5.1

General Considerations

Design issues and thinking points

This section provides some general ideas based on the principles, which should be useful to think through when defining restoration projects on the Yarra River.

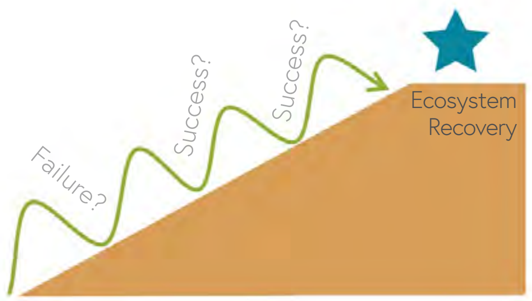
Ecological restoration is step-based and follows a logical progression

Depending on the current condition of the site, revegetation may follow the reconstruction or assisted regeneration pathway as per Principle 2 (Section 2.2, pg 26). It may be useful to use the decision tree below to assist with revegetation planning and to start thinking about the pathway. For example, if tree, shrubs and the ground-layers are all absent, reconstruction will be necessary. Alternatively, if the site has an intact tree and shrub layer but no ground-layer, then assisted regeneration such as through direct seeding with native grasses might be needed. Ultimately the aim is to re-vegetate the site to the point of natural regeneration, where only minimal management, such as pest and weed control, is necessary for the site to recover. These steps should guide the restoration works towards the end goal of the reference model in a logical progression.

ONE LONG-TERM GOAL

The only goal that has been defined is the long-term goal of recovery.

Recovery has not been achieved, though successes have occurred along the way, but they have not been recognised.



MULTIPLE SHORT-TERM GOALS

Progression of short-term goals leading to the same long-term goal of recovery.

Recovery has not yet been achieved, though successes have been recognised along the way, and they have been recognised.

★ Progress evaluated against monitoring data and goals, new goals defined, and management adjusted as necessary

Figure 4. Conceptual diagram of the differences between only creating one long-term goal (left) and creating a succession of short-term goals (right) which lead to the same long-term goal of ecosystem recovery.

It is essential to create clear goals, targets, and objectives that follow the above progression

Ecological restoration can be slow, costly, difficult, and at times frustrating. Therefore, it is essential to set achievable goals, targets, and objectives (see Principle 3 in Section 2.3,) which create a logical progression to an end goal of successful regeneration (see Principle 4 in Section 2.4).

It can be easy to lose track of progress over time when full recovery is the only goal (Figure 4, left), which highlights the importance of creating short-term goals so that successes can be recognised and celebrated (Figure 4, right), or management adapted at various points in the case of disappointing outcomes. As long as projects are always 'climbing up the steps' of this progression to the target condition and functioning ecological processes, and recognising achievements along the way, then the project is a success.

The objectives of a site must be realistic

The reality of many conservation projects is that funding ebbs and flows and may only be guaranteed for a single season. Because of this, how much time and resources are available needs to be considered when designing the restoration works. A good plan for a site will include opportunities to seek future funding. The works can be designed in stages so there are clearly defined opportunities that can be put to funders. This is especially relevant to ensure that sites can be maintained sufficiently after initial work has been completed. Most community groups do not expect that a single grant will cover all the work a site requires to fully regenerate. One significant value of community groups, especially Friends and Landcare groups, is that they are committed to maintaining a site over time.

If the budget or resources are only adequate to secure a year or two of maintenance, then a decision needs to be made as to whether the objectives of the project should be modified. To give one example: alternative to planting with native grasses that require ongoing maintenance for a number of years to ensure that the weeds do not regenerate and out compete plantings, would be to plant canopy species and shrubs (if appropriate for the reference model), as after a year or two they can establish and out compete regenerating weeds. In a subsequent stage when these trees and shrubs have begun to shade out more vigorous weeds, an indigenous understorey of native grasses can be established.

Monitoring provides invaluable insights, and doesn't have to be onerous

While monitoring can sometimes be seen as time-consuming and expensive, it can be made efficient, and is important for a number of reasons. Monitoring should take place in way in which data is useful to managers and scientists (see Principle 5 in Section 2.5) and allows restoration practices to be adaptive. A key part of monitoring is to assess how well the site is contributing to the connectivity of the corridor.

5.2

Ecological Restoration Project Design

This section covers three of the initial steps in ecological restoration project design: selecting the site, determining the reference ecosystem, and defining goals, targets and objective (Figure 5). The worksheet (Table 4) and decision tree (Figure 6) are useful when beginning a restoration project design.

Figure 5. Conceptual diagram showing the steps covered in Section 5.2.

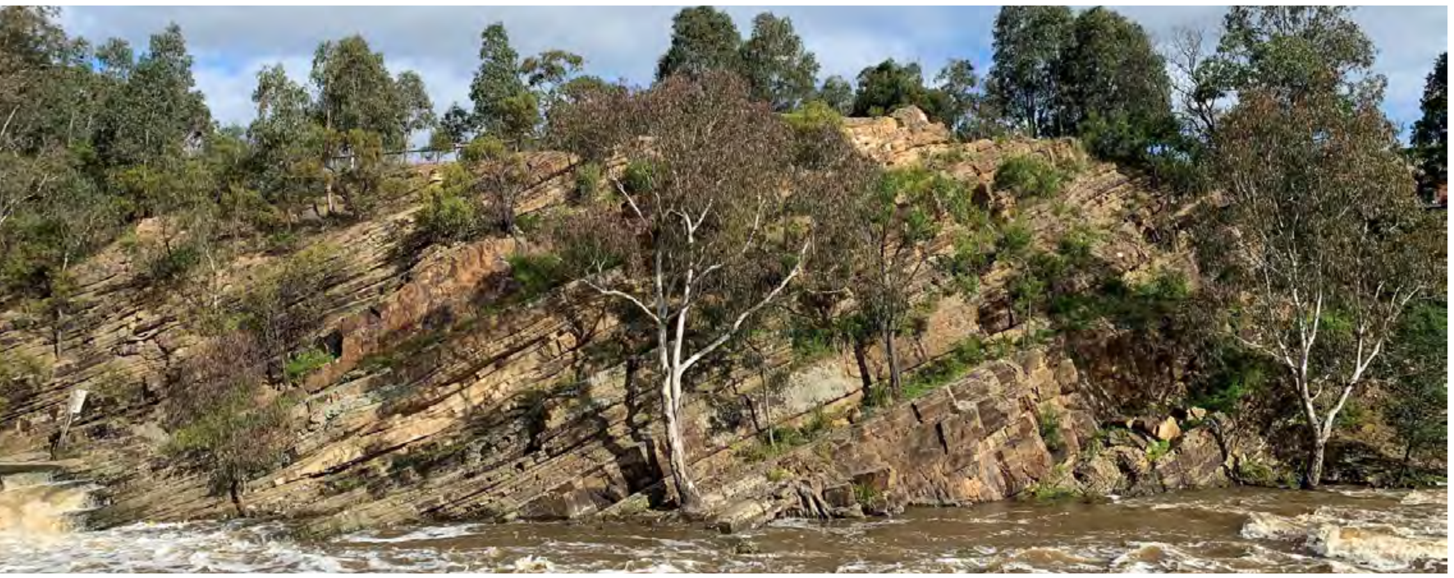


Image 26. The banks of the Yarra River near Dights Falls in Abbotsford. An example of Silurian escarpments south of the falls. Daniel Miller (Practical Ecology).

