Yarra River Regeneration Guide

Cremorne Railway Bridge
to Westerfolds Park

Yarra River Ecological Regeneration Guide

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Note about authorship:

This guide was commissioned by the Yarra Riverkeeper Association from Practical Ecology and the core of the practical advice was provided by the consultants. The thinking underpinning the guide has been the work of the Yarra Riverkeeper, and the Association takes responsibility for the approach to regeneration (or restoration) taken in these pages.

Opening Words from the Yarra Riverkeeper

This is the first of our guides to regenerating, or restoring, our Yarra river. A lot of thinking has gone into this guide. The thinking behind our use of the word 'regeneration' started with our then president Christopher Balmford's reading of George Monbiot's *Feral: Searching for Enchantment on the Frontiers of Rewilding*. Christopher was enchanted by the vision of a wilder, less managed, less manicured world where people had regained a connection with nature and ecosystems were rich in creatures, and were self-organising and resilient. Monbiot's book led us to Dave Foreman's *Rewilding North America: A Vision for Conservation in the 21st Century* and then to Isabelle Tree's *Wilding: The Return of Nature to a British Farm*. We moved from thinking about rewilding to wilding and finally to regeneration, as the Yarra or Birrarung has been managed for tens of thousands of years by Traditional Owners.

All three books are a response to the Anthropocene, where people have come to dominate the world on a geological scale. There is scarcely a single place now on earth that is not affected by humans. We now need to recalibrate our relationship with the natural world in which we are embedded, of which we are but one part.

For an association that is the community advocate for the whole river corridor, the landscape scale of the wilding or rewilding idea resonated. The idea of regenerating ecosystems on a landscape scale also resonated with the central idea of the Yarra River Protection (Willip-gin Birrarung murron) Act, which river as 'one living and integrated natural entity'.

A seed grant was provided through the Waterkeeper Alliance. We were then fortunate to obtain a grant from the federal government to commence this work and that grant was augmented from other grants from the electoral offices of Kevin Andrews, Katie Allen and Adam Bandt. We are grateful for all these grants.

As an association we are just at the beginning of our regeneration journey. These first sites will deliver real outcomes but they will also create a reservoir of skills both in the community and within the Association. The implementation of this work has been made challenging by the covid lockdown, and I would like to acknowledge the efforts of the staff in keeping our regeneration project moving forward in such difficult times.

I take this opportunity to acknowledge the fantastic work done by Friends groups on the river since 1970s. They are a reservoir of knowledge. A significant portion of the river and its tributaries have been replanted since the first Friends group formed. Friends show the power of the community to deliver net gain for our environment.

Andrew Kelly, Yarra Riverkeeper

Acknowledgement of Country

The Yarra Riverkeeper Association acknowledges that the lands and waterways of the Yarra Catchment and beyond, are the unceded territories of the Wurundjeri Woi Wurrung people. We pay our respect to their Ancestors, who cared for Country since time began, and to all Wurundjeri Woi Wurrung community, to all the Kulin Nation, to all Traditional Owners, who continue to speak and care for their Country. We acknowledge that the river now called the Yarra has always been known as the Birrarung by its custodians.

Practical Ecology acknowledges the Traditional Custodians of the land, the Wurundjeri Woi Wurrung people of the Kulin Nation, on which our office is located. We pay our respects to their Elders, past and present. We also acknowledge the Traditional Custodians of the lands on which we conduct our business throughout Australia. We pay our respects to their Elders, past, present and emerging, and the Elders of other communities who may be present on those lands.

Prior to the invasion and subsequent colonisation of Naarm (Melbourne), the area around the Birrarung (Yarra River) was and remains culturally significant to the Wurundjeri people. The connection to places along the Birrarung extends back to the Dreamtime.

To learn more about the Country of the Birrarung, contact Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation through their website: https://www.wurundjeri.com.au/

This guide does not presume to summarise or appropriate the knowledge of First Nations people, but here highlights the importance of listening and collaborating throughout regeneration planning in both this area and throughout the country.

Contents

Image 1. Wombat, photographed by Corentin Massuyeau

1

Introduction

This practical guide is designed to assist the Yarra Riverkeeper Association and its partners in the implementation of its vision for the ecological regeneration of the Yarra (Birrarung) River corridor from the mountains to the bay.

The aspiration of the Association's vision is for the ecological integrity and ecological functioning of the river corridor to be regenerated for the whole length of the river. It is a long-term vision of a river that is self-organising and made-up of a functioning series of interconnected ecosystems that reflect soil, position, aspect and climate, and which require a minimum of maintenance and interference.

This guide is based in good part on the second edition *National Standards of Ecological Restoration* (*National Standards)* and is also informed by the second edition of the *International Principles and Standards of Ecological Restoration* (*International Principles*). As a more recent document, the *International Principles* is informed by and extends the thinking in the Australian *National Standards*. The International Principles in particular have useful additional principles.

The Association uses the term 'regeneration' rather than 'restoration'. Restoration begs the question: restoration to what state? There is also a possible implication in the term 'restoration' of a restoration to a wild natural state, without the presence of humans in the ecosystems. Yet the landscape of Australia has been managed by Traditional Owners for tens of thousands of years.

Settlement has in good part interrupted that management, particularly interrupting the use of the primary tool of cool burning. The landscape of the Yarra catchment has been altered so radically that the landscape cannot now be returned to what it was in 1835. The ecological functioning and integrity though can be returned. Self-organising ecosystems that are resilient and have a high degree of naturalness can be encouraged to develop.

The word 'regeneration' is more open-ended than 'restoration'. Regeneration is about the operation of processes rather than a defined outcome. The term acknowledges that trajectories are unpredictable. Regeneration also aligns with the ideas of regenerative farming, and that is appropriate as much of the Yarra Valley is now farmed. Regenerative farming is a system of farming principles and practices that rehabilitates the farm as an entire ecosystem with an emphasis on soil health but also considering water Management and indigenous vegetation.

The Association acknowledges that the word 'regeneration' is used in particular ways in the restoration literature. It is most often linked with the regeneration of the seedbed, natural or assisted. It is also an approach identified in Principle 2 of the *National Standards*. The Association uses 'regeneration' more broadly.

The Association has commenced its regeneration work by identifying seven trial sites on the lower Yarra to replant, and to maintain and monitor. The work on these sites will be a testing ground for the future implementation of the Association's vision. The work will build the Association's capacity to deliver its vision by embedding knowledge and experience.

The Association's work also aligns with the declaration of the United Nation's Decade on Ecosystem Restoration. The decade begins in 2021.

This guide encapsulates the goals, values, and processes that the Association wishes to include and utilise in our approach to restoration work.

The Association's thinking around its regeneration vision for the Yarra has four key components:

1) ecologically healthy cores, such as nature reserves, parks and national parks on the river,

2) ecologically healthy corridors that connect these cores, which allows migration of species upstream and downstream in response to climate and urbanisation pressures,

3) a landscape-scale view of the Yarra that treats the river as 'one living and integrated natural entity' (Yarra River Protection [Willip-gin Birrarung murron] Act), and

4) a focus on enhancing the ecological processes (and therefore ecological integrity) of the river corridor.

Ecosystems are always dynamic, sometimes changing slowly and sometimes quickly. The arrival of European settlers created a period of rapid change in which the ability of ecosystems to retain ecological robustness and ecological integrity was compromised. Connections and flows between ecosystems were interrupted. The deep learnings of Traditional Owners about the landscape were ignored and their careful management of Country interrupted. It is not possible to return the landscape of the Yarra catchment to what it was in 1835 when the *Enterprize* sailed up the Yarra with its load of European settlers. However, the ecological integrity of the Yarra corridor can be returned by restoring robust ecological processes. The use of the term 'regeneration' was influenced by the rewilding work of Dave Foreman in the US and the wilding work of Isabella Tree and Charlie Burrell in the United Kingdom at the Knepp estate. They in turn have been influenced by and have influenced many others.

The Yarra catchment has been managed by the Wurundjeri Woi Wurrung for tens of thousands; so, though the Association supports more 'nature' being created in the catchment, it is not appropriate to refer to rewilidng or wilding. Instead of using either of these two words the Association has taken up the suggestion of Tom Frawley, then the Association's Stewardship Officer, and replaced 'restoration' with 'ecological regeneration' or simply 'regeneration' The Association acknowledges the influence and value of the work done through the lens of restoration.

The practical work in this guide is based on the second edition of the *National Standards* produced by the Society for Ecological Restoration Australasia (SERA). The *National Standards* provide a high-level conceptual framework for the structure of this guide. They are a reference rather than a road map. The second edition of the *International Principles* produced by the Society for Ecological Restoration (SER) also guides our work. There are principles and additional thinking in the *International Principles* that align with the Association's thinking around ecological regeneration. This alignment includes a clearer acknowledgment that landscapes are cultural as well as natural. That is appropriate in Australia where the landscape has been managed for tens of thousands of years.

A concern for the Association is that the Ecological Vegetation Classes (EVCs) used under the *National Standards* do not clearly recognise the ongoing role of management of the landscape over tens of thousands of years by Traditional Owners in the Yarra catchment; and the need for this management to be ongoing if an EVC's condition is to be maintained. The Association is using the EVCs as a guide for planting and the regeneration of habitat, and seeks to introduce as full a range of species as possible. The key role of regular cool burns is not usually possible in urban settings, so the outcomes of the plantings will follow a different trajectory to what might have been established following similar plantings in 1835.

This guide also takes into consideration the thinking in the *International Principles* of a reference model, derived from several ecologically appropriate reference ecosystems, as the target condition of the site planting and maintenance, which acknowledges that ecosystems are dynamic and trajectories uncertain.

Any target condition of regeneration requires that ecosystems have robustness and complexity, have ecological integrity, and deliver the key ecological services not only to people but to the variety of species in the catchment, with a minimum of human interference.

In establishing a target condition for the regeneration of a site, the Association is seeking an environmental net gain for the Yarra corridor. A net gain is a reflection of the Association's commitment to stewardship which means leaving a place in a better state. Net gain is a theme in the *International Principles,* which state, among other references to net gain: 'Consequently, ecological restoration programs, whether mandatory or voluntary, should strive to do more than seems necessary to secure overall net gains of biodiversity and ecosystem services.' The *International Principles* also state: 'Ecological restoration therefore promises a net gain in extent and functioning of native ecosystems, together with the delivery of critical human wellbeing benefits.'

Currently the EVCs are the best guide as reference models for the target condition of the ecosystem being regenerated. The creation of a reference model is an exercise in adaptive management, and the target conditions will be modified as more is learned. The Association is on a journey to evolve reference models that are informed by the EVCs, that respect and incorporate Traditional Owner knowledge, are supported by growing on-ground community knowledge and experience, and are achievable at a landscape scale

This guide is a beginning of a river journey, as the Association learns more about the Birrarung and its hinterlands. This is the first of several guides to be produced by Association. Future guides will cover stretches of the river both upstream and downstream of the study area.

Note: The complete document of the second edition of *the National Standards for the Practice of Ecological Restoration in Australia* is available at:

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

The complete document of the second edition of the second edition *International Principles and Standards for the Practice of Ecological Restoration* is available at:

https://www.ser.org/page/SERStandards/International-Standards-for-the-Practice-of-Ecological-Restoration.htm

1.2

Study Area

The study area for this guide covers the stretch of the Yarra River from the Cremorne Railway Bridge just west of Herring Island, upstream to Fitzsimmons Lane at the eastern edge of Westerfolds


Image 7. Burnley regeneration site, Anthony Despotellis

The study area includes green open space directly adjacent to the Yarra, extending into golf courses, reserves, parks, and low-density urban developments.

The division of the Yarra into reaches while useful is arbitrary and based on the purpose of different river managers and particular reports. The study area overlaps the Lower Yarra and the Middle Yarra reaches under most management divisions of the river into reaches.

The Association now prefers to consistently use the division into the reaches applied in the *Community Vision for the Yarra.*

The writing of the *Community Vision* was required by the Yarra River Protection (Willip-gin Birrarung Murron) Act. The vision was developed by the community under the guidance of Melbourne Water as lead agency. The vision is included as an appendix to the guide.

Of the reaches used in the *Community Vision*, The study area covers part of the Inner-City Reach (which ends at Dights Falls) and part of the Suburban Reach (with Westerfolds Park falling more or less at the halfway point of this reach). The reaches reflect a combination of changing geomorphologies and also intensity of development.

The choice of the lower endpoint of the study area reflects a pragmatic decision by the Association, as it was successful in applying for a number of grants, including a Federal Restoration Grant, that delimited that endpoint.

While the lower border is somewhat arbitrary, the river corridor below the lower boundary shows increasing intensification of development that reduces the width of the green verge of the river downstream of the Cremorne Railway Bridge. There are few naturalistic areas below the Cremorne Railway Bridge until Westgate Park on the other side of the city. The last great area of naturalistic green space is the Herring Island/Loys Paddock/Como collection of parklands, which is upstream of the Cremorne Railway Bridge.

The study area is urban. Melbourne was settled by Europeans in 1835 and the city grew quickly. The river corridor is more intensely urban at the downstream end, reflecting the inner city's history of dense residential and industrial development.

There are still substantial open spaces below Dights Falls, with contiguous green space running along the river. Above Dights Falls the corridor opens out into significant public parklands and golf courses. The lower part of the study area has developed urban characteristics, with moderately intensive residential and industrial development dating from the 1800s among substantial parklands with significant natural areas and remnant habitats in many areas. Above Fitzsimmons Lane, the river has the extensive Yarra Valley Parklands and newer suburban neighbourhoods distant from the river.

The river is predominantly freshwater, with Dights Falls as the hard boundary between salt and fresh water. The end of the saltwater wedge of the estuary typically fluctuates around the Johnston Street Bridge. Prior to the arrival of European settlers, there was a rock bar at site of Queens Bridge which prevented saltwater coming upstream. This bar was blown up in the 1870s to enable the river to be navigated upstream and to assist in flood control. The riverbanks are either broad, wide flood plains with some of the original billabongs remaining and floodplain vegetation supported by flooding or groundwater in the alluvial deposits, or steep escarpments with drier ecosystems. The dominant tree along this reach of the Yarra is the Red Gum *Eucalyptus camaldulensis* but upstream of Fitzsimmons Lane the flood plains are narrower, with more mudstone and sandstone escarpments lining the banks and Manna Gums *Eucalyptus viminalis* being the dominant tree.

The study area is a river reach of opportunities for restoring ecological function to the river. The riverbanks were rapidly cleared after the first European settlers arrived from Tasmania on the *Enterprize* in 1835. As demand for timber lessened, the floodplains and river escarpments were allowed to re-vegetate. Some of this secondary regrowth is now well over 100 years old. This secondary regrowth is mainly woodland trees and some areas have retained remnant undergrowth and groundcover vegetation. There has been extensive replanting of indigenous species, particularly of trees by community groups, Melbourne Water, Parks Victoria, local councils, and by developers, when required by a planning permit, in the study area. The study area provides an opportunity, as the river retains a strip of varying width of green space on both sides of the river and the parklands periodically bell out into substantial parklands. The river corridor parklands are bordered by residential suburbs that provide the community support for regenerating the river. The corridor retains a canopy of almost continuous native species, mainly eucalypts. Many of these trees are yet to fully mature and the river corridor will be enhanced as they do. The river, and the study area, provide a significant opportunity to build on the work of the past and create robust connected ecosystem along the river frontage.

1.3 Purpose of this Guide

The purpose of this guide is to provide a guide to the Yarra Riverkeeper Association in the work in this reach of the river in wilding or rewilding the river to fulfill their long-term vision of a healthy, protected and loved river.

The regeneration work of the Association aligns with Melbourne Water's *Healthy Waterways Strategy 2018–28* and reflects the *Yarra River 50 Year Community Vision* See appendix 3 and it mirrors the vision of the Yarra River Protection (Willip-gin Birrarung murron) Act which sees the river as 'one living and integrated natural entity'. This guide also acknowledges the vision of the Wurundjeri people of the Yarra catchment in *Nhanbu narrun ba ngargunin twarn Birrarung: Ancient Spirit and Lore of the Yarra*. Further it recognises the work of the Wurundjeri Woi wurrung Tribe Land Council's Narrap team in building connection to Country and in healing Country.

This report is also a guide for the Association's partners, including community partners, along the river who are also working to regenerate the environment, environmental services and ecological utility of the Yarra and its corridor. This guide will be useful for land managers, both public and private, as well as for landowners and other stakeholders along the Yarra River including golf courses, urban planners, owners corporations with Yarra River escarpments as part of their responsibility and even members of the public with small or large gardens adjacent to reserves and the river.

The restoration guide provides principles that can be consistently applied in ecological restoration and maintenance projects to build further habitat improvement on the existing qualities of the river corridor and to resist further degradation. An important function of this guide is to provide consistency for ecological regeneration or restoration work along the Yarra. A critical aspect of this function is to establish a series of reference models that can inform targets for projects along the river.

Of particular focus throughout this guide is the importance of long-term planning aided by monitoring, evaluation and collaboration. The *National Standards* and *International Principles* have been re-framed within the guide to be applied appropriately to a highly modified urban river, and are combined with local ecological information and context to support a consistent approach across all land tenures.

