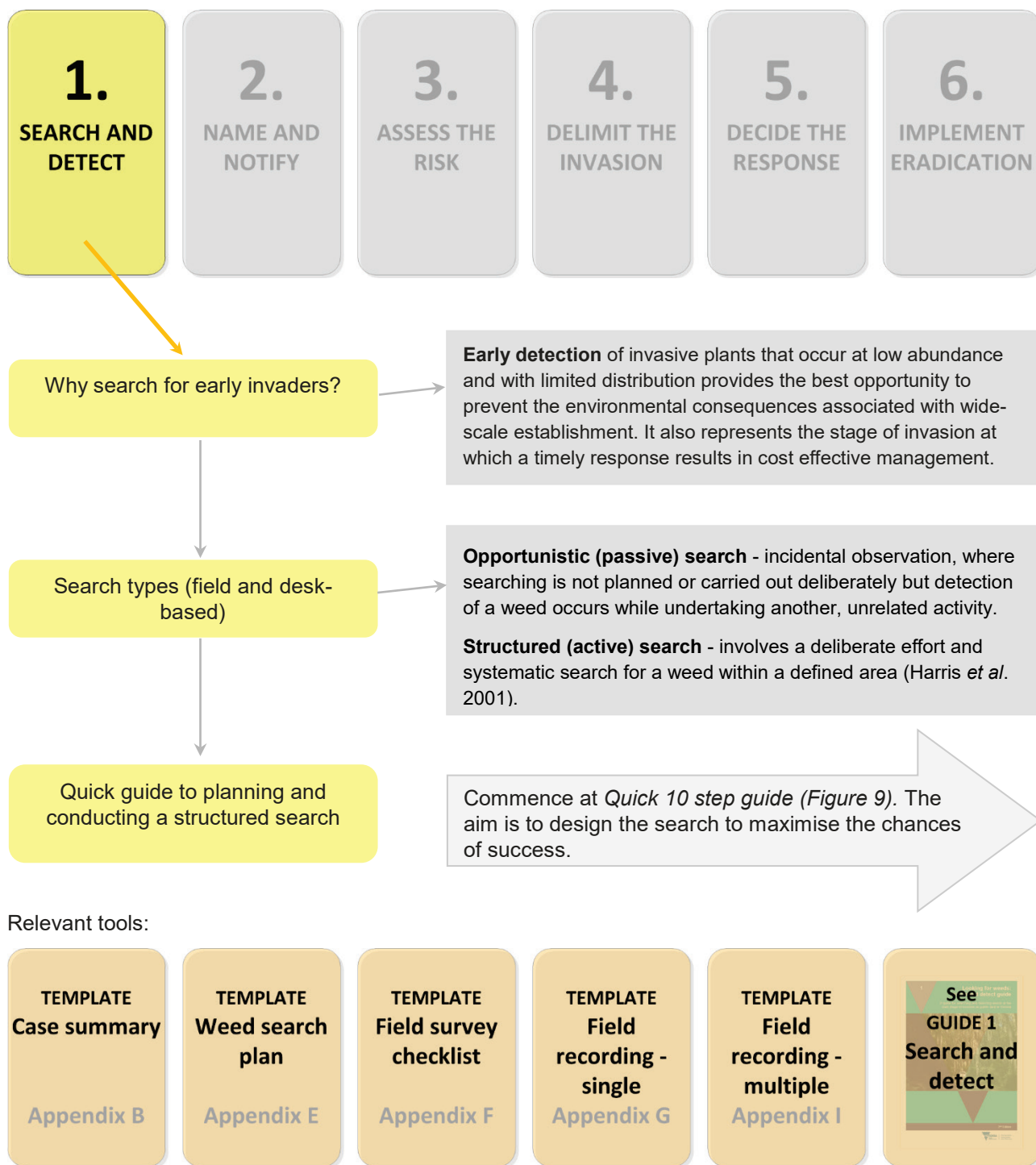


Figure 8: How to use the search and detect section.



4.1 Step 1. Define the purpose of the search

The reason for the search determines what approach to take. Write down the purpose of your search in the case summary template (Appendix B) and regularly refer to it during planning to stay on track. Consider using the search plan template (see Appendix E).

4.2 Step 2. Determine the focus of the search

Weed focus - The most important, and often the most difficult, thing to decide is what weed to focus on. The target species should pose the most serious threat to the area you seek to protect.

Pathway focus - In this situation, it is often beneficial to focus the search effort on pathways of introduction and spread that are common to a suite of weed species, rather than focusing on a specific weed.

Site focus - If you do not have a clear understanding of which of the existing weeds on your public land pose the most serious risk, a site focus approach can be useful. Consider all the weeds on an area of public land. A combination of a field search and desk-top search can be a good way of bringing all the information together. See Section 3 'Tips and tricks' for information on how to build a weed list for a piece of public land.

4.3 Step 3. Timing the search

When to search, search frequency and search intervals are detailed in Guide 1 'Search and detect'.

4.4 Step 4. Identify search areas within your site

Identify sites to search within the public land, and then work out more specific search areas (see Figure 7). Include pathways, priority conservation sites for protection, sites at high risk of weed invasion, weed hot spots near and within your patch, and potential habitat for target weeds. Consider establishing a **buffer or watch zone** around the reserve.

4.5 Step 5. Select a search technique

Guide 1 'Search and detect' offers lots of help in choosing a search technique and Table 1 has a summary of some of those techniques.

4.6 Steps 6 to 10.

See Guide 1 'Search and detect' for lots of advice on continuing to plan for and conducting a structured search.

Figure 9: Quick guide to planning and performing a structured search.

Searching is the act of looking for something and **detection** is the finding of something.

Table 1: Search technique options for search and detect, and delimiting surveys.

Search technique	Useful for	Suggested method	Safety (See Appendix H)
Vehicle-based search	<p>Searching linear reserves such as roadsides e.g. used to search for Buffel Grass (<i>Cenchrus ciliaris</i>), an introduced invasive grass detected on roadsides in the Victorian Mallee in 2014 (James <i>et al.</i> 2016).</p> <p>Before you search:</p> <p>If possible, go to an area with a known infestation to get accustomed to the weed in the habitat to be searched.</p> <p>Familiarise yourself with look-alike species that occur along the search route.</p> <p>Plan the search route before leaving the office.</p>	<p>At least two people are needed - driver and observer/recorder.</p> <p>Travel between 5 and 40 km per hour, depending on vegetation type and road conditions.</p> <p>Scan back and forth at right angles to the road. Keep line of sight level with the front of the vehicle. Do not look straight out the side window, as the vegetation appears to move faster at this point.</p> <p>Be mindful of hot spots along the route where extra attention may be required e.g. culverts and cuttings, water diversion channels, rest areas, road works storage areas, disturbed sites etc. Prepare to slow down for these hot spots.</p> <p>If unsure, the observer should get out of the vehicle and have a closer look if safe to do so.</p>	<p>Use hazard lights (where appropriate), headlights and a flashing beacon mounted on the vehicle. Consider using 'vehicle frequently stopping' or 'slow moving vehicle' signs.</p> <p>Use appropriate roadwork signage on the roadside e.g. place signs at intervals no greater than 2 km, at major intersections and along the road you are working. Check road manager requirements.</p> <p>Notify appropriate authorities (VicRoads or local municipalities). Adhere to their requirements.</p> <p>Wear a high visibility vest.</p>
Foot-based search	<p>Searches by foot, while slower, allow you to search at high intensity, maximising the likelihood of detection if a weed is present. This technique is effective in a range of habitats and for all weed forms. It is useful for linear reserves, tracks or property boundaries where vehicle access is limited, as well as larger areas such as target area searches. It is often the technique most suitable for searches in remote areas, sensitive sites or dense vegetation.</p>	<p>Foot searches need to be structured and systematic to ensure all areas are covered. The easiest way is to walk transects (straight lines) and continuously search along and either side of the transect line (Figure 10). Use flagging tape, other markers, referencing landmarks or a GPS app to assist in ensuring a straight line. Use linear features such as tracks, creeks or boundary fences as the transect line. If it is an area search, set up a series of transects parallel to each other across the search area (Figure 11).</p> <p>Transect spacing - depends on vegetation type, overall size of the search area and the visibility of the target weed within the vegetation. Searching for a tree or shrub in large open grasslands may need transects 50 – 100 m apart. Most habitats will require closer spacing. Most vegetation types and weed growth forms is 5 - 10 m.</p> <p>Transect alignment - Going across a slope rather than up and down may prove physically easier for the observers/recorders and provide better visibility. Test visibility with the sun either behind you or the target plant - sun glare in the eyes of the observer could make detection more difficult or a weed may become more visible with back lighting.</p>	<p>Snakes are a major risk to field staff conducting a foot-based search, particularly in grasslands. Wear long trousers, gaiters, and boots and carry appropriate first aid and communication equipment.</p> <p>Be aware of past land uses and potential hazards such as traps, old fences, mine shafts etc.</p> <p>It is both for safety and for practicality that at least two observers/recorders should conduct a foot search, walking adjacent transects.</p> <p>Wear a high visibility vest and other personal protective equipment.</p> <p>Wearing a hat helps sun protection and reduces glare benefiting weed visibility.</p> <p>A checklist for field searches is in Appendix F including safety equipment.</p>

Search technique	Useful for	Suggested method	Safety (See Appendix H)
Aerial (desk-top) search	Involves the analysis of vegetation from aerial images, either photographs or remote sensing data.	Try using Google Earth. It has a year scroll - scroll through changes in vegetation and zoom into areas of interest.	
Aerial (field) search	Large, remote or difficult to access areas. There are many laws that govern this area and the costs may be prohibitive but this may be an option depending on the circumstances.	Search from the air such as from a helicopter, or via remote camera such as from a drone (unmanned aerial vehicles (UAV)).	Extensive laws and safety requirements.
Boat-based search	Narrow and difficult to access riparian areas and large water bodies.		Many safety requirements.
Detector dogs	Used for detecting weeds that occur in very low numbers. This approach can improve our ability to reduce search time and increase detection rates. Dogs are only trained for one species at a time.	Handlers with trained dogs, fitted with GPS devices, move through areas which allow mapping of where searching has been carried out. Dogs stop and indicate when they find the target plant.	Many safety requirements.



Figure 10: (left) Walking a transect undertaking a targeted survey for *Cylindropuntia pallida* (formally *C. rosea* as stated in the map legend) in Ouyen State Forest.

Credit: Sally Lambourne, DELWP

Figure 11: (right) Aerial photograph of the survey area showing GPS track logs of the transects that were walked (grey lines) and located infestations (yellow triangles).

Credit: Digital mapping compilation by Bec James, DELWP

5. (2) Name and notify

As we travel around our local patch, we become familiar with the common weeds. Occasionally, something new or unfamiliar catches our eye. This section has been designed to assist in finding out what an unfamiliar plant is (Figure 12). It may be an early invader.

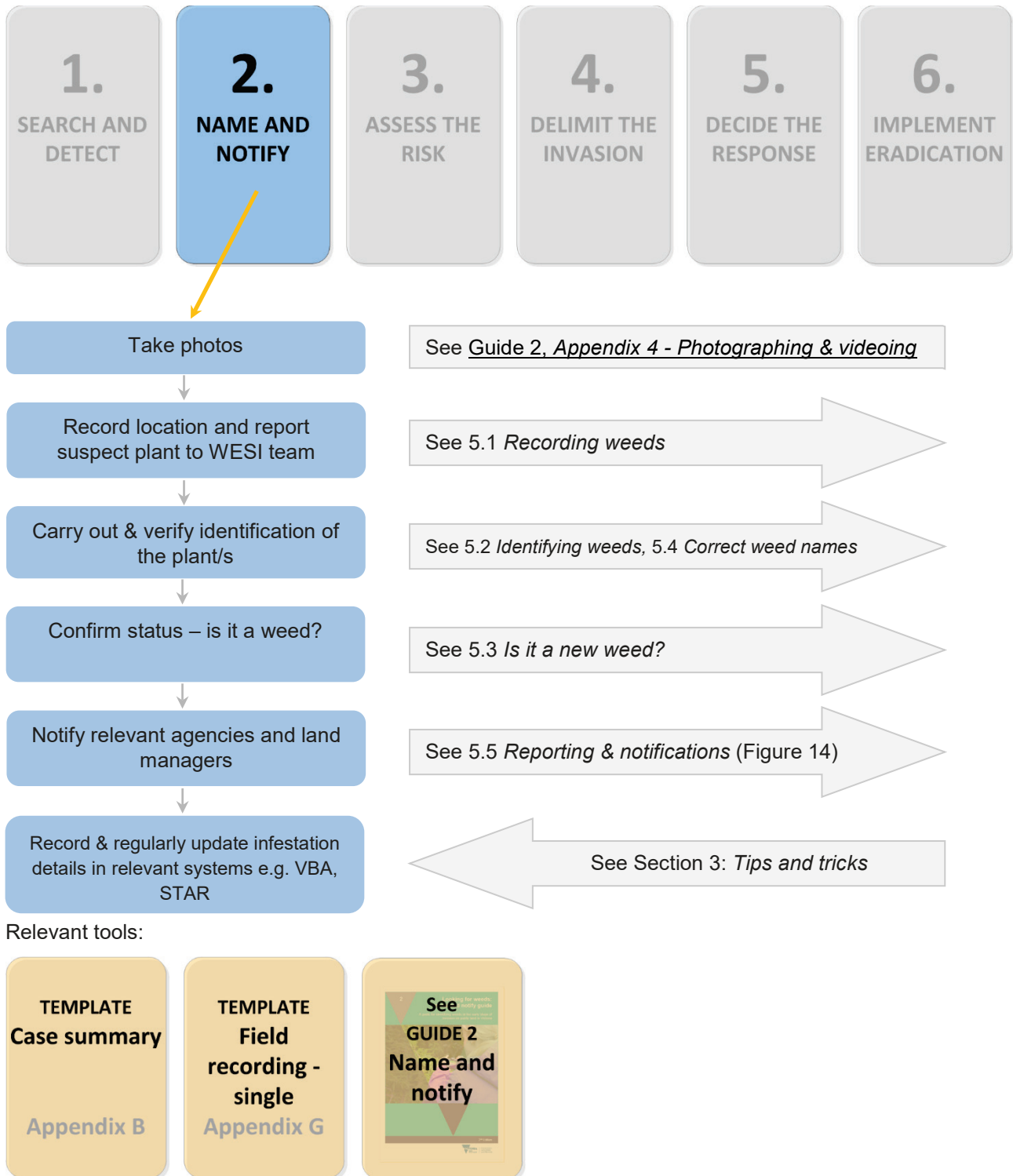


Figure 12: How to use the name and notify section.

5.1 Recording weeds

“Spot, stop and take a shot”.

Once a weed (or possible weed) is located, it is important to accurately and promptly record its details. It is particularly important when dealing with plants at the early stage of invasion, as it allows the source, extent and spread of infestations across a landscape to be determined.

If at first the identity of the plant is unknown, it is important to record the location and date as a minimum so the location can be found again. Taking a number of photographs can assist with both identification and relocating the plant. The sooner information is entered into a digital format the better. Use *VBA Go* while in the field to record the distribution and images of a weed. Enter it once when you find the plant so information processing is not delayed. See Section 3 ‘Tips and tricks’ for more information on what to record.

5.2 Identifying weeds

Accurate identification of an unknown plant is an important step to determining whether a plant is in its early stage of invasion. Identification is 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 in a book or electronic source e.g. through the internet or mobile application. There are lots of information sources in Appendix D.

Until a plant’s identification has been verified through the collection and submission of a specimen (see recording templates in Appendix G and I) to the National Herbarium of Victoria (Herbarium), a proposed or preliminary name can only be called a ‘provisional’ identification (e.g. Figure 13). For authoritative identifications (called a ‘determination’), specimens can be collected with the guidance of the WESI project team and submitted to the Herbarium.

If identification is not possible using the available information sources, or you are not confident with an identification, a specimen can be sent to the Herbarium for verification (fees may apply).



Figure 13: This *Opuntia* species is probably a new invasive species in Victoria. A specimen was collected by Bec James who discovered the plant near Mildura and it is being assessed at the National Herbarium of Victoria.

Credit: Kate Blood, DELWP

5.3 Is it a 'new' weed?

Is it new to my patch? - Check reserve, park or forest flora lists to see if the species has already been recorded. Local flora lists are available in the VBA and are easily viewed through NatureKit. If you have local survey information that has not been included in the VBA, contact the VBA or your local biodiversity officer for advice.

Is it new to Victoria? - All the recorded weeds in Victoria are listed at VICFLORA <https://vicflora.rbg.vic.gov.au/> maintained by the National Herbarium of Victoria. If the weed does not occur on VicFlora and is not recorded as present in the State in the VBA, then WESI will make enquiries with the Herbarium, VBA and inform 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).

What is its legal status? - To check to see if the weed is declared in Victoria under the *Catchment and Land Protection Act 1994* (CaLP Act), go to the Agriculture Victoria website and search for 'invasive plant classification'. You will be able to see the list of weeds declared in the different categories in Victoria. Some weeds and threatening processes are listed under the *Flora and Fauna Guarantee Act 1988*.

5.4 Correct weed names

There is lots of information on writing and learning weed names in Guide 2 'Name and notify'.

Common names - It is recommended that common names are spelt with capital letters (but conventions differ within and between agencies), for example:

White Spanish Broom

Berry-flower Heath

Many weeds have more than one common name. This can be very confusing when searching for information in books or on the internet. The same common name can be used for different weeds. It is always better to use botanical names whenever possible.

Botanical names - The two words that make up the species name (genus and specific epithet) are written in italics, and a species can sometimes be broken into smaller categories: subspecies, variety or form, or cultivar, for example:

Ferraria crispa

Erica discolor subsp. *andreseanthus*; or *Erica discolor* ssp. *andreseanthus*

Fallopia japonica var. *compacta*

Zantedeschia aethiopica 'Green Goddess'

The genus, e.g. *Ferraria* above, is spelt with a capital for its first letter; the specific epithet (sometimes simply called 'species') e.g. *crispa* above, is with lower case.

Synonyms - Synonyms (shortened to syn.) are outdated or formerly-used botanical names and are often included after the current name within brackets, for example:

Alstroemeria aurea (syn. *Alstroemeria aurantiaca*) - i.e. *Alstroemeria aurantiaca* is the old name.