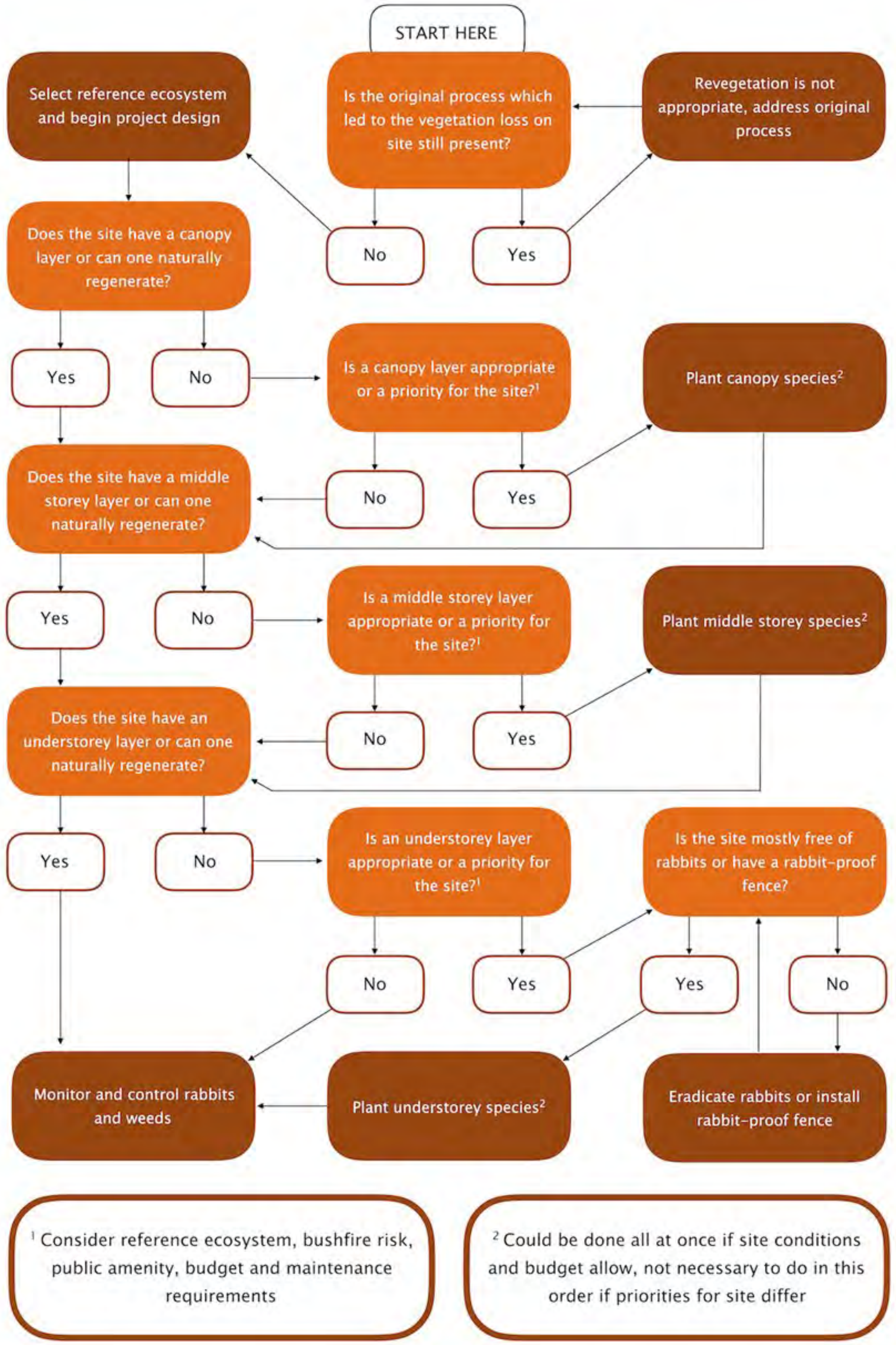


Figure 6. Decision tree for revegetation project design. Please note that this decision tree is intended to facilitate thinking and is not prescriptive.

Date:	Site Name:	Completed By:

Question	Notes
Is remnant native vegetation present?	
Does the remnant native vegetation indicate the likely vegetation community on the site?	
What are the underlying geological substrates or soils?	
What is the topography of the site?	
Is the site significantly changed from original condition?	
Can the original vegetation community be determined so that a reference ecosystem can be selected?	
Which restoration approach (reconstruction/ assisted regeneration/natural regeneration) is needed?	
Are sources of local provenance seeds or plants available?	
Are social and safety design issues considered?	
Are design considerations for bushfire safety considered?	
Are there other design issues to be considered?	
Is there enough budget for maintenance following this project?	
Once the project is finished, how well can the site function without intervention?	
Other notes:	

Table 4. Initial worksheet for regeneration projects adapted from a similar worksheet in the *National Standards*.

5.2.1

Choosing and Prioritising Sites

While restoration works are beneficial in any location, there are a number of principles that can be used to improve the ecological benefit, which will help to decide where to target works. Four of the most important factors (which are intrinsically linked), presented in Table 5 below. While it is difficult to create a precise set of priorities, the following is intended to present ideas that can be used as a starting point in choosing sites.

Additionally, a number of other considerations (here presented as questions) that could be asked when prioritising and choosing sites are:

Is the vegetation community on site relatively widespread and secure, and if so, could priorities be adjusted to focus restoration works on sites with less widespread and secure vegetation communities?

Do the works have the support of stakeholders?

Is access to the site difficult, and can another similar site be chosen with easier access, making the works more efficient?

Does the site have a conflict between human uses and restoration, and is this too prohibitive?

Factor	Main effect	Action/outcome
Fragmentation	Reduced gene flow, barriers to fauna dispersal	Restore areas between disjunct patches to connect existing remnants
Isolation		Locate new restoration areas as close as possible to existing remnants
Edge Effects (between remnants and modified areas such as parks, not between two different vegetation communities)	Increased weed invasion and colonisation	Design new sites with a low perimeter relative to area (as below), and infill existing remnants with the same principle  Area – 1cm^2 Perimeter – 6cm; Area – 1cm^2 Perimeter – 4cm
Reduced habitat size	Fewer species, smaller populations, less genetic diversity, populations more susceptible to random events,. The relationship between habitat size and biodiversity values is not linear, but is a curve, i.e. a 2 ha patch will usually host much more than double the number of species and individuals as a 1 ha patch	Increase the size (and quality) of existing remnants rather than creating new ones

Table 5. Four important ecological factors to consider addressing when prioritising sites for regeneration.

5.2.2

The Reference Model

Determining the reference model and reference ecosystem or ecosystems, for a project is perhaps the most critical step in the process. In this case, the reference ecosystems for this project are the thirteen vegetation communities, and they have been used as the target conditions detailed in Section 3.2.

The target conditions may be modified as more is learned about what is possible along the river corridor through an adaptive management process.

Does the area have enough remnant vegetation present to indicate a community?

YES : Consult community descriptions and maps to determine the community that currently exists.

NO : Continue below.

Does the geology/soil type/topography of the site relate to only one vegetation community listed the community descriptions?

YES : Use this as the reference ecosystem.

NO : Continue below.

Do other sites nearby with similar geology/soil type/topography contain remnant vegetation that indicates a community?

YES : Use this as the reference ecosystem.

NO : Continue below.

Do the above questions lead to two or three similar vegetation communities that cannot be separated?

YES : Create a planting palette combining aspects of these two or three communities – the site may occur in a transitional area.

NO : The site may be modified beyond the point of its original state. Use hardy species widespread throughout a number of vegetation communities.

Implementing constructed wetlands according to Melbourne Water Guidelines (2010) could be a significant resource for restoring indigenous vegetation along the Yarra River while providing flood control and stormwater treatment. Melbourne Water has been investing in good design for constructed wetlands, and created the opportunities for many contractors to develop good skills in constructing and planting them over at least two decades. This means that they are a standard for general restoration approaches that also meet engineering and water quality objectives.

