DELWP Output delivery standards

For the delivery of environmental activities

Version 2.1 – June 2015
Includes standards for fence, vegetation management, weed control and vertebrate animal control

Department of
Environment, Land,
Water & Planning

State Government Victoria

Printed by Impact Digital – Brunswick.

ISBN 978-1-74146-546-4 (print)
ISBN 978-1-74146-547-1 (pdf)

Accessibility

If you would like to receive this publication in an alternative format, please telephone the DELWP Customer Service Centre on 136186, email customer.service@delwp.vic.gov.au, or 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

Disclaimer

Contents

Part 1 Overview

Purpose of the Output Delivery Standards

The Department of Environment, Land, Water and Planning (DELWP) Output Delivery Standards (the Standards) is one of several sets of Standards developed under the Monitoring, Evaluation and Reporting Framework (MER Framework).

The Standards detail the minimum state-wide standards for the delivery of environmental activities and is to be used for all DELWP investment programs.

The Standards aim to:

- describe best practice for delivery of outputs through investment
- provide documentation for training
- enable evaluations/audits against the Standards to demonstrate how effectively investments are being implemented.

Individual investment programs should identify how the Standards will be applied in their specific circumstances.

Although the Standards currently apply to DELWP investment programs, they could also be applied to other investment programs and funding sources.

Introduction

These Standards are the result of the review of the Vegetation Work Standards. The Vegetation Work Standards were developed in 2011 using extensive literature reviews to define minimum standards for vegetation works to be applied across Victoria and support the successful delivery of investment programs.

Following a review in 2014, the Vegetation Work Standards were updated to better align with DELWP's MER Framework and Output Data Standards.

As with the Vegetation Work Standards, the Output Delivery Standards cover a limited number of activities related to vegetation, weed control and vertebrate animal control. There is the potential for future versions of the Standards to cover the delivery of other investment programs.

The 2014 review identified that there was a clear role for a state-wide document to establish best practice approaches for the delivery of outputs. The review found that further guidelines could be developed to provide more regional- or site-specific aspects of investment delivery, including checklists for site planning, implementation and maintenance.

The Output Delivery Standards and the Output Data Standards are key components of the DELWP MER Framework. The Output Delivery Standards provide guidance for consistent management activities and delivery of outputs and the Output Data Standards provide guidance on reporting those management activities and outputs.

Related Documents

Monitoring, Evaluation and Reporting Framework

The DELWP MER Framework aims to help state-wide and regional programs deliver better environmental outcomes by supporting a consistent approach to documentation and implementation of monitoring, evaluation and reporting.

Central to the MER Framework approach is the concept of 'adaptive management'. Adaptive management is a cyclical process that ensures meaningful and appropriate relationships between strategy and planning and the program or project implementation and monitoring, which will enable high-quality evaluation and reporting (see Figure 1).

An adaptive management approach ensures there are appropriate mechanisms in place to maximise opportunities for learning and improvement during, and following, the implementation of policies, programs and projects. The Standards were developed to help ensure that there could be consistent assumptions about the quality of on-ground activities and, therefore, the likely impact of those activities, across agencies.

Figure 1: Key elements of the adaptive management cycle.

The MER Framework promotes the use of a program logic as the basis for the information requirements for plans and strategies. Using a basic logic identifies appropriate information to guide the implementation of strategies and plans, targeted monitoring, and high-quality evaluation and reporting.

A program logic can help clarify the desired changes, the assumed long-term outcomes, the assumed shorter-term management outcomes, and the required activities and outputs. An additional benefit is that program managers do not need to visit and measure the impact of every project, but can make reliable assumptions about their impact when activities are implemented to the Standards.

The simplified program logic described in Figure 2 provides a framework for project and program planning to ensure appropriate information gathering and reporting. Standardised language and assumptions in the planning process will support consistent reporting, especially where information is gathered from multiple programs and projects and, potentially, multiple agencies.

Figure 2 illustrates the importance of the Output Delivery Standards in the underlying logic that links the activities to, in this case, catchment condition. If all elements of the program logic are in place and documented, the following information can be derived:

- appropriate activities and outputs to implement a strategy or plan
- the assumptions made about the contribution of activities to expected outcomes
- the measureable management outcomes expected during the life of strategies and plans
- the longer-term outcomes expected from investment via strategies and plans
- a description of how these elements support the broader achievement of policy objectives to protect and enhance the environment.

Consistency is required in each stage of the program logic. If we *plan* using consistent language and support the collection of consistent data, we can then *report* using consistent language and data. The Output Data Standards support consistency within the lower levels of the logic and will support consistent planning and reporting on activities within and between agencies.

DELWP Output Data Standards

DELWP's Output Data Standards describe the minimum information requirements for reporting on a broad range of project activities. The Output Data Standards describe these requirements for common goods and services (i.e. outputs) that agencies purchase through a range of investment programs. The Output Data Standards also provide a framework for Output Delivery Standards

The Output Delivery Standards and the Output Data Standards developed under the MER Framework are designed to provide specific guidance for planning, implementation, evaluation and reporting under service level agreements linked to investment programs.

Outputs covered by the Output Delivery Standards

Outputs are classified within the Output Data Standards under four categories: Structural works; Environmental works; Management services; and Planning and Regulation. The Delivery Standards do not – as yet – cover all these outputs. Table 0-1 lists the current outputs in the Output Data Standards and shows those that are covered in these Delivery Standards. The Standards may cover other outputs in future.

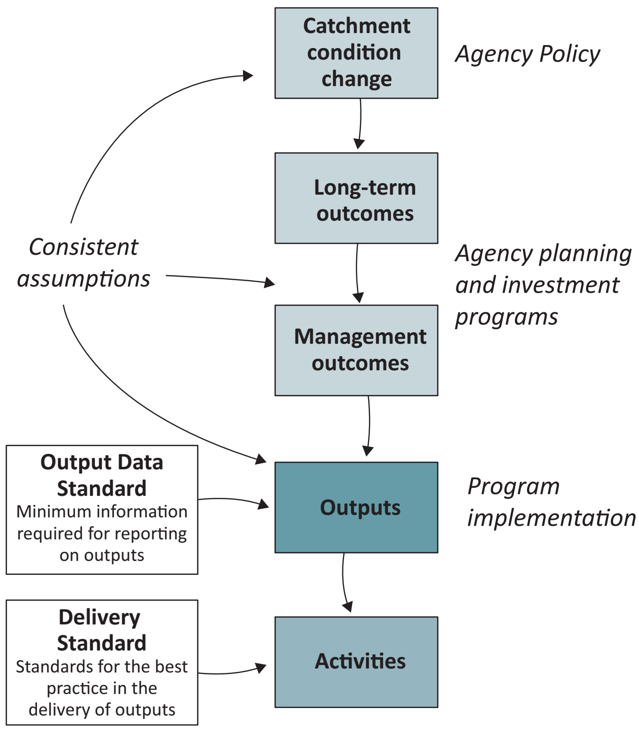


Figure 2: A program logic that links the outputs delivered through a program to the expected management outcomes, long-term outcomes and, ultimately, the condition of the environment.

Table 0-1: DELWP Standard Outputs showing those covered in these Standards.

	Outputs in DELWP Output Data Standards	Outputs covered in these Standards	Section
Structural works	Channel		
	Water storage		
	Pump		
	Irrigation infrastructure		
	Waterway structure		
	Terrestrial structure		
	Terrestrial habitat		
	Monitoring structure		
	Fence	Stock fencing	1
	Visitor facility		
	Road		
	Crossing		
Environmental works	Vegetation	Plant establishment	2
		Planting density, diversity and placement for seedlings	3
		Ecological thinning of Eucalypt species	4
		Soil preparation for replanting	5
		Ecological grazing	6
	Weed control	Herbaceous weed control	7
		Minimising the spread of weeds and plant pathogens	8
		Woody weed control	9
	Vertebrate animal control	Vertebrate animal control	10
	Over-abundant wildlife	Vertebrate animal control	10
	Threatened species recovery		
	Emergency species recovery		
	Soil treatment		
	Earth works		
Management services	Water regime		
	Fire regime		
Planning and regulation	Approval and advice		
	Management agreement		
	Assessment		
	Engagement event		
	Partnership		
	Plan		
	Publication		
	Information management system		

Use of the standards

Delivering investment activities

The Output Delivery Standards provide valuable information and guidance on:

- applicability (i.e. when does a particular activity apply or not apply?)
- technique (i.e. which approaches best fit the project's need and situation?)
- timing (i.e. what resources are required, and when and in what order should activities take place?)
- licences or permits that may be required.

The Standards are designed to be applied across the State. Specialist skills and local knowledge may be required to implement and interpret the Standards effectively. For example, specialist botanical skills may be required to implement ecological grazing regimes while local knowledge may be required to determine plant availability for revegetation projects.

Where appropriate, practitioners are encouraged to consider relevant legislation or policy frameworks such as Victorian *Catchment and Land Protection Act 1994*, the *Planning and Environment Act 1987* and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* in the use of these Standards.

Flexibility

While the Standards have been developed to specify the minimum standard for investment delivery, sometimes a diversion from a Standard or a component of a Standard may be appropriate for specific site conditions.

Flexibility around how the Standards are applied should be negotiated with the investment program. In such cases, the onus is on the project manager to explain why an alternative approach is necessary. This can be achieved by documenting:

- why the Standard wasn't appropriate
- the alternative approach adopted
- how the alternative approach will be evaluated.

In some cases, agencies may need to provide project managers with more region-specific advice and will develop more detailed guidelines at a regional or sub-regional scale to address specific aspects of delivery. Such regional guidelines should align with the relevant standard.

Part 2 Output Delivery Standards

1. Fence – Stock fencing

The project manager is responsible for determining whether stock fencing is an appropriate activity for a particular vegetation management project. Thedecision will depend on a number of factors, including:

- The project goal.
- The relevant ecological vegetation class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch, i.e. revegetation.
- Specific site conditions, e.g. soil type, slope, location in the landscape (e.g. floodplain).
- The type and severity of threats present.

1.1 Scope

This Standard covers typical methods to exclude the most common domestic livestock that can threaten areas of native vegetation, in particular, beef cattle, dairy cattle and sheep.

It does not cover methods to exclude pest animals, e.g. rabbits. For these animals, refer to *10 Vertebrate animal control and management.*

1.2 Background

Livestock grazing and trampling can seriously damage both remnant and planted native vegetation. In areas adjoining waterways and wetlands, livestock can also compact soils, destabilise beds and banks, and degrade water quality.

Livestock grazing can open up bare ground which, together with increased nutrient levels from animal manure and urine, creates an ideal situation for weed establishment (Land and Water Resources Research and Development Corporation 1996).

If the area adjoining a project site is grazed or there is a risk of future grazing, the project site must be fenced according to the methods described in this Standard.

Appropriate stock fencing will also be required if an ecological grazing regime is to be implemented as a management tool for a project site. Refer to *6 Vegetation – Ecological grazing* for more details.

1.3 Method

The most common types of stock exclusion fencing are:

- conventional fencing, i.e. standard post and wire fencing, typical on many rural properties
- mesh fencing, i.e. prefabricated wire fencing often used for sheep (e.g. ring-lock, hinge joint) electric fencing (often added to conventional fencing to enhance livestock control).

1.3.1 Applicability

Each fencing type has advantages and disadvantages. Choosing the type most appropriate to a particular project site will depend on several factors, in particular:

- the type of stock to be excluded
- the risk of damage, e.g. from flooding
- site topography, e.g. river meanders
- cost (Staton and O'Sullivan 2006).

Tables 1-1 to 1-3 list the advantages and disadvantages of each fencing type.

Table 1-1: Conventional fencing – advantages and disadvantages.

Advantages	Disadvantages
• Collects less flood debris than mesh fencing • Cheaper than mesh fencing • Simple to cut to reduce damage if flooding is imminent • Can be designed to lay down in flood events • Simple to repair • Relatively effective against cattle • Additional wires can improve effectiveness against sheep and lambs	• Higher cost if droppers (used to spread stock pressure from a single wire to all wires in a fence) are needed, depending on post spacing • Difficult to follow curves (e.g. river meanders) • Less effective against sheep than mesh fences

Adapted from Department of Sustainability and Environment (2006) and Staton and O'Sullivan (2006).

Table 1-2: Mesh fencing – advantages and disadvantages.

Advantages	Disadvantages
• Forms a solid, impenetrable barrier to cattle, sheep and some vermin • Most effective against lambs • Stronger than conventional fences at the same post spacings • Copes well with minor damage as snapped wires are supported by surrounding wires	• Expensive in relation to other types of fencing • Susceptible to flood damage • Difficult to follow curves (e.g. river meanders) • Difficult to repair if many wires are cut • Can restrict the movement of wildlife

Adapted from Department of Sustainability and Environment (2006) and Staton and O'Sullivan (2006).

Table 1-3: Electric fencing – advantages and disadvantages.

Advantages	Disadvantages
• Comparatively cheap and quick to erect as less wire, and fewer and smaller posts are required • Relatively flood proof • Effective against a range of stock and feral animals • Curved fence line possible • Can be used easily to fence off stock crossings and watering points • Easy to move (good option for temporary fencing) • Less damage or injury to cattle (compared to conventional barbed wire fencing) • Can be used flexibly to manipulate stock numbers and grazing impact	• Not as effective against sheep (but additional wires and closer spacing can improve effectiveness) • Droppers may be needed • Requires a reliable source of power and a strong electric current • Can affect wildlife through electrocution • Vegetation and animals can cause shorting (the risk of vegetation shorting can be reduced by slashing or spraying along fencelines) • Can be a fire risk • More labour intensive as fence needs to be checked regularly • Can be an issue for: – remote or large properties – absentee landholders

Adapted from Department of Sustainability and Environment (2006) and Staton and O'Sullivan (2006).

A decision tree (Figure 3) based on the information in these tables has been developed to help determine the most likely type of stock exclusion fence required for a particular project site. This decision tree should only be used as a guide as it does not consider all variables relevant to a particular site.

Where the risk of flood damage to a fence is high, alternatives to the standard fence types may be required, e.g. drop down fences (where property boundaries run perpendicular to flood flows) or sacrificial fences (where fences cross high energy reaches of a waterway). Detailed information on these alternative flood-resistant fence types can be obtained at the Waterways WA Program website.

1.3.2 Technique

The following sections present recommended standards for:

- fence location
- fencing wire (based on fence type and stock type)
- wildlife movement
- in-line posts (including spacings) and end assemblies
- gates.

1.3.3 Fence location

Fences should be a suitable distance from native vegetation (about 10m from the drip-line of the tree canopy) to minimise damage to vegetation during construction and maintenance requirements from fallen branches, etc, during the life of the fence.

A fence's location should also take into account land classes and topographic features (e.g. waterways, gullies, steep slopes).

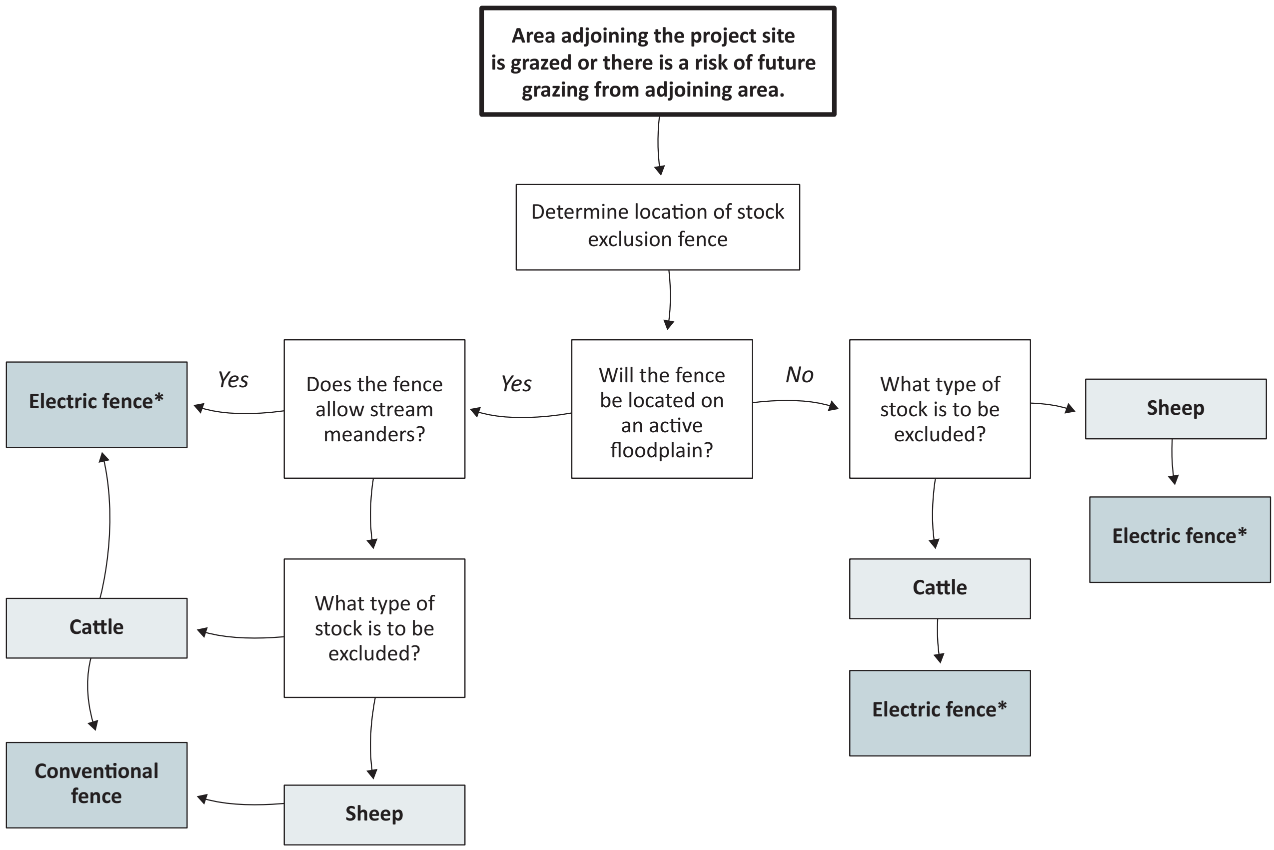


Figure 3: Decision tree to assist in determining the most likely type of stock exclusion fence.

* *Electric fencing may be inappropriate in some situations, e.g. remote or large properties or properties with absentee landholders.*

1.3.4 Fencing wire

Wire specifications for the three most common types of stock exclusion fencing are detailed in Table 1-4. These specifications should be applied to all fencing projects aimed at controlling stock access. Exceptions are where:

- fencing will be erected on flood-prone land (the project manager must determine the most appropriate number of wires to control livestock and minimise flood damage to fences)
- fencing restricts the movement of native wildlife.

1.3.5 Wildlife movement

Fences need to be designed to suit local wildlife species and conditions. They can disrupt the feeding, migration, breeding and social patterns of native wildlife, as well as cause deaths.

The spacing and location of wires can affect wildlife (Corangamite Seed Supply and Revegetation Network 2006). For example:

- Kangaroos may become caught in the wires of an electric fence and be killed by the current (Platt and Temby 1999).
- Fence visibility can be an issue near wetlands where large birds need sufficient space to land and take off.
- Ringlock can be a potential hazard to wildlife, e.g. brolgas.
- Live wires low to the ground may kill animals such as echidnas and snakes (Platt and Temby 1999).

1.3.6 Wire spacings and fence height

Given the vast diversity in the size, shape and movements of wildlife, a set of standards for wire spacings and fence height cannot be ascribed (Land for Wildlife Queensland, no date). However, guidelines that enable wildlife movement include:

- allowing a 50cm gap between the ground and the lowest fence strand to assist the movement of ground-living wildlife
- ensuring fences are no more than 1.2 metres high (Land for Wildlife Queensland, no date).

1.3.7 Barbed wire

Avoid the use of barbed wire wherever possible, particularly in high wildlife risk areas, e.g. along ridgelines or near waterways, feed or roosting trees.

More than 70 Australian wildlife species have been identified as occasional or regular victims of barbed wire fences. Most entanglements occur on the top one or two strands (Land for Wildlife Queensland, no date).

An alternative to barbed wire may be electric fencing, which is more effective at containing cattle than barb wire (Platt and Temby 1999, Department of Sustainability and Environment 2006).

Where electric fencing is inappropriate (see Table 1-3), the following methods will reduce the risks to wildlife:

- use plain wire for the top two strands of the fence
- make the fence more visible and easier to cross by stringing electric fence tape above the top strand of barbed wire (Land for Wildlife Queensland, no date).

1.3.8 In-line posts and end assemblies

A number of in-line post types are suitable for livestock fencing and include treated pine, concrete, recycled plastic and steel. An alternative to in-line posts involves steel pickets with the occasional wooden/steel/concrete post at direction changes for stability.

The general in-line post spacing for livestock control should be 8–10 m, with either:

- wooden, steel or plastic droppers at 2.5 m to 3 m spacings
- 1,650 mm or 1,800 mm steel pickets at 4 m to 5 m spacings.

Site conditions can have a significant bearing on the actual spacing of posts, e.g. wider spacings are possible on flat country. The recommended spacings are provided as a guide only.

End assemblies are generally constructed from treated pine, concrete and/or pre-fabricated metal, e.g. Ezy Slot posts, Adjusta-Stays.

Table 1-4: Wire specifications by stock type.

Fence type	Beef cattle	Dairy cattle	Sheep
Conventional	7-strand plain wire*		
Mesh	Standard 6/70/30 or 7/90/30 ringlock and plain wire*		
Electric	4-strand plain wire with at least 2 electrified strands	3-strand plain wire with at least 2 electrified strands	5-strand plain wire with at least 3 electrified strands, ensuring that the bottom wire is earthed**

** A common addition to these fence types (that can prolong their life) involves installation of an electrified offset wire. The height of this wire should be about two-thirds the height of the animal to be excluded.*

***Long grass may short-out fences, so the site will require regular maintenance.*

Table adapted from Department of Sustainability and Environment (2006) and Staton and O'Sullivan (2006).

1.3.9 Gates

Gates are important features of fencing projects, allowing:

- efficient removal of any stock that may stray into a project area
- management of livestock access where ecological grazing is being implemented
- access for spot spraying weeds, baiting for vermin or firefighting (Staton and O'Sullivan 2006).

For management access, incorporate at least one gate in any fencing project (or two gates for riparian projects, one at either end of a project area).

The type of gate (e.g. prefabricated gate, electric fence gate or 'cocky's gate') will depend on the type of fence constructed and the level/type of access required.

1.3.10 Timing

Fencing must be completed before any other vegetation management works (e.g. pest plant and animal control) are undertaken. Possible exceptions include where:

- large earthmoving equipment is required to access and negotiate a site, e.g. for willow removal or deep-ripping
- livestock can be removed from the project site during the works phase, e.g. to another paddock.

Fencing should be undertaken when the soil is easy to work (e.g. for post hole construction) but not so wet that posts cannot be stabilised (e.g. to tension wires). In addition, avoid fencing during the fire danger period (especially if using welders or other heat-generating equipment).

1.4 References

Corangamite Seed Supply and Revegetation Network (2006). *Improving Biodiversity Outcomes in Revegetation Activities – Protocols, Resources and Supporting Documents.*

Department of Sustainability and Environment (2006). *Native Vegetation Revegetation Planting Standards – Guidelines for Establishing Native Vegetation for Net Gain Accounting.* Department of Environment, Land, Water and Planning, Victorian Government, East Melbourne.

Land and Water Resources Research and Development Corporation (1996). *Managing Stock. Riparian Management Fact Sheet 6.*

Land for Wildlife Queensland (no date). *Wildlife Friendly Fencing and Netting. Note G4*

Platt, S. and Temby, I. (1999). *Fencing Wildlife Habitat.* Land for Wildlife Notes – LW0029. Department of Natural Resources and Environment. Victoria.

Staton, J. and O'Sullivan, J. (2006). *Stock and Waterways: A Manager's Guide*. Land & Water Australia, Canberra.

2. Vegetation – Plant establishment

Determining whether plant establishment is an appropriate activity for a particular vegetation management project is the project manager's responsibility and will depend on a number of factors, including:

- The project goal.
- The condition and extent of remnant vegetation at the project site, which, in turn, determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside a remnant patch, i.e. replanting.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

2.1 Scope

This Standard covers typical methods to establish plants as part of a revegetation project, such as direct seeding, planting seedlings, long-stem planting and introducing seed banks to wetlands.

It does not cover the establishment of plants by encouraging natural regeneration, although this method should always be considered the first option for a revegetation project.

2.2 Background

Native vegetation is a vital component in the sustainability of the landscape and a key factor in the functioning of natural ecosystems. In particular, native vegetation:

- binds, protects and nourishes soils
- filters, purifies and protects waterways and wetlands
- provides connectivity and corridors across the landscape for native species
- lowers groundwater tables, helping to combat the effects of salinity
- provides shelter for stock and improves farm productivity
- creates essential habitats for birds, frogs and other animals
- provides aesthetic and landscape significance (Peters 2010).

2.3 Method

The following sections describe appropriate techniques and timing to re-establish native vegetation species using:

- direct seeding
- seedling planting
- long-stem planting
- seed bank introduction.

2.3.1 Direct seeding

This method involves sowing seeds (either dry or pre-germinated[1]) directly onto a site to achieve germination and establishment (Corr 2003). There are several direct seeding techniques:

- Hand sowing – seed, usually mixed with a bulking agent, is placed onto a prepared seed bed.
- Mechanical direct seeding – specialised direct seeding equipment, which is calibrated for different seed sizes and planting depths is used (Greening Australia 2008a).
- Brush mulching – cut stems of a plant with ripe fruit present are laid across a prepared site. This technique is often suitable in areas with few weeds or for coastal sites.
- Hydromulching – a slurry of mulch, water, fertiliser and seed is sprayed across bare ground. It can be quite useful for erosion control.

The two main methods (hand sowing and mechanical direct seeding) are discussed in detail in following sections.

Applicability

Direct seeding is a cost-effective and highly efficient technique, particularly for broad-scale projects (Corr 2003).

Project site factors

In addition to the above, to determine whether direct seeding is a suitable technique for plant establishment, a number of project site factors should also be considered, in particular:

- soil type
- landscape setting
- project scale.

1 Pre-germination (seed conditioning or trimming) can significantly improve the success rate of direct seeding by bringing about a number of early germination stages. Species that give good results include: *Acacia* spp.; *Eucalyptus* spp.; *Melaleuca* spp.; *Callistemon* spp.; *Allocasuarina* spp and *Dodonea viscosa* (NSW Department of Infrastructure, Planning and Natural Resources 2004).

Table 2-1: Direct Seeding – advantages and disadvantages.

Advantages	Disadvantages
• Natural look and more diversely structured • Establishes healthier plants • Enables early establishment of root systems • Increased growth rates of established plants post sowing, e.g. within two years of germination most successful direct seeding plantations are larger, more diverse and better established than tubestock planted at the same time • Less labour intensive than replanting and therefore often easier and cheaper to plan and implement • Existing farm equipment can be used together with direct seeding machines (which are often available for hire from local organisations, e.g. Landcare) • Plants 'self select' suitable establishment sites within the revegetation area, particularly if a diverse seed species mixture is sown • Higher plant densities after germination provide better shelter to new seedlings and reduce weed competition (this also allows natural selection of the stronger plants without creating gaps to be replanted) • Less maintenance is required after direct-seeded plants are established as a complete canopy cover is established much quicker (due to the huge increase in stems/hectare)	• Long establishment times (can be patchy and can take several years) may lead to more maintenance such as weed control • Ants have been known to take seed • Growth rates and bough development can be delayed if plant densities are too high. This may require thinning at a later date • Not all species germinate from seed successfully • Mechanical direct seeding requires an experienced operator to ensure seed is not too deep or too shallow

Table adapted from Greening Australia (2008a).

Table 2-2: Suitability of direct seeding based on soil type (using hand and mechanical techniques).

Soil type	Hand	Mechanical
Sands	✓	✓
Non-wetting sands	✓	✓
Light soils	✓	✓
Heavy clays	✓	✓
Sticky clays	✓	✓
Cracking clays	✓	
Heavy wet soils	✓	✓
Saline soils	✓	✓

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Table 2-3: Suitability of direct seeding based on landscape setting (using hand and mechanical techniques).

Landscape setting	Hand	Mechanical
Flats	✓	✓
Light granitic hills	✓	✓
Rocky or stony country	✓	✓*
Waterlogged	✓	✓**
Rocky hill tops (difficult access)	✓	✗
Steep hills	✓	✓***
Intact remnants and ground flora	✓	✗
Riparian	✓	✗
Isolated dead trees	✓	✓

✓ – suitable ✗ – unsuitable

** Burford/Hamilton Tree Seeder*

*** M-Profile mounding*

**** Burford Tree Seeder, Rippa Seeder, Dozer Terracing*

Table adapted from Corr (2003).

Table 2-4: Suitability of direct seeding based on project scale (using hand and mechanical techniques).

Project scale	Hand	Mechanical
Broadscale	✓	✓
Medium (e.g. belts)	✓	✓
Small (e.g. spots)	✓	✗

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Technique

Specific techniques for direct seeding are set out in the Greening Australia handbook *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria*.

These techniques, together with local knowledge and expertise (e.g. DELWP staff, landcare networks), should be used to guide direct seeding projects.

Timing

Direct seeding relies on effective weed control to allow development of a moisture bank in the soil during winter when evaporation is low. Following germination and initial growth, further plant growth can draw on the soil-stored moisture, even if rainfall is inadequate. This is usually sufficient for establishment if there have been adequate winter rains.

The establishment and growth of plants is enhanced by good follow-up rains. This is especially the case in light soil and during dry years when the moisture bank may be insufficient for plant establishment. Direct seeding should be timed, where possible, to coincide with predictable, follow-up rainfall (Corr 2003).

Table 2-5 provides recommended seasons for undertaking direct seeding based on annual rainfall and should be used to assist in planning a direct seeding project.

2.3.2 Seedling planting

This method involves planting seedlings by hand or with a mechanical seedling planter. Seedlings are grown in a variety of containers to suit the scale and purposes of works; the most common are individual containers (e.g. forestry tubes) or cells (multi-celled containers arranged in trays) (Corr 2003).

Applicability

Advantages and disadvantages of seedling planting compared with direct seeding are provided in Table 2-6.

Table 2-6: Seedling planting – advantages and disadvantages.

Advantages	Disadvantages
• More reliable and immediate results • Placement of individual plants is controlled • Revegetation is visible to passers-by • Uses small quantities of seed	• Often results in unnatural looking rows • Higher establishment costs than direct seeding (particularly for large areas) • Substantially more labour intensive and costly than direct seeding

Table adapted from Greening Australia (2008a).

Project site factors

A number of project site factors should also be considered in determining whether seedling planting is a suitable revegetation technique, in particular:

- soil type
- landscape setting
- project scale
- desired end result.

These factors are presented in Tables 2-7 to 2-10.

Table 2-5: Recommended seasons for direct seeding.

Climatic region	Annual rainfall (mm)	Recommended season for direct seeding*		
		Autumn	Winter	Spring
Semi-arid areas	250–500	✓	✓	✗
Medium to high rainfall areas	>500	✗	✗	✓
Frost-prone areas	N/A	✗	✗	✓

✓ – suitable ✗ – unsuitable

** Based on the long-term average annual rainfall. Actual timing should be based on the local environmental conditions.*

Table adapted from Corr (2003).

Table 2-7: Suitability of seedling planting techniques based on soil type (using hand and mechanical techniques).

Soil Type	Hand	Mechanical
Sands	✓	✓
Non-wetting sands	✗	✗
Light soils	✓	✓
Heavy clays	✓	✗
Sticky clays	✓	✗
Cracking clays	✓	✗
Heavy wet soils	✓	✗
Saline soils	✗	✗

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Table 2-8: Suitability of seedling planting techniques based on landscape setting (using hand and mechanical techniques).

Landscape setting	Hand	Mechanical
Flats	✓	✓
Light granitic hills	✓	✗
Rocky or stony country	✓	✗
Waterlogged	✓	✗
Rocky hill tops (difficult access)	✓	✗
Steep hills	✓	✗
Intact remnants and ground flora	✓	✗
Riparian	✓	✗
Isolated dead trees	✓	✗

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Table 2-9: Suitability of seedling planting techniques based on project scale (using hand and mechanical techniques).

Project scale	Hand	Mechanical
Broadscale	✗	✓
Medium (e.g. belts)	✓	✓
Small (e.g. spots)	✓	✗

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Table 2-10: Suitability of planting techniques based on desired end result (using hand and mechanical techniques).

Desired end result	Hand	Mechanical
Random or natural	✓	✗
Uniform spacings	✓	✓

✓ – suitable ✗ – unsuitable

Table adapted from Corr (2003).

Technique

The following sections present techniques for:

- planting seedlings (either by hand or mechanical planter)
- guarding, watering and fertilising seedlings at planting.

Planting by hand

The most common tools used for hand planting seedlings are:

- mattock and shovel
- planting spade
- Hamilton tree-planter (or similar)
- Pottiputki tree planter
- powered or hand auger

Techniques, advantages and disadvantages of these tools are provided Table 2-11.

