

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



© The State of Victoria Department of Environment, Land, Water and Planning 2016



This work is licensed under a Creative Commons Attribution 4.0 International licence. You are free to re-use the work under that licence, on the condition that you credit the State of Victoria as author. The licence does not apply to any images, photographs or branding, including the Victorian Coat of Arms, the Victorian Government logo and the Department of Environment, Land, Water and Planning (DELWP) logo. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>

Prepared by Matt Sheehan (Wild Matters), Bec James and Kate Blood (DELWP), with input from the WESI Steering Group (Nigel Ainsworth, Simon Denby, Ben Fahey, Daniel Joubert, Stefan Kaiser, Sally Lambourne, Kate McArthur, Melodie McGeoch, and former members David Cheal and Penny Gillespie). Guide series review and editing by Dr F. Dane Panetta, Bioinvasion Decision Support.

How to cite this document: 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)

Printed by Impact Digital, Brunswick.

Cover photo: Yarra Ranges National Park, February 2015 (Photo by Bec James).

Other guides in this series:

Adair, R., James, R. and Blood, K. (2016) Managing weeds: eradication response guide. A guide for planning and undertaking an eradication response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-010-4 (Print); ISBN 978-1-76047-011-1 (pdf/online).

Blood, K. and James, R. (2016) 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. (2016) 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., 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).

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).

Disclaimer

This publication may be of assistance to you but the State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Accessibility

If you would like to receive this publication in an alternative format, please telephone DELWP Customer Service Centre 136 186, email customer.service@delwp.vic.gov.au, via the National Relay Service on 133 677 www.relayservice.com.au. This document is also available on the internet at www.delwp.vic.gov.au

Contents

About this guide	4
About WESI	4
Working within a framework	4
The guide series	5
Weed management including eradication	5
What is 'in the early stage of invasion'?	5
The aim of this guide	6
Before you start	6
How to use this guide	7
Why search for new weeds?	8
Search types	9
Opportunistic (passive) search	9
Structured (active) search	10
Planning a structured search	11
Quick 10 step guide to planning and performing a structured search	11
Step 1. Define the purpose of the search	12
Step 2. Determine the focus of the search	12
Weed focus	13
Pathway focus	13
Site focus	15
Step 3. Timing the search	16
When to search	16
Frequency of survey	16
Step 4. Identify search areas within your site	17
How to locate search sites to target	17
Step 5. Select a search technique	19
Vehicle-based search	19
Foot-based search	21
Other types of search	22

Step 6. Data collection, capture and storage	23
What to record	23
Why record absence data?	23
Step 7. Training and preparing the search team	24
Step 8. Obtain permits and access permission	24
Step 9. Perform the search	25
Step 10. Store, tabulate and analyse the search data	25
Search scenarios	26
What next?	34
Where are you up to?	34
Planning what to do next	34
Bibliography	35
Cited references	35
Further reading	36
Appendix 1 - Decision making framework (with scenarios)	37
Appendix 2 - Information sources and tools	38
Victorian environmental weed risk database	38
Other priority weeds	38
Field guides	39
People, social media and networks including weed id network	40
Mobile apps	41
On-line information	41
Appendix 3 - Weed sources and pathways in Australia	43
Appendix 4 - Search frequency	47
Appendix 5 - Field recording template for weeds	48
Appendix 6 - Wellbeing, safety and hygiene for field work	49
Wellbeing and safety	49
Hygiene	49
Appendix 7 - Field recording template for opportunistic sightings and herbarium specimens	51

Appendix 8 - Methods for data recording	52
<hr/>	
Appendix 9 - Equipment required for undertaking a field search	53
<hr/>	
Appendix 10 - Further contacts	54
<hr/>	
Contact the WESI project team	54
Agency contacts	54
Glossary and abbreviations	55
<hr/>	
Glossary	55
Abbreviations	58
List of Figures and Tables	60
<hr/>	

About this guide

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 guide is designed to assist with searching for and detecting weeds at the early stage of invasion.

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

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

About WESI

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

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

WESI is funded through the Weeds and Pests on Public Land Program.

Working within a framework

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

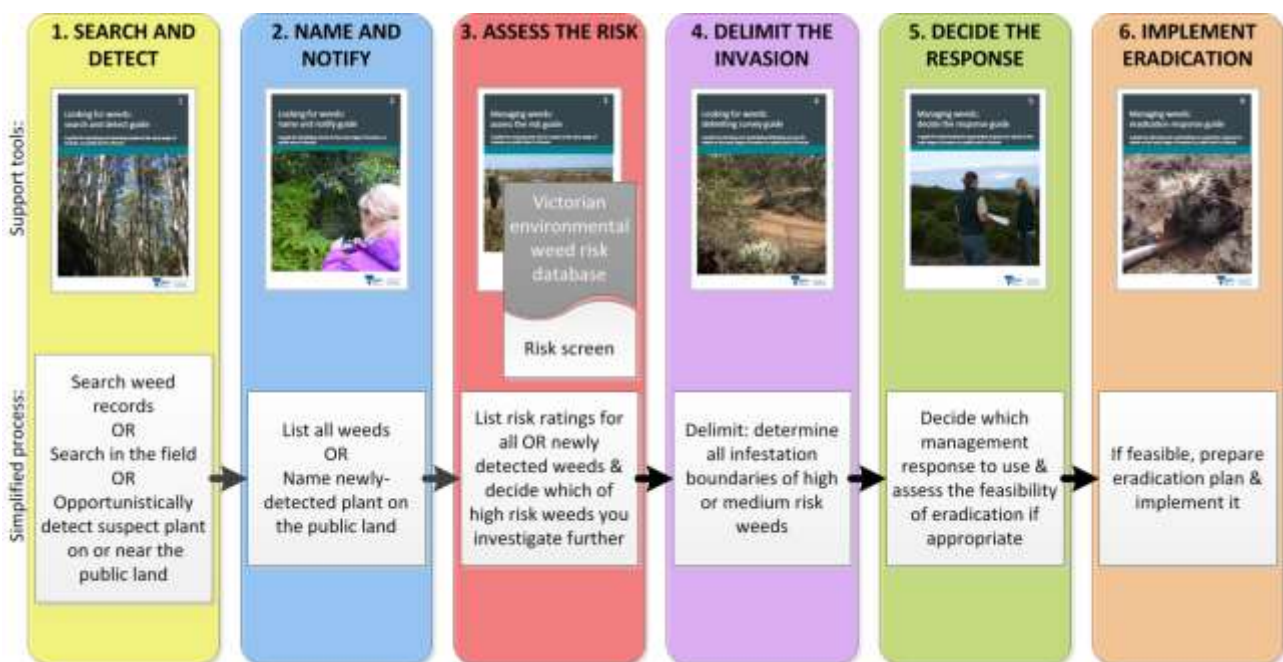


Figure 1 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. There is an enlargement of the framework with scenarios in Appendix 1.

The guide series

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

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

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

The 'Looking for weeds' and 'Managing weeds' guide series is one of a number of tools available through the WESI project. The series provides step-by-step guides to plan and undertake the following work:

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

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 these guides will help you make better decisions.

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

What is 'in the early stage of invasion'?

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

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

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

The aim of this guide

The aim of this guide is to assist users with the process of searching for and detecting weeds in the early stage of invasion on public land. It aims to assist in identifying target species and weed spread pathways. It provides advice on looking for weeds opportunistically during the completion of routine tasks, as well as information on the development of more structured approaches to searching.

This guide supports the 'Search and detect' step in the framework shown in Figure 1. It is consistent with the recommendations and approaches outlined in the "National Invasive Plant Surveillance Strategy", and with other state and regional approaches to weed surveillance throughout Australia. Use Figure 2 to help you navigate your way around this guide and the others in the series.

Before you start

These guides are full of different 'tools' and hints to help you through the weed management process. You may want to start at the beginning and work your way through step-by-step or browse for ideas in your topic of interest. Managing public land involves balancing many requirements of which weeds are only one. Decisions about which weeds to manage have to be made in this broader context. These guides lead you through the process to eradication of early invaders, but generally eradication will not be the aim for most weeds. It is essential to be aware of the guides' limitations, as well as the ongoing need for their modification in light of experience, intuition and local knowledge. Effective environmental weed management comes through long-term observations, learned skills and being able to make decisions based on the local conditions. These guides are to help, not substitute for, these important skills (Blood *et al.* 1996).

How to use this guide

This guide explains the process used to search for and detect early invaders, and provides the tools to develop and implement a search program.

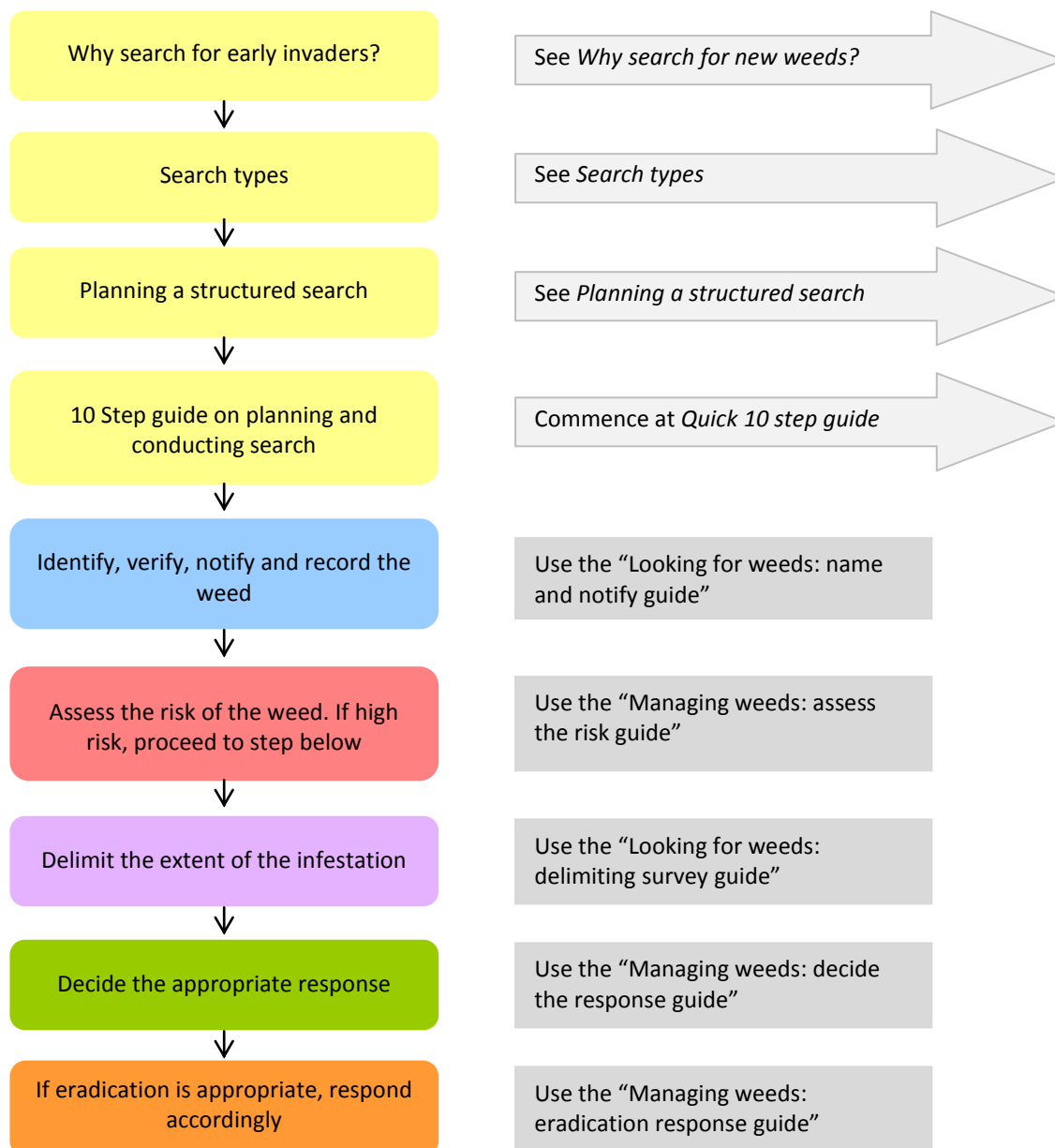


Figure 2 - How to use this guide.