Definitions of Different Vegetation Layers

This guides refers to various 'layers' or 'strata' of vegetation, to easily group plants into structural groups. While various words are used, the three main terms used are 'tree layer', 'shrub layer', and 'ground-layer'. 'Climbers' are referred to separately, as by definition they occur across the three previous layers. It is important to note that not all ecosystems naturally contain all of these layers, and some ecosystems contain more definable layers. Restoration of all three is not always appropriate or achievable. Connectivity should be considered at all available layers. The key layer to begin with is the canopy layer. Species will move up and down the layers during the day, perhaps choosing safe roosting spots at night, while feeding in the shrub layer during the day. Connectivity of the canopy layer is what constitutes an urban forest. The other layers can be just as important. A healthy ground-layer, and associated leaf litter, is a nursery for regenerating seeds and protects against weed invasion. A target condition needs to consider all layers.

Tree Layer

Sometimes referred to as the 'overstorey' (Commonwealth English), 'overstory' (American English), 'canopy layer', or 'upper layer'.

Refers to the uppermost layer of vegetation, on the Yarra this is usually trees of the Eucalyptus genus, though sometimes She-oaks *Allocasuarina* spp. or tall Wattles *Acacia* spp. such as the Blackwood *Acacia melanoxylon*. Where appropriate, we may break this down into two groups:

Canopy layer: The tallest species in the tree layer, almost always *Eucalyptus* spp.; and
Sub-canopy layer: Trees that occur in a lower strata within the tree layer such as She-oaks and tall Wattles.

Shrub Layer

Sometimes referred to as the 'middle storey' (Commonwealth English) 'middle story' (American English), or 'middle layer'.

Refers to plants in the vertical 'middle' of vegetation. On the Yarra this is often shrubs such as Sweet Bursaria *Bursaria spinosa*, Hopbush *Dodonaea viscosa*, Tree Violets *Melicytus dentatus* and shrubby Wattles such as Hedge Wattle *Acacia paradoxa*.

Where appropriate, we may break this down into two groups:

Large shrubs: Shrubs that grow roughly to and above head-height such as Tree Violets and Sweet Bursaria; and
Small-medium shrubs: Shrubs that stay lower to the ground such as Hop Goodenia *Goodenia ovata*. This does not include prostrate shrubs such as Berry Saltbush *Atriplex semibaccata*, which are included in the ground-layer.

Ground-layer

Sometimes referred to as the 'understorey' (Commonwealth English), 'understory' (American English), 'underbrush' or 'undergrowth'.
Refers to the lowest growing plants which are extremely diverse and include grasses such as Common Tussock-grass *Poa labillardierei*, herbs, and prostrate shrubs such as Creeping Bossiaea *Bossiaea prostrata*. Most plants in the ground-layer fall into the following groups:

- Grasses such as Common Tussock-grass;
- Rushes and sedges such as Wattle Mat-rush *Lomandra filiformis* and Tall Sedge *Carex appressa;*
- Ferns such as Austral Bracken *Pteridium esculentum* and Maidenhair Ferns *Adiantum* spp.;
- Herbs and forbs (excluding grasses, rushes and sedges, and ground ferns, which are technically herbaceous) such as Flax-lilies *Dianella* spp., Kidney Weed *Dichondra repens* and Native Bluebells *Wahlenbergia* spp.; and
- Prostrate shrubs such as Creeping Bossiaea *Bossiaea prostrata* and Berry Saltbush *Atriplex semibaccata.*

Climbers

This group of plants cannot be separated by their vertical structure, as by definition they occur throughout the three above layers. Examples of climbers that occur along the Yarra include Small-leaved Clematis *Clematis microphylla* and Purple Coral-pea *Hardenbergia violacea.*

Weeds

When any of the above four vegetation components are referred to in this guide, please note that this refers only to native plant species, and not exotic weeds which could be categorised into these groups (e.g. African Boxthorn* *Lycium ferocissimum* is not included in the shrub layer but is referred to separately). Also, an asterisk(*) is used in front of the scientific name of a recognised weed species to denote exotic or introduced species, as demonstrated in the previous sentence.

Please note that examples from other sources in this report may use other terms than those above.

Box 1. Definitions of different vegetation structures used throughout this guide.

Image 9. This planting next to a bike path in Kew provides both local amenity and biodiversity values. Daniel Miller (Practical Ecology).

Image 8. This bank of the Yarra River in Abbotsford has great potential for enhancement with ground-layer plantings. Daniel Miller (Practical Ecology).

Definitions of 'Vegetation Communities' and 'Native Vegetation'

Vegetation Communities/Ecological Vegetation Classes (EVCs)

Ecological Vegetation Classes (EVCs) are a systematic organisation of plant communities into common types that occur in similar environmental conditions throughout Victoria. Each vegetation type is identified on the basis of its floristic composition (the plant species present), vegetation structure (such as woodland, grassland and saltmarsh), landform (such as gully, foothill and plain) and other environmental characteristics including soil type and climate.

Floristic/vegetation communities refer to groupings of plant species that occur in specific locations based on geology, topography and climate. For example, grassy vegetation dominated by Kangaroo Grass *Themeda triandra*, with no trees, growing on clay soils, on relatively flat land on the basalt plains in Western Victoria can be referred to as the 'Western (Basalt) Plains Grasslands Community' (and is listed as such under the Flora and Fauna Guarantee Act 1988).

Where such floristic/vegetation communities occur in similar forms across wide areas (for example, grassy vegetation with no trees occurring across the state on a mix of geologies), then these communities may be grouped together as Ecological Vegetation Classes (EVCs). In other words, florist/vegetation community is a more specific grouping than EVC.

In the case of this guide, 'vegetation communities' refers to the specific groupings of plants that occur in various location throughout the study area, rather than the generalised EVCs that occur across the state. By ensuring that 'vegetation communities' are used as reference ecosystems, regeneration projects will utilise the best adapted plants possible (i.e. those that naturally occur in the same geologies, topographies and climates of the area being restored).

It is important to note that in many cases, the terms 'floristic/vegetation communities' and 'EVCs' are used interchangeably, but in this guide, whenever groupings of plants are referred to, we are referring to the specific groupings of plants that were naturally occur along the study area of the Yarra River.

For the purpose of this guide we will use the term 'vegetation communities' Please note this is a matter of practical convenience more than strict scientific procedure as it has long been recognised that distinctive 'floristic communities", i.e. vegetation communities with specific characteristic flora species, are considered to be a subset of EVCs.

Throughout this guide, reference ecosystems will be defined based on vegetation communities.

Box 2 continues on page 19

Native Vegetation

There are numerous words used to describe species distributions such as 'native', 'indigenous', 'endemic', and 'cosmopolitan'. The two main terms are 'native', which usually refers to whether a species naturally occurs in a wide area such as a country or continent (e.g. Australia), and 'indigenous', which usually refers to whether a species naturally occurs in a more localised area such as a state (e.g. Victoria) or region (e.g. the Victorian Alps).

If a species is referred to as indigenous to a region (e.g. the Victorian Alps), it can still occur elsewhere – but its description as indigenous refers to the fact that it does occur in this region – and species that are restricted to a certain region (i.e. not found anywhere else) are correctly referred to as 'endemic'.

This guide may use both 'native' and 'indigenous' to refer to plants which are naturally found in the study area of the Yarra River, and for this purpose are interchangeable.

Box 2. Definitions of 'vegetation communities' and 'native vegetation' used in this guide.

Image 10. The Yarra River bank. Anthony Despotellis

Image 11. The Yarra River bank. Anthony Despotellis

2

Principles of Ecological Regeneration

The National Standards are being applied in the context of a radically and permanently altered river corridor that is surrounded by a major city.

This guide is based on the principles in the *National Standards*. The guide also includes number of refinement of principles and additional principles from the *International Principles*.

The *National Standards* identify '…the need and purpose of ecological restoration and explains its relationship with other forms of environmental repair. [The National Standards] identify the principles underpinning restoration philosophies and methods, and outlines the steps required to plan, implement, monitor and evaluate a restoration project to increase the likelihood of its success. The Standards are relevant to – and can be interpreted for – a wide spectrum of projects ranging from minimally resourced community projects to large scale, well-funded industry or government projects."

The term 'ecological regeneration' is used as an overarching term for several common terms in widespread use over time, from 'ecological restoration', 'rehabilitation', to 'revegetation', to 'rewilding'. The *National Standards* define 'ecological restoration' as '… the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed".

The Association notes that any ecosystem that is being assisted has been simplified by recent processes such as urban development and weed and feral species invasion, and both its biodiversity richness and abundance have been reduced at the genetic, species and ecosystem levels. The aim of the Association's broader regeneration project is to restore the ecological processes and the variety of ecosystems (or communities) that originally existed in the Yarra River corridor

The Yarra River corridor is defined for the sake of this report as the area on either side of the river that retains a vegetated cover. The width of this corridor fluctuates. The corridor is largely naturalistic with an overstorey of eucalypts and varying degrees of undergrowth and ground-layers.

Much of this landscape was cleared to fulfill the demand for timber by the expansion of early Melbourne, including roof shakes, fence posts and firewood. Major parts of this landscape were then farmed. Notable former farms include a dairy farm at Burke Road Billabong and at Westerfolds Park. Some former farms have been converted into parks and have now returned or been returned to semi-indigenous vegetation.

What is seen as the natural landscape of the river today is often secondary regrowth. The landscape has regrown or been replanted. Some of the ancient trees remain, such as the Blakely's Red Gums (*Eucalyptus blakelyi*) downstream of Bonds Road, that pre-date European settlement.

The *National Standards* define ecological restoration as any activity with the goal of achieving substantial ecosystem recovery relative to an appropriate reference model, regardless of the time required to achieve recovery. Under the *International Principles*, reference models used for ecological restoration projects are informed by native ecosystems, including many traditional cultural ecosystems Ecological restoration projects or programs include one or more targets that identify the native ecosystem to be restored (as informed by the reference model), and project goals that establish the level of recovery sought. Full recovery is defined as the state or condition whereby, following restoration, all key ecosystem attributes closely resemble those of the reference model. These attributes include absence of threats, species composition, community structure, physical conditions, ecosystem function, and external exchanges. The intent is restoration of attributes rather than particular plant assemblages.

Australian Principles	Matching International Principles
Principle 1: Ecological restoration practice is based on an appropriate local indigenous reference ecosystem	Principle 3 is informed by native reference ecosystems, while considering environmental change
Principle 2: Restoration inputs will be dictated by level of resilience and degradation	Principle 8: Ecological restoration is part of a continuum of restorative activities
Principle 3: Recovery of ecosystem attributes is facilitated by identifying clear targets, goals and objectives	Principle 5: Ecological restoration is assessed against clear goals and objectives, using measurable indicators
Principle 4: Full recovery is the goal of ecological restoration wherever possible, even if outcomes take long time frames or involve high inputs	Principle 6: Ecological restoration seeks the highest level of ecosystem recovery possible
Principle 5: Restoration science and practice are synergistic	
Principle 6: Social aspects are critical to successful ecological restoration	Principle 1: Ecological restoration engages stakeholders
	Principle 2: Ecological restoration draws on many types of knowledge
	Principle 4: Ecological restoration supports ecosystem recovery processes
	Principle 7: Ecological restoration gains cumulative value when applied at large scales

Table 1. Comparison of Australian Principles and International Principles of Restoration.

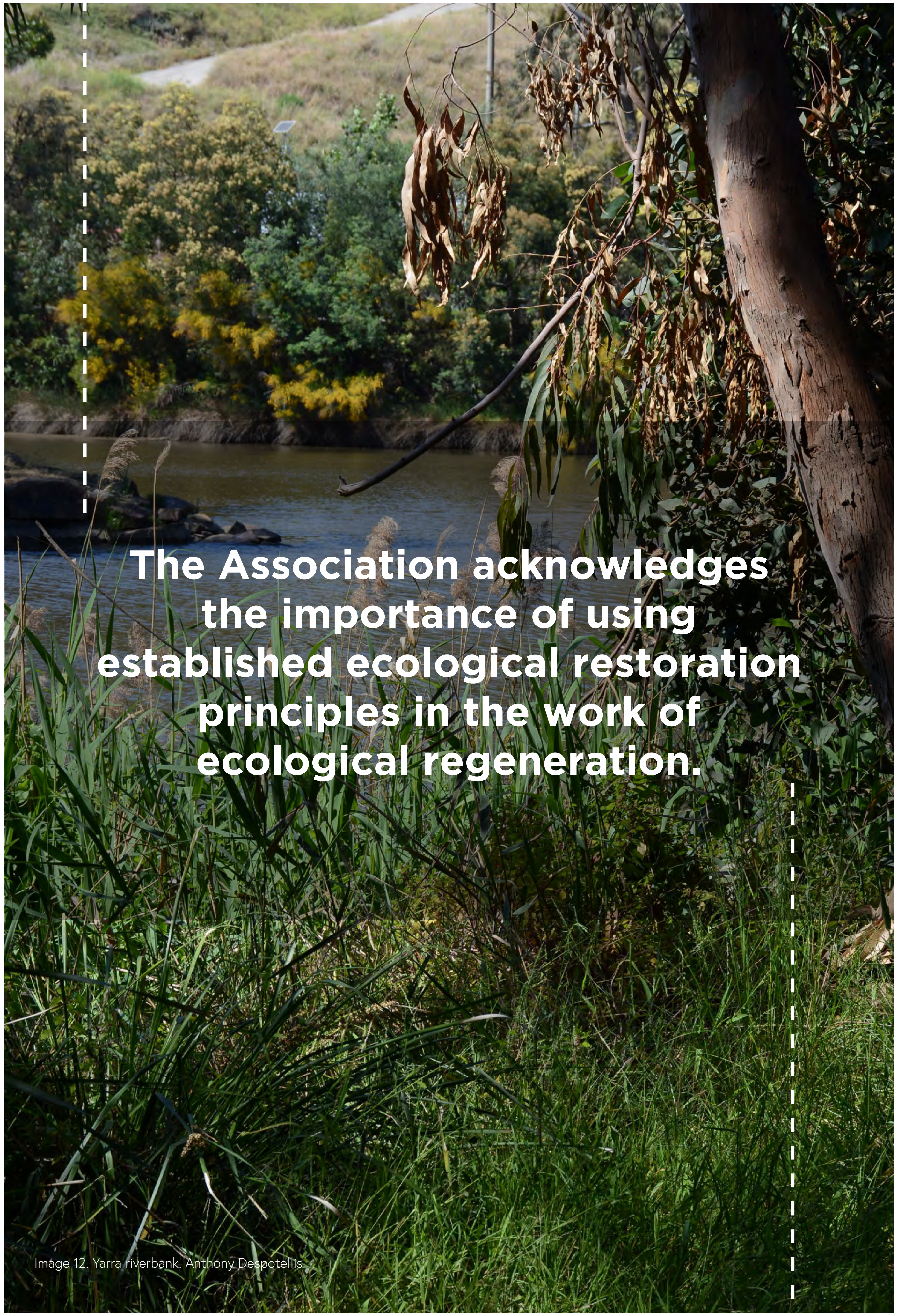


Image 12. Yarra riverbank. Anthony Despotellis.

2.1

National Principle 1

'Ecological restoration practice is based on an appropriate local indigenous reference ecosystem'

The first principle of the *National Standards* aligns with the third principle of the *International Principles,* which is that '[Restoration] is informed by native reference ecosystems, while considering environmental change". The *International Principles* is more inclusive of environmental change.

A reference ecosystem is a model, or target condition, adopted by the *National Standards,* to identify the particular ecosystem that is the target of the restoration project. This involves describing the compositional, structural and functional ecosystem attributes requiring reinstatement before the desired outcome (the restored state) can be said to have been achieved. In other words, reference ecosystems are the guide to how to manage, plant and maintain the site.

In a highly modified system or landscape such as the Yarra corridor, what is achievable in terms of long-term outcomes has to be considered in any regeneration project. For restoration and rehabilitation work a target is needed. A vision for the future outcomes needs to be kept in mind. The key outcome is regeneration of the ecological processes of the river corridor. The planting needs to be linked with the desired ecological processes of the target condition.

The second edition of the *International Principles* refines the thinking of the *National Standards*: 'The Standards also make clear that appropriate reference models for ecological restoration are not based on immobilizing an ecological community at some past point in time, but rather increasing potential for native species and communities to recover and continue to reassemble, adapt, and evolve."

In the case of indigenous reference ecosystems, the target is also a notional baseline against which monitoring is measured.

The *International Principles* states: 'Climate change necessitates target-setting informed by ongoing research on related anticipated effects on species and ecosystems. While uncertainty exists, we know that species turnover and community reassembly under climate change will result in large shifts in entire ecosystems in many geographic areas."

The Association expects that vegetation communities will move upstream as rainfall reduces and temperatures increase and that the communities will shift down the riverbank towards the river. The baseline includes both the conditions at the site at the time the project commenced and the original conditions of the site prior to 1835, prior to the development of the city of Melbourne. The reference ecosystems are a useful guide, but as ecosystems and landscapes are always dynamic, and climate is now rapidly changing, additional elements need to be considered including the projected climate for the area, what is possible in the area, the ability of the restoration site to be self-regenerative, resistance to further threats, and how the area functions to restore the ecological conditions and processes of the river. A key aspect of the project is how the planting assists the connectivity of ecosystems along the river, and the movement of genes and native species up and down the river.