It is common for weeds to have many synonyms, which can be very confusing.

5.5 Reporting and notifications

Once information is captured and recorded, the relevant information needs to be shared and passed on to others who may need to act further on it (see Figure 14). Follow this guide:

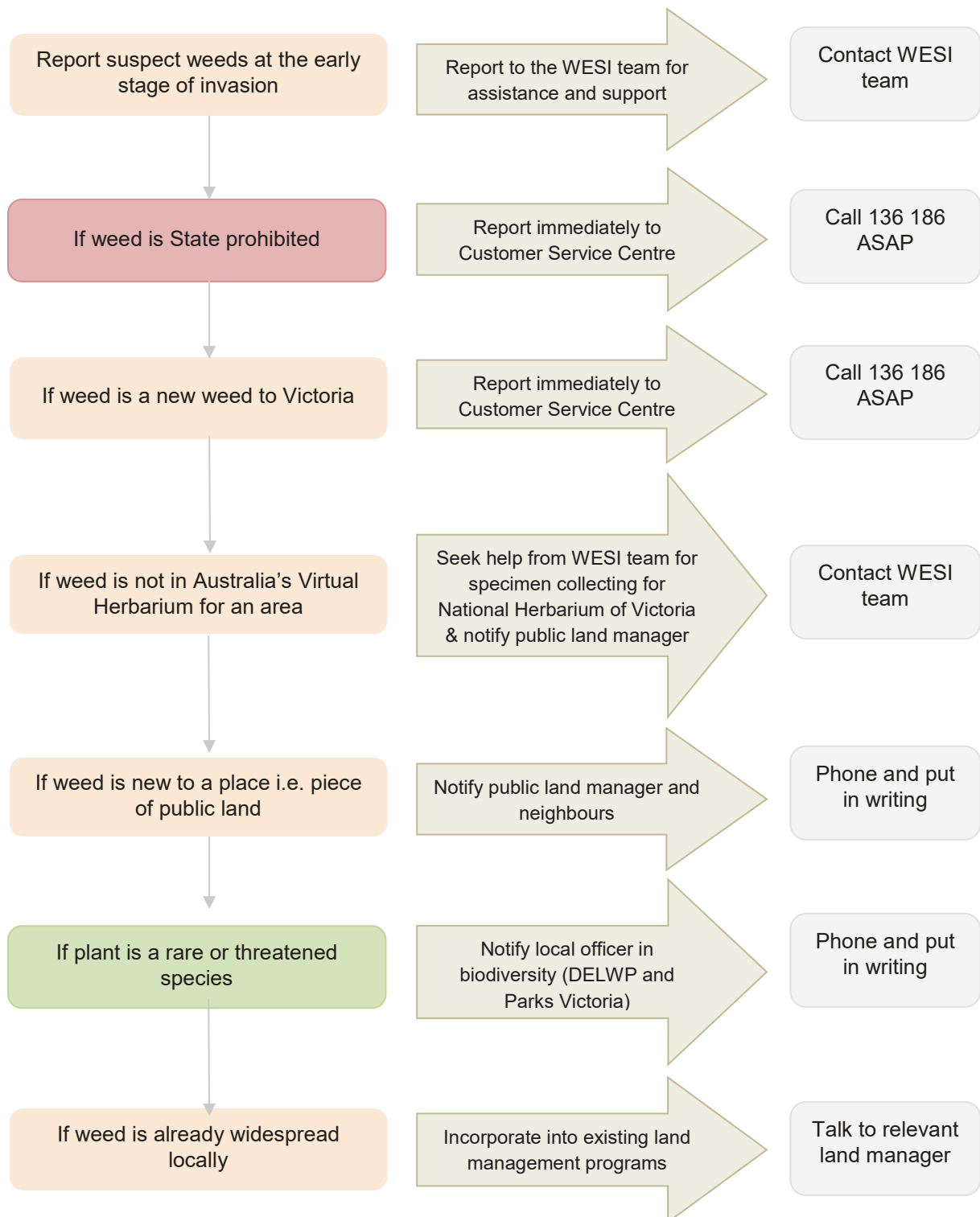
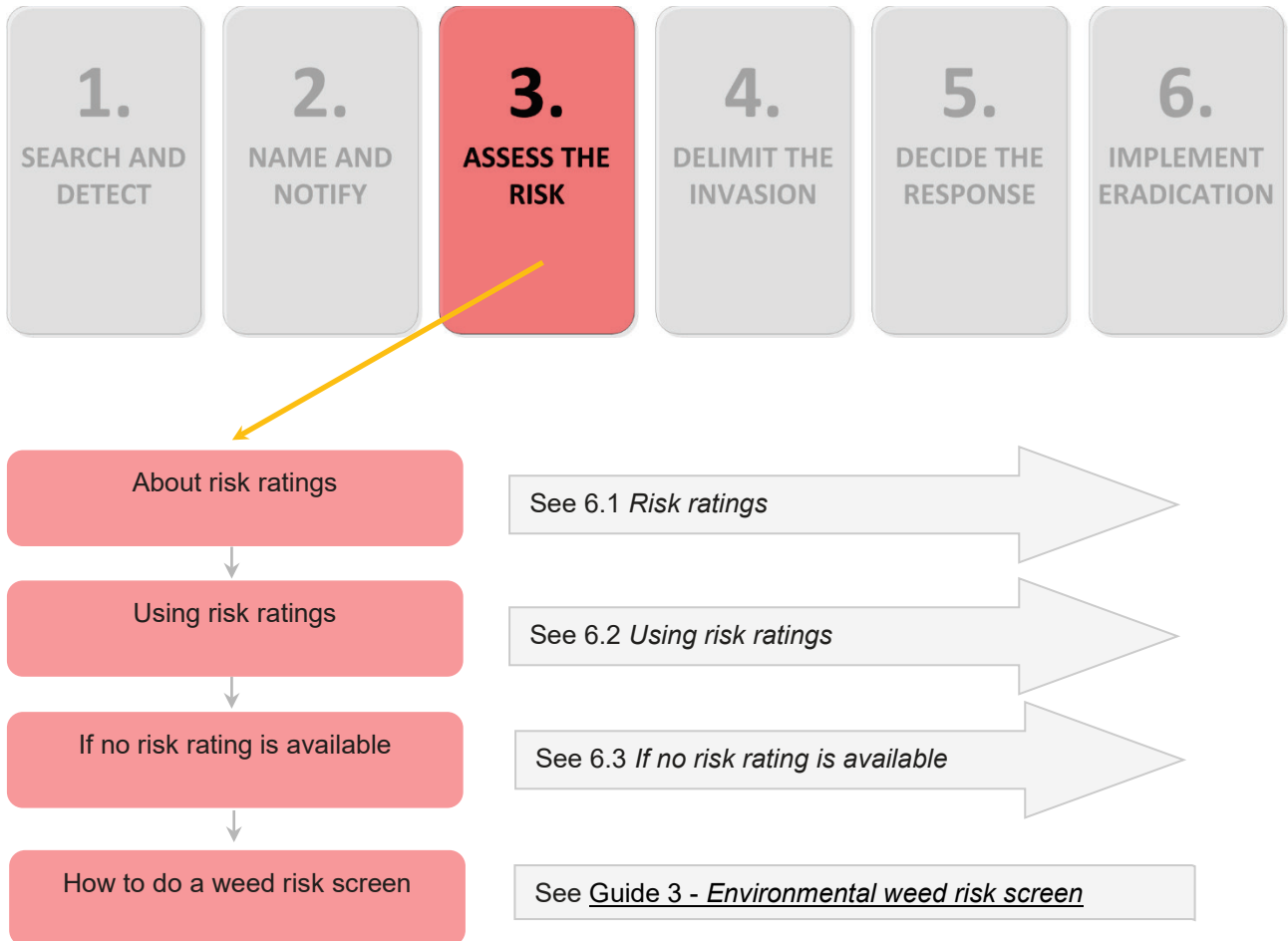


Figure 14: Who to notify about early invaders.

6. (3) Assess the risk

You have found an unusual weed and worked out what it is. How do you know if it is a future problem? What risk does it pose where it is growing (see Figure 15)?



Relevant tools:

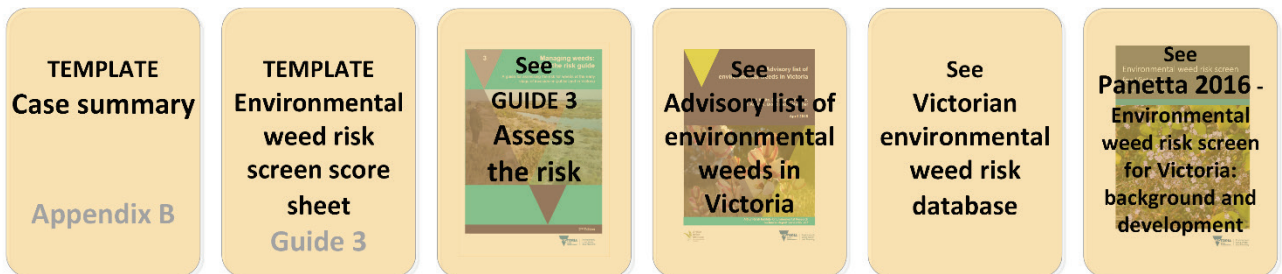


Figure 15: How to use the assess the risk section.

6.1 Risk ratings

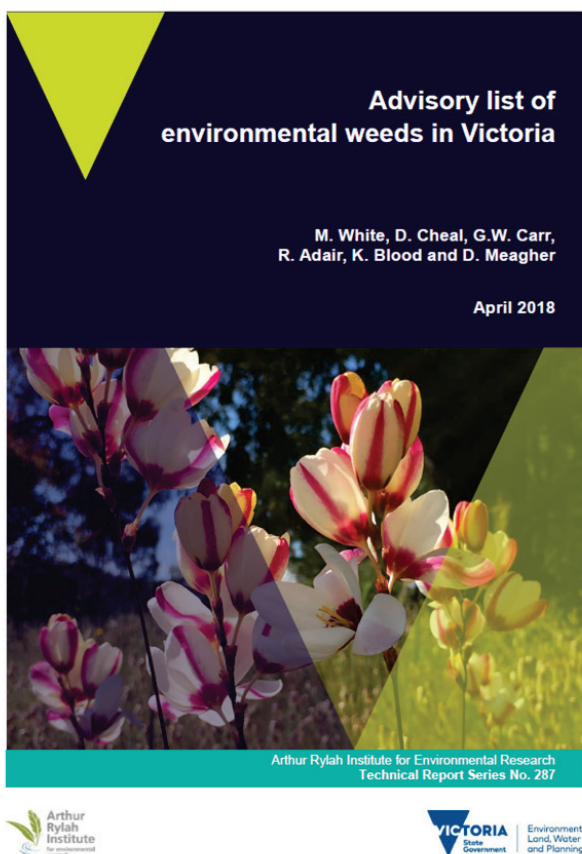
Risk ratings are useful to help work out which weeds pose the most serious threat.

Risk ratings provide an indication of the level of threat posed by a weed. This section is focused on the threat from weeds to biodiversity, particularly on public land. What are the weed's likely impacts and how invasive is it? There are a number of sources of risk rating available for Victoria summarised in Table 2. Guide 3 'Assess the risk' has a lot more information.

Table 2: Sources of Victorian weed risk rating information.

Weed risk rating process	Comments
Advisory list of environmental weeds in Victoria DELWP	The advisory list was updated and expanded in 2018 (White <i>et al.</i> 2018) to include early invaders, replacing five lists published in 2008-2009. It contains 1786 vascular and non-vascular plant species, including 1235 that are environmental weeds. The list includes a risk ranking score (between 0 and 33.3) for the weeds recorded in different bioregions. There are six risk ratings (very high, high, moderately high, medium, lower and potential risk). The information is the view of six experts, assessed against five questions.
Victorian Weed Risk Assessment Agriculture Victoria	A full Victorian Weed Risk Assessment (WRA) contains evidence-based (referenced) detailed information. There are components of the WRA that focus on invasiveness and impact on biodiversity. This information is likely to be the most comprehensive risk assessment for a weed. Since 2002, over 600 have been produced. Each weed is assessed against 41 questions, and a single weighted score is generated (pest plant score). This score can be compared to other weeds that have been assessed using WRA. 'Present' and 'potential' distribution maps are produced. It takes about a week to complete at a cost of \$3,500 to \$4,000 each.
Environmental weed risk screen See Guide 3 'Assess the risk' for more information. DELWP	The screen was developed in 2015 (Panetta 2016) to assess the weed risk posed by a plant that has been either newly detected, or has been known to be present for some time but not assessed previously. Its purpose is to provide a means for identifying the plants that pose the highest threat to biodiversity, particularly on public land at the local scale e.g. national park, conservation reserve, State forest.
Transformer species DELWP	The list of transformer species (weeds that have the ability to change ecosystems) contains 384 weeds that are the very high risk weeds from the environmental weed advisory lists published in 2008/2009. Information on these environmental weeds is used by Arthur Rylah Institute to spatially model areas in Victoria that are susceptible to invasion.
Biosecurity rapid assessment procedure Agriculture Victoria	Since 2009, new weeds recorded in Victoria are put through a Biosecurity rapid assessment procedure that focuses on agricultural and social impacts. Assessments contain some detailed information and attachments. To 2018, approximately 80 rapid assessments have been produced. Since April 2013, many contain ratings for High, Medium, or Low. The rapid assessment is used to determine if a species is of sufficient risk to warrant further investigation e.g. to undertake a full WRA.
Environmental weed risk to vegetation formations	In 1992, a group of three authors published a book titled "Environmental weed invasions in Victoria" (Carr <i>et al.</i> 1992). Included in the book is a table of 584 taxa (576 species). The table contains coded information, including a risk rating for each weed. The risk ratings used indicate the short to long term threat posed to one or more of 15 vegetation formations in Victoria, categorised as very serious, serious, potential, or not a threat.

Taxon (plural 'taxa') = A taxonomic group at any rank.



6.2 Using risk ratings

The risk ratings most commonly used by the WESI Project are from two main sources:

- Advisory list of environmental weeds in Victoria (Figure 16); and
- Victorian Weed Risk Assessments (WRA) - In the context of new detections, WRA considers the probability that a plant will persist and spread (its invasiveness) and the consequences of such spread (its impact). These are summarised in the Victorian environmental weed risk database.

Each of these *Excel* databases is a decision support tool that can assist in generating lists of detection priorities of existing and potential species in and around a parcel of public land at a particular date, helping to provide a structured approach to detection surveys on public land anywhere in Victoria. The scoring in each database is different so they need to be used independently of each other.

Figure 16: Cover of the 2018 report component of the advisory list of environmental weeds in Victoria.

By sorting the spreadsheet(s), it is possible to start prioritising weeds based on the comparative risk they pose. Remember it is only a guide. The spreadsheet(s) can be attached to the STAR project you have created for this case.

For weeds that do not have a risk rating available, use the weed risk screen to determine if the weed should be monitored for further change, or if a delimiting survey should be undertaken. It is possible to proceed through the decision making framework without a risk rating if a risk screen has been completed and it recommends 'to delimit'.

If a weed list is not already available for a piece of public land, the spreadsheet(s) can form the start of such a list. Delete the weeds that are not relevant.

The risk rating databases are available on the external website (search for 'early invaders Victoria weeds'), on STAR and on Enterprise Content Management (ECM).

6.3 If no risk rating is available

If you are looking for the risk rating of a weed that has not been assessed in Victoria, Guide 3 'Assess the risk' describes a process called the "Environmental weed risk screen" that can help determine the risk the weed poses at a location.

The Environmental weed risk screen's purpose is to assess the risk posed by a weed to biodiversity. The plant may have been either newly detected, or has been known to be present for some time but not assessed previously. The purpose of the screen is to provide a means for identifying the plants that pose the highest threat to biodiversity. It can be used for introduced weeds and non-local native species.

The screen only needs to be used if a risk rating for the weed is not already available in either the Advisory list of environmental weeds in Victoria, or the Victorian environmental weed risk database. If a weed is not in either risk database, double check that it is not under an old or a newer botanical name for the same weed. Use of the risk screen is optional and is a guide only.

The screen output is a recommendation to either 'delimit' (determine the full extent in the field) or 'monitor'. It does not create a score that is comparable to the advisory list. It can be used at a local scale such as, for example, a park, forest or reserve. Attach completed risk screens to STAR and ECM.

7. (4) Delimit the invasion

Once you have identified a high risk weed, you need to find out how far the infestation has spread. Knowing this information will provide clarity on the scale and task ahead for managing the infestation (Figure 17).