Planting using a mechanical seedling planter

Mechanical planters work on the principle of opening the soil with a broad tyne or shank so that a plant can drop into the space. Press wheels then push the soil back around the plant as the machine travels forward. Different machines are able to plant different seedling stock, including cells, tubestock and open-rooted seedlings (Corr 2003).

Tree-planting machines provide an efficient option for large-scale revegetation in the right conditions, e.g. flat to undulating country with friable soil conditions. They are particularly suitable for projects that require regular, known spacings of tree seedlings of similar size, such as farm forestry or narrow shelterbelts (Corr 2003).

Guarding

Placing tree guards around seedlings is common practice and aims to increase the survival rate of plant establishment projects. Tree guards may be beneficial in protecting seedlings from:

- rabbits and hares (particularly their browsing of tasty new seedling shoots)
- hot and cold winds
- insect damage (e.g. wingless grasshoppers)
- frost (particularly when planting in autumn in frost-prone areas)
- spray drift from herbicides.

In addition, tree guards may stimulate plant growth by:

- creating a warm and moist micro-climate
- funnelling rainwater to the roots of plant.

However, tree guards that shelter plants from wind may lead to development of non-sturdy 'leggy' stems and weaker roots by over-sheltering plants. Plant stems can also be damaged or weakened by rubbing on tree guards as they are blown in the wind.

Tree guards that restrict light penetration (e.g. milk cartons) may also lead to weak or 'leggy' growth of short seedlings. Milk cartons also provide no significant protection from browsing/grazing animals once the plant grows clear of the tree guard.

Table 2-11: Seedling planting by hand – techniques, advantages and disadvantages.

Planting tool	Technique	Advantages	Disadvantages
Mattock and shovel	1. Dig a hole slightly larger than the tubestock 2. Place the plant in the hole so that the top of the potting mix is just below ground surface 3. Backfill the hole ensuring that no air pockets exist 4. Leave a depression around the plant to catch water	• Good for heavy/sticky clay or inaccessible sites	• Hard on the back • Slow and physically demanding
Planting spade	1. As for mattock and shovel	• Relatively quick. Best for bare-rooted stock	• Requires soft soil • Requires bending
Hamilton tree planter and similar	1. Push in to the depth of the planter 2. Place plant in hole 3. Crumble soil plug (from previous hole) around plant 4. Firm in with hand or boot	• Easy to use • Cuts hole to the shape of the tubestock	• Requires bending • Not good for clay soils as: – sides of the hole left smoothly polished and impenetrable to emerging roots – soil plug difficult to remove – on loose soils, hole shape may collapse
Pottiputki	1. Drive into the ground and lever open to create a hole 2. Drop seedling down the tube into the hole 3. Press in place with foot	• Very quick, no bending, good root-soil contact • Good for cell tray stock	• Requires well-prepared soil
Powered or hand auger	1. Turn the auger until the desired hole depth is achieved (for most purposes a 100 mm long bit will be sufficient) 2. Roughen the sides of any polished holes 3. Place plant in hole 4. Firm in with hand/boot	• Can enable penetration of compact soils • Most suitable for: – relatively soft soil – small seedlings such as plugs or Hiko cells	• Less control over depth of planting hole • Not good for clay soils as sides of the hole left smoothly polished and impenetrable to emerging roots

Table adapted from Greening Australia (2008a) and TreeProject (2003).

***Planting Notes**: Plants must be moist prior to planting – soak thoroughly in their containers prior to planting. Remove the plant from the tube or cell by turning upside down and tapping the rim of the tube. Never pull plants out by their stem. Soil should not cover any previously exposed stem of a plant as this can lead to stem rot.*

Types

Tree guards should only be used for small- to medium-scale tubestock plantings. They add considerable cost to large-scale plantings, and their use should be carefully weighed up against the cost of replacing plants lost in the first few years of the planting (Greening Australia 2008b).

The most common tree guards used to aid plant establishment are either milk cartons or translucent plastic sleeves. The advantages and disadvantages of each type are described in Table 2-11.

Where grazing/browsing of larger animals (e.g. wallabies) is an issue, neither milk cartons nor plastic sleeve provide adequate protection. To protect plants from these animals, an option is very tall tree guards of rigid corrugated plastic or heavy-duty weld mesh (refer to 10.16.2 in the Vertebrate animal control and management Standard for further details).

Maintenance

If tree guards are used, maintenance and future removal may be required (Corr 2003).

Plastic tree guards must be removed after the seedlings are healthy and well established – usually after 3–4 years[2] to prevent the plastic from blowing away and causing a litter problem (TreeProject 2003). If the tree guards are to be re-used for other projects, a shorter timeframe should be applied to avoid damage to both the guard and the plant.

Milk cartons may be left around the plant to breakdown naturally as they are biodegradable; however, this may be inappropriate in high profile and/or urban areas (TreeProject 2003).

Watering

At planting

If planting into very dry ground, the plant will require some watering in. If soil moisture is high this is not necessary. However, an initial watering at the time of planting is advantageous to help overcome any transplant shock, help remove air pockets from the roots and establish good root to soil contact (Corr 2003).

One or two litres of water (or more) poured slowly around the planted seedling should be sufficient (TreeProject 2003, Perry 2004).

Table 2-12: Tree guards – advantages and disadvantages.

Tree guard	Technique	Advantages	Disadvantages
Milk carton	Supported by two bamboo stakes	• Most economical (TreeProject, 2003) • Biodegradable • Suitable for areas with the softer loamy or sandy soils (TreeProject 2003)	• Not suitable in hard clay soils • Denies light and air flow to small seedlings, *reducing* their growth • Potential litter problem if site not maintained • High labour costs to install
Conflute guards	Supported by two hardwood stakes	• Height of guard up to 600mm • Offers good protection from browsing animals, resistant to bending • Triangular profile resists dislodgement in floods • Reusable	• More expensive (materials and labour)
Plastic sleeve	Supported by three bamboo stakes (or hardwood stakes for clay soils)	• Larger – provide greater protection, enable greater growth, allow more light penetration (TreeProject 2003) • More suitable for harder ground as the stakes can be hammered in (TreeProject 2003)	• More expensive (materials and labour) • Not suitable near waterways, as the guards can easily get in to the waterway, posing a risk to fish and wildlife (TreeProject 2003). • Can 'cook' seedlings in summer • Not biodegradable, so follow-up removal is required

2 Establishment times can vary greatly, e.g. as short as 18 months in well-prepared riparian areas to as long as 10 years in dry areas such as the Mallee.

Post planting

Provided soil preparation and weed control has been adequate, further watering should not be necessary. In fact, watering after plant establishment tends to encourage shallow rather than deep root development, reducing the plants ability to cope with dry conditions.

The only time that follow-up watering should be applied is if plants have been established in very dry seasons (Corr 2003) or when a lack of summer rains has induced drought stress (Perry 2004, TreeProject 2003).

Fertilising

As indigenous plants are generally adapted to low-nutrient soils, fertilisers should not be used for revegetation programs (Corr 2003, TreeProject 2003, Perry 2004).

The exceptions are highly eroded sites with infertile soils. Planting under these conditions may be less successful without the addition of a slow release fertiliser (e.g. NPK) to enhance growth in the first few months (TreeProject 2003, Perry 2004).

If the addition of a fertiliser is deemed necessary, the planting site should be free from competitive weeds (refer *7 Herbaceous weed control*). If weeds are present, fertilising will stimulate further weed growth, which will do much more harm than good to the success of the planting project (Anderson 2003).

Timing

The general principle to follow (given good weed control) is the lower the rainfall, the earlier the planting (Corr 2003).

South of the Great Dividing Range in Victoria, planting in spring allows good prior weed control and avoids most frosts and cold or waterlogged soil. If spring rainfall fails, planting after the following autumn break may be preferential.

In areas north of the Great Dividing Range with less reliable spring rains, earlier planting in autumn or winter is recommended. This takes advantage of the winter rains (TreeProject 2003, Anderson 2003, Perry 2004).

Table 2-13 provides recommended seasons for undertaking seedling planting based on annual rainfall and should be used to assist in planning a planting project.

Maintenance

Good preplanting weed control minimises the need for post-planting spraying (TreeProject 2003, Perry 2004). However, weeds often grow back after planting and should be controlled (TreeProject 2003). Refer to the Herbaceous weed control Standard for specific techniques and timing.

In addition, some tubestock on planting sites may be lost in the short term (e.g. due to low rainfall). In these situations, it may be appropriate to include replanting (in subsequent years) within the project site as part of a maintenance program.

An appropriate allocation of resources to maintenance should be included as an essential component in all replanting projects. If replanting sites cannot be maintained in an appropriate condition they should not be established.

2.3.3 Long-stem planting

This method involves planting long-stem tubestock by hand. Long-stem seedlings are grown in pots for 10 to 18 months, so that they develop long woody stems. These seedlings are then planted with about three-quarters of their length below the soil surface (i.e. about one metre deep) (Australian Plants Society 2010).

Applicability

Long-stem planting is considered a successful method for a wide range of environments and conditions. In particular, long-stem planting can improve the survival of plants where:

- surface soil conditions are generally unfavourable, e.g. low moisture levels, high temperatures, high salinity
- surface ground movement is likely to occur, e.g. regularly flooded areas (Australian Plants Society 2010).

Table 2-13: Recommended seasons for seedling planting.

Climatic region	Annual rainfall (mm)	Recommended season for planting*		
		Autumn	Winter	Spring
Semi-arid areas	250-500	✓	✓	✗
Medium to high rainfall areas	>500	✓	✗	✓**
Frost-prone areas	N/A	✗	✗	✓**

✓ – recommended ✗ – not recommended

* *Based on the long-term average annual rainfall. Actual timing should be based on the local environmental conditions.*

** *Traditional spring plantings may need to be reconsidered depending on the previous season's rainfall. Projects should be designed so that an earlier planting can be implemented if required.*

Table adapted from Corr (2003).

Advantages and disadvantages of long-stem planting compared with traditional seedling planting are provided in Table 2-14.

Technique

The following method, developed by the Australian Plants Society (2010), should be used to guide long-stem planting projects in Victoria:

1. Dig holes that are deep enough to allow three-quarters of the plant to be buried.
2. Pour about one litre of water into the hole and allow it to soak in.
3. Prune side branches or large leaves from the lower portion of the stem that impede placement of the seedling in the hole when planting.
4. Place the plant in the hole and backfill carefully, using soil and water alternately to ensure that no air pockets are left. This is important to prevent the roots from drying out.
5. Create a dish-shaped depression around the stem of the plant and add the remaining water. The depression will assist in catching any rain.
6. Since the root ball will be below the root zone of most weeds, competition from weed roots will be minimal. However, some weed management may be necessary in moist environments to prevent smothering weeds from affecting the above ground parts of the plant, e.g. Lonicera sp. (honeysuckle).

Planting tools

Typical tools used to dig planting holes include shovels, post-hole diggers or augers.

Where water is readily available (e.g. from a nearby stream), holes may be dug using equipment that delivers water under high pressure (such as a water lance).

Watering

If a water supply is not available and the water needs to be carried to the site, two litres of water per plant (or more if the subsoil is dry) should be sufficient (Australian Plants Society 2010).

Timing

Refer to Timing section under seedling planting.

2.3.4 Introducing soil seed banks to wetlands

Applicability

For wetland revegetation, an additional option to restore vegetation is to introduce a soil seed bank[3] from another wetland i.e. a donor wetland.

Advantages and disadvantages of introducing soil seed banks to wetlands are provided in Table 2-15.

Table 2-14: Long-stem planting – advantages and disadvantages.

Advantages	Disadvantages
• Plants are more stable in the ground, e.g. deeper plantings are better able to withstand effects of moving water such as flood conditions in riparian zones • Increases the chance of plant survival as: – the root ball is insulated from substantial changes in soil temperature, moisture or salt-encrusted topsoils – the plants are older and stronger at planting • Reduces post-planting maintenance as shallow-rooted weeds do not compete with deep root ball	• Longer time required to dig holes • Higher cost per plant (due to longer timeframe within nursery)

Table adapted from Australian Plants Society (2010).

Table 2-15: Introducing soil seed banks – advantages and disadvantages.

Advantages	Disadvantages
• Requires only a small amount of seed from donor wetland • Cheaper than installing propagated plants	• Requires a nearby donor wetland • Takes resources from donor wetland, which can result in damage • Can introduce or spread undesirable species

Table adapted from Brock and Casanova (2000).

3 A soil seed bank is the store of dormant seeds in the sediment of the wetland (Brock and Casanova 2000).

Technique

The following steps, described in Brock and Casanova (2000), should be followed when introducing a soil seed bank to a wetland:

1. Determine how much seed bank you will need to collect for the recipient wetland. Two or three 10 litre buckets of seed bank material will be sufficient for 20 lines, 10m long and 0.1m wide. Remember, you are not aiming to install wetland vegetation in one go. You are simply providing a starting point for plant colonisation.
2. Choose a site in the donor wetland and mentally divide it into different zones in relation to the water level, e.g. high on the bank, the water's edge, and under the water. Within each zone, decide how much seed bank you want to collect, then work within the zone.
3. Dig up a trowel-full of soil and put it in the bucket. Move to a spot a metre away and repeat. Continue until you have as much seed bank from that zone as you think you will need. When you have completed collecting in one zone, move to the next and do the same thing.
4. Take the soil (seed bank) home, spread it out on a large piece of plastic and mix well. Mixing soil from all the zones means that wherever you eventually put the seed bank, all species have an opportunity to establish. This is a useful strategy when you don't know how water levels will vary over time.
5. Let the soil dry out in the sun. This may take days or weeks (2–20 days), depending on the weather. Cover it overnight or if it rains. Drying the seed bank will maximise the number of plants germinating. When the seed bank is dry take it to the recipient wetland.
6. Spread the seed bank material in lines perpendicular to the water's edge, going from above the water level to some way under the water. Make these lines at least a couple of metres apart. The lines of seed bank can be up to 30 m apart and still be effective in allowing plants to establish. Work from above the high water mark to as deep in the water as you care to go, and spread a narrow line of seed bank. By spreading the seed bank down the slope you will be giving all species the chance of establishing, especially if water levels fluctuate in your wetland.

Timing

The best time to encourage the establishment of wetland plants is when wetland soil conditions are muddy/moist (i.e. when water is receding from wetland fringes).

Maintenance

If disturbance by ducks or other animals is likely to be a problem, project managers should consider covering the strips of soil seed bank with wire netting until plants are established (Brock and Casanova 2000).

2.4 References

Anderson, G. (2003). *Site Preparation for Farm Forestry. Agriculture Notes AG0770*. Department of Primary Industries, Victorian Government, East Melbourne.

Australian Plants Society (2010). *The Long-Stem Planting Guide.* The Australian Plants Society NSW Ltd.

Brock, M. and Casanova, M. (2000). *Are There Plants in Your Wetland? Revegetating Wetlands.* LWRRDC, UNE, DEWC and EA.

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Department of Infrastructure, Planning and Natural Resources (2004). Georges River Catchment. *Guidelines for Better Practice in Foreshore Works*. Department of Infrastructure, Planning and Natural Resources, Sydney, New South Wales.

Department of Natural Resources and Environment (2002). *Victoria's Native Vegetation Management. A framework for Action*. Department of Natural Resources and Environment, East Melbourne.

Greening Australia (2008a). *Revegetation Techniques.*

Greening Australia (2008b). *Site Preparation – Moisture Conservation.*

Perry, D. (2004). *Tree Planting and Aftercare. Landcare Notes LC0104*. Department of Primary Industries, Victorian Government, East Melbourne.

Peters, G. (2010). *Valuing Floodplains.*

TreeProject (2003). *Preparing and Planting your Revegetation Site.*

3. Vegetation – Planting density, diversity and placement for seedlings

Determining whether seedling planting is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch, i.e. replanting.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

3.1 Scope

This Standard covers approaches to determining the density, diversity and placement of seedlings[4] for planting projects.

It does not cover approaches to determining the density, diversity and placement of seed as part of direct seeding projects.

3.2 Background

Species selection is an important step in delivering a seedling planting project. It is usual for seedling planting projects to include a variety of species with representatives from all lifeform strata within the native vegetation community (a typical native vegetation community is comprised of species within an overstorey, understorey and ground cover).

The presence of a broad range of vegetation lifeforms (or structural diversity) provides a mix of habitats for the many different animals that live in the area, creating a more diverse ecosystem (Bruce and McInnes 2008).

It is also important to use species that are locally indigenous. These species:

- require relatively lower inputs to be established and maintained
- are more likely to recruit new individuals (without becoming weedy)
- are tolerant of local environmental conditions
- maintain the ecology and biodiversity of an area
- provide a balanced and suitable habitat for native fauna
- contribute to the productivity of farm enterprises
- maintain the unique character of the landscape (Johnson 2001).

3.3 Method

The following sections detail three key elements in planning a replanting project:

- plant density, i.e. the number of plants required for the site
- plant diversity, i.e. the number/type of species to be planted (the species list)
- plant placement, i.e. where the plants will be placed in the landscape.

3.3.1 Plant density

Technique

To determine the number of plants required for a specific project site, the project manager must:

1. determine the planting objective for the site
2. identify the relevant Victorian Bioregion[5] and EVC[6]
3. calculate the planting survival target for the relevant EVC
4. determine the total number of seedlings required to achieve the planting survival target.

4 Seedlings are grown in a variety of containers to suit the scale and purposes of works; the most common being either individual containers (e.g. forestry tubes) or cells (multi-celled containers arranged in trays) (Corr 2003).

5 Bioregions are areas based on the patterns of ecological characteristics and the underlying environmental features. There are 28 bioregions across Victoria.

6 Ecological Vegetation Class is a classification of plant communities defined by a combination of floristics, lifeform, position in the landscape, and an inferred fidelity to particular environments. About 300 EVCs have been described for Victoria.

These stages are detailed in the following sections.

Stage 1 – Determine the replanting objective

Replanting projects can be undertaken for many objectives, including:

- restoring habitats for native vegetation and wildlife
- rehabilitating landscapes (e.g. riparian stabilisation)
- providing shade and shelterbelts
- improving the amenity and/or aesthetics of an area.

The number and type of plants required for a particular project will vary (e.g. stabilising a streambank may require the planting of deep-rooted shrubs and tussock grasses only).

Based on the most common objectives for replanting projects, four planting standards have been developed (see Table 31). Project managers should apply the appropriate planting Standard to meet their specific project objective, e.g. if the replanting objective for a project site is to restore important structural components of Ecological Vegetation Classes then the 'EVC Multi-Strata Planting Standard' must be applied.

Stage 2 – Identify the relevant Ecological Vegetation Class

To identify the relevant EVC for the project site, the following steps should be followed:

Step 1: Locate the geographical area of interest (Use DELWP's *Biodiversity Interactive Map*).

Step 2: Identify the Bioregion and EVC for the area of interest

- Click vegetation folder under map layer and change map scale to ≤1:100,000.
- Tick 1750 EVCs and the adjacent information icon ⓘ.
- Click refresh map (map will now display 1750 EVCs map layer).
- Click mouse on area of interest.
- Read off EVC name, EVC number and Bioregion. Some sites may contain more than one EVC and/or be a transitional zone (ecotone) between EVCs.
- Confirm by groundtruthing, with particular emphasis on:
  - where the site is in the landscape, e.g. slope, gully, plain

Table 3-1: Planting standards for various project objectives.

Objective	Approach to replanting	Planting standard
• Restore the structure and diversity of EVCs and maximise resilience to climate change driven stresses • and/or • Restore critical biodiversity functions/ habitat requirements	• Consider species diversity targets • Consider species tolerance to climate change • Consider establishment processes on successional stages • Should include establishment of particular overstorey, understorey and ground cover structure/diversity for key species habitat needs (e.g. feeding/foraging/nesting) in high priority fauna locations	Best Practice
• Restore important structural components of Ecological Vegetation Classes	• Base on DELWP Net Gain* objectives • Use EVC benchmarks • Include DELWP Net Gain* density targets for overstorey and understorey woody lifeforms (and large tussocks in some grassy EVCs)	EVC Multi-Strata
• Restore the overstorey of Ecological Vegetation Classes	• Use EVC benchmarks • Include DELWP Net Gain* density targets (overstorey only)	EVC Overstorey
• Rehabilitate landscapes, e.g. streambank stabilisation, salinity control, general habitat improvements	• Use mixed indigenous and/or non-indigenous native species with no density targets • Initial planting may focus on trees (and possibly shrubs) with future plantings undertaken as appropriate • Should reference EVC benchmarks and Net Gain* density targets	Mixed Species

** Refer to Stage 3 (below) and Native Vegetation Revegetation Planting Standards – Guidelines for Establishing Native Vegetation for Net Gain Accounting Department of Sustainability and Environment 2006) for details.*

– the dominant overstorey structure, either remnant canopy on-site or in nearby remnant vegetation, e.g. forest, woodland

– the dominant understorey structure, either remnants on-site or in nearby remnant vegetation, e.g. grassy, shrubby

– any other site attributes, e.g. soils, moisture, aspect

– local knowledge (including local revegetation guides).

- Download the relevant EVC benchmark from DELWP's *EVC benchmarks for each bioregion*.

Stage 3 – Calculate the replanting survival target

The followings steps are the same as the 'Net Gain' approach adopted by the Department of Sustainability and Environment (2006) to calculate the target number of trees, understorey plants and ground covers (per hectare) that should be surviving[7] after 10 years for proposed planting project sites[8].

These steps must be applied for the following planting standards:

- EVC Multi-Strata standard (see steps 1 to 7 below)
- EVC Overstorey standard (see steps 1, 2 and 7 below).

For other planting standards (Best Practice and Mixed Species), a number of site-specific factors will dictate the actual number and type of plants required:

- Best Practice Standard – exact requirements must be determined on a case-by-case basis in consultation with DELWP
- Mixed Species Standard – steps 1 to 7 should be used to guide plant numbers/types, but are not mandatory requirements.

Step 1: Determine if the EVC benchmark for your area of interest includes an overstorey tree layer.

- Does the EVC name include the descriptors woodland or forest? If yes, go to Step 2. If no, go to (b).
- Does the EVC benchmark include a tree canopy layer? If yes, go to Step 2. If no, Eucalypt species should be excluded from the plant list for the project site (go to Step 3).

Step 2: Calculate the 10-year planting survival target (per hectare) for trees using Table 3-2.

Table 3-2: 10-year planting survival target for overstorey trees.

EVC type	Target number of overstorey trees plants/ha
Woodland	50
Dry forest	100
Riverine/lowland/ foothill forest	150
Damp/wet forest	200

Step 3: From the EVC benchmark, identify percentage cover for the following understorey lifeforms:

- understorey tree or large shrub (T) >5 m tall
- medium shrub (MS) 1–5 m tall
- small shrub (SS) <1 m tall

Step 4: For each understorey lifeform, calculate the 10-year planting survival target (per hectare) using Table 3-3.

Table 3-3: 10-year planting survival target for understorey lifeforms (excluding large tufted graminoids*).

Understorey lifeforms	Target number of plants/ha (for each 5% cover in EVC benchmark)	Notes
Understorey tree or large shrub (T) >5 m tall	50	Assume 10 plants/ha where benchmark cover is 1%
Medium shrub (MS) 1–5 m tall	200	Assume 40 plants/ha where benchmark cover is 1%
Small shrub (SS) <1 m tall	500	Assume 100 plants/ha where benchmark cover is 1%

** 'Tussock' grass or grass-like plant >1m tall.*

7 The actual number of plants that must be planted to achieve the replanting survival target for a particular project site will generally be higher than the survival target numbers, considering some expected attrition. Refer to Stage 4 for details.

8 DELWP mandates the numbers of plants from selected lifeforms required to meet net gain objectives. Species are not nominated and only the following lifeforms are included: canopy trees, understorey tree or large shrubs, medium shrubs, small shrubs and (where benchmark foliage cover exceeds 10%) large tufted graminoids. Floristic restoration works commonly extend to other lifeforms so DELWP's prescriptions should be considered a *minimum* standard.

Step 5: From the EVC benchmark, identify percentage cover of large tufted graminoids (LTG) >1m tall.

Ground covers and native grasses are often substantially reduced in planting programs due to the high risk of failure from herbaceous weed competition. However, the planting of more robust ground covers (e.g. tussock grasses) may be considered for particular EVCs, e.g. riparian zones if their benchmark state foliage cover exceeds 10% (Department of Environment and Sustainability 2006) or for supplementary plantings at a later date.

Step 6: Calculate the 10-year planting survival target (per hectare) for large tufted graminoids using Table 3-4.

Step 7: Calculate the 10-year planting survival target for your area of interest

Multiply the plant numbers identified in Steps 2, 4 and 6 by your area of interest (in hectares).

Stage 4 – Determine the total number of seedlings required to achieve the planting survival target

The actual number of seedlings required to achieve the planting survival target for a particular project site will depend on a number of modifying factors, most notably:

- the extent and type of remnant vegetation
- general plant losses (e.g. from browsing, climatic conditions)
- potential for species to regenerate naturally
- the success of site preparation (pest plants and animals)
- the degree of landscape modification
- adverse climatic or hydrologic conditions (particularly in wetlands).

Consider these factors in determining the number of plants required at planting. However, they should not take away from the need for well-planned site preparation and post-planting maintenance programs.

Timing

Plant numbers should be determined at least 12 months prior to planting to allow adequate time to either source seed and propagate plants or order plants from a nursery.

3.3.2 Plant diversity

The basic criteria for the selection of plant species are that the plants:

- are suitable for the site conditions
- can be reliably propagated in sufficient numbers (species availability from local nurseries may influence final species selection, particularly the use of small shrubs and ground covers)
- will achieve the objectives of the planting
- will last on the site (Corr 2003).

Local native (indigenous) species with a diversity of lifeforms are the preferred choice for use wherever possible.

Local indigenous plants

Applicability

Planting for biodiversity purposes must first consider local native (indigenous) species because these species:

- are best suited to the local conditions, for example, they are adapted to the soils, rainfall patterns and frosts and can survive droughts, flood and fire (Corr 2003, TreeProject 2003)
- provide the best habitat for locally dependent fauna (Corr 2003, TreeProject,2003, Greening Australia 2008)
- have their pollinators, predators and symbionts present (Greening Australia 2008)
- are well suited to regenerating without assistance (Corr 2003).

Technique

To ensure that plantings include a range of suitable, local native (indigenous) species, a detailed species list is required. The following information sources are recommended for developing site-specific species lists:

- regional/local indigenous plant guides
- regional/local expertise, e.g. DELWP, CMA.

Table 3-4: 10-year planting survival target for large tufted graminoids.

Understorey lifeforms	Target number of plants/ha (for each 5% cover in EVC benchmark)	Notes
Large tufted graminoid (LTG) >1 m tall	500	Apply only where benchmark cover for LTG lifeform is ≥10%

Non-local native plants

Applicability

On some sites, conditions may have altered to a point where the exclusive use of local native (indigenous) vegetation is no longer practical or beneficial (Corr 2003, TreeProject 2003). For example. where:

- the environment has changed to the extent that some local species can no longer survive, e.g. due to salinity, altered soil structure, waterway morphology waterlogging, frost (Corr 2003, TreeProject 2003, Greening Australia 2008)
- a species is needed to modify the environment so local species can thrive, such as where a salt-tolerant species is used to lower watertables to reduce soil salinity (Greening Australia 2008).

Under these conditions, the incorporation of non-indigenous native vegetation to a replanting project may be considered, although all locally native (indigenous) vegetation should be explored first. There is almost always local species that will suit the site, e.g. salt-tolerant plants.

Where exclusive use of local species is considered unsuitable, species from adjoining and nearby EVCs should be the next consideration (EVCs tend to grade into each other along a continuum). For example, a former swamp that is now a dry, eroded, pasture-dominated site in the middle of an agricultural landscape may now suit grassy woodland species.

3.3.3 Plant placement

Applicability

A general species list does not ensure that you have matched soil type, geology, hydrology, aspect and site conditions to a plant's growing conditions and requirements. Understanding the site requirements of a particular species is important for planting success (Corangamite Seed Supply and Revegetation Network 2006).

Technique

Currently, no recommended technique.

Zonation

The key to good plant placement is putting species where they would have naturally grown (Corr 2003). This means matching species with soil type, aspect and where they occur in the landscape.

For example, Table 3-5 describes appropriate riparian planting zones for six commonly planted acacia.

Regional revegetation guides should be used in conjunction with local knowledge. It is also important that observations be made on site to identify where species are naturally occurring.

In some circumstances, plant placement may need to be modified/adjusted to cater for social and/or economic factors, for example:

- particular trees or shrubs may be excluded from some plantings near dwellings to decrease fire risk
- dense shrubs may be excluded in some urban plantings to increase sight lines for cyclists.

Vegetation mosaics

In addition to planting within the correct zone, planting should also aim to replicate nature by establishing patchiness within vegetation (particularly with understorey species) rather than ordered rows or spacings of plants.

This technique creates a mosaic effect that provides:

- greater opportunities for wildlife (Bennett, Kimber and Ryan 2000 in Corr 2003)
- a competitive advantage against weeds in the dense patches (Department of Sustainability and Environment 2006).

Table 3-5: Riparian planting zones example.

Botanical name	Common name	Swampy	Wet	Moist	Well-Drained	Dry
Acacia dealbata	Silver Wattle		✓	✓	✓	
Acacia mearnsii	Black Wattle				✓	✓
Acacia melanoxylon	Blackwood		✓	✓	✓	
Acacia paradoxa	Hedge Wattle				✓	✓
Acacia pycnantha	Golden Wattle				✓	✓
Acacia verticillata	Prickly Moses		✓	✓		

3.4 References

Bruce, S. and McInnes, C. (2008). *Indigenous Flora Species Selection Guide For Bairnsdale and Surrounds.* Greening Australia, Victoria.

Corangamite Seed Supply and Revegetation Network (2006). *Improving Biodiversity Outcomes in Revegetation Activities – Protocols, Resources and Supporting Documents.*

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Department of Environment and Sustainability (2006). *Native Vegetation Revegetation Planting Standards – Guidelines for Establishing Native Vegetation for Net Gain Accounting.* Department of Environment, Land, Water and Planning, Victorian Government, East Melbourne.

Greening Australia (2008). *Species and Provenance Selection.*

Johnson, H. (2001). *The Benefits of Using Indigenous Plants. Landcare Notes LC0133.* Department of Natural Resources and Environment.

Staton, J. and O'Sullivan, J. (2006). *Stock and Waterways: A Manager's Guide.* Land & Water Australia, Canberra.

TreeProject (2003). *Preparing and Planting your Revegetation Site.*

4. Vegetation – Ecological thinning of Eucalypt species

Determining whether ecological thinning is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The condition and extent of remnant vegetation at the project site.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

4.1 Preface

The outcomes from thinning as a tool for managing native vegetation can be variable and complex. Ecological thinning (eco-thinning) is the removal of some trees or stems within native vegetation where the current canopy cover is significantly higher than would be expected. The strategy of ecological thinning aims to:

- restore an appropriate number and distribution of overstorey trees
- increase the growth rate and time to maturity of retained overstorey trees
- facilitate an increase in the diversity and cover of native understorey.

Eco-thinning may be more effective in vegetation types that are not regularly subject to natural disturbances that contribute to thinning and recruitment. The decision to intervene and selectively remove trees or stems from within a site faces a number of issues. Determining the number of stems to be removed will require consideration of:

- current and likely/predicted future health of individual trees
- the number of stems per hectare to retain in order for natural processes to be reinstated
- the impact of disturbance (use of tractors or other equipment)
- retention of existing biodiversity values such as species habitat (e.g. adequate canopy cover)
- likely outcomes for the site if eco-thinning was undertaken, i.e. will the action achieve the objectives?
- requirements for planning permits.

Users should carefully consider the range of management options when deciding whether eco-thinning is an appropriate management action. This Standard requires specialist knowledge to plan and implement this activity.

Project managers should first identify the expected management outcomes for the site and use this as the basis for determining whether eco-thinning is the most appropriate management strategy.

4.2 Scope

This Standard considers the ecological thinning of Eucalypt species as a management tool to re-establish natural processes and allow the remaining dominant trees to grow faster and ultimately larger.

It does not consider:

- the thinning of Eucalypt species for non-ecological purposes e.g. flood mitigation, access, firewood collection
- ecological thinning of other early successional species (e.g. Acacia spp.) as they play a different role in the vegetation community and there is currently insufficient knowledge of this role to set management principles (Department of Sustainability and Environment 2009).

4.3 Background

In some circumstances, regeneration (and some direct seeding and revegetation projects) may result in dense stands of seedlings that may take decades to naturally thin themselves (Greening Australia 2008). This type of regeneration may result from both natural (e.g. flood, fire) or anthropogenic (e.g. forest clearing) events.

Having a large number of trees competing for limited resources (light, water, nutrients) usually results in smaller trees with poor growth rates and tree form (the shape or branching habit of a tree) and a limited understorey (Murray and Thompson 2000).

Vesk et al. (2007) found that densely planted revegetation projects resulted in reduced tree girth growth rates that can delay the development of large boughs, tree hollows and fallen timber by decades. Such habitat is essential for establishing and maintaining viable faunal populations.