The best reference ecosystems availlable at the moment to build referernce models from are the variety of Ecological Vegetation Classes (EVCs, hereafter referred to simply as 'vegetation communities') that occur or once occurred along the Yarra River. The approximate past and present distributions of these vegetation communities were determined using DELWP mapping (DELWP 2018), and their composition described according to Oates and Taranto (2001). As this project, and the broader project in which it is embedded, develops, the reference models will be adaptively refined using the monitoring data and other climate data.

We assume that native species will usually provide the greatest range of mutual ecosystem utility to other species, such as food, pollination, roosting and nesting sites, protection. In some cases, introduced species may be a useful component of the ecology of the site.

The reference ecosystems to be used as the basis for design of restoration projects along the Yarra River are presented in Section 3.2.

Image 13. The Yarra River bank, Anthony Despotellis

2.2

National Principle 2

‘Restoration inputs will be dictated by level of resilience and degradation’

For effective design of a regeneration project the current condition of a site – including the presence of remnant vegetation, replanting work, weeds, pest animals, soil conditions and hydrology – needs to be assessed. By first determining the existing conditions of the site, it can then be compared to the target condition of the EVC, which makes it easier to determine which degradation processes are important to control and which inputs are required to get to the recovered state.

For example, at sites where the original soil is present, with minimal disturbance there is the chance that soil-stored seed of native vegetation is present (Figure 1), and therefore the required input may be weed control, and resources otherwise used to purchase plants could be used elsewhere. Contrastingly, on sites where the original soil is highly modified by farming or development, it is unlikely that any native soil-stored seed remains, and the required inputs will be direct seeding/planting and weed control.

Sites that appear highly modified may still have interesting and significant indigenous flora species present, and it can be important to carefully inspect a site in different seasons if possible, to determine how degraded it is. The presence of orchids at a former dairy farm in Westerfolds Park highlights that other indigenous species may be present in the stored seed bank and could naturally regenerate over time.

The *National Standards* defines three general pathways determined by existing site conditions: reconstruction, assisted regeneration and natural regeneration. These are explained with the following examples, and depicted graphically in Figure 2.

Figure 1. Surprisingly, Greenhood Orchids *Pterostylis* sp. were found at a site in Westerfolds Park (formerly a dairy farm).

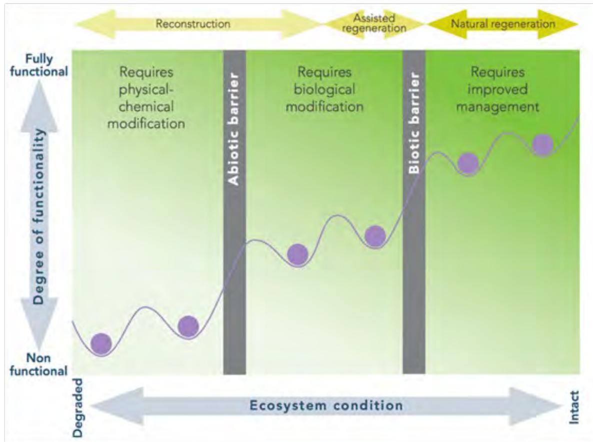
Sites with no remnant vegetation that have been subject to significant soil disturbance over time will need to be treated as reconstruction sites using nursery stock and/or direct seeding, perhaps with the import of topsoil.

Overstorey eucalypts may be present with significant ground disturbance and a groundstorey dominated by exotic grasses. Understorey species would be sensitively added through nursery stock or direct seeding to prevent damage to the roots of the trees. This would be assisted regeneration.

Native grass lawns may occur with some indigenous herbaceous species present in some sites. The site can be managed by no longer mowing the site and doing sensitive weed control while infilling the gaps of bare ground with nursery stock or applying direct seeding to allow assisted regeneration.

Relatively intact examples of woodland or wetland on the Yarra will need sensitive weed control over time to facilitate natural regeneration.

In summary, Principle 2 is primarily about recognising the current ecological values and conditions on a site and working with them for improved efficiencies and outcomes.



The troughs in the diagram represent basins of stability in which an ecosystem can remain in a steady state prior to being shifted by a restoration or a degradation event past a threshold (represented by peaks in the diagram) towards a higher functioning state or a lower functioning state. (Note: Not all sites in need of physical/chemical amendment depend upon reintroduction for the return of biota, e.g. if colonisation potential in that ecosystem is high.)

In the Yarra corridor, the restoration may be based on previous restoration work, and this is included in the assessments of the site. For example, weed mats may have been left, and a key part of regeneration planning may be the removal of weed mats. It may also be appropriate to plan for the thinning of previous plantings as the trees have now become established.

Determining the capacity of a desired restoration site to regenerate from indigenous flora, or soil-stored seed, and designing in response to this possibility is important in managing the cost of restoration and maintaining the quality of the plants at a site. A natural ecosystem has so many individual plants and species present that it is impossible to replace them all through the expensive process of producing and installing nursery stock and any 'volunteers' need to be protected and nurtured. Facilitating natural regeneration when it is possible also achieves a higher quality ecological outcome; regeneration or recruitment of indigenous flora is a sign of a healthy ecosystem and necessary to achieve to create a self-sustaining ecosystem on a site.

Figure 2. Conceptual model of ecosystem degradation and restoration according to the *National Standards*.

2.3

National Principle 3

'Recovery of ecosystem attributes is facilitated by identifying clear targets, goals and objectives'

'Ecological references identify the particular terrestrial or aquatic ecosystem that is the target of the restoration project. This involves describing the specific compositional, structural and functional ecosystem attributes requiring reinstatement before the desired outcome (the restored state) can be said to have been achieved. The Standards list the ecosystem attributes (rationalised from those of the SER Primer) as: absence of threats, physical conditions, species composition, community structure, ecosystem function, and external exchanges … These attributes in combination can then be used to derive a five-star rating system (see Principle 4) that enable practitioners, regulators and industry to track restoration progress over time and between sites.' – *National Standards*

The *National Standards* Principle 3 aligns with the International Principle 5 '[Restoration] is assessed against clear goals and objectives, using measurable indicators.'

Given the urban context of this reach of the river, it is important to define achievable goals or target conditions for each restoration project in the study area. There is often a need to have more restricted, short-term goals for the initial steps of a regeneration project due to limits on initial resources. The core target is restoring the connectivity of ecosystems along the Yarra to maximise resilience while also maximising habitat.

The target condition at each site needs to be designed to be limited in its goals so that it reflects the current possibilities of the site. In a degraded site with ongoing heavy usage by people, no existing remnant vegetation and limited funds, it may be appropriate to aim to re-establish overstorey trees and possibly the shrub layer. A staged approach over time is often necessary in any event; it has taken more than 150 years to destroy or degrade natural areas in the study area, and a long-term view is required to restore such sites. Further detail on defining targets, goals and objectives is presented in Box 3.

While determining the goals of any ecological regeneration project is the first step, a monitoring framework needs to be designed at the beginning of a project. This framework will specifically measure the success along the way according to the project's objectives and adapt management practices and target conditions over time in response to monitoring assessments if necessary. This is also important when those funding the restoration project require an indication of success in order to secure future funding for ongoing restoration and maintenance. The monitoring framework needs to be carefully constructed in order to effectively measure the desired outcomes, and not be overly onerous and difficult to implement.

Targets, goals and objectives – what terms should we use?

Using a hierarchy of terms such as 'target', 'goals' and 'objectives' helps to better organise planning so that proposed inputs are well-matched to the desired ultimate outcomes.

While there is no universally accepted terminology and many groups will prefer to use their traditional terms, the *National Standards* broadly adopt the terminology of the Open Standards for the Practice of Conservation.

It helps to think of objectives needing to be SMART (Specific, Measurable, Achievable, Reasonable and Time-bound). They should be directly connected to key attributes of the target ecosystem. This is achieved by the use of specific indicators.

Hypothetical example:

Target. Where the aim is full recovery, the target of a restoration project should align with the specific reference community to which the project is being directed – e.g. 'Box-Ironbark Forest' – and will include a description of the ecosystem attributes. In projects where substantial (but less than full) recovery is the aim, the target may not fully align with the reference.

Goal/s. The goal or goals provide a finer level of focus in the planning hierarchy compared to the target. They describe the status of the target that you are aiming to achieve and, broadly, how it will be achieved. For example, goals in this hypothetical project may be to achieve:

i An intact and recovering composition, structure and function of remnants A and B within five years;

ii 20 ha of re-vegetated linkages between the remnants within 10 years; and,

iii 100% support of all stakeholders and neighbours within five years.

Objectives. These are the changes and intermediate outcomes needed to attain the goal/s. For example preliminary objectives may be to achieve:

i Less than 1% cover of exotic plant species and recruitment of at least two obligate seeding native shrub species in the remnants within two years;

ii A density of 300 stems/ha of native trees and shrubs, at least three native herb species 10 m^2 and a coarse woody debris load of 10 m3 /ha in the reconstructed linkages within three years; and,

iii Cessation of all livestock encroachment and weed dumping within one year and formation of a 'friends' group representing neighbours within two years.

Box 3.. Targets, Goals and Objectives

2.4

National Principle 4

‘Full recovery is the goal of ecological restoration wherever possible, even if outcomes take long time-frames or involve high inputs’

Principle 4 reflects the notion of restoring an ecosystem to the vegetation community that existed before European settlement. While this is certainly aspirational and well-meaning, it is unlikely to be achievable, and if it is achieved it may not be sustainable, as Traditional Owner management tools such as cool burning are not available in urban settings. The practical reality of budgets and difficult conditions often mean that full recovery is not possible to aim for at the beginning of an ecological restoration project. The setting of the target condition needs to take into account a range of issues that do not necessarily exist for the model reference system. For example, if a regeneration site is near assets at risk from bushfire, then a modified ecosystem with lower fuel loads may be all that is possible (and is still a good outcome for an otherwise degraded site).

Constructed wetlands also challenge the notion of recovery. These are novel ecosystems –artificial and built for a particular purpose– and the ecological goals are limited by the functional requirements of the wetlands, principally nutrient and pollution control. No former state exists for constructed wetlands to be restored to, and outcomes are limited by their practical goals. They do, however, provide good habitat and contribute to biodiversity, and primarily consist of local provenance indigenous species if constructed to Melbourne Water Constructed Wetland Manual (Melbourne Water 2010).

Principle 6 of the *International Principles* is a little more nuanced, and states '[Restoration] seeks the highest level of ecosystem recovery possible'.

While the target condition may take years, decades or even centuries to achieve, the short-term steps towards this long-term goal are valuable and can be built on in future iterations of restoration. For example, at sites where only ground-layer plants present, it will take decades for planted trees and shrubs to reach the maturity seen in reference models. However, planting trees in the first year of a project is a step towards the target condition and will increase the ecological quality of the site and lay the ground for future work.

To help track progress towards project goals over time, the *National Standards* offers a ranking tool for progressively assessing and ranking the degree of recovery over time. This tool is summarised in Table 2 and could be used conceptually as a thinking point, or practically by scoring sites throughout the life of restoration projects.

An important issue to consider under this principle is what target condition is appropriate for the time-frame of the regeneration project. Later land managers may choose to restore to a higher level based on earlier successes, or to reset the target condition.

Number of stars	Recovery outcome (Note: modelled on an appropriate local indigenous ecological reference)
1	Ongoing deterioration prevented. Substrates remediated (physically and chemically). Some level of indigenous biota present; future recruitment niches not negated by biotic or abiotic characteristics. Future improvements for all attributes planned and future site management secured.
2	Threats from adjacent areas starting to be managed or mitigated. Site has a small subset of characteristic indigenous species and there is low threat from undesirable species on site. Improved connectivity arranged with adjacent property holders.
3	Adjacent threats being managed or mitigated and very low threat from undesirable species on site. A moderate subset of characteristic indigenous species are established and evidence of ecosystem functionality commencing. Improved connectivity in evidence.
4	A substantial subset of characteristic biota present (representing all species groupings), providing evidence of a developing community structure and commencement of ecosystem processes. Improved connectivity established and surrounding threats being managed or mitigated.
5	Establishment of a characteristic assemblage of biota to a point where structural and trophic complexity is likely to develop without further intervention other than maintenance. Appropriate ecosystem exchanges are enabled and commencing and high levels of resilience is likely with return of appropriate disturbance regimes. Long-term management arrangements in place.

Table 2. Summary of generic standards for one to five-star recovery levels from the *National Standards*. Note that each level is cumulative, and the different attributes will progress at different rates.

Image 14. Baby possum. Corentin Massuyeau

2.5

National Principle 5

‘Restoration science and practice are synergistic’

'Ecological restoration is a rapidly emerging practice that often relies upon processes of trial and error, with monitoring increasingly being informed by scientific approaches. Formal field experiments can also be incorporated into restoration practice, generating new findings to both inform adaptive management and provide valuable insights for the natural sciences.

Science is not the preserve of professional scientists – rather it is a logical approach to thinking based on systematic, repeatable observations and, ideally, controlled experiments to test a prediction (hypothesis).

To optimise our ability to gain knowledge from restoration practice and be informed by science partnerships should be encouraged. Such partnerships will help optimise potential for innovative restoration approaches to provide reproducible data and robust guidance for future activities.' – *National Standards*

The application of this principle, through adaptive management, to regeneration projects on the Yarra River will deliver better outcomes for a particular project and for other regeneration projects along the Yarra managed by the Association. The aim of this principle is to encourage science, citizen science and designed experiments to be part of the regeneration of sites. The application of designed experiments can be to individual sites or to a suite of sites in an ecological corridor or across a landscape.

Each site can be considered a valuable opportunity to learn more about the practice and science of restoration. These learnings can then be applied at future sites so regeneration or restoration is more efficient and effective. Each project or series of projects can be designed as ecological experiments to evaluate different techniques and aspects of restoration and develop better practice for the future while also contributing to cumulative scientific knowledge.

The application of science and citizen science begins with proper monitoring of the site, and comparison of the 'before and after' states of the site. Rigorous scientific experiments may be outside of the scope of some restoration projects (unless partnerships with research institutions are established) but monitoring of the success of the restoration of the site is an important way to evaluate the success of regeneration work. Monitoring needs to be considered across multiple sites. The cumulative impact of a number sites and the connectivity between sites is worth building into the monitoring plan.

Monitoring needs to be realistic in its design and framed within the available resources. Small discrete sites may need a minimum of targeted monitoring.

In addition, it is important to consider the cumulative effects of ongoing restoration projects in a landscape or region. It is important to monitor the success of a single site, but the bigger aim is to restore ecological function and connectivity to a landscape with multiple, prioritised projects. Using large-scale monitoring over longer periods of time to assess the combined impacts of many projects over time is also an important part of the science driving ecological restoration.

2.6

National Principle 6

'Social aspects are critical to successful ecological restoration'

'Restoration is carried out to satisfy not only conservation values but also socioeconomic values, including cultural ones. Without considering these values, particularly relationships between a site and its stakeholders, a restoration project may not gain the social support needed for success and may fail to deliver important benefits to ecosystems and to society. Few ecosystems are without human influence – whether positive or negative. Some human-induced disturbance regimes are intrinsic to the structure and function of a local indigenous ecosystem (e.g. Indigenous fire management regimes that have long exposed sites to fire or protected them from it); while others can progressively erode ecosystems or shift them to cultural ecosystems. This means that values and behaviours of humans (whether positive or negative) will dictate the future of ecosystems. Conserving and restoring ecosystems therefore depends upon appreciation by society of the negative and positive effects of different behaviours; and involvement by all stakeholders in finding solutions to ensure that ecosystems and society mutually prosper.
– *National Standards*

This principle is both about general acceptance of an ecological restoration project by local stakeholders, i.e. the people who use or care about the land, and the acceptance by managers that people will continue to use the land into the future. There are both value-driven and practical aspects to this issue. Do the stakeholders accept that restoration of indigenous vegetation is an appropriate land use and is the required funding supported over time? Are the practical aspects of bushfire risk, personal safety and other aspects of human use of landscapes considered in the project design?

All of the ecological projects considering and implemented along the Yarra River must be reconciled with the overall objectives for land use in the area. Fortunately, ecological restoration of the Yarra River is clearly already accepted by much of the community given its history of revegetation. However local community objectives should always be considered in any restoration project.

Landscape is a key part of the social aspect of restoration of the Yarra corridor. The natural appearance of the restoration is important to its success. The Association acknowledges the importance of the integration of landscape architecture with site planning. There is a strong preference by stakeholders along the Yarra for a naturalistic, weed-free appearance but this appearance will need to be consciously designed to ensure maximum support from users. It needs not only to be good but to look good. It may be necessary to frame the ecosystems with familiar forms. (This thinking is explored in Joan Iverson Nassauer in the journal article 'Messy ecosystems, orderly frames' published in the *Landscape Journal* Vol. 14 No. 2) The Association recognises that landscape is being deliberately created in regeneration projects on the Yarra, and that these regeneration projects need to consider design and aesthetics. This naturalistic landscape is a key value for users of the corridor.