Why search for new weeds?

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

The WESI project focuses on the early stage of invasion of high risk weeds that threaten biodiversity.

However, when managing public land, the most obvious threats to biodiversity are usually established weeds such as Bridal Creeper (*Asparagus asparagoides*), Blackberry (*Rubus* species), willows (*Salix* species) or Gorse (*Ulex europaeus*), depending on where you are in Victoria. In some parts of Victoria, these weeds may be absent or at the early stage of invasion. Management of well-established species is long-term, resource-intensive and time-consuming, which is why it is important to prevent new weeds from becoming established.

Early detection of invasive plants that occur at low abundance and with limited distribution provides the best opportunity to prevent the environmental consequences associated with wide-scale establishment. It also represents the stage of invasion at which a timely response results in cost effective management. By using the tools and strategies provided in this guide it is possible to be on the lookout for new weed threats, while continuing to address other management priorities.

Search types

Searching can occur in the field or away from the field e.g. in the office, also called a 'desk-top' search. It is typically characterised as one of two types, 'passive' or 'active'. Passive, or opportunistic, searching refers to incidental observation, where searching is not planned or carried out deliberately but detection of a weed occurs while undertaking another, unrelated activity.

Active, or structured, searching, involves a deliberate effort to find something. The advantages and disadvantages of both search types are discussed below (Tables 1 and 2).

Opportunistic (passive) search

Description: Casual, chance observations which usually occur during day-to-day activities. Also known as incidental or ad-hoc detection.

Examples:

- Driving through public land while undertaking other routine duties and unexpectedly spotting a new plant you have not noticed before on the roadside
- Inspecting walking track condition and finding an unusual plant (see scenario A)
- Patrolling during planned burning and noticing a species that is a weed of concern (see scenario B)
- Finding a record of an unfamiliar weed on an old map in the office (see scenario G)

Table 1 - Advantages and disadvantages of opportunistic searching.

Advantages	Disadvantages
Economical because the detection occurs during other activities	Ad-hoc and not strategic. Not targeted to specific species, pathways or high risk areas
Anyone can do it, but most people who search for weeds opportunistically are very familiar with a particular area and the plants present in that area.	Unlikely to provide a reliable measure of distribution unless the distribution is very restricted and obvious
Data quality can be high	Usually limited to highly accessible areas such as roadsides, so many areas can go unsearched
A way of involving the local community in natural resource management	To be detected by chance there is a high likelihood that the weed has already reached a sizable population that may be beyond eradication.
	There is often a delay between noticing the weed and reporting it, meaning that the infestation could have spread.
	Absence data is rarely collected

Structured (active) search

Description: 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 strategic, formal or targeted searches.

Examples:

- Searching areas within a defined radius around all boundary gates, car parks and entry points to a piece of public land (see scenario D)
- Searching and logging the route taken while inspecting along pathways of weed movement e.g. along walking tracks, roads, watercourses etc.
- Walking transect lines
- Using remote sensing
- Looking through plant databases for recorded weeds in a geographic area (see scenario G)

Table 2 - Advantages and disadvantages of structured searching.

Advantages	Disadvantages
Greater chance of detecting species in the early stages of invasion, meaning that eradication is more achievable	More expensive than opportunistic searching
More thorough and considered	Resource and time intensive
Absence data is often recorded, and acknowledged as being as useful as presence data	May require experienced and/or specialised personnel

Planning a structured search

A structured search requires pre-planning in order to maximise the likelihood of detection should a high risk weed occur within the search area. This section lists 10 steps that will assist in planning and conducting a structured search.



Quick 10 step guide to planning and performing a structured search

If you are planning a structured search from scratch, follow the steps (Figure 3) in their logical order. Alternatively, you can go to the relevant section of the guide for the advice you require.

The aim is to design the search to maximise the chances of success.

Figure 3 - Steps to planning and performing a structured search.

Step 1. Define the purpose of the search

There are a number of reasons for conducting a weed search. Knowing the reason for the search is a critical step in deciding what approach you will take. Common reasons for weed searching include:

1. a desire to detect a weed in the early stages of invasion and suspected of being within or near the public land;
2. a desire to detect weeds in the early stage of invasion that are not known to be present in the public land;
3. a desire to develop a list of weeds present in the public land; and
4. a desire to demonstrate absence of a weed or suite of weeds from public land.

This guide series is primarily concerned with the detection and response to infestations of weeds at the early stage of invasion (reasons 1 and 2 above). However, it is also important to be aware of all weeds that are either present or absent in the landscape. This information allows you to manage any weed threats to your conservation areas.

TIP: Write down the purpose of your search. Referring back to it during planning will help ensure the approach, scope and method you choose meet your needs.

Step 2. Determine the focus of the search

Typically the search for weeds at the early stage of invasion will focus on either a specific weed (weed focus), or the pathway of spread of a suite of weeds (pathway focus). A search can also consider all the weeds on an area of public land to work out the highest priority for eradication (site focus). The best approach to take will depend on your individual situation and the resources available (see Table 3) and may include a combination of these approaches.

Table 3 - Types of search focus.

	Weed focus	Pathway focus	Site focus
Situation	When considering a single species or a very small number of species that pose the most serious threat to the public land you want to protect	When there is more than one weed species of concern that is or may affect the public land you want to protect	When you want to know which of the existing weeds on your public land pose the most serious risk

Weed focus

When searching for weeds at the early stages of invasion, it makes sense to target those weeds that pose the most serious threat to the public land you want to protect.

Weed focused searches are both cost effective and targeted, allowing you to concentrate on the most serious threat to your area of public land. Focusing on a single species (or a very small number of species) will maximise the likelihood of detection.

What do you need to know to conduct a search with a weed focus?

If you choose a 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. Critical information for the preparation of a species focused search includes:

- name(s) of the focus weed(s) and its importance (weed risk);
- identification features of the weed(s);
- likely pathways of entry, spread and potential land type/habitat to be affected; and
- life cycle of the weed(s) and the most appropriate time to conduct a search.

Appendix 2 outlines 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.

Pathway focus

When protecting conservation values on public land there is often more than one serious weed threat. The time spent searching for one weed might be long enough for another weed to enter unnoticed and become established.

In this situation, it is often beneficial to focus the search effort on pathways of introduction and spread (see examples in Figure 4) that are common to a suite of weed species, rather than focusing on a specific weed. Even if a weed focus is used, considering spread pathways will maximise the likelihood of detecting the target weed. It also enables the observer to be open-minded and potentially notice other high risk weeds that are not the target of the search.

Below (Table 4) are some of the likely pathways relevant to public land in Victoria. A full list of potential weed spread pathways is included in Appendix 3.

Table 4 - Accidental and natural pathways for weed spread in Australia, adapted from Sindel *et al.* 2008. Pathways are grouped according to accidental spread by humans, and natural spread.

Pathway type	Pathway vector	Examples
Accidental spread by humans	Human apparel and equipment	Attachment of seeds and plant parts to clothes and footwear
	Machinery and vehicles	Attachment of seeds and plant parts to passenger vehicles, slashers, farm equipment, boats, and earth moving equipment
	Construction and landscaping materials	Contamination of gravel, soil, sand, mulch and turf
	Agricultural produce*	Contamination of hay, grain and pasture seed
	Research sites	Escape from research sites
	Livestock movement	Through faeces or attached to livestock such as sheep, cattle, horses and goats
	Waste disposal	Unsafe dumping of garden refuse and aquarium

Pathway type	Pathway vector	Examples
		plants
Natural spread	Birds	Through consumption and excretion of seeds and fruits or attachment of plant parts
	Other animals	Through consumption and excretion of seeds and fruits, and external attachment to native and introduced wildlife
	Wind	Distribution of wind-blown seeds and plant parts
	Water	Distribution of seeds or plant parts via waterways

* These products are sometimes used on public land or fall from transport vehicles while travelling through or past public land.

If you chose to take a pathway approach, be mindful that greater planning is required and therefore this activity may require more resources. Consideration still needs to be given to specific categories of weeds that might be found, otherwise the search may be too broad and not detect anything.

An understanding of spread pathways will assist in the selection of appropriate search techniques and can help in deciding what to look for and where. Figure 4 uses a hypothetical nature reserve to illustrate some of the common accidental and natural pathways of weed spread into public land. Linear easements such as road, rail, and service easements provide a corridor for movement of plant propagules, either on their own or via a vector such as vehicles or machinery. Likewise, waterways provide a transportation system for some plant propagules.



Figure 4 - Examples of common weed spread pathways that can be the target of pathway focused weed searches on or near public land.

Other pathways that are harder to predict include wind dispersal or dispersal by animals such as birds, foxes and kangaroos. Having knowledge of dominant wind directions or the habitats utilised by animals

that may spread weeds can help with the prediction of sites at higher risk of weed invasion from these pathways.

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.

If you do not have a good understanding of the weeds present, a combination of a field search and desk-top search can be a good way of bringing all the information together. From that sound base, it is possible to work out the highest priority for eradication.

Build a weed list for public land

Desk-top searches focus on data sources such as weed databases, publications (including on the internet) and spatial or mapping systems. The aim is to compile e.g. in an *Excel* spreadsheet, distribution records or observations of a weed or list of weeds in an area. The desk-top search is a component of structured (active) searching.

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.

Databases and sources of information (see Appendix 2) that should be checked include:

- Spatial, Temporal, Activity Recorder (STAR) (for DELWP and Parks Victoria);
- Victorian Biodiversity Atlas (VBA): <https://vba.dse.vic.gov.au/vba/>
- VicFlora: <http://data.rbg.vic.gov.au/vicflora/>
- Flora Information System (FIS) (Viridans Pty Ltd);
- Environmental Information System (EIS) (access through Parks Victoria);
- Bioweb, Bioweb2, MAX (access through DEDJTR);
- Crown Land Manager (CLM) Pest Infestation Sites (access through DELWP);
- Australia’s Virtual Herbarium (AVH): <http://avh.chah.org.au/>
- Atlas of Living Australia (ALA): <http://www.ala.org.au/>
- herbarium specimens and records viewable through AVH & ALA otherwise by appointment with National Herbarium of Victoria;
- Victorian Resources Online (VRO):
http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_plants_common_a
- local databases, spread sheets, maps, Geographic Information System (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; and
- other local DELWP or Parks Victoria staff, as well as local community networks.

It can be a challenging process to bring together multiple sources of weed reports and distribution information. However, once done, this forms a valuable resource for ongoing conservation planning.

If you do not have a list to start with, you can copy the Victorian environmental weed risk database (see “Managing weeds: assess the risk guide” for more information) and remove the weeds not relevant to your public land.

Regardless of the focus, your search will be more strategic and will maximise the likelihood of weed detection if you consider spread pathways when planning and conducting your search.

Step 3. Timing the search

When to search

Some plants are only detectable when in flower, seed or fruit or in some other distinctive growth stage. Others become dormant and die back at certain times of the year. For these reasons, timing of a structured search needs to consider the life cycle of the target weeds. Even pathway-focused searches will require consideration of the types of plants that may be encountered in order to choose the most appropriate time to conduct a search. There will also be logistical constraints to timing.

When planning the timing of the search consider the:

- time of year when the weed is most visible;
- length of time that a weed will stay in a state where it is visible and identifiable;
- weather conditions or events that may influence the weed's life cycle, survival, detectability or site access;
- availability of resources (i.e. staff, vehicles, equipment etc.);
- timing of other management activities that may reduce detectability (i.e. planned burning or slashing etc.);
- seasonal growth of surrounding plants, including look-alike plants; and
- the time of year when there is most risk of spreading a weed e.g. when a plant is shedding seeds that readily adhere to clothing.

Frequency of survey

It will be necessary to search more than once to detect the weed. Ideally, search intervals (i.e. times between subsequent searches) will be frequent enough to ensure weeds are detected while the infestation is still small enough to treat and before the weed has a chance to reproduce. Refer to Appendix 4 for a search frequency guide. The rate at which a weed establishes and spreads, and the detectability of a weed at a new site, are both a function of the:

- weed's inherent biological capacity for growth and spread;
- habitat type the weed is invading;
- degree of disturbance at the site(s); and
- the weed's growth form.