In essence, a constructed wetland is an engineered water retention basin with wetland plants installed as the living stormwater treatment process. They represent good habitat for frogs, birds and other native fauna, and have been refined with various wetland types and indigenous wetland species. While constructed wetlands are artificial ecosystems that don't specifically represent a particular EVC, it is possible and necessary to consider the EVCs that are appropriate to instal around the ephemeral and terrestrial edges. Several EVCs described in this guide will be appropriate to use as reference ecosystems for terrestrial vegetation communities around constructed wetlands, often in bands or mosaics in relation to water levels. Constructed wetlands can also be placed along current drainage systems entering the Yarra. Taking existing barrel drains and 'daylighting' them by re-creating drainage lines open to the air, or as a series of stepped constructed wetlands, can be an important part of utilising existing water resources for supporting better habitats. Further detail can be found at the following link:

https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/standards-and-specifications/constructed-wetlands

Constructed wetlands are one example of novel ecosystems that have deliberately or accidentally appeared in the river corridor. Novel ecosystems are modified ecosystems that have evolved out of engineering works or construction work by people. They are unique niches or blends of species that exist in places that have been altered in structure and function by human agency.

The concept of the target condition is particularly useful when applied to novel ecosystems, as there is no specific reference ecosystem.

The Yarra is the home to a number of threatened or endangered native but not indigenous species including the Macquarie Perch *Macquaria australasica* and Murray Cod *Maccullochella peelii*. It also has valued native species such as the Eastern Water Dragons *Intellagama lesueurii* and Long-necked Turtles *Chelodina longicollis* that need to be accounted for in target conditions.

Image 27. Yarra riverbank. Anthony Despotellis

5.2.3

Goals, Targets and Objectives

Defining the project

The creation of goals, targets and objectives is explained in detail in Box 3 on page 29, Some 'case study' examples from projects the Association has been working on in the study area are presented below.

Case Study 1: Westerfolds Park

Current Site Condition (Image 28 on page 87): The area surrounding the proposed planting site is highly modified from its natural state, and is a high traffic area with a large carpark which provides access to a canoe launching area, and has a number of walking and cycling trails as well as picnic areas.

The proposed planting site has very high tree cover, dominated by River Red Gums *Eucalyptus camaldulensis* and some Blackwoods *Acacia melanoxylon* (many of which are dead), and is almost entirely devoid of shrubs and ground-layer plants, with the exception of some prostrate shrubs and (surprisingly) Greenhood Orchids *Pterostylis* sp.

Weed cover is quite low and is dominated by various low-threat exotic grasses, which is likely a function of the high canopy cover suppressing growth of more vigorous weeds. There is evidence of extensive rabbit activity on site in the form of scats and diggings.

Reference Ecosystem: Riparian Forest at the northern end of the site, transiting to Plains Grassy Woodland throughout the southern portion.

What limits planting on site?

There is extensive rabbit activity on site and all plantings will need to be protected;

The canopy is quite thick, so sun-loving plants will not thrive; and

The project is constrained by budget.

Target (broad aim for the site as a whole):

To maintain the public amenity of the site, while reinstating absent vegetation components (especially shrubs and ground-layer plants) and species (especially prostrate shrubs, and herbs and forbs) which are present in intact Plains Grassy Woodland and Riparian Forest communities.

Goals (general aims for each area):

Reinstatement of a shrub layer protected from rabbit grazing with tree guards;

Creation of ground-layer plantings protected from rabbit grazing with netting;

An increase in native bird activity.

Objectives (SMART. [specific, measurable, achievable, reasonable, and time-bound)

Survival of 80% of planted shrubs after two years;

No signs of rabbit activity within rabbit-proof exclosures after one year*;

80% cover of indigenous ground-layer plants within all rabbit-proof exclosures after two years;

25% increase in the number of native birds (both individuals and species) observed on site after two years; and

50% increase in the number of native birds (both individuals and species) observed on site after five years.

*While the aim of rabbit-proof plantings is to increase soil in the seed back and ultimately expand these areas through recruitment, rabbits are not likely to be controlled in the life of the monitoring, and therefore rabbits will likely destroy any germinants. Therefore, lack of rabbit activity in these areas, and survival of plantings is to be used as a surrogate indicator.

Image 28. Westerfolds park, Daniel Miller

Case study 2: Burnley (East of McConchie Reserve)

Current site condition (Image 29 on page 89): The site is highly modified from its natural state, and is a high traffic area with a number of seating areas, providing access to the adjacent Burnley Bouldering Wall (see the map at the end of this guide). The site has previously been replanted with native vegetation.

There is reasonably high tree cover on the site, dominated by River Red Gums *Eucalyptus camaldulensis* and Drooping She-oaks *Allocasuarina verticillata*, with a few small Lightwoods *Acacia implexa*.

There are very few shrubs on site, with a couple of small Tree Violets *Melicytus dentatus* (syn. *Hymenanthera dentata*) and River Bottlebrushes *Callistemon sieberi*.

The ground-layer is also quite sparse, with a number of Fragrant Saltbushes *Rhagodia parabolica* along the riverside growing quite vigorously, and some areas of Common Tussock Grass *Poa labillardierei* and Spiny-headed Mat-rushes *Lomandra longifolia*.

Weed cover is quite high, especially on the sloping area below the billboard, with a number of vigorous weed species including Kikuyu Grass **Pennisetum clandestinum*, Soursob **Oxalis pes-caprae*, and Carpet Weed **Galenia pubescens*.

Topography of the eastern part of the site is very flat, while the western part of the site has a steep section sloping down from the billboard (see the map at the end of this guide).

Reference ecosystem: Riparian Woodland.

What limits planting on site?

The view to the Yarra River should be maintained;

There are a number of 'desire paths' through the trees and open areas frequently used by visitors which are likely to continue to be used;

Some areas have high cover of weeds, which will need to be sprayed during active growth (which is not possible for all species before the community planting day). This is especially important with the high cover of Kikuyu Grass in some areas, which will need to be sprayed in summer, and would otherwise smother plantings;

The site should be kept relatively open;

The area is small;

The project is constrained by budget; and

There are safety concerns on the steepest areas of the site and directly adjacent to the river (steeper areas are not possible without ropes; nominated areas on the slope will require physical mobility.

Target (broad aim for the site as a whole):

To maintain the public amenity of the site, while reinstating absent vegetation components (especially shrubs and ground-layer plants) and species (especially prostrate shrubs, and herbs and forbs) which are present in intact Riparian Woodland communities.

Goals (general aims for each area):

Site-wide Goal: An increase in native bird activity throughout the site.

Area-specific goals:

Area 1:
Suppression of exotic weed growth; and
Reinstatement of a shrub layer.

Area 2:
Reinstatement of a ground-layer.

Areas 3-5:
Reinstatement of a shrub layer; and
Reinstatement of a ground-layer.

Image 29. Burnley regeneration site, Daniel Miller

Area 6:
Suppression of exotic weed growth;
Reinstatement of a shrub layer; and
Increased canopy diversity.

Objectives – SMART [specific, measurable, achievable, reasonable, and time-bound]:

Site-wide Objectives:
25% increase in the number of native birds (both individuals and species) observed on site after 2 years; and

50% increase in the number of native birds (both individuals and species) observed on site after 5 years.

Area-specific Objectives:

Area 1:
25% decrease in cover of exotic weeds after 5 years; and
Survival of 80% of planted shrubs after 2 years.

Area 2:
Indigenous ground-layer cover of 80% within 2 years.

Areas 3–5:
Survival of 80% of planted shrubs after 2 years; and
Indigenous ground-layer cover of 80% within 2 years.

Area 6:
25% decrease in cover of exotic weeds after 5 years;
Survival of 80% of planted shrubs after 2 years; and
Survival of 80% of planted trees after 2 years.

5.3

Restoration Types

Once the goals, targets, and objectives for a site have been defined, there are a number of ways to achieve these aims, which are discussed in the following sections.