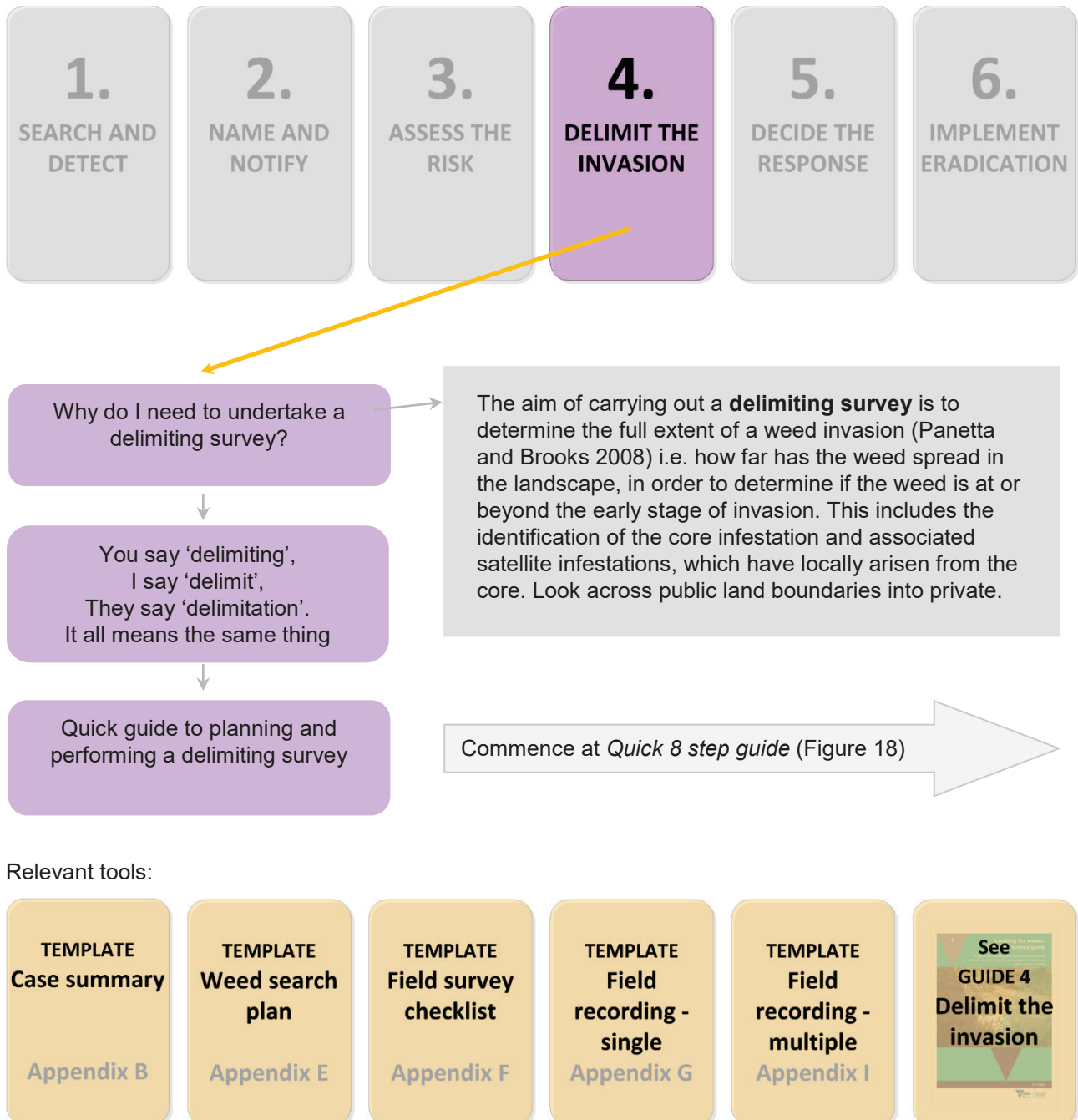


Figure 17: How to use the delimit the invasion section.

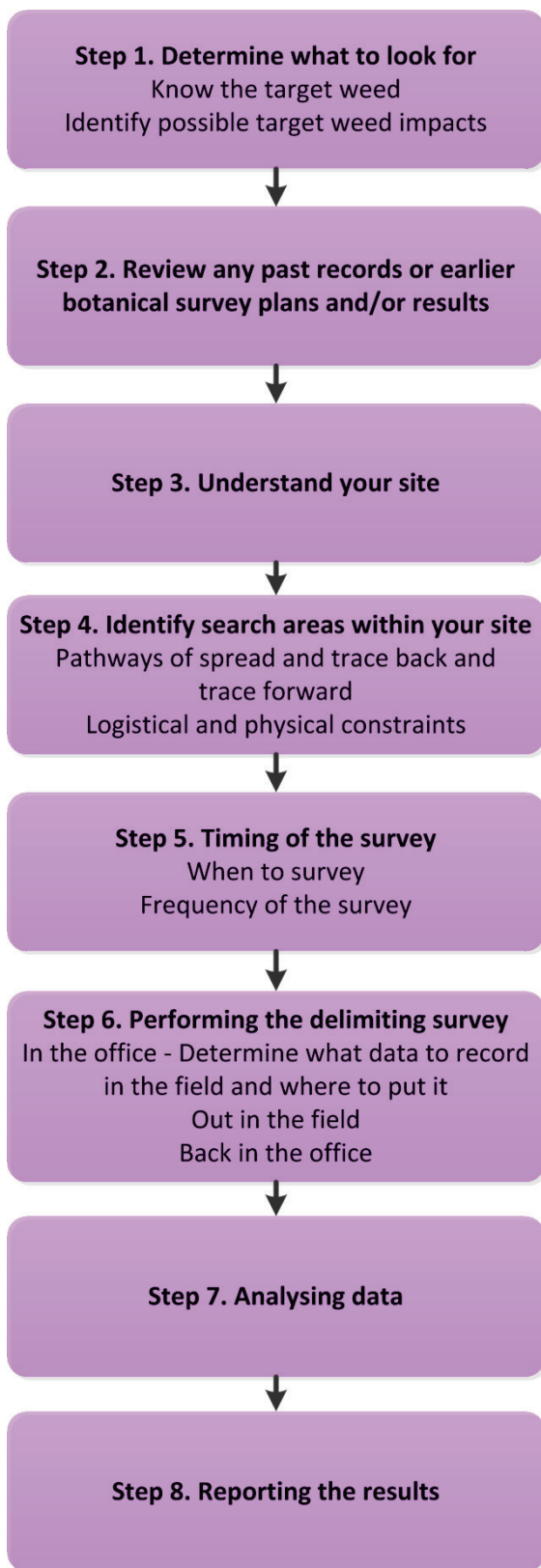


Figure 18: Quick guide to planning and undertaking a delimiting survey.

7.1 Step 1. Determine what to look for

There is lots of information on knowing the target weed in Guide 4 'Delimit the invasion'. Use the optional search plan template (Appendix E) to record the search target.

7.2 Step 2 to 3.

See Guide 4 'Delimit the invasion' for details and hints.

7.3 Step 4. Identify search areas within your site

Figure 7 assists with defining sites, search areas and targeted survey areas.

To prioritise where to search in large landscapes, carry out a **pathway analysis** (to identify invasion pathways and the risk associated with each). **Trace forward** from an identified infestation and determine where else the target weed may have spread. Then **trace back** to where you think the weed may have come from (the source). Identify which one(s) of these pathways will be your highest priority for searching. Draw the search areas on a map and include this in your search plan (refer to Appendix E).

7.4 Step 5. Timing of the survey

The more quickly a survey can be planned and organised the better, as this will reduce the opportunity for the weed to spread further. Ideally the best time to look for a weed is when the growing conditions are ideal and the plant is flowering or exhibiting some other form of growth that makes it easy to see. Plan for good conditions and with sufficient time allowed.

7.5 Step 6. Performing the delimiting survey

Lots of information and hints in Guide 4 'Delimit the invasion'. Reminder: When conducting a delimiting survey it is important never to assume that all infestations have been identified (Jeffery 2012). There is almost always more than you think.

7.6 Step 7. Analysing data

Reminder: It is important to remember that delays in analysis are likely to result in delays in treatment.

7.7 Step 8. Reporting the results

It is important to report and communicate any findings or recommendations from the analysed survey data to the appropriate people.

Confirming the true boundary of a new weed infestation is a fundamental task required to make a decision on whether eradication is feasible. It will also provide you with clarity on the scale of the task ahead and the resources required to survey and treat the infestation (Jeffery 2012).

8. (5) Decide the response

Should I eradicate this weed, contain it, control it sufficiently to protect the biodiversity values, or monitor it? This section has been designed to assist you make a decision about what management approach to take with a weed at the early stage of invasion (Figure 19).

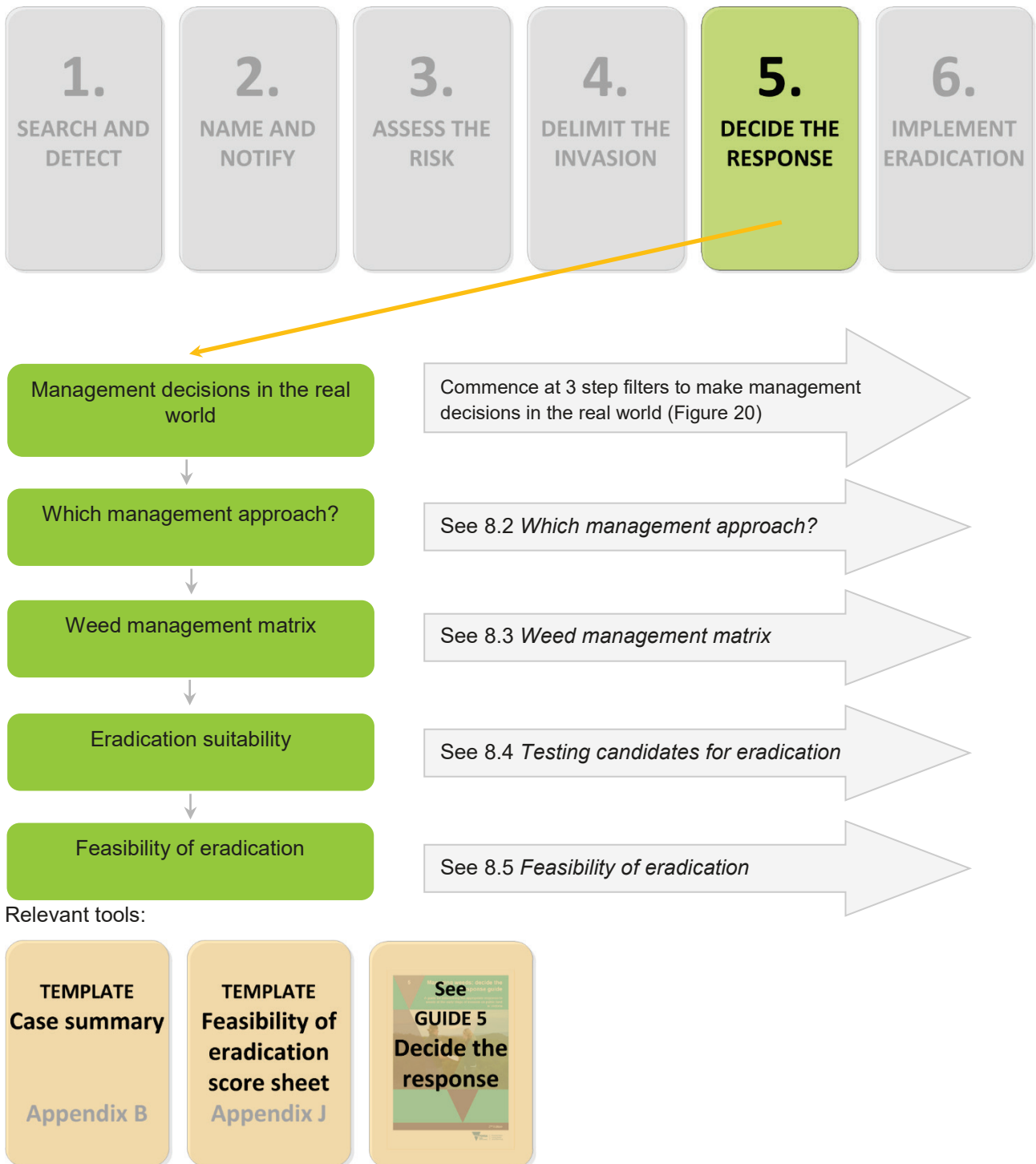


Figure 19: How to use the decide the response section.

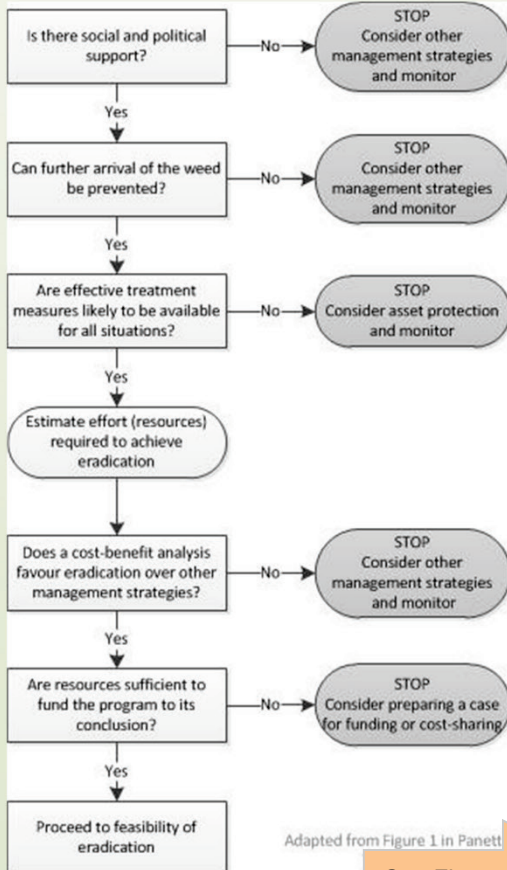
Step 1. Weed management matrix

		Weed distribution (from delimiting survey)	
		In early stage of invasion	Beyond early stage of invasion
Weed risk (from Advisory list &/or Victorian environmental weed risk database)	Low	Include in local management activities as required and Monitor	Include in local management activities as required and Monitor
	Medium	Contain and Monitor	Protect biodiversity asset and Monitor
	High	Consider eradication if feasible	Contain OR Protect biodiversity asset and Monitor

Go to Testing candidates for suitability for eradication

See Figure 21

Step 2. Suitability for eradication



See Figure 22

Step 3. Feasibility of eradication score sheet

See Step 3

8.1 Making management decisions in the real world

It is important to think about the big picture first. This is the time to consider all the fundamental realities of the situation you work in. It calls on being brutally honest with your circumstances.

The reality is that no matter how personally torn you are about protecting an ecosystem or the components within it, in the cold hard light of day if you don't have the resources or political support to act, trying to do so will most likely end in failure, and at its worst, end in compromising your job satisfaction and wellbeing.

By commencing eradication responses that are very unlikely to succeed, the risk is that you'll create a perception that eradication 'never works' and is 'not worth trying'. By picking overambitious targets the effect is to make it less likely that good targets will be funded in the future.

If you are not riding a wave of support and resources to manage what you want now, perhaps the next wave will come soon. If you have done some of the fundamental planning, you can help prepare yourself or the next land manager to carry on that plan and 'bid' for the required resources and implement your plan when the time is right. Remember that future land manager(s) need to be able to find your plan after you have moved on. The hope is that the weed is not too far gone when resources are available.

Guide 5 'Decide the response' has lots of information and hints on weed management.

Figure 20 gives an overview of the three step approach for determining weeds feasible for local eradication.

Figure 20: Filters used in the decide the response section to determine weeds feasible for local eradication (Figures 21 and 22 have clearer versions of components).

8.2 Which management approach?

Where is it best to invest limited resources?

If you have been following the decision making framework in its logical progression up to this point, you may have already dropped a number of weeds from consideration for eradication due to their low risk. This is the time when some hard decisions need to be made about which ones to target for eradication.

This is not easy. There are so many variables and every combination of weed and place where it is growing is different. This guide is just that – a guide. You will need to make decisions based on your own circumstances. Get some help. Call in others who are involved in the care and use of the site to help you make the decision.

Management approach options

Weed activities fall into four broad categories: prevention, eradication, containment and asset-based protection.

Prevention - It can be assumed that because a weed is being considered for eradication, it is present so beyond the prevention approach. However, observations about the weeds that are present and knowledge of the land use and plants growing around public land can help to focus effort for appropriate prevention activities for the future. Prevention also includes following hygiene protocols for vehicles, equipment, people and materials etc. being brought into the public land. Investing in good hygiene practices is the most effective way of preventing the arrival and establishment of new weeds, pathogens etc.

Protect biodiversity asset (asset protection, asset-based approach) - A biodiversity asset is the area (e.g. nature reserve or park) that is being managed to preserve biodiversity values. In this approach multiple weed management activities are prioritised based on the relative value of the biodiversity assets that will be protected by the management activities. The aim is to maintain the viability of the important biodiversity assets and maximise biodiversity outcomes.

Containment - Containment is the prevention or reduction of 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). Containment is commonly advocated as fall-back to eradication, but it is not necessarily easier than eradication. Tip: If you can't eradicate, chances are that you cannot contain either, at least in an absolute sense, which means total prevention of further spread. When containment is the aim, there is no end point to management.

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

The longevity of viable seeds (or other propagules) will indicate the length of the eradication response. The weed's seedbank and budbank must be completely exhausted to ensure no new plants will grow and reproduce. Tip: If the weed does regrow and reproduce, the 'response clock' must go back to zero and counting started again, delaying success or tipping a response beyond feasible.

Monitoring - Monitoring is an important component of all these management approaches. For the purposes of this manual, to monitor is 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. Generally, monitoring at yearly intervals is recommended (Panetta 2016).

In some cases if a decision cannot be made about the appropriate management approach or if resources are not available to undertake treatment, monitoring an infestation over a period of time can provide more information and inform a future decision.

There are other forms of monitoring, depending on the purpose. Of most relevance to this manual, apart from weed monitoring, is monitoring biodiversity for changes associated with invasive plants (see Ainsworth *et al.* 2008). Monitoring results should be recorded in STAR.

Tip: Parks Victoria have a draft monitoring guide available from the agency's research team. The NSW Bitou Bush monitoring manual (Hughes *et al.* 2009) provides useful information and templates.

8.3 Step 1. Weed management matrix

The matrix below (Figure 21) brings together the information you have collected so far on weed risk and distribution information from delimiting surveys. Remember it is not an exact science, it is a guide.

Reminder: Always record your management decisions in the case summary template (see Appendix B) and save to STAR.