The *International Principles* acknowledge the importance of both Traditional Owner knowledge and community knowledge in 'Principle 2: Ecological Restoration Draws on Many Types of Knowledge'. This a principle to be applied in our work on the Yarra. A key source of knowledge is Traditional Owner knowledge. There is also the knowledge built up by Friends groups, practising ecologists, local council horticulturists and bush crews working over the past decades on the waterways.

Image 15. This planting in Abbotsford has great structural complexity and provides habitat for a variety of fauna, though still with some potential room for improvement in ground-layer diversity. Daniel Miller.

2.7

International Principle 2

‘Restoration draws on many types of knowledge’

The second international principle expands the thinking around where knowledge comes from. The principle refers to Traditional Ecological Knowledge (TEK) and Local Ecological Knowledge (LEK).

The Association wishes to draw on both the in-depth knowledge of the indigenous science of Traditional Owners (where that is considered appropriate to be shared by Traditional Owners) and the broad knowledge and expertise that community and community organisations have built up by working on Country for a long time. This principle recognises that the land is both a natural and a cultural landscape and that indigenous science has built up deep knowledge over tens of thousands of years, and conservation principles have evolved that allowed the management of the land that is respectful of all species and requiring a minimum of strategic human intervention to sustain the resilience of ecosystems. Cool burning is a principle that works on a landscape scale (seventh principle) and is growing in its application, though the urbanisation of the lower catchment limits its use as an ecological tool.

As a community group, the Association sees community as a key, but under-valued, part of regeneration work. Much of the restoration work done on waterways in the catchment has been done by community groups, mostly unheralded. The work of the Friends groups is a critical part of the regeneration work along the river. Groups such as the Friends of Merri Creek, Friends of Damper Creek and the Friends of Burke Road Billabong (to name but three) have been successfully regenerating the waterways of the lower Yarra catchment for decades, patiently learning how to create and grow and enhance habitat effectively. They have seen the land move through the seasonal cycles over decades.

Image 16. The Yarra riverbank. Anthony Despotellis

2.8

International Principle 4

'Restoration supports ecosystem recovery processes'

Principle 4 supports ecosystem recovery processes. Process is integral to the Association's vision for regeneration. The net gain envisioned for the river corridor is a gain in, or recovery of, process, of autonomous processes. Regeneration is about assisting nature to create sustainable processes that build ecological integrity and are resilient and self-sustaining. Process is a central consideration of the concept of regeneration. The word 'regeneration' contains a sense of unpredictability about the outcome, of allowing nature to take its course, of allowing processes to take the needed time. 'Restoration' includes a suggestion of returning something to a previous steady state. Ecosystems are dynamic on longer or shorter time scales.

'Process' includes for the Association an acknowledgement that the trajectory of a project is not predictable. Not only will climate change but many other processes will bear on the path a project takes in ways that are difficult to predict. The projected outcome though is a richly biodiverse series of interconnected ecosystems, or ecotopes, that contribute to resilience on a landscape scale. It is about the recovery of ecological processes rather than the restoration of past ecosystems per se.

One critical process is regeneration from a healthy seedbank. The ideal scenario of regenerating a site is to clear a site of weeds until the native species can re-establish themselves from an existing but unexpressed seedbank, and eventually shade out weeds to build a resilient ecosystem. In turn that site-appropriate vegetation will develop its own robust seedbank, enriched from propagule from recovering sites upstream and downstream.

Peregrine Falcons

Box 4. Peregrines on 367 Collins

Peregrine falcons are seen by many as the ultimate wild creature – the fastest creature of all, dropping onto prey at speeds of an almost unbelievable 390 km an hour. Yet, peregrines cohabitate with us in the hearts of our great cities. They look at the functionality of a nesting site and associated territory. Peregrine pairs do not distinguish city from countryside, cliff face from city building. Not far from the Yarra, above the 30th floor at 367 Collins Street in Melbourne's CBD, peregrines have successfully bred for decades (https://www.367collinsfalcons.com.au/).

They see orientation to light and heat, safety from predators, and the presence of prey species as the attributes, or processes, that create appropriate habitat. Like the peregrine, the Association regeneration policy looks at the functional qualities and processes of the waterway corridors rather than a notional past. Novel ecosystems, such as skyscrapers as cliff-faces, have the potential to deliver net gain and increased biodiversity where appropriately managed.

Image 17. Peter Green, Peregrine falcon on 367 Collins

2.7
International Principle 7

‘Restoration gains cumulative value when applied at large scales’

The seventh international principle is very much in accord with the Association's vision for the return of ecological integrity of the whole of the river corridor from mountains to bay. It resonates with the motif of the Yarra River Protection (Willip-gin Birrarung murron) Act of regarding the river as 'one living and integrated natural entity'. The principle is consonant with Michael Foreman's rewilding thinking of cores and corridors, which has been a significant influence on our regeneration thinking.

A river functions on a landscape scale. The rain falling on the highlands eventually arrives at the sea, hydrating and enriching the landscape on the way. Rivers and waterways are the great landscape connectors, the great migratory corridors. Regenerating the ecological processes of the river corridor on the landscape scale builds resilience in the face of climate change, allowing species to shift in as weather regimes change.

Regeneration requires consideration of the whole river corridor and the key sites along the river that can restore ecological functioning and integrity of the waterway corridors.

Key sites include confluences with tributaries, which are both culturally significant and a core of biodiversity – ecotones where different ecosystems meet. High-quality habitat as confluences enhances migration opportunities during wetter times as the climate dries overall. In the upper reaches, confluences are on the floodplain, which represents good grazing land and therefore have often been stripped of streamside vegetation. Revegetating and regenerating these locations represent an opportunity to connect the river corridor habitat with the forested foothills, restoring ecological processes and integrity.

Much of the focus of landscape-scale restoration, such as the Great Divide has been on mountain ranges, as they have been relatively under-developed along their spines. Rivers offer equal if not more robust opportunities for building ecosystem continuity. Waterways connect mountains to the sea and traverse a broad range of ecosystems, allowing flexibility in the face of climate change as ecosystems shift.

Australian Grayling

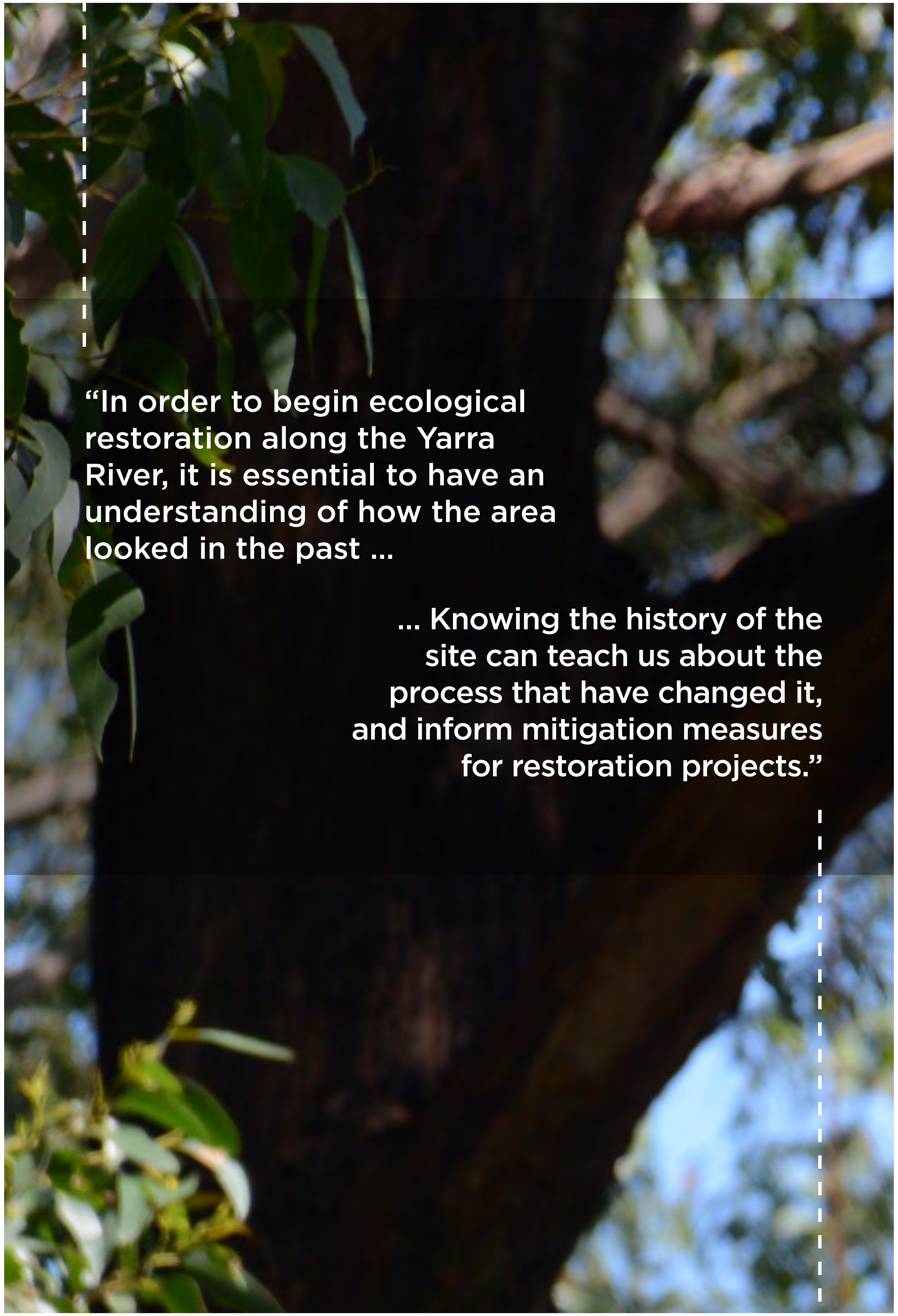
Box 5. Australian Grayling.

The grayling's life cycle is symbolic of the connectivity of the Yarra River. Eggs are laid in the gravel riffles in the upper reaches, and when hatched the current carries the larvae down to the estuary, where they mature for six months before returning to further mature in the freshwater upstream. On the Yarra, the upstream migration was interrupted by the weir at Dights Falls. Melbourne Water has now built a fish ladder, which restores the connectivity of the estuary with the upper reaches. The grayling can be seen as symbolic of the work that needs to be done in restoring the connectivity of the river.

Image 18. Australian Grayling. Tarmo A. Raadik,.

3

What the Yarra Looked Like in the Past



"In order to begin ecological restoration along the Yarra River, it is essential to have an understanding of how the area looked in the past ...

... Knowing the history of the site can teach us about the process that have changed it, and inform mitigation measures for restoration projects."

3.1

Bioregions, Geology and Soils

As there is a strong relationship between soils and vegetation community composition, understanding the geology and soils of a site is critical to successfully implementing ecological regeneration projects. The study area is complex because it is the meeting place of several dominant geology substrates across the Victorian Volcanic Plain, Gippsland Plain and Highlands Southern Fall bioregions. These three bioregions are partially defined by different geological substrates and they come together in this section of the Yarra River. Much of the riverbanks of the Yarra are Quaternary Alluvial Flats and Terraces, which transition to Silurian Sandstones and Mudstones further up the banks. From the Silurian soils, Tertiary sands, clays and gravels occur to the south of the river in what is now western Kew, and Quaternary Basalt in what is now Fairfield, north and west of the Yarra River and Darebin Creek.

A snapshot of the geology around Yarra Bend is shown in Figure 3. Due to the fine-scale nature of the geology in the area, a full map is not included by the Melbourne and Suburbs 1:31 680 geological map (1959) is available at the following link:

http://earthresources.efirst.com.au/product.asp?pID=725&cID=58

It is relatively straightforward to recognise the original geological substrates, and subsequent soil creation over time along the Yarra.

Flat open flood plains along the Yarra are ancient quaternary deposits of sediments from river flows and typically are comprised of fine silts and sometimes gravels. Over millennia the Yarra River has often changed course and left billabongs filled up by flood water or stormwater scattered across the flood plains. These are relatively wet environments because of available flood water or aquifers underground.

Silurian escarpments and hills are rocks that were deposited in ancient oceans around 400 million years ago and these sandstones and mudstones have been twisted and uplifted dramatically over time. These geological substrates can be recognised by the yellow or grey colours of the rocks and distinctive layers that are often twisted at odd angles.

Basalts and associated soils can be recognised by their distinctive brown to bluish colours and the lack of any distinctive layers. Basalt resulting from lava flows from volcanoes west and north of Melbourne in the last million years pushed Darebin Creek and the Yarra River up hard against the Silurian escarpments that are currently south and east of the Yarra predominantly in Yarra Bend Park and south along the east bank of the river.

The last geological substrate to recognise is the Tertiary sediments across the higher areas of west Kew. These soils are fine alluvial deposits laid over top of underlying Silurian sediments in the last million years.

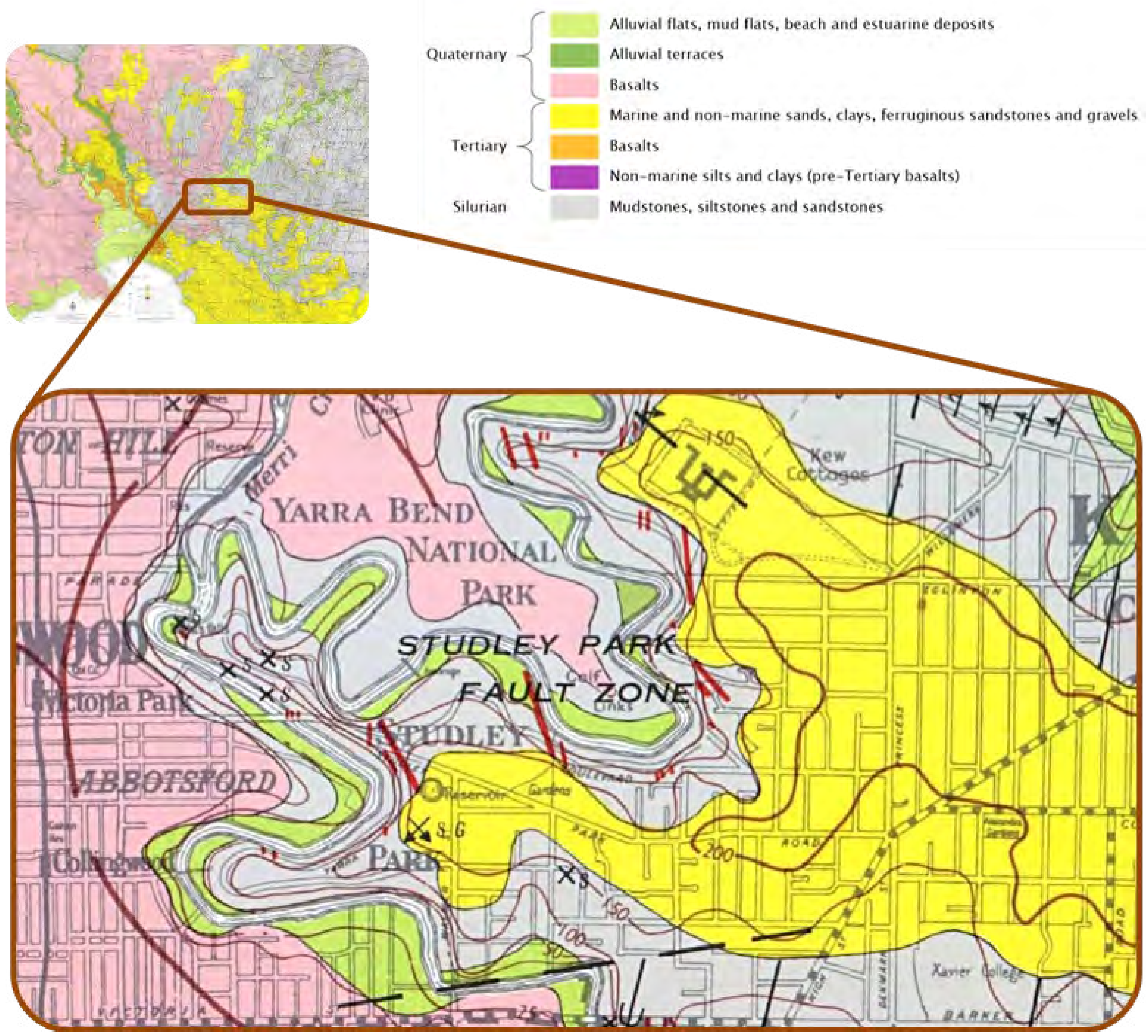


Figure 3. A snapshot of the variable geology at Yarra Bend Park, Victorian Department of Mines (1959).