Image 30. Riverbank. Anthony Despotellis
Image 31. Plant in pavement. Anthony Despotellis

5.3.1

Goals, Targets and Objectives

Defining the project

Revegetation is probably the most common method used for ecological regeneration, as vegetation provides the structural component of an ecosystem.

The process of revegetation is commonly used and its methods likely well understood by most using this guide, so only a few points are highlighted:

The sites chosen is based on well-thought-out priorities for the wider landscape, considering the objectives of reducing fragmentation, edge effects, isolation, and reduced habitat;

Plant selection is based on the reference ecosystem, which are detailed in the planting palettes (Appendix 2);

It is the goal of all regeneration projects to match all of the vegetation components of the reference model, unless safety, public amenity, or other concerns dictate otherwise;

Reinstating all components can take years or decades, however there can always be a logical progression of short-term steps designed to achieve the long-term goal of the target condition.

It may be the goal of a site to provide habitat for fauna species that depend on specific plant species or vegetation structures. It is appropriate to prioritise these components if this aligns with the reference modle; and

Revegetation should be monitored where possible, to allow evaluation of goals, targets and objectives, and facilitate adaptive management.

The importance of local provenance propagules

While it is important to use local sources for nursery stock, cuttings or seeds used for revegetation where possible, this should not be treated as a constraint on plant selection. Ideally terrestrial species would be produced from propagules within 10 km of the site, and grasses and wetland plants may come from as far as 40 km away. Propagules, ideally, need to also be sourced from sites with similar geology, soils and topography to the revegetation site. By using local provenance propagules, plantings are more likely to be adapted to local conditions, and establish with greater success. Climate change may alter the success of local propagules, and may mean a reconsideration of how local the propagules need to be, which is further discussed in Section 5.5.1.

Many sites are constrained by factors such as limited space, mixed uses, and budgets. Almost all sites, however, have potential for improvement in some way. Planting even one indigenous tree is beneficial. Where stakeholders have limited scope for revegetation, creative thinking may be necessary to achieve gains. Some examples of creative planting design include:

- The creation of native vegetation 'islands' in between networks of paths (Figure 7) whether they be in a park, garden, or even amenity planting in a development;
- Establishing rabbit-proof exclosures for the development of ground-layer plantings to build the seed bank while rabbit eradication is underway (Figure 8 on page 94);
- Designing roughs on golf courses according to a reference ecosystem;
- Creating amenity plantings with indigenous ground-layer species; and
- Landscaping (either on large scales or in private gardens) according to a reference ecosystem.

Image 32. Flourishing vegetation at Kew Billabong – an excellent example of a site with successful regeneration. Daniel Miller (Practical Ecology).

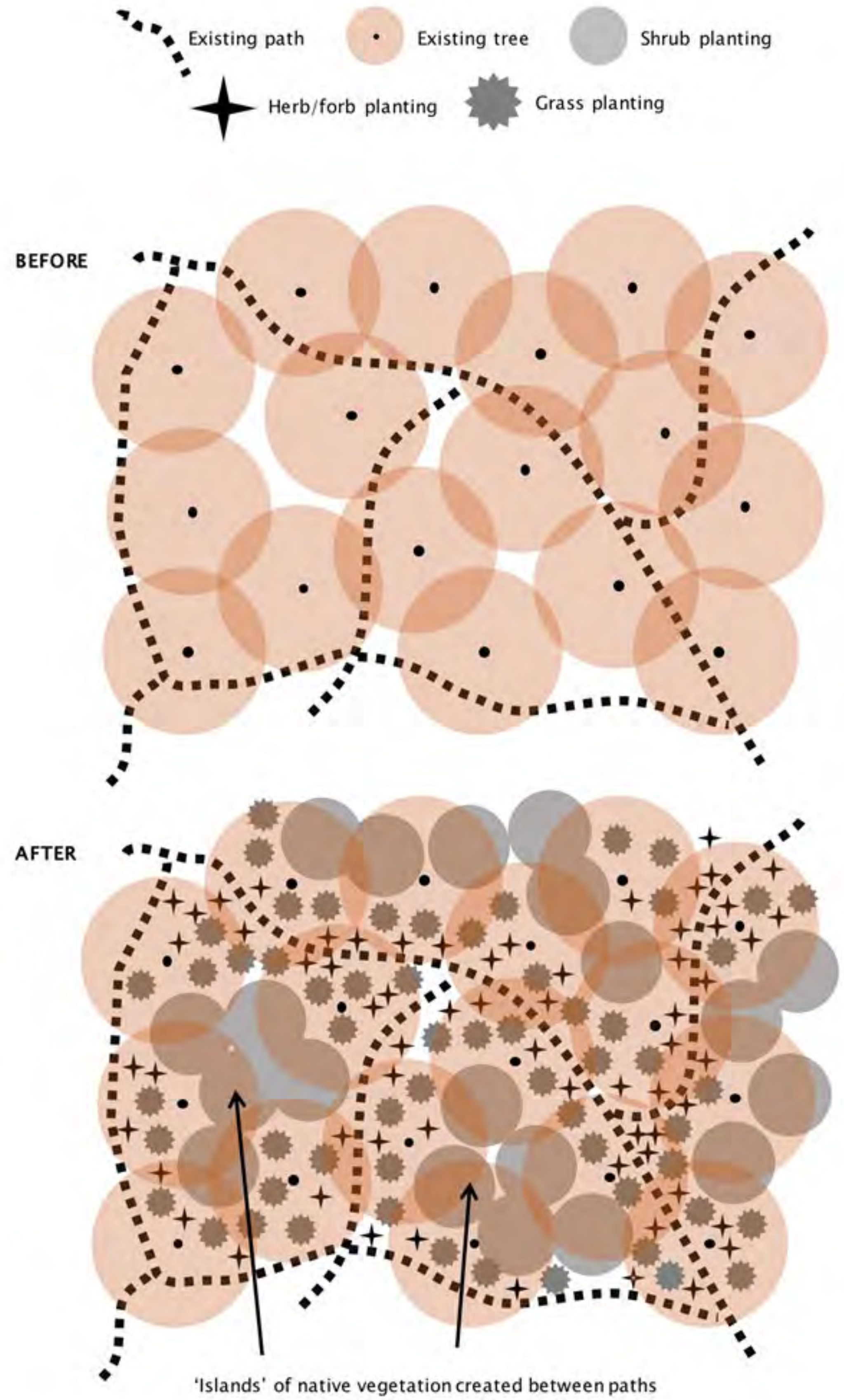


Figure 7. Potential design of native vegetation 'islands' among paths.