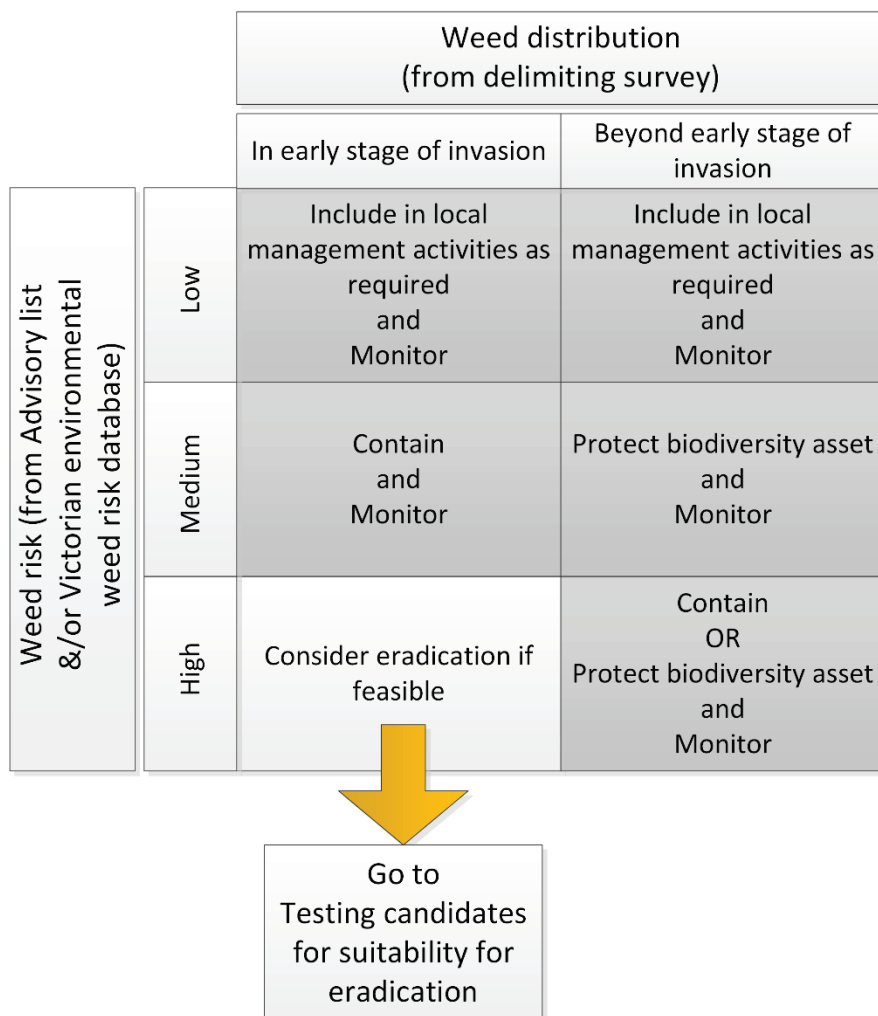


Figure 21: Weed management matrix.

Note: The weed management matrix above should not be confused with the weed risk matrix described in the Guide 3 'Assess the risk'.

If the weed(s) you are considering are high risk and in the early stages of invasion, move on to the next step, suitability for eradication. The next part of the process will help you further test if they are candidates for eradication. If they are either not high risk and in the early stages of invasion, or are not high risk and beyond the early stages of invasion, then consider the other appropriate management approaches recommended in the weed management matrix.

This manual is very focussed on the initial decision concerning whether to attempt eradication. This decision is based on the information available at the time. As an eradication response proceeds it is frequently found that new information emerges e.g. additional sites are found, 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 be halted after a short time – be prepared for this possibility.

8.4 Step 2. Testing candidates for eradication suitability

The process below (Figure 22) guides you through a series of questions to test if the weed(s) are suitable candidates for eradication. There is lots of detail about these questions in Guide 5 'Decide the response'.

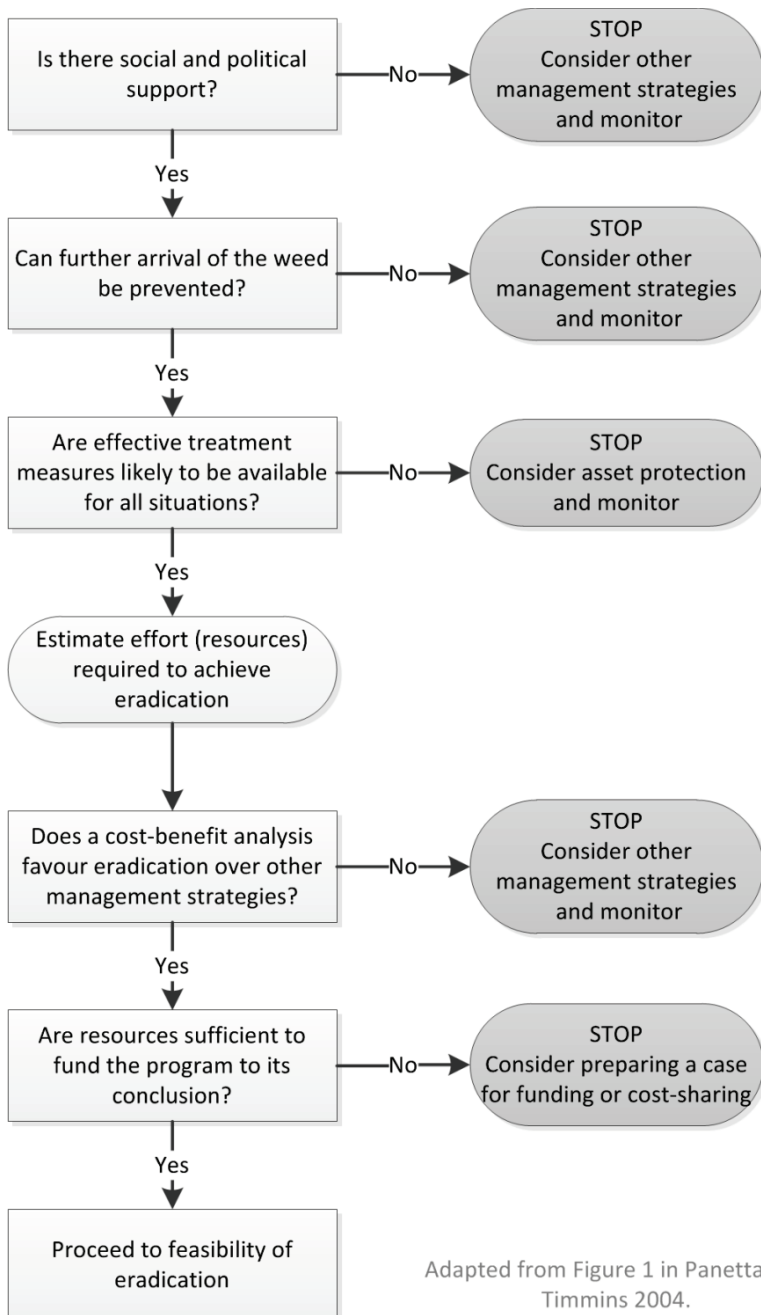


Figure 22: Suitability for eradication to test and narrow numbers of eradication candidates (based on Panetta and Timmins 2004).

8.5 Step 3. Feasibility of eradication

If you have got this far with weed(s) that appear to be suitable candidates for eradication, they are now about to be tested for their feasibility of eradication. A score sheet has been developed to assess the feasibility of eradication (Appendix J).

Keep in mind that while the answers to the questions in the score sheet can help you test if eradication is feasible, your decisions will still depend on the real world situation that you operate in and will rely on the support of the agency manager.

The completed score sheet will show a score that will indicate the effort required to eradicate a weed from a particular place. The score can be compared to other weeds at the same location to see if one is more feasible to eradicate than another.

How to use the Feasibility of eradication score sheet

1. Record the appropriate score for each question then sum the scores at the bottom of the table.
2. The score produced by using the table gives an indication of the comparative eradication effort i.e. the effort required to eradicate a weed from a particular place. Estimates of eradication effort are by nature crude, but can be useful guides, especially when trying to determine if one weed is more feasible to eradicate than another. There is no cut-off or threshold score – you do as much as you can with the funding available.
3. Attach a copy of the completed score sheet to the appropriate case record in STAR.

Interpreting the feasibility of eradication score - The total score produced by the score sheet will range from two (2) for a 'good' scenario (i.e. more feasible to eradicate) to seventy-nine (79) or more for a 'bad' scenario (i.e. less feasible to eradicate) as illustrated in Figure 23 below. The lower the score, the more feasible eradication is. The higher the score, the more likely eradication will fail.

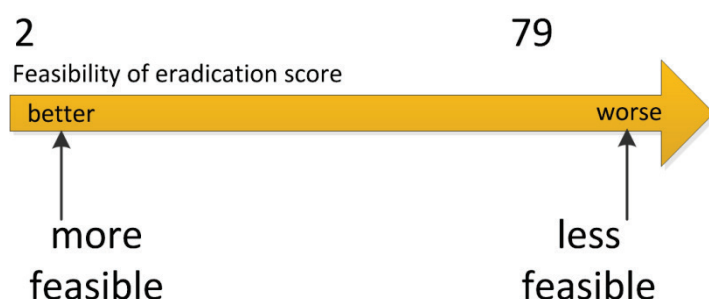


Figure 23: Illustration to indicate the range and meaning behind the feasibility of eradication score.

If eradication is not feasible - Go back to the weed management matrix and consider the other management approaches which may be more appropriate e.g. containment or asset protection.

When dealing with more than one eradication candidate - Guide 5 'Decide the response' has a number of hints on how to make decisions when there are more than one eradication targets.

9. (6) Implement eradication

If eradicating a weed is a feasible aim (removing it completely from your patch), having a plan improves your chances of success. This section will assist you to plan and carry out eradication works (Figure 24).

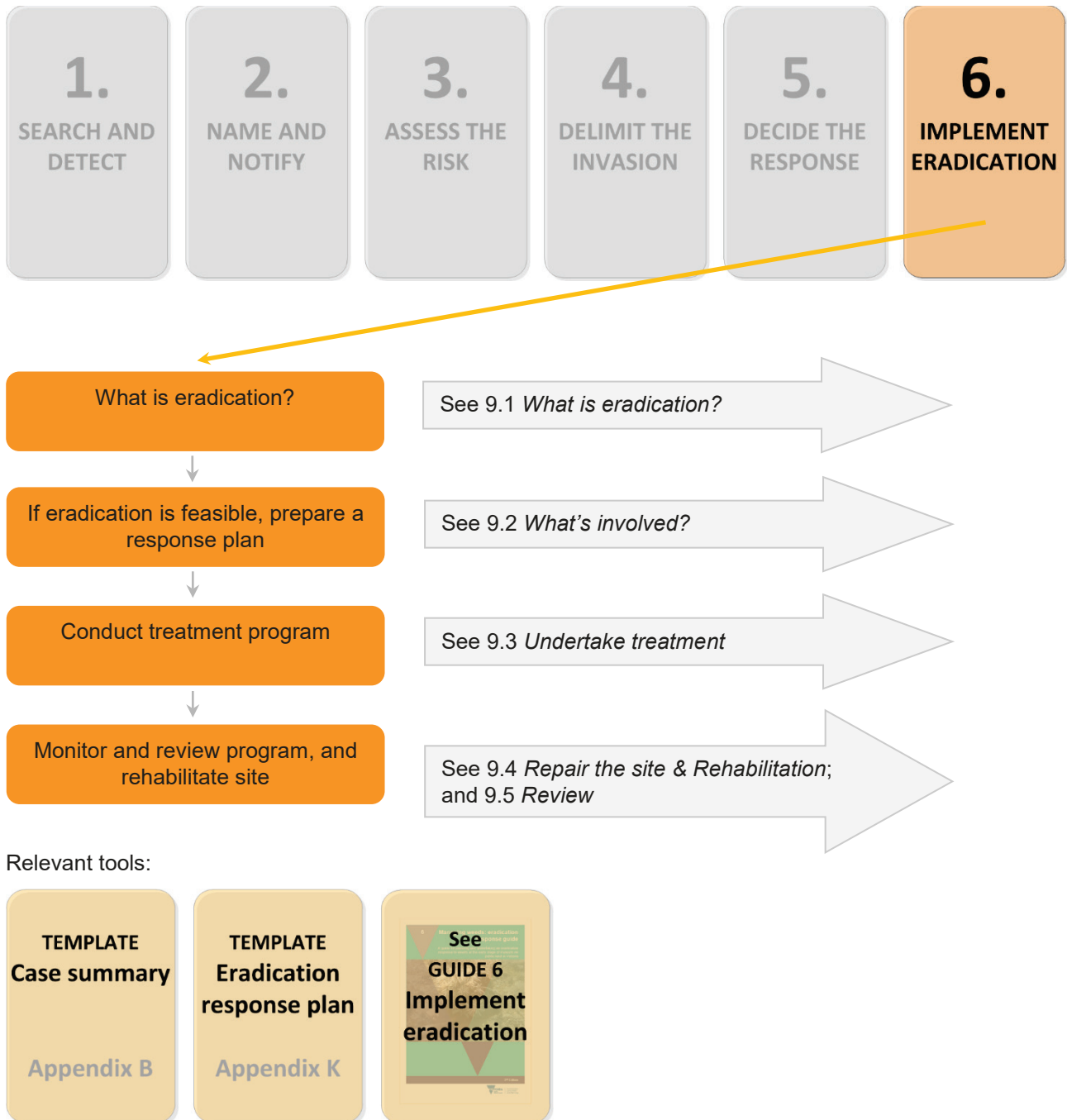


Figure 24: How to use the implement eradication section.

9.1 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 manual, the term extirpation will be referred to as **localised eradication**.

Reminder: By choosing eradication targets carefully using the earlier sections in this manual, the likelihood of success should increase considerably.

Factors influencing eradication success - These are summarised in Table 3.

Table 3: 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. 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.
Propagule longevity	The shorter the life span of propagules (seeds, bulbs, buds etc.) the more feasible to eradicate. 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. 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.
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. 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	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. 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).
Monitoring rate	The more frequently eradication efforts are monitored, the more feasible to eradicate. 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	Species that have no conflicting perceptions within the public forum are more feasible to eradicate.

9.2 What's involved in an eradication response?

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. A plan is also useful for reporting purposes (to funders) and for seeking more funding.

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 K. 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. A completed example of an eradication response plan is provided in Guide 6 'Implement eradication' Appendix 3.

Reminder: Attach eradication response plans to cases in STAR and save on ECM.

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 of established plants and new recruits; and the **monitoring phase**, where search effort is directed at locating any individuals of the species to determine if further recruitment is occurring from the seedbank in the soil or budbanks (Panetta 2007) (Figure 25).

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).

Record treatment and monitoring activity for cases in STAR.

Hygiene, wellbeing and safety - Planning for hygiene to ensure weeds are not spread is very important.

Reminder: The wellbeing and safety of staff, contractors, site visitors and neighbours are crucial. Appendix H outlines some general points to incorporate into eradication response planning and activities.

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.

The production of seeds or other propagules by the target species during the course of an eradication program (called a reproductive escape) (Panetta 2007) causes the 'response clock' to go back to zero and counting started again, delaying success or tipping a response beyond feasible.

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).

There is lots more information about eradication in Guide 6 'Implement eradication'.

9.3 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.

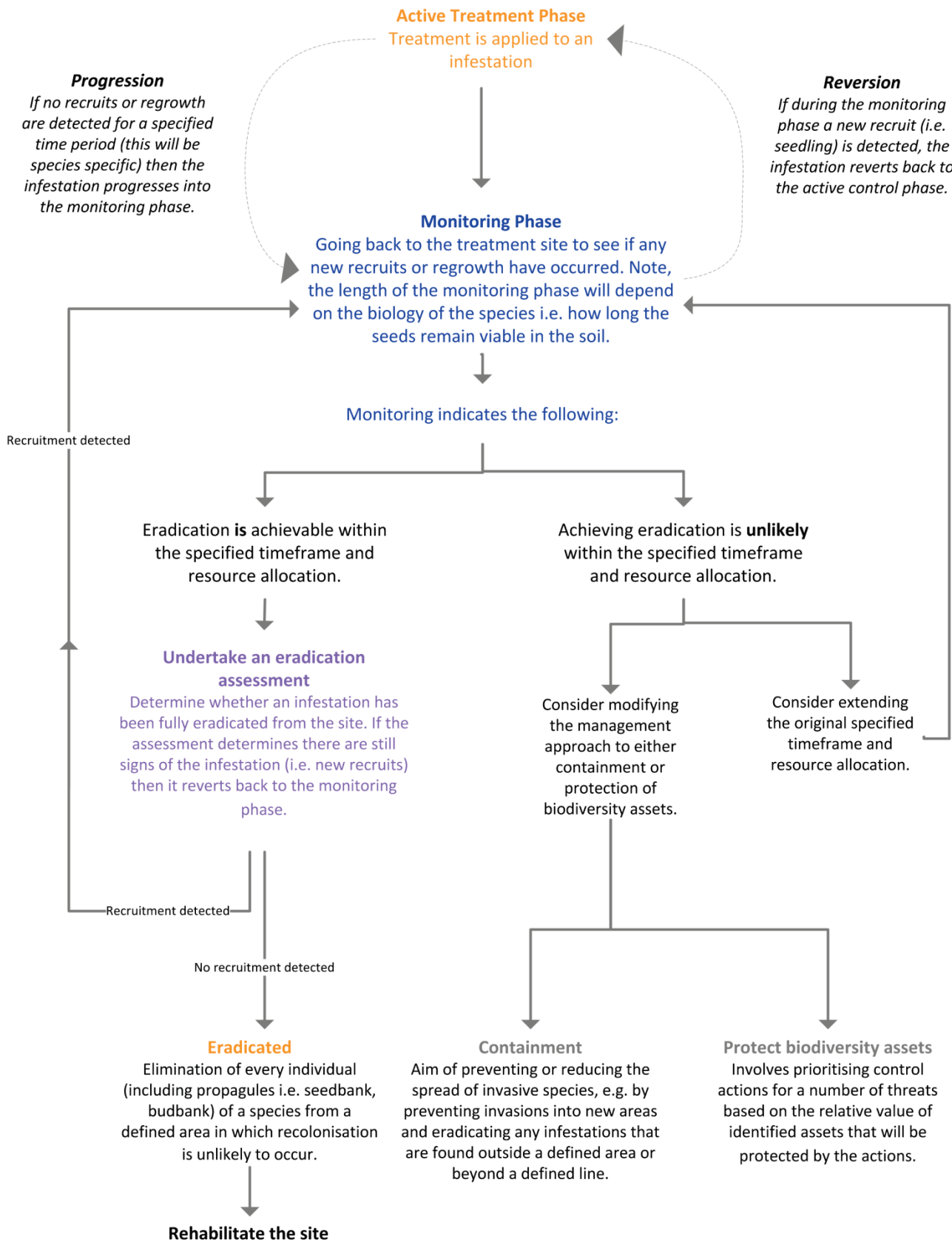


Figure 25: Operational phases within an eradication response.

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

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.

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 structures (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. 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 L).

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) <https://portal.apvma.gov.au/pubcris>

Reminder: 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. The Material Safety Data Sheet for herbicide products specifies what constitutes suitable protective clothing and equipment.