4.4 Method

Ecological thinning allows the remaining trees or stems to reach their mature size faster (Department of Sustainability and Environment 2009, Parks Victoria 2010). This, in turn:

- increases structural diversity, including restoration of an appropriate number and distribution of overstorey trees on the site
- promotes better tree form
- allows for the development of large boughs and tree hollows (Vesk et al. 2009)
- allows for the regeneration of understorey species by increasing light and water penetration to the ground layer and reducing competition from overstorey species (Department of Sustainability and Environment 2009).

4.4.1 Applicability

Ecological thinning operations must have clear 'ecological objectives' and should only be considered where there are demonstrable single or multiple ecological benefits.

Ecological thinning is typically used on sites where there are trees of young, even-aged regeneration (Department of Sustainability and Environment 2009). This can be the result of:

- unnatural disturbance events, e.g. timber harvesting or clearing for agriculture
- natural disturbance events, e.g. mass germination following a flood or fire
- mass planting and direct seeding of tree species in revegetation plots.

This work should be undertaken as part of, or in combination with, other ecological management/ enhancement interventions for a remnant patch, e.g. remnant fencing, stock exclusion, supplementary planting, etc.

4.4.2 Technique

The following sections detail the key tasks for ecological thinning of Eucalypt species:

- assessing the site prior to thinning
- identifying the target number of trees to be retained
- determining the appropriate thinning method to apply.

Pre-works site assessment

Project managers need to develop detailed risk assessments to determine whether ecological thinning is an appropriate management action for a particular project site.

The risk assessment should consider:

- the extent, conservation status and condition of the vegetation types to be thinned
- the extent, conservation status and habitat requirements of any rare or threatened species occurring in the area to be thinned
- any other specific values within the proposed thinning area, e.g. habitat features such as hollows, shrubby cover, leaf litter.

Target number

The goal of ecological thinning is to remove only enough stems to allow natural processes to be restored.

Ecological Vegetation Class (EVC) benchmarks provide an approximate density of mature trees per hectare, e.g. the density of mature trees for Floodplain Riparian Woodlands (EVC 56) is 15 large trees/ha.

However, many seedlings and young trees die over time and it is important that any proposed ecological thinning operation leaves enough trees to cover future losses from storms, disease, termites, fire or wind.

As an example, Rawlings et al. (2010) cited the following target numbers for thinning trees in grassy woodlands (to achieve a benchmark density of 30 trees/ha):

- for small trees (less than 10 cm diameter at breast height), leave at least 400 stems/ha (about 5 m x 5 m spacing)
- for larger trees, thin to no less than 250 stems/ha (6 m x 7 m spacing).

As there are a number of factors affecting the actual composition of an EVC, the exact requirements for ecological thinning must be determined on a case-by-case basis in consultation with experienced practioners and investors.

Ecological thinning methods

There are numerous methods available for thinning depending on the size of the project, the density and age of tree species and the cost. These include:

- slashing (suitable for young seedlings only)
- brush-cutter (for young plants, i.e. <5 years with a diameter <7 cm)
- stem-injection (where dead stems are allowed to remain standing – refer to the Woody Weed Control standard for technical details)
- chainsaws for felling of larger trees (Greening Australia 2008, Murray and Thompson 2000).

Whichever method is adopted, follow these principles (adapted from Department of Sustainability and Environment (2009):

- Avoid unnecessary disturbance of trees or native understorey plants to remain on the site.
- Thin only enough stems to allow natural processes to be restored or sped-up.
- All ecological thinning plans should include the retention of all:
  - large and senescing trees
  - standing dead trees
  - trees containing hollows or the largest age-class trees in the patch
  - trees with signs of current or recent occupation by fauna.
- Thin from below, i.e. remove the youngest and the smallest tree from a group, especially in multi-stemmed or coppice growth.
- Thin so that retained trees are distributed (but not evenly) over the whole site. This is important as most of the younger cohorts are in patches without any mature trees. Creating a 'patchy' mosaic is more ecologically desirable.
- Thin so that the current proportion of tree species within the site is more or less retained (unless ecological knowledge of the site indicates otherwise).

In addition, retain all felled timber on-site to provide ground habitat, except where this is inappropriate, e.g. where the volume of felled timber would pose a significant impediment to understorey regeneration or where it would pose an unacceptable fire risk to nearby property assets.

4.4.3 Timing

Mechanical thinning operations must be avoided when:

- the risk of fire is high
- the ground will be excessively disturbed (e.g. following rain events)
- vegetation is providing active animal habitats (e.g. bird nesting).

Based on these restrictions, the optimum time of year to undertake ecological thinning operations is generally from autumn to early winter when the ground is hard.

4.4.4 Licences/permits

Clause 52.17 of the Victorian Planning Provisions requires a permit to remove, destroy or lop native vegetation. As ecological thinning in remnant areas involves the removal of native vegetation, a planning permit from the relevant local council will be required (unless the removal is exempt under the planning scheme).

A permit may also be required for native vegetation removal under a planning scheme overlay such as the Environmental Significance Overlay, Vegetation Protection Overlay, Significant Landscape Overlay, Heritage Overlay, Salinity Management Overlay, Erosion Management Overlay or Public Acquisition Overlay.

The removal of timber from a site as part of a thinning operation may also trigger the Timber Production provisions of the Victorian Planning Provisions.

If ecological thinning is proposed within a project site, the project manager must determine if a permit is required from the relevant local council.

4.5 Maintenance

4.5.1 Weed management

While ecological thinning can encourage regeneration of understorey species, it can also increase the number of weeds (by either increasing light/water penetration to the ground layer or direct disturbance of the site).

Where the understorey is susceptible to weed invasion, targeted weed control must be planned and implemented for the period following any thinning operations (refer to *7 Herbaceous weed control* for details).

4.5.2 Regrowth

At a minimum, all thinned trees with diameters ≥7 cm should be routinely checked over a 12-month period and any regrowth treated (refer to *8 Woody weed control* for details).

4.6 References

Department of Environment and Sustainability (2009). *BushTender Standards for Management – Ecological Thinning of Eucalypts, Information Sheet No. 12.* Victorian Government, Melbourne.

Greening Australia (2008). *Maintenance – Thinning*.

Murray, J. and Thompson, D. (2000). *Native Regrowth – A Farmer's Guide to Maintaining Biodiversity When Thinning Regrowth Forest.* Rural Industries Research and Development Corporation, ACT.

Parks Victoria (2010). *Box-Ironbark Ecological Management Strategy & Ecological Thinning.*

Rawlings, K., Freudenberger, D. and Carr, D. (2010). *A Guide to Managing Box Gum Grassy Woodlands.* Commonwealth of Australia.

Vesk, P.A., Nolan, R., Thomson, J.R., Dorrough, J.W., MacNally, R. (2007). *Time Lags in Provision of Habitat Resources Through Revegetation.* Biological Conservation 141:174-186.

5. Vegetation – Soil preparation for replanting

Determining whether soil preparation for replanting is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The relevant ecological vegetation class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch, i.e. revegetation.
- Specific site conditions, e.g. soil type, slope, location in the landscape (e.g. floodplain).
- The type and severity of threats present.

5.1 Scope

This standard covers standard physical methods to prepare soil for replanting:

- ripping
- mounding.

It does not cover chemical methods to address poor soil health (e.g. nutrient deficiencies or pH issues).

5.2 Background

In some areas, soil preparation is required to produce loose, well-drained and aerated soil ready for replanting (Corr 2003).

The major benefits and potential issues associated with soil preparation are outlined in Table 5-1.

Table 5-1: Soil preparation: benefits and issues.

Major benefits	Potential issues
• Creates an easier path for roots to penetrate the soil • Makes replanting easier	• Cost • Can stimulate weed germination

Table adapted from Greening Australia 2008.

5.3 Method

The following sections describe appropriate techniques and timing to prepare soils for replanting.

5.3.1 Ripping

Ripping is used to improve aeration, rainwater infiltration and moisture retention of particular soils to improve the root development of seedlings through faster downward root growth and deeper soil penetration (Anderson 2003, Perry 2004, Corr 2003, TreeProject 2003).

In addition, ripping can enable the efficient use of manual planting tools and mechanical planters (Corr 2003).

Applicability

To determine whether ripping is necessary/ suitable for a replanting project, a number of factors must be considered, in particular:

- soil type and condition
- landscape setting
- sites of cultural heritage significance (to ensure they are not disturbed).

These factors are detailed in the following sections and have been developed into a decision tree (see Figure 4). Use the decision tree to determine whether ripping is necessary/suitable for a particular replanting project site.

Soil type and condition

Ripping should only be used for those soil types and conditions that impede root growth. For other soils, ripping will result in either negligible project benefit or an overall degradation of the project area.

Landscape setting

Ripping produces a high level of soil disturbance, which may make it inappropriate for soil preparation on some sites (Corr 2003). In particular, ripping must not be undertaken on:

- the banks of waterways (Perry 2004) and waterlogged areas
- riparian areas
- sites of cultural significance
- rocky ground (Perry 2004)
- sites where there is a high level of intact native ground flora (Corr 2003).

Table 5-2: Ripping suitability for various soil types and conditions.

Soil type	Suitability	Comments
Clay loams	✓	Assists root development by re-aerating soils (Corr, K., 2003)
Compacted soils	✓	Breaks up subsoil and allows deeper penetration and faster growth of plant roots by improving aeration and infiltration of rain water (Stackpole, D., 1998; TreeProject, 2003)
Cracking clays	✗	Tends to crack along the rip lines in summer, exposing the plant roots to the drying air and pests (TreeProject, 2003)
Heavy clay soils or subsoils	✓	Breaks up subsoil allowing root penetration and exploration (Stackpole, D., 1998; Corr, K., 2003)
Highly erodible soils	✗	Disturbance should be minimised on highly erodible soils
Light, sandy soils	minimal benefit	Little advantage in ripping sands as water will readily penetrate to the roots of the seedlings (TreeProject, 2003; Stackpole, D., 1998)
Sodic soils	✗	Can bring sodic material to the soil surface and cause or increase soil crusting (McMullen, B., 2000)
Soils with a hardpan layer	✓	Breaks up any impediments to tree root development (Anderson, G., 2003)
Wet soils	minimal benefit	Unlikely to have any benefits as the soil needs to be dry to produce cracks (McMullen, B., 2000)

✓ – suitable   ✗ – unsuitable

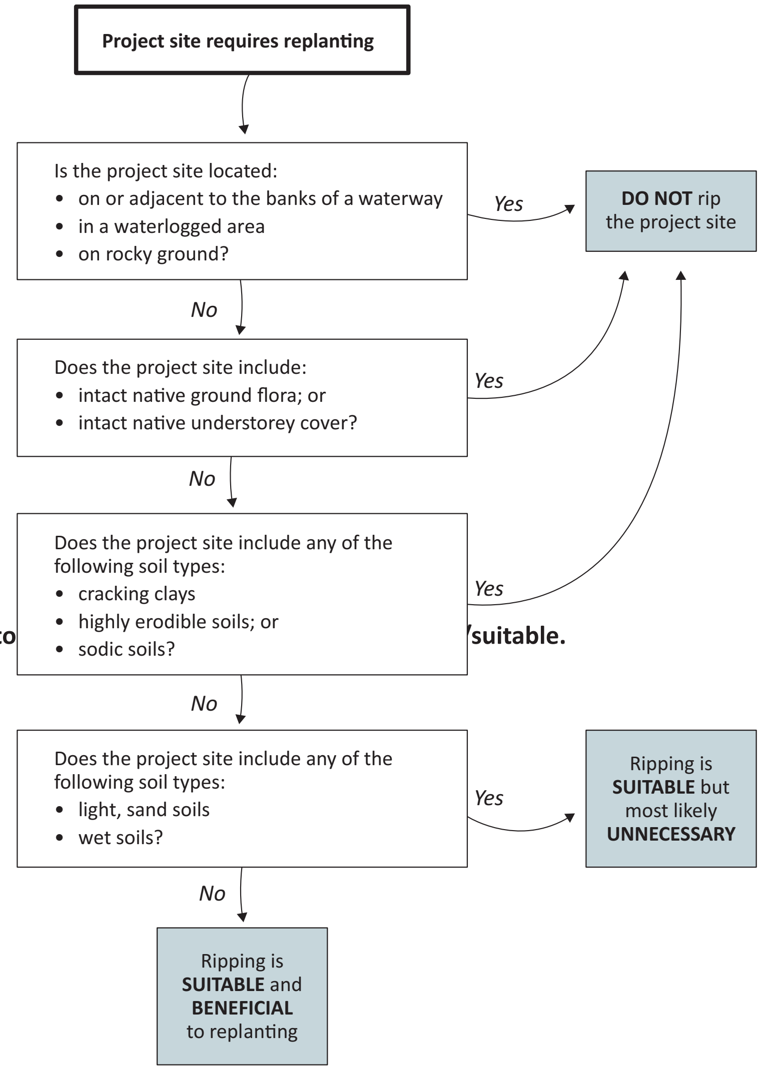


Figure 4: Decision tree to /suitable.

Technique

Ripping is usually done with either a bulldozer or three-point linkage, tractor-mounted, winged ripping tyne (Corr 2003). The addition of 'wings' to the ripping tyne maximises the shattering and soil lifting effect as well as improving weed control by throwing the sod sideways.

The key considerations when ripping replanting lines are:

- depth of rip lines
- removal of air pockets
- orientation of rip lines
- topography of project area
- proximity to existing vegetation.

Depth

The recommended depth of rip lines varies from 30 cm to 100 cm (Anderson 2003, Corr 2003, TreeProject 2003, Perry 2004), depending on the depth of the impeding soil layer.

For most replanting projects, ripping to a depth of 50–60 cm should be sufficient to alleviate compaction. Deeper ripping (up to 100 cm) should only be required to increase drainage in dense subsoils.

Removal of air pockets

- It is essential that ripping does not create air pockets beneath the soil.
- A concrete roller (at least 60 cm wide) should be attached behind the ripper to help crush rocks, remove air pockets and settle the soil. Alternatively, a tractor tyre can be used, although narrow tractor tyres should be avoided as they can cause compaction and guttering.

Orientation

To create a more natural aesthetic, ripping should follow either:

- a 'wavy' pattern
- a linear pattern (to allow for ease of management, e.g. weed maintenance) with plants installed alternatively across rip lines.

Topography

On slopes, riplines must follow contours to reduce erosion risk (Perry 2004, TreeProject 2003).

Proximity to existing vegetation

To avoid damage to remnant vegetation, do not rip:

- where there is intact native understorey and/or ground flora
- within an area twice the diameter of the canopy of existing indigenous trees.

Timing

Deep ripping must be timed to allow maximum shattering of the soil, ensuring that the soil is easy to work but not so wet that the soil glazes, affecting root penetration (Perry 2004). These conditions tend to occur in late summer/autumn (Anderson 2003, TreeProject 2003, Corr 2003).

Ripping before the autumn break may prove difficult with commonly available equipment, so the standard practice is often to rip after the autumn break (Perry 2004, TreeProject 2003).

All ripping should be done at least six months in advance of replanting. This will allow enough time for:

- rain and soil settling to minimise air pockets between soil clods
- adequate weed control prior to replanting (see Maintenance section below).

Longer timeframes may be required on some sites, e.g. those with clay or compacted soils.

Licences/permits

High-impact activities in culturally sensitive landscapes (e.g. deep ripping within 200 m of a named waterway) can cause significant harm to Aboriginal cultural heritage.

In these situations, the *Aboriginal Heritage Act 2006* may require the project manager to prepare a Cultural Heritage Management Plan or obtain a cultural heritage permit or enter into a cultural heritage agreement with the relevant Registered Aboriginal Party.

If ripping is proposed within a culturally sensitive landscape, the project manager must determine if a Cultural Heritage Management Plan or cultural heritage permit is required.

Specific information on considering Aboriginal cultural heritage needs can be sourced through the Department of Premier and Cabinet website.

Maintenance

The extensive soil disturbance created by ripping may inevitably lead to an increase in weed cover, either through invasion or the spread of weed seed through the soil.

This weed cover must be controlled quickly to minimise any competition with replantings (refer to *7 Herbaceous weed control* and *8 Woody weed control* for details).

5.3.2 Mounding

This is a technique involving the mounding of topsoil over a rip line to provide improved conditions for tree establishment (Anderson 2003).

Applicability

The five main reasons for mounding are to:

- provide soft soil, which makes replanting easier
- improve drainage and soil aeration
- build up a friable soil bed to allow rapid root growth
- combat cracking soils
- combat saline soils (Corr 2003).

Mounding is most commonly undertaken to facilitate early plant growth on:

- heavy soils (Corr 2003)
- wet and poorly drained sites[9] (Corr 2003, Stackpole 1998, Perry 2004)
- saline soils (critical for moderate to highly saline soils) (Corr 2003, Perry 2004).

Mounding produces a high level of soil disturbance and is unsuitable on:

- fragile saline sites (Perry 2004)
- sites with cultural heritage values (Perry 2004)
- sites where there is a high level of intact native ground flora (Corr 2003).

Technique

Specific techniques for mounding (e.g. m-profile mounding for saline sites, mouldboard ploughing for heavy wet soils) are set out in Greening Australia's handbook *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria* (pages 78–82).

These techniques should be followed for mounding projects in Victoria.

Timing

Mounds should be created at least six months in advance of replanting to enable the mound to settle and, in saline areas, to allow salts to flush out (Corr 2003, TreeProject 2003, Stackpole 1998).

5.4 References

Anderson, G. (2003). *Site Preparation for Farm Forestry. Agriculture Notes AG0770.* Department of Primary Industries, Victorian Government, East Melbourne.

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Greening Australia (2008). *Site Preparation – Ground Preparation.*

McMullen, B. (2000). *SOILpak for Vegetable Growers. NSW Agriculture.*

Perry, D. (2004). *Tree Planting and Aftercare. Landcare Notes LC0104.* Department of Primary Industries, Victorian Government, East Melbourne.

Stackpole, D. (1998). *Eucalypt Plantation Establishment – Site Preparation.* Department of Natural Resources and Environment.

TreeProject (2003). *Preparing and Planting your Revegetation Site.*

9 Wet and poorly drained sites do not refer to natural wetlands. Mounding is considered an inappropriate method for wetlands.

6. Vegetation – Ecological grazing

This Standard forms part of a set of state-wide Standards for the delivery of vegetation management activities at the landholder scale.

Determining whether ecological grazing is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The relevant ecological vegetation class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch, i.e. revegetation.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

DELWP's *Managing grazing on riparian land – Decision support tool and guidelines* (published in 2013) refers to grazing on riparian land for ecological purposes and provides general guidance about factors to consider when establishing a controlled grazing regime. Typically, it discusses the timing, duration and intensity of grazing. These guidelines can be accessed through the DELWP website.

The outcomes from grazing as a tool for managing native vegetation are complex and can be variable. Ecological grazing is a strategy that aims to maintain and improve the condition of native vegetation. The removal of biomass may be an important management strategy in some grassy vegetation systems that require maintenance of open areas to recruit native species. Grazing may also be a useful tool for reducing weed cover in areas where other weed management strategies are difficult to implement.

Grazing native vetegation may have multiple outcomes – some positive and others negative. For example, the use of grazing to reduce weed cover can also result in soil compaction and increased nutrient levels, which may exacerbate weed invasion.

Due to the uncertainties and the potential for adverse impacts, users should carefully consider the range of available management options when deciding whether ecological grazing is appropriate.

A decision-support Standard is under development that will allow users to determine when grazing may be appropriate to achieve improved native vegetation and broader environmental outcomes. In the meantime, project managers should use the objectives for the site as the basis for determining the appropriate grazing management strategy.

6.1 Scope

This Standard covers the use of livestock (in particular sheep and cattle) as a management tool to maintain or enhance the cover and diversity of native plants within:

- grasslands
- the grassland areas within grassy woodlands.

This standard does not cover:

- grazing in the high country for fuel and bushfire risk management; the EPBC Regulations 2000 require that domestic grazing in the Australian Alps National Parks and Reserves must be referred to the Australian Government for assessment
- grazing of woodland areas within grassy woodlands (ecological grazing within these areas should not be required as the trees reduce light and moisture levels, preventing excessive grass cover [Barlow 1998])
- grazing within non-grassy EVCs
- the use of livestock to control herbaceous or woody weeds (refer to *7 Herbaceous weed control* and *8 Woody weed contro*l for information and methods)
- the use of other livestock (e.g. goats) as a management tool.

6.2 Background

Natural grassy vegetation communities in temperate Australia have a ground layer dominated by tussocky perennial plants, often composed of only a few species of tussock grasses and an exceptionally diverse array of herbaceous plants and wildflowers including lilies, peas, daisies and other ground flora (Tremont and McIntyre 1994, cited in Water Technology 2009).

For such vegetation communities, significant research has shown repeatedly that the ground layer vegetation is strongly controlled by the relationship between the tussock-forming graminoids (grasses, sedges, rushes) that dominate this layer and the gaps between them (Water Technology 2009), with the majority of non-grass plant species growing in the inter-tussock spaces (Eddy 2002).

When the tussock canopy closes over these gaps, it shades and out-competes the smaller non-grass plants (Eddy 2002). Some form of biomass reduction (e.g. grazing, slashing, fire) may be required to maintain the structure and botanical composition of grasslands and sparsely treed grassy woodland ecosystems.

6.3 Grassland management

6.3.1 Pre-European settlement

Before domestic livestock and rabbits were introduced and many species of native fauna displaced, biomass reduction in grasslands was performed by:

- native animals, including large and small mammals, and grasshoppers and other insects
- fires, both naturally occurring and those lit by Indigenous Australians (Eddy 2002).

6.3.2 Post-European settlement

Since European settlement, commercial grazing by domestic livestock has been (and is likely to continue to be) the primary use of native grasslands – and consequently the main method of biomass reduction (Eddy 2002).

The use of traditional grazing strategies (e.g. continuous or set-stocking) within native grasslands and grassy woodlands encourages weed invasion and degrades native vegetation. This is because palatable plants are continually selected by the grazing animals, allowing only unpalatable species to increase. Additionally, regular soil disturbance caused by hooves and nutrient increase from animal droppings provide a constant supply of suitable sites in which weeds can establish (Barlow 1998).

These grazing strategies also deplete the energy reserves of perennial native grasses, prevent native seed set and prevent recruitment of woody species within grassy woodlands, leading to their decline and an increase in annual grass and broad-leaf weed cover.

Continuous grazing is not considered an appropriate tool to maintain or enhance the cover and diversity of grasslands and grassy woodlands.

6.4 Ecological grazing

Considering that many vegetation types (particularly grassy ecosystems) still require some level of disturbance (e.g. grazing, slashing, fire), the use of livestock in limited and carefully controlled conditions (known as ecological grazing) can form part of a sustainable vegetation management plan. For example, ecological grazing can:

- allow for native regeneration – grazing in grasslands can prevent excessive grass cover and therefore maintain a diverse array of plants and fauna habitats that would otherwise be smothered
- maintain habitat structure
- control weeds (predominantly the management of annual exotic grasses) (Barlow 1998).

With any grazing, the pressure applied to an individual plant varies with site location, stock density, continuity and time (Water Technology 2009).

Continuous grazing gives vegetation no chance to recover and often leaves a patchwork of overgrazed and overrested plants (Savory 1999). This results in either:

- native vegetation dying out and being replaced with unpalatable, weedy species, or
- an over-abundance of particular native species that are unpalatable to livestock (Staton and O'Sullivan 2006).

In contrast, ecological grazing that includes both active grazing periods and rest/recovery periods (e.g. rotational or cell grazing) can be effective in maintaining grasslands and grassy woodlands. Continuous grazing must not be used as a management tool to maintain or enhance the cover and diversity of grasslands and grassy woodlands.

6.4.1 Method

The recommended approach for developing and implementing an ecological grazing program involves:

- describing the desired goal (or ecological objective) for the project
- assessing the problem
- considering the control options/methods available and determining if ecological grazing would:
  - be effective in treating the problem
  - be practical in treating the problem
  - create potential risks to either on-site or off-site values
- developing an ecological grazing strategy
- implementing the strategy
- maintaining a monitoring and review program.

6.4.2 Applicability

The view that stock grazing is always detrimental to ecosystem integrity is not universal. VEAC (2006 and 2007, cited in Water Technology 2009) recognised that stock grazing can have positive effects on the environment if applied in a targeted manner in a limited range of grassy ecosystems. This is supported by BushTender (Department of Sustainability and Environment 2009), where ecological grazing is identified as a potential tool for maintaining/enhancing native vegetation quality in specific grasslands.

Table 6-1: Ecological grazing – advantages and disadvantages.

Advantages	Disadvantages
• Removal of biomass maintains inter-tussock spaces (important habitat for a range of flora and fauna species) • A higher proportion of plants are grazed (without over-grazing*) rather than a smaller proportion of overgrazed plants (as often occurs with continuous grazing where the regrowth from a grazed plant is more palatable to livestock, leading to a mix of over-grazed and over-rested** plants) • Inexpensive • Productivity benefit to primary producers	• Timing limitations • Effort to manage • Inappropriate for many ecosystems (e.g. forests) • Can degrade system if not managed appropriately by: – compacting soils – encouraging weed growth – damaging native vegetation – preventing natural recruitment – elevating nutrient levels in soil and water – initiating/accelerating erosion – degrading habitat for threatened species

* *Over-grazing – severe/repeated grazing during a plant's active growing period that results in reduced vegetation production and ultimately death of the plant.*

** *Over-resting – Prolonged absence of grazing that creates an accumulation of old plant material, which in turn decreases light penetration, resulting in reduced growth and/or death of the plant.*

BushTender (Department of Sustainability and Environment 2009) has identified two grassy ecosystems where the use of ecological grazing can assist in maintaining or enhancing the cover and diversity of native plants and fauna habitats:

- high rainfall grasslands
- treeless grassy areas within dryland grassy woodlands.

Based on this information, a decision tree has been developed to identify those project sites where ecological grazing may be an applicable management tool (see Figure 5).

High rainfall grasslands

In high rainfall grasslands (i.e. rainfall areas above 500 mm per year), the absence of periodic biomass removal (e.g. by fire) increases the risk of the native grassy sward becoming dominant over time, leading to a loss of the inter-tussock spaces that are important as habitat for a range of plant and animal species. If biomass is not removed, there can be a dramatic decline in overall vegetation quality within a 10-year period (Department of Environment, Land, Water and Planning 2009).

For high rainfall grassland EVCs, avoiding a decline in site condition requires some form of active biomass management (Department of Sustainability and Environment 2009). This may include ecological grazing.

Treeless grassy areas within dryland grassy woodlands

Dryland grassy woodlands often occur naturally as a mosaic of two structural components, 'woody' areas containing mature trees, regenerating trees or woody understorey interspersed with 'grassy' areas lacking woody vegetation (Department of Sustainability and Environment 2009).

Different management approaches may be required to maintain and enhance native vegetation quality within these different grassy vegetation types (Department of Sustainability and Environment 2009). One approach may include ecological grazing.

Ecological grazing is typically only appropriate in the grassy areas within a grassy woodland, and stock should be excluded from any area containing trees and shrubs (to allow woody regeneration to occur).

6.4.3 Technique

Development of an ecological grazing regime depends on a number of factors, most notably:

- the protection of valued site attributes from grazing
- the type of livestock to be used
- the grazing pressure exerted by livestock (e.g. stocking rates, grazing durations and rest periods)
- the timing of grazing.

The following sections detail approaches to addressing these factors, namely:

- assessing the site prior to ecological grazing
- considering the grazing habits of the livestock
- determining the grazing intensity
- identifying the optimum time to undertake grazing.

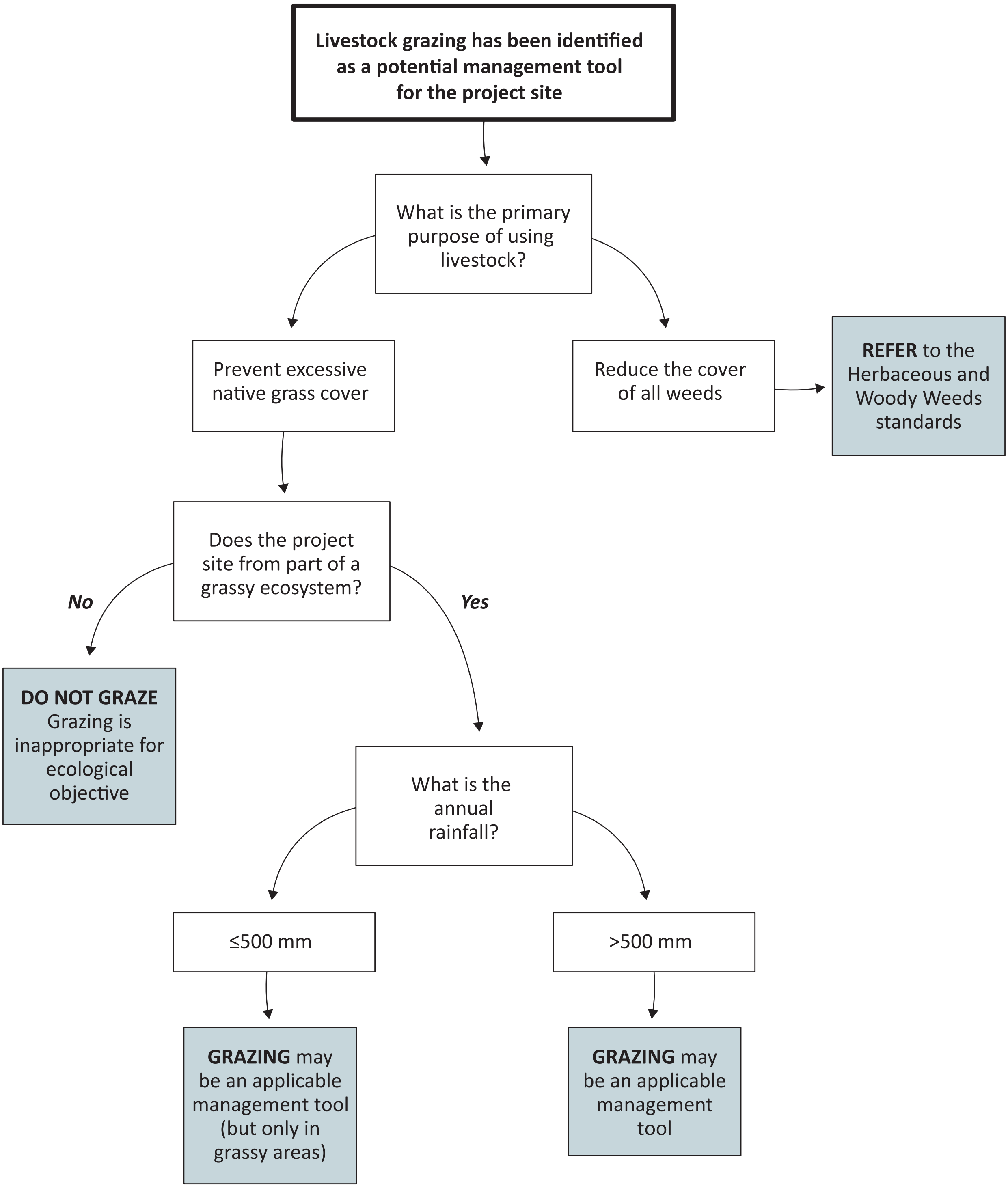


Figure 5: Decision tree to identify projects sites where ecological grazing may be an applicable management.

Assessing the site prior to ecological grazing

Due to the uncertainties (and potential negative impacts) in implementing ecological grazing programs, project managers need to develop detailed risk assessments to determine whether ecological grazing is an appropriate management action for a particular project site.

The risk assessment should consider:

- the type of vegetation and its dependence on some form of biomass reduction (e.g. grazing, slashing, fire) to maintain structure and botanical composition
- the appropriateness of using ecological grazing (rather than other disturbance mechanisms) to maintain/ enhance native vegetation cover and diversity
- the extent, conservation status and condition of the vegetation types to be grazed
- the extent, conservation status and habitat requirements of any rare or threatened species occurring in the area to be grazed.

Considering the grazing habits of the livestock

Most grazing animals graze selectively to some extent, preferentially grazing some species and avoiding others. This tends to disadvantage the most palatable, accessible and actively growing plant species (Water Technology 2009).

Project managers must be aware of the differences in the grazing pressures likely to be exerted by livestock and plan accordingly. For example:

- sheep are more selective grazers than cattle (Barlow 1998)
- sheep graze closer to the ground than cattle (Water Technology 2009)
- sheep tend to cause greater soil compaction, but less pugging, than cattle (Barlow 1998).

Determining the grazing intensity for a project site

Grazing intensity is a collective term that is a function of two components of the grazing regime: stocking rate and duration (Water Technology 2009).