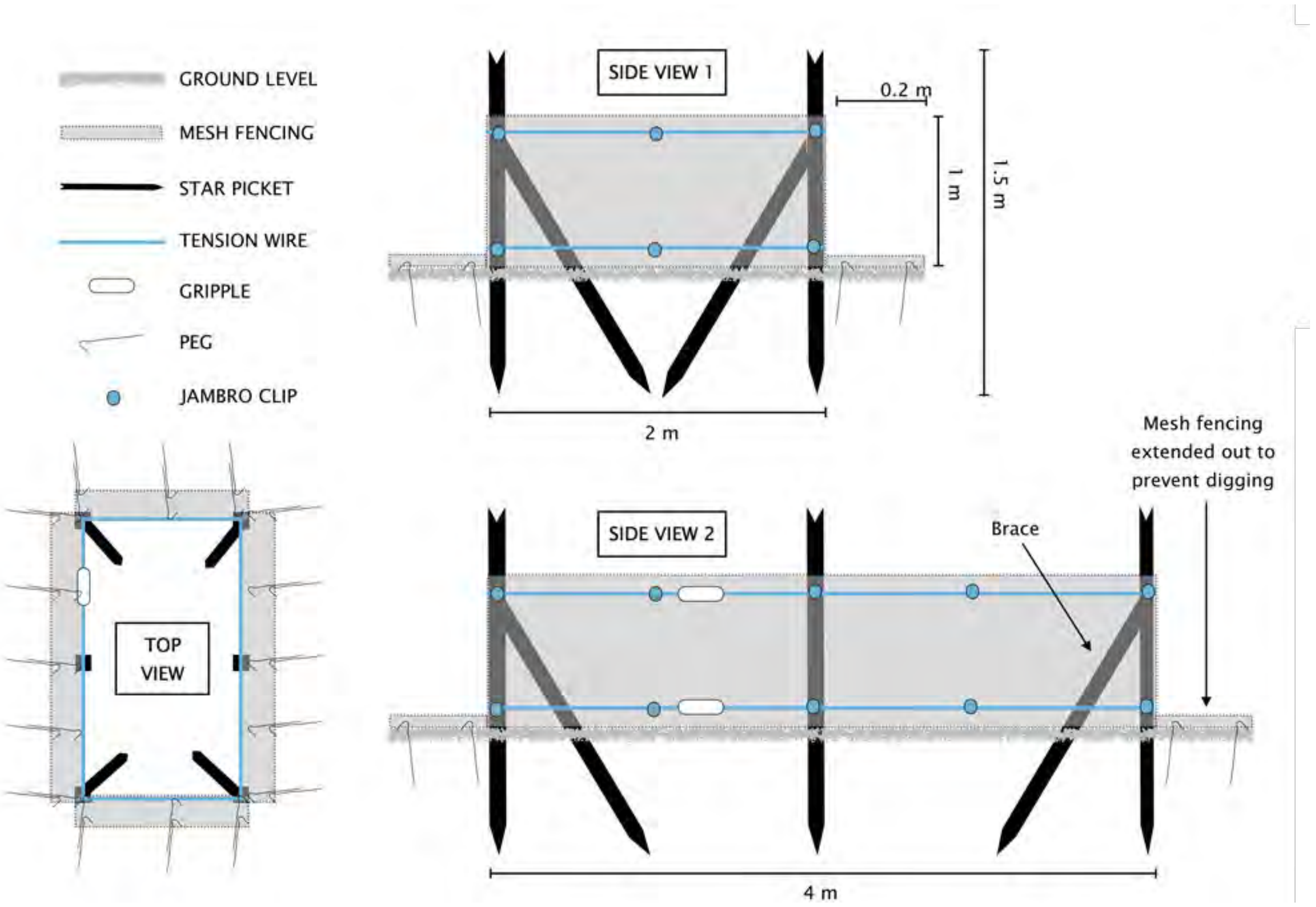


Figure 8. Potential design of rabbit-proof exclosures in which to establish ground-layer plantings and build the native seed bank while rabbit eradication is underway.

Image 33. Wild rabbit. Massaudubon.
Image 34. Riverbank scrub,.Anthony Despotellis.

5.3.2

General Habitat Enhancement

While revegetation will improve fauna habitat, there are specific steps that can be taken to further enhance habitat as part of regeneration. These features, including their benefits, methods for enhancement, and targets, are outlined in Table 6, which was adapted from Lindenmayer et al. (2003).

Image 35. Leaf Litter. Anthony Despotellis.
Image 36. Yarra riverbank. Anthony Despotellis.

Habitat feature	Benefit	Method for enhancement	Target
Hollows	Shelter and breeding sites for birds and arboreal mammals	Retention of stags (dead trees) through habitat pruning Creation of artificial hollows Installation of nest boxes (though only if ongoing maintenance is assured) Canopy revegetation	Ideal density of artificial and natural hollows, until trees reach maturity and provide natural hollows
Logs	Basking surfaces for reptiles Perches for birds Breeding sites for insects and reptiles (especially in hollows) Shelter for insects, reptiles and mammals (especially in hollows) Foraging sites for birds and reptiles (through insects that feed on rotting logs) Runways for ground-dwelling mammals	Installation on site with new materials (such as from street tree pruning) Retention of dead material on site Uncovering of existing logs via weed control	Abundance of logs on site
Leaf litter	Shelter for insects and reptiles Foraging sites for reptiles, birds, and mammals Camouflage for reptiles, birds and mammals	Retention of existing material on site Installation of logs and rocks to collect fallen material Revegetation	Abundance of naturally regenerating leaf litter layer on site
Rocks	Basking surfaces for reptiles Perches for birds Shelter for reptiles and mammals Collection site for lichen and moss (used by birds for nest-building)	Installation on site Uncovering of existing rocks via weed control	Abundance of rocks on site

Table 6. General habitat features for potential enhancement at regeneration sites.

5.3.3

General Habitat Enhancement

While the addition of all habitat features at all appropriate sites identified in Section 5.2.3 is the ultimate goal, this is would be cost-and-time-prohibitive and impossible to achieve due to the amount of built infrastructure and level of usage by people. Therefore, where the goal is to improve habitat for a particular species, it is appropriate only to target certain features. This will require a degree of research from those doing the works, a couple of common examples are given in Table 7.

Fauna species/group	Habitat feature (or vegetation structure/ species) to improve
Sugar Gliders *Petaurus breviceps*	Hollows and tree layer
Frogs	Logs, leaf litter, rocks, and ground-layer
Fairy-wrens *Malurus* spp.	Logs, leaf litter, ground-layer, and shrub layer
Powerful Owls Ninox strenua	Hollows and tree layer
Parrots	Hollows, tree layer, and shrub layer

Table 7. Examples of species-specific habitat features for potential enhancement. This is not intended to be a thorough list of all species, but rather an example of how certain species can be targeted.

5.3.4

Daylighting

Daylighting refers to the uncovering waterways that have been turned into stormwater drains (Figure 9). Some of these creeks would have been ephemeral and some would have been permanent. Among the creeks that have been barrel drained in part are Scotchmans Creek and Back Creek in the KooyongKoot/Gardiners Creek catchment. It may be thought that the undergrounding of waterways is now a practice that is outdated, but the North-East Link Authority proposes to barrel drain part of Banyule Creek. Daylighting stormwater drains that connect to the Yarra River is an excellent but expensive opportunity for both land managers and urban planners to consider creating new riparian habitats that enhance the ecological connectivity of waterways.

Figure 9. Examples of river and stream daylighting from a case study in Tehran, Andik and Sarang (2017).

5.3.5

Priority Weeds and Control Methods

If regeneration is to be successful, the re-invasion of weeds needs to be prevented. Sites need to be revisited regularly, and further weeding conducted.

Table 8 lists important weeds to look out for, and recommended control methods. This list is a guide and is not exhaustive.

Figure 10. A depiction of the cut and paint method.

Control Method Legend

H = Hand weeding: Ensure that the whole plant (including roots) is removed; knife, chisel and mattock are useful.

C = Cut and paint**: Cut the stem or trunk of the plant completely and as near to the ground as possible, then immediately paint an appropriate herbicide on the freshly cut surface. Initial cut and paint 'sweep' should be followed annually on newly emergent individuals.

S = Spot spray**: Spray target weed species with an appropriate herbicide avoiding damage to non-target species; this can be facilitated by use of a dye and a low pressure; don't spray when plants are stressed e.g.too hot or cold).

**Research appropriate herbicide for target weeds depending on method, as glyphosate is not appropriate for all species.

***While some trees (especially Weeping Willows *Salix babylonica*) may provide public amenity, and some ecological value, as say nesting sites, erosion prevention and protection from predators, and can be retained, it is important to ensure that they do not spread, and ideally that no more are planted and indigenous trees planted in their place.