Step 4. Identify search areas within your site

A *site* needs to be described at various scales and the approach used throughout this guide series is illustrated in Figure 5. 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 the delimiting survey guide.

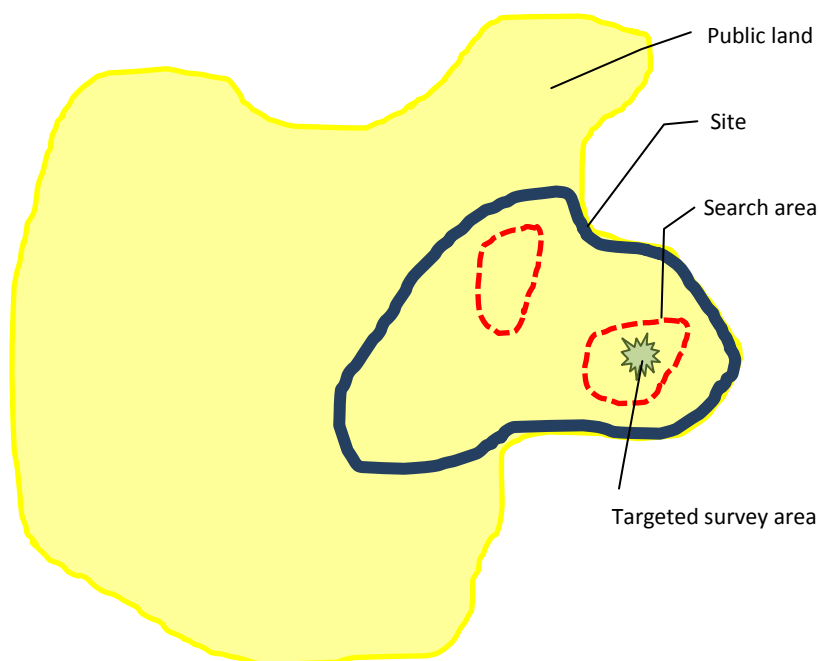


Figure 5 - An illustration of the different scales of site and the terminology assigned to them - the concept of public land, site, search area and targeted survey area.

A logical approach to selecting search areas for weeds at the early stage of invasion is to target sites where new species are most likely to arrive and establish, thereby biasing site selection in favour of finding the species (Biosecurity SA, 2014). This targeted method is often the most reliable and time efficient. For an example of how to target a site search refer to Figure 6.

How to locate search sites to target

It may be useful to use a digital or paper map to overlay various geographical areas of interest when identifying search sites. This can include:

- pathways (refer Appendix 3);
- priority conservation sites for protection;
- sites at high risk of weed invasion;
- weed hot spots near and within your site; and
- potential habitat for target weeds.

Also consider:

- existing weed distribution data, climate models and other sources to identify preferred habitat;
- expert opinion to identifying locations at greatest threat from invasion;
- key biodiversity assets you want to protect from weeds (e.g. threatened species/ecological communities);
- logistical constraints; and
- practicality.

The hypothetical conservation area in Figure 6 shows pathways and other points of interest that may help in both identifying the risks to the reserve and in targeting sites where searching could occur. High risk areas within the reserve include spread pathways such as roads, railway lines and watercourses that traverse it. Other high risk points could include picnic areas, parking areas, camping grounds and other amenities such as walking tracks or maintenance sites. There may also be sites within the reserve where illegal disposal of garden waste occurs, presenting a serious weed risk.

It can also be useful to establish a buffer or watch zone around the reserve. This may be a 5, 10 or 20 km radius in which threats or high-risk sites and their relationship to spread pathways is determined. In this example, the presence of a new weed has been identified along two direct pathways to the reserve. There is also a gravel quarry used for road construction located within the watch zone. These sites can also be hot spots for the establishment and spread of new weeds.

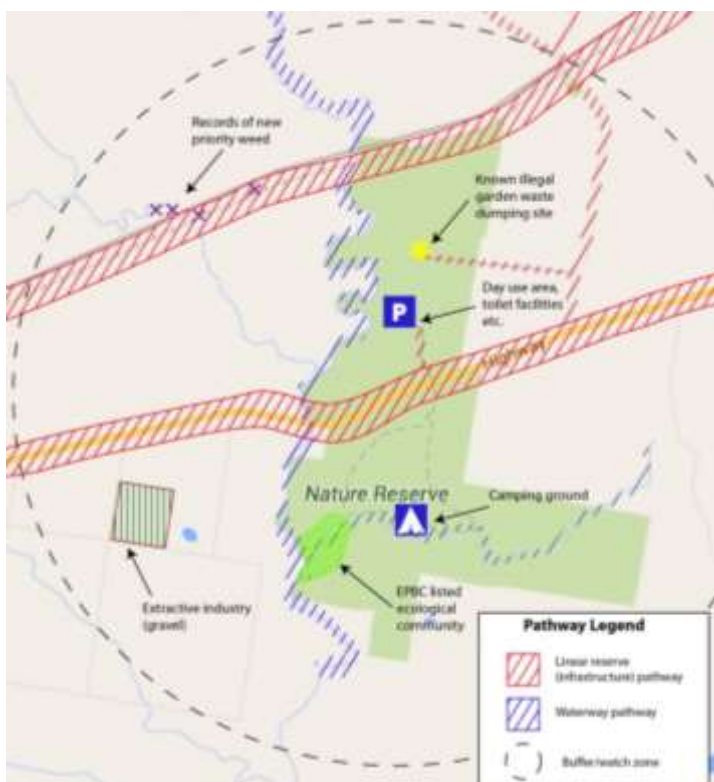


Figure 6 - Example of how to annotate a map to assist with selecting targeted sites.

Step 5. Select a search technique

As previously discussed, search techniques can range from opportunistic observations, through to very structured, systematic surveying. Often the initial search for weeds is opportunistic or involves structured searching that is limited in scope and scale. This section focuses on some of the most common search techniques that will maximise the likelihood of detection.

The same search method can be used for both initial detection surveys and delimiting surveys (determination of the full extent of the weed infestation). For a more comprehensive discussion of search methods refer to the “Looking for weeds: delimiting survey guide” in this series.

When choosing a search technique consider the following questions:

- **What is practical?** How many sampling sites can be feasibly surveyed within the limitations of staff and their expertise, time, cost, weather or other factors?
- **What are the likely pathways of introduction?** Consider how weeds may enter the search area and therefore where they are most likely to appear first.
- **Are there any constraints?** Does the size, terrain or accessibility of the site preclude a particular search technique? Is there a high risk that one or more methods of searching may spread the weed further?

TIP: Always record the search method so that future efforts can be repeated and results compared.

There are some useful publications for further reading in the reference section of this guide.

Vehicle-based search

Vehicle-based surveys (Figure 7) are particularly useful when searching linear reserves such as roadsides. The effectiveness of vehicle-base searches is influenced by a number of factors, including:

- width of the search area;
- vegetation type and how conspicuous the weed is;
- the number of species you are searching for;
- terrain;
- speed of travel;
- traffic level and type; and
- weather and light conditions.

As previously mentioned (Step 3) timing will also influence search effectiveness. Undertaking a routine trip at a different time of year may result in early invader discoveries.

Before you search:

- If possible, go to an area with a known infestation to get accustomed to the weed in the habitat to be searched.
- Familiarise yourself with look-alike species that occur along the search route.
- Plan the search route before leaving the office.



Figure 7 - A vehicle-based search.

Suggested method

The suggested method for vehicle-based search (see Figure 8) is described here:

- Vehicle-based surveys require two people - driver and observer/recorder.
- Travel between 5 and 40 km per hour, depending on vegetation type and road conditions.
- 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.
- 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.
- If unsure, the observer should get out of the vehicle and have a closer look if safe to do so.
- Do you know the plant?

YES – record location with a Global Positioning System (GPS) (point data or line), using Appendix 5 to record other information.

NO - record location with GPS (point data or line). Refer to “Looking for weeds: name and notify guide” for information on photographing and collecting specimens.

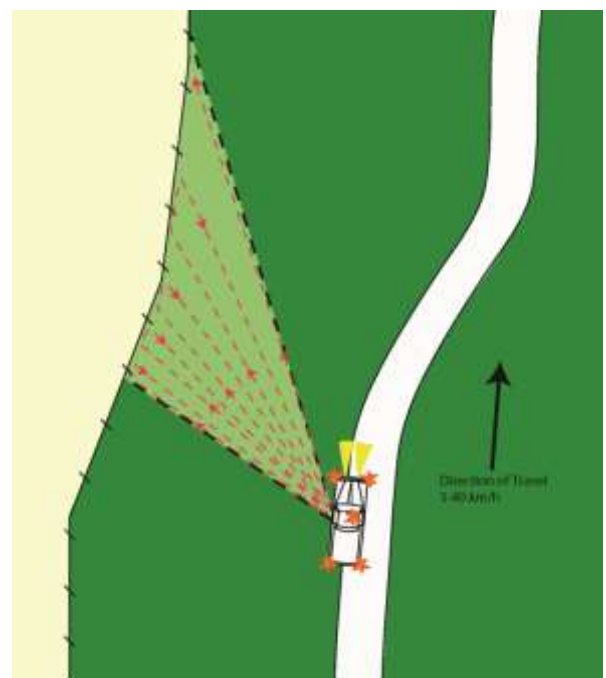


Figure 8 - Sketch of a vehicle-based search.

Safety

- Use hazard lights (where appropriate), headlights and a flashing beacon mounted on the vehicle. Also consider using 'vehicle frequently stopping' or 'slow moving vehicle' signs.
- Use appropriate roadwork signage on the roadside. Check requirements of the road manager. As a guide, place signs at intervals no greater than 2 km, at major intersections and along the road you are working.
- Notify appropriate authorities (VicRoads or local municipalities) of your intended search method, including safety/visibility equipment and procedures. Adhere to any additional requirements or modify your procedures to meet their requirements.
- Wear a high visibility vest.
- Other important safety and hygiene information can be found in Appendix 6.

Foot-based search

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 (refer to example in Step 4). It is often the technique most suitable for searches in remote areas, sensitive sites or dense vegetation.



Figure 9 a) - Walking a transect undertaking a targeted survey for *Cylindropuntia pallida* (formally *C. rosea* as stated in the map legend) in Ouyen State Forest. b) Aerial photograph of the survey area showing GPS track logs of the transects that were walked (grey lines) and located infestations (yellow triangles).

Suggested method

Foot searches need to be structured and systematic to ensure all areas are covered. The easiest way to do this is to walk transects (straight lines) and continuously search along and either side of the transect line (Figure 9a). The use of flagging tape, other markers, referencing landmarks or a GPS app can assist in ensuring you maintain a straight line. If the search area is a linear feature such as a track, creek or boundary fence, use that feature 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 9b).

Transect spacing

Spacing will depend on vegetation type, the overall size of the search area and the visibility of the target weed within the vegetation. If you are searching for a tree or shrub in large open grasslands, transects 50 – 100 m apart might be appropriate. However, most habitats will require closer spacing. A good spacing for most vegetation types and weed growth forms is 5-10 m.

Transect alignment

In some circumstances the direction or alignment of the transects may help or hinder the search effort and could be worth considering. For example, going across a slope rather than up and down may prove physically easier for the observers/recorders, as well as provide better visibility. Sun glare in the eyes of the

observer could make detection more difficult or a weed may become more visible with back lighting. Testing visibility with the sun either behind you or the target plant may influence the direction you walk.

Safety

- 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.
- Be aware of past land uses and potential hazards such as traps, old fences, mine shafts etc.
- It is both for safety and for practicality that at least two observers/recorders should conduct a foot search, walking adjacent transects.
- Other important safety and hygiene information can be found in Appendix 6.

Other types of search

Aerial (desk-top) search

Sometimes effective searching does not require you to leave the office. Aerial-based desk-top searches involve the analysis of vegetation from aerial images, either photographs or remote sensing data. These methods are useful when there is a clear distinction between the target weed and the surrounding vegetation, either with the naked eye, as shown on aerial photographs, or the difference in the absorption of light between different plant species, as shown through remote sensing imagery. Note that we are concentrating on weeds at the early stages of invasion and therefore depending on growth form and species distinctiveness or uniqueness, target weeds may not occur at densities that can be detected by such a method.