The optimal number of livestock and grazing duration to maintain or enhance the cover and diversity of native plants will be different for each project site. The exact requirements for ecological grazing must be determined on a case-by-case basis in consultation with DELWP. However, the presence of the following taxa should be used as indicators of the likely grazing intensity that may be appropriate for a site:

- Many species within genera such as Austrostipa (Spear-grasses), Austrodanthonia (Wallaby grasses), Chloris (Windmill grasses), Juncus (rushes) and Carex (sedges). These species have been shown to tolerate moderate-intensity grazing.
- Species such as Microleana (Weeping Grass) and Joycea (Wallaby-grass) and many Acacia (wattles). These species have been shown to be tolerant of low-intensity grazing.
- Orchids, lilies, saltbushes, and grasses such as Poa and Themeda (Kangaroo Grass) spp. These plants are sensitive to grazing, and have been shown to decline rapidly in abundance with even low stock grazing intensities.

Identifying the optimum time to undertake grazing

The appropriate time to undertake ecological grazing depends on:

- the growth phase of desirable plant
- site-specific conditions, e.g. soil moisture levels.

Growth phase of desirable plants

Heavy grazing when indigenous graminoids are entering their annual growth phase can damage or substantially weaken natural vegetation by reducing its ability to set seed and send out new growth (Staton and O'Sullivan 2006).

Ecological grazing must not be used when native plants are in flower or setting seed, i.e. during spring and early summer (Water Technology 2009, Staton and O'Sullivan 2006).

Ecological grazing should be implemented when the majority of native plants are dormant, i.e. from late summer to early winter (provided the ground is not too wet nor too dry), ensuring that the total vegetation cover does not fall below 70% (Department of Sustainability and Environment 2009, Staton and O'Sullivan 2006).

Site-specific conditions

Irrespective of the time of year, ecological grazing must not be used when:

- soil moisture levels are high; grazing at such times will lead to pugging and compaction (Staton and O'Sullivan 2006, Water Technology 2009).
- soil is very dry, e.g. during a drought; at such times, the ground layer may be too sparse, leading to over-grazing and soil erosion (Staton and O'Sullivan 2006, Water Technology 2009).

In addition, ecological grazing must not be used following heavy rains, floods or wildfire as these events usually trigger germination in native plants (Staton and O'Sullivan 2006).

6.5 Animal hygiene

6.5.1 Entering a project site

To prevent the introduction of weeds, livestock must be grazed on weed-free fodder or pasture for between one and seven days (depending on the type of livestock and seed ingested) before they are introduced to the project site (Water Technology 2009).

Sheep should not enter a project site until after shearing. This will ensure that weed seeds carried in their fleeces are not brought into the project site (Staton and O'Sullivan 2006).

6.5.2 Exiting a project site

Following ecological grazing, all livestock must be kept in a controlled area until any seeds ingested have the opportunity to pass through their system (between one and seven days). This will prevent the introduction of any weeds to other sites. Stock containment areas are particularly useful for this purpose.

6.6 References

Anderson, G. (2003). *Site Preparation for Farm Forestry. Agriculture Notes AG0770.* Department of Primary Industries, Victorian Government, East Melbourne.

Barlow, T. (1998). *Grassy Guidelines. How to Manage Native Grasslands and Grassy Woodlands on Your Property.*

Cooperative Research Centre for Australian Weed Management (2004). *Introductory Weed Management Manual.*

Department of Sustainability and Environment (2009). *Ecological Grazing. BushTender Information Sheet No 13.* Victorian Government, Melbourne.

Eddy, D.A. (2002). *Managing Native Grassland: A Guide to Management for Conservation, Production and Landscape Protection.* WWF Australia, Sydney.

Perry, D. (2004). *Tree Planting and Aftercare. Landcare Notes LC0104.* Department of Primary Industries, Victorian Government, East Melbourne.

Savory, A. (1999). *Holistic Management – A New Framework for Decision Making.*

Staton, J. and O'Sullivan, J. (2006). *Stock and Waterways: A Manager's Guide.* Land & Water Australia, Canberra.

TreeProject (2003). *Preparing and Planting your Revegetation Site.*

Water Technology (2009). *An Investigation of Controlled Grazing as a Riparian Management Tool.* Report for the Department of Environment, Land, Water and Planning.

7. Weed control – Herbaceous weed control

Determining whether herbaceous weed control is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The relevant ecological vegetation class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch, i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch, i.e. revegetation.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

7.1 Scope

This Standard provides technical information for a range of chemical, mechanical and manual methods to control herbaceous[10] weeds:

- in preparation for replanting
- to assist native species regeneration within remnant vegetation.

This Standard does not provide advice on:

- assessing the problem (e.g. weeds present, mode of spread, etc)
- undertaking risk assessments (e.g. plant densities/ distributions) to determine if particular control methods are required/appropriate.
- ecological grazing of native species (see 6 Vegetation – Ecological grazing)

7.2 Background

Herbaceous weeds compete with native plants for space, light, nutrients and water (Schirmer and Field 2000, TreeProject 2003, Corr 2003).

Careful weed control can be one of the most important factors contributing to the survival and growth rates of both planted vegetation (Schirmer and Field 2000) and natural regeneration.

7.2.1 Impacts in replanting areas

Weed control is usually the most important factor for the successful establishment of vegetation in agricultural areas (Corr 2003).

Young seedlings need time to develop a vigorous and deep root system that can tap into reliable sources of soil moisture (Greening Australia 2008c). Weeds can reduce a plant's early growth rate by up to 70% compared with weed-free sites, and can decrease survival from an expected 90% of trees planted to as little as 10% (TreeProject 2003). This is supported by Casey and Chalmers (1993 cited in Schirmer and Field 2000), who reported that tree seedlings grown in a weed-free soil bed showed up to 20 times the canopy volume of seedlings grown in weed-infested areas after only 12 months.

The effects with direct seeding are even more dramatic. Failure to control competing herbaceous vegetation can result in complete failure of direct sowing attempts.

7.2.2 Impacts in remnant vegetation

Within remnant vegetation, herbaceous weeds can have an impact on:

- abundance – by entirely occupying a niche utilised by an indigenous plant
- diversity – by displacing one or more plants simply by competition
- structure – by displacement of a strata or stratum
- function – by altering or excluding critical resources for fauna (e.g. herbaceous weeds outcompeting native wallaby grass, which is an essential food source for Golden Sun Moth)
- process – by altering nutrient composition and cycling of soils and hence altering the process of a site to advantage further exotic colonisation.

10 A herbaceous plant has leaves and stems that die down at the end of the growing season to the soil level. They have no persistent woody stem above ground. They may be annual, biennial or perennial and include forbs (herbaceous flowering plants that are not graminoids) and graminoids (grasses, sedges and rushes).

7.2.3 Replanting sites

Weeds should be controlled when they are actively growing, before they set seed and before they begin to compete with newly installed plants (Greening Australia 2008a). Reducing surrounding competition is most important when seedlings are in their first year of growth (Heytesbury District Landcare Network 2009).

To maximise survival and growth of newly installed plants, the area within one metre of plantings must be kept weed-free for a minimum of two summers following plant installation (TreeProject 2003, Perry 2004, Greening Australia 2008a).

7.2.4 Natural regeneration

Herbaceous weed control to assist natural regeneration within remnant vegetation may require several years of follow-up treatment (dependent on species, degree of infestation and site conditions). Once again the objective is to remove the competitive mass of the weed, and/or exhaust the seed bank so that niches are available for regeneration of indigenous plants to occur.

7.3 Method

The recommended approach for developing and implementing a weed control program involves:

- describing the desired vegetation community (i.e. the vision or goal)
- assessing the problem
- considering the control options/methods and determining:
  - their effectiveness in treating the problem
  - their practicality in treating the problem
  - potential risks of application to both on-site and off-site values (this needs to also consider the risks around the control options)
- developing a weed control program
- implementing the program
- maintaining a monitoring and review program.

As problem assessment and control option considerations depend on site-specific values, conditions and weed species, the scope of this Standard is limited to the most common techniques to control herbaceous weeds:

- chemical control
- mechanical/manual control.

7.4 Chemical control

7.4.1 Applicability

Advantages and disadvantages of chemical control are provided in Table 7-1.

2.4.2 Technique

The following sections detail the key standards for the use of herbicide to control herbaceous weeds:

- determining the appropriate technique to apply the herbicide
- identifying the type of herbicide applicable to the landscape feature.

2.4.3 Herbicide application techniques

In preparation for replanting

Site preparation weed control usually aims for selective removal of undesirable vegetation present on the site (Schirmer and Field 2000).

In highly disturbed areas, the most common herbicide application technique is strip (or boom/line) spraying. This technique uses machinery such as a tractor or quad bike to spray strips 2–4 metres wide with a grassy strip retained between rows (Greening Australia 2008c, Corr 2003, TreeProject 2003, Perry 2004). Preplanting weed control is likely to be ineffective if application bands are too narrow (perennial weeds can regrow across a narrow band). Blanket spraying of an entire area should be avoided as it leaves the site open to further weed invasion and soil erosion.

Table 7-1: Chemical control – advantages and disadvantages.

Advantages	Disadvantages
• Cost-effective and efficient option compared with mechanical or manual methods • Can be used selectively, with precision, in difficult topography • Often the only effective method for weeds that are difficult to control, e.g. perennial weeds • Limits physical disturbance to site and avoids promotion of subsequent weed establishment associated with mechanical methods	• High risk in sensitive areas, such as along waterways • Risk of off-target damage to desirable native herbs (and remnant vegetation generally), unless skilfully applied • Risk of off-target damage to adjoining properties (e.g. vineyards undergoing springtime bud-burst) • Not appropriate for organic farms • Precise hand spraying can be time consuming • A high degree of expertise is required, particularly when working in high-quality remnants • Requires an Agricultural Chemical Users Permit (ACUP) for use of some chemicals • Has associated chemical safety requirements for storage and use of chemicals

An alternative technique, spot spraying, uses knapsack sprayers to apply herbicide in spots 1–1.5 m in diameter (Corr 2003, TreeProject 2003, Perry 2004). This technique should be employed where:

- supplementary planting will be undertaken within existing remnants (to reduce potential off target damage to native vegetation from spray drift)
- there has been minimal weed infestation
- replanting will be undertaken adjacent to a waterway
- existing herbaceous weed cover is considered advantageous, e.g. buffer protection from catchment runoff, habitat for fauna.

Figure 6 presents the recommended approach that should be followed to determine the most appropriate technique to apply herbicide in preparation for replanting.

To assist native species regeneration within remnant vegetation

Applying chemicals to control herbaceous weeds in remnant vegetation requires an even more targeted approach than those described for replanting site preparation. Specialist plant identification and herbicide application skills are essential.

The two most common techniques for chemical control of herbaceous weeds in remnant vegetation are:

- Spot-spraying: In many cases, this technique will require the use of specialised nozzles. Where sensitive and important ground flora is present, it may also be necessary to carry out some level of hand weeding prior to spraying.
- Wick-wiping: This is a targeted technique that involves the use of a herbicide-coated wick to wipe herbicides onto specific weeds.

Chemicals must be accurately applied to the foliage of herbaceous weeds with no overspray. This is particularly important where extensive areas of herbaceous weeds are controlled and regeneration is the objective.

Liquid marking dye additives should be used to assist in the control of overspray and to ensure that all necessary areas have been treated.

7.4.4 Types of herbicide

There are three main types of herbicide used to control herbaceous weeds prior to replanting:

- Contact herbicides: These herbicides kill the above-ground parts of weeds, acting by contact on the plant's green tissue. They are most useful for control of annual weeds. They will not control perennial weeds that can propagate from underground parts (e.g. couch grass) as they only affect tissue they contact. Generally, contact herbicides are non-selective, which means that they damage or kill any type of plant (Hannah 2004).

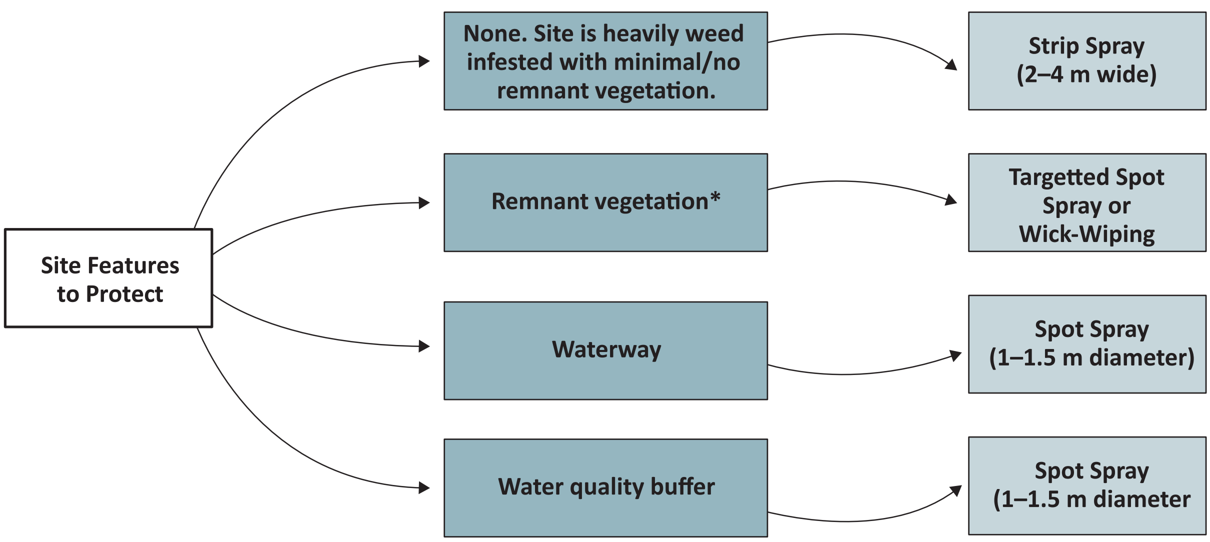


Figure 6: Determining the appropriate technique to apply herbicide in preparation for replanting.

** Spraying within remnant vegetation may require greater precision; 1–1.5 m diameter spots are inappropriate.*

- Systemic knockdown herbicides: These herbicides are translocated throughout the plant, and can kill perennial plants and those with underground perennating organs. Generally, systemic herbicides are broad-spectrum, i.e. they are non-selective and will kill most species (if applied at sufficient concentration). They can be used selectively by, for example:
  - spatially targeted application (to avoid desirable plants)
  - reduced concentration application to target annual and other highly susceptible plants among perennial or otherwise resistant plants
  - seasonal application to minimise impact on dormant species while targeting actively growing weeds.
- Residual (pre-emergent) herbicides: These herbicides are applied to bare, moist soil and kill the germinating weeds before they emerge from the soil (but may have little or no effect on existing weeds). Residuals remain active in the soil for 2-12 months, depending on the type of chemical, application rate and soil type (Hannah 2004).

When used correctly, these herbicides can be very effective with limited impact to the environment. This is particularly true in non-riparian situations where correctly applied herbicides tend to remain at or close to the point of application until they break down to harmless substances (Ainsworth and Bowcher 2005).

However, application of these herbicides in riparian areas can pose a greater risk to aquatic and riparian plants and animals through spray drift, runoff or overbank flooding. Some residual herbicides can be toxic to aquatic plants and animals, including fish and invertebrates (Noble 2002).

Avoid using residual herbicides in riparian areas. The same recommendation applies to the use of surfactants and wetting agents in riparian areas (unless they are approved for use in aquatic environments). Any herbicide selected for use to control herbaceous weeds must be registered, i.e. on label, for that particular weed problem and situation.

Figure 7 presents the recommended approach to determine the appropriate herbicide type to control herbaceous weeds.

7.4.5 Timing preparation for replanting

The experience of many practitioners around Australia shows that the best results are achieved by keeping the planting zone weed-free for two years prior to planting (Andrews 2000). Satisfactory results are achieved by controlling weeds for at least one full year before planting (Greening Australia 2008c).

To ensure that plantings have the best chance of success, site preparation should include both pre-season and preplanting weed control (see Figure 8). This involves applying a herbicide in the year before planting (when weeds/grasses are actively growing) followed by a second application one month before planting (Corr 2003, Perry 2004). This pre-season application is essential if highly competitive but winter-dormant perennial weeds (e.g. Couch grass, Sorrel) are present (as they cannot be controlled by the preplanting application).

The aim of weed control in remnants is to remove the competitive mass of the weed and/or exhaust the weed seed bank so that niches are available for regeneration of indigenous plants. For example, control of Yellow Flag Iris on waterways before or at flowering in early spring prevents seed set and enables a niche to be exploited by

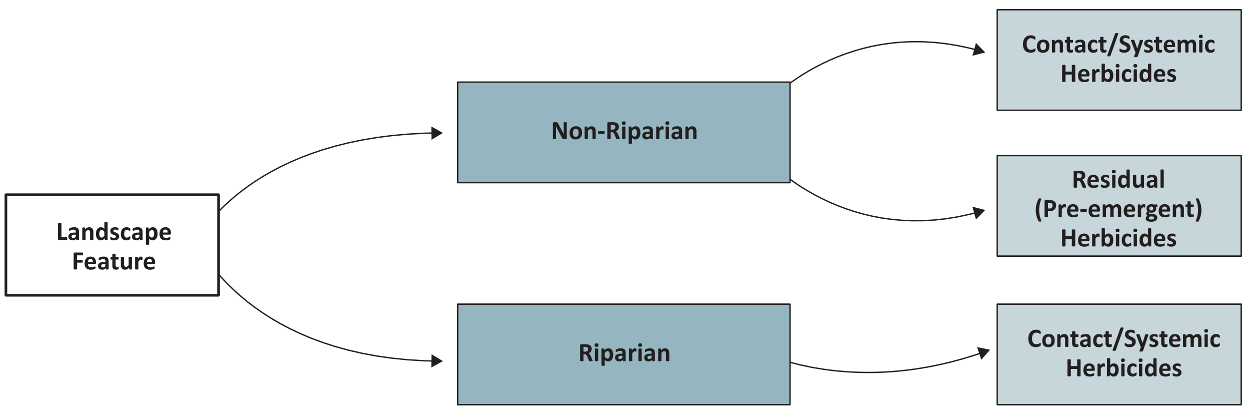


Figure 7: Determining the appropriate herbicide type to control herbaceous weeds.

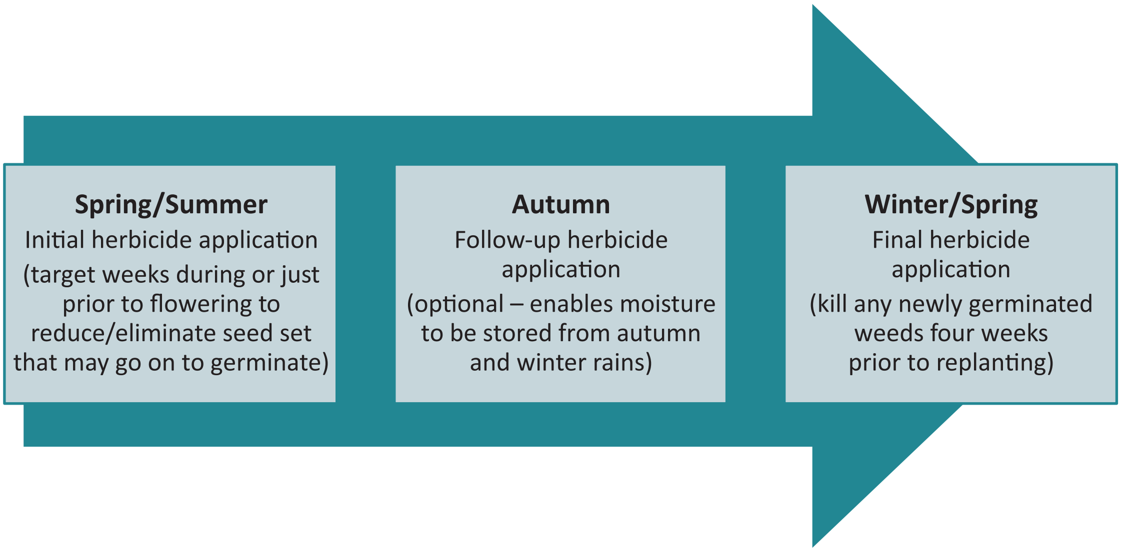


Figure 8: Timeline for herbicide application prior to replanting.

* *Where weeds are difficult to control, herbicide application should begin at least two years prior to planting to assist native species regeneration within remnant vegetation*

Tall Sedge that releases seed in February and germinates opportunistically to occupy available niches. Similarly, the control of Galenia in early spring provides a niche to be occupied by Wallaby Grasses, which set seed in early summer and germinate in autumn and spring or when conditions are favourable.

Herbaceous weed control should be timed in a way that takes account of the mechanism for seed dispersal and establishment of both desired and undesired flora and times action to advantage the indigenous species. As is standard with any weed management, intervention control should be carried out when plants are actively growing.

To manipulate the site to advantage remnant vegetation and exclude/suppress exotic vegetation, project managers should utilise contractors with proven skills in plant identification (indigenous and exotic) and ecological restoration.

7.4.6 Licences/permits

Before using any herbicide:

- ensure that it is registered for the particular weed problem and situation
- read the product label and follow all label instructions carefully.

Legal use of some chemicals requires a Agricultural Chemical User Permit (ACUP). In Victoria, an ACUP is required to use agricultural chemical products that are ‘restricted use’ chemicals. These are chemicals that have a potentially higher risk of adversely affecting the user’s health, the environment and trade. They include ester formulations of MCPA, 2,4-D, 2,4-DB or triclopyr, which are particularly relevant for woody weed control. A full list of restricted use chemicals can be found on the DELWP website.

Other restrictions apply within Chemical Control Areas (CCAs). Nine CCAs have been established in Victoria to protect high-value herbicide-sensitive crops. These areas can be found on the DELWP website.

7.4.7 Maintenance

Good preplanting weed control minimises the need for post planting spraying (TreeProject 2003, Perry 2004). However, weeds often grow back after planting (TreeProject 2003).

An appropriate allocation of resources for weed maintenance is an essential component in all replanting projects. If replanting sites cannot be maintained in an appropriate condition, they should not be established.

The long-term success of a planting project will depend on the level of maintenance. Herbaceous weed control in remnant vegetation will require ongoing maintenance depending on the invasiveness of the target herbaceous weed and the value/sensitivity of the remnant flora being protected.

Technique

Options for weed management post-planting include:

- manual weed removal (see hand removal or chipping section)
- chemical control by overspray with a selective herbicide, e.g. where grasses are dominant, plantings may be over-sprayed with a selective herbicide that does not damage broadleaved plants (TreeProject 2003)
- chemical control by spot spraying or wick-wiping.

Timing

Currently, no recommendations.

7.5 Mechanical/manual control

In many cases, it is more environmentally sensitive to consider non-chemical weed control (TreeProject 2003), particularly when using herbicides near waterways. It is important to consider techniques that can be alternatives, or complementary, to the use of herbicides (Ainsworth and Bowcher 2005).

The suitability of the most common mechanical/manual approaches used to control herbaceous weeds are summarised in Table 7-2 and detailed in the following sections.

Table 7-2: Mechanical/manual approaches to control herbaceous weeds.

Control option	Suitability for application	
	Assisted native species regeneration	In preparation for replanting
Cultivation	✗	✓
Scalping	✗	✓
Mulching	✗	✓
Weed matting	✗	✓
Fire	✓	✓
Grazing, slashing or mowing	✓	✓
Hand removal or chipping	✓	✓

✓ – suitable ✗ – unsuitable

7.5.1 Cultivation

Applicability

Cultivation is carried out to remove competing weeds, thereby improving moisture and nutrient availability to planted seedlings (Stackpole 1998).

However, it can also allow other weeds to invade or aid the spread of weed seed through the soil (Perry 2004).

Use Table 7-3 to assess the suitability of cultivation for herbaceous weed control under a range of landscape conditions.

Cultivation must not be used for herbaceous weed control within remnant vegetation.

Timing

Where applicable, cultivation should be undertaken in the season before planting. This will increase the effectiveness of any preplanting herbicide that may be used (Perry 2004, TreeProject 2003).

7.5.2 Scalping

Applicability

Scalping involves removing the top few centimetres of soil containing the weed seeds (Corr 2003, Perry 2004). This can be undertaken by machine (e.g. grader) or by hand (e.g. shovel).

It gives effective long-term weed control by removing the nutrient-rich topsoil (Perry 2004) and a large proportion of weed propagules and can provide conditions suitable for restoration of indigenous ground flora.

Scalping must be undertaken if the site has been sprayed using residual or pre-emergent herbicide (Corr 2003).

Scalping should not be used within remnant vegetation.

Do not use a machine for scalping on hilly terrain or highly cultivated erodible soils.

Table 7-3: Suitability of cultivation for herbaceous weed control.

Condition	Suitability	Comments
Light, well drained and friable soils	✓	Increases water infiltration and stimulates germination of weed seed by exposing it to light and water (Perry 2004) Caution is required in areas prone to wind erosion
Heavy soils	✗	May destroy soil structure (Perry 2004)
Soils of high and very high erosion classes	✗	On slopes above 10% and 15% respectively (Stackpole 1998)
Areas of high erosion potential, e.g. proximity to waterway	✗	
Areas of very high rainfall	✗	For some moderate and moderate-high erosion class soils above 15% slope (Stackpole 1998)
Cultural heritage sites	✗	
Sites with intact native cover	✗	

✓ – suitable ✗ – unsuitable

Timing

Scalping should be undertaken just prior to planting.

7.5.3 Mulching

Applicability

Mulches should only be used for very small-scale projects (Corr 2003).

They should not be used to assist natural regeneration within remnant vegetation.

Mulches are likely to be ineffective if not used in combination with other techniques, in particular herbicide treatment.

Technique

Currently, no recommended technique.

Materials

Many materials can be used as mulch, including straw or hay, bulk organic material such as wood chips, sawdust or cotton waste, newspaper, rice hulls, gravel, carpet, grass or leaf mould (Corr 2003, Greening Australia 2008b, TreeProject 2003, Perry 2004). Some materials (e.g. hay and straw) may include seeds of weed species not already on site (or in the district) – refer to the *Minimising the Spread of Weeds and Plant Pathogens* standard for details.

Other materials include commercial jute mats and woven jute matting (refer to weed matting section).

Once a material has been selected, the main considerations when placing mulches are:

- thickness
- proximity to plant stems.

Thickness

While a thick layer of mulch placed around young plants helps to conserve soil moisture, improve soil structure, modify soil temperatures and suppress weed growth (Greening Australia 2008b, TreeProject 2003, Perry 2004, Corr 2003), take care to ensure that mulch layers are not too thick.

The most commonly used mulches (wood chips and barks) should be layered to a thickness no greater than 100 mm. Thicker mulch layers can:

- be expensive
- limit opportunities for natural regeneration from seed fall from revegetated plants (Corr 2003)
- retain too much moisture in the root zone leading to root rot
- inhibit water penetration from rainfall, leading to drought stress
- increase susceptibility to frost by preventing radiant heat being released overnight.

As a general rule, the thickness of the mulch layer depends on the material being used with finer materials resulting in thinner mulch layers.

Proximity

Mulching materials must be kept clear of the seedling stem as contact can cause collar rot (Greening Australia 2008b, Corr 2003, TreeProject 2003, Perry 2004).

Timing

Mulches should generally be applied either just before or at the time of planting.

In very cold areas, mulches should not be placed during winter as they can prevent the soil from warming and lead to frozen soil around the roots (Greening Australia 2008b).

7.5.4 Weed matting

Applicability

Advantages and disadvantages of weed matting are provided in Table 7-4.

Table 7-4: Weed matting – advantages and disadvantages.

Advantages	Disadvantages
• Improve soil moisture content by acting as a mulch • Effective way of suppressing weed growth, particularly in areas where herbicides are undesired or inappropriate	• Inhibits ability of plants to uptake moisture • Expensive when revegetating a large area • Decomposes quickly especially in riparian areas

Table adapted from (TreeProject 2003).

In low rainfall areas, weed matting can inhibit a plant's ability to uptake moisture. As such, the use of weed matting should generally be limited to areas with medium to high rainfall (annual rainfall >500 mm) where weed competition is the greater issue not moisture availability.

In addition, weed matting should not be used to assist natural regeneration within remnant vegetation.

Technique

Weed matting can be purchased as either:

- long rolls of weed mat (with pre-cut slits) for lines of plantings
- small squares of weed mat for individual seedlings (TreeProject 2003).

After unrolling, weed matting rolls are secured in place with metal pins at a rate of 4–5/m^2 (allow for extra pins in flood-prone areas).

Weed mat squares have three slits for stakes (so that they can be used in conjunction with plastic tree guards and stakes) and a central slit for the seedling. Where no tree guard is used, the weed mat is secured with four pins.

Timing

Weed matting rolls should be installed after at least one initial spray run and prior to planting (with the plants subsequently installed into the pre-cut holes). Weed mat squares should be put down after plants are in the ground. This will prevent soil clods being left on top of the matting and reduce maintenance costs.

Mulch can also be placed over weed mat or jute rolls to increase the site's resistance to weed invasion and retain moisture.

7.5.5 Fire

Applicability

Fire is generally used to control herbaceous weeds where there is an objective to reduce chemical use. It is more effective on broadleaf weeds than grasses, which are more resistant to heat (CRC for Australian Weed Management 2003).

Techniques

Spot burning with a flame burner is the preferred technique for fire treatment of herbaceous weeds.

Flame burners use propane gas or kerosene as fuel to provide a constant flame and use a hand wand to allow the flame to be applied onto the target weeds. The method does not require that the plant is burnt; in fact, for many species this may stimulate regrowth. Rather, the method works best when plant leaves are severely wilted as a result of exposure to the intense heat and subsequently die (CRC for Australian Weed Management 2003).

Spot burning should target a particular plant or small area rather than a general burn of an area.

Timing

Spot burning should be undertaken in spring to reduce weed seed set.

7.5.6 Grazing, slashing or mowing

Applicability

Replanting sites

Grazing, slashing or mowing of a replanting site can be used to reduce weed biomass prior to chemical control (Perry 2004).

Natural regeneration

Within remnant vegetation, ecological grazing is an available technique but should only be used within specific vegetation communities (refer to *6.4 Ecological grazing* for details).

Technique

Currently, no recommended technique.

7.5.7 Grazing

Grazing should be managed to maximise the vegetation condition, rather than for animal condition. This optimal grazing should be applied based on a combination of the indigenous plant diversity, vegetation structure, and the plant biomass (Water Technology 2009). Refer to *6.4 Ecological grazing* for specific details.

7.5.8 Slashing/mowing

Slashing/mowing will not eradicate weeds but can prevent or greatly reduce weed seed production if timed appropriately, i.e. after weed flowering but before seed set.

The basic technique is to slash/mow the weeds as low as possible. General equipment for slashing/mowing includes:

- tractor slashers (for large areas)
- mowers, brush-cutters or whipper-snippers (for medium to small areas).

Timing

Currently, no recommendations.

Grazing for natural regeneration

The key to the control of weeds within grassy ecosystems is to time grazing with the critical stages in the weed life cycle (CRC for Australian Weed Management, 2004). This is usually after weed flowering but before seed set, i.e. over spring and summer. However, this timing coincides with the critical life stages of native plants that tend to flower and set seed during late spring and early summer.

Grazing for herbaceous weed control should only occur in combination with appropriate fencing to protect adjacent native vegetation in autumn and late winter/early spring. Irrespective of the time of year, livestock must not be used to control herbaceous weeds when:

- Soil moisture levels are high: grazing at such times will lead to pugging and compaction (Staton and O'Sullivan 2006, Water Technology 2009).
- Soil is very dry, e.g. during a drought: at such times, the ground layer may be too sparse, leading to over-grazing and soil erosion (Staton and O'Sullivan 2006, Water Technology 2009).

Grazing in replanting sites

Grazing should be avoided where there has been replanting until plants are beyond browsing height. This will normally be after three years from planting (TreeProject 2003, Perry 2004).

Applicability

Pulling out weeds by hand or digging them out with a hoe (chipping) along or beside a seeding or planting line, is a simple and effective method for small-scale projects (Corr 2003). However, it does not prevent growth of new weed seedlings (Horlock 1998 in Corr 2003).

Technique

When removing weeds by hand, take care to:

- create minimal disturbance
- avoid disturbing the roots of any remnant, sown or planted seedlings
- remove all plant parts capable of re-growth (Corr 2003).

Timing

This technique should be undertaken before weeds flower and produce seed (generally late winter/early spring) (Horlock 1998 in Corr 2003).

7.6 References

Adair, R. and Groves, R. (1998). *Impact of Environmental Weeds on Biodiversity – A Review and Devlopment of a Methodology.* Enviornment Australia, Canberra, ACT.
Ainsworth, N. and Bowcher, A. (2005). *Herbicides: Guidelines for Use In and Around Water.* Cooperative Research Centre for Australian Weed Management.

Anderson, G. (2003). *Site Preparation for Farm Forestry. Agriculture Notes AG0770.* Department of Primary Industries, Victorian Government, East Melbourne.

Cooperative Research Centre for Australian Weed Management (2004). *Introductory Weed Management Manual.*

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Department of Sustainability and Environment (2010). *Burning Off On Private Land.* Department of Environment, Land, Water and Planning , Victorian Government, East Melbourne.

Department of Sustainability and Environment (2009). *Standards for Management – Ecological Burning. Bush Broker Information Sheet No. 14.* Department of Environment, Land, Water and Planning , Victorian Government, East Melbourne.