Weed species		
Common name	Scientific name	Control method*
African Boxthorn	*Lycium ferocissimum*	S, C
Blackberry	*Rubus fruticosus* spp. agg.	H (immature plants), S, C
Blue Periwinkle	*Vinca major*	H, S
Bridal Creeper	*Asparagus asparagoides*	H
Chilean Needle-grass	*Nassella neesiana*	S
Carpet Weed	*Galenia pubescens*	S
Couch Grass	*Cynodon dactylon*	H, S
English Ivy	*Hedera helix*	H (immature plants), S (immature plants), C
Fennel	*Foeniculum vulgare*	H (immature plants), S (immature plants), C
Gorse	*Ulex europaeus*	H (immature plants), S (immature plants), C
Kikuyu Grass	*Pennisetum clandestinum*	H, S
Madeira Vine	*Anredera cordifolia*	H (immature plants), S (immature plants), C
Montpellier Broom	*Genista monspessulana*	H (immature plants), S (immature plants), C
Panic & Annual Veldt Grass	*Ehrharta erecta* & *E. longiflora*	H, S
Patterson's Curse	*Echium plantagineum*	H, S
Serrated Tussock	*Nassella trichotoma*	S
Spear Thistle	*Cirsium vulgare*	H, S
Sweet Briar	*Rosa rubiginosa*	S (immature plants), C
Sweet Pittosporum	*Pittosporum undulatum*	H (immature plants), S (immature plants), C
Wandering Tradescantia	*Tradescantia fluminensis*	H, S
Willows***	*Salix* spp.	S (immature plants), C

Table 8. Priority weeds and recommended control methods (Boroondara City Council 2018: George and Erickson 2007: Yarra City Council 2013).

5.3.6

Pest Animal Control

Pest animal control is largely outside of the scope of this guide, though is essential for successful regeneration projects.

A brief summary of the three most common pest animals encountered along the Yarra (rabbits, foxes and cats) is given below.

Rabbits

Rabbit monitoring is essential prior to any site selection or restoration activity, as rabbits can cause dramatic and ongoing degradation, and frustrate any regeneration work. The extent of the infestation by rabbits can inform site selection and the site plan. Monitoring can include the recording of scats, diggings, grazing and sightings. These records can be used to advocate to land managers for pest control programs. If the rabbits need to be controlled on the site, it is best done in cooperation with neighbouring properties as part of an ongoing integrated plan. Parks Victoria has a staged program for removal of rabbits in the Yarra corridor. As part of the site plan, surface harbour such as woody weeds and man-made materials can be removed, and the hand-collapsing of warrens (with or without fumigation).

Information on initiating and implementing rabbit control programs is available at the link below.

http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-animals/invasive-animal-management/established-invasive-animals/integrated-rabbit-control-in-urban-and-semi-urban-areas

Foxes

Foxes have a significant impact on native wildlife. Easy targets include most ground-dwelling mammals, while birds, possums, lizards, beetles and other insects are often consumed. Foxes are also known carriers and spreaders of weed seeds.

Like rabbits, control of foxes requires an integrated approach coordinated with landowners in the surrounding area. The major methods of fox control include shooting, soft-jaw trapping and baiting by a licensed pest controller. All of these methods need to be undertaken by appropriately skilled and qualified personnel. They must have appropriate training and certification regarding baiting. They also need to use their skills and experience to choose the most appropriate control methods.

Information on initiating and implementing fox control programs is available at the link below:

http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-animals/invasive-animal-management/established-invasive-animals/integrated-fox-control-for-urban-and-semi-urban-areas

Monitoring for foxes is the first step in managing the fox problem. Scats, diggings and sightings can be recorded. Community groups can use this evidence to encourage land managers to implement a fox-management program. Where a den is identified, it can be collapsed if that is safe and it does not damage the immediate area.

With permission of the land manager, the engagement of a suitably qualified contractor to undertake a management program in conjunction with adjacent landholders may be part of the site plan.

Cats

Cats (both domestic and feral) are perhaps one of the most complicated issues affecting biodiversity in the urban landscape of this area of the Yarra River, and this is largely outside of the scope of this guide. More information is available at the link below.

http://agriculture.vic.gov.au/agriculture/animal-health-and-welfare/animal-welfare/humane-vertebrate-pest-control/humane-cage-trapping-of-domestic-unowned-and-wild-cats

Image 37. Vegetation near Wallen Road bridge. Anthony Despotellis.

5.4
Monitoring

The following sections present three simple monitoring methodologies (vegetation cover, photo points and bird censuses), which can be established and conducted relatively easily and efficiently, while still providing useful data for both informing adaptive management and presenting success stories to others.

It is acknowledged that many of these monitoring methodologies measure long-term changes in sites that land managers are likely to be aware of (or in many cases already conduct these methods). However, quantification of these changes is useful where positions change and new staff come on board existing projects, or where data needs to be presented externally.

Definitions of Monitoring and Sampling Areas

To discuss monitoring, we define two terms that are often used interchangeably, but for the purpose of this guide are useful to use separately:

Monitoring area

A monitoring area can be defined in many ways, and may be a whole reserve, isolated vegetation patch, or even a discrete group of plants such as a garden bed. Choosing how to define monitoring areas largely depends on the project being monitored, though this process is usually somewhat intuitive.

For example, in large reserves where weed control is being undertaken across the site, the whole reserve is an appropriate monitoring area. In smaller projects where the scope is simply to plant a few separated areas of trees with some understorey shrubs, these individual areas could become the monitoring areas.

The most important thing to consider when defining monitoring areas is that the impact of the works will be seen across whole monitoring area. For example, if the goal is to plant shrubs through a reserve to increase bird habitat, then monitoring the whole reserve is appropriate as bird activity is likely to increase throughout. If the goal is to reduce the cover of weeds next to management tracks, then a monitoring area of say 5m either side of all tracks may be more appropriate.

The monitoring area for two or more goals may be defined differently for different parts of the site. For example, it may be useful to monitor birds over a whole reserve, but plantings in only discrete areas where they actually occur.

Sampling area

This is where the actual data is collected, and often involves vegetation quadrats or transects. It can be useful to break up monitoring areas into smaller sampling areas in order to be able to accurately and efficiently collect data, which can then be extrapolated to the monitoring area as a whole.

For example, if weed cover is being monitored in a 1 ha reserve, then establishing ten 5 x 5m sampling areas in which to monitor weeds each year would be much more efficient than trying to estimate cover across the whole site.

In summary, the monitoring area is the entire area that regeneration works aim to influence, and the sampling area is the location in which representative data is collected.

Box 19. Definitions of 'monitoring' and 'sampling' areas for the purpose of this guide.

5.4.1
Vegetation Cover

Monitoring vegetation cover is perhaps the most commonly used methodology in ecological science, and translates perfectly to ecological regeneration projects.

Estimating vegetation cover over large areas is difficult and impractical. Consequently, it is common practice to break up a site into smaller areas. Once the monitoring area/s have been chosen (Box 19 on page 105) sampling areas should then be defined. While defining sampling areas (Box 17) using other criteria is perfectly appropriate, the Association recommends the following protocol:

For monitoring areas <500 m^2 (0.05 ha) the sampling area can cover the whole site; and

For monitoring areas >500 m^2 (0.05 ha) establish one 25m^2 (i.e. 5 x 5m) quadrat per 250m^2 (i.e. 10 % of the monitoring area is sampled). This is considered ideal, but could be reduced if budgets don't allow.

This size of this quadrat has been chosen as the larger size means sampling errors due to changes in where the edge of the quadrat are placed over the years is reduced, and it allows a representative sample of 10% of the monitoring area.

Please note that it is not necessary to physically mark out the edges of the quadrat (although this may be useful) but simply to mark each corner. However, it is essential to accurately record (or mark) the corner of each quadrat for ease of replication. This can be done with a GPS and ideally marked with star pickets, though additionally measuring distance from certain landmarks can be useful.

In order to standardise and make efficient the placement of each quadrat (as well as to tie in with the photo points below), we recommend defining and placing the corners in the following way:

Corner 1: NW from the centre;

Corner 2: NE from the centre;

Corner 3: SE from the centre; and

Corner 4: SW from the centre.