When selected carefully **herbicides** 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. There are a number of ways of applying herbicide including:

- Foliar application
- Granular application
- Cut stump (cut and paint)
- Scrape and paint
- Stem injection (drill and fill)
- Frilling or chipping
- Basal bark
- Soil fumigation (gas) and drenching (liquid)

Physical treatment or removal – There are many other weed treatment techniques and not all will be relevant for early invaders including:

- Mechanical - slashing or mowing, grubbing out and hand pulling, cutting and felling, ringbarking, and scalping
- Grazing
- Heat - fire, flame weeding, hot water/steaming, and solarisation

Other treatment techniques

- Mulching, smothering
- Water or nutrient manipulation
- Competition through regeneration or revegetation
- Biological control
- Seed and bud bank treatments

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. Tip: 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.

9.4 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?

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.

9.5 Review

This section 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.

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

What next?

Celebrate (Figure 26) and share your successes including with the WESI project team (Appendix C).



Figure 26: Celebrating success and involvement are important for wellbeing and to recognise sustained strategic work.

Credit: Kate Blood, DELWP

10. Bibliography

Note: There are many other useful references listed in the bibliographies of the early invader guide series. Below are only those cited in this manual.

- Abercrombie, M., Hickman, C. J. and Johnson, M. L. (1973) *A dictionary of biology* (6th edn). Penguin Books, Ringwood Vic. ISBN nil.
- Adair, R., James, R. and Blood, K. (2018) *Managing weeds: eradication response guide* (2nd Edition). A guide for planning and undertaking an eradication response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-049-5 (Print); ISBN 978-1-76077-050-1 (pdf/online/MS word).
- Ainsworth, N., Adair, R. and Cheal, D. (2008) *A method of monitoring biodiversity for changes associated with invasive plants*. Department of Sustainability and Environment, Melbourne. ISBN 978-1-74208-174-8 (print).
- Albrecht, D. (1993) *Collecting and preserving herbarium specimens*. National Herbarium of Victoria, Royal Botanic Gardens, Victoria. ISBN 0 9599758 5 3.
- Beentje, H. (2010) *The Kew plant glossary: An illustrated dictionary of plant terms*. Royal Botanic Gardens, Kew UK. ISBN 978-1-84246-422-9.
- Bekker, R. M., Bakker, J. P., Grandin, U., Kalamees, R., Milberg, P., Poschlod, P., Thompson, K. and Willems, J. H. (1998) Seed size, shape and vertical distribution in the soil: indicators of seed longevity. *Functional Ecology* **12**: 834–842.
- Blood, K. (2016) Use of social media for sharing invasive species information, in Randall, R., Lloyd, S., and Borger, C. (eds.) *20th Australasian Weeds Conference papers and proceedings, 11-15 September 2016, Perth, Western Australia*. Weeds Society of Western Australia. ISBN 978-0-646-96031-9.
- Blood, K. and James, R. (2016a) *Looking for weeds: name and notify guide*. A guide for identifying weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-002-9 (Print); ISBN 978-1-76047-003-6 (pdf/online).
- Blood, K. and James, R. (2016b) *Managing weeds: decide the response guide*. A guide for determining the appropriate response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-008-1 (Print); ISBN 978-1-76047-009-8 (pdf/online).
- Blood, K. and James, R. (2018a) *Looking for weeds: name and notify guide* (2nd Edition). A guide for identifying weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-041-9 (Print); ISBN 978-1-76077-042-6 (pdf/online/MS word).
- Blood, K. and James, R. (2018b) *Managing weeds: decide the response guide* (2nd Edition). A guide for determining the appropriate response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-047-1 (Print); ISBN 978-1-76077-048-8 (pdf/online/MS word).
- Blood, K., Cox, D. and Robinson, K. (1996) *Coastal weed workshops*. Weed Science Society of Victoria, Department of Natural Resources and Environment, Vic. ISBN 0 7306 6195 4.
- Blood, K., James, R. and Panetta, F. D. (2016) *Managing weeds: assess the risk guide*. A guide for assessing the risk for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-004-3 (Print); ISBN 978-1-76047-005-0 (pdf/online).
- Blood, K., James, R. and Panetta, F. D. (2018) *Managing weeds: assess the risk guide* (2nd Edition). A guide for assessing the risk for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-043-3 (Print); ISBN 978-1-76077-044-0 (pdf/online/MS word).
- Carr, G. W., Yugovic, J. V. and Robinson, K. E. (1992) *Environmental weed invasions in Victoria. Conservation and management implications*. Department of Conservation & Natural Resources and Ecological Horticulture Pty Ltd, Melbourne, Vic. ISBN 0 7306 2651 2.

- Delbridge, A., Bernard, J. R. L., Blair, D., Butler, S., Peters, P. and Yallop, C. (eds) (1998) *The Macquarie dictionary* (3rd edn). The Macquarie Library, NSW. ISBN 0 949757 89 6.
- Dodd, A. J., Ainsworth, N., Burgman, M. A. and McCarthy, M. A. (2015) Plant extirpation at the site scale: implications for eradication programmes. *Diversity and Distributions* 21: 151–162.
- Downey, P. O., Johnson, S. B., Virtue, J. G. and Williams, P. A. (2010a) Assessing risk across the spectrum of weed management. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 5, No. 038. Online ISSN 1749-8848.
- Downey, P. O., Scanlon, T. J. and Hosking, J. R. (2010b) Prioritizing weed species based on their threat and ability to impact on biodiversity: a case study from New South Wales. *Plant Protection Quarterly* 25 (3): 111-126.
- Downey, P. O., Williams, M. C., Whiffen, L. K., Auld, B. A., Hamilton, M. A., Burley, A. L and Turner, P. J (2010) Managing alien plants for biodiversity outcomes - the need for triage. *Invasive Plant Science and Management* 3(1); 1-11.
- DSE (2009) Securing our natural future: A white paper for land and biodiversity at a time of climate change. Department of Sustainability and Environment, Melbourne.
- Ensbey, R. (2014) *Noxious and environmental weed control handbook – A guide to weed control in non-crop, aquatic and bushland situations* (6th edn). Department of Primary Industries, a part of the Department of Department of Trade and Investment, Regional Infrastructure and Services. ISSN 1443–0622.
- FloraOnline - Compiled and edited by staff of the National Herbarium of New South Wales © 1999 – 2010 Royal Botanic Gardens & Domain Trust, Sydney Australia. Web source viewed online 11/5/2010: <http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm>
- Harris, S., Brown, J. and Timmins, S. (2001) Weed surveillance - how often to search? *Science for Conservation* 175. Department of Conservation, New Zealand. ISBN 0-478-22029-4, ISSN 1173-2946.
- Hester, S., Hauser, C. and Robinson, A. (2010) Post-border surveillance techniques: review, synthesis and deployment. Australian Centre of Excellence for Risk Analysis, University of New England, NSW.
- Howell, C. J. (2012) Progress toward environmental weed eradication in New Zealand. *Invasive Plant Science and Management* 5: 249–258.
- Hughes, N. K., Burley, A. L., King, S. A. and Downey, P. O. (2009) Monitoring manual for Bitou Bush control and native plant recovery. Department of Environment, Climate Change and Water, Sydney, NSW. <http://www.environment.nsw.gov.au/bitouTAP/monitoring.htm>
- International Code of Nomenclature for algae, fungi, and plants (Melbourne Code). *Regnum Vegetabile* 154. Koeltz Scientific Books. ISBN 978-3-87429-425-6. Ref viewed online 27 May 2013: <http://www.iapt-taxon.org/nomen/main.php?page=glo>
- James, B., Blood, K. and Raleigh, R. (2016) Buffel grass (*Cenchrus ciliaris* L.), an early invader in Victoria, in Randall, R., Lloyd, S., and Borger, C. (eds.) *20th Australasian Weeds Conference papers and proceedings, 11-15 September 2016, Perth, Western Australia*. Weeds Society of Western Australia. ISBN 978-0-646-96031-9.
- James, R. and Blood, K. (2016) Looking for weeds: delimiting survey guide. A guide for planning and undertaking delimiting surveys for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-006-7 (Print); ISBN 978-1-76047-007-4 (pdf/online).
- James, R. and Blood, K. (2018) Looking for weeds: delimiting survey guide (2nd Edition). A guide for planning and undertaking delimiting surveys for weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-045-7 (Print); ISBN 978-1-76077-046-4 (pdf/online/MS word).
- Jeffery, M. (2012) Eradication: lessons learnt from 17 years of the National Siam Weed Eradication Program in Eldershaw, V. (eds) (2012) *Proceedings of the 18th Australasian Weeds Conference*, pp. 92-95. Weed Society of Victoria Inc., Melbourne.
- Kruger, H., Stenekes, N., Clarke, R. and Carr, A. (2010) Biosecurity engagement guidelines: Practical advice for involving communities. Bureau of Rural Sciences, Canberra. ISBN 978 1 921192 41 8.

- Long, R. L., Gorecki, M. J., Renton, M., Scott, J. K., Colville, L., Goggin, D. E., Commander, L. E., Westcott, D. A., Cherry, H. and Finch-Savage, W. E. (2015) The ecophysiology of seed persistence: a mechanistic view of the journey to germination or demise. *Biological Reviews* 90: 31–59.
- MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Royle, A. and Langtimm, C. A. (2002) Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83: 2248–2255.
- McMaugh, T. (2005) Guidelines for surveillance for plant pests in Asia and the Pacific. Australian Centre for International Agricultural Research (ACIAR) Monograph. ACIAR Monograph No. 119, 192pp. ISBN 1 86320 456 3 (online).
- McNaught, I., Thackway, R., Brown, L. and Parsons, M. (2008) *A field manual for surveying and mapping nationally significant weeds* (2nd edn). Bureau of Rural Sciences, Canberra. ISBN 0 9750443 6 2.
- Melville, R. (ed) (March 2008) Landcare note: Declared noxious weeds - listed by scientific name. Department of Primary Industries, Vic. ISSN 1329-833X.
- Panetta, F. D. (2007) Evaluation of weed eradication programs: containment and extirpation. *Diversity and Distributions* 13: 33–41.
- Panetta, F. D. (2009) Weed eradication: An economic perspective. *Invasive Plant Science and Management* 2: 360–368.
- Panetta, F. D. (2015) Weed eradication feasibility: Lessons of the 21st century. *Weed Research* 55: 226–238.
- Panetta, F. D. (2016) Environmental weed risk screen for Victoria: background and development. A report prepared for the Department of Environment, Land, Water and Planning, Vic. ISBN 978-1-76047-017-3 (Print); ISBN 978-1-76047-018-0 (pdf/online).
- Panetta, F. D. and Brooks, S. J. (2008) Evaluating progress in weed eradication programs, in van Klinken, R.D. *et al* (eds) Proceedings of the 16th Australian Weeds Conference, pp. 418–420. Queensland Weeds Society, Cairns.
- Panetta, F. D. and Timmins, S. M. (2004) Evaluating the feasibility of eradication for terrestrial weed incursions. *Plant Protection Quarterly* 19 (1): 5–11. ISSN 0815 - 2195.
- Randall, R. P. (2017) A Global Compendium of Weeds (3rd edn) Perth, Western Australia. [Has over 3,000 pages and there are several sources of this document]:
<https://nla.gov.au/nla.obj-512788350/view>
<https://www.cabi.org/isc/FullTextPDF/2017/20173071957.pdf> or
https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/Compendium_3rd_Edition_2017.pdf or
- Regan, T. J., McCarthy, M. A. Baxter, P. W. J., Panetta, F. D. and Possingham, H. P. (2006) Optimal eradication: when to stop looking for an invasive plant. *Ecology Letters* 9: 759–766.
- Rejmanek, M. and Pitcairn, M. J. (2002) When is eradication of exotic pest plants a realistic goal? In: Turning the Tide: The Eradication of Island Invasives (eds Vietch, C. R. & Clout, M. N.). IUCN SSC Invasive Species Speciality Group IUCN, Gland, Switzerland and Cambridge, UK, pp. 249–253.
- Richardson, D. M., Pyšek, P., Rejmanek, M., Barbour, M. G., Panetta, F. D. and West, C. J. (2000) Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6: 93–107.
- Riches, P. (ed) (2005) Book 1: An introduction to engagement. Effective Engagement: building relationships with community and other stakeholders (Version 3). The Community Engagement Network, Department of Sustainability and Environment, Melbourne. ISBN BOOK 1 1 74152 241 2; ISBN SET 1 74152 259 5.
- Riches, P. (ed) (2005) Book 2: the engagement planning workbook. Effective Engagement: building relationships with community and other stakeholders (Version 3). The Community Engagement Network, Department of Sustainability and Environment, Melbourne. ISBN BOOK 2 1 74152 247 1; ISBN SET 1 74152 259 5.
- Riches, P. (ed) (2005) Book 3: the engagement toolkit. Effective Engagement: building relationships with community and other stakeholders (Version 3). The Community Engagement Network, Department of Sustainability and Environment, Melbourne. ISBN BOOK 3 1 74152 253 6; ISBN SET 1 74152 259 5.

- Sheehan, M. R. and Potter, S. (2017) *Managing Opuntoid Cacti in Australia: Best practice control manual for Austrocyllindropuntia, Cyllindropuntia and Opuntia species*. Department of Primary Industries and Regional Development (WA), Perth. ISBN 978 0 9923083 7 7 (book), ISBN 978 0 9923083 6 0 (pdf version).
- Sheehan, M., James, R. and Blood, K. (2016) *Looking for weeds: search and detect guide*. A guide for searching and detecting weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-000-5 (Print); ISBN 978-1-76047-001-2 (pdf/online).
- Sheehan, M., James, R. and Blood, K. (2018) *Looking for weeds: search and detect guide (2nd Edition)*. A guide for searching and detecting weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76077-039-6 (Print); ISBN 978-1-76077-040-2 (pdf/online/MS word).
- Spencer, R., Cross, R. and Lumley, P. (2007) *Plant names. A guide to botanical nomenclature* (3rd edn). CSIRO Publishing, Collingwood. ISBN 9780643094406.
- Victorian environmental weed risk database (2018), search online for 'early invader weeds'. The Victorian environmental weed risk database is an *Excel* spreadsheet that contains a summary of the scores from the Victorian Weed Risk Assessments.
- Victorian Government (2010) *Invasive plants and animals policy framework*. Department of Primary Industries, Melbourne. ISBN 978-1-74217-878-3 (print); ISBN 978-1-74217-884-4 (online).
- Welsh, S. (2000) *Tasmanian weed mapping guidelines* (3rd edn). Tasmanian Weed Mapping Network, Kings Meadow, Tas. ISBN 0 72466 240 5.
- White, M., Cheal, D., Carr, G. W., Adair, R., Blood, K. and Meagher, D. (2018). *Advisory list of environmental weeds in Victoria*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 287. Department of Environment, Land, Water and Planning, Heidelberg, Victoria. ISBN 978-1-76077-001-3 (pdf/online).

Appendix A Decision making framework – with scenarios

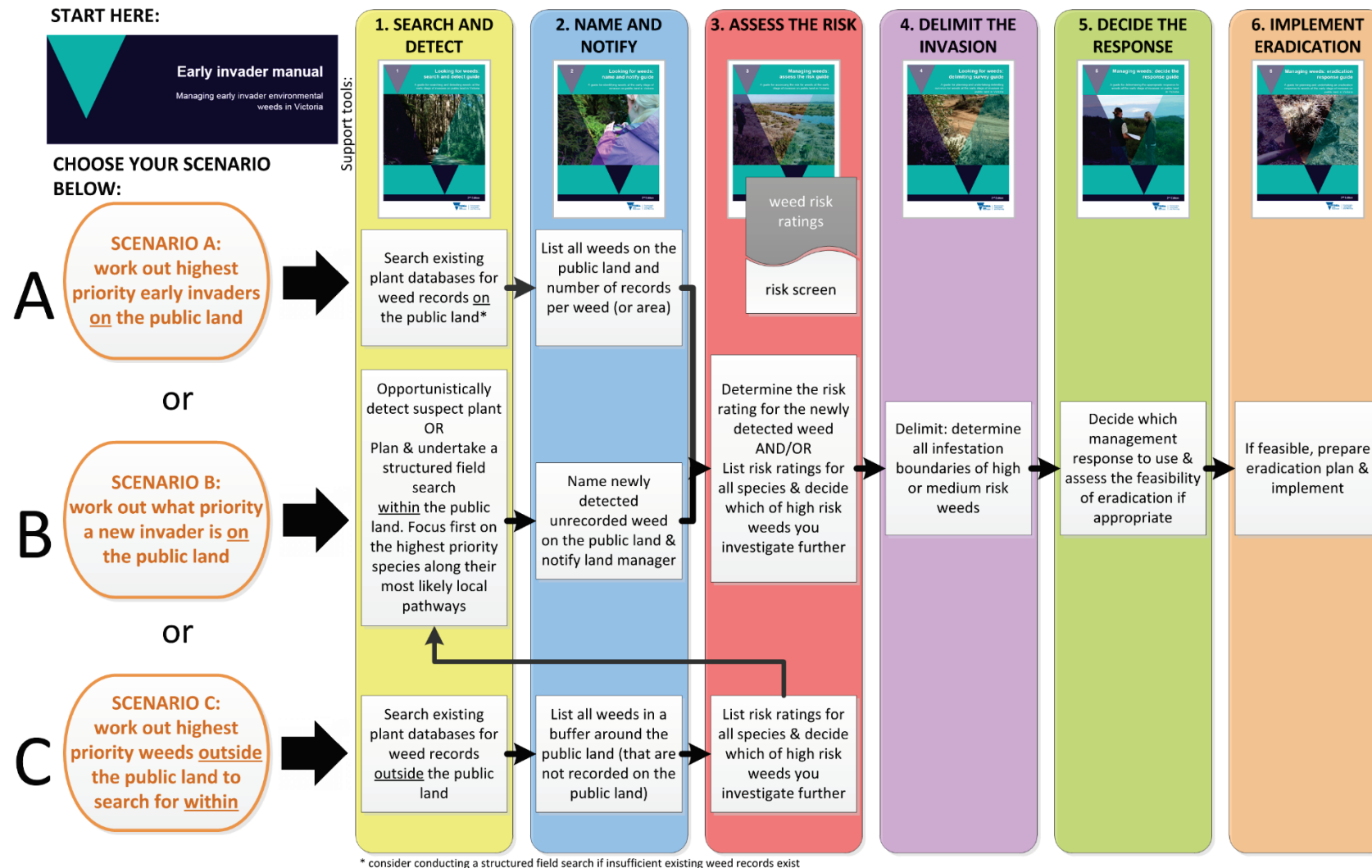


Figure 27: This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. This version illustrates three typical scenarios faced by public land and biodiversity managers.