Eddy, D.A. (2002). *Managing Native Grassland: A Guide to Management for Conservation, Production and Landscape Protection.* WWF Australia, Sydney.

Greening Australia (2008a). *Maintenance After Planting – Weed Control and Assessment.*

Greening Australia (2008b). *Site Preparation – Moisture Conservation.*

Greening Australia (2008c). *Site Preparation – Weed Control.*

Hannah, R. (2004). *Chemical Control of Weeds in Vines.* Department of Primary Industries Victoria.

Heytesbury District Landcare Network (2009). *Site Preparation for Revegetation. Fact Sheet No. 6.*

Murray, J. and Thompson, D. (2000). *Native Regrowth – A Farmer's Guide to Maintaining Biodiversity When Thinning Regrowth Forest.* Rural Industries Research and Development Corporation, ACT.

Noble, M. (2002). *Guideline for Safe and Effective Herbicide Use Near Water.* Department of Primary Industries, Water and Environment. Tasmania.

Perry, D. (2004). *Tree Planting and Aftercare. Landcare Notes LC0104.* Department of Primary Industries, Victorian Government, East Melbourne.

Schirmer, J. and Field, J. (2000). *The Cost of Revegetation* – Forestry, Australian National University.

Stackpole, D. (1998). *Eucalypt Plantation Establishment – Site Preparation.* Department of Natural Resources and Environment.

Staton, J. and O'Sullivan, J. (2006). *Stock and Waterways: A Manager's Guide.* Land & Water Australia, Canberra.

TreeProject (2003). *Preparing and Planting your Revegetation Site.*

Water Technology (2009). *An Investigation of Controlled Grazing as a Riparian Management Tool.*

8. Weed control – Woody weed control

Determining whether woody weed control is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The relevant ecological vegetation class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch i.e. revegetation.
- specific site conditions, e.g. soil type, slope.
- the type and severity of threats present.

8.1 Scope

This Standard provides technical information for a range of chemical, mechanical and manual methods to control woody weeds (including trees, shrubs, scramblers, climbers and vines).

This Standard does not provide advice on:

- assessing the problem (e.g. weeds present, modes of spread, etc)
- undertaking risk assessments (e.g. plant densities/ distributions) to determine if particular control methods are required/appropriate.

8.2 Background

Woody weeds can pose a serious threat to biodiversity and primary production. They contribute to land and water degradation and losses in productivity, and they can significantly impact native flora and fauna populations (Department of Sustainability and Environment 2009). Some woody weeds can also provide suitable harbour for pest animals (e.g. blackberry for rabbits).

8.3 Method

The recommended approach for developing and implementing a woody weed control program involves:

- Describing the desired vegetation community (i.e. the vision or goal).
- Assessing the problem (including identifying the presence of indigenous vegetation that must be protected from any control activities as well as any biodiversity values [e.g. bird habitat] associated with the woody weeds).
- Considering the control options/methods and determining:
  - their effectiveness in treating the problem
  - their practicality in treating the problem
  - potential risks of application to both on-site and off-site values; this needs to also consider the risks around the control options.
- Developing a weed control and maintenance program.
- Implementing the program.
- Maintaining a monitoring and review program.

However, as problem assessment and control option considerations depend on site-specific values, conditions and weed species, this Standard is limited to the most common techniques to control woody weeds:

- chemical control
- mechanical control
- manual control
- burning
- grazing.

These techniques are presented in the following sections. Useful links to specific control options for some woody weeds (i.e. Weeds of National Significance and/ or Victorian Declared Noxious Weeds) can be found in Appendix 8.1.

Biological control of woody weeds (e.g. gorse spider-mite or blackberry rust fungus) has not been included in this Standard. However, its use should still be considered as part of an integrated program with specialist advice sought from DELWP.

8.3.1 Chemical control

Applicability

A number of chemical control options are available for the management of woody weeds. The most common are:

- stem injection
- cut and paint
- foliar spray
- stem scrape.

Table 8-1 assesses the suitability of these chemical control options for a range of woody weed lifeforms. This table should be used to determine which chemical control option (or range of options) is most appropriate for a particular project site.

Technique

The following sections detail the key standards that apply to the three most common chemical control options for woody weeds. In particular:

- the recommended technique for each control option
- the type of herbicide applicable to the particular woody weed.

Table 8-1: Chemical control options based on woody weed lifeform.

Woody weed lifeform	Chemical control option			
	Stem injection	Cut and paint	Foliar spray	Stem scrape
Seedling (small root system and simple stem)	✗ Stems too small	✗ Too laborious	✓	✗
Small woody weed (< 0.5m tall with extensive fine stems)	✗ Stems too small	✗ ** Stems too thin and too many	✓	✗
Woody weed (> 0.5m tall)	✓ * Stems or trunks greater than 5cm in diameter	✓ Preferred method for saplings too small to be stem injected	✓ If practical	✓ If bark tissue is thin and relatively soft
Single or multi-stemmed woody weed tree	✓ * Stems or trunks greater than 5cm in diameter	✓	✗ Not cost-effective	✗
Regrowth (following mechanical clearing or poor cut stump treatment)	✗ Stems too small	✓ If practical	✓ Where regrowth has sufficient leaf area	✗
Scramblers and climbers at ground storey and mid-storey	✗ Stems too small	✓ Appropriate method to protect remnant vegetation values	✓ Preferred method for large infestations	✓
Scrambler and climbers entering over storey	✓ Appropriate on for very large climbers	✓ Preferred method for the majority of large climbers	✗ Foliage is out of reach	✓

✓ – control option recommended *✗ – control option not recommended*

* *Stem injection methods kill the woody weed where it stands. Therefore, this treatment should only be used where either the woody weed can be safely left to die and rot in situ or be felled and removed at a later date (Ensbey and Johnson 2007).*

** *However, the cut and paint technique may be more appropriate than foliar spraying for some small woody weeds (e.g. ash).*

Table adapted from Dow AgroSciences (2009).

Stem injection

This technique involves drilling or cutting through the bark into the sapwood tissue in the trunks of woody weeds. The aim is to reach the sapwood layer just under the bark (the cambium growth layer), which will transport the chemical throughout the plant (Ensbey and Johnson 2007).

Stem injection is particularly suitable for large climbers, shrub and tree species where you want to kill the plant but do not wish to immediately remove it from the landscape (e.g. you may wish for it to remain in place for its habitat and soil stabilisation functions until other species establish or removal is considered too costly, risky or impractical).

Recommended techniques that should be followed when applying the stem injection method are detailed in Table 8-2.

Cut and paint

This technique involves cutting the plant as close to the ground as possible and then immediately painting the stump with a suitable herbicide.

It is used mainly for large scramblers/climbers, trees and woody weeds (Ensbey and Johnson 2007) and is particularly useful in sensitive environments, e.g. areas of remnant vegetation or near waterways (CRC for Australian Weed Management 2003). However, caution should be exercised in using this technique as some species can sucker if treated this way, e.g. poplar species (Ensbey and Johnson 2007). In these circumstances, the 'drill and fill' technique should be employed.

The recommended technique that should be followed when applying the cut and paint method is detailed in Table 8-3.

Table 8-2: Stem injection – recommended techniques.

Method	Recommended technique
Drill and fill (also referred to as 'tree injection' or 'stem injection')	1. Use a battery-powered drill to make a downward-angled hole into the cambium layer of the trunk (i.e. the thin layer of generative tissue lying between the bark and the wood*), as close to the ground as possible. 2. Immediately apply herbicide** (within 10 seconds of drilling) into the hole using a backpack reservoir and syringe that can deliver measured doses of herbicide solution. 3. Continue drilling and filling holes at regular spacings (refer to the herbicide product label for recommended spacings).
Cut and fill (also referred to as 'frilling and killing' or 'flaring and filling')	1. Use an axe, chainsaw, tomahawk or hammer and chisel to make horizontal cuts into the cambium layer of the trunk as close to the ground as possible. 2. While still in the cut, lean the axe, chainsaw, tomahawk or chisel out to make a downward angled pocket and immediately apply herbicide[4] (within 3 seconds.) 3. Continue cutting and filling around the circumference of the trunk at regular spacings (refer to the herbicide product label for recommended spacings). It is important not to entirely ringbark the trunk, as this will decrease the uptake of the herbicide into the plant. 4. Where low branches are encountered, place a cut immediately below the branch.

** More specifically, depth of drilling should be limited to the phloem layer and not into the xylem layer.*

*** Prompt herbicide application is necessary because the plant can seal the cut quickly, thus barring the chemical penetrating into the cambium layer.*

Table adapted from Dow AgroSciences (2009) and Ensbey and Johnson (2007).

Table 8-3: Cut paint: recommended technique.

Method	Recommended technique
Cut and paint (also referred to as 'cut stump')	1. Use a chainsaw, brush-cutter, loppers or secateurs (depending on the thickness of the stem/ trunk) to completely cut off the plant at its base. 2. Stems/trunks should be cut as close to the ground as possible. 3. Immediately spray or paint the herbicide solution on to the exposed surface of the cut stump (a delay of more than 10 seconds for water-based herbicides and 1 minute for diesel soluble herbicides between cutting and applying the chemical will give poor results). 4. Use a brightly coloured dye in the solution to mark the stumps that have been treated. 5. For trees with large circumferences, it is only necessary to place the solution around the edge of the stump (as the objective is to target the cambium layer inside the bark). The stump circumference should be bruised with the back of an axe and each successive blow treated with herbicide.

Table adapted from Dow AgroSciences (2009), Ensbey and Johnson (2007) and Department of the Environment, Water, Heritage and the Arts (2007).

Foliar spray

This technique involves spraying the foliage of a plant to the point of runoff.

Foliar spraying can be done a number of ways, depending on the size of the weed plant and/or the infestation. The main methods are:

- Blanket spraying: Blanket spraying using a boom spray from a tractor or 4WD vehicle can be used to treat large areas completely infested with weeds, especially with selective herbicides, e.g. extensive blackberry infestations that occupy a high cover abundance on a specified site.
- Targeted spraying: For large infestations that need targeted applications of herbicide, a hose and handgun can be used to spray solution from a herbicide rig with tank and pump carried by a tractor or vehicle. Smaller infestations can be sprayed using a backpack/knapsack spray unit.
- Spot spraying: Spot spraying is used to treat individual weed plants or areas that have only small clumps of weed infestations (Ensbey and Johnson 2007).

Regardless of which method is chosen, the technique detailed in Table 8-4 should be followed.

While foliar spraying may be a quick and economical method of chemical control, it has the potential for spray drift and off-target damage (Ensbey and Johnson 2007). Hence, its use should be avoided (or limited) when there is potential for adverse impacts, e.g. in close proximity to waterways or native vegetation.

Stem scrape

This technique involves scraping a very thin layer of bark from a section of stem then immediately applying herbicide to the exposed soft underlying green tissue. It is mainly used for the control of vines (and some woody weeds where the surface bark can be peeled away easily).

The recommended technique that should be followed when applying the stem scrape method is detailed in Table 8-5.

Types of herbicide

There are a number of herbicides registered for the control of woody weeds under various conditions. The selected herbicide must be registered for that particular weed problem and situation (refer to licences/permits section).

Timing

Chemical control methods work best when applied to actively growing plants that are not showing signs of stress.

Woody weeds should be treated with herbicide when they are actively growing (usually from spring to early autumn, depending on the species). If the season preceding treatment has been dry, treatment should be delayed until there has been sufficient rainfall.

Herbicides should not be applied by foliar spray when plants are in full flower or when bees are active.

Maintenance

Woody weed control programs may require several years of follow-up treatment (depending on species, degree of infestation and site conditions). At a minimum, all treated woody weeds must be appropriately maintained over a 24-month period after herbicide application and any regrowth treated.

At least 50 cm of regrowth should be present before treatment. However, annual treatment of regrowth may be important in some situations (rather than waiting for plants to reach a required height).

Table 8-4: Foliar spray – recommended technique.

Method	Recommended technique
Foliar spray	1. Dilute herbicide with water or diesel at a specified rate. 2. Spray herbicide solution over the foliage to the point of runoff (i.e. until every leaf is wetted, but not dripping). 3. Ensure the entire leaf area of the plant is treated. 4. Ensure very accurate application so that no native plants near the target plant are sprayed.

Table adapted from Ensbey and Johnson (2007).

Table 8-5: Stem scrape – recommended technique.

Method	Recommended technique
Stem scrape	1. Using a knife or chisel, scrape away 10cm of the bark on one side of the vine to expose the sap wood (be careful not to cut through the vine) 2. Immediately (within 10 seconds) apply herbicide with a paint brush to the scraped surface on the stem.

8.3.2 Mechanical control

Applicability

For some species, and in certain circumstances, mechanical clearing with heavy earth-moving equipment (e.g. bulldozers or groomers) can form an effective part of integrated weed management, particularly for severe infestations of larger woody weeds (CRC for Australian Weed Management 2004).

Advantages and disadvantages of mechanical clearing are provided in Table 8-6.

Technique

The key machinery used for mechanical clearing of woody weeds is:

- excavators
- bulldozers.

Excavators

Techniques to clear woody weeds using excavators include:

- Grooming: Excavators fitted with groomers (a rotating drum fitted with free-swinging blades) can be effective in controlling large infestations of woody weeds in hard-to-reach places, e.g. riparian zones. The groomer shreds plant material down to ground level, reducing biomass (and subsequent follow-up herbicide volume) and leaving a surface mulch, which helps suppress the growth of new (and existing) weeds.
- Tree removal: Excavators fitted with a log grab or claw are ideal for lifting and stockpiling tree limbs that have been cut down using chainsaws. Some machines are fitted with a specialised chainsaw head.

Bulldozers

Techniques to clear woody weeds using bulldozers include:

- Blade ploughing: A large plough device attached to the bulldozer cuts off trees below the soil surface and below the zone from which they can rebud. This is best done when trees are young and easier to cut through (CRC for Australian Weed Management 2004)
- Dozer pushing: Established plants are cut off near the soil surface using the dozer blade. It is favoured in situations where minimal soil disturbance and subsequent weed seed germination is desired (CRC for Australian Weed Management 2004).
- Chain pulling: Plants are knocked to the ground by two bulldozers dragging a heavy chain through dense infestations (CRC for Australian Weed Management 2004).

Bulldozers must not be used in the following environments:

- riparian and wetland areas (due to the high level of disturbance and soil compaction)
- sites that require selective weed control (e.g. sites within remnant vegetation).

Timing

Mechanical clearing must only occur if the ground is dry and should be undertaken after weed flowering but before seed set, i.e. over spring and summer.

Where woody weeds are providing habitat for native animals, project managers must ensure that either:

- alternative habitats are established before woody weed removal (e.g. replanting of comparable indigenous vegetation), or
- woody weed removal is staged so that an acceptable level of habitat is maintained throughout the project transition.

Table 8-6: Mechanical clearing – advantages and disadvantages.

Advantages	Disadvantages
• Can be quick • Can be cost-effective for extensive infestations (prickle bushes) • Removes pest animal harbour	• Significant disturbance of soil and native vegetation (which may reactivate previously dormant weed species) • Can only be conducted when ground is dry • Vehicle hygiene risks • Expensive for small infestations • Root systems may be left intact to regrow, hence comprehensive follow-up may be required • Removes native fauna habitat • Can affect cultural heritage values through soil disturbance • Underground assets need to be identified prior to starting or planning works, which may affect costs

Adapted from CRC for Australian Weed Management (2004).

Maintenance

Mechanical clearing can cause major disturbance to vegetation and soil and should only be contemplated where resources exist to carry out necessary follow-up work. This includes restoration of the site with desirable vegetation (CRC for Australian Weed Management 2004).

Manual control – slashing

Applicability

Where smaller woody weed infestations occur or where access issues exclude the use of heavy machinery, slashing with brush-cutters may be an acceptable approach.

Advantages and disadvantages of slashing are provided in Table 8-7.

Timing

The use of brush-cutters will not eradicate weeds but can prevent or greatly reduce weed seed production if timed appropriately, i.e. after weed flowering but prior to seed set.

8.3.4 Manual control – hand removal or chipping

Applicability

Pulling out weeds by hand or digging them out with a hoe is a simple, effective method best suited to small-scale projects (Corr 2003). However, it does not prevent growth of new weed seedlings (Horlock 1998 in Corr 2003).

Technique

When removing weeds by hand, care should be taken to:

- create minimal disturbance
- avoid disturbing the roots of any remnant, sown or planted seedlings
- remove all plant parts capable of re-growth (Corr 2003).

Timing

This technique should be undertaken before weeds flower and produce seed (Horlock 1998 in Corr 2003).

8.3.5 Fire

Applicability

As part of an integrated control program, fire can assist in the control of some woody weed species by reducing weed biomass and stimulating seed germination, enabling more efficient and effective control (CRC for Australian Weed Management 2003).

However, the use of fire is not an appropriate strategy for all vegetation types. Advantages and disadvantages of burning to control woody weeds are provided in Table 8-8.

Technique

Pre-burn

Before undertaking a burn, assess the following attributes and develop appropriate protection/replacement strategies:

- the extent, proximity, conservation status and fire-dependence of any native vegetation types within the proposed burn area
- the extent, conservation status and habitat requirements of any rare or threatened species occurring within the proposed burn area
- any other specific values within the proposed burn area e.g. habitat features (such as hollows, shrubby cover, leaf litter), sites of cultural significance, recreation areas (Fire Ecology Working Group 2004).

Burn

The best fire strategy for woody weeds is a prescribed burn that aims to burn only the weedy area using firebreaks and back-burning techniques (Ensbey and Johnson 2007).

Table 8-7: Slashing – advantages and disadvantages.

Advantages	Disadvantages
• Minimises soil disturbances • Minimises risks to local flora • Can prevent seeding and spread • Removes excess foliage (for follow-up treatments) • Supplements other methods • Helps to weaken plants, making them susceptible to other forms of control • Inexpensive on small projects	• Usually doesn't eradicate weeds if the infestation is large • Can prevent seeding by local flora • Can introduce/spread weed propagules • Can encourage weed growth • Can increase fuel loads over the short term (dried material) • Labour intensive

Adapted from CRC for Australian Weed Management (2004).

Table 8-8: Burning – advantages and disadvantages.

Advantages	Disadvantages
• Removes rank and excessive foliage (for follow-up spray treatments) • Supplements other methods • Encourages local flora regeneration • Encourages germination of soil-stored weed seedbank for some species (for follow-up treatments)* • Relatively inexpensive • Kills weed seedbanks of some weed species*	• Usually does not eradicate weeds • Inappropriate for non-fire adapted ecosystems • Seasonal and timing limitations • Encourages weed growth/germination of some weed species* • Altered nutrient-moisture availability can favour weeds • Potential for runoff/erosion • Fauna, people, health, property risks • Can be costly if establishment of fire breaks, spelling of pasture and personnel required to control fire are involved • Specialist knowledge required • Creation of fire breaks can damage native vegetation

** Burning can affect different weed species in different ways. For example, fire encourages germination of some species (e.g. Gorse) and destroys the seedbanks of other species (e.g. Sweet Pittosporum). Its use must be specific to the weed species identified for control.*

Adapted from CRC for Australian Weed Management (2004).

The success of a prescribed burn depends on a number of factors, most notably:

- The response of the weed to burning: Some weeds do not burn well while alive (CRC for Australian Weed Management 2004) and may require prior chemical control.
- The fire regime employed: The factors that govern the impact of a fire on woody weeds include the amount of fuel, the speed and intensity of the fire, and the time of year that burning takes place (Ensbey and Johnson 2007).

Timing

Burning is best undertaken in the first year of a woody weed control program to reduce biomass to a more manageable level. It should be timed to allow plants to regrow to at least one metre before starting a herbicide treatment.

Spring is the optimum time to reduce woody weed biomass. However, autumn burning should be considered to reduce the impact on native fauna that may utilise woody weeds for habitat.

For large areas of woody weeds, the site should be burnt in patches over a number of years rather than conducting a prescribed burn across an entire site at the same time. This approach will provide refuge areas for native animals to escape the fire and maintain habitat during the transition from woody weeds to native vegetation.

Licences/Permits

During the fire season, project managers must apply for a permit from the relevant local government before undertaking a prescribed burn. In addition, some local governments may have other burning restrictions. Project managers should discuss a proposed burn with the relevant local government regardless of the time of year that the burn will take place (Department of Sustainability and Environment 2010).

Even if a local government permit is not required, the following steps must be followed (adapted from Department of Sustainability and Environment (2010):

- Burn plan: Depending on the size of the intended burn area, develop a burn plan that takes into account issues such as aspect, slope, fuel load, humidity, isolations, exposures, ignition points, public and private assets, evacuation tracks, staging areas, etc.
- Fire breaks: Clear at least 3 m around the area to be burned to stop fires spreading (taking care to avoid/minimise impacts to native vegetation). Slashing or raking fire breaks is recommended rather than using mechanical or chemical methods. Ploughing or spraying a fire break will remove competition by native plants and encourage germination of weeds, creating a strip of weedy vegetation (Eddy 2002).
- Notification: Notify all neighbours when a burn date has been set and at least two hours prior to burning. Also notify the Country Fire Authority and the Department of Environment, Land, Water and Planning to avoid confusion from visible smoke.
- Weather: Before burning – check weather conditions for the next 48 hours. Only burn if forecasts indicate low temperatures and weak breezes. Windy conditions increase the chance of fire spreading.
- Supervision: Most fires escape when no-one is present as fuels can smoulder without being obvious. Supervise your burn off.
- Be prepared: Accidents do occur. Have firefighting equipment and a good water supply nearby.

In addition, burning adjacent to a designated waterway will require a Works on Waterways permit or written authorisation from the responsible CMA or Melbourne Water.

Maintenance

While fire can be useful in reducing dense thickets of woody weeds to ground level, it does not necessarily kill the plant. Moreover, fire can stimulate weed-seed germination. For example, burning gorse stimulates seed growth but also destroys much of the grass beneath the bush, creating an ideal environment for re-establishment.

Follow-up weed control (chemical, manual or both) must be planned and implemented for the period following the fire.

8.3.6 Grazing

Applicability

Grazing by livestock (in particular sheep and goats) can be a useful contributor to woody weed control. For example:

- Goats eat a number of woody weed species dependent on the palatability of the weed (highly palatable weeds include blackberry, sweet briar and scotch broom) (Ensbey and Johnson 2007).
- Sheep can be moderately effective in controlling gorse seedlings before spines are formed; however, high stocking rates are needed to force sheep to graze on gorse rather than other species (CRC for Australian Weed Management 2003).

Advantages and disadvantages of grazing to control woody weeds are provided in Table 8-9.

Technique

Currently, no recommended technique.

Timing

The best time to implement grazing is when the weeds are most palatable (generally spring). However, this coincides with the critical life stages of native plants that tend to flower and set seed during late spring and early summer.

Grazing for woody weed control should only occur in autumn and late winter/early spring, in combination with appropriate fencing to protect adjacent native vegetation.

Goats

To control localised woody weed infestations, isolate the area from other parts of the project site with fencing. This will protect adjoining vegetation from goat browsing and reduce the number of goats required to control the weed (Holst and Simmonds 2000).

In dense infestations of woody weeds (e.g. blackberry, gorse) slash paths through the infestation to allow greater access for goats (Holst and Simmonds 2000).

Sheep

Sheep are generally used as a maintenance/follow-up tool to control woody weed regrowth following the implementation of other control methods, e.g. the use of sheep to control gorse seedlings after a dense gorse infestation has been removed.

Site conditions

Irrespective of the time of year, livestock must not be used to control woody weeds when:

- Soil moisture levels are high: Grazing at such times will lead to pugging and compaction (Staton and O'Sullivan 2006, Water Technology 2009).
- Soil is very dry, e.g. during a drought: At such times, the ground layer may be too sparse, leading to over-grazing and soil erosion (Staton and O'Sullivan 2006, Water Technology 2009).

Table 8-9: Advantages and disadvantages of grazing to control woody weeds.

Advantages	Disadvantages
• Selective (depending on grazing animal and weed species being targeted) • Can remove excess foliage (for follow-up treatments) • Can reduce flowering and seed dispersal • Can stress weed plants • Supplements other controls • Inexpensive	• Timing limitations • Disturbs soils • Can introduce/spread weed propagules • Encourages weed growth • Damages or destroys native vegetation and prevents natural recruitment • Inappropriate for many ecosystems • Can elevate nutrient levels • Potential for erosion/runoff • Site rehabilitation required • On-going management required • Danger to stock if weed is toxic

Adapted from CRC for Australian Weed Management (2004).

8.4 Licences/permits

8.4.1 Herbicide

Before using any herbicide, users must:

- ensure that it is registered for the particular weed problem and situation (using herbicides other than as strictly described on the label will often require a permit; consult Department of Economic Development, Jobs, Transport and Resources [DEDJTR] for details)
- read the product label and follow all label instructions carefully.

Legal use of some chemicals requires the user to possess an Agricultural Chemical User Permit (ACUP). In Victoria, an ACUP is required to use agricultural chemical products that are 'restricted use' chemicals. These are chemicals that have a potentially higher risk of adversely affecting the user's health, the environment and trade and include ester formulations of MCPA, 2,4-D, 2,4-DB or triclopyr, which are particularly relevant for woody weed control. A full list of restricted use chemicals can be found on the DEDJTR website.

Other restrictions on chemical use apply within Chemical Control Areas (CCAs). Nine CCAs have been established in Victoria to protect high value herbicide sensitive crops. These areas can be found on the DEDJTR website.

8.4.2 Vegetation removal

In some situations, the removal of woody weeds (including the removal of some non-indigenous native species) may require a local government planning permit. For example:

- species such as poplars, pines and holly (above a certain size) may be included within tree protection local laws in some municipalities
- vegetation may be protected under a Significant Landscape Overlay.

8.4.3 Aboriginal cultural heritage

High-impact activities in culturally sensitive landscapes can cause significant harm to Aboriginal cultural heritage. In these situations, the *Aboriginal Heritage Act 2006* may require the project manager to prepare a Cultural Heritage Management Plan or obtain a cultural heritage permit or enter into a cultural heritage agreement with the relevant Registered Aboriginal Party.

If mechanical clearing is proposed within a culturally sensitive landscape, the project manager must determine if a Cultural Heritage Management Plan or cultural heritage permit is required. Specific information on considering Aboriginal cultural heritage needs can be found on the DEDJTR website.

8.4.4 Other permits

For woody weed control projects in or adjacent to a designated waterway (gazetted under the *Water Act 1989)*, a Works on Waterways permit (or written authorisation from the responsible CMA or Melbourne Water) must be obtained prior to any vegetation removal.

A 'Dial before you Dig' assessment may also be required to establish if underground assets are within the area planned for mechanical control.

8.5 References

Cooperative Research Centre for Australian Weed Management (2004). *Introductory Weed Management Manual.*

Cooperative Research Centre for Australian Weed Management (2003). *Weed Management Guide – Gorse.*

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Department of Sustainability and Environment (2010). *Burning Off On Private Land.*

Department of Sustainability and Environment (2009). *Pest Plants.*

Department of the Environment, Water, Heritage and the Arts (2007). *Chemical Control.*

Dow AgroSciences (2009). *Woody Weed Control Guide.*

Eddy, D.A. (2002). *Managing Native Grassland: A Guide to Management for Conservation, Production and Landscape Protection.* WWF Australia, Sydney.

Ensbey, R. and Johnson, A. (2007). *Noxious and Environmental Weed Control Handbook. A Guide to Weed Control in Non-Crop, Aquatic and Bushland Situations – 3rd Edition.* NSW Department of Primary Industries.

Holst, P. and Simmonds, H. (2000). *Weed Control Using Goats*. Australian Cashmere Growers Association.

Appendix 8.1 – Recommended chemical control methods and timing for specific woody weeds

Table 8-11: Chemical control methods for trees.

Common name	Botanical name	Chemical control method: Stem injection	Cut and paint	Foliar spray	Timing
TREES					
Black Willow	*Salix nigra*	✓	✓		Late Spring/Summer
Box Elder	*Acer negundo*	✓	✓		Winter/Spring
Cherry Plum	*Prunus cerasifera*	✓	✓		Autumn/Winter
Desert Ash	*Fraxinus angustifolia*	✓	✓	✓	Winter/Spring
Elm	*Ulmus* sp.	✓	✓	✓* seedlings	Spring/Summer
Fig	*Ficus* spp	✓	✓		Winter/Spring
Hawthorn	*Crataegus* spp	✓	✓	✓ seedlings	Spring/Summer
Mesquite	*Prosopis* sp.		✓	✓	Spring/Summer/early Autumn
Olive Tree	*Olea europaea*	✓	✓	✓	Spring/Summer
Peppercorn	*Schinus molle*	✓	✓	✓	Spring/Summer
Poplar	*Populus spp*	✓			Winter to Summer
Privet	*Ligustrum spp*	✓	✓	✓ seedlings	Winter/Spring
Pussy Willow	*Salix cinerea*	✓	✓	✓ seedlings	Winter/Spring
Sweet Pittosporum**	*Pittosporum undulatum*	✓	✓	✓	Summer
Tree of Heaven	*Ailanthus altissima*	✓	✓	✓ seedlings	Winter/Spring/Summer
Tree Tobacco, Madeira Winter Cherry.	*Solanum* spp	✓	✓	✓ seedlings	All Year
Willow species	*Salix* sp	✓	✓	✓ seedlings	All Year

** Ensure elm 'seedlings' are not in fact juvenile suckers (spraying suckers can affect the non-target parent tree).*

*** Pittosporum undulatum is native to parts of Victoria but poses a threat in other areas; a permit to remove native vegetation may apply to its control.*

Table 8-12: Chemical control methods for shrubs.

Common name	Botanical name	Chemical control method			Timing
		Stem injection	Cut and paint	Foliar spray	
SHRUBS					
African Boxthorn	*Lycium ferocissimum*	✓	✓	✓ seedlings	Spring/Summer
Boneseed	*Chrysanthemoides monilera*		✓	✓	Autumn/Winter
Briar Rose	*Rosa rubiginosa*		✓	✓	Spring/Summer
Cotoneaster	*Cotoneaster* spp	✓	✓	✓ seedlings	Winter/Spring
English Broom	*Cytisus scoparius*		✓	✓	Winter/Spring
Gorse	*Ulex europaeus*		✓	✓	Autumn/Winter
Montpellier Broom	*Genista monspessulana*		✓	✓	Summer

Table 8-13: Chemical control methods for scramblers and climbers.

Common name	Botanical name	Chemical control method				Timing
		Stem injection	Cut and paint	Foliar spray	Stem scrape	
SCRAMBLERS AND CLIMBERS						
Asparagus Ferns	*Asparagus* sp			✓		
Banana Passionfruit	*Passiflora mollissima*		✓		✓	
Blackberry	*Rubus fruticosus**		✓	✓		Spring/early Summer
Blue Periwinkle	*Vinca major*			✓		Spring/early Summer
Bridal Creeper	*Asparagus asparagoides*			✓		Autumn just prior to flowering
Cape Ivy	*Deleria odorata*			✓		Autumn/Spring/early Summer
English Ivy	*Hedera helix*	✓	✓	✓	✓	Spring/early Summer
Japanese Honeysuckle	*Lonicera japonica*		✓	✓	✓	Autumn/Spring/early Summer
Moth Plant	*Araujia sericifera*		✓	✓	✓	Spring/Summer
Old Mans Beard	*Clematis aristata*		✓	✓		Spring/Summer
Rambling Dock	*Acetosa sagittata*		✓	✓	✓	Spring/Summer
Tradescantia	*Tradescantia fluminensis*			✓		Autumn/Spring/Summer

** Variable habit, could be classed as a shrub.*

9. Weed control – Minimising the spread of weeds and plant pathogens

9.1 Scope

This Standard presents methods to minimise the spread of weeds and plant pathogens (hereafter referred to as 'invasive species') into, within, and from a project site.

It covers:

- planning ahead
- risk mitigation measures
- safeguarding clean sites
- general hygiene protocols for vehicles, plants and equipment.

9.2 Background

Invasive species can be spread by human activities, with any isolated outbreaks being the result of movement via contaminated:

- machinery and equipment
- clothing and footwear
- materials (such as topsoil, fill, gravel, potting mix, plant stock, mulch, water, etc) Department of Primary Industries 2009, Environmental Protection Agency 2009, South West Pest Plant and Animal Program 2001).

Individuals and organisations have a duty of care – and in some cases a legal responsibility under the *Catchment and Land Protection Act 1994* (CaLP Act) – to minimise the spread of invasive species, particularly those that may cause significant economic or environmental damage (South West Pest Plant and Animal Program 2001). Transporting or depositing onto land declared noxious weeds that are capable of growing is illegal under the CaLP Act (unless a permit from the DELWP Secretary is obtained). This applies even to the seeds or plant fragments of a noxious weed that may be on a vehicle (Department of Primary Industries 2009).

9.3 Method

9.3.1 Planning ahead

Pre-work risk assessments

Machinery, equipment and vehicle users must aim to limit the introduction or spread of invasive species within a project site (Tyers et al. 2004).