Data to record

Vegetation cover can be estimated using projective foliage cover i.e. the area that would cast a shadow if the sun was directly overhead, to the nearest 10% increment (as estimating vegetation cover to smaller increments is not possible to do accurately).

The following data should be collected for each area:

1. Sampling area details (site, revegetation area number, date, and name of recorder);
2. Indigenous vascular plant cover broken down into:
   a. Ground-layer cover*;
   b. Shrub layer cover**; and
   c. Tree layer cover.
3. Bryophyte and lichen cover;
4. Weed cover broken down into:
   a. Total weed cover; and
   b. High threat weed*** cover
5. Leaf litter cover; and
6. Bare ground cover.

*Includes grasses, rushes and sedges, ferns, herbs and forbs, and prostrate shrubs as defined in Box 1 on page 16.

**All shrubs excluding prostrate shrubs – which are included in the ground-layer.

***High threat weeds defined as those with high invasiveness and impact, for example Kikuyu *Pennisetum clandestinum* and Carpet Weed *Galenia pubescens*, often called 'transformer weeds' as they can alter vegetation composition, and prohibit germination and growth of indigenous species. This does not include ruderal annuals and exotic Wood-sorrels Oxalis spp., which do not usually transform sites, but rather colonise bare ground and disturbed areas.

Replicating surveys and analysing data

Ideally, surveys should be replicated every year (including a baseline survey before works begin).

Statistical analyses such as linear regression could be completed using this data, but for the purposes of this guide simply identify trends is considered more than adequate.

Data should be collated into a spreadsheet, and can be presented graphically such as in Figure 11 (easily created in Microsoft Word or Excel) below.

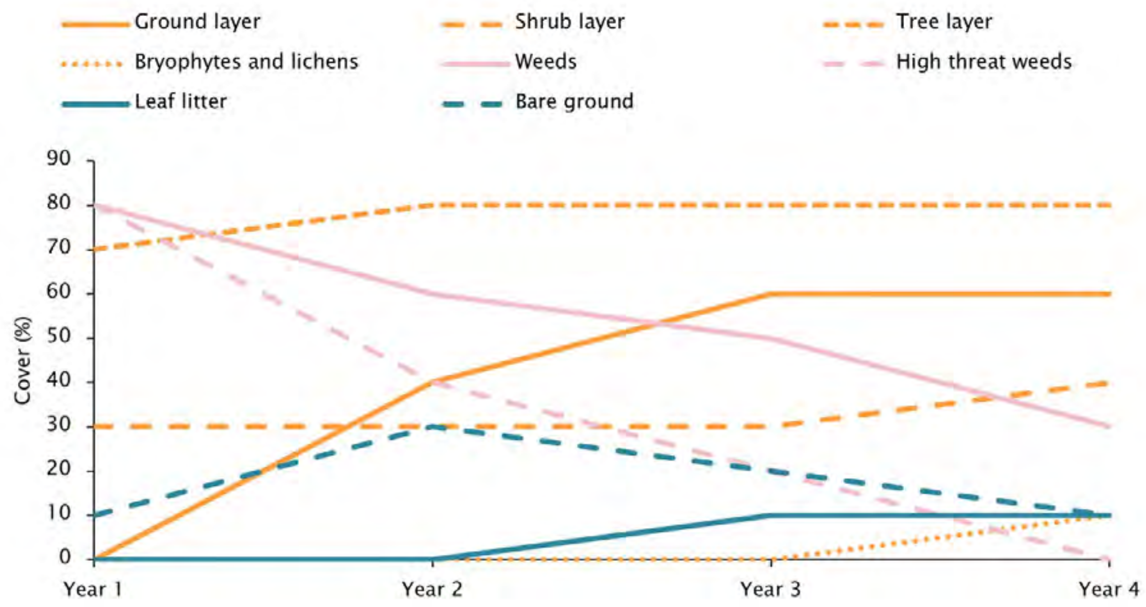


Figure 11. Theoretical representation of how to display vegetation cover data.

Image 38. Yarra River. Anthony Despotellis.

5.4.2

Photo Points

Photo points are a simple yet extremely useful tool for tracking changes in a site over time and are especially useful when presenting the progress of revegetation works to stakeholders or other interest groups.

As with vegetation cover, it is appropriate to establish photo points in a number of way. However we suggest the following:

For monitoring areas <500m^2 (0.05 ha) establish one or two photo points in a spot with fixed landmarks (where possible such as a building or other infrastructure, or otherwise something such as a tree or rock) visible in the frame and record the location. It may be additionally useful to mark the location and direction with a star picket if the spot could be hard to relocate; and

For monitoring areas >500m^2 (0.05 ha) establish four photo points at each 25m^2 (i.e. 5 x 5m) quadrat, with one taken from each corner facing the centre in the following arrangement:

Photo Point 1: from Corner 1 (NW from the centre) facing Corner 3 (SE);

Photo Point 2: from Corner 2 (NE from the centre) facing Corner 4 (SW);

Photo Point 3: from Corner 3 (SE from the centre) facing Corner 1 (NW); and

Photo Point 4: from Corner 4 (SW from the centre) facing Corner 2 (NE).

Data to record

Replicating the photo points as often as possible is always best, but for efficiency once a year is recommended, at the same time as the vegetation cover surveys.

5.4.3

Bird Census

The Survey Techniques developed by BirdLife Australia (2020) are a standardised set of methods that are easily applied and used, and are the most appropriate for bird monitoring at sites along the Yarra. Additionally, data can be recorded on a mobile phone using the Birdata app, making it easily accessible.

Defining the sampling area

For projects along the Yarra, two types of bird surveys are the most appropriate. For sites less than 2 ha, the fixed route monitoring methodology is the most thorough, while at sites greater than 2 ha, the 2 ha, 20-minute systematic bird survey is thorough yet not onerous. A breakdown of these methods is given below. For a detailed breakdown of the Survey Techniques from BirdLife, see: birdata.birdlife.org.au/survey-techniques.

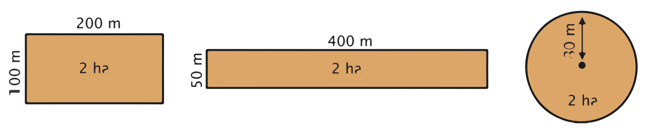
Control sites

In addition to the monitoring area, it can be useful to set up control sites (i.e. sites where no regeneration works are occurring) if rigorous data is needed. Control sites should be similar in size, vegetation type, quality, human activity, and location to the regeneration site being monitored. By using a control site, it makes it clearer to see exactly what effect the regeneration works have, and which changes in bird activity might be due to seasonal or yearly variations.

Image 39. Gang-gang Cockatoo. Anthony Despotellis.

2 ha, 20 minute systematic bird survey

"This involves searching for birds in a two-hectare area for 20 minutes. The recommended shape for the two hectares is 100 x 200m. You can use other shapes, such as a circle with a radius of 80m, or a strip 400m long x 50m wide. Only record birds within the two-hectare area (though see Embedded Survey below). Birds flying over the search area should be included.



Do not automatically choose a site which yields the most birds. On occasion choose a site where birds may not be as prevalent. This provides [BirdLife Australia and managers] with a good cross-section of data.

Try to introduce a degree of randomness into your site selection. A good way to do this is to choose a site on a map before you arrive so your choice will not be influenced by the surroundings. You could also randomly choose from sites with similar habitat and management conditions.

Your site should be representative of the particular habitat you are surveying. As much as possible, avoid mixing habitat types (e.g. half grassland/half forest, or half grazed/half ungrazed) in the same 2 ha search area. If you are surveying two nearby 2 ha areas on the same day, make sure that the centre of the two areas are at least 400m apart, so there is no overlap between them.'