3.2

Vegetation Communities

In the past

Ecosystems are recognised by the vegetation they support. Communities is a term recognised in the Fauna and Flora Guarantee Act. Communities are in turn amalgamated into Ecological Vegetation Classes (EVCs), which can be found in many reports, but level of communities is used here. Oates and Taranto (2001) have completed comprehensive maps of vegetation communities across Port Phillip and Western Port. This mapping included detailed descriptions of various aspects of these vegetation communities including their geology, floristics, structure and present distribution. These descriptions were of very high quality, and so the relevant community descriptions are quoted in the following sections. Past and present distribution data is from DELWP (2018) and while extremely useful, is somewhat indicative due to the obvious difficulties in mapping past vegetation communities. There is a noticeable transition at the upstream end of the project area from River Red Gums *Eucalyptus camaldulensis* to manna gums ***Eucalyptus viminalis***. A number of communities are described as woodland and a few as forest. The two most common communities are woodlands. Woodlands differ from the more familiar forests by the height, spacing and crown cover of the component trees. Richard Hobbs defined woodlands as 'ecosystems that contain widely spaced trees with their crowns not touching' (Lindenmeyer, Crane & Michael, 2005).

'Projected Foliage Cover' is another measures separating woodlands from forests. This is the percentage of the soil surface that is shaded by the tree crowns. In woodlands it is usually between 10 and 30%. In areas where the trees are regenerating after clearing and there are a high proportion of saplings in stands that are denser than in the mature woodland, the ground cover can be higher. Trees in woodlands are sometimes less than 10m tall, depending on environmental conditions such as rainfall, and the trunk is never longer than half the height of the crown.

3.2.1 Floodplain Riparian Woodland

Floodplain Riparian Woodland was the most common community in the study area, occurring all the way along the Yarra from what is now South Yarra and Burnley to Templestowe (DELWP 2018). The community extended up the banks of the Yarra, often transitioning into Plains Grassy Woodland.

Open woodland-dominated over a medium to tall shrub layer with a ground-layer consisting mainly of grasses, herbs and sedges. Occurs along the floodplains of the larger meandering rivers, characteristically in conjunction with one or more wetland communities. Elevation and rainfall are relatively low and the soil is a deep, fertile clay or loam/silt alluvium subject to periodic major flooding.

Altitude: 20–170m.

Topography: River and stream floodplains.

Geology: Quaternary basalt and recent river alluvium.

Soils: Sands, silts and clays, often high in organic matter and subject to seasonal inundation.

Floristics: The overstorey is dominated by River Red Gum *Eucalyptus camaldulensis* in the drier areas, replaced by Manna Gum *Eucalyptus viminalis* and Swamp Gum *Eucalyptus ovata* at higher rainfalls (>700mm per annum).

The variable lower stratum usually has a diversity of small trees, mostly Acacia species such as Silver Wattle *Acacia dealbata*, Black Wattle *Acacia mearnsii* and Blackwood *Acacia melanoxylon*. Also present are the shrubs Sweet Bursaria *Bursaria spinosa*, River Bottlebrush *Callistemon sieberi*, Tree Violet *Hymenanthera dentata*, Woolly Tea-tree *Leptospermum lanigerum* and Swamp Paperbark *Melaleuca ericifolia*.

The ground-layer includes a mixture of perennial and annual herbs capable of withstanding periodic flooding. These variously include Common Blown-grass *Agrostis avenacea*, Water Plantain *Alisma plantago-aquatica*, Lesser Joyweed *Alternanthera denticulata*, Sea Celery *Apium prostratum*, Marsh Club-sedge *Bolboschoenus medianus*, Tall Sedge *Carex appressa*, Swamp Crassula *Crassula helmsii*, Kidney-weed *Dichondra repens*, Nodding Club-sedge *Isolepis cernua*, Loose-flower Rush *Juncus pauciflorus*, Broom Rush *Juncus sarophorus*, Angled Lobelia *Lobelia anceps*, Small Loosestrife *Lythrum hyssopifolia*, Weeping Grass *Microlaena stipoides* var. *stipoides*, Common Reed *Phragmites australis*, Common Tussock grass *Poa labillardierei*, Slender Knotweed *Persicaria decipiens*, River Club-sedge *Schoenoplectus validus*, Shiny Swamp-mat *Selliera radicans*, Water Ribbons *Triglochin procerum* and Large Bindweed *Calystegia sepium*.

Structure: Woodland, open woodland, shrubland, herbfield, sedgeland, reed bed.

Box 6. Description of the Floodplain Riparian Woodland community (across Port Phillip and Western Port, not specific to The Yarra; from Oates and Taranto [2001]).

3.2.2 Plains Grassy Woodland

Plains Grassy Woodland was the second most common community in the study area, occurring all the way along the Yarra from what is now Abbotsford to Templestowe (DELWP 2018). The community occurred on the upper banks of the Yarra, often transitioning from Floodplain Riparian Woodland lower on the banks.

An open, grassy eucalypt woodland in low (mostly <700mm per annum) rainfall areas occurring on fertile soils on flats and gently undulating plains at low elevations. The understorey consists of a few sparse shrubs over a diverse grassy, herb-rich ground-layer. Widespread and extensive in the past, it has now been largely cleared for agriculture, and more recently for urban development resulting in few relatively intact remnants remaining in the Port Phillip/Western Port area. Plains Grassy Woodland is a variable EVC and includes a range of communities. The original floristics of many are now conjectural. Within the study area there are at least three formally recognised floristic communities of Plains Grassy Woodland and undoubtedly others do exist.

Altitude: 10–60m.

Topography: Undulating to flat plain.

Geology: Quaternary sediments.

Soils: Fertile, duplex consisting of sand and silt or loam over clay.

Floristics: The overstorey is dominated by River Red Gum *Eucalyptus camaldulensis* with Black Wattle *Acacia mearnsii* and Blackwood *Acacia melanoxylon* often present. Other trees include Rough-barked Manna Gum *Eucalyptus viminalis* subsp. *pryoriana*, Drooping She-oak *Allocasuarina verticillata* and Black She-oak *Allocasuarina littoralis*. There may be scattered shrubs of Hedge Wattle *Acacia paradoxa*, with less common occurrences of Grey Parrot-pea *Dillwynia cinerascens* and Prickly Tea-tree *Leptospermum continentale*.

The ground-layer is usually grassy and herbaceous with sedges and lilies also present. Frequent grasses are Weeping Grass *Microlaena stipoides* var. *stipoides*, Kangaroo Grass *Themeda triandra*, Striped Wallaby-grass *Austrodanthonia racemosa*, Kneed Wallaby-grass *Austrodanthonia geniculata*, Purplish Wallaby-grass *Austrodanthonia tenuior*, Veined Spear-grass *Austrostipa rudis*, Common Tussock-grass *Poa labillardierei*, Common Love-grass *Eragrostis brownii* and Mat Grass *Hemarthria uncinata*. Other species include Common Bog-sedge *Schoenus apogon*, Yellow Rush-lily *Tricoryne elatior*, Twining Fringe-lily *Thysanotus patersonii*, Vanilla-lilies *Arthropodium* spp., Sheep's Burr *Acaena agnipila*, Scaly Buttons *Leptorhynchos squamatus*, Narrow Plantain *Plantago gaudichaudii*, Slender Bottle-daisy *Lagenophora gracilis*, Yellow Pennywort *Hydrocotyle foveolata*, Kidney-weed *Dichondra repens*, Star Cudweed *Euchiton involucratus*, Small Poranthera *Poranthera microphylla* and Trailing Speedwell *Veronica plebeia*. Narrow Rock Fern *Cheilanthes sieberi* is also sometimes present.

Structure: Woodland to open woodland over a grassy and herbaceous ground-layer.

Box 7. Description of the Plains Grassy Woodland community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.3 Box-Ironbark Forest

Box-Ironbark Forest was relatively uncommon in the study area, occurring only at higher elevations with high exposure and poor soils on the Yarra, in what is now Abbotsford (DELWP 2018).

Occurs in low-rainfall areas on gently undulating rises, low hills and peneplains. Soils ranging from fertile clays to more infertile gravel deposits. An overstorey of Red Ironbark and Red Box is often present over a small tree or shrub mid-storey with an open ground-layer of herbs and grasses.

Altitude: 120–300m.

Topography: Medium to strongly sloping exposed sites.

Geology: Tertiary fan deposits, and Devonian, Silurian and Ordovician sediments.

Soils: Shallow, infertile, sodic, duplex.

Floristics: The overstorey is variously dominated by Red Ironbark *Eucalyptus tricarpa* or with Red Box *Eucalyptus polyanthemos* subsp. *vestita*, Bundy *Eucalyptus goniocalyx*, Yellow Gum *Eucalyptus leucoxylon* subsp. *connata* and Red Stringybark *Eucalyptus macrorhyncha*.

Golden Wattle *Acacia pycnantha* often forms a dense to open small tree layer. Cherry Ballart *Exocarpos cupressiformis* is also frequently present. The shrub layer consists of Shiny Cassinia *Cassinia longifolia*, Wedge-leaf Hop-bush *Dodonaea viscosa* subsp. *cuneata*, Gold-dust Wattle *Acacia acinacea*, Cranberry Heath *Astroloma humifusum* and Grey Everlasting *Ozothamnus obcordatus*.

Herbs present in the ground-layer include Saloop Saltbush *Einadia hastata*, Common Raspwort *Gonocarpus tetragynus*, Variable Stinkweed *Opercularia varia* and Trailing Speedwell *Veronica plebeia*. Common grasses include Common Blown-grass *Agrostis avenacea*, Soft Tussock-grass *Poa morrisii*, Silvertop Wallaby-grass *Joycea pallida*, Kneed Wallaby-grass *Austrodanthonia geniculata*, Striped Wallaby-grass *Austrodanthonia racemosa*, Bristly Wallaby-grass *Austrodanthonia setacea* and Purplish Wallaby-grass *Austrodanthonia tenuior*. Thatch Saw-sedge *Gahnia radula* is abundant at some sites.

Structure: Open forest.

Box 8. Description of the Box-Ironbark Forest community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.4 Creekline Grassy Woodland

Creekline Grassy Woodland was relatively uncommon in the study area, occurring only at the northern end of the study area, along what is now called Templestowe Creek and Porter Street Drain, along Banyule Creek, Salt Creek, and Irvine Road Drain, and a small creek near the confluence of the Yarra and Plenty Rivers.

Eucalypt-dominated woodland with occasional scattered shrub layer over a mostly grassy/ sedgy to herbaceous ground-layer. Occurs on low-gradient ephemeral to intermittent drainage lines, typically on fertile colluvial/alluvial soils, on a wide range of suitably fertile geological substrates, within Plains Grassy Woodland in lower rainfall areas. These minor drainage lines can include a range of graminoid and herbaceous species tolerant of water-logged soils, and are presumed to have sometimes resembled a linear wetland or system of interconnected small ponds. Formerly widespread in narrow bands within suitable habitat, now almost entirely cleared or eroded as a consequence of altered hydrology.

Altitude: 20–120m.

Topography: Ephemeral drainage lines of lower slopes of foothills and outlying hills to smaller intermittent creeks of the floodplain.

Geology: Minor alluvium within sedimentary or basalt soils.

Soils: Sands, silts and clays.

Floristics: The overstorey is dominated by Red Gum *Eucalyptus camaldulensis*.

A scattered shrub layer includes Black Wattle *Acacia mearnsii*, Blackwood *Acacia melanoxylon*, Sweet Bursaria *Bursaria spinosa* and sometimes Swamp Paperbark *Melaleuca ericifolia*. The ground-layer is dense with grasses and sedges, most commonly Tall Sedge *Carex appressa*, Common Tussock-grass *Poa labillardierei*, Weeping Grass *Microlaena stipoides* var. *stipoides*, Kangaroo Grass *Themeda triandra*, Common Wheat-grass *Elymus scabra*, Common Blown-grass *Agrostis avenacea* and Rushes *Juncus* spp.

Structure: Woodland to open woodland over a scattered medium to tall shrub layer and a dense layer of sedges and grasses. Creek banks lined with tall sedges and shrubs.

Box 9. Description of the Creekline Grassy Woodland community [across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto (2001)].

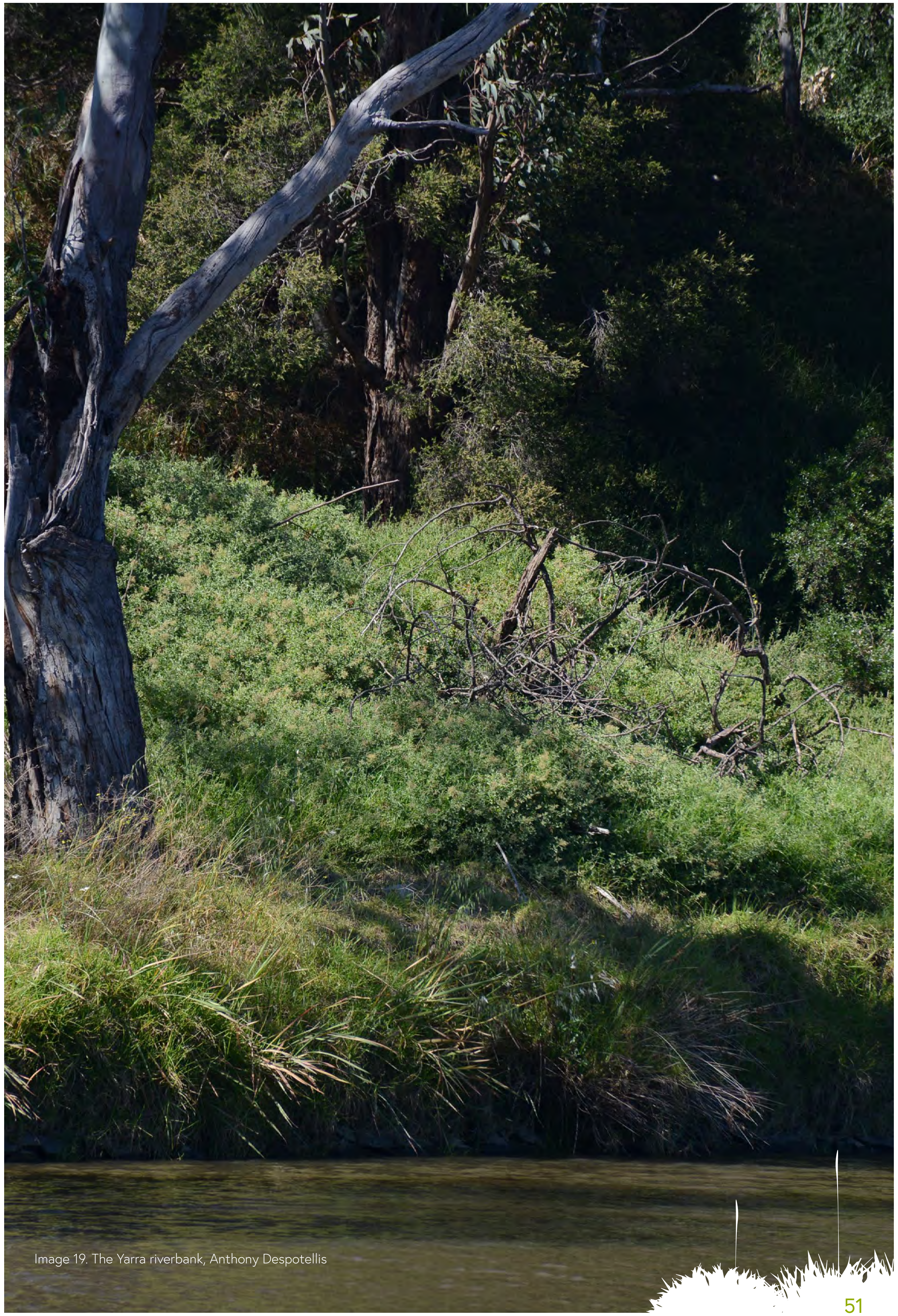


Image 19. The Yarra riverbank, Anthony Despotellis

3.2.5 Creekline Herb-rich Woodland

The EVC mapping by shows an area of Swampy Riparian Complex, which is a group of a number of EVCs (DELWP 2018). Based on surrounding EVCs and the topology and geology of the area, it is extremely likely that this was the Creekline Herb-rich Woodland community, and is therefore referred to as such. Creekline Herb-rich Woodland in the study area was restricted to one small area along what is now Bolton Street Drain.

A woodland of low-gradient swampy gullies with a grassy/sedgy to rushy ground-layer including a component of species associated with wetland habitats.

Altitude: 20-180m.

Topography: Low-gradient swampy gullies within relatively open grassy vegetation (usually in association with Valley Grassy Forest).

Geology: Various.

Soils: Alluvial sands, silts and clays.

Floristics: The overstorey is dominated by Swamp Gum *Eucalyptus ovata* and Yarra Gum *Eucalyptus yarraensis*, with Candlebark *Eucalyptus rubida* also frequent in less boggy sites. A range of other eucalypt species such as Red Stringybark *Eucalyptus macrorhyncha*, Yellow Box *Eucalyptus melliodora*, Narrow-leaf Peppermint *Eucalyptus radiata* and Messmate *Eucalyptus obliqua* may also be present.

The understorey includes scattered shrubs such as Blackwood *Acacia melanoxylon*, Silver Wattle *Acacia dealbata*, Sweet Bursaria *Bursaria spinosa*, Prickly Tea-tree *Leptospermum continentale* and Burgan *Kunzea ericoides*.