Aerial (field) search

It is possible to search from the air in person, such as from a helicopter, or via remote camera such as from a drone (unmanned aerial vehicles (UAV)). There are many laws that govern this area and the costs may be prohibitive but this may be an option depending on the circumstances.

Detector dogs

Detector dogs have long been used in the detection of biosecurity risks at quarantine facilities around Australia. Dogs are now being trialled for detecting weeds that occur in very low numbers, either because they are new arrivals or because they have been subject to eradication and numbers are lower than what can be detected easily by humans. Trials conducted in Victoria have shown that trained dogs can successfully distinguish a number of different plant species from each other. Trials in the field for the detection of hawkweed (*Hieracium* species) have commenced in Victoria and New South Wales to see whether dogs can detect weeds outside controlled experimental situations (Figure 10). Dogs are fitted with GPS devices, which allow mapping of where searching has been carried out. This approach has the potential to improve our ability to reduce search time and increase detection rates.



Figure 10 - Missy the Springer Spaniel detector dog currently deployed in Victoria to search for Hawkweed. Source: OEH, NSW.

Step 6. Data collection, capture and storage

Once a suspect plant has been detected, it is important to consider the following:

- what to record;
- what data recording method to use (e.g. paper form, mobile devices);
- where data will be stored; and
- how the information will be shared.

A useful phrase to remember particularly for opportunistic detections is “Spot, stop and take a shot”.

What to record

At the initial search stage, the aim is to determine the suspect plant's identity and to confirm (or otherwise) the detection of a new species (refer to the “Looking for weeds: name and notify guide” in this series). Therefore, the most important information to record is **where it is** so it can be relocated either if required for further verification or to conduct a more comprehensive delimiting survey. In the case of weed focused searching, it is equally important to record **where it is not** i.e. where it is absent.

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. Additional information, such as data to assess impacts and determine required treatment measures, can be collected at a later stage during a weed risk screen (refer to “Managing weeds: assess the risk guide”) or the delimiting survey (refer to “Looking for weeds: delimiting survey guide”).

Recording sheets for both opportunistic sightings and multiple infestation recording are located in the following appendices:

- Appendix 5: Field recording template for weeds; and
- Appendix 7: Field recording template for opportunistic sightings and herbarium specimens.

Why record absence data?

Absence data, that is, locations searched where the weed was not observed is just as useful as presence data.

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.

Options for data recording methods can be found in Appendix 8.

Step 7. Training and preparing the search team

Depending on the focus, scale and scope of the search, there may be a need for several people to be involved, either in the field as observers or drivers, or back in the office providing logistical support, identification expertise or data entry services.

Prior to the search:

- Identify the roles and duties to be performed.
- Organise appropriate information and training for each role.
- Check for consistency in observation recording and identification skills of survey team members.

Personnel involved in surveys need adequate training in survey methods, plant identification, specimen collection, hygiene, safety and preparation. It is important to assess if people in the team observe and record weeds in a similar way. Consider running workshops or pilot studies before going out in the field to improve identification skills and consistency between observers. You can also prepare field kits or reference material that shows examples of the target weeds and look-alike species. These can be of great assistance in the field, especially if loaded on mobile devices. An equipment checklist is provided in Appendix 9.

People see what they know so make sure the search team are fully trained in recognition of the target weed(s) and have information and images with them to double check. For information on plant identification, see the “Looking for weeds: name and notify guide”.

For opportunistic detections of unexpected plants, ask the team to also record and photograph (geotagged) what they don’t know.

Step 8. Obtain permits and access permission

During the early planning stages of a search it is wise to check what access permission or permits might be needed. This guide is primarily concerned with searching for weeds on public land by public land managers, therefore permission may not be required. However, some circumstances may require permits or access permission. For example:

- Road reserves within park boundaries that are managed by local municipalities or VicRoads may require access permission or permits, or at least notification of the planned search.
- If you are investigating pathways or establishing a watch zone around your reserve, you may want access to private land adjacent to the management area. To this end, consider developing and keeping updated a simple communication plan concerning the stakeholders to be kept informed and how information about the search effort will be communicated e.g. in the media and/or on social media. Seek advice from your agency communication staff.
- The collection and transport of plants, including specimens, listed under the *Flora and Fauna Guarantee Act 1988* (FFG), and weeds declared under the *Catchment and Land Protection Act 1994* (CaLP Act) require a permit.

TIP: Always ensure that you take copies (including on mobile devices) of the relevant permits and permission with you in the field.

Step 9. Perform the search

Conduct the search according to the decisions and considerations that were made while planning the search (steps 1-8 above) and collect and record data. Some important reminders:

- Have you notified all the relevant people and authorities?
- Is your job safety plan in place for reporting your movements in the field?
- Have you got good weed identification information?

Appendix 9 contains a checklist of basic field equipment that may be useful to adapt for your purposes. Once you have refined your own list, it is easy to print a sheet for each field trip and check off equipment as it is packed.

Step 10. Store, tabulate and analyse the search data

Make the most of the data collected so you and others can use it into the future:

- Use the “Looking for weeds: name and notify guide” to verify plant identify and follow the steps to notify.
- Upload the field record(s) to a central database e.g. Spatial, Temporal, Activity Recorder (STAR).
- Interpret or analyse the data and link back to the original purpose of the search in Step 1. Use the results to demonstrate both the presence and absence of the target species within the survey area (e.g. map output).

Search scenarios

This section of the guide provides several search scenarios that may arise, and uses the steps outlined in this guide to illustrate how to plan and conduct your search.

SCENARIO A – Inspecting walking track condition and finding an unusual plant.

Search Type: OPPORTUNISTIC

Search Focus: not applicable (N/A)

Being in the field is the perfect opportunity to familiarise yourself with the vegetation and to observe anything new or unusual.

Steps:

1. Record



Take photos and use recording sheet in Appendix 7.
Mark site to help find again or alert others.

2. Name & notify



Use the “Looking for weeds: name and notify guide”

HELPFUL HINTS: Always carry GPS or smart phone mapping application (app).

If you find a suspect plant during routine activities, report promptly to minimise *opportunity for spread*.

SCENARIO B – Patrolling during planned burning and noticing a species that is a weed of concern.

Search Type: OPPORTUNISTIC

Search Focus: N/A

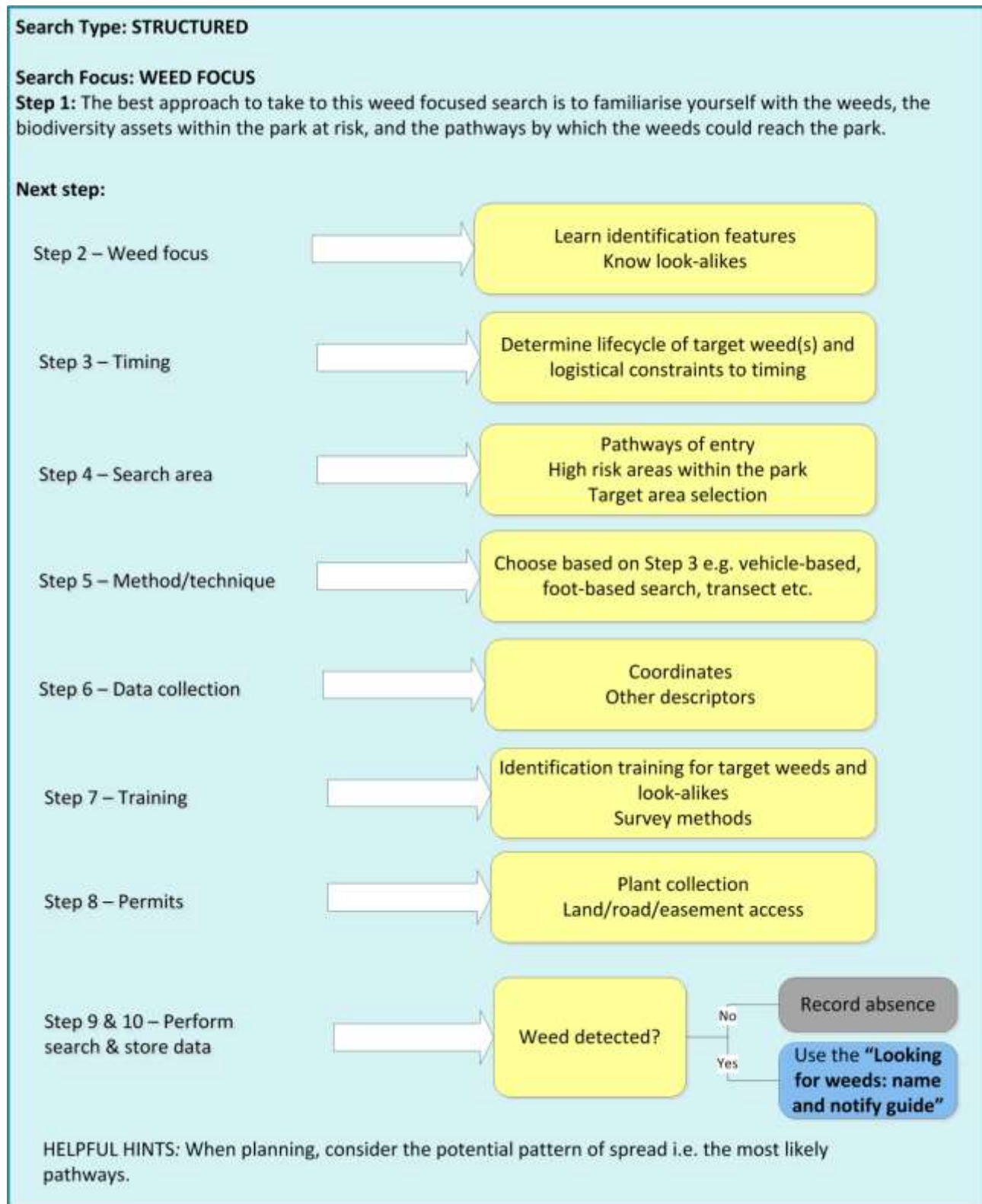
Carrying out patrolling during planned burning or other routine tasks such as track inspections, presents a perfect opportunity to observe other changes to conditions within the public land you are working in. This may include disturbance to vegetation, threatening processes, sightings of rare and endangered species and new weeds.

Steps:



HELPFUL HINTS: Always carry GPS or smart phone mapping app. If you find a suspect plant during routine activities, report promptly to minimise opportunity for spread. Record location and collect a sample (refer to notes on sample and specimen collection in the "Looking for weeds: name and notify guide").

SCENARIO C – The WESI project team told me the top five weed threats to the park and I want to look for them.