Appendix B Case summary template

Use this template to record a summary of the decisions you make as you work through the decision making framework. An editable version of this template is available on the early invader website at <https://www.environment.vic.gov.au/invasive-plants-and-animals/early-invaders> Reminder: Attach case summaries to STAR and save on ECM to record your management decisions.

Last update:

CASE NAME: Botanical name: Common names: Date: Manager: Location: Region: Situation: Main contacts:	Simplified process:	1. SEARCH AND DETECT Use guide 1 Search weed records OR Search in the field OR Opportunistically detect suspect plant on or near the public land <input type="checkbox"/> Complete field recording template OR template for opportunistic sightings and herbarium specimens Record notes here:	2. NAME AND NOTIFY Use guide 2 List all weeds OR Name newly-detected plant on the public land <input type="checkbox"/> Complete template for opportunistic sightings and herbarium specimens Record notes here:	3. ASSESS THE RISK Use guide 3 List risk ratings for all OR newly detected weeds & decide which of high risk weeds you investigate further <input type="checkbox"/> Complete environmental weed risk screen score sheet template (if required) Record notes here:	4. DELIMIT THE INVASION Use guide 4 Delimit: determine all infestation boundaries of high or medium risk weeds <input type="checkbox"/> Complete search plan template for delimiting survey Record notes here:	5. DECIDE THE RESPONSE Use guide 5 Decide which management response to use & assess the feasibility of eradication if appropriate <input type="checkbox"/> Complete feasibility of eradication score sheet template Record notes here:	6. IMPLEMENT ERADICATION Use guide 6 If feasible, prepare eradication plan & implement it <input type="checkbox"/> Complete eradication response plan template Record notes here:	NOTES Distribution details recorded: <input type="checkbox"/> VBA: <input type="checkbox"/> STAR: <input type="checkbox"/> Other: Information sources: Chronology of actions/decisions:
		<input type="checkbox"/> Complete field recording template OR template for opportunistic sightings and herbarium specimens	<input type="checkbox"/> Complete template for opportunistic sightings and herbarium specimens	<input type="checkbox"/> Complete environmental weed risk screen score sheet template (if required)	<input type="checkbox"/> Complete search plan template for delimiting survey	<input type="checkbox"/> Complete feasibility of eradication score sheet template	<input type="checkbox"/> Complete eradication response plan template	
		Record notes here:	Record notes here:	Record notes here:	Record notes here:	Record notes here:	Record notes here:	
		Advisory list risk rating: OR Weed Risk Assessment risk ratings: OR Risk screen outcome:	Identification confirmed (date and by whom):	Delimiting survey outcome: <input type="checkbox"/> in early stage of invasion OR <input type="checkbox"/> beyond early stage of invasion	Weed management matrix outcome: Suitability for eradication outcome: Feasibility of eradication score:	Feasible to eradicate: <input type="checkbox"/> feasible OR <input type="checkbox"/> not feasible		

Department of Environment, Land, Water and Planning (DELWP), Victoria, Australia

WESI Kate Blood & Bianca Gold; DMF case summary Oct 2018 V3_A3

Appendix C Contacts

a) Contact the WESI project team

Contact the WESI project team for assistance with any stage of the process with early invaders.

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

The WESI project team:

Bianca Gold

bianca.gold@delwp.vic.gov.au

Phone via the Customer Service Centre 136 186.

Kate Blood

kate.blood@delwp.vic.gov.au

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 including Facebook, Yammer, Twitter and Instagram. Social media is a great way of seeking assistance with weed identification. Search for handle **@weedyk8** and hashtags **#WESIProj #weedID #invasivespecies #earlyinvaders**

b) Agency contacts

Victorian Government Customer Service Centre: 136 186 (for DELWP and Agriculture Victoria DEDJTR/DJPR)

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

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

Parks Victoria: 13 1963

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

Appendix D Information sources

Below are some information sources and tools available to assist in determining what weed could be focused on, along with existing priorities that can help narrow the search.

a) Advisory list of environmental weeds in Victoria, and Victorian environmental weed risk database

The “Advisory list of environmental weeds in Victoria” and the “Victorian environmental weed risk database” are *Excel* spreadsheets that contain risk ratings from different sources.

The *Excel* databases are decision support tools that can assist in generating lists of detection priorities of existing and potential species in and around a piece of public land at a particular date, helping to provide a structured approach to detection surveys on public land anywhere in Victoria. Information on how to use the databases can be obtained from Guide 3 ‘Assess the risk’.

b) Other priority weeds

i) State prohibited weed

State prohibited weeds are the highest category of declared noxious weeds in Victoria. By definition, they are either absent in Victoria, or present in small numbers, such that their eradication is still considered possible. Under the *Catchment and Land Protection Act 1994* (CaLP Act), it is an offence to buy, sell, display or transport a State prohibited weed within Victoria. Agriculture Victoria aims to prevent the introduction of State prohibited weeds into Victoria and to detect and eradicate any infestations before they become widespread. A list of State prohibited weeds and information on high-risk areas in Victoria can be obtained from the Agriculture Victoria website: <http://economicdevelopment.vic.gov.au/>. It is important to report any detection of State prohibited weeds (e.g. Figures 28 and 29) to the Customer Service Centre on 136 186.

ii) Regionally prohibited weeds

This is the second highest category of noxious weeds listed under the CaLP Act. While these weeds may not be eradicable from the State, they may be absent from regions or present only in small numbers, and therefore are considered regionally preventable or eradicable. Contact Agriculture Victoria for a list of Regionally prohibited weeds (e.g. Figure 30): <http://economicdevelopment.vic.gov.au/> or report any sightings on 136 186.

iii) Weeds of National Significance (WONS)

Weeds of National Significance (WONS) cause negative impacts to many of Australia’s natural and productive landscapes. Collaborative national action can help to reduce the impacts and prevent further spread of these weeds. Most WONS currently occurring in Victoria are widespread and some WONS do not currently occur in Victoria and have the potential to invade and spread. For information on the 32 WONS, their distribution, identification and management, visit <http://weeds.ala.org.au/WoNS/> and <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>



Figure 28: (left) Orange Hawkweed (*Hieracium aurantiacum*).

Credit: Agriculture Victoria

Figure 29: (right) King Devil Hawkweed. *Hieracium* species are State prohibited weeds in Victoria.

Credit: Agriculture Victoria



Figure 30: Bitou Bush, Regionally prohibited in parts of Victoria.

Credit: Hillary Cherry



c) Field guides

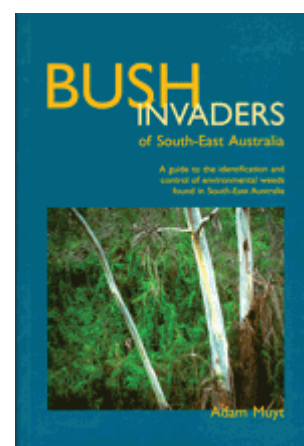
Bush invaders of South-East Australia: a guide to the identification and control of environmental weeds found in South-East Australia.

Author: Adam Muyt

Publisher: R. G. & F. J. Richardson.

Publication date: 2001.

Contains colour photographs, diagnostic features for identification, how they spread, similar looking plants and management information.



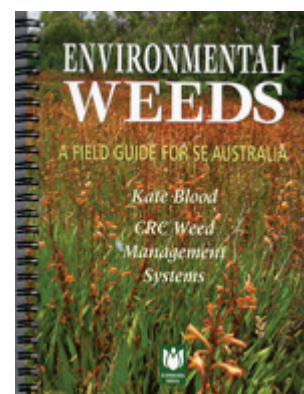
Environmental weeds: a field guide for SE Australia.

Author: Kate Blood

Publisher: Blooming Books, Melbourne.

Publication date: 2001.

Contains colour photographs, descriptions for identification, look-alikes, how they spread, ecology, reporting sheet to copy and distribution maps.



Weeds of the south-east: an identification guide for Australia (3rd edn).

Authors: F. J. Richardson, R. G. Richardson & R. C. H. Shepherd.

Publisher: R. G. and F. J. Richardson.

Publication date: 2016.

Contains colour photographs and includes brief descriptions and summary distribution information.



Flora of Victoria (Volumes 1-4).

Editors: D. B. Foreman and N. G. Walsh; and N. G. Walsh and T. J. Entwisle.

Publisher: Inkata Press.

Publication dates: Between 1993 and 1999.

Large books with botanical descriptions and keys for indigenous and introduced plants. Some line drawings, distribution maps and glossary of botanical terms. Updated information is now available at VICFLORA: <https://vicflora.rbg.vic.gov.au/>

Other specialist guides

Sainty, G. R. and Jacobs, S. W. L. (2003) *Waterplants in Australia. A field guide* (4th edn). Sainty and Associates, NSW.

Hosking, J., Sainty, G. and Jacobs, S. (2006) *Alps invaders. Weeds of the Australian high country* (2nd edn). Australian Alps Liaison Committee, Canberra.

Matters, J. and Bozon, J. (1995) *Spotting soil salinity: A Victorian field guide to salt indicator plants*. Department of Conservation and Natural Resource, Melbourne.

d) People, social media and networks including weed ID network

i) People

Often the best information is nearby, especially when it comes to when weeds arrived and where they occur. Tap into the knowledge of people by contacting them directly. Ask local DELWP, Agriculture Victoria or Parks Victoria staff for information. Contact your Catchment Management Authority, local governments, consultants and contractors. Tap into local community networks, including field naturalists, friends groups, Landcare groups, conservation groups, Weed Society of Victoria, garden clubs and horticultural groups etc.

ii) Social media

Connect with others through social media e.g. Facebook, Twitter, Instagram, and your agency's internal social media e.g. Yammer for DELWP. **Tip:** Try search terms and hashtags such as **#invasivespecies** **#earlyinvaders** **#invasiveplants** **#weeds** (but be prepared for drug related material) **#weedID** **#plantID**. There are a number of Australian state or regionally-based groups on Facebook including 'The Weed Society of Victoria Inc'. More information on the use of social media for sharing information on invasive species can be found in Blood, 2016.

The WESI team **#WESIProj** is utilising social media for weed identification (weedID) support using the **#weedID** search term/hashtag.

There are internet-based networks of weed practitioners such as:

iii) Enviroweeds

The ENVIROWEEDS listserver was created by the Cooperative Research Centre for Australian Weed Management (Weeds CRC) to help distribute and discuss information on the management of environmental weeds in natural ecosystems mainly in Australia. The Weeds CRC no longer exists but the listserver is still hosted by the University of New England. Participants can share information, ask questions, participate in discussions and respond to the queries of others.

The audience is those who are managing natural ecosystems, whether on private or public land and water, or those working with environmental weed information.

You can subscribe for free at <https://mail.une.edu.au/lists/cgi-bin/listinfo/enviroweeds>

iv) ALIENS-L

ALIENS-L is the mailing list of the Invasive Species Specialist Group (ISSG) (www.issg.org) of the International Union for Conservation of Nature (IUCN) Species Survival Commission. The group aims to "reduce the threats posed by invasive species to natural ecosystems and their native species, through increasing awareness of invasive species and means of controlling or eradicating them". This list is a contribution to that mission. It allows users to freely seek and share information on invasive species and the threats which they pose to the biodiversity of our planet.

The ISSG is a worldwide network of experts on the conservation impacts of invasive species. Membership is by invitation, but it is not necessary to be a full member of the group to contribute to the cause of reducing conservation threats posed by invasive species.

ISSG provides advice on threats from invasive species and control or eradication methods to IUCN members, conservation practitioners, and policy makers. The group concentrates on reducing or preventing the adverse effects of alien invasions on conservation values.

The list homepage: <https://list.auckland.ac.nz/sympa/info/aliens-l>

General information about mailing lists: <https://list.auckland.ac.nz/sympa/help/introduction>

e) Mobile apps

The development of mobile applications (apps) for mobile phones and tablets is a rapidly growing area. Mobile apps are useful to have in the field where there is internet connectivity. Apps can assist with field data collection, mapping and identification.

f) On-line information

i) Agency internal information on weeds, their distribution and management

Spatial, Temporal, Activity Recorder (STAR) (for DELWP and Parks Victoria):
<https://star.biodiversity.vic.gov.au> (performs best in Google Chrome)

Victorian Biodiversity Atlas (VBA): <https://www.environment.vic.gov.au/biodiversity/victorian-biodiversity-atlas>
and for log-in: <https://vba.dse.vic.gov.au/vba/#/>

Environmental Information System (EIS) (access through Parks Victoria)

Bioweb, Bioweb2, MAX (access through Agriculture Victoria)

Crown Land Manager (CLM) Pest Infestation Sites (access through DELWP)

Local databases, spread sheets, maps, GIS layers, works plans of weed infestations, note books, filing systems, and registry files

Local reserve, forest, and park etc. management plans that may include weed lists

ii) Plant Identification and information

Weeds in Australia (Federal Government) <http://www.environment.gov.au/biodiversity/invasive/weeds/>

Weed information notes including environmental weeds - Agriculture Victoria:
<http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/weeds/a-z-of-weeds>

Various keys including weeds at Lucid: <https://keyserver.lucidcentral.org/>

Fact sheets on over 1,000 species: <https://keyserver.lucidcentral.org/weeds/data/>

Lucid key to Environmental Weeds of Australia (originally developed with CRC Weed Management & updated by Qld Herbarium) is online Apps iOS - <https://itunes.apple.com/au/app/environmental-weeds-australia/id898685476?mt=8> ; Android - <https://play.google.com/store/apps/details?id=org.lucidcentral.mobile.ewa&hl=en>

Weeds of National Significance (WONS): <http://weeds.ala.org.au/WoNS/> and <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>

National Herbarium of Victoria - Identification (some services for fee) and information services. Herbarium specimens and records viewable through Australia's Virtual Herbarium (AVH) & Atlas of Living Australia (ALA) otherwise by appointment with the Herbarium: <https://www.rbq.vic.gov.au/science/herbarium-and-resources/identification-and-information-services>

VICFLORA – Flora of Victoria, comprehensive and current guide to the wild plants of Victoria including weeds. Includes plant profiles, identification tools and illustrations: <https://vicflora.rbq.vic.gov.au/>

Victorian Noxious weed status - Weeds declared in Victoria under the *Catchment and Land Protection Act 1994* (CaLP Act), are listed at the Agriculture Victoria website: <http://economicdevelopment.vic.gov.au/>. Information is also available through the Customer Service Centre on 136 186.

Local Government Resources - Use your favourite search engine to search for local government brochures and field guides.

iii) Weed risk and biodiversity modelling

Advisory list of environmental weeds in Victoria - <https://www.environment.vic.gov.au/invasive-plants-and-animals/weed-risk-ratings> or web search for 'early invaders Victoria weed'.

Victorian environmental weed risk database – as above for advisory list.

Weed risk assessments - available on Victorian Resources Online (VRO) (see Guide 3 'Assess the risk' for more detail on risk ratings):
http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_plants_common_a

Weed Futures - decision-support tool to interrogate profiles for over 500 species within Australia and assess weed threats for regions of interest under current and predicted future climates: <http://weedfutures.net/>

NatureKit - tool to map and report on Victoria's biodiversity values and investment prospects. Includes NaturePrint and Strategic Management Prospects (SMP):
<http://maps.biodiversity.vic.gov.au/viewer/?viewer=NatureKit>

iv) Weed lists and distribution

VICFLORA – Flora of Victoria, comprehensive and current guide to the wild plants of Victoria including weeds. Includes plant profiles, identification tools and illustrations: <https://vicflora.rbg.vic.gov.au/>

NatureKit - tool to map and report on Victoria's biodiversity values and investment prospects: <http://maps.biodiversity.vic.gov.au/viewer/?viewer=NatureKit>

Victorian Biodiversity Atlas (VBA): <https://www.environment.vic.gov.au/biodiversity/victorian-biodiversity-atlas> and for log-in: <https://vba.dse.vic.gov.au/vba/#/>

Australia's Virtual Herbarium (AVH): <http://avh.chah.org.au/>

Atlas of Living Australia (ALA): <http://www.ala.org.au/>

Flora Information System (FIS), and Illustrated Flora of South-east Australia - available from Viridans Pty Ltd.

iNaturalist: <https://www.inaturalist.org/>

Global Biodiversity Information Facility (GBIF): <http://www.gbif.org/>

v) Names and nomenclature

VICFLORA – Flora of Victoria guide to the wild plants of Victoria including weeds: <https://vicflora.rbg.vic.gov.au/>

Australian Plant Name Index (APNI): <http://www.anbg.gov.au/apni/>

Australian Plant Census (APC): <http://www.anbg.gov.au/chah/apc/>

International Plant Names Index (IPNI):
<http://www.ipni.org/ipni/plantnamesearchpage.do>

More useful plant name links here:
<https://www.anbg.gov.au/cpbr/databases/names.html>

vi) Grass information

Grassbase the Online World Grass Flora: <https://www.kew.org/data/grasses-db.html>

AusGrass2: <http://ausgrass2.myspecies.info/>

vii) Opuntoid Cacti information

Managing Opuntoid Cacti in Australia manual and field identification guide:
<https://www.agric.wa.gov.au/invasive-species/opuntoid-cacti-best-practice-control-manual>

Opuntoid Cacti resources: <http://weeds.ala.org.au/WoNS/opuntoidcacti/>

Australian Invasive Cacti Network: <http://www.aicn.org.au/>

Global working group on the management of cactus species:
<http://academic.sun.ac.za/cib/projects/cactuswg/invasivecactus.asp>

viii) Other resources

Global compendium of weeds (3rd edition) has over 3,000 pages and there are several sources of this document:

<https://www.cabi.org/isc/FullTextPDF/2017/20173071957.pdf> or

https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/Compendium_3rd_Edition_2017.pdf or

<https://nla.gov.au/nla.obj-512788350/view>

Centre for Invasive Species Solutions (CISS). Expect to see more weed information on this website in the future: <https://invasives.com.au/>

VicVeg online: <http://www.vicveg.net.au/vvInfo.aspx>

BioControl Hub: <https://biocollect.ala.org.au/biocontrolhub>

BioCollect Hubs: <https://www.ala.org.au/biocollect/biocollect-hubs/>



Appendix E Search plan template

Use for structured field searches including search and detect surveys and delimiting surveys. Reminder: Attach optional weed search plans to STAR and save on ECM.