Species of the ground-layer include Common Tussock-grass *Poa labillardierei*, Soft Tussock-grass *Poa morrisii*, Slender Tussock-grass *Poa tenera*, Common Maidenhair *Adiantum aethiopicum*, Bidgee-widgee *Acaena novae-zelandiae*, Centella *Centella cordifolia*, Austral Brooklime *Gratiola peruviana*, Joint-leaf Rush *Juncus holoschoenus*, Angled Lobelia *Lobelia anceps*, Prickfoot *Eryngium vesiculosum* and Lanky Goodenia *Goodenia elongata*. Thatch Saw-sedge *Gahnia radula* and Austral Bracken *Pteridium esculentum* are present at some sites.

Structure: Woodland to open woodland with a variable shrub component, a grassy/sedgy (to rushy) ground-layer with a component of species affiliated with wetland habitats.

Box 10. Description of the Creekline Herb-rich Woodland community (mapped as the Swampy Riparian Complex community, description is across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.6 Escarpment Shrubland

Escarpment Shrubland was scattered in the study area, occurring on a number of steeper sections of the Yarra from what is now Abbotsford to Templestowe (DELWP 2018).

An open shrubland generally associated with steep embankments beside major watercourses in low-rainfall areas.

Altitude: 140–200m.

Topography: Escarpments associated with the edges of basalt flows or where watercourses have cut deeply into the bedrock.

Geology: Mainly Quaternary basalt, with some Silurian sedimentary sites.

Soils: Fertile, skeletal.

Floristics (on basalt): Apart from the occasional Drooping She-oak *Allocasuarina verticillata* along the escarpment rim, the tallest stratum is the shrub layer. Common shrub species include Tree Violet *Hymenanthera dentata*, Black Wattle *Acacia mearnsii*, Lightwood *Acacia implexa*, Hedge Wattle *Acacia paradoxa*, Sweet Bursaria *Bursaria spinosa* and Sticky Hop-bush *Dodonaea viscosa*. Other species recorded include White Cypress Pine *Callitris glaucophylla*, Cassia *Senna artemisioides*, Myoporum *Myoporum viscosum*, Rock Correa *Correa glabra* and Rosemary Grevillea *Grevillea rosmarinifolia*. Many of these species are now extremely rare in the study area.

The ground-layer consists of a few grasses and herbs such as Striped Wallaby-grass *Austrodanthonia racemosa* var. *racemosa*, Weeping Grass *Microlaena stipoides* var. *stipoides*, Kidney-weed *Dichondra repens*, Kangaroo Grass *Themeda triandra* and Nodding Saltbush *Einadia nutans* subsp. *nutans*. In sheltered rocky sites the ferns Necklace Fern *Asplenium flabellatum*, Annual Fern *Anogramma leptophylla* and Sickle Fern *Pellaea falcata* may be found.

Floristics (on Silurian sediments): There are often scattered eucalypts, variously River Red Gum *Eucalyptus camaldulensis*, Bundy *Eucalyptus goniocalyx*, Yellow Gum *Eucalyptus leucoxylon*, Red Stringybark *Eucalyptus macrorhyncha*, Yellow Box *Eucalyptus melliodora* or Manna Gum *Eucalyptus viminalis* subsp. *viminalis*. The shrub layer is dominant and includes Black Wattle *Acacia mearnsii*, Lightwood *Acacia implexa*, Hedge Wattle *Acacia paradoxa*, Golden Wattle *Acacia pycnantha*, Spreading Wattle *Acacia genistifolia*, Black She-oak *Allocasuarina littoralis*, *Cassinia* spp., Tree Violet *Hymenanthera dentata*, Tree Everlasting *Ozothamnus ferrugineus*, Burgan *Kunzea ericoides* and Prunus Pomaderris *Pomaderris prunifolia*.

Ground-layer species in more intact remnants include Pink Bindweed *Convolvulus erubescens*, Shiny Everlasting *Bracteantha viscosa*, Prickly Starwort *Stellaria pungens*, Bedstraw *Galium* spp., Variable Sword-sedge *Lepidosperma laterale*, Weeping Grass *Microlaena stipoides* var. *stipoides*, Spiny-headed Mat-rush *Lomandra longifolia* subsp. *longifolia*, Saloop *Einadia hastata* and Nodding Saltbush *Einadia nutans* subsp. *nutans*.

Structure: Open shrubland.

Box 11. Description of the Escarpment Shrubland community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

Image 20. The Yarrariver bank. Anthony Despotellis

3.2.7 Floodplain Wetland Aggregate

Floodplain Wetland Aggregate was scattered throughout the study area, occurring all the way along the Yarra from what is now South Yarra and Burnley to Templestowe (DELWP 2018). The community was generally surrounded by the Floodplain Riparian Woodland, in billabongs along the Yarra.

This is a complex of a number of formally described and undescribed wetland EVCs including Billabong Wetland (which surrounds deep, often permanent water bodies, typically billabongs on the flood plain of major rivers) and shallow seasonal billabongs. All entities included in this complex are rare within the study area. Where biotic features still exist, the floristic composition has generally been radically altered, making detailed descriptions or on-ground distinctions between them impossible.

Altitude range: 20–70m.

Topography: Low lying areas, depressions and billabongs on floodplains of major rivers.

Geology: Swamp and lagoonal deposits.

Soils: Silts, peats and clays.

Floristics: The overstorey typically consists of River Red Gum *Eucalyptus camaldulensis*. The shrub layer is sparse to non-existent.

The understorey is diverse or dominated by a few species such as Cumbungi *Typha orientalis*, Rush Sedge *Carex tereticaulis* or Pacific Azolla *Azolla filiculoides*. Other species that may be present include Clove-strip *Ludwigia peploides* subsp. *montevidensis*, Water-milfoil *Myriophyllum* spp., Creeping Knotweed *Persicaria prostrata*, River Buttercup *Ranunculus inundatus*, Thin Duckweed *Spirodela punctata*, Tall Flat-sedge *Cyperus exaltatus*, Hollow Rush *Juncus amabilis*, Green Rush *Juncus gregiflorus*, Giant Rush *Juncus ingens*, Tall Rush *Juncus procerus*, Common Spike-sedge *Eleocharis acuta*, Spiny Mud-grass *Pseudoraphis spinescens*, Lesser Joyweed *Alternanthera denticulata*, Common Blown-grass *Agrostis avenacea* and Tall Spike-sedge *Eleocharis sphacelata*.

Structure: Woodland to open woodland over varied sedgeland-grassland and/or aquatic herbland.

Box 12. Description of the Floodplain Wetland Aggregate community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.8 Grassy Dry Forest

Grassy Dry Forest occurs in the northern area of the study area in what is now Templestowe (DELWP 2018). The community occurred on upper banks of the Yarra, and onto areas of flat land above the river.

Occurs at low elevations in lower rainfall areas on a range of sedimentary rock types. The structure varies from an open forest to woodland. The understorey usually consists of a sparse shrub layer with a dominant ground-layer of drought-tolerant grasses, forbs and resurrection ferns.

Altitude: 40–350m.

Topography: Exposed aspects and crests of ridges or on sheltered slopes in the driest areas of the study area.

Geology: Devonian and Silurian sedimentary soils north-east of Melbourne and Ordovician sediments west of Melbourne.

Soils: Moderately fertile stony loams and clay loams.

Floristics: The overstorey is characteristically dominated by mixtures of Red Box *Eucalyptus polyanthemos* subsp. *vestita*, Red Stringybark *Eucalyptus macrorhyncha* and Bundy *Eucalyptus goniocalyx*. Green Scentbark *Eucalyptus fulgens* (*Eucalyptus ignorabilis* s.l.) and Messmate *Eucalyptus obliqua* can be present in moister sites with Yellow Box *Eucalyptus melliodora* and occasionally Candlebark *Eucalyptus rubida* on more fertile sites. Scattered tall shrubs/small trees such as Black Wattle *Acacia mearnsii* and Burgan *Kunzea ericoides* may be present.

The ground-layer is usually low and open and dominated by tussock grasses such as Silvertop Wallaby-grass *Joycea pallida* and Grey Tussock-grass *Poa sieberiana*. Kangaroo Grass *Themeda triandra* can be conspicuous in sites with relatively fertile soils. Other species present include Yam-daisy *Microseris scapigera* spp. agg., Sprawling Bluebell *Wahlenbergia gracilis*, Common Raspwort *Gonocarpus tetragynus*, Grass Trigger-plant *Stylidium graminifolium*, Variable Stinkweed *Opercularia varia*, Common Rice-flower *Pimelea humilis*, Grey Parrot-pea *Dillwynia cinerascens*, and Common Wedge-pea *Gompholobium huegelii*, Variable Sword-sedge *Lepidosperma laterale*, Soft Tussock-grass *Poa morrisii*, Wallaby-grasses *Austrodanthonia* spp., Blue Pincushion *Brunonia australis*, Bulbine Lily *Bulbine bulbosa*, Weeping Grass *Microlaena stipoides* var. *stipoides*, Button Everlasting *Helichrysum scorpioides*, Small St John's Wort *Hypericum gramineum*, Common Plume-grass *Dichelachne rara*, Wattle Mat-rush *Lomandra filiformis* and a wide range of ground-orchids.

Structure: Low open forest/woodland, understorey primarily open and grassy.

Box 13. Description of the Grassy Dry Forest community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.9 Grassy Woodland

Grassy Woodland was not widespread in the study area, occurring only in small patches of what is now Abbotsford and Templestowe (DELWP 2018)

A variable open eucalypt (or occasionally she-oak) woodland over a diverse ground-layer of grasses and herbs. The shrub component is usually sparse. It occurs on sites with moderate fertility on plains or undulating hills on a range of geology. Previously widespread and locally extensive but now largely cleared for agriculture. Remnants are generally heavily grazed or altered by fire regimes.

Altitude: 20–100m south and east of Melbourne, 200–400m north-east of Melbourne.

Topography: Undulating to flat plain.

Geology: Mainly Tertiary sediments but also Ordovician and Silurian sediments and granite/granodiorite.

Soils: Variable, ranging from duplex soils to humic gley soils to ferruginous sands and sandy clays.

Floristics: The overstorey is variously dominated by Drooping She-oak *Allocasuarina verticillata* and Black She-oak *Allocasuarina littoralis* or eucalypt species, e.g. Narrow-leaf Peppermint *Eucalyptus radiata*, Coast Manna Gum *Eucalyptus viminalis* subsp. *pryoriana*, Snow Gum *Eucalyptus pauciflora*, Swamp Gum *Eucalyptus ovata*. Other eucalypts in more ecotonal habitats include Messmate *Eucalyptus obliqua*, Mealy Stringybark *Eucalyptus cephalocarpa*, Grey Box *Eucalyptus microcarpa* or Bundy *Eucalyptus goniocalyx*.

Other woody species variously include Black Wattle *Acacia mearnsii*, Blackwood *Acacia melanoxylon*, Hedge Wattle *Acacia paradoxa*, Cherry Ballart *Exocarpos cupressiformis*, Prickly Tea-tree *Leptospermum continentale*, Sweet Bursaria *Bursaria spinosa*, Black She-oak *Allocasuarina littoralis*, Common Flat-pea *Platylobium obtusangulum* and Common Heath *Epacris impressa*.

The very diverse ground cover includes Weeping Grass *Microlaena stipoides* var. *stipoides*, Kangaroo Grass *Themeda triandra*, Soft Tussock-grass *Poa morrisii*, Grey-tussock Grass *Poa sieberiana*, Velvet Wallaby-grass *Austrodanthonia pilosa*, Bristly Wallaby-grass *Austrodanthonia setacea*, Wetland Wallaby-grass *Notodanthonia semiannularis*, Reed Bent-grass *Deyeuxia quadriseta*, Veined Spear-grass *Austrostipa rudis*, Milkmaids *Burchardia umbellata*, Tall Sundew *Drosera peltata* subsp. *auriculata*, Ivy-leaf Violet *Viola hederacea* subsp. *hederacea*, Yellow Rush-lily *Tricoryne elatior*, Chocolate Lily *Arthropodium strictum*, Kidney-weed *Dichondra repens*, Shade Raspwort *Gonocarpus humilis*, Common Raspwort *Gonocarpus tetragynus*, Variable Stinkweed *Opercularia varia*, Common Rice-flower *Pimelea humilis*, Small Poranthera *Poranthera microphylla*, Common Apple-berry *Billardierii scandens*, Love Creeper *Comesperma volubile*, Common Bottle-daisy *Lagenophora stipitata*, Annual Fireweed *Senecio glomeratus*, Honeypots *Acrotriche serrulata*, Spiny-headed Mat-rush *Lomandra longifolia*, Wattle Mat-rush *Lomandra filiformis*, Black-anther Flax-lily *Dianella revoluta*, Small Grass-tree *Xanthorrhoea minor* subsp. *lutea*, Austral Bracken *Pteridium esculentum* and Thatch Saw-sedge *Gahnia radula*. Sweet Pittosporum *Pittosporum undulatum* is also often present, outside its natural range.

Structure: Woodland, open woodland with grassy/herbaceous understorey.

Box 14. Description of the Grassy Woodland community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.10 Riparian Forest

Riparian Forest occurred only in a small section of the study area, along the northern portion of the Yarra in what is now Templestowe (DELWP 2018).

A tall forest widespread along major river courses and associated alluvial terraces. The soil is derived from fertile alluvium and is subject to inundation. Dominated by tall eucalypts but also has an open to sparse secondary tree layer of Silver Wattle and Blackwood with scattered dense patches of shrubs, ferns, grasses and herbs.

Altitude: 160–500m.

Topography: Alluvial flats of larger streams.

Geology: Quaternary alluvium.

Soils: Deep, fertile, moderately well-drained sands, loams and sandy loams.

Floristics: The overstorey is typically dominated by tall Manna Gum *Eucalyptus viminalis* subsp. *viminalis*. Yellow Box *Eucalyptus melliodora*, Messmate *Eucalyptus obliqua*, Narrow-leaf Peppermint *Eucalyptus radiata* and Swamp Gum *Eucalyptus ovata* can also be present. A layer of Silver Wattle *Acacia dealbata* and Blackwood *Acacia melanoxylon* is usually present.

A diverse range of shrubs is common in the understorey. These include Hazel Pomaderris *Pomaderris aspera*, Snow Daisy-bush *Olearia lirata*, Common Cassinia *Cassinia aculeata*, Prickly Currant-bush *Coprosma quadrifida*, Victorian Christmas-bush *Prostanthera lasianthos*, Hop Goodenia *Goodenia ovata*, Tree Everlasting *Ozothamnus ferrugineus*, Tree Violet *Hymenanthera dentata* and Sweet Bursaria *Bursaria spinosa*.

In more open areas the ground-layer is dominated by large tussocks of Common Tussock-grass *Poa labillardierei* or Sword Tussock-grass *Poa ensiformis*, Spiny-headed Mat-rush *Lomandra longifolia* and Tall Sedge *Carex appressa*. Ferns (e.g. species of *Blechnum* and *Hypolepis*, occasionally tree-ferns) are a variable component of the vegetation, increasing in importance at higher elevations. Species with distinctive niches may be localised in specific habitats such as stream verges or levees. Character species include Common Maidenhair *Adiantum aethiopicum*, Small-leaf Bramble *Rubus parvifolius* and Weeping Grass *Microlaena stipoides* var. *stipoides*.

Structure: Open forest to tall woodland, understorey layered, with components of small trees and tall shrubs over a ground-layer largely dominated by tussock grasses and sedges.

Box 15. Description of the Riparian Forest community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

Image 21. The Yarra riverbank. Anthony Despotellis

3.2.11 Riparian Woodland

Riparian Woodland was not widespread in the study area, occurring only in small patches of what is now Abbotsford and Templestowe (DELWP 2018).

Woodland dominated by River Red Gum *Eucalyptus camaldulensis* over a Common Tussock-grass *Poa labillardierei* dominated understorey. It occurs beside permanent streams, typically on narrow alluvial deposits.

Altitude: 100–160m.

Topography: Adjacent to permanent streams.

Geology: Quaternary basalt and recent alluviums with restricted occurrences within sedimentary soils.

Soils: Moderately deep, fertile alluvial loams.

Floristics: The overstorey is dominated by River Red Gum *Eucalyptus camaldulensis*, with occasional Manna Gum *Eucalyptus viminalis* subsp. *viminalis*.

Other major woody species include Black Wattle *Acacia mearnsii*, Swamp Paperbark *Melaleuca* ericifolia, Tree Violet *Hymenanthera dentata*, Sweet Bursaria *Bursaria spinosa*, River Bottlebrush *Callistemon* sieberi, Woolly Tea-tree *Leptospermum lanigerum* and Hemp Bush *Gynatrix pulchella*.

Ground-layer species include Striped Wallaby-grass *Austrodanthonia racemosa*, Kidney-weed *Dichondra repens*, Saloop Saltbush *Einadia hastata*, Common Tussock-grass *Poa labillardierei*, Slender Dock *Rumex brownii*, Shrubby Groundsel *Senecio minimus* and Trailing Speedwell *Veronica plebeia*.

Structure: Woodland.