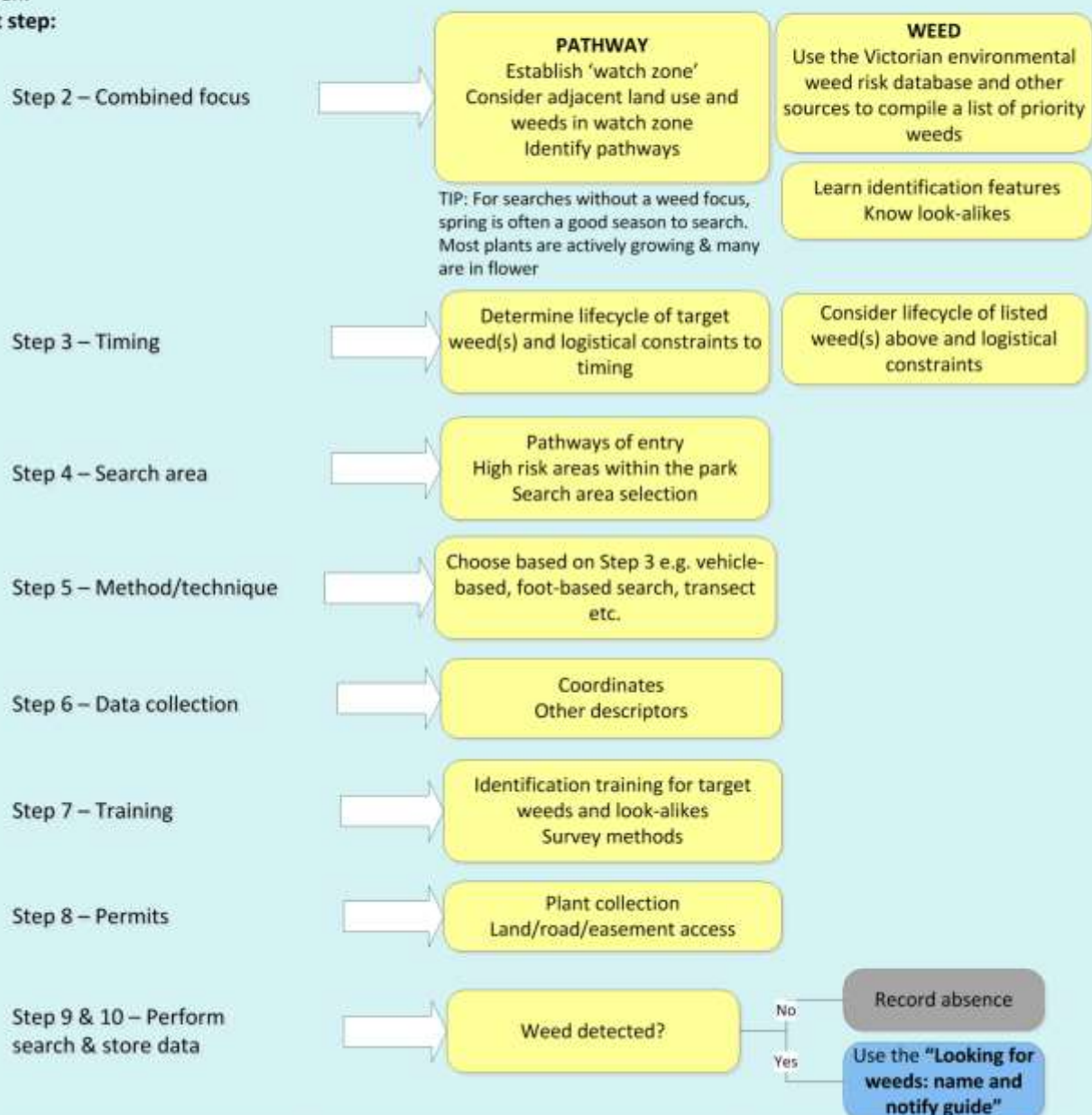
SCENARIO D – Every 6 months I walk the boundary of my reserve to look for weeds.

Search Type: **STRUCTURED**

Search Focus: **Combined - PATHWAY with consideration of priority species**

Step 1: Boundaries of reserves are the interface between conservation values within the reserve and the surrounding landscape. Reserves are often adjacent to roads and other linear easements, urban and industrial areas and farm land, all of which are where weeds establish and spread. Patrolling boundaries for new weeds is a strategic and worthwhile activity that can prevent new weeds entering the reserve. Continuous searching of a strip along the boundary is an effective method, paying particular attention to points where pathways adjoin or intersect the boundary (e.g. reserve entrance points). Concentrating on your top threats by combining a pathway and weed focus is recommended. This may not be practical for large pieces of public land, in which case some lengths of boundary may be strategically chosen.

Next step:



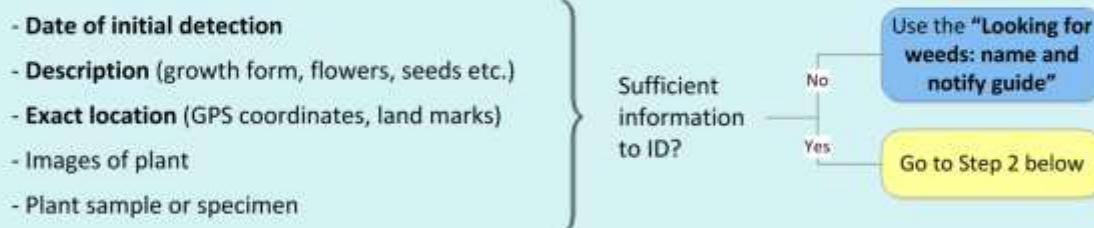
HELPFUL HINTS: When planning, consider the potential pattern of spread i.e. the most likely pathways.

SCENARIO E – Someone told me they saw an odd plant in the park and I’m going to check it out.

Search Type: STRUCTURED - PRECAUTIONARY

Search Focus: SPECIES SPECIFIC

Step 1: The original sighting of this weed was OPPORTUNISTIC, however the follow-up is STRUCTURED. It is important to gain as much information about the plant and its location from the reporter as possible. Ideally, you will be able to identify the plant using this information without relocating the weed in the field, and determine if further action is required. Below is a list of information you should try to obtain about the ‘odd plant’ from the reporter. Critical information is shown in **bold**. It may be a plant that is indigenous to the site.



Step 2 – Weed focus

Prepare a short list of potential look-alike weeds and indigenous plants
Use Victorian environmental weed risk database tool

Step 3 – Timing

As close to original sighting time as possible

Note: If weed is located but not identifiable, mark locality and come back when it is flowering/fruitle

Step 4 – Search area

Determine where the search area will be

Step 5 – Method/technique

Targeted survey (refer to “Looking for weeds: delimiting survey guide”)
Foot-based search

Step 9 & 10 – Perform search & store data

Weed detected?

No → Seek further info/ widen search

Yes → Use the “Looking for weeds: name and notify guide”

HELPFUL HINTS: Act as quickly as possible.

Enlist the assistance of an expert in the field to help with identification.

Communicate the findings of your search and any intended management response to the person who reported it. This will encourage continued looking for and reporting of suspect plants.

SCENARIO F – I’ve got a grant to find out the weeds in my area.

Search Type: STRUCTURED

Search Focus: PATHWAY

Step 1: Having a budget specifically for finding weeds allows for a structured approach and inclusion of a structured or formalised method to increase accuracy. Searching could take either a weed focus or a pathway focus, but again, given that there is a grant it will be more holistic to focus on pathways. This scenario suggests that you are interested in all weeds, so this means developing a baseline of weed data for the public land. Having such a dataset is a great resource that allows for the determination of weed management priorities, which can be used to justify further management activities in the public land. However, compiling a complete weed list is considerable work and achieving this goal will depend on how many weeds are present, the size of the public land, the vegetation types, the amount of information you already have on weed distribution, and of course, the amount and duration of the grant. A strategic approach would be to prioritise the public land based on key assets requiring protection from weeds. Search these areas first and then move into lower priority areas until the entire public land area has been searched.

Next step:

Step 2 – Pathway focus

Divide the public land into vegetation types. Rank from highest conservation value/risk of weed invasion to lowest.

Establish a buffer/watch zone around public land. Identify high risk point sources within the watch zone and pathways of spread that adjoin/intersect the public land.

Step 3 – Timing

TIP: For searches without a weed focus, spring is often a good season to search. Most plants are actively growing and many are in flower.

Step 4 – Search area

Make priority areas **sites**.
Locate spread pathways.
Establish **search areas** within sites.

Step 5 – Method/technique

Various – refer to Step 6 in the “**Looking for weeds: delimiting survey guide**”
e.g. Targeted survey “**Looking for weeds: delimiting survey guide**”

Step 6 – Data collection

Coordinates/
Other descriptors

Step 7 – Training

ID training for indigenous plants, target weeds and look-alikes
Survey methods

Step 8 – Permits

Access permission to adjoining land
Plant collection permits
Works on roadsides permission

Step 9 & 10 – Perform search & store data

Weeds detected?

No

Record absence

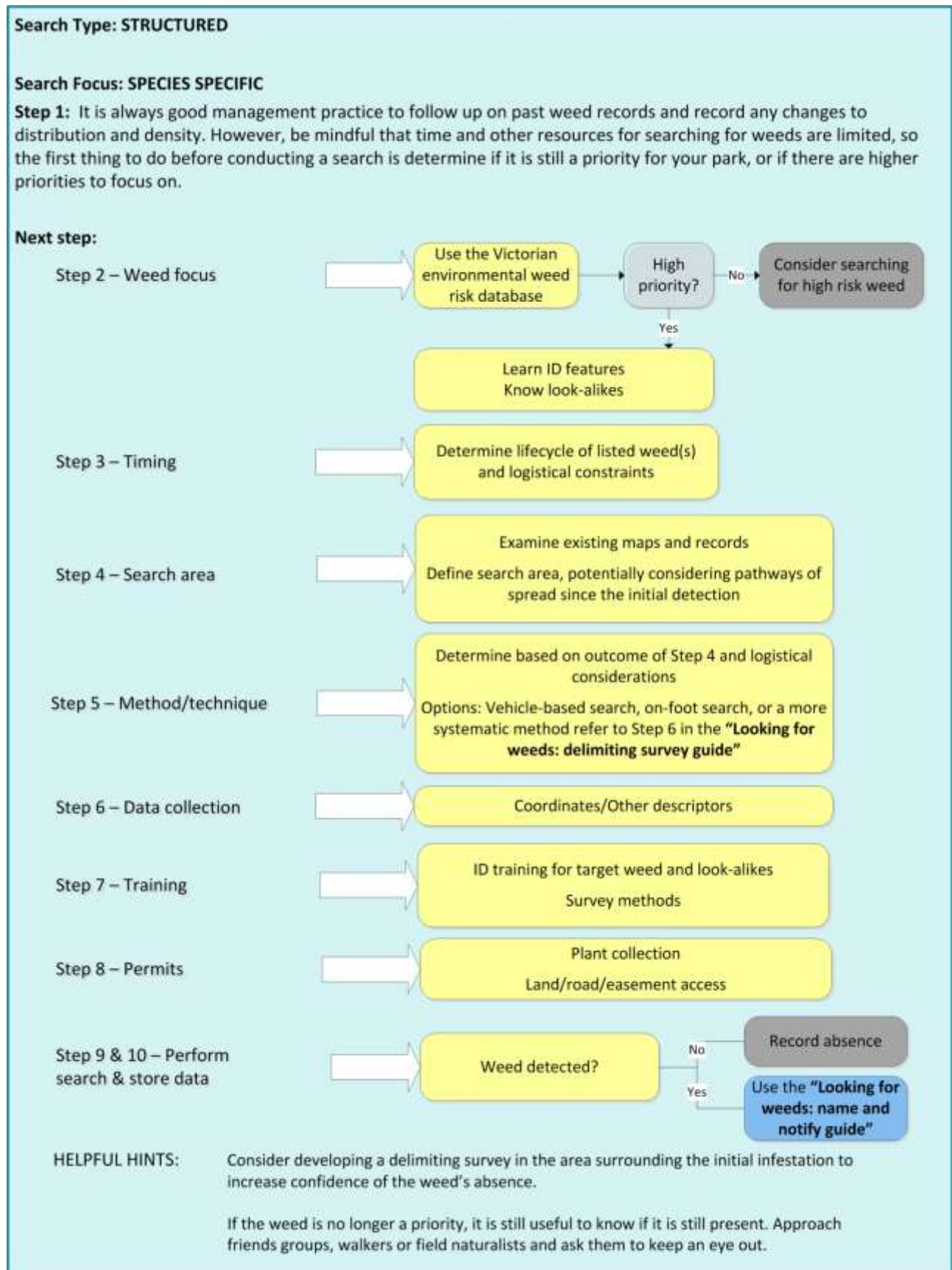
Yes

Use the “**Looking for weeds: name and notify guide**”

HELPFUL HINTS:

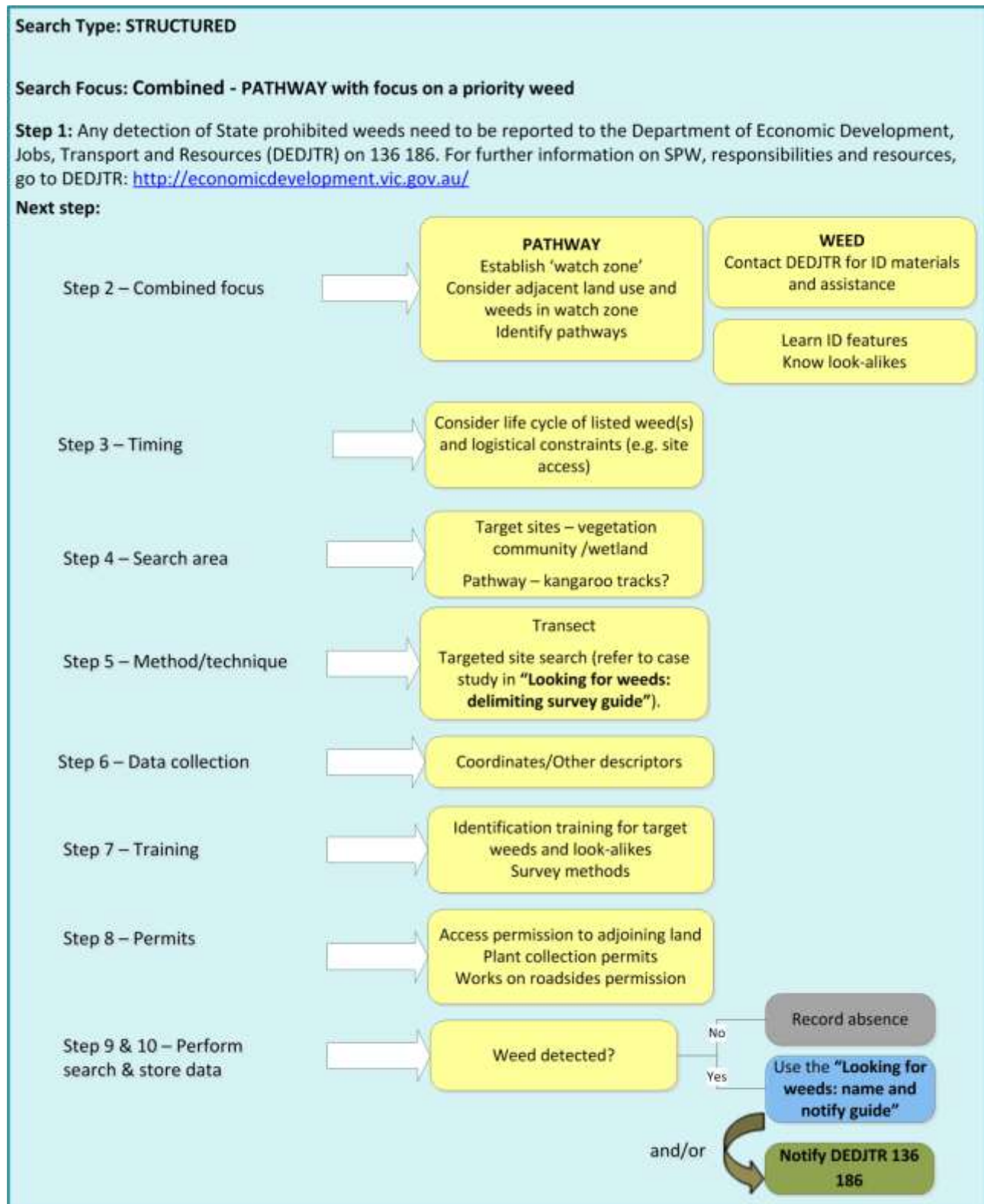
Having a list of indigenous species for your public land and recording detection of new indigenous species could be useful to managing the public land.

SCENARIO G – I found an old record of a weed that used to be in the park and I’m going to see if it is still there.



SCENARIO H – A State prohibited weed (SPW) was found in farm land 1 km from your State Forest and is being controlled.

The most likely potential vector of spread to the State Forest is kangaroos. Kangaroos graze in weed-contaminated pastures at night and visit a wetland and associated vegetation in the State Forest during the day. Seeds could drop from their coat at these sites. You wish to conduct a search for the State prohibited weed.



What next?

Where are you up to?

At this stage you have detected a suspect plant(s) either by opportunistically searching or by undertaking a structured search.

Planning what to do next

The next step (see Figure 11) is to identify, verify, notify and record your suspect plant(s). Use the following guides with the help of the WESI team:

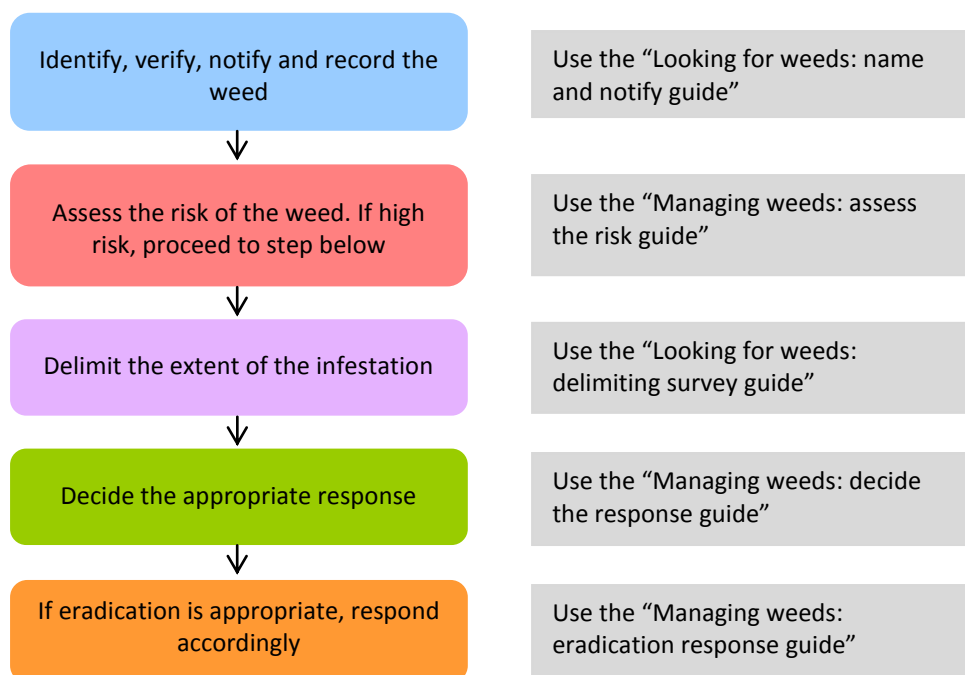


Figure 11 - Planning what to do next.

For assistance with planning and conducting search and detection activities, contact the WESI project team (see details in Appendix 10).

Bibliography

Cited references

- Biosecurity SA (2014) Searching for new weeds: Surveillance guideline for weed managers in South Australia. Department of Primary Industries and Regions, SA.
- 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., 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).
- 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.
- 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.
- 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.
- 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.
- 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).
- 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.
- 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. (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 Timmins, S. M. (2004) Evaluating the feasibility of eradication for terrestrial weed incursions. *Plant Protection Quarterly* 19 (1): 5-11. ISSN 0815 - 2195.

Richardson, D. M., Pysek, 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.

Sindel, B., van der Meulen, A., Coleman, M. and Reeve, I. (2008) Pathway risk analysis for weed spread within Australia. Land & Water Australia.

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).

Further reading

Adair, R., James, R. and Blood, K. (2016) Managing weeds: eradication response guide. A guide for planning and undertaking an eradication response to weeds at the early stage of invasion on public land in Victoria. Department of Environment, Land, Water and Planning, Victoria. ISBN 978-1-76047-010-4 (Print) ISBN 978-1-76047-011-1 (pdf/online).

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).

Biosecurity SA (2014) Searching for new weeds: Surveillance guideline for weed managers in South Australia Department of Primary Industries and Regions SA.

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).

Brown, K. and Brooks, K. (2002) *Bushland weeds. A practical guide to their management*. Environmental Weeds Action Network, Greenwood WA. ISBN 0 9579001 1 2.

Brown, L. (2008) National weed incursion toolkit—Draft compilation—Final report. Bureau of Rural Sciences, Australian Government.

Grantley, J., McPherson, F., Moran, P. and Petroeschevsky, A. (2009) Recognising water weeds: Early detection survey guidelines for weed professionals. NSW Department of Primary Industries, Grafton, NSW.

<http://www.environment.nsw.gov.au/threatenedspecies/surveymethodsfauna.htm> (accessed June 2012)

Kean, J. M., Phillips, C. B. and McNeill, M. R. (2008) Surveillance for early detection: lottery or investment? In K. J. Froud, A. I. Popay and S. M. Zydenbos (eds.) Surveillance for biosecurity: Pre-border to pest management. pp. 11-17. New Zealand Plant Protection Society Inc., Hastings, New Zealand.

MAFBNZ (Ministry of Agriculture and Forestry Biosecurity New Zealand) (2008) Biosecurity Surveillance Strategy: Review of the Current State of the Biosecurity Surveillance System
<<http://www.biosecurity.govt.nz/files/pests/surv-mgmt/surv/mafbnz-surv-strategy-current-state.pdf>>.

McMaugh, T. (2005) Guidelines for surveillance for plant pests in Asia and the Pacific. ACIAR Monograph No. 119, 192pp.

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.

Rew, L. J., Maxwell, B. D., Dougher, F. L. and Aspinall, R. (2006) Searching for a needle in a haystack: evaluating survey methods for non-indigenous plant species. *Biological Invasions* 8: 523–539.

Welsh, S. (2000) Tasmanian weed mapping guidelines (3rd edn). Tasmanian Weed Mapping Network, Kings Meadow, Tas. ISBN: 0 72466 240 5.

Appendix 1 - Decision making framework (with scenarios)

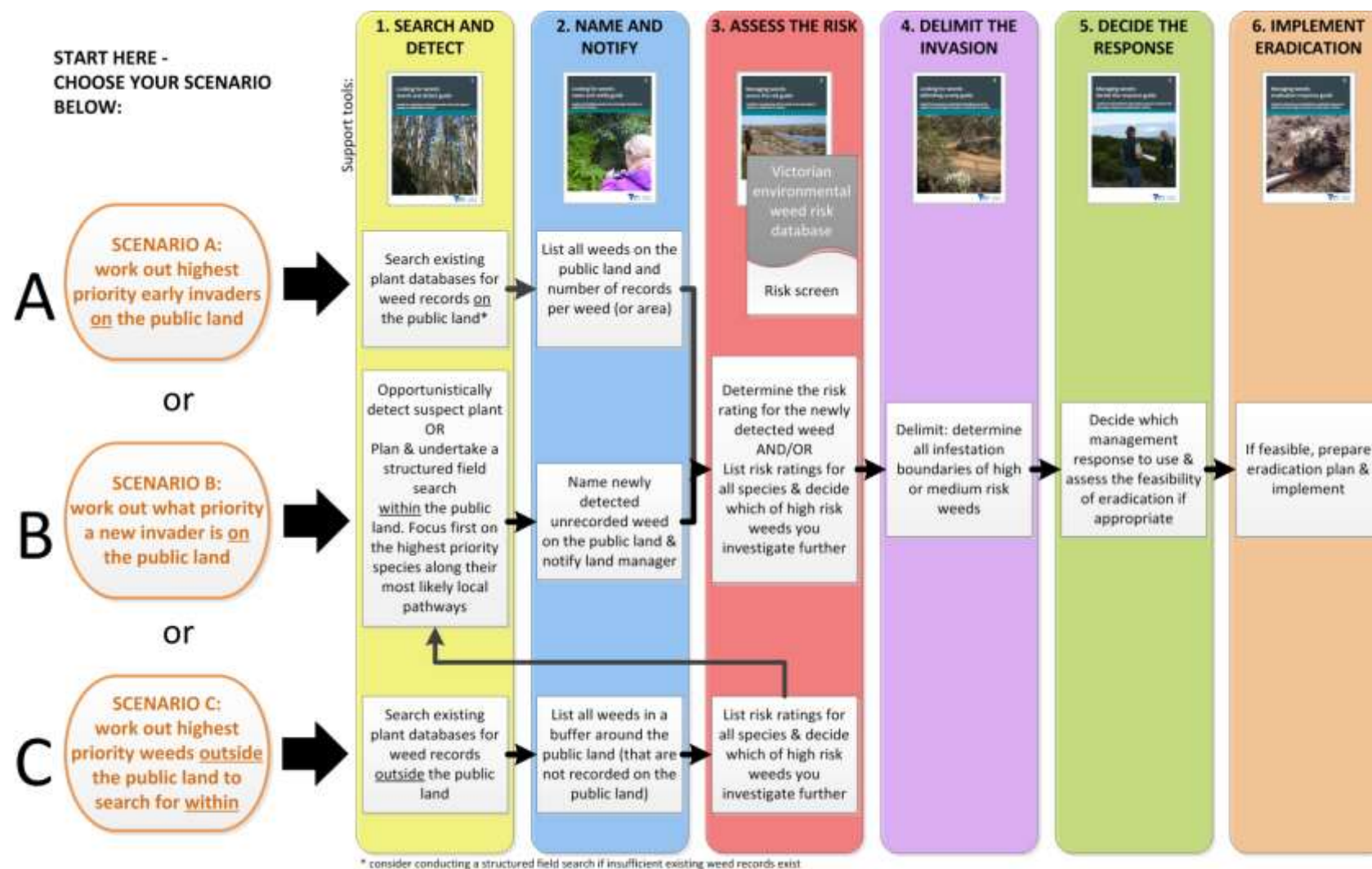


Figure 12 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. This version illustrates three typical scenarios faced by public land managers.