This is best achieved by undertaking a detailed risk assessment that involves assessment of:

- the likelihood of introducing and/or spreading invasive species to, within or from a site
- the consequences of such actions.

Pre-work risk assessments must be conducted prior to the commencement of any works on a project site (Department of Primary Industries 2009).

Assessing the likelihood

Before commencing any works on a project site, the project manager should assess the likelihood of:

- introducing invasive species to a site
- spreading them from an already infested site via:
  - unclean vectors (i.e. vehicles, plant and equipment and personal attire)
  - contaminated materials (i.e. topsoil, fill, sand, gravel, mulch, water or tube stock).

Assessing the likelihood of introducing or spreading invasive species may include:

- pre-work surveys, reference to plans/databases and/or discussions with staff/other agencies/local experts to identify opportunities for vectors to contact/transmit invasive species during works, taking into account the:
  - degree of infestation and the biology of the invasive species (e.g. time of seed set, pathogenicity of diseases)
  - types of activity and vectors used
  - weather and site conditions
- visual examination of vectors to be used on the project
- checks of materials to be used or moved as part of the project.

Assessing the consequences

Where the likelihood of introduction or spread is identified, quantify the consequences:

- breaching provisions of the CaLP Act 1994, section 70A.
- the potential impact of spreading invasive species further in an area or introducing invasive species, taking into account issues such as the:
  - management objectives of the project
  - susceptibility of the project site to plant diseases
  - scale of the activity relative to other activities in the area that may spread or introduce invasive species.

Assessing the consequences of introducing or spreading invasive species may include reference to plans/databases and/or discussions with staff/other agencies/local experts.

Planning based on the level of risk

Based on the likelihood and consequences of a particular activity, a plan may be required to minimise the risk of introducing or spreading invasive species from known or potentially infested sites. The detail of the plan must be commensurate with the risk.

A key requirement is that all vehicles, plant and equipment used on a project site are clean and free of reproductive material before leaving a contaminated project site or entering a clean site. See Appendix A for details on methods such as:

- inspecting machinery and equipment before departure from a project site
- establishing clean-down areas (where justified)
- applying appropriate clean-down options
- maintaining clean-down areas
- disposing of waste and contaminants.

The plans should aim to minimise the time and effort spent cleaning machinery, vehicles and equipment. This may be achieved by using the risk mitigation measures described below.

9.3.2 Risk mitigation measures

Minimising spread from known or potentially infested sites

Where the spread of invasive species within a project site has been identified as a potential risk, project managers must develop and implement appropriate measures to minimise or remove the risk. Possible measures include:

1. Time and coordinate work to limit contamination and spread by avoiding:
   - times when weed seeds and diseases may be picked up.
   - wet weather and muddy sites when there is a greater likelihood of contamination.

Driving/walking on poorly maintained roads, tracks, paddocks or bushland in wet weather or heavy dew increases the likelihood of reproductive material sticking on vehicles, plant and/or equipment (Environmental Protection Agency 2009).

2. Consider chemical treatment or manual removal of weeds before starting work. When undertaking management or control of any invasive species, staff and/or contractors could begin control operations at the outlying limits of an infested area. In addition, where long-term vehicle or pedestrian movements within a project site may result in the spread of reproductive material, the potential sources along any access routes could be treated before work starts (Environmental Protection Agency 2009).
3. Establish and monitor entry and exit points for contamination on vehicles and machinery.
4. Avoid movement through higher risk areas by:
   - limiting off-track movement where feasible
   - choosing routes less likely to lead to contamination
   - quarantining highly infested sites from unnecessary access to people and machinery (areas may be fenced off)
   - leaving vehicles on site for duration of activities to minimise clean down effort
   - leaving work in these areas until last (other than direct invasive species management).
5. Use machinery, equipment, etc, that is:
   - clean and free of reproductive material upon entry to minimise cleaning effort upon exit
   - least likely to cause soil disturbance (e.g. using rubber tracked machines such as slashers/mulchers rather than bulldozers for vegetation clearance)
   - more readily cleaned and least likely to become contaminated; consider using modified machinery to reduce contamination (e.g. use slasher covers, or removable screens over grills to prevent seeds lodging in internal parts such as the radiator).
6. Ensure all vectors are 'clean upon exit' (this includes waste and contaminants disposal) – refer to Appendix A and the *Guide for Machinery Hygiene for Civil Construction* (Civil Contractors Federation 2011). Before leaving a site known to be infested with invasive species, workers should clean off any reproductive material on, or in, clothing and footwear to prevent the spread of reproductive material beyond the infested area. Washing and disinfecting footwear should be standard practice before entry and exit of every property (South West Pest Plant and Animal Program 2001).
7. Ensure time and resources are scheduled for:
   - on-site clean-down, including waste and contaminant management
   - on-going inspection and management, if necessary, of materials if stockpiled and not transported away.
8. Ensure contaminated material is not taken:
   - from the infested area to be used in other clean areas.
   - without a permit from DELWP to allow transport of soil, sand, gravel or stone containing declared noxious weeds.

Where a risk is unavoidable, it may be appropriate to decide to not start or continue with the planned project or activity that gives rise to the risk (where this is practicable). Standards Australia/Standards New Zealand (2004) notes that risk avoidance can occur inappropriately if individuals or organisations are unnecessarily risk-averse. This avoidance may increase the significance of other risks on the project site.

9.3.3 Safeguarding clean sites

To safeguard clean sites, project managers must develop and implement appropriate measures to avoid of invasive species being introduced. Possible measures include:

1. Schedule activities before working in infested areas: Where feasible, work (other than direct invasive species control) should be undertaken first in areas not subject to invasive species, and then in any infested areas (Environmental Protection Agency 2009, Tyers et al. 2004). If not feasible, then vehicles, plant, equipment and footwear must be cleaned before entering an uninfested area (Environmental Protection Agency 2009).
2. Ensure vectors are 'clean-on-entry': All vehicles, trucks, earthmoving equipment and other machinery, as well as clothing, boots and tools, must be clean and free of foreign matter on arrival at a project site (South West Pest Plant and Animal Program 2001). In particular:
   - The project manager must take all reasonable steps to ensure that:
     – vehicles, plant and/or equipment are clean and free of reproductive material prior to entering a project site
     – clothing and footwear of staff are clean and free of reproductive material prior to entering a project site
     – watercraft (including trailers and other relevant equipment) are clean (particularly of plant material) prior to entering a waterway.
   - All contractors engaged to work on a project site must supply all plant and equipment in a clean state, free of foreign reproductive material. The project manager must take all reasonable steps to ensure that contractors:
     – understand all machinery hygiene requirements
     – apply machinery hygiene protocols as a standard practice
     – inspect their equipment before entering a project site to confirm that, as far as practicable, it is clean and free of reproductive material (Tyers et al. 2004).
3. Quarantine higher risk sites from unnecessary access – where practical.
4. Ensure material intended for use in an area is 'clean': All imported materials such as soil, mulch or rock have the potential to spread invasive species to a project site (Environmental Protection Agency 2009). Therefore, all material imported to a project site must be:
   - clean and free of reproductive material and should come from sources known or likely to be clean (i.e. sources tested free of invasive species or suppliers whose operations are accredited for hygiene protocols)
   - stored or stockpiled in locations that are clean and inspected regularly for outbreaks of invasive species (Environmental Protection Agency 2009).
5. Adopt hygiene standards for livestock: Graze livestock on weed-free fodder or pasture for 17 days (depending on the type of livestock and seed ingested) before they are introduced to a project site for ecological grazing (Water Technology 2009). Sheep should not enter a project site until after shearing; they can carry many kinds of weed seeds in their fleeces (Staton and O'Sullivan 2006).
6. Prevent the spread of certain horticultural pests and diseases: There are restrictions on the movement of certain plants, plant products and agricultural machinery within Victoria. Four types of zones are established in Victoria concerned with:
   - Queensland fruit fly (movement of fruit)
   - Phylloxera (grapes, grapevine material, agricultural equipment and soil)
   - Potato cyst nematode (potatoes, potato plant material, agricultural equipment and soil)
   - Toolangi Plant Protection District (nursery plants, cut flowers, leafy vegetables, strawberry plants, rubus plants and potato tubers).

   Project managers must adhere to all prohibitions, restrictions and requirements when working within these zones.

9.3.4 General hygiene protocols for vehicles, plant and equipment

Inspecting machinery and equipment

The process of inspecting machinery and equipment will vary according to its type, the working environment and the level of contamination (Department of Primary Industries 2009).

Establishing clean-down areas

A clean-down area is justified where:

- the consequences of invasive species being spread are high
- vehicles are considered the most likely vectors/carriers of invasive species
- there are no existing wash-down facilities nearby and no alternatives exist (Environmental Protection Agency 2009).

A clean-down area is not justified where:

- the consequences of invasive species spread are minimal
- vehicles are not considered the most likely vectors/ carriers of invasive species
- there are existing wash-down facilities nearby (Environmental Protection Agency 2009).

Where a clean-down area is required, apply the following minimum standards:

- Locate the clean-down site well away from watercourses and drainage lines to reduce the potential for reproductive material spread and/or watercourse pollution (e.g. from grease, detergents) (Department of Primary Industries 2009, Environmental Protection Agency 2009).
- Ensure the clean-down site is easily identified (e.g. with a painted post and GPS location) for future reference, as this location will need monitoring for future outbreaks in the following seasons (Environmental Protection Agency 2009).

In addition, clean-down areas should be**:**

- relatively flat (to help prevent runoff and for safety reasons)
- in a well-grassed area to:
  - reduce mud during cleaning down (Environmental Protection Agency 2009)
  - provide competition for any weed seed that later germinates (Environmental Protection Agency 2009)
  - enable efficient weed control (Tyers et al. 2004)
- close to exit/entry points (Department of Primary Industries 2009)
- close to the infested area (to prevent further spread) (Environmental Protection Agency 2009).

Applying clean-down options

The most effective clean-down options are:

- removal by hand
- wash-down
- air blast
- vacuuming (Tyers et al. 2004, Department of Primary Industries 2009).

The project manager should determine the most appropriate clean-down option according to the level of contamination.

Physical removal

It is essential to remove the soil and debris from tools, equipment and machinery before decontamination can be carried out (South West Pest Plant and Animal Program 2001).

Physical removal may be labour intensive, but it will ensure that contaminants are removed and disposed of correctly. Brooms, brushes, shovels and scraping tools can help with clean-down procedures (Tyers et al. 2004).

Wash-down

Apply water to the machinery at high pressure using a pressure cleaner or spray tank and pump. The critical areas on equipment must be rigorously targeted and thoroughly washed clean. The use of approved cleaning detergents should be considered. These may aid in the removal of built up grease, dirt and mud that can contain weed seeds (Tyers et al. 2004).

Pressure hosing with water will be sufficient to remove debris from most tools, equipment and machinery (South West Pest Plant and Animal Program 2001).

Air blast

Air blast assists decontamination of machinery, especially for those hard-to-reach areas such as cavities and joints. A compressor with hose and suitable nozzles is required (Tyers et al. 2004).

Vacuuming

Vacuuming can help remove contaminants from the interior surfaces of machinery, e.g. driver's cab carpet (Tyers et al. 2004).

Maintaining clean-down areas

Clean-down areas must be monitored for invasive species outbreaks (Environmental Protection Agency 2009) and appropriate action taken to control spread.

Disposing of waste and contaminants

Contaminants resulting from clean-down procedures must be disposed of in an appropriate manner (Tyers et al. 2004). Where possible, contaminants and waste should be destroyed within the clean-down area (Department of Primary Industries 2009), e.g. using herbicides to control weed seed germination in the clean-down areas.

9.4 References

Civil Contractors Federation (2011). *A Guide for Machinery Hygiene for Civil Construction.*

Department of Primary Industries (2009). *Machinery Hygiene.*

Environmental Protection Agency (2009). *Pest plant and pathogen spread prevention*. Operational Policy. State of Queensland.

South West Pest Plant and Animal Program (2001). *Guidelines for the Prevention of Plant or Livestock Diseases and Pests onto Public and Private Land*. Department of Natural Resources and Environment.

Standards Australia/Standards New Zealand (2004). *AS/NZS 4360:2004: Risk Management.*

Staton, J. and O'Sullivan, J. (2006). *Stock and Waterways: A Manager's Guide*. Land & Water Australia, Canberra.

Tyers, G. Grech, C. and Baldyga, N. (2004). *Machinery Hygiene – Landcare Notes LC0425.* Department of Primary Industries, Victoria.

Water Technology (2009). *An Investigation of Controlled Grazing as a Riparian Management Tool.*

10. Vertebrate animal control and management

Determining whether pest or native animal management is an appropriate activity for a particular vegetation management project is the responsibility of the project manager and will depend on a number of factors, including:

- The project goal.
- The relevant Ecological Vegetation Class (EVC) for the project site.
- The condition and extent of remnant vegetation at the project site, which in turn determines whether the project will focus on:
  - protection of remnant vegetation
  - establishment of overstorey and/or understorey plants within a remnant patch i.e. supplementary planting
  - establishment of native vegetation in formerly cleared areas outside of a remnant patch i.e. revegetation.
- Specific site conditions, e.g. soil type, slope.
- The type and severity of threats present.

10.1 Scope

This Standard covers methods for the control of the most common (state-wide) vertebrate pest animal species, native herbivores and other wildlife (e.g. deer) that can be a threat to native vegetation projects:

- rabbits
- hares
- pigs
- goats
- deer
- native herbivores (particularly kangaroos and wallabies).
- This Standard does not cover:
  - preliminary site assessments (e.g. animal densities/ distributions) to determine if control methods are required
  - methods for the control of invertebrate pest animal and native herbivore species.

10.2 Background

Native plants (especially the more palatable species) are most vulnerable to animal damage when less than one metre in height (as they can be completely eaten or severely damaged at this stage). Above this height, plants can still be attacked through leaf and shoot browsing, trampling, scratching, rubbing or bark chewing (Greening Australia 2008).

Adequate and appropriate animal control can reduce grazing and browsing pressure, maintaining the integrity of remnant native vegetation and enabling the establishment and maintenance of planted vegetation.

10.3 Method

The recommended approach for developing and implementing an animal management program involves:

1. Describing the desired goal for a project.
2. Assessing the problem.
3. Considering the control options/methods and determining:
   - their effectiveness in treating the problem
   - their practicality in treating the problem
   - potential risks of application to both on-site and off-site values. This needs to also consider the risks around the control options.
4. Developing a pest animal or native herbivore management program.
5. Implementing the program.
6. Maintaining a monitoring and review program.

The following sections cover the third point, the options/ methods to manage the most common (state-wide) pest animal, native herbivore and other wildlife that can be a threat to native vegetation projects.

10.4 Rabbits

Rabbits are preferential grazing animals that:

- compete with native wildlife for food and shelter (Deppeler 2007)
- graze native plants
- prevent plant regeneration by eating seeds and seedlings (Deppeler 2007, Corr 2003)
- damage and destroy planted trees (Corr 2003)
- increase soil disturbance
- increase weed spread
- can be particularly destructive in riparian zones where soils are soft (Deppeler 2007).

Rabbits are particularly abundant in areas of deep sandy soils (where warrens can be easily established), but occur across a range of habitats. They will also inhabit infestations of woody weeds and escarpments (rocky outcrops) when digging is not possible (Deppeler 2007).

Control options

Effective long-term control of rabbits requires:

- coordinated group action
- an integrated control program
- ongoing maintenance.

Coordinated action

Coordinated group action at a landscape scale involving neighbouring landholders and land managers (regardless of land tenure) provides the most effective means of large-scale rabbit control (Department of Primary Industries 2007, Corr 2003).

Working in isolation is rarely effective in suppressing rabbits except for short periods (Department of Primary Industries 2007).

Integrated control

A number of control options are available for the management of rabbits:

- baiting
- warren fumigation
- warren destruction
- shooting
- fencing
- harbour removal
- guarding
- habitat manipulation.

The following sections provide technical information for implementing each control option. To achieve the best outcome from rabbit control, an integrated approach employing a number of complementary control techniques should be adopted (Deppeler 2007, Department of Sustainability and Environment 2009). A good example of integrated rabbit management has been documented by Read et al. (2011).

A set of decision trees has been developed that considers control options for a range of project types and site conditions (see Appendix A). Use the decision trees to guide the development of rabbit control programs.

Regardless of which control option (or options) is used, any rabbit management program must be appropriately planned and coordinated using the most effective, safe and humane methods available – refer to the *Model Code of Practice for the Humane Control of Rabbits* (Sharp and Saunders 2004a) for details.

Ongoing maintenance

For long-term success (i.e. to keep rabbit numbers at an acceptably low level[11]), monitoring of the project site must be maintained and appropriate action undertaken if/when required. Failure to maintain a site for the long term can result in the site returning to its pre-control condition in just a few years.

A good resource for guidance on assessing rabbit numbers at project planning and following treatment can be found at the PestSmart (Invasive Animals CRC) website.

10.4.1 Baiting

Applicability

Baiting with poisoned carrots or oats is the most common first-step method to reduce rabbit populations, particularly when densities are medium to high (Department of Primary Industries 2007). Advantages and disadvantages of baiting are provided in Table 10-1.

Technique

Currently, no recommended technique.

Types of bait

There are two toxins available for the baiting of rabbits in Victoria:

- 1080 (sodium monofluoroacetate)
- Pindone.

The most efficient, humane and species-specific lethal poison registered to control vertebrate pest species (rabbits, foxes, wild dogs and wild/feral pigs) is 1080 (Department of Primary Industries 2007). For rabbit poisoning, 1080 is applied to carrots or oats and laid in a trail or broadcast from the ground or air.

Pindone is an anticoagulant poison that acts by reducing the blood clotting abilities of the body. The time to death after rabbits ingest pindone is around 10 to 14 days, during which time the poison can cause distress, disability and/or pain. Pindone baiting must only be used to reduce rabbit populations in areas where 1080 rabbit bait cannot be used, i.e. close to urban areas where the risk of accidental poisoning to humans and pets is greatest.

Baiting technique

All pest animal bait products must be used in accordance to the directions for use and the product label.

11 Acceptable rabbit densities (as determined by the project manager) will be proportionate to the vegetation community. For example, low rabbit density in a high rainfall area may be acceptable but low rabbit density in a semi-arid area may still pose a risk to vegetation.

Table 10-1: Baiting – advantages and disadvantages.

Advantages	Disadvantages
• Relatively cheap if 1080 can be used, otherwise not cheap • Can be used in difficult terrain, including by aerial application • Useful to reduce dense rabbit populations prior to ripping and fumigation campaigns, thereby reducing recolonisation • Can be integrated with stock quarantine measures • Pindone bait has an antidote, vitamin K1, and is generally safer to use than 1080 where non-target animals like domestic dogs are at risk	• Risk of non-target kills if correct procedures are not followed (while rabbits are susceptible to the effects of 1080, other species including humans, native animals and birds, and domestic livestock are also vulnerable) • Risk of secondary poisoning from 1080 where scavengers and carnivores feed upon unrecovered rabbit carcasses • Short-term effectiveness if not implemented in conjunction with other control techniques • Population dynamics and availability of alternative feed affect efficacy • Need to remove stock and provide suitable water supplies, pasture and fencing • Only part of grazing properties can be treated in any one year, increasing the risk of recolonisation • Difficult to know when it is safe to return stock to poisoned paddocks • 1080 baiting cannot be used where there is an unacceptably high risk to humans or companion animals, such as in urban/residential environments • There is no effective antidote for 1080 poison

Timing

Baiting must be timed to occur when rabbits are least territorial and when other foods are scarce (Platt and Temby 1999). This is generally in the late summer/early autumn (Department of Primary Industries 2007, Platt and Temby 1999).

Licences/permits

All pest animal bait products are dangerous and care must be taken to ensure they are used safely. They must be used in accordance with the directions for use and the product label.

The Australian Pesticides and Veterinary Medicines Authority allows registration of a number of products that are suitable for poisoning rabbits as part of a control program. The relevant product label for the prepared bait or poison concentrate provides specific directions for use and must be read and understood prior to use.

1080: As 1080 poison is a Schedule 7 Dangerous Poison, its use must be consistent with the directions for the use of 1080 pest animal bait products in Victoria. Special precautions are required during manufacture, handling or use as 1080 bait products have high potential to cause harm at low exposure levels. Special regulations restrict their availability, possession, storage and use and 1080 pest animal bait products must only be purchased and used by operators holding a current *Agricultural Chemical User Permit (ACUP)* with a 1080 endorsement.

Pindone: Pindone concentrate is a restricted chemical product rated as an S6 poison; only to be supplied to or used by an authorised person holding a current ACUP. Pindone must be used according to instructions on approved labels and relevant State guidelines.

10.4.2 Warren fumigation

Applicability

Advantages and disadvantages of warren fumigation are provided in Table 10-2.

Technique

Fumigation of rabbits in burrows is an important part of rabbit control. Fumigation usually takes place after ripping, which is about 34 weeks after poisoning. Where appropriate and possible, fumigation activities may include the use of dogs to drive the rabbits back into their burrows before fumigation. Fumigation is an essential follow-up technique to ripping and poisoning (Bloomfield 1999).

There are two types of fumigation:

- Pressure fumigation: Fumigant gases or vapours are generated outside the warren and forced into the warren under pressure, usually from a pump (Williams et al. 1995, Platt and Temby 1999). This technique is considered inhumane (Sharp and Saunders 2004a) and should not be used.

- Diffusion fumigation: Tablets are placed in active burrows and the gas generated is allowed to diffuse through the warren (Williams et al. 1995, Platt and Temby 1999). Phosphine is currently the preferred toxin for diffusion fumigation until more humane methods are developed. Chloropicrin (trichloronitromethane) is considered to be highly inhumane and must not be used (Sharp and Saunders 2004b).

Table 10-2: Warren fumigation – advantages and disadvantages.

Advantages	Disadvantages
• Suitable follow-up/retreatment for ripped sites • Useful in inaccessible places, e.g. steep slopes • Suitable near settled areas • Indicator smoke often locates unseen entrances, especially in long grass (particularly pressure fumigation) • Little equipment needed (diffusion fumigation only) • Suitable for impromptu treatment of isolated or re-opened warrens (diffusion fumigation only) • involves minimal disturbance to bushland areas	• Effectiveness depends on the skill of the operator • Treated warrens are readily recolonised if not destroyed • Can kill non-target native species that utilise warrens for shelter • Labour-intensive and slow • Expensive • Not suitable for large areas • Uncomfortable and tiring for operators • Equipment can be heavy and cumbersome, although lighter fumigators are available (pressure fumigation only)

Table adapted from Williams et al. (1995) and Platt and Temby (1999).

Timing

Fumigation should be undertaken in autumn/winter then followed by warren destruction (Platt and Temby 1999). Fumigation should only be used either in areas where ripping is inaccessible or as a follow-up treatment where warrens have reopened.

When fumigating with aluminium phosphide tablets, damp soil conditions give the best results (Bloomfield 1999).

Licences/permits

The Australian Pesticides and Veterinary Medicines Authority allows registration of a number of products that are suitable for fumigating rabbit warrens as part of a control program. The relevant product label provides specific directions for use and must be read and understood prior to use.

Some chemicals require the user to possess an ACUP and, in some cases, further endorsements on that permit. In Victoria, an ACUP is required to use agricultural chemical products that are restricted-use chemicals. These are chemicals that have a potentially higher risk of adversely affecting the user’s health, the environment and trade.

10.4.3 Warren destruction

Applicability

Warren destruction is a key follow-up action in a control program to prevent rabbits from re-infesting a project site.

Advantages and disadvantages of warren destruction by mechanical ripping are provided in Table 10-3.

Technique

The most common technique for warren destruction is ripping.

Where broad-scale ripping is appropriate (such as on open and cleared land), it should start at least 4 m out from the outermost warren opening. The distance between rip lines should be no more than 50 cm. Interline ripping between the rip lines after the first pass will help destroy the warren structure (Bloomfield and Cummings 2003).

Cross ripping may be necessary in some areas. Cross ripping involves ripping in one direction and then ripping again at an angle of 90 degrees to the original ripping (Bloomfield and Cummings 2003).

Table 10-3: Warren destruction – advantages and disadvantages.

Advantages	Disadvantages
• Ripping targets the key in the rabbits defence – its ability to rebound and recolonise • The most long lasting of the prescribed techniques • The most cost-effective of the standard techniques in the long term • Compatible with prior poisoning and fumigation, as well as follow-up fumigation • Suitable for large-scale operations	• Unsuitable for steep slopes and very rocky land • Requires heavy equipment • Can damage/disturb native understory and ground flora • May facilitate weed invasion among native vegetation • Can affect habitat for some native animals, e.g. carpet python, southern brown bandicoot, stripped legless lizard • Can damage/disturb cultural heritage sites • Where rabbits are high in number, may require poisoning to precede this option • May require planning, waterway or cultural assessments to be conducted prior to implementation

Table adapted from Williams et al. (1995), Department of Sustainability and Environment (2009) and Platt and Temby (1999).

Depth of riplines

The warren should be ripped to a depth of 1.5 m or more if possible. The deeper the ripping, the greater the destruction of the warren system (Bloomfield and Cummings 2003).

Soil erosion

Ripped warrens should be track rolled to reduce the risk of rabbits burrowing in on the rip line caused by the dozer. Track rolling will also help compact the soil surface and reduce the risk of erosion (Bloomfield and Cummings 2003).

The site should be revegetated with appropriate vegetation as soon as possible (Bloomfield and Cummings 2003).

Native fauna habitat

If warrens are providing a refuge for native fauna species, consideration must be given to eradicating the rabbits by other methods, e.g. by erecting rabbit-proof fencing around the warren (Bloomfield and Cummings 2003).

Timing

Ripping should typically be carried out 23 days after fumigation (Platt and Temby 1999). Ripping should be conducted two or three days after a 1080 bait poison or 2–3 weeks after a Pindone poison. Fumigation should only be used either in areas where ripping is inaccessible or as a follow-up treatment where warrens have re-opened.

Licences/permits

High-impact activities in culturally sensitive landscapes (e.g. warren destruction within 200 m of a named waterway) can cause significant harm to Aboriginal cultural heritage.

In these situations, the *Aboriginal Heritage Act 2006* may require the project manager to prepare a Cultural Heritage Management Plan or obtain a cultural heritage permit or enter into a cultural heritage agreement with the relevant Registered Aboriginal Party.

If ripping is proposed within a culturally sensitive landscape, the project manager must determine if a Cultural Heritage Management Plan or cultural heritage permit is required. Specific information on considering Aboriginal cultural heritage needs can be found on the DEDJTR website.

10.4.4 Shooting

Applicability

Advantages and disadvantages of shooting are provided in Table 10-4.

Technique

Shooting can be a humane method of destroying rabbits when:

- it is carried out by experienced, skilled and responsible shooters
- the animal can be clearly seen and is within range
- the correct firearm, ammunition and shot placement are used (Sharp and Saunders 2004a).

Achieving a humane kill with a single shot can be difficult as rabbits are a small target. Wounded rabbits must be located and dispatched as quickly and humanely as possible (Sharp and Saunders 2004a).

Timing

Where appropriate, shooting can be undertaken at any time.

Licences/permits

Users of firearms must adhere to relevant laws and restrictions. All firearm users must be appropriately licensed and hold current accreditations.

The use of firearms for the humane destruction of pest animals on Crown land is also subject to conditions.

Firearms must not be carried or discharged in national parks, state parks and a range of reserves without appropriate authorisation.

Table 10-4: Shooting – advantages and disadvantages.

Advantages	Disadvantages
• Directly targets the problem • Effective method for targeting the remaining individuals following baiting, harbour removal and/or warren destruction.	• Only effective when rabbits are at extremely low-population levels and is relatively ineffective at any other time (Department of Primary Industries 2007) • Only appropriate as part of an integrated program • Cannot be used in semi-urban or urban areas • Requires firearm licence

10.4.5 Fencing

Applicability

Soundly constructed and well-maintained rabbit-proof netting fences are the only reliable and long-term barriers to rabbit movement (Department of Primary Industries 2007) especially where there is a high risk of rabbit invasion from areas adjoining the site (Department of Sustainability and Environment 2009a).

Advantages and disadvantages of rabbit-proof fencing are provided in Table 10-5.

Technique

Rabbit-proof fences must be a minimum of 1,050 mm width, 30 mm hexagonal netting (Moseby and Read 2006, Department of Sustainability and Environment 2009a).

Netting should be fixed so that it reaches at least 900 mm above the ground and is either buried (to 150 mm depth) or laid down to a width of 30 cm along the ground, facing outwards and secured with pegs, rocks or timber (Moseby and Read 2006, Department of Sustainability and Environment 2009a).

Netting should be attached to an appropriate stock fence (refer to *1 Stock fencing* for details).

10.4.6 Harbour removal

Applicability

Harbour can include both rubbish dumped on site and weeds, e.g. blackberries, gorse (Department of Sustainability and Environment 2009a).

Advantages and disadvantages of harbour removal are provided in Table 10-6.

Technique

Refer to *8 Woody weed control* for details. Where woody weeds are providing habitat for native animals, project managers must ensure that either:

- alternative habitats are established before woody weed are removed (e.g. replanting of comparable indigenous vegetation); or
- woody weed removal is staged such that an acceptable level of habitat is maintained throughout the project transition.

Where native vegetation is providing harbour, all available control options, (e.g. erection of rabbit-proof fence around vegetation and removal of rabbits by shooting) must be attempted before harbour removal is considered.

Licences/permits

Clause 52.17 of the Victorian Planning Provisions requires a permit to remove, destroy or lop native vegetation.

If harbour removal involves the removal of native vegetation, a planning permit from the relevant local council must be obtained (unless the removal is exempt under the planning scheme).

A permit may also be required for native vegetation removal under a planning scheme overlay such as the Environmental Significance Overlay, Vegetation Protection Overlay, Significant Landscape Overlay, Heritage Overlay, Salinity Management Overlay, Erosion Management Overlay or Public Acquisition Overlay.

Table 10-5: Fencing – advantages and disadvantages.

Advantages	Disadvantages
• Can be designed to enable effective pest animal control irrespective of lack of control on adjacent land • Enables sequential control operations on large management units • Eradication may be possible within enclosures • High-value, functional and capital asset • Better management of pastures • Functions also as a stock fence • Facilitates poisoning operations	• High cost • Requires high maintenance, e.g. rabbits are able to gain access through even a small hole in the fence • May require additional water points for stock • Can restrict wildlife movement • Susceptible to flood damage

Table adapted from Williams et al. (1995) and Platt and Temby (1999).

Table 10-6: Harbour Removal – advantages and disadvantages.

Advantages	Disadvantages
• Increases efficiency of control programs • Opens up warrens and dens for treatment • Retards recolonisation • Assists in on-site management of weed species	• May reduce habitat for native animal species • May require local government planning permits regarding disturbance of native vegetation • May require CMA authorised waterway permits

Table adapted from Williams et al. (1995).

10.4.7 Guarding

Applicability

While tree guards are effective in stopping rabbits from destroying young plants, they do not provide adequate plant protection from browsing of plant tops (Greening Australia 2008, Corr 2003). This is especially true for tree guards using milk cartons and plastic sleeves.

Consider alternative control options before deciding to individually guard plants (Anderson 2003).

Advantages and disadvantages of tree guards are provided in Table 10-7.

Technique

Refer to *2 Plant Establishment* for details.

Tree guards must not be used as a substitute for adequate pest control (Corr 2003).

10.4.8 Habitat manipulation

Applicability

Heavy planting of trees and shrubs can reduce available grass for rabbits and reduce the carrying capacity of some sites for rabbits. This technique may be particularly suited to sites that were cleared and can be managed as revegetated sites (Department of Primary Industries 2007).

This technique is inappropriate for grasslands or grassy woodlands and therefore must not be used in these vegetation communities.

Technique

Refer to *3 Planting density, diversity and placement for seedlings* for details.

10.5 Hares

Unlike rabbits, hares are solitary animals and do not build warrens, resting instead in a shallow depression called a 'form'. Hares prefer grassland and open woodland habitats (Platt and Temby 1999).

A limited number of control options are available for the management of hares:

- shooting
- fencing
- guarding
- habitat manipulation.

- These options are presented in the following sections with integrated control options (decision trees) in Appendix B. The decision trees should be used to guide the development of hare control programs.

10.5.1 Shooting

Refer to Rabbits section.

10.5.2 Fencing

Refer to Rabbits section.

10.5.3 Guarding

Refer to Rabbits section.

10.5.4 Habitat manipulation

Refer to Rabbits section.

Table 10-7: Guarding – advantages and disadvantages.