General weed information

Scientific name:	Photo
Common name:	Source:

Purpose of the search

(For search and detect, delimiting, or monitoring surveys. Simple statement)

Identification characteristics

Life form (e.g. tree, shrub, climber, creeper, herb, succulent, grass):

Leaves:

Flower:

Fruit:

Spines:

Stems/bark:

Look-alike plants:

Biology and spread mechanisms

(e.g. reproduction method, annual growth cycle, dispersal mechanisms, vectors)

Method of reproduction (e.g. seed, vegetative, suckering)

Seed longevity (e.g. seeds can remain dormant in the soil up to x years)

Budbank (e.g. tubers underground)

Timing of flowering and fruiting

Time between flowering and seed set

Spread by (e.g. wind, water, garden dumping, humans, animals)

Dormancy (Is the plant dormant below the ground at certain times of the year?)

Understand your site Consider:
habitat preference, land use/tenure
of survey area, topography, access,
vegetation types present

Previous recorded sightings locations

(e.g. any previous surveys indicate plant was present in the past, or where it could spread. Check VBA, AVH, ALA, CLM, local records etc)

Potential sites, sources and vectors in the survey area

(i.e. where the weed is likely to have come from, places the weed is more likely to establish, how the weed got there and where it could spread to)

Identify, prioritise and map the search areas within your site

Operational information related to carrying out survey

Preferred search period: (e.g. during flowering from mid-August to mid-September)

Expected time required to complete search: (e.g. 4 days with 2 people)

Search intervals: (times between subsequent searches; how often are repeat surveys required?)

Special notes (e.g. people to contact or particular site/weed hazards, permits or special equipment required)

Absence data: (did you record if weed was absent?)

Data collection method: (paper, mobile device, specify software/method)

Search focus: (was the focus on a weed species, pathway or site?)

Search technique(s): (vehicle, on foot, aerial, detector dog etc?)

Data storage: (where have you recorded your data e.g. VBA, STAR etc?)

VBA: Victorian Biodiversity Atlas, FIS: Flora Information System, AVH: Australian Virtual Herbarium, CLM: Crown land manager

Prepared by:

Date:

References:

Appendix F Equipment for a field search/survey

These are the items that could be carried in your vehicle so you can collect the information and material you need if you find a potential weed at the early stage of invasion. Keep a field kit in an easy-to-lift plastic box(es) ready for quick deployment. Adapt for your own purposes.

Develop a checklist for field surveys that can be used on each trip. A list in 'Word' with check boxes can easily be updated and printed for future field trips or use a list applications (apps) (similar to a shopping list) on your mobile device. Tip: Laminate a copy of the checklist and attach it to the lid of the box.

- Hand-held GPS and spare batteries or charger
- Maps or pre-loaded maps & search polygons on the GPS or mobile device
- Native plant and weed identification books, pamphlets, mobile device apps etc.
- Recording equipment such as mobile device, clipboard, notebook, pens that don't run in the wet, pencils
- Recording sheets - digital and printed (see Appendices G and I) (paper sheets are a good back-up if devices fail)
- Camera/devices with spare batteries and capacity for photographs and video
- Materials for marking infestations (i.e. bright coloured survey ribbon)
- Hygiene equipment to reduce weed and soil-borne disease spread
- Plastic bags, secateurs
- Gloves, pliers and long-handled tongs for handling prickly plants
- Plant press – if you are trained and competent in collecting plant specimens
- Hand lens
- Relevant permits and access permission documentation

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

- Approved job safety plan and emergency contact numbers and radio frequencies
- First-aid kit and snake bite kit;
- Personal protective equipment; and
- Satellite phone and emergency position-indicating radio beacon (EPIRB) if in remote locations.

Appendix G Field recording template – single

Record opportunistic sightings in the Victorian Biodiversity Atlas (VBA). Use the VBA Go app in the field. Use this sheet (one site or weed per sheet) to accompany specimens to the National Herbarium of Victoria. Attach the sheet to the appropriate project in Spatial, Temporal, Activity Recorder (STAR).

*Required fields

Observer details	
Person recording*:	
Phone number*:	
Email*:	
Date sighted/collected*:	____/____/20____

Weed location	
Describe where it is* (Address; or distance & direction from place; or attach mud map)	
GPS reading* Datum used with GPS*	Grid Reference E _____ N _____ Latitude ____° ____, ____ S Longitude ____° ____, ____ E <input type="checkbox"/> WGS84 <input type="checkbox"/> GDA94 <input type="checkbox"/> Other
Patch type* (check)	<input type="checkbox"/> Point (one or few plants) <input type="checkbox"/> Linear (e.g. roadside) <input type="checkbox"/> Polygon (non-linear shape)
Land tenure (check)	<input type="checkbox"/> Private <input type="checkbox"/> Public / government <input type="checkbox"/> Roadside <input type="checkbox"/> Unsure
Land use* (check)	<input type="checkbox"/> Agriculture <input type="checkbox"/> Horticulture <input type="checkbox"/> Forestry <input type="checkbox"/> Garden <input type="checkbox"/> Conservation <input type="checkbox"/> Roadside <input type="checkbox"/> Urban <input type="checkbox"/> Aquatic <input type="checkbox"/> OTHER _____
Land owner (if known)	

Weed characteristics	
Plant name (if known)	Scientific preferable
Number of plants* (check)	<input type="checkbox"/> 1 - 10 <input type="checkbox"/> 10 – 50 <input type="checkbox"/> 50 + OTHER: _____
Area of infestation* (check)	<input type="checkbox"/> under 1 m ² <input type="checkbox"/> 1-10 m ² <input type="checkbox"/> 10-100 m ² <input type="checkbox"/> over 100 m ² OTHER: _____
Plant form* (check)	<input type="checkbox"/> Tree <input type="checkbox"/> Shrub <input type="checkbox"/> Herb <input type="checkbox"/> Vine <input type="checkbox"/> Grass <input type="checkbox"/> Aquatic <input type="checkbox"/> OTHER
Maturity (check)	<input type="checkbox"/> Mature <input type="checkbox"/> Intermediate <input type="checkbox"/> Seedling (may be more than one growth stage present)
Reproductive state (check)	<input type="checkbox"/> No flowers <input type="checkbox"/> Flower or bud <input type="checkbox"/> Fruiting <input type="checkbox"/> Seeding <input type="checkbox"/> Vegetative parts
Comments	
Photos	Close-up (file names): _____ Habitat (file names): _____
Plant specimen details (if applicable)	

Post or deliver specimens and information to: Identifications and Information Service, Royal Botanic Gardens Victoria, Private Bag 2000, South Yarra, Victoria 3141. Fees may apply. More information at <https://www.rbg.vic.gov.au/science/herbarium-and-resources/identification-and-information-services>

Appendix H Wellbeing, safety and hygiene

a) 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:
 - i. spines or barbs that may have sheaths, toxins or irritants. Avoid stick injuries and treat punctures immediately.
 - ii. sap that can cause skin irritation immediately or after exposure to sunlight.
 - iii. fine hairs that can cause skin irritation and become lodged in clothing, or inhaled.
 - iv. pollen and perfumes that can cause allergic reactions including respiratory irritation and hayfever.
- Tip: 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 Opuntoid 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.

b) 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 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.
- Reminder: 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*).

c) Support

Working with invasive species can be overwhelming at times. Seek help if you are feeling anxious, 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 I Field recording template – multiple records

If you don't have digital field data capture, use this optional sheet for recording multiple species or multiple sites of the same species on public land during structured field searches. Reminder: Attach field recording sheets to STAR and save on ECM. The VBA has a bulk upload template if required.

Recorder details		Name: Name of people assisting:					Inspection date:		
Site details (site = the property/parcel boundary within which the weed propagules are located)		Location:					GPS accuracy (m):		
		Site address/name:					Datum: <input type="checkbox"/> GDA 94 <input type="checkbox"/> WGS84		
		Location description:					MGA Zone: <input type="checkbox"/> Zone 54 <input type="checkbox"/> Zone 55		
		Land tenure (e.g. State Forest, National Park):					Survey method: <input type="checkbox"/> Searching <input type="checkbox"/> Delimiting survey (determine infestation boundaries) <input type="checkbox"/> Treatment monitoring survey <input type="checkbox"/> Ad hoc (opportunistic detection)		
GPS ref #	Species	Pattern of infestation (Individual, Scattered, Continuous) For point data	Density % cover (less than 1%, 1-5% 6-25%, 26-50% 51-75%, 76-100%) For line & polygon data	Area of infestation For point data	Count	Age class (e.g. seedling, juvenile, sapling, mature)	Eastings	Northings	Comments (e.g. roadside, gully)
e.g. 1	<i>Cenchrus ciliaris</i>	Scattered	6-25%	5x5 m	20	seedling	548011	6207117	2 m from road edge on north side

Appendix J Feasibility of eradication score sheet

How to use the score sheet template (Table 4) below for weeds at the early stage of invasion and under consideration for local eradication on public land:

1. Record the appropriate score for each question then sum the scores at the bottom of the table.
2. The score produced by using the table gives an indication of the comparative eradication effort i.e. the effort required to eradicate a weed from a particular place. It is only an estimate but can be a useful guide, especially when trying to determine if one weed is more feasible to eradicate than another. There is no cut-off or threshold score – you do as much as you can with the funding available.
3. Attach a copy of the completed score sheet to the appropriate record in the Spatial, Temporal, Activity Recorder (STAR) and save on ECM.

Table 4: Feasibility of eradication score sheet (based on the work of Panetta and Timmins (2004) and Dodd *et al.* (2015), with modifications according to Aaron Dodd, Kate Blood and Bec James).

Species:	Name of assessor:
Location of weed:	Date of feasibility assessment:

Factor	Feasibility of eradication question	Score options for <u>gross</u> infestations e.g. “can we eradicate weed from the park?”	Score
Area ##	What is the gross area of the weed infestation being assessed? (See Figure 31 below)	Less than 1 ha = score 0	
		2 to 10 ha = score 2	
		10 to 100 ha = score 4	
		100 to 1,000 ha = score 6	
		Greater than 1,000 ha = score 12	
Number ##	How many infestations are there? Infestations are geographically distinct and not as feasible if crew have to pack up equipment and drive between infestations.	1 = score 0	
		2 to 3 = score 3	
		Greater than 3 = score 6	
Site accessibility ##	What is the general accessibility of infestations? Consider terrain, ability to move through vegetation, travel times and seasonal difficulties (e.g. flooding).	Low (most sites difficult to access) = score 6	
		Medium (most sites readily accessible) = score 3	
		High (all sites readily accessible) = score 0	

Factor	Feasibility of eradication question	Score options for <u>gross</u> infestations e.g. “can we eradicate weed from the park?”	Score
Detectability period ##	Is the weed conspicuous within the matrix of invaded vegetation? Score for the type of vegetation in which the weed would be expected to be least visible.	Yes, conspicuous (i.e. easy to see) stage lasting for:	
		Less than 1 month = score 12	
		1 to 3 months = score 6	
		Greater than 3 months = score 1	
Search/detection distance ##	For plants that reproduce by seeds or detachable vegetative propagules, how detectable is the species prior to reproduction? Score for the type of vegetation in which the weed would be expected to be least visible.	Difficult to detect (non-emergent from vegetation and with no distinctive features) = score 6	
		Moderately easy to detect (either emergent or with distinctive features) = score 3	
		Very easy to detect (emergent and with distinctive features) = score 0	
Vegetative reproduction	Can the species reproduce through detachable vegetative propagules i.e. bulbils, aerial tubers, stem segments?	Yes = score 3	
		No = score 0	
Pre-reproductive (juvenile) period	For species that reproduce by seeds or detachable vegetative propagules, what is the <u>minimum</u> length of the pre-reproductive period?	Less than 1 month = score 6	
		1 to 12 months = score 4	
		1 to 2 years = score 2	
		Greater than 2 years = score 0	
Propagule longevity	What is the <u>maximum</u> longevity of seeds or detachable vegetative propagules? **	Greater than 10 years = score 6	
		5 to 10 years = score 4	
		2 to 5 years = score 2	
		Less than 2 years = score 0	
		Default in absence of information = score 4 for seed-producing species; score 0 for those producing vegetative propagules	
Treatments	How many treatments are required to control the largest plants? 'Largest plants' may be clones in vegetatively reproducing species.	Number of treatments = score n (where 'n' is the number of treatments)	
		Does more than 10% of the	
		Yes = score 3	

Factor	Feasibility of eradication question	Score options for <u>gross</u> infestations e.g. “can we eradicate weed from the park?”	Score
	total infestation occur in situations that require treatment methods that are more expensive than standard methods? For example, proximity to watercourses may limit use of herbicides.	No = score 0	
Propagule dispersal	Potential for managing propagule dispersal. Affects ease of containment and area over with searching must be conducted. Human-mediated dispersal should be easier to influence.	Dispersal primarily abiotic (e.g. wind and/or water) or biotic (i.e. from living organisms) but not involving humans = score 6	
		Dispersal occurs through a balanced mixture of human- and non-human-mediated modes = score 3	
		Dispersal primarily human-mediated (includes stock) = score 0	
	Total	Add scores together	

** For more information on modelling persistence of seeds, see Long *et al.* 2015, and Panetta 2015.

Information that needs to be collected in the field for this site.

Definitions of terms used in this score sheet appear in the glossary.

Gross and net infestations - Net infested area is the area requiring treatment (Panetta and Timmins 2004; Dodd *et al.* 2015), while gross infestation area includes the net areas that require treatment plus the surrounding area that must be searched in return trips following treatments (Panetta and Timmins 2004).

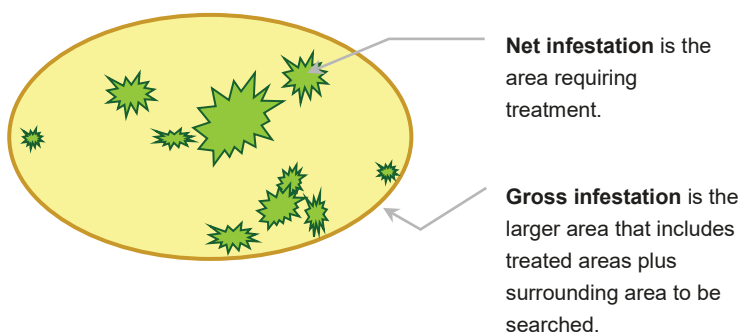


Figure 31: Illustration explaining the difference between net and gross infestations.

Vegetative structures, joined or detachable - Propagules are detachable structures that can grow into new plants. These are commonly seeds, but also include detachable vegetative structures such as stem segments, bulbils, and aerial tubers. Vegetative reproduction can occur via such detachable structures, but more commonly occurs via connected or joined vegetative structures, such as roots, rhizomes, stolons or creeping stems. The latter contribute to local spread, whereas seeds and detachable vegetative structures can be dispersed, thereby contributing to spread over larger areas (Panetta 2016).

Appendix K Eradication response plan template

Use for all eradication cases. Much of the information for your case has already been accumulated in earlier templates in the process and can be copied into this template. Reminder: Attach eradication response plans to STAR and save on ECM.

General weed information

Scientific name:	Photo
Common name:	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 [continue for required number of years]:

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 requirements

Site (e.g. avoid movement through infested site) .

Transport (e.g. wash down vehicle and equipment prior to entering and leaving infested site) .

Disposal (e.g. deep burial) .

Treatment strategies

Method	Method detail	Situation	Timing	Comments
e.g. Chemical control, mechanical control	List all possible treatments and consider all life stages and follow up treatments	e.g. a dense infestation, sensitive area (threatened species, EVCs), along watercourse	(months)	(record observations on target response)
Chemical*	.			.
Mechanical control	.			.
Other	.			.