Appendix 2 - Information sources and tools

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.

Victorian environmental weed risk database

The Victorian environmental weed risk database is an *Excel* spreadsheet that contains a number of worksheets with data from two main sources:

- Victorian Weed Risk Assessments; and
- Victorian environmental weed advisory lists.

The Excel database is a decision support tool 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 database can be obtained from the “Managing weeds: assess the risk guide”.

Other priority weeds

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. DEDJTR 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 DEDJTR website:

<http://economicdevelopment.vic.gov.au/>. It is important to report any detection of State prohibited weeds to the Customer Service Centre on 136 186.



Figure 13 (left) - Orange Hawkweed. Figure 13 (right) - King Devil are State prohibited weeds in Victoria. Source: DEDJTR.

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 DEDJTR for a list of Regionally prohibited weeds: <http://economicdevelopment.vic.gov.au/> or report any sightings on 136 186.



Figure 14 - Bitou Bush, Regionally prohibited in North Central, North East & Gippsland catchments. Source: H. Cherry.

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 www.weeds.org.au



Field guides

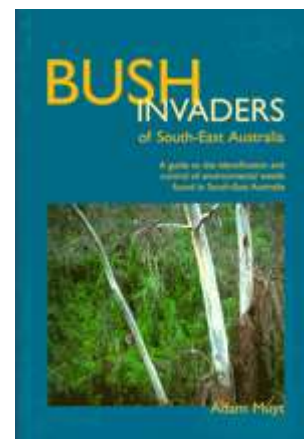
Bush invaders of South-East Australia: a guide to the identification and control of environmental weeds found in South-East Australia.

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.



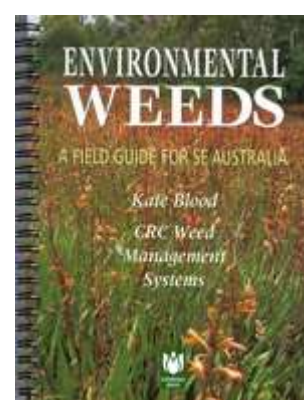
Environmental weeds: a field guide for SE Australia.

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 (2nd edn).

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

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

Publication date: 2011.

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:

<http://data.rbv.gov.au/vicflora/>

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.

People, social media and networks including weed id network

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, DEDJTR 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.

Connect with others through social media e.g. Facebook, Twitter, Instagram, and your agency's internal social media e.g. Yammer for DELWP. Try search terms and hashtags such as #invasivespecies #invasiveplants #weeds (but be prepared for drug related material) #weedid #plantid #I_SPEI (see below).

The WESI team is utilising an existing social media weed identification (weed id) network utilising the existing #weedid search term/hashtag.

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

Envioweeds

The ENVIOWEEDS 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 have the opportunity to 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/envioweeds>



I-SPEI

I-SPEI stands for Invasive Species Prevention and Early Intervention and is pronounced 'I-spy'. I-SPEI is an email-base network/discussion group established in October 2012 to encourage national and international communication and knowledge sharing on invasive species prevention and early intervention. This discussion group is open to anyone who is interested in the topic. The list can be subscribed to for free by visiting the website:

<http://lists.i-spei.com/lists/info/i-spei>

Once you have a login, you can post to this group by simply emailing i-spei@lists.i-spei.com

The hashtag #I_SPEI is also used on social media such as Twitter (note the different placement of the dash in the search term).

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>

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.

On-line information

Agency internal information on weeds, their distribution and management

Spatial, Temporal, Activity Recorder (STAR) (for DELWP and Parks Victoria)

Victorian Biodiversity Atlas (VBA): <https://vba.dse.vic.gov.au/vba/>

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

Bioweb, Bioweb2, MAX (access through DEDJTR)

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

Local databases, spread sheets, maps, Geographic Information System (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

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: <http://keys.lucidcentral.org/>

Weeds Australia - National Portal, Interactive weed identification tool (based on Lucid):

<http://www.weeds.org.au/weedident.htm> [may be discontinued soon]

Weeds of National Significance (WONS): www.weeds.org.au [may be discontinued soon]

National Herbarium of Victoria - Identification (some services for fee) and information services.

Herbarium specimens and records viewable through AVH & ALA otherwise by appointment with the Herbarium: <http://www.rbg.vic.gov.au/science/herbarium-and-resources/identification-and-information-services>

VicFlora - the definitive online resource to the plants, fungi and algae of Victoria including weeds:

<http://data.rbg.vic.gov.au/vicflora/>

Victorian Noxious weed status - Weeds declared in Victoria under the *Catchment and Land Protection Act 1994* (CaLP Act), are listed at the DEDJTR website:

<http://economicdevelopment.vic.gov.au/>. Information is also available through the Customer Service Centre on 136 186.

Weed risk assessments - available on Victorian Resources Online (VRO) (see “Managing weeds: assess the risk guide” for more detail on risk ratings):

http://vro.depi.vic.gov.au/dpi/vro/vrosite.nsf/pages/invasive_plants_common_a

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

Weed lists and distribution

VicFlora - the definitive online resource to the plants, fungi and algae of Victoria including weeds:

<http://data.rbg.vic.gov.au/vicflora/>

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

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

Flora Information System (FIS) - available from Viridans Pty Ltd.

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

Names and nomenclature

VicFlora - the definitive online resource to the plants, fungi and algae of Victoria including weeds:

<http://data.rbg.vic.gov.au/vicflora/>

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>



Grass information

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

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

Other resources

Global compendium of weeds: <http://www.hear.org/gcw/>

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

Appendix 3 - Weed sources and pathways in Australia

A comprehensive review of weed spread pathways in Australia identified 17 pathways of weed spread (Sindel *et al.* 2008). The review grouped pathways according to deliberate spread by humans, accidental spread by humans, and natural spread. New weeds are less likely to be introduced to public land by any of the deliberate pathways, but arrive and establish accidentally through pathways associated with humans or natural spread. This is the full list of 17 pathways, along with other information on weed sources and pathways in Australia below.

Table 5 - Weed sources in Australia based on a survey of scientific experts. Weed sources are listed in decreasing order of importance (after Table 5.2 in Sindel *et al.* 2008). In terms of the survey, a weed source was defined as a site or area of land where weeds are actively growing and from which new invasions may occur.

Weed sources	Examples
Transport	roads, railways, ports and water transport, airports, etc.
Horticulture – ornamental	fresh flowers, garden plants, aquarium plants, bulbs and seeds, etc.
Land in transition	degraded, abandoned, unused land
Private gardens	includes water gardens and aquariums
River	natural water courses, streams, creeks, etc.
Pasture/rangelands	cattle, sheep, dairy, goats, etc.
Utilities	sites used for energy or telecommunication i.e. for generation, storage, transmission
Cropping	dryland and irrigated
Channel/aqueduct	artificial water courses for supply or drainage
Public gardens	botanic, civic, zoos, schools, water gardens etc.
Waste treatment and disposal	landfill, green waste, stormwater, sewage, etc.
Horticulture - edible	fruit, nuts, bulbs, roots, seeds, berries, herbs, vegetables, etc.
Forestry	native and planted forests
Minimal use	stock route, residual native cover, rehabilitation etc.
Defence	land owned or managed by the Australian Defence Forces
Intensive animal use	feedlots, pigs, poultry, saleyards, aquaculture, etc.
Research	plant research and development facilities
Nature conservation	nature reserves, national parks, flora and fauna reserves, traditional/indigenous land, other protected landscapes
Mining	mines, quarries, tailings, etc.
Marsh/wetland	ephemeral and permanent
Estuary/coastal waters	beach, dunes, mangroves, etc.

Weed sources	Examples
Reservoir/dam	artificial body of standing water
Manufacturing and services	commercial centres and industrial estates
Lake	natural body of standing water

Table 6 - Other weed sources in Australia, and their importance, based on a survey of scientific experts (after Table 5.4 in Sindel *et al.* 2008).

Weed sources	Importance
Animal movement	Very Important
Aquatic plant traders	Very Important
Birds	Very Important
Community weekend markets	Very Important
Domestic animal spread	Very Important
Farm machinery	Very Important
Fund raising events through groups, schools etc. via catalogues	Very Important
Native or feral animals	Very Important
Nursery industry	Very Important
Other infrastructure	Very Important
Quarries	Very Important
Quarries as source of contaminated material	Very Important
Road maintenance (grading, mowing, etc.)	Very Important
Roads	Very Important
Roadworks and civil construction	Very Important
School and church fairs/ markets	Very Important
Soil conservation	Very Important
Stock feed	Very Important
Transported produce and seed	Very Important
Wild animal spread	Very Important
Abandoned orchards/plantations	Important
Agricultural machinery	Important
Airports	Important
Deliberate introduction	Important
Docks	Important
Herbicide tolerant genetically modified crops	Important
Introduced pasture species	Important

Weed sources	Importance
Market sellers, plant nurseries	Important
Neglected private land	Important
Overseas contaminated products	Important
Area around farm equipment sheds at farms	Slightly Important
Powerline easements	Slightly Important
Vegetation regeneration sites	Slightly Important
Herbicide tolerant genetically modified crops	not rated
Wind - rubber vine	not rated

Table 7 - Pathways for weed spread in Australia. Pathways identified for weed spread in Australia through a review of the literature (from Table 6.1 in Sindel *et al.* 2008) - the 17 pathways are grouped according to deliberate spread by humans, accidental spread by humans, and natural spread. Pathways were defined as the *means* by which weed propagules are moved.

Pathway type	Pathway source	Examples
Deliberate spread by humans	Ornamental plant trade	Through nursery sales and escape of garden and landscaping plants
	Aquarium plant trade	Through sales at nurseries, pet shops and escape into waterways
	Medicinal plant trade	Plants propagated and sold in nurseries and among alternative medicine enthusiasts
	Food plant trade	Plants grown and promoted as food for humans
	Fodder trade	Sales and planting of fodder plants for livestock grazing
	Revegetation and forestry	Planting for soil conservation and to produce timber
Accidental spread by humans	Human apparel and equipment	Attachment of seeds to clothes and footwear
	Machinery and vehicles	Attachment of seeds to passenger vehicles, slashers, farm equipment, boats and earth moving equipment
	Construction and landscaping materials	Contamination of gravel, soil, sand, mulch and turf
	Agricultural produce	Contamination of hay, grain and pasture seed
	Research sites	Escape from research sites
	Livestock movement	Through faeces or attached to livestock such as sheep, cattle, horses and goats
	Waste disposal	Unsafe dumping of garden refuse and aquarium plants
Natural spread	Birds	Through consumption and excretion of seeds and fruits

Pathway type	Pathway source	Examples
	Other animals	Through consumption and excretion of seeds and fruits, and external attachment to native and introduced wildlife
	Wind	Distribution of wind-blown seeds
	Water	Distribution of seeds or plant parts via waterways

Appendix 4 - Search frequency

The rate at which a weed establishes and spreads, and the detectability of a weed at a new site, are both a function of:

- the weed's arrival rate at the site and its inherent biological capacity for growth and spread;
- the habitat type the weed is invading;
- the degree of disturbance at the site(s); and
- the weed's growth form.