Advantages	Disadvantages
• Protects seedlings from rabbits and hares • Reduces potential impacts to plants from: – hot and cold winds – insect damage (e.g. wingless grasshoppers) – frost (particularly when planting in autumn in frost-prone areas) – spray drift from herbicides. • Can stimulate plant growth by: – Creating a warm and moist micro-climate – Funnelling rainwater to the roots of plant	• Does not provide adequate plant protection from browsing of plant tops • Can lead to development of non-sturdy 'leggy' stems and weaker roots by over-sheltering from wind • Guards that restrict light penetration (e.g. milk cartons) may also lead to weak or 'leggy' growth of short seedlings • Milk cartons also provide no significant protection from browsing/grazing animals • Very expensive (often costing more than the trees) (Anderson 2003)* • More labour is required to guard all trees planted • Can create litter/waste if follow-up removal is not undertaken (particularly plastic tree guards)

** When planting large areas, it may be more cost effective to rabbit-proof fence the whole site and remove all rabbits inside the fenced area prior to planting (Department of Primary Industries 2007).*

10.6 Pigs

Feral pigs are found across Victoria, mainly on public land and to a limited extent on private land. There is evidence that feral pigs, through habitat degradation and predatory feeding, are threatening biodiversity and agricultural values.

The main control options used to manage feral pigs are:

- shooting
- fencing
- baiting
- trapping.

These control options are detailed in the following sections with integrated control options (decision trees) provided in Appendix C. The decision trees should be used to guide the development of pig control programs.

Regardless of which control option (or options) is used, any feral pig management program must be appropriately planned and coordinated using the most effective, safe and humane methods available – refer to the *Model Code of Practice for the Humane Control of Feral Pigs* (Sharp and Saunders 2004c) for details.

10.6.1 Shooting

Applicability

Shooting has been long established as a control technique for feral pigs. Until about 1980, shooting was a ground-based operation undertaken by recreational hunters and landholders. Since 1980, shooting from helicopters has become a more frequent form of control (Choquenot et al. 1996).

Ground shooting

The feral pig is commonly taken from the ground by either:

- landholders (generally on an opportunistic basis)
- hunters (with trained pig dogs) (Choquenot et al. 1996).

It is generally considered that ground shooting plays an insignificant role in feral pig control except where it is intensively conducted on small populations (Choquenot et al. 1996).

Advantages and disadvantages of ground shooting are provided in Table 10-8.

Shooting from the air

Shooting from the air using helicopters is perceived to be a more effective technique for feral pig control than ground shooting because it reduces the effects of immigration. However, it is not effective for reducing pigs to very low densities because the cost of finding and shooting the remaining pigs increases greatly as numbers decline (Choquenot et al. 1996).

Advantages and disadvantages of shooting from the air are provided in Table 10-9.

Timing

Where appropriate, shooting can be undertaken at anytime.

Licences/permits

Users of firearms must adhere to relevant laws and restrictions. All firearm users must be appropriately licensed and hold current accreditations.

Table 10-8: Shooting from the ground – advantages and disadvantages.

Advantages	Disadvantages
• Can remove individual pigs in a disease outbreak • Species-specific	• Rarely effective for damage control • Can disperse pigs • Costs increase greatly as pig numbers decrease • Requires skilled operators • Not long-lasting nor effective for large-scale control

Table adapted from Choquenot et al. (1996).

Table 10-9: Shooting from the air – advantages and disadvantages.

Advantages	Disadvantages
• Ideal for rapid population knockdown over a number of properties • Takes up little landholder time • Species-specific • Allows control in inaccessible terrain • Unaffected by seasonal conditions	• Can disperse animals • Costs increase greatly as pig numbers decrease • Annual shoots ineffective for keeping pig numbers low • Ineffective in woodland and forest

Table adapted from Choquenot et al. (1996).

The use of firearms for the humane destruction of pest animals on Crown land is also subject to conditions.

Firearms must not be carried or discharged in national parks, state parks and a range of reserves without appropriate authorisation.

10.6.2 Trapping

Applicability

Trapping is best used where poisoning is impractical or as a follow-up control measure after poisoning (Agriculture Protection Board 1991 cited in Choquenot et al. 1996).

Advantages and disadvantages of trapping are provided in Table 10-10.

Technique

Landholders often permanently locate traps in areas of feral pig activity and activate the traps when pig signs become evident or on a strategic basis to protect a susceptible enterprise (Choquenot et al. 1996).

Hone et al. (1980 cited in Choquenot et al. 1996) list the following points that should be considered when trapping for feral pigs:

- type of trap to use
- number of traps to use
- where to put traps
- number of nights each trap is used
- type and amount of bait to use
- amount and duration of free-feeding.

Various trap designs exist and the choice revolves around the experience, knowledge and resources available to the trapper (Choquenot et al. 1996).

Baiting

Applicability

Although shooting and trapping can be used as control techniques, baiting using 1080 is the most effective option for controlling feral pigs (Twigg et al. 2006).

Advantages and disadvantages of baiting are provided in Table 10-11.

Technique

Currently, no recommended technique.

Types of bait

The Australian Pesticides and Veterinary Medicines Authority has registered 1080 as a lethal poison for the control of feral pigs.

Baiting technique

Feral pig bait products must be used in accordance to the directions for use and the product label.

Timing

Feral pigs will often travel along defined tracks, creating pads similar to those of sheep and cattle. Evidence of feral pigs is usually most pronounced at the end of autumn and early winter when food supply is more limited and pigs need to travel further to find food. Baiting should occur between the end of autumn and early winter (Twigg et al. 2006).

Table 10-10: Trapping – advantages and disadvantages.

Advantages	Disadvantages
• Can be incorporated into existing management practices • Pig numbers can be monitored • Traps can be re-used • Landholders can offset trap costs by selling trapped pigs • Does not affect normal pig behaviour • More humane than other methods	• Must be checked regularly • Labour intensive; best used as follow-up control • Not practical for large-scale control

Table adapted from Choquenot et al. (1996).

Table 10-11: Baiting – advantages and disadvantages.

Advantages	Disadvantages
• Proven method • Widely accepted in rural community • Fast and effective initial knockdown • Relatively cheap	• Non-target risks • Animal welfare implications • Requires registration • May cause vomiting and result in bait-shy pigs or development of resistance • Usually requires prior free-feeding

Table adapted from Choquenot et al. (1996).

Licences/permits

All pest animal bait products are dangerous and care must be taken to ensure they are used safely and in accordance with the directions for use and the product label.

The Australian Pesticides and Veterinary Medicines Authority allows registration of a number of products that are suitable for poisoning pigs as part of a control program. The relevant product label for the prepared bait or poison concentrate provides specific directions for use and must be read and understood prior to use.

1080

As 1080 poison is a Schedule 7 Dangerous Poison, its use must be consistent with the directions for the use of 1080 pest animal bait products in Victoria (Department of Economic Development, Jobs, Transport and Resources [DEDJTR] website). Special precautions are required during manufacture, handling or use as 1080 bait products have high potential to cause harm at low exposure levels. Special regulations restrict their availability, possession, storage and use and 1080 pest animal bait products must only be purchased and used by operators holding a current Agricultural Chemical User Permit (ACUP) (DEDJTR website) with a 1080 endorsement.

10.6.4 Fencing

Applicability

Fencing is not a popular control technique for feral pigs except to protect valuable enterprises in relatively small areas.

Advantages and disadvantages of fencing are provided in Table 10-12.

Technique

The minimum wire specifications that must be applied for feral pig fencing projects are detailed in Table 10-13.

10.7 Goats

Goats are generalist herbivores, eating a wide variety of plant foods with the highest-quality food available often selected. The feral goat is a major environmental and agricultural pest that has a significant impact on native vegetation. As selective feeders, feral goats can reduce the diversity of plant species, preventing regeneration of some trees and shrubs and leaving only unpalatable plants or those resistant to browsing (Department of Employment, Economic Development and Innovation 2010, Queensland).

Feral goats also compete with native fauna for food, shelter and water, particularly in semi-arid areas (Department of Employment, Economic Development and Innovation 2010, Queensland).

The main control options used to manage feral goats are:

- shooting
- trapping
- mustering
- fencing.

- Regardless of which option is used, any feral goat management program must be appropriately planned and coordinated using the most effective, safe and humane methods available – refer to the *Model Code of Practice for the Humane Control of Feral Goats* (Sharp and Saunders 2004d) for details.

Table 10-12: Fencing – advantages and disadvantages.

Advantages	Disadvantages
• Effective protection for lambing paddocks or small high-value resource areas • More humane than other control methods	• Can be expensive and requires a high level of maintenance • Fences will eventually be breached • Not practical for large-scale control

Table adapted from Choquenot et al. (1996).

Table 10-13: Minimum wire specifications by stock type.

Fence type	Feral pigs
Mesh	Standard 8/80/15 ringlock and plain wire
Electric	6-strand plain wire with at least three electrified strands ensuring that the bottom wire is earthed* To reduce fence damage and breaches, installation of two electric trip wires should be included (trip wire 1 – 375 mm off the ground and 200 mm in front of the fence; trip wire 2 – 200 mm off the ground and 350 mm in front of the fence). Trip wires supported by posts spaced at 10–15 m intervals.

** Note: long grass may short-out fence, hence site will require regular maintenance.*

Table adapted from Choquenot et al. (1996).

10.7.1 Shooting

Applicability

Controlling feral goats by shooting can be undertaken from the ground or from the air.

Ground shooting

Ground shooting is labour intensive but can produce good results if control programs are well planned and the effort is maintained (Department of Employment, Economic Development and Innovation 2010, Queensland).

It is often employed in areas of high cover, e.g. within forested areas.

Shooting from the air

Helicopter shooting is extremely effective and can result in a rapid and substantial reduction in goat numbers when there is no extensive cover in the form of dense scrub, caves, or rock piles. However, helicopter shooting is expensive and is used only when the need for a reduction in feral goat numbers is great and when cheaper alternatives are not available (Department of Employment, Economic Development and Innovation 2010, Queensland).

Advantages and disadvantages of shooting (from both ground and air) are provided in Table 10-14.

Judas goat

In areas where it is difficult to find goats (e.g. moderate to dense vegetation, hilly terrain), the 'Judas goat' technique can be used.

This technique involves fitting a feral goat with a radio transmitter and releasing it in a known feral goat area to join the herd. The radio-collared 'Judas' goat is then tracked and local feral goats are shot. The 'Judas' goat can be allowed to escape and the process repeated (Department of Employment, Economic Development and Innovation 2010, Queensland).

Timing

Where appropriate, shooting can be undertaken at any time.

Licences/permits

Users of firearms must adhere to relevant laws and restrictions. All firearm users must be appropriately licensed and hold current accreditations.

The use of firearms for the humane destruction of pest animals on Crown land is also subject to conditions.

Firearms must not be carried or discharged in national parks, state parks and a range of reserves without appropriate authorisation.

10.7.2 Trapping

Applicability

A critical weak-point in the feral goat's normal resilience to management is their reliance on water. During dry times, feral goats can be trapped when they concentrate around water (Parkes et al. 1996).

Advantages and disadvantages of trapping are provided in Table 10-15.

Technique

Traps consist of a goat-proof fence surrounding a water point that is entered through one-way gates or ramps. There are a variety of designs for these gates or ramps, which permit the goats to enter, but not to exit (Department of Employment, Economic Development and Innovation 2010).

Maintenance

Traps must be cleared regularly to avoid starvation and stress, and operated only during the daytime to avoid catching macropods (Parkes et al. 1996).

Table 10-14: Shooting – advantages and disadvantages.

Advantages	Disadvantages
• Proven method • Can target particular goats	• Requires skilled shooters to ensure humane kills

Table adapted from Parkes et al. (1996).

Table 10-15: Trapping – advantages and disadvantages.

Advantages	Disadvantages
• Sale of goats can offset costs of building and maintaining traps • Can be done by landowners • The traps can also be used to muster sheep	• Has several welfare problems (e.g. irregular checking of traps can lead to stress or starvation of animals) • Can only be used during dry times • Ineffective where extensive bodies of permanent water are present

Table adapted from Parkes et al. (1996).

10.7.3 Mustering

Applicability

Mustering reduces goat populations and has the additional advantage that costs can be offset from the sale of captured goats. However, mustering may not always be as effective as it has been perceived (Parkes et al. 1996).

Advantages and disadvantages of mustering are provided in Table 10-16.

Technique

Two general methods are used to herd goats into yards:

- mustering by helicopters or light aircraft (to flush goats out of rough country or move animals closer to the yards)
- mustering by people on horses or on motorbikes usually with the aid of one or more dogs (Parkes et al. 1996).

10.7.4 Fencing

Applicability

Fences can be utilised in a number of ways to manage feral goats, for example, to:

- limit the dispersal of feral goats or to break up large land areas into manageable blocks
- exclude feral goats from some water points to concentrate them at others where they can be trapped (refer to Trapping section directly above)
- constrain captured feral goats (Parkes et al. 1996).

Advantages and disadvantages of fencing are provided in Table 10-17.

Technique

The minimum wire specifications for feral goat fencing projects are detailed in Table 10-18.

While no two fence designs will be exactly the same, the following standards (adapted from Parks and Wildlife Service Tasmania 2003) must be applied:

- Goats can escape by climbing diagonal braces/stays. Stays must be enclosed and either:
  - situated on the outside of the wire (if possible); or
  - constructed of 40 mm or narrower galvanised pipe (goats can't climb up this).
- Goat fencing must be a minimum height of 900 mm but preferably 1200 mm.
- The bottom wire must be no more than 50 mm above the ground. On uneven terrain, consider reducing the interval between posts to maintain this maximum gap.

Table 10-16: Mustering – advantages and disadvantages.

Advantages	Disadvantages
• Sale of goats can offset costs of control • Can be done by landowners	• Has several welfare problems (e.g. irregular checking of traps can lead to stress or starvation) • Only economic and efficient at high goat densities

Table adapted from Parkes et al. (1996).

Table 10-17: Fencing – advantages and disadvantages.

Advantages	Disadvantages
• Can limit dispersal • Useful during control campaigns to compartmentalise larger areas • Can be used to exclude goats from some water supplies and force them to drink at sites where they can be trapped	• Fences will always be breached eventually, thus they are tactical, not strategic • Effective fences are very expensive

Table adapted from Parkes et al. (1996).

Table 10-18: Minimum wire specifications by stock type.

Fence type	Feral goats
Mesh	Standard 7/90/30 or 8/90/30 ringlock and plain wire
Electric	6-strand plain wire with at least three electrified strands ensuring that the bottom wire is earthed*

** Note – long grass may short-out fence, hence site will require regular maintenance.*

Table adapted from Parkes et al. (1996)

10.8 Deer

Under the *Wildlife Act 1975*, deer are defined as wildlife and six species are declared as game under a Governor in Council Order. The deer species declared as game are Sambar, Red, Fallow, Hog, Rusa and Chital Deer.

All other deer species (except Sika and Wapiti) are prohibited pest animals under an Order in Council made under the *Catchment and Land Protection Act 1994.* However, no deer species are known to be present in Victoria apart from those declared to be game.

Under the *Wildlife Act 1975* (the Act) and Wildlife (Game) Regulations 2012, game deer can be hunted on public or private land by people who hold an appropriate Game Licence, during prescribed seasons using approved hunting equipment and methods. Under the Act, problem deer can also be controlled without the need for a Game Licence (see Shooting section below).

Deer will graze and browse young plants, disturb soil, create large wallows around water holes and depressions (opening up the soil for weed invasion) and damage the bark of trees by rubbing their antlers on tree trunks, particularly in autumn.

Deer activity can impede natural and planned revegetation and can often result in the establishment of weeds. This occurs as a result of deer browsing young plants and damaging the ground cover with their hooves. The reduction in ground cover can often lead to a decline in soil stability, water quality, habitat for ground dwelling animals, foraging habitat and reduced biodiversity (Molonglo Catchment Group, no date).

Deer control can be difficult and is generally limited to shooting and fencing.

10.8.1 Shooting

Licences/permits

In Victoria, a Game Licence must be acquired for the recreational hunting of game deer. Outside of recreational hunting, there are a number of options allowing people to control problem deer.

Controlling problem deer on Crown Land

Land management agencies can apply to DELWP for a permit to control problem deer on Crown Land. These permits (known as Authority to Control Wildlife permits) are provided for under the Act. A permit issued under the act can impose any conditions and can only be issued for a maximum of three years. Where a landmanager holds a relevant permit, they can engage agents to undertake the necessary control work on their behalf.

Controlling problem deer on private property (Governor in Council Order)

Arrangements have been changed to help private landowners in Victoria control problem deer if they are causing damage to private property, subject to certain conditions.

Previously, deer causing damage on private property could only be destroyed after landowners had applied for and received an Authority to Control Wildlife permit or by using licensed deer hunters. This created an administrative burden and often delayed control.

The following species have been declared ‘unprotected’ wildlife on private property by way of a Governor in Council Order under section 7A of the *Wildlife Act 1975:*

- Sambar Deer
- Fallow Deer
- Red Deer including Wapiti
- Sika Deer
- Sika Deer – Red Deer hybrids
- Rusa Deer.

Problem deer may be destroyed at night under spotlight which is one of the most efficient and effective ways to control deer. There are certain conditions that relate to the control of deer under this order and these are detailed in a fact sheet at the GMA website.

Landowners who would like to control other deer species or utilise methods that are not provided for in the order can apply to DELWP for an Authority to Control Wildlife permit.

Users of firearms must adhere to relevant laws and restrictions. All firearm users must be appropriately licensed and hold current accreditations.

The use of firearms for the humane destruction of pest animals on Crown land is also subject to conditions.

Firearms must not be carried or discharged in national parks, state parks and a range of reserves without appropriate authorisation.

For further information, refer to Game Management Authority’s (GMA) website.

Hunting locations

Recreational deer hunting can occur on more than 8.5 million hectares of Crown Land within Victoria. This includes state forest, forest parks, unreserved Crown land and some state game reserves, national parks, coastal parks, wilderness parks and regional parks.

Deer hunting on private land can occur with the permission of the owner/manger. Deer hunting can also occur on leased and licensed Crown land with the permission of the lesee/licencee.

For further information, refer to GMA’s web page.

10.8.2 Fencing

Technique

Mesh exclusion fencing must be sturdy and high (at least 2 m), and can be constructed from star pickets and wire netting.

10.9 Native herbivores

In some areas, wallabies and kangaroos may damage revegetation projects by damaging fences and browsing plants (Corangamite Seed Supply and Revegetation Network 2006, Corr 2003). For example:

- Wallabies enjoy a varied diet, which includes the leaves of young seedlings with a preference for browsing overstorey species such as Eucalypts, She-oaks and Acacias (Deppeler 2007, Temby 2003).
- Kangaroos can cause significant damage to some revegetation sites by camping and grazing in the areas that have been planted (Deppeler 2007).

Native herbivores are protected wildlife under the *Wildlife Act 1975*. Non-lethal methods of control should be fully explored before lethal control methods are employed.

The most common methods used to minimise the impact of wallabies and kangaroos are:

- fencing
- guarding
- plant selection
- repellents
- shooting (as a last resort).

These control options are detailed in the following sections with integrated control options (decision trees) provided in Appendix D. Use the decision trees to guide the development of wallaby and kangaroo control programs.

10.9.1 Fencing

Applicability

Where native animals are damaging seedlings, exclusion fencing may be an option (Corr 2003). However, large-scale fencing to exclude wildlife may be inappropriate and should consider the wildlife's movement needs (Corangamite Seed Supply and Revegetation Network 2006).

Technique

Constructing fencing that gives 100% protection from kangaroo browsing is difficult and very expensive (Deppeler 2007) because they generally push through fences, as well as jumping over them (Temby 2003).

Electric fence configurations are available that will keep most kangaroos out most of the time. An electric fence design gaining increasing acceptance is a 45 degree, 12-wire sloping electric fence that leans into the paddock. The second, fourth, sixth and eighth wires are live, with the next three carrying an induced current. This design is capable of excluding kangaroos as well as foxes and other species (Temby 2003).

10.9.2 Guarding

Applicability

Very tall tree guards of rigid plastic mesh or heavy-duty weld mesh can be used to prevent kangaroo or wallaby browsing in some areas (Greening Australia 2008).

These individual tree guards are suitable for growing isolated trees but are considered a costly method of revegetation. However, in some locations they may be the only option to get some species represented (Deppeler 2007).

Traditional guards, such as plastic sleeves or milk cartons, must not be used to protect plants from wallaby grazing (Deppeler 2007).

10.10 Plant selection

10.10.1 Applicability

The use of locally indigenous prickly or less palatable species as companion plants to more palatable species can be another effective deterrent to browsing animals (Corr 2003, Corangamite Seed Supply and Revegetation Network 2006, Deppeler 2007). For example, the planting of prickly Hedge Wattle (*Acacia paradoxa*) in niches with palatable She-oaks (*Allocasuarina* spp.).

This technique must be used with caution as plant selection should be based on locally native (indigenous) species.

10.10.2 Technique

Where the impact of browsing animals is assumed to be significant, the most common techniques employed are:

- exclude palatable species in the first few years of planting
- increase the proportion of prickly or less palatable species when developing plant order.

10.11 Repellents

One effective, short-term repellent for wallabies is a three-part product applied to certain seedling trees to help reduce browsing damage. The distributors say the repellent will deter browsing of certain tree seedlings by:

- Bennett's Wallaby (*Macropus rufogriseus rufogriseus*)
- Swamp Wallaby or Black Wallaby (*Wallabia bicolor*)
- Red-necked Wallaby (*Macropus rufogriseus*)
- Pretty-faced Wallaby (*Macropus parryi*)
- Tasmanian Pademelon (*Thylogale billardierii*).

10.11.1 Applicability

The protection given by the repellent is limited to 68 weeks (Corr 2003). It is important to inspect plants for evidence of grazing/browsing pressure during and immediately after this timeframe and apply appropriate management if required, e.g. guarding.

10.11.2 Technique

The repellent is applied to seedlings as follows:

1. Part A (whole egg solids) and Part B (acrylic polymer adhesive) are mixed together with water and sprayed onto foliage of the trees.
2. Then, before the mixture dries, Part C (silicon carbide grit) is sprinkled onto the foliage.

Browsing behaviour is reduced when animals associate the odour of the liquid with the unpalatable texture of the grit.

10.11.3 Timing

The repellent should be applied as a single application one to seven days prior to, or after, planting.

10.11 Shooting

As presented in previous sections, many problems can be resolved using non-lethal measures that may provide more effective solutions than simply resorting to killing wildlife. In general, appropriate non-lethal wildlife management options must be attempted and documented before the Department of Environment, Land, Water and Planning will consider issuing an Authority to Control Wildlife under the *Wildlife Act 1975.*

It is usually a requirement that the shooting of kangaroos and wallabies under an Authority to Control Wildlife be done in accordance with the Australian Government *Code of Practice for the Shooting of Kangaroos.*

10.12 References

Anderson, G. (2003). *Site Preparation for Farm Forestry. Agriculture Notes AG0770.* Department of Primary Industries, Victorian Government, East Melbourne.

Bloomfield, T. and Cummings, D. (2003). *Rabbits: Warren Destruction and Harbour Management. Landcare Note 0297.* Department of Natural Resources and Environment, State of Victoria.

Bloomfield, T. (2002). *Rabbit Control Using Pindone Poison. Landcare Note 0296.* Department of Natural Resources and Environment, State of Victoria.Bloomfield, T. (1999). *Rabbits: Methods of Fumigating Rabbit Burrows. Landcare Note 0295.* Department of Natural Resources and Environment, State of Victoria.

Choquenot, D., McIlroy, J. and Korn, T. (1996). *Managing Vertebrate Pests: Feral Pigs.* Bureau of Resource Sciences, Australian Government Publishing Service, Canberra.

Corangamite Seed Supply and Revegetation Network (2006). *Improving Biodiversity Outcomes in Revegetation Activities – Protocols, Resources and Supporting Documents.*

Corr, K. (2003). *Revegetation Techniques. A Guide for Establishing Native Vegetation in Victoria.* Greening Australia, Victoria.

Department of Employment, Economic Development and Innovation (2010). *Feral Goat (Capra hircus). Declared Class 2 Pest Animal Fact Sheet.* Queensland Government

Department of Primary Industries (2007). *Rabbits: Using Integrated Rabbit Control.* Department of Primary Industries, Victorian Government, East Melbourne.

Department of Environment and Sustainability (2005). *Game Hunting in Victoria – Where Can I Hunt? Series No 9.*

Department of Environment and Sustainability (2009a). *Standards for Management – Rabbits. Bushbroker. Information Sheet No. 7* Department of Sustainability and Environment, Victorian Government, East Melbourne.

Department of Environment and Sustainability (2009b). *Standards for Management – Fencing. Bushbroker. Information Sheet No. 7.* Department of Sustainability and Environment, Victorian Government, East Melbourne.

Deppeler, L. (2007). *Browsers and Grazers. River Reflections Edition 2.* Melborne Water.

Greening Australia (2008). *Site preparation – Protection from Grazing by Livestock and Feral Animals.*

Manningham City Council, Banyule City Council, Nillumbik Shire Council, Yarra Ranges Shire Council and Port Phillip and Westernport Catchment Management Authority (2009). *Rabbit Control in Urban and Peri Urban Areas. How to Protect Your Property and Minimise the Damage.*

Molonglo Catchment Group (no date). *Pest Animal Fact Sheet – Deer.*

Moseby, K.E. and Read, J.L. (2006). The Efficacy of Feral Cat, Fox and Rabbit Exclusion Fence Designs for Threatened Species Protection, *Biological Conservation* 127: 429-437.

Parkes, J., Henzell, R. and Pickles, G. (1996). *Managing Vertebrate Pests: Feral Goats*. Bureau of Resource Sciences and Australian Nature Conservation Agency.

Parks and Wildlife Service Tasmania (2003). *Feral Goats.* State of Tasmania.

Platt, S. and Temby, I. (1999). *Rabbit Control in Wildlife Habitat. Land for Wildlife Notes Series No LW0031.* Department of Natural Resources and Environment.

Read, J.L., Moseby, K.E., Briffa, J., Kilpatrick, A.D, and Freeman, A. 2011. Eradication of Rabbits from Landscape Scale Enclosures: Pipedream or Possibility? *Ecological Management and Restoration* Vol 12 (1) 46-53.

Sharp, T. and Saunders, G. (2004a). *Model Code of Practice for the Humane Control of Rabbits*. Department of Environment and Heritage.

Sharp, T. and Saunders, G. (2004b). *Diffusion Fumigation of Rabbit Warrens* (RAB005). Department of Environment and Heritage.

Sharp, T. and Saunders, G. (2004c). *Model Code of Practice for the Humane Control of Feral Pigs.* Department of Environment and Heritage.

Sharp, T. and Saunders, G. (2004d). *Model Code of Practice for the Humane Control of Feral Goats.* Department of Environment and Heritage.

Temby, I. (2003). *Problems Caused By Kangaroos and Wallabies. Flora and Fauna Notes – FF0019.* Department of Sustainability and Environment, Victorian Government, East Melbourne.

Twigg, L., Lowe, T. and Martin, G. (2006). *Feral Pigs and 1080 Baiting – What You Need to Know.* Pestnote 197. Department of Agriculture and Food. The State of Western Australia.

Umina, P. (2008). *Redlegged Earth Mite. Agriculture Notes AG0414.* Department of Primary Industries, Victorian Government, East Melbourne.

Williams, C.K., Parer, I., Coman, B.J., Burley, J. and Braysher, M.L. (1995). *Managing Vertebrate Pests: Rabbits.* Bureau of Resource Sciences/CSIRO Division of Wildlife and Ecology, Australian Government Publishing Service, Canberra.

Appendix A – Decision trees for rabbit control

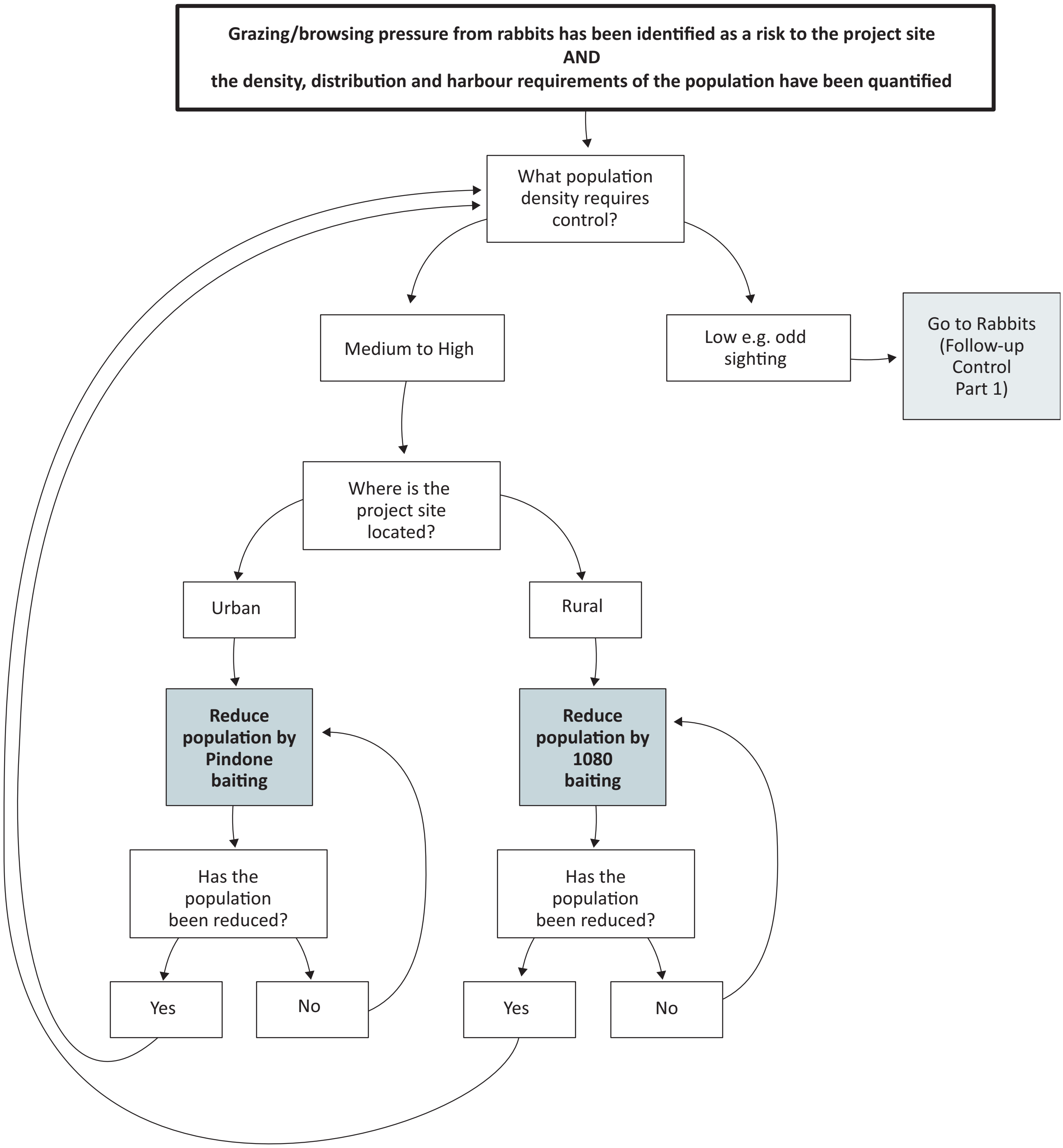
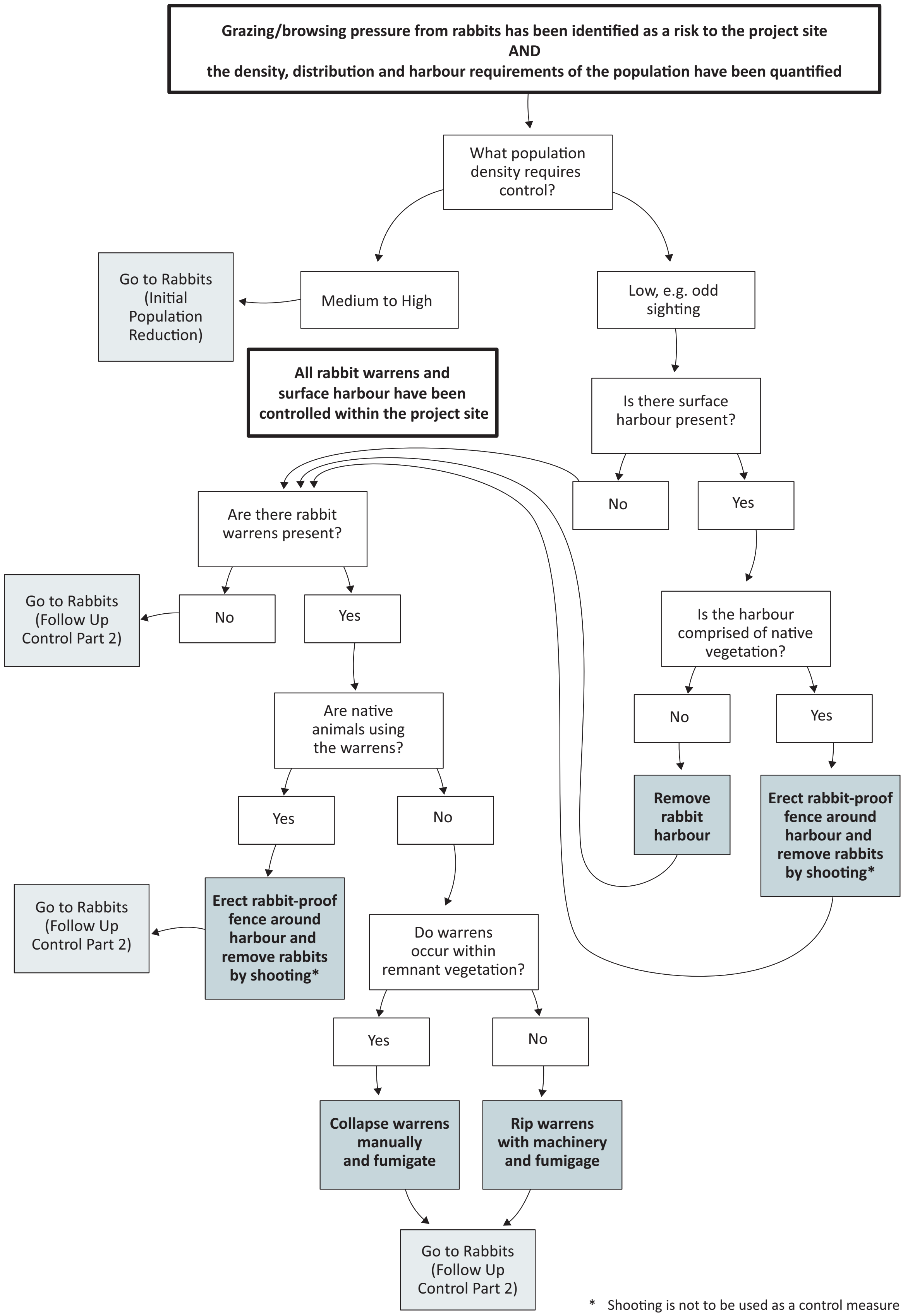


Figure 9: Pest animal management – rabbits (initial population reduction).