Box 16. Description of the Riparian Woodland community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.2.12 Stream Bank Shrubland

Stream Bank Shrubland was restricted in the study area to the confluence of the Merri Creek and Yarra River (DELWP 2018).

Shrubland or occasionally a low open woodland, occurring on the rocky banks and beds of creeks and major rivers that have cut deeply into the plains.

Altitude: 20–200m.

Topography: Rocky river banks, flat, rocky stream beds and broad gravel banks of larger rivers that are often dry but subject to regular flooding by fast flowing waters.

Geology: Basalt or on sediments, often where the watercourse has cut through the basalt into the underlying rock.

Soils: Skeletal sedimentary soil or alluvial sands and gravels.

Floristics: The overstorey is generally sparse, usually consisting of Manna Gum *Eucalyptus viminalis* subsp. *viminalis* or Red Gum *Eucalyptus camaldulensis*, though Swamp Gum *Eucalyptus ovata* has also been recorded in the Midlands.

The shrub layer is dominant and can include Woolly Tea-tree *Leptospermum lanigerum* and River Bottlebrush *Callistemon sieberi* among the rocks on the stream bed and Sweet Bursaria *Bursaria spinosa*, Tree Violet *Hymenanthera dentata*, Shiny Cassinia *Cassinia longifolia* and Hop Goodenia *Goodenia ovata* occupying the stream banks.

Common species among the rocks and gravel on the stream bed are Bidgee-widgee *Acaena novae-zelandiae*, Willow-herbs *Epilobium* spp., and Spiny-headed Mat-rush *Lomandra longifolia*. Broader fringing flood-prone terraces can include herbs such as Centella *Centella cordifolia*, Shield Pennywort *Hydrocotyle verticillata*, Slender Knotweed *Persicaria decipiens* and Swamp Crassula *Crassula helmsii*.

Structure: Open shrubland.

Box 17. Description of the Streambank Shrubland community [across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto (2001)].

Image 22. The Yarra riverbank. Anthony Despotellis

3.2.13 Swamp Scrub

Swamp scrub was restricted in the study area on the southern bank of the Yarra in a very restricted distribution (DELWP 2018).

Closed scrub at low elevations on alluvial deposits along streams or on poorly drained sites with higher nutrient availability. The vegetation characteristically lacks a eucalypt overstorey and is dominated by Swamp Paperbark *Melaleuca ericifolia* (or sometimes Woolly Tea-tree *Leptospermum lanigerum*), which often forms a dense thicket, out-competing other species. Where light penetrates to ground level, a moss/lichen/liverwort or herbaceous ground cover is often present. Dry variants have a grassy/herbaceous ground-layer.

Altitude: 5–110m.

Topography: Flood plains, water courses and drainage basins.

Geology: Mainly on Quaternary and Tertiary deposits, rare on basalt.

Soils: Variable, ranging from peat on poorly drained sites and on lower slopes prone to periodic seepages, to organic loam on the margins of freshwater wetlands.

Floristics: The tallest stratum typically consists of a dense shrub layer of Swamp Paperbark *Melaleuca ericifolia* (or Woolly Tea-tree *Leptospermum lanigerum*, particularly on basalts). Occasionally there may be emergent Swamp Gum *Eucalyptus ovata*.

The extent of the development of the ground cover depends on the amount of light reaching the ground. Species at wetter sites include Swamp Club-sedge *Isolepis inundata*, Water Ribbons *Triglochin procerum*, Streaked Arrow-grass *Triglochin striatum*, Swamp Mazus *Mazus pumilo*, Austral Brooklime *Gratiola peruviana*, Centella *Centella cordifolia*, Soft Water-fern *Blechnum minus*, Swamp Goodenia *Goodenia humilis* and Rushes *Juncus* spp. Species at drier sites include Small-leaf Bramble *Rubus parvifolius*, Kidney-weed *Dichondra repens*, Bidgee-widgee *Acaena novae-zelandiae*, Common Tussock-grass *Poa labillardierei*, Slender Tussock-grass *Poa tenera*, Wetland Wallaby-grass *Notodanthonia semiannularis*, Shrubby Groundsel *Senecio minimus*, Austral Bracken *Pteridium esculentum* and Weeping Grass *Microlaena stipoides* var. *stipoides*.

Structure: A closed scrub variously with a moss/lichen/liverwort or herbaceous ground-cover where light penetrates to ground level.

Box 18. Description of the Swamp Scrub community (across Port Phillip and Western Port, not specific to the Yarra; from Oates and Taranto [2001]).

3.3
Fauna Diversity
In the past

Many of the mammal species that lived in the study area have now disappeared. Forests and woodlands were cleared, farms followed, and they in turn were subdivided for housing. This stretch of the river also has a strong industrial history. The river was used by the early European settlers as a source of water for manufacturing and as a way of disposing of often toxic wastes. It was a preferred site to establish industrys it provided a source of water and a way of easily disposing of wastes. As an ecological corridor than covered a vast landscape and various habitat types, the Yarra River would have hosted an extremely diverse array of fauna prior to colonisation. While some of these fauna still remain today, a number of historical accounts of fauna in the area reveal vast changes. This guide does not aim to thoroughly categorise these changes; however, the paragraph below gives a general indication of how the Yarra used to look. Development of the city has steadily pushed fauna upstream.

Eastern Grey Kangaroos *Macropus giganteus* and Emus *Dromaius novaehollandiae* were said to be extremely abundant throughout Melbourne in 1839, but by the 1850s they were considered rare (Presland 2009). Other common mammals throughout Melbourne included Platypuses *Ornithorhynchus anatinus*, Short-beached Echidnas *Tachyglossus aculeatus*, Southern Brown Bandicoots *Isoodon obesulus*, and Eastern Bettongs *Bettongia gaimardi*, with Eastern Quolls *Dasyurus viverrinus* (Image 2323) even remaining in Yarra Bend until at least 1946 when a carcass was recorded by the botanists Bibby and Willis (Lacey 2004).

Clearly there has been a huge shift in fauna diversity along the Yarra since colonisation. There is still a surprising diversity of species in the corridor in the study area: parrots, cockatoos, kookaburras, water and small bush birds can be seen, along with bats, platypus, wombats, several species of possums, echidnas and eastern grey kangaroos. However, looking into the past presents a unique opportunity, to envision the direction that ecological restoration could take the area into in the future, and begs the question.

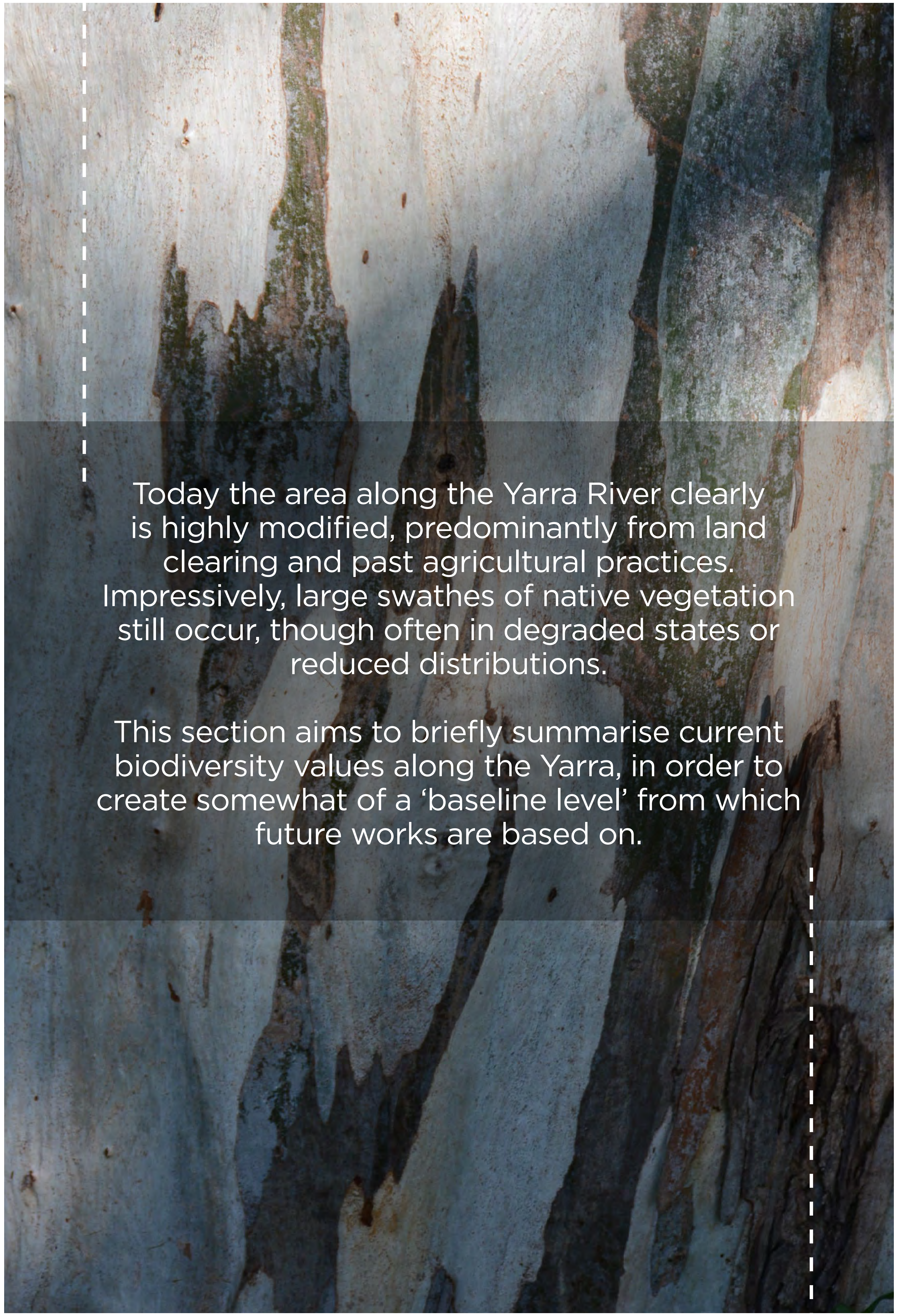
Could Eastern Quolls, Southern Brown Bandicoots, and Eastern Bettongs call the Yarra River home again?

Image 23. Eastern Quoll. World Wildlife Fund

If so, how can we achieve this?

4

How the Yarra Looks Now



Today the area along the Yarra River clearly is highly modified, predominantly from land clearing and past agricultural practices. Impressively, large swathes of native vegetation still occur, though often in degraded states or reduced distributions.

This section aims to briefly summarise current biodiversity values along the Yarra, in order to create somewhat of a 'baseline level' from which future works are based on.

4.1 Soils

Over the past 180 or so years, the land along the Yarra has been cleared, the land used for agriculture, and, then on the lower Yarra, undergone extensive urban development. This has disturbed, depleted and changed the soil, and the soil profiles, in the river corridor.

Prior to European settlement when the landscape was under Traditional Owner management, the soil had an established profile and was open and absorbed the rain, and much of the water was then transpired rather than running off the impervious surfacing of much of the urban catchment. Since 1835, soils in the river corridor have been compacted and eroded.

The soils on the regeneration site may not be able support the full range of plants and structure in the original vegetation community for the site. Soils may be drastically different to the original conditions. In these cases, it is important to recognise and work with what is currently on the site, rather than to attempt to place the original vegetation community, as this may not be realistic.

For example, nutrient loads on a site may be so high that exotic weeds will continue to out compete indigenous ground-layer plants into the foreseeable future. Rather than investing in weed control at such sites, it may be more effective to focus on establishing the shrub and tree layer. The shrub and tree layer can provide connectivity for bird, insect and wildlife movement and can begin to build a seed bank. This is a good example of a first step for the site, and over the years nutrient levels are likely to decline to a point where ground-layer plantings can be established.

A healthy leaf litter layer is important in protecting and maintain the upper layer of the soil. Litter is one of the structural layers in the vegetation and is rich in invertebrate life that enriches the soil through promoting decay. This can be one goal of site regeneration.

In summary, as much as it is tempting to believe that original vegetation communities can be re-established, the current condition of a site dictates what is achievable and best sequence of steps to achieve the target condition.