Harris *et al.* (2001) developed a guide to determine search frequency for different vegetation types and different growth forms based on studies conducted in New Zealand. A summary of these data is provided in Table 8, based on a 95 percent certainty of detection. The greater the interval between searches, the larger the infestation and the greater the cost of eradication. Note that these data are specific to New Zealand and have been included here simply to illustrate the need to consider different search intervals based on habitat type and weed growth form. However, Victoria has broad habitat types comparable to those included in Table 8, and shares many common weed problems with New Zealand, so this table could be used as a rough guide when designing searches, in combination with with local expert knowledge or studies.

Table 8 - Example of search frequency based on habitat type and weed growth form for New Zealand, modified from Harris *et al.* (2001). Intervals shown give a 95 percent certainty of finding a new weed infestation if it is present, while eradication is still considered feasible.

Habitat type	Weed growth form	Surveillance interval (years)
Forest	Climbing vine	1 year
	Ground creeper	1 - 4
	Shade tolerant shrub/tree	3 - 6
Shrubland	Vine	1 - 5
	Shrub/tree	1 - 5
Short vegetation	Short weed	1 - 3
	Shrub/tree	3 - 6
Wetland	Short weed	1 - 4
	Shrub	6 - 10
	Tree	10
Open habitats	Short weed	1 - 3
	Taller weed	2 - 5

Appendix 5 - Field recording template for weeds

Use this sheet for recording multiple species or multiple sites of the same species on public land during structured field searches.

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 <input type="checkbox"/> Ad hoc (opportunistic detection)					
GPS ref #	Species	Pattern of infestation Individual, Scattered, Continuous	Density % cover <1%, 1-5% 6-25%, 26-50% 51-75%, 76-100%	Area	Count	Age class (Seedling, sapling, mature)	Eastings	Northings	Comments (e.g. roadside, gully)
e.g. 1	<i>Cenchrus ciliaris</i>	Scattered	6-25%	5x5m	20	seedling	548011	6207117	2 m from road edge on north side

Appendix 6 - Wellbeing, safety and hygiene for field work

Wellbeing and safety

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

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

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

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

Hygiene

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

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

- Clean footwear and clothing including seeds in laces and socks, and soil on soles before and immediately after a site visit.
- Avoid placing carry bags and packs on weeds that are in seed.
- Regularly check camera bags and clothing pockets for seeds.
- Plastic sample bags can build up static electricity to which weed seeds can readily adhere.
- Avoid driving vehicles into weed infestations and check and clean the vehicle regularly including within the cabin and boot or tray.
- Consider undertaking WeedStop training to maintain suitable vehicle hygiene standards.
- Ensure other staff and contractors conducting field work are following appropriate hygiene standards.
- Be aware that the transportation of plant propagules of declared noxious weeds without a permit is prohibited. If collection of a sample or herbarium specimen is required for identification purposes, contact 136 186 for further advice.
- Companion 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*).

Appendix 7 - Field recording template for opportunistic sightings and herbarium specimens

*Required fields

Use this sheet to record opportunistic sightings (one site or weed per sheet), particularly suspected weeds at the early stage of invasion, and to accompany specimens to the National Herbarium of Victoria. Copy information into the Victorian Biodiversity Atlas (VBA) or Spatial, Temporal, Activity Recorder (STAR).

OBSERVER DETAILS

*Person recording: _____

*Phone number: _____

Email: _____

*Date sighted/collected: ____/____/20____

WEED LOCATION

*Describe where it is <i>(Address; or distance & direction from place; or attach map).</i>			
*GPS reading *Datum used with GPS	Grid Ref: E _____ N _____ Lat. ____°____, ____ S Long. ____°____, ____ 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 / govt. <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)	<i>Scientific preferable</i>		
*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 1m ² <input type="checkbox"/> 1-10m ² <input type="checkbox"/> 10-100m ² <input type="checkbox"/> over 100m 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"/> Seedling		
Reproductive state (check)	<input type="checkbox"/> No flowers <input type="checkbox"/> Flower or bud <input type="checkbox"/> Fruiting <input type="checkbox"/> Seeding		
Comments			
Photos	Close-up (file names):	Habitat (file names):	
Plant specimen details (if applicable)			

Appendix 8 - Methods for data recording

Paper-based recording

Use a field notebook with tabulated worksheets and fields that correspond to those of the spreadsheet or database that the data will be stored in. Care must be taken to ensure that data entry errors are avoided when transferring hand written raw data into electronic databases. An incorrect number in the coordinates could prevent the weed being located at future site visits. Scanning the original hand written sheets and storing them electronically can provide a source of information that can be checked if there may be errors in the data entry. Consider using the recording sheet in Appendix 5 or 7.

Smart phones

There are many GPS equipped, map-based smart phone applications (apps) (Figure 15) that allow you to work off-line, record data directly and later export or email the data. These are particularly useful for remote locations and reduce data entry errors. Use the STAR and VBA field data capture apps when they are developed. In the meantime, an example of a useful app is Memory Map: www.memory-map.com.au



Figure 15 - Smart phone applications can help with navigation in the field.

Personal Digital Assistants (PDA) and hand-held computers

A PDA or hand-held computer equipped with GPS can be programmed to function as an electronic form. Pre-programmed fields capture all the information a surveyor needs in relation to each field observation and any samples collected. The information can then be uploaded to a database in a computer upon return from the search. WESI has developed such an electronic form that can be used on iPad (Figure 16).



Figure 16 - Mobile devices are very useful for recording data and mapping in the field.

Appendix 9 - Equipment required for undertaking a field search

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.

- ☐ Hand-held GPS and spare batteries or charger
- ☐ Maps or pre-loaded maps & search polygons on the GPS
- ☐ Native plant and weed identification books/pamphlets/mobile device applications (apps) etc.
- ☐ Recording equipment such as clipboard, notebook, datasheets, pen, pencil or electronic device
- ☐ Camera with spare batteries and capacity
- ☐ Materials for marking infestations (i.e. bright coloured survey ribbon)
- ☐ Recording sheets (see Appendices 5 & 7)
- ☐ Hygiene equipment to reduce weed and soil-borne disease spread
- ☐ Plastic bags, secateurs
- ☐ Gloves and BBQ tongs for handling prickly plants
- ☐ Plant press – if you are trained and competent in collecting plant specimens, including a plant press might be appropriate
- ☐ 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:

- ☐ 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 10 - Further contacts

Contact the WESI project team

Contact the WESI project team for assistance with planning and conducting searches. The team can also assist with advice on new weed detections and working out what to do next.

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

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

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: (L:) statewide > Department business share > WESI

To report the detection of a possible weed at the early stage of invasion to the WESI project team, contact Bec (Rebecca) James or Kate Blood via email or phone.

Bec James

rebecca.james@delwp.vic.gov.au

03 9210 9357 or 0429 154 399

Kate Blood

kate.blood@delwp.vic.gov.au

03 5349 2833 or 0417 135 356

Agency contacts

Victorian Government Customer Service Centre: 136 186 (for DELWP and DEDJTR)

<http://www.delwp.vic.gov.au/>

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

Parks Victoria: 13 1963

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

Glossary and abbreviations

Glossary

Absent, absence data - Locations searched where the weed was not observed. 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).

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

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

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

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).

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.

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).

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, in order 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).

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'.

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

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

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 guide series 'park-scale eradication' is used instead.

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

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

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

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

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).

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).

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

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).

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).

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

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.

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.* 2010a).

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

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.

Present, presence data - Information collected to indicate that, in this case, a weed exists at a location.

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

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

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

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*.

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).

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).

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 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.

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.

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*.

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.

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).

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

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.

Transect - A straight line used during surveys.

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

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.

Victorian environmental weed risk database - Contains the risk ratings of weeds from two main sources: Victorian Weed Risk Assessments and Victorian environmental weed advisory lists. The database is a decision support tool that can assist in generating lists of detection priorities for 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 (Blood *et al.* 2016).

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 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).

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

Abbreviations

ALA	Atlas of Living Australia
APC	Australian Plant Census
APNI	Australian Plant Names Index
app	application
AVH	Australia's Virtual Herbarium
CaLP	Catchment and Land Protection
CLM	Crown Land Manager
CSC	Customer Service Centre
DEDJTR, Ecodev	Department of Economic Development, Jobs, Transport and Resources
DELWP	Department of Environment, Land, Water and Planning
DMF	decision making framework
ED	Early Detection

EIS	Environmental Information System
EPIRB	Emergency Position Indicating Radio Beacon
<i>et al.</i>	et alia
FFG Act	<i>Flora and Fauna Guarantee Act 1988</i>
FIS	Flora Information System
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GPS	Global Positioning System
id, ID	identification
IPNI	International Plant Names Index
I-SPEI	Invasive Species Prevention and Early Intervention
ISSG	Invasive Species Specialist Group
IUCN	International Union for Conservation of Nature
OH&S, OHS	Occupational Health and Safety
PDA	personal digital assistants
SPW	State prohibited weeds
STAR	Spatial, Temporal, Activity Recorder
UAV	unmanned aerial vehicle
URL	Uniform Resource Locator
VBA	Victorian Biodiversity Atlas
VRO	Victorian Resources Online
VWRA	Victorian weed risk assessment
Weeds CRC	Cooperative Research Centre for Australian Weed Management
WESI Project	Weeds at the Early Stage of Invasion Project
WONS	Weed of National Significance

List of Figures and Tables

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

Figure 2 - How to use this guide.

Figure 3 - Steps to planning and performing a structured search.

Figure 4 - Examples of common weed spread pathways that can be the target of pathway focused weed searches on or near public land.

Figure 5 - An illustration of the different scales of site and the terminology assigned to them - the concept of public land, site, search area and targeted survey area.

Figure 6 - Example of how to annotate a map to assist with selecting targeted sites.

Figure 7 - A vehicle-based search.

Figure 8 - Sketch of a vehicle-based search.

Figure 9 a) - Walking a transect undertaking a targeted survey for *Cylindropuntia pallida* (formally *C. rosea* as stated in the map legend) in Ouyen State Forest. b) Aerial photograph of the survey area showing GPS track logs of the transects that were walked (grey lines) and located infestations (yellow triangles).

Figure 10 - Missy the Springer Spaniel detector dog currently deployed in Victoria to search for Hawkweed. Source: OEH, NSW.

Figure 11 - Planning what to do next.

Figure 12 - This is the WESI decision making framework that guides the process for dealing with weeds at the early stage of invasion. This version illustrates three typical scenarios faced by public land managers.

Figure 13 (left) - Orange Hawkweed. Figure 13 (right) - King Devil are State prohibited weeds in Victoria. Source: DEDJTR.

Figure 14 - Bitou Bush, Regionally prohibited in North Central, North East & Gippsland catchments. Source: H. Cherry.

Figure 15 - Smart phone applications can help with navigation in the field.

Figure 16 - Mobile devices are very useful for recording data and mapping in the field.

Table 1 - Advantages and disadvantages of opportunistic searching.

Table 2 - Advantages and disadvantages of structured searching.

Table 3 - Types of search focus.

Table 4 - Accidental and natural pathways for weed spread in Australia, adapted from Sindel *et al.* 2008. Pathways are grouped according to accidental spread by humans, and natural spread.

Table 5 - Weed sources in Australia based on a survey of scientific experts. Weed sources are listed in decreasing order of importance (after Table 5.2 in Sindel *et al.* 2008). In terms of the survey, a weed source was defined as a site or area of land where weeds are actively growing and from which new invasions may occur.

Table 6 - Other weed sources in Australia, and their importance, based on a survey of scientific experts (after Table 5.4 in Sindel *et al.* 2008).

Table 7 - Pathways for weed spread in Australia. Pathways identified for weed spread in Australia through a review of the literature (from Table 6.1 in Sindel *et al.* 2008) - the 17 pathways are grouped according to

deliberate spread by humans, accidental spread by humans, and natural spread. Pathways were defined as the *means* by which weed propagules are moved.

Table 8 - Example of search frequency based on habitat type and weed growth form for New Zealand, modified from Harris *et al.* (2001). Intervals shown give a 95 percent certainty of finding a new weed infestation if it is present, while eradication is still considered feasible.

www.delwp.vic.gov.au