Source:

***Off-label permit required?** Yes No **Comments:**

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

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

5. Other (specify) Yes/No

Site works plan

Works plan						Annual works 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 Parks Victoria specify which)
Year 1 – 2018/19														
Year 2 – 2019/20														
Year 3 – 2020/21														
Year 4 – 2021/22														
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

Prepared by:

Date:

References:

Appendix L Choosing chemicals in Victoria

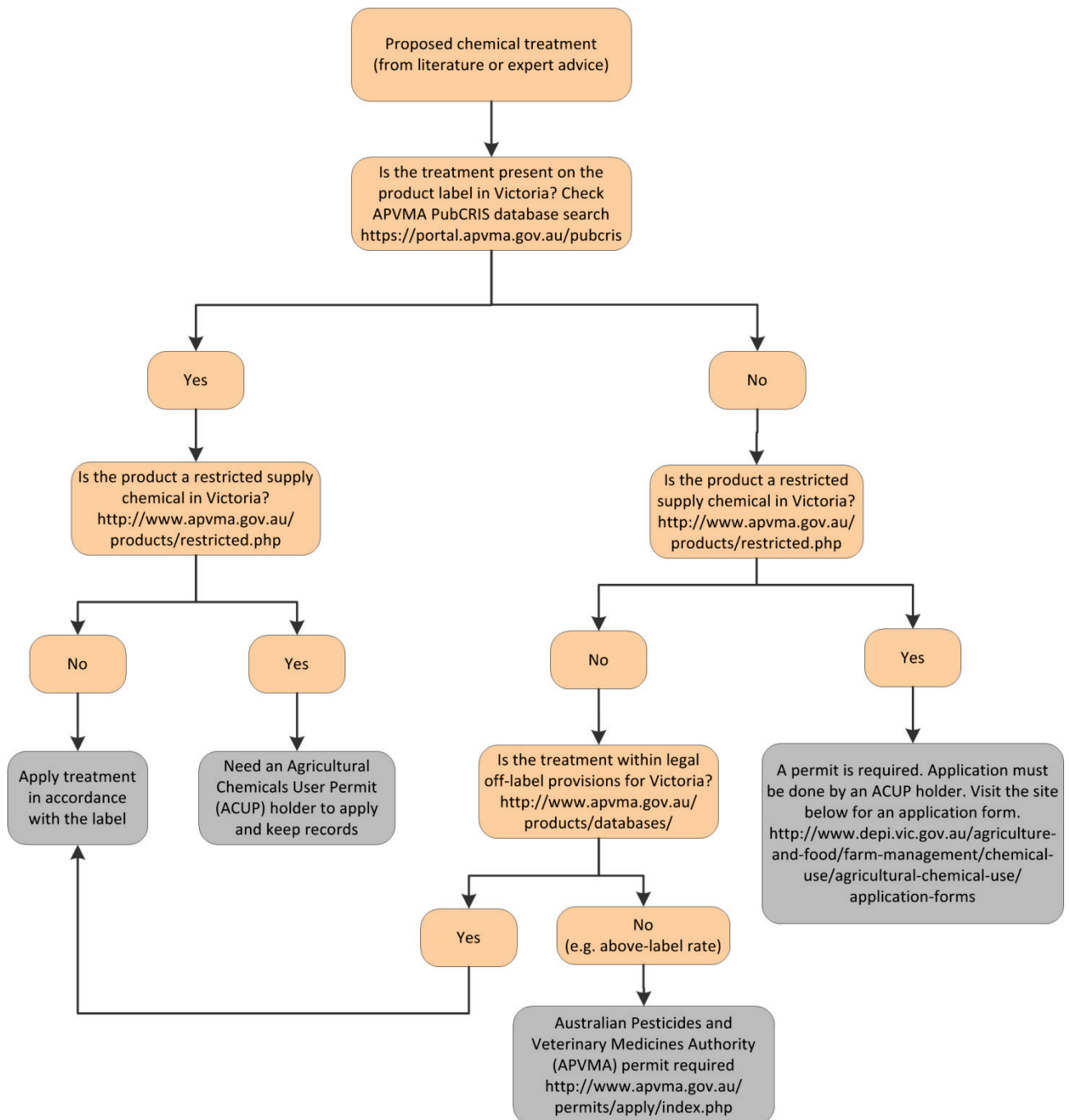


Figure 32: A guide to choosing an appropriate chemical for the control of invasive plants in Victoria (based on Nigel Ainsworth 5/3/2014).

11. Abbreviations and glossary

Abbreviations

ACUP	Agricultural Chemicals Users Permit	id, ID	identification
ALA	Atlas of Living Australia	iOS	Apple mobile device operating system
app	application	ISBN	International Standard Book Number
APVMA	Australian Pesticides and Veterinary Medicines Authority	ISSG	Invasive Species Specialist Group
ASAP	as soon as possible	IUCN	International Union for Conservation of Nature
AVH	Australia's Virtual Herbarium	km	kilometre
CaLP	Catchment and Land Protection	m	metre
CISS	Centre for Invasive Species Solutions	MGA	Map Grid of Australia
CLM	Crown Land Manager	NSW	New South Wales
DEDJTR	Department of Economic Development, Jobs, Transport and Resources (replaced by DJPR on 1 January 2019)	OH&S, OHS	Occupational Health and Safety
DELWP	Department of Environment, Land, Water and Planning	pdf	Portable Document Format
DJPR	Department of Jobs, Precincts and Regions (commencing 1 January 2019) and includes Agriculture Victoria	PubCRIS	Public Chemical Registration Information System
ECM	Enterprise Content Management	Qld	Queensland
edn	edition	SMP	Strategic Management Prospects
e.g.	example	sp. (singular)	species
EPIRB	Emergency Position Indicating Radio Beacon	spp. (plural)	species
<i>et al.</i>	et alia	ssp., subsp.	subspecies
etc.	et cetera	syn.	synonym
EVC	Ecological Vegetation Class	STAR	Spatial, Temporal, Activity Recorder
GDA	Geocentric Datum of Australia	UAV	unmanned aerial vehicle
GIS	Geographic Information System	URL	Uniform Resource Locator
GIST	general impression of size and texture	var.	variety
GPS	Global Positioning System	VBA	Victorian Biodiversity Atlas
ha	hectare	Weeds CRC	Cooperative Research Centre for Australian Weed Management
		WESI Project	Weeds at the Early Stage of Invasion Project
		WONS	Weed of National Significance
		WRA	weed risk assessment

Glossary

Abiotic - Not involving living organisms (Beentje 2010).

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.

Annual - A plant that completes its lifecycle in one year or less. It grows from seed, matures, flowers and produces seed before dying.

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).

Authoritative identification - See 'determination'.

Biennial - A plant that completes its lifecycle in more than one year, but less than two years. It grows from seed, matures, flowers and produces seed before dying.

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).

Biomes - Groupings of bioregions that are a landscape-scale approach to classifying the environment using a range of attributes such as climate, geomorphology, geology, soils and vegetation. There are 28 bioregions identified within Victoria (White *et al.* 2018).

Bioregion - Broad scale mapping unit that captures the patterns and ecological characteristics in the landscape. These units classify the environment using a range of attributes such as climate, geomorphology, geology, soils and vegetation. There are 28 bioregions identified within Victoria.

Biosecurity - A process designed to mitigate the risks and impacts to the economy, the environment, social amenity or human health associated with pests and diseases (Victorian Government 2010).

Biotic - Biotic factors are environmental influences that arise from the activities of living organisms (as distinct from e.g. climatic factors) (Abercrombie *et al.* 1973).

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).

Buffer - An area around, in this case, public land in which weeds are searched for and treated to prevent them reaching the public land. The radius of the buffer could be hundreds of metres to 5, 10 or 20 km depending on the situation.

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).

Case - In this instance, a particular site or species related circumstance.

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).

Cost-benefit analysis - A technique to compare options by analysing the total costs expected for an option versus the total expected benefits, to determine if the benefits outweigh the costs, and to what extent.

Cultivar - Cultivated variety, a variety developed in cultivation. An assemblage of cultivated individuals distinguished by any characters significant for the purposes of agriculture, forestry or horticulture, and which, when reproduced such a variety retains its distinguishing features (FloraOnline 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).

Desk-top search - A search that focuses on data sources such as weed databases, publications and spatial or mapping systems, to compile distribution records or observations of a weed or list of weeds in an area. They typically are carried out on computer or through publications while at a desk, and increasingly anywhere with mobile technology. The desk-top search is a component of structured (active) searching.

Detectability - The probability of a particular target individual being detected using a particular sampling technique (Hester *et al.* 2010).

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).

Determination (authoritative identification) - Giving the correct name to a specimen: identification (Albrecht 1993).

Drone - See 'unmanned aerial aircraft'.

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).

Engagement - Planned process with the specific purpose of working with identified groups of people to address issues affecting their well-being. The broad interactions between people including one-way communication, information delivery, consultation, involvement, collaboration, and empowered action. Can cover extension, communication, education, public participation, and working in partnership (Riches 2005 book 1).

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).

Environmental weed risk screen, risk assessment screen - A method designed to identify species that pose the greatest weed risk, based upon measures of (or characteristics related to) invasiveness (the 'likelihood' component of risk) and impact (the 'consequence' component of risk). The screen was developed in 2015 to assess the weed risk posed by a plant that has been either newly detected, or has been known to be present for some time but not assessed previously. Its purpose is to provide a means for identifying the plants that pose the highest threat to biodiversity, particularly on public land at the local scale e.g. national park, conservation reserve, State forest.

Epithet - Used for the words in a combination other than the generic name and any rank-denoting term (International Code of Nomenclature 2013).

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 effort - The effort required to eradicate a weed from a particular place. Estimates of eradication effort are by nature crude, but can be useful guides, especially when trying to determine if one weed is more feasible to eradicate than another.

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

Established - A species that, for the foreseeable future, will perpetuate within an area after entry (Victorian Government 2010).

Extirpation - Denotes local, as opposed to global, elimination of a species (Panetta 2007). For this manual 'localised 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).

Feasibility of eradication score sheet - A score sheet consisting of a number of questions that calculates the probability that eradication will be achieved.

Genus - Consists of one or more kinds of plants that share a distinctive set of characters (i.e. closely related species). Its name is a singular noun in Latin form, such as *Rhododendron* (Spencer *et al.* 2007). Plural is 'genera'.

Geotagging - The process of adding geographical identification metadata to various media such as a geotagged photograph or video, constituting a form of geospatial metadata. These data usually consist of latitude and longitude coordinates, though they can also include altitude, bearing, distance, accuracy data, and place names (Reference viewed online 1/9/2015: <https://en.wikipedia.org/wiki/Geotagging>).

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).

Impact - The effects that an alien plant species has on native species, supported with quantitative data (e.g. 'the invasion impacted the native species by reducing its density by 70% within 12 months'). However, where weed risk assessment is concerned the term impact is generally employed in the context of whether a weed species has the ability to cause an impact, rather than by describing the actual impact (Downey *et al.* 2010).

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.

Introduced (exotic) - Not native to the area; not indigenous (FloraOnline 2010).

Introductory pathways - See 'pathways'.

Invasion - The process of spread (see 'invasive plants'). The propensity to spread (invasiveness) is one of the two components of weed risk assessment, the other being impact. It is important not to confuse these two components (Panetta 2016).

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).

Invasive species - A species occurring, as a result of human activities, beyond its accepted normal distribution and which threatens valued environmental, agricultural or other social resources by the damage it causes (Victorian Government 2010).

Juvenile period (synonym pre-reproductive period) - The time between when a plant appears as a seedling and when it first produces propagules (Panetta 2016).

Land tenure - The status of the land e.g. private or Crown land (Blood and James 2016b).

Line survey - A survey often along a linear feature such as a roadside, and defined by start and end coordinates.

Local performance - On-ground evidence of a plant's invasiveness and impact (as opposed to the predictions of invasiveness and impact that are generated through desktop weed risk assessment procedures) (Panetta 2016).

Look-alikes - Plants that look similar and can be confused with another species of plant (Blood and James 2016a).

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.

Native species - Species that is believed to have occurred in a specified part of Australia prior to European settlement (Victorian Government 2010).

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.

Opportunistic search or detection - Casual, chance observation, where searching is not planned or carried out deliberately but detection of a weed occurs incidentally while undertaking another, unrelated activity. Also known as passive, casual, incidental or ad-hoc search or detection.

Parcel - A defined piece of land.

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>).

Pathway - The combined processes that result in, or drive, the introduction of non-indigenous species from one geographical location to another (Panetta 2016).

Pathway analysis - Identifies the invasion pathways (for both deliberate and accidental introductions), assesses the degree of risk associated with each and the management options needed for high risk pathways. Pathway analysis also identifies weak links in the invasion pathways and the species which use high risk pathways (Downey *et al.* 2010).

Pathway focus - A search that concentrates on pathways of introduction and spread for a suite of weeds.

Perennial - A plant whose life-span is longer than two growing seasons i.e. longer than an annual or biennial.

Pest plant score - A single weighted score generated when a weed is assessed against 41 questions in the Victorian Weed Risk Assessment process. This score can be compared to other weeds that have been assessed using the same process.

Point location - A pair of coordinates used to pinpoint a location.

Polygon - A number of joined spatial points representing an area when the first point is joined to the last (Sheehan *et al.* 2016).

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

Pre-reproductive period (synonym Juvenile period) - The time between when a plant appears as a seedling and when it first produces propagules (Panetta 2016).

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

Probability - The likelihood that something will occur.

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).

Provisional name - A proposed name for a plant until it is verified at an Herbarium.

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

Recognition - The ability to be able to instantly recognise a plant, if it is a weed or indigenous, possibly even be able to name it. It is the ability to know that a plant fits within the context that you are viewing it. You may not be able to recall its full botanic name, even its common name, but you know that you have seen it before.

Regionally Prohibited weeds - Are not widely distributed in a Region but are capable of spreading further. It is reasonable to expect that they can be eradicated from a Region and they must be managed with that goal. Land owners, including public authorities responsible for Crown land management, must take all reasonable steps to eradicate Regionally Prohibited weeds on their land (Melville 2008). Regionally prohibited weeds are a category of noxious weed declared under the *Catchment and Land Protection Act 1994*.

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).

Remote sensing - The process of using non ground-based techniques such as aerial photography, multispectral airborne sensors; satellite imagery for surveillance (Hester *et al.* 2010).

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

Response clock - A way of timing how long it takes to exhaust a seedbank or budbank before a weed can be assessed as locally eradicated. If the plant has the chance to produce propagules, the response clock has to go back to zero and counting started again.

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).

Risk ranking score - Rankable scores (between 0 and 33.3) used during the development of the advisory list of environmental weeds in Victoria to indicate level of risk. Scores were grouped into six risk rating categories (very high, high, moderately high, medium, lower and potential risk).

Risk rating - A generic term used to provide, in this case, an indication of the level of threat posed by a weed in Victoria (Blood *et al.* 2016).

Risk screen - See 'environmental weed risk screen'.

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

Search areas - The specific area(s) within the site that will be actively searched during the survey for the target weed. These may be vegetation communities, or high risk locations such as roadsides (James and Blood 2016).

Search distance - See 'detection distance'.

Search frequency - How often an area or site is searched. This should be designed to have the best chance of detection before the weed has a chance to reproduce.

Search intervals - Time between subsequent searches; should ideally be short enough to ensure weeds are detected before they have a chance to reproduce.

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).

Site focus - Consider all the weeds on an area of public land to work out the highest priority for eradication.

State prohibited weeds - Either do not occur in Victoria, or are present and can reasonably be expected to be eradicated. State Prohibited Weeds are the highest category of noxious weeds under the *Catchment and Land Protection Act 1994*.

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.

Structured search - A deliberate and systematic search for a weed within a defined area (Harris *et al.* 2001). This approach is usually targeted at a particular species or a group of weeds that are likely to occur within a geographic location and can consist of a formal, repeatable method. The search may be conducted in the field or when looking through information about the area. Also known as an active, strategic, formal or targeted search.

Suitability for eradication - The status of a weed with regard to a range of criteria, including social and political support, prevention of further arrival, effective treatment options, estimated effort for eradication, cost-benefit analysis and the availability of sufficient resources for the duration of a proposed eradication effort (based on Panetta and Timmins 2004).

Surveillance - The collection, collation, analysis, interpretation and timely dissemination of information on the presence, distribution or prevalence of pests or diseases and the plants or animals that they affect (Hester *et al.* 2010).

Synonym - One of two or more names that apply to the same, in this case, plant.

Target survey area - An area within the search area that is intensively surveyed (detailed small scale survey), especially during delimiting surveys (Sheehan *et al.* 2016).

Targeted survey - A detailed, small scale survey that is conducted in areas of a delimiting survey where close attention is required i.e. areas that have had previous infestations of a target weed. It involves having a thorough look for any infestations that may have arisen from a core infestation or would be likely to have been missed (i.e. off road network, secluded area).

Threat - Describes a possible danger (or exposure to harm), combined with the likelihood of that harm occurring to the native species present, without describing the nature of the threat (Downey *et al.* 2010b), i.e. anything that could conceivably cause damage to something we value is a threat. Threat identification is broader and more all-encompassing than risk assessment.

Threatening process - A physical process that increases the probability that biodiversity values will decline at the local, regional, national or global level (DSE 2009).

Trace forward, trace back - Trace forward and trace back are usually related to human assisted transport of weeds, both deliberate and unintentional. Trace forward considers where the weed might have been moved on to from the detected infestation. Trace back considers where did the detected infestation come from and how did it get here? These terms are more commonly used during biosecurity emergency responses but can

also be used by public land managers when considering the arrival or spread of weeds into and from a public land area. Tracing unassisted dispersal by means such as wind, water or wildlife is usually concerned with much shorter distances and is a component of delimitation (Nigel Ainsworth DEDJTR pers comm, 4/9/2015).

Transect - A straight line used during surveys.

Transformer weeds, transformer species, ecosystem transformers - A subset of invasive plants that change the character, condition, form or nature of a natural ecosystem over a substantial area (Richardson *et al.* 2000). These plants, comprising perhaps in the order of 10% of invasive species, have profound effects on biodiversity and should be prioritised for delimitation.

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

Tuber - Usually an underground (but sometimes aerial) storage organ formed by the swelling of a stem (FloraOnline 2010). A vegetative propagule.

Unmanned aerial vehicle - An aircraft without a human pilot onboard. Its flight is controlled remotely by a person or autonomously by onboard computers. Also known as drones or remotely piloted aircraft (Reference viewed online 3/9/2015: https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle).

Vector - Something that carries, in this case, weed propagules (Sheehan *et al.* 2016).

Vegetative structures, joined or detachable - Propagules are detachable structures that can grow into new plants. These are commonly seeds, but also include detachable vegetative structures such as stem segments, bulbils, and aerial tubers. Vegetative reproduction can occur via such detachable structures, but more commonly occurs via connected or joined vegetative structures, such as roots, rhizomes, stolons or creeping stems. The latter contribute to local spread, whereas seeds and detachable vegetative structures can be dispersed, thereby contributing to spread over larger areas (Panetta 2016).

Verify, verified, verification - Confirming the correct identification and name for a plant through the collection of a specimen, and submission to an herbarium.

Victorian environmental weed risk database - The Victorian environmental weed risk database is an *Excel* spreadsheet that contains a summary of the scores from the Victorian Weed Risk Assessments.

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).

Weed focus - A search that focuses on a specific weed.

Weed history - Evidence that a species has been recorded as a weed previously, either in Australia or elsewhere in the world. Weed history is regarded as one of the most reliable predictors of behaviour as a weed when a plant is introduced to a new area or region (Panetta 2016).

Weed management matrix - A matrix that brings together weed distribution information from delimiting surveys and weed risk ratings to recommend a preferred management approach for different situations.

Weed Risk Assessment - An evidence-based process estimating the relative weed risk of plant species, based on their biological characteristics, impacts on agriculture, the environment and human health, and the ratio of the species' present and potential distribution (Victorian Government 2010).

Weed risk matrix - A matrix that brings together Weed History and Local Performance to recommend either to delimit the species (as a precursor to further determination of eradication feasibility) or to monitor it in the future to detect changes in its invasiveness and/or impact, should these occur (Blood *et al.* 2016).

Weeds risk screen - See 'environmental weed risk screen'.

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

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