- BirdLife Australia (2020).

Fixed-route monitoring

"This method allows you to conduct repeat surveys at your favourite birding spot. It doesn't matter where it is – your local park, a wetland, a patch of forest or a paddock. All you have to do is register your survey site, establish a birdwatching route through it and count the birds that you see along the way. It's easy, but there are a few simple rules to keep your surveys consistent:

Make sure you keep to the same route on each survey (it can be as long as you like).

Conduct your surveys at the same time of day.

Take the same amount of time to do each survey.

Ideally, conduct your surveys once a month.'
– BirdLife Australia (2020).

Frequency of Surveys

Ideally, bird surveys should be performed once a month to gather comprehensive data which takes seasonal variations into account. However, this is not always possible, and therefore performing surveys once each in Spring, Summer, and Winter can give an indication of bird activity at a site.

How long this monitoring will extend for is largely dependent on the goals being monitored. However, it is unlikely that any changes in bird activity will occur within the first year or two of regeneration works.

Analysing data

The two most efficient ways to quantify and analyse the data are:

1. Species richness (the total number of indigenous bird species); and

2. Abundance (the total number of indigenous bird individuals).

Additionally, other measures such as species evenness and diversity may be useful for more complex analyses, but these are not further discussed here. Statistical analyses such as linear regression could be completed using this data, but for the purposes of this guide simply identify trends is considered more than adequate.

Data can be collated into a spreadsheet, and can be presented graphically such as in Figure 12 (easily created in Microsoft Word or Excel) below.

In addition to the numerical analyses, it can be worth looking at the data and asking more general questions such as:

Which bird species have changed in their abundance? Is this due to planting a certain species?

Is one particular group of birds dominating the site and are resources too homogenous?

Are exotic birds over-represented, and is this an issue that should be addressed?

Are birds just using the site for feeding and are roosting and nesting sites available?

Is a certain guild such as ground-foraging insectivores absent and, if so, how can resources for this guild be improved?

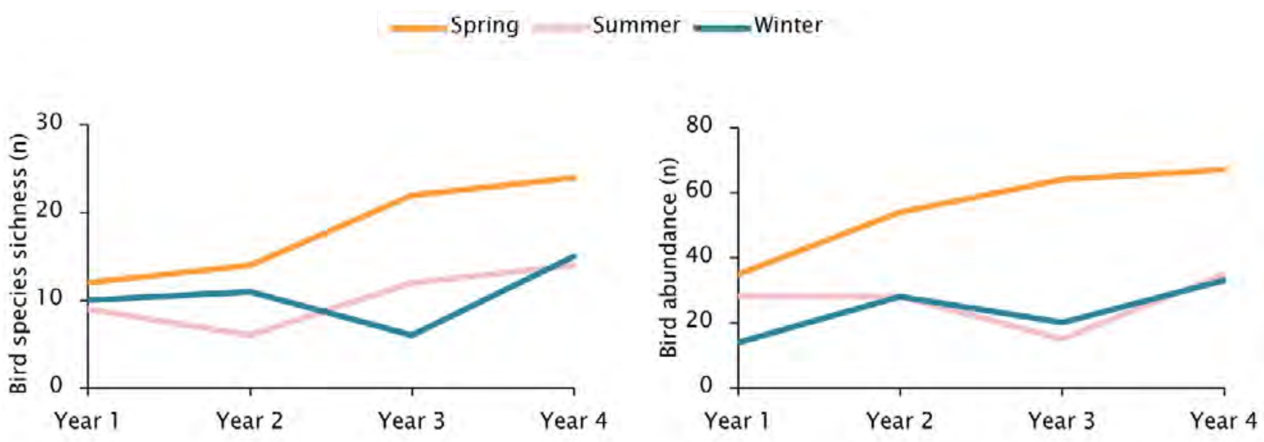


Figure 12. Theoretical representation of how to display bird monitoring data.

5.4.4

Other Monitoring Methodologies

While the three methodologies already discussed are the most efficient to use over a wide variety of sites, some examples of other monitoring methodologies could include:

Survival of planted trees and shrubs (especially useful if the monitoring timeline is limited and an increase in tree or shrub layer cover is not expected within the timeframe);

Detailed vegetation surveys in addition to the vegetation cover surveys, collating a comprehensive species list to show changes in species richness;

Reptile monitoring (though this is best performed by or in partnership with a professional due to safety concerns);

Microbat monitoring (though, as above, this is best performed by or in partnership with a professional due to safety concerns as well as animal welfare considerations);

Frog monitoring (especially in riparian habitats) – see Melbourne Water's Frog Census description at https://www.melbournewater.com.au/water-data-and-education/get-involved/be-citizen-scientist/frog-census;

Spotlighting surveys for nocturnal mammals and birds.

Image 40. Westerfolds Park. Stewart Marshall.

5.5
Maintenance

Maintaining a site for many years after revegetation or other works is necessary for successful regeneration. Whether weed control, nest box maintenance or planned burning, it is essential to consider if a site can be maintained after the initial works. Generally, these types of works will be similar to those described in Section 5.3.

Perhaps most relevant here is if regeneration works are performed on a site by one party (e.g. a Friends group) and will be later handed over to another party (e.g. local council), that the receiving party is consulted early on in the process. Local councils often have well-planned and tightly resourced maintenance plans, and it is essential to ensure that any extra sites can be incorporated and, if not, adjustments to the project design considered.

External Climate-proofing Resources

Greening Australia's Climate Proofing Australia available at:

https://www.greeningaustralia.org.au/what-we-do/climate-proofing-australia/

Society for Ecological Restoration Australia's National standards for the practice of ecological restoration in Australia Appendix 3 Genetics, fragmentation and climate change – implications for restoration of local indigenous vegetation communities (page 39) available at:

http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf

A number of reports and papers linked from the CSIRO's Ecological engineering for biodiversity adaptation to climate change available at:

https://research.csiro.au/biodiversity-knowledge/projects/ecological-engineering-biodiversity/

5.5.1
Climate Change

Building resilience for a changing climate

Climate change is the greatest biodiversity threat in historic memory. The Yarra River covers a sequenced range of latitudes and elevations. The area has excellent potential for climate-proofing, such that species can move up and down the river corridor. It is also still a connected parkland above Princes Bridge.

Currently, regeneration planning for the impacts of climate change are in the experimental stage, although well-known ecological principles can be applied. For example, it is well known that plant species are variously adapted to their respective 'climate envelopes', and that within a species there can be a range of genetic variation related to climate adaptations.

As a result of climate change, species' climate envelopes are projected to move either longitudinally (in the case of the Southern Hemisphere – South) or altitudinally (higher in elevation). Along the Yarra River, this means that climate envelopes will move either downstream, or up the banks.

The most practical (and widely used) method for climate-proofing ecosystems is to include genetic material from 'future climate envelopes' i.e. north-east in revegetation projects. For the Yarra,this may mean collecting seed from provenances to the north of the actual planting site, whether from areas further upstream on the Yarra, or from similar vegetation communities in other areas.

The Association does not set out concrete instructions for climate-proofing the Yarra here, but rather highlights the importance of this process. Additionally, the Association flags that collaboration with academic institutions may be the best path forward in this situation, to both bring resources, as well as the capability to rigorously analyse results of this emerging practice and communicate them to the wider scientific and land management communities.

Climate envelope

The climate range in which a species currently exists can be referred to as its 'climate envelope'. During climate change this climate envelope is likely to uncouple from the current location in which the species exists and, where conditions become hotter, move further poleward or to higher elevations. This means that the species may be lost from the more equatorial extreme of the range and need more help to adapt as it, or its genotypes, move poleward or to higher elevations. However, as precipitation is likely to change in less predictable ways, it is likely that the displacement of climate envelopes will be more complex.