* Shooting is not to be used as a control measure in urban areas

Figure: 10: Pest animal management – rabbits (follow-up control part 1).

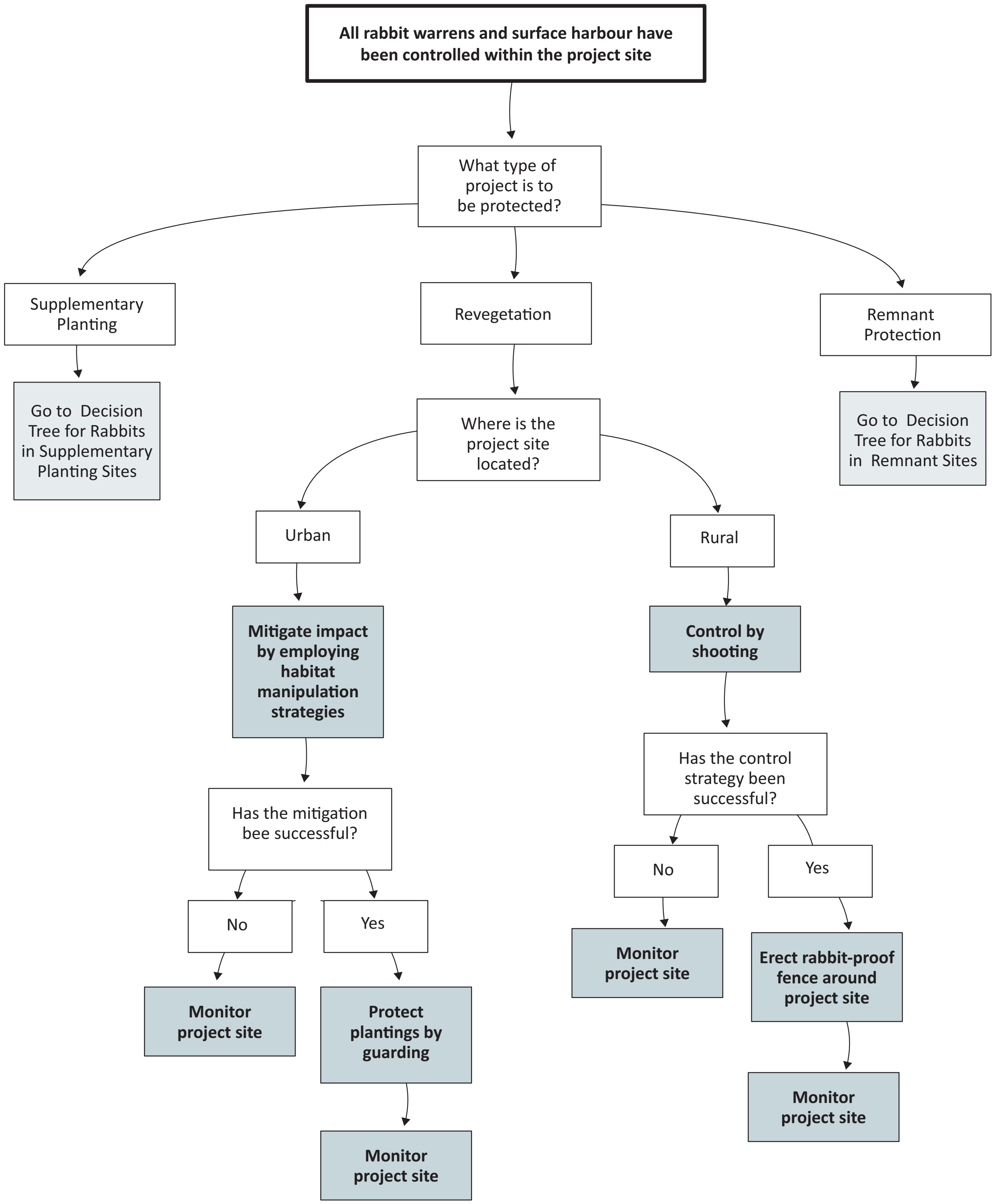


Figure 11: Pest animal management – rabbits in revegetation sites (follow-up control part 2).

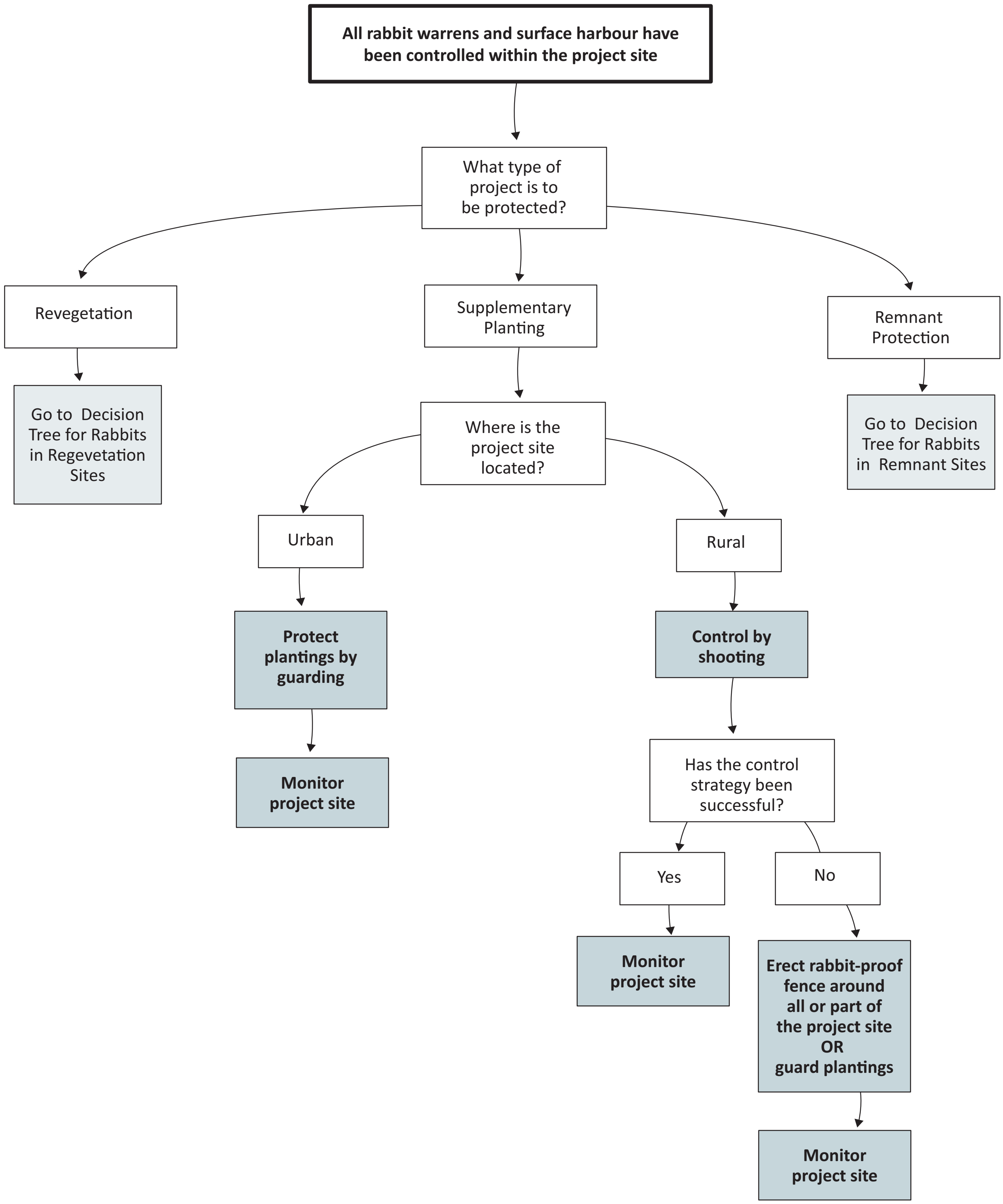


Figure 12: Pest animal management – rabbits in supplementary planting sites (follow-up control part 2).

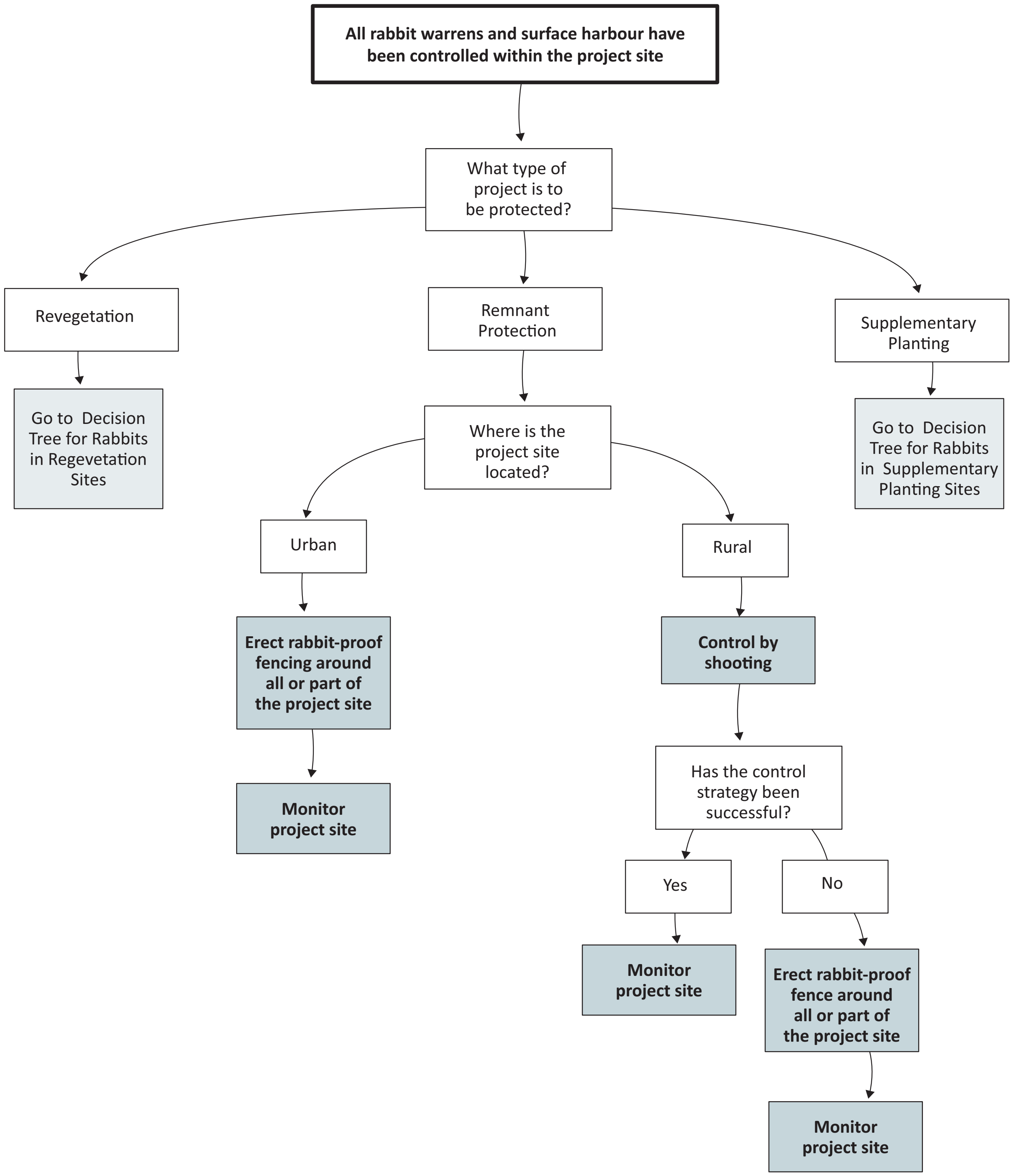


Figure 13: Pest animal management – rabbits in remnant protection sites (follow-up control part 2).

Appendix B – Decision trees for hare control

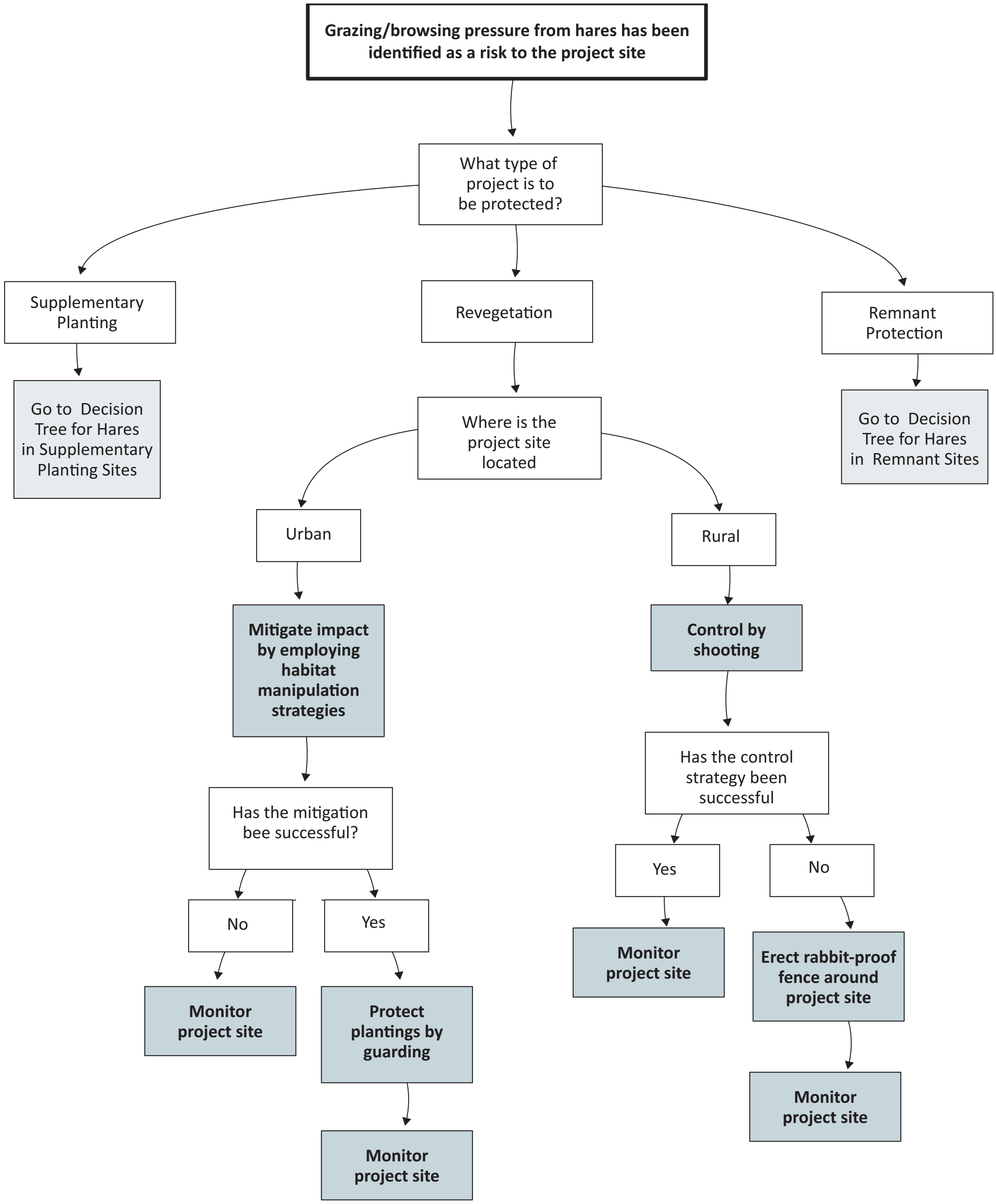


Figure 14: Pest animal management – hares in revegetation sites.

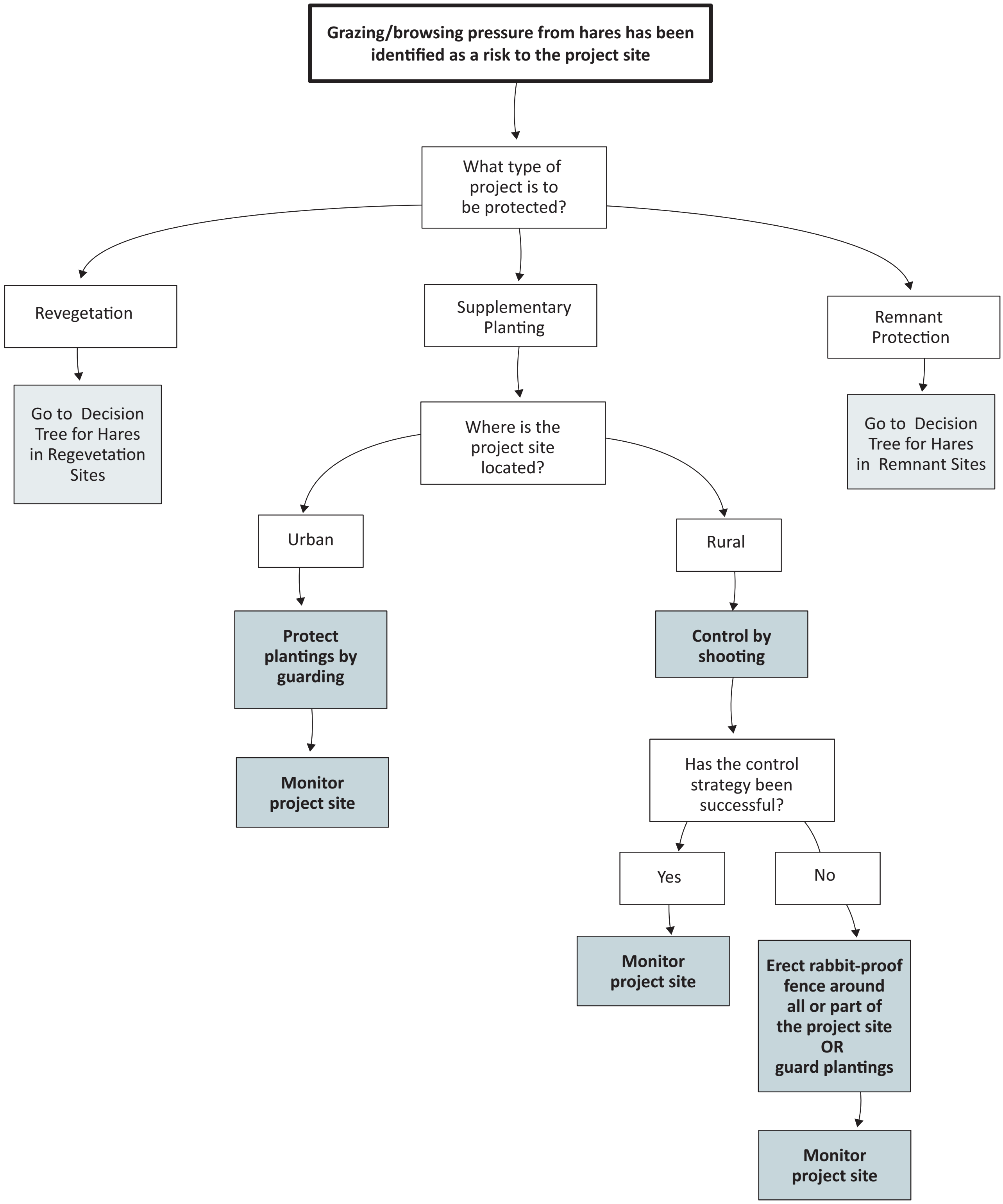


Figure 15: Pest animal management – hares in supplementary planting sites.

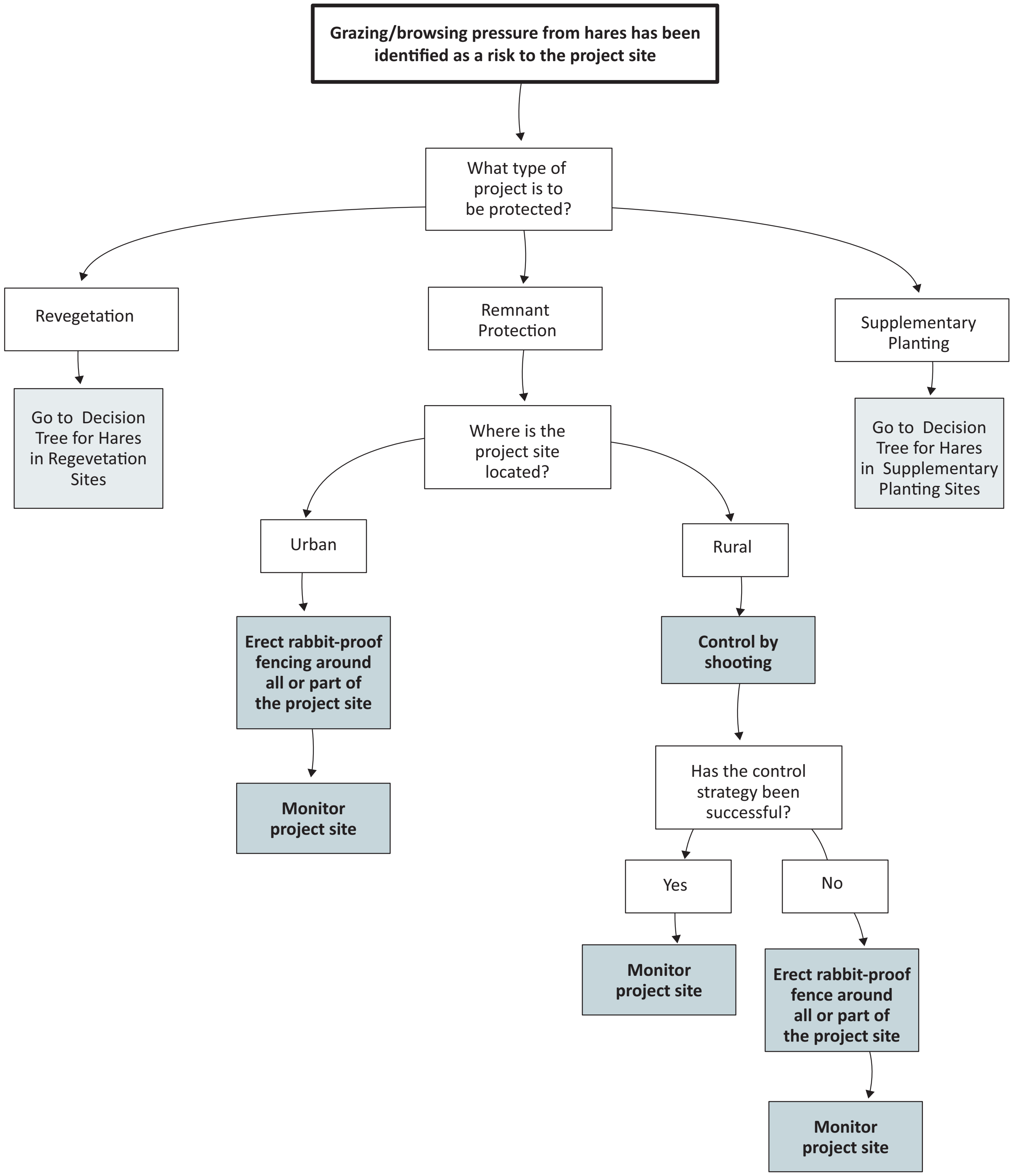


Figure 16: Pest animal management – hares in remnant protection sites.

Appendix C – Decision tree for feral pig control

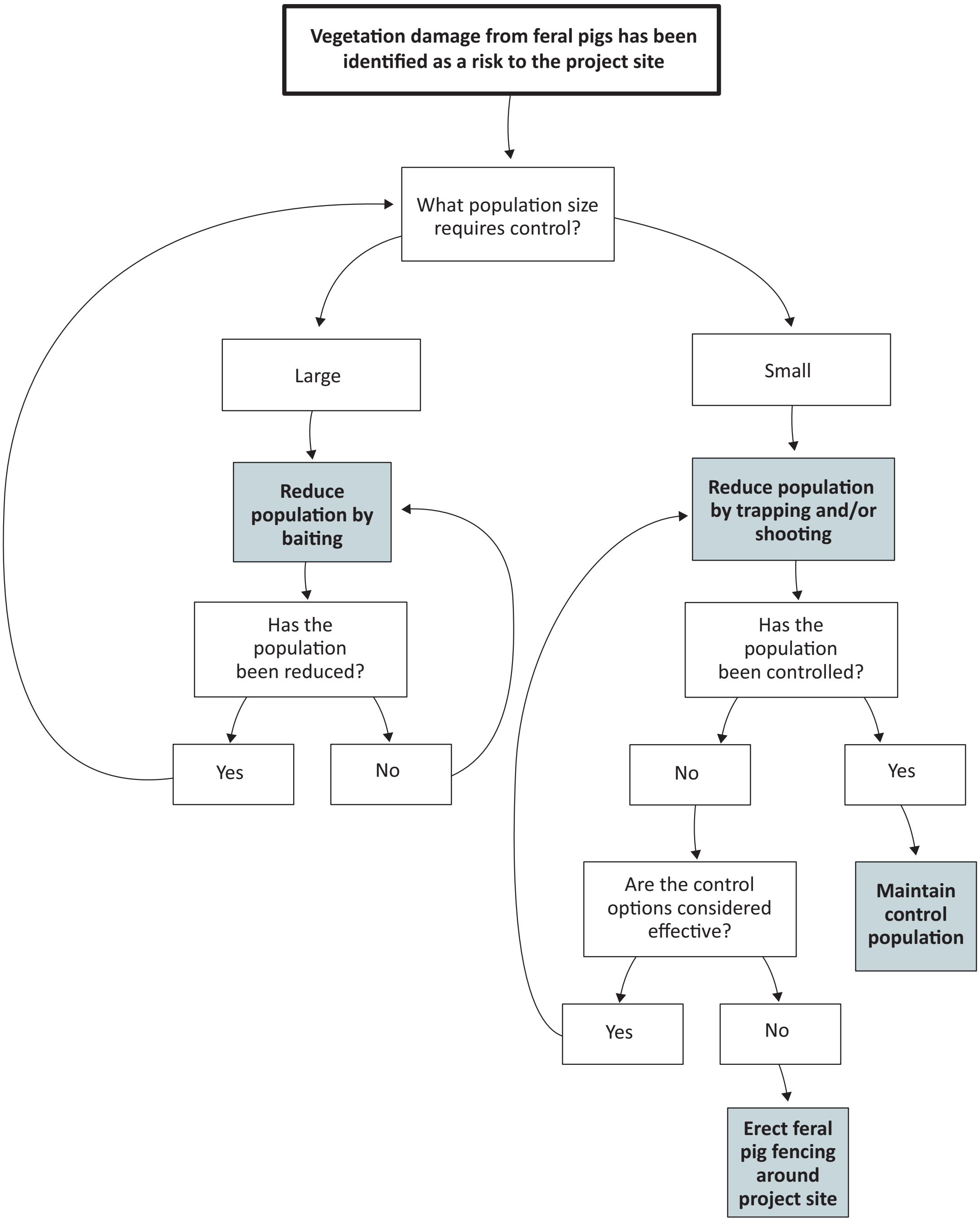


Figure 17: Pest animal management – pigs.

Appendix D – Decision tree for wallaby control

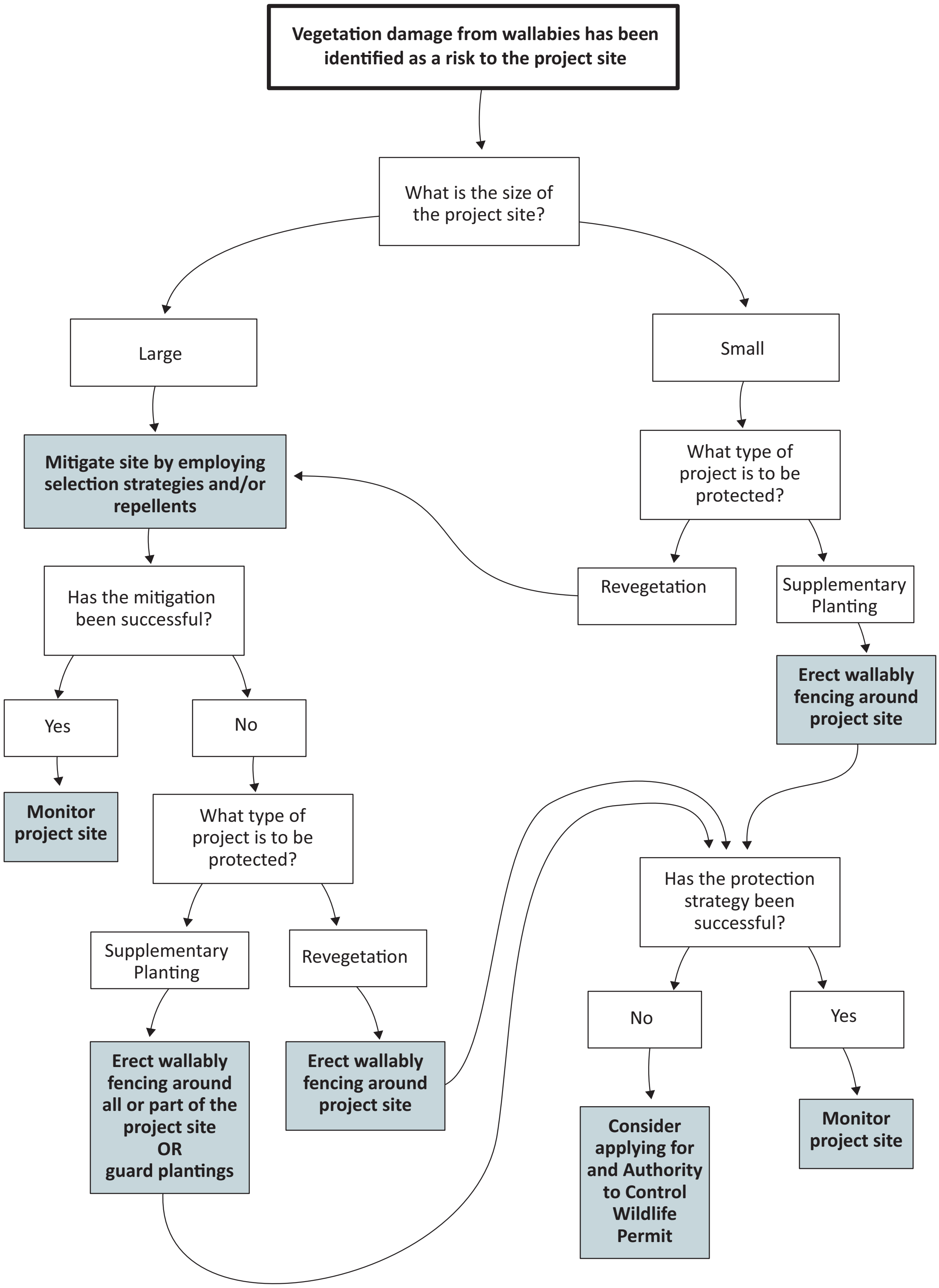


Figure 18: Native herbivore management – wallabies.

Bibliography

DELWP (2015) *DELWP Output Data Standards version 2.1.* Published by the State of Victoria Department of Environment, Land, Water and Planning. Melbourne.

Department of Sustainability and Environment (2012) *Monitoring, evaluation and reporting framework. Land, water and biodiversity.* Published by the State of Victoria Department of Environment, Land, Water and Planning. Melbourne October 2012.

Department of Sustainability and Environment (2011). *Vegetation Work Standards – Victorian Investment Framework.* Published by the State of Victoria Department of Environment, Land, Water and Planning. Melbourne November 2011.

www.delwp.vic.gov.au