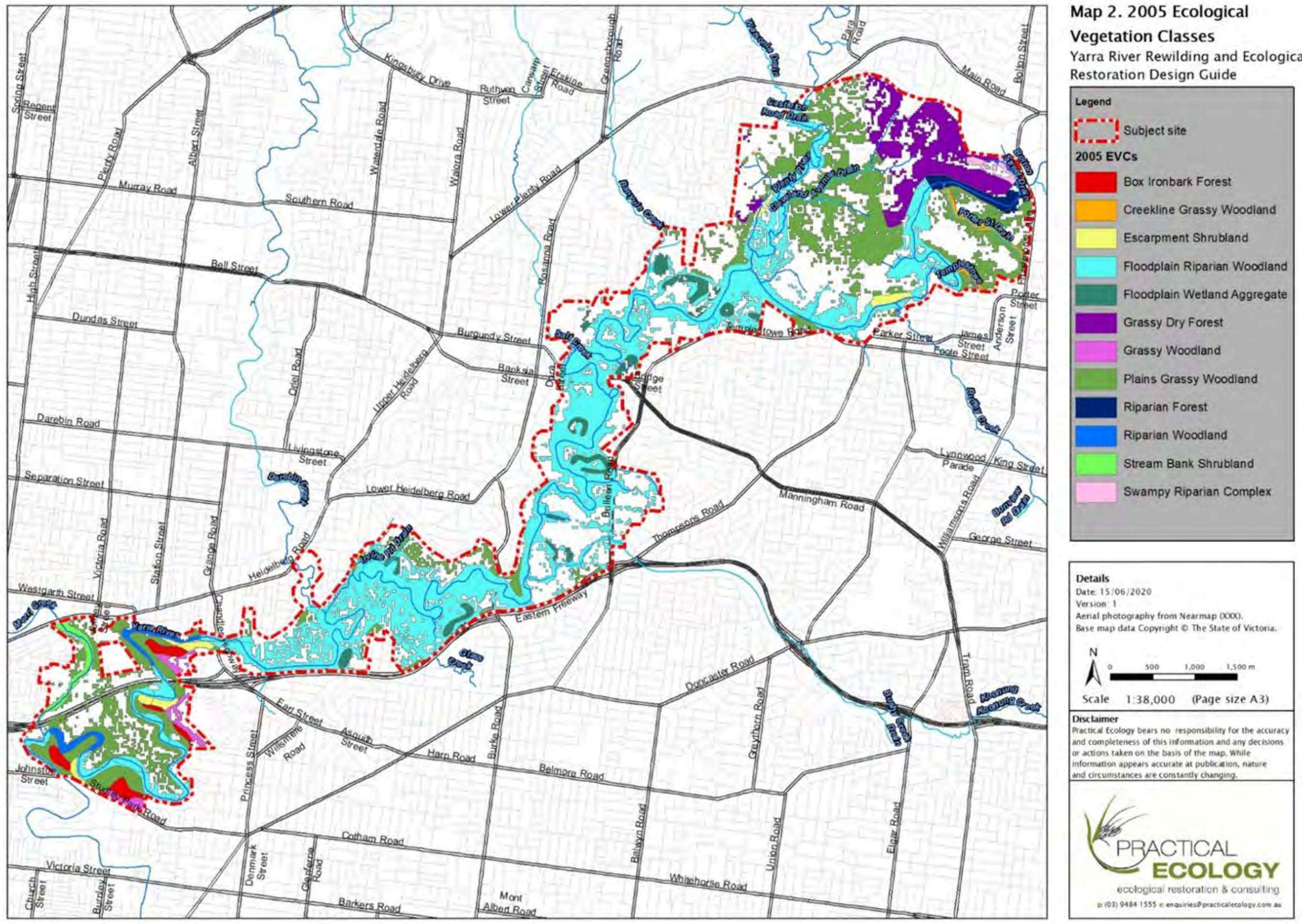
4.2 Vegetation Communities

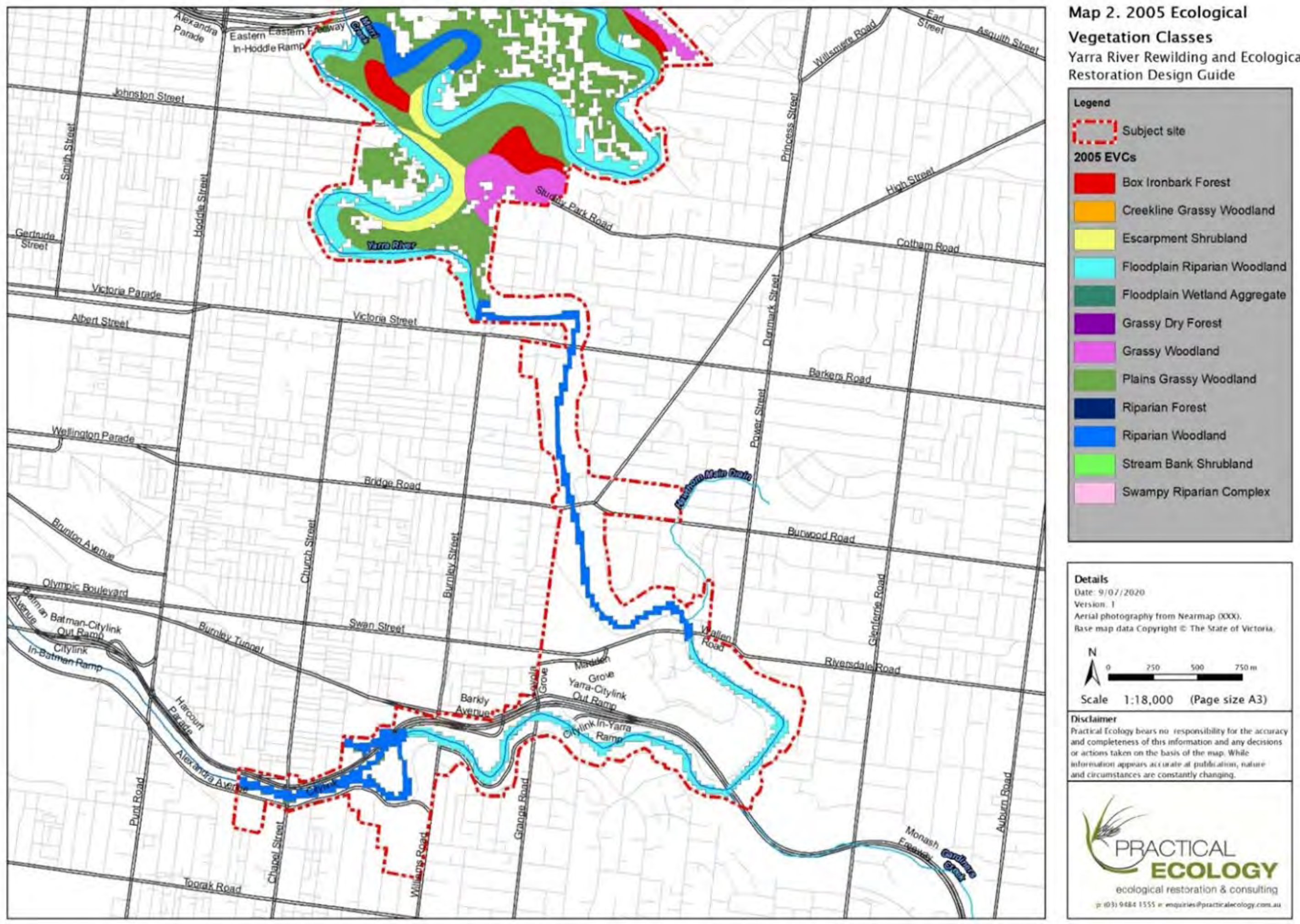
Current

Surprisingly, all of the original vegetation communities are still present throughout the study area with the exception of Swamp Scrub, which occurred only in a very restricted area (Map 2, Table 3 on page 70). The Swampy Riparian Complex (a combination of a number of similar communities) referred to on Map 2 has been deemed most likely to be Creekline Herb-rich Woodland, and is otherwise referred to as such. For detailed descriptions of these communities, see Section 3.2.

Vegetation community	Still present?	Still present in all original locations in the study area?	Still at original size?
Box-Ironbark Forest	Yes	Yes	No – though not substantially reduced
Creekline Herb-rich Woodland	Yes	No – southern patches now absent	No – somewhat reduced throughout whole of range
Creekline Grassy Woodland	Yes	No – now absent from locations at Banyule Creek and Salt Creek	No – substantially reduced in area near Plenty River
Escarpment Shrubland	Yes	Yes	No – northern patch somewhat reduced
Floodplain Riparian Woodland	Yes	Yes	No – somewhat reduced throughout whole of range with the exception of around Yarra Bend
Floodplain Wetland Aggregate	Yes	Yes	No – somewhat reduced throughout whole of range
Grassy Dry Forest	Yes	Yes	No – reduced throughout the study area
Grassy Woodland	Yes	No – northern and southern patches now absent	No – reduced throughout the study area
Plains Grassy Woodland	Yes	No – southern patches now absent	No – substantially reduced throughout whole of range, especially in the south
Riparian Forest	Yes	Yes	No – reduced throughout the study area
Riparian Woodland	Yes	Yes	No – reduced throughout the study area with the exception of around Yarra Bend
Stream Bank Shrubland	Yes	Yes	No – reduced throughout the study area
Swamp Scrub	Yes	No – very restricted	No – very restricted

Table 3. Current vegetation community distributions and size throughout the study area.





4.3

Fauna Diversity

Current

The Yarra River still contains a wide variety of fauna diversity to this day, in fact large enough that summarising it in this guide would be impractical and even a disservice to the ecological complexity of the catchment. Some common mammals in the study area include Short-beaked Echidnas *Tachyglossus aculeatus*, Common Brushtail and Ringtail Possums *Trichosurus vulpecula* and *Pseudocheirus peregrinus*, the famous Grey-headed Flying-foxes *Pteropus poliocephalus*, Gould's Wattled Bats *Chalinolobus gouldii*, and Rakali *Hydromys chrysogaster* (Lacey 2004).

With the revegetation of the river corridor through initiatives such as the Melbourne Water's Stream Frontage Grants program, fauna has been repopulating the banks of the river, moving downstream. Wombats have moved into the flood plain corridor downstream from Healesville. Sugar gliders have now been recorded as far down stream as Burke Road Billabong. This is an encouraging sign for the increase of biodiversity in the study area. The connectivity of the river also allows for the migration of feral species downstream such as deer, which have now been seen as far downstream as Ivanhoe and the Green Acres Golf Course.

Possums have adapted well to urban habitats and both Brushtail and the Ring-tail Possums *richosurus vulpecula* and *Pseudocheirus peregrinus* are common in the parks and private gardens of Melbourne.

Reptiles common in the study area include Common Long-necked Turtles *Chelodina longicollis*, Eastern Blue-tongued Lizards *Tiliqua scincoides*, Tiger Snakes *Notechis scutatus*, Eastern Water Dragons *Intellagama lesueurii lesueurii* and Eastern Brown Snakes *Pseudonaja textilis* (Lacey 2004).

Both the Long-necked Turtles and the Eastern Water Dragons are introduced populations from pet releases.

A number of frogs occur in the study area including Striped and Spotted Marsh Frogs, *Limnodynastes peronii* and *Limnodynastes. tasmaniensis*, Common Froglets *Crinia* signifera, and Southern Brown Tree Frogs *Litoria ewingii* (Lacey 2004).

Birds are the most often encountered group along the Yarra, with some more unique species such as Tawny Frogmouths *Podargus strigoides* and Powerful Owls *Ninox strenua*, as well as many common species such as parrots, honeyeaters, robins, herons, egrets, kingfishers, and fairy-wrens.

Water birds are a significant feature of the wildlife along the river in the study area. Coots *Fulica atra*, Dusky Moorhens *Gallinula tenebrosa* and Purple Swamp Hens *Porphyrio porphyrio* are common along the river. Cormorants especially the Little Black and Little Pied Cormorants *Phalacrocorax sulcirostris* and *Microcarbo melanoleucos* are frequently seen. More occasionally Black and Pied Cormorants, *Phalacrocorax sulcirostris*

Image 24. Fishing rods. Anthony Despotellis

and *Phalacrocorax varius*, are seen. Seabirds such as the Crested Tern *Thalasseus bergii* and Silver Gull *Chroicocephalus novaehollandiae* are seen as far upriver as Herring Island. Both Pacific Black Duck *Anas superciliosa* and Australian Wood Duck *Chenonetta jubata* are frequently seen along the river. Both the Eastern Great Egret *Ardea alba modesta* and Little Egret *Egretta garzetta* can be found in the study area. The Australasian Darter *Anhinga novaehollandiae* is also regularly seen, as is the White-faced Heron *Egretta novaehollandiae* and the Nankeen Night Heron *Nycticorax caledonicus*. Black swans *Cygnus atratus* are also occasionally seen.

The Yarra River itself is also habitat for several species of threatened native fish, not all indigenous to the Yarra. Three threatened native fish species, Australian Grayling *Prototroctes maraena*, Macquarie Perch *Macquaria australasica* and Murray Cod *Maccullochella peelii*, have significant populations present in the Yarra. Any restoration work that improves riparian habitats and water quality will help protect these species.

Unfortunately, many species of native fauna have been eliminated from the study area and only the resilient species that can cope with lack of natural habitat, introduced predators and ongoing disturbance. Restoration works will help enhance the habitat of the remaining native fauna, and allow the possibility of reintroductions.

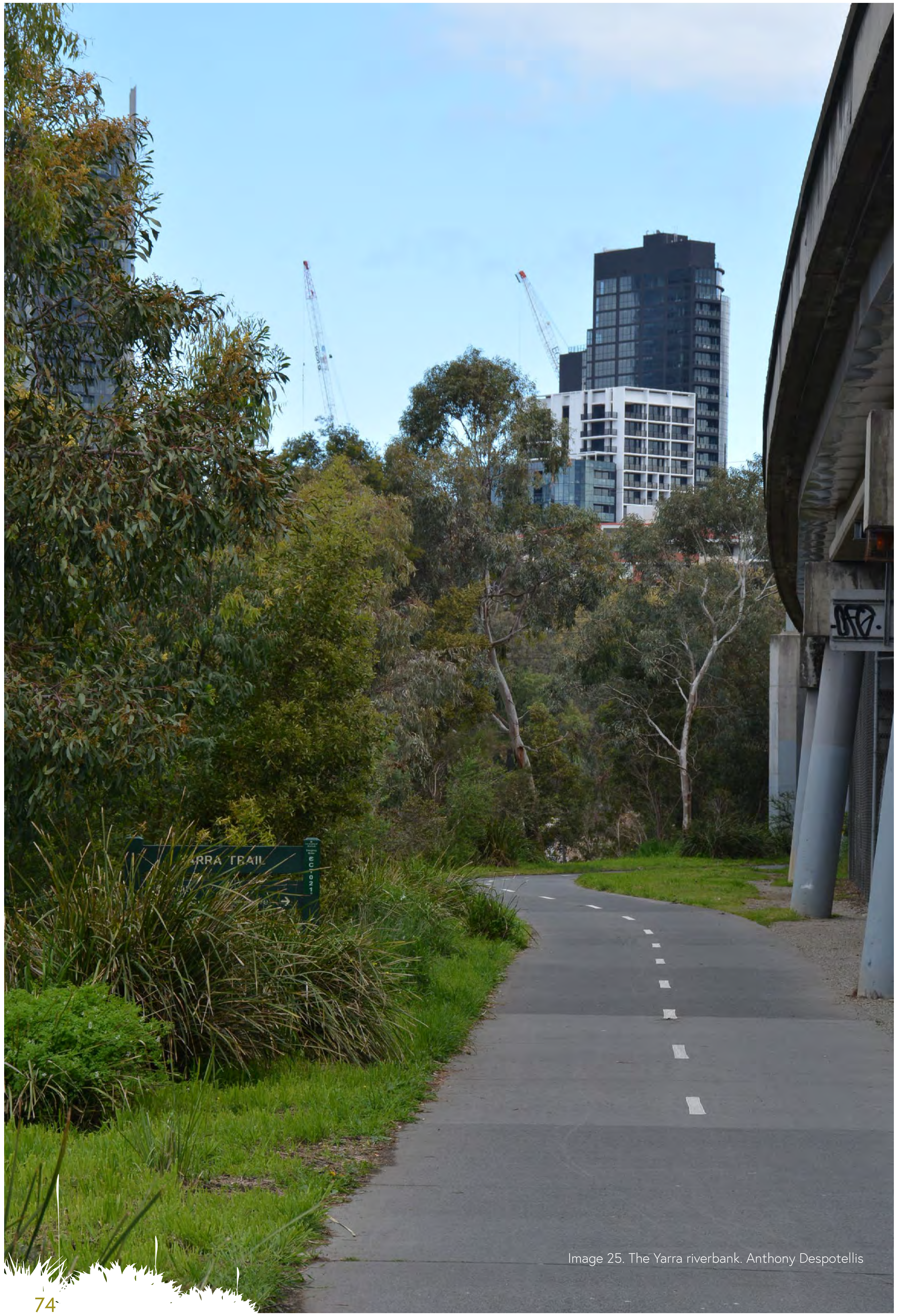


Image 25. The Yarra riverbank. Anthony Despotellis

4.4

Threats to Biodiversity

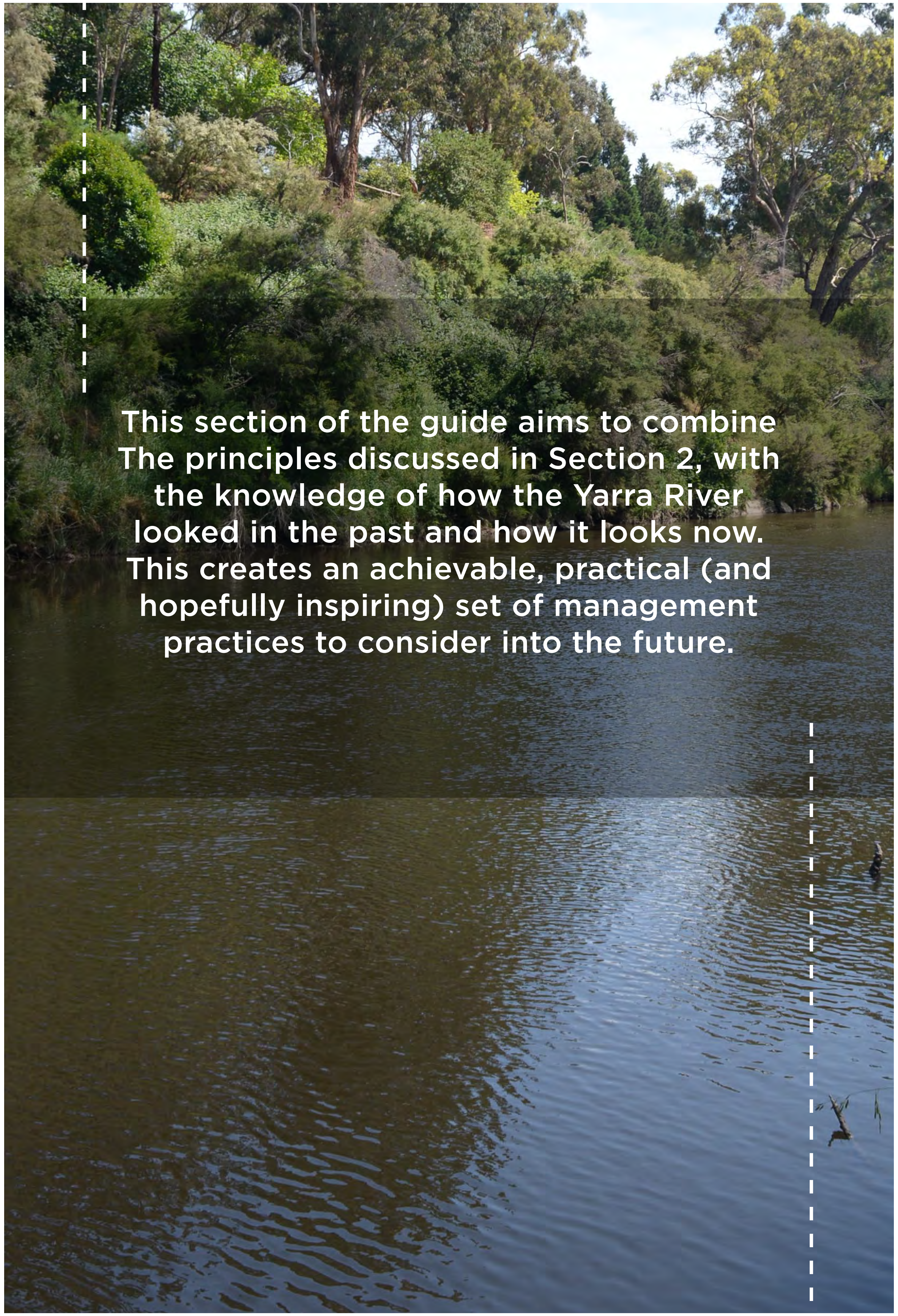
Current

While this guide does not aim to document all of the processes threatening biodiversity along the Yarra, it is still important to understand what threats exist, in order to create restoration projects to mitigate their affects. Six of the most relevant issues to restoration along the Yarra that will be addressed in our wilding work are:

- Habitat loss;
- Fragmentation of habitat;
- Disturbance from humans (mountain bikes, four-wheel drives, motor bikes, fossicking, panning, timber-getting);
- Weed invasion and subsequent colonisation;
- Lack of structural complexity and habitat features in many areas;
- Pest animals and pets, both predators, grazers, and the taking of habitat niches;
- Unaccounted for extinction lag;
- Urbanisation and stormwater runoff;
- Climate change (Victoria's climate has already warmed by 1°C since records were first kept in 1910,and Melbourne is experiencing hotter days, bushfire smoke, more intense storms and flooding as well as sea level rise).

5

What the Yarra Could Look Like



This section of the guide aims to combine The principles discussed in Section 2, with the knowledge of how the Yarra River looked in the past and how it looks now. This creates an achievable, practical (and hopefully inspiring) set of management practices to consider into the future.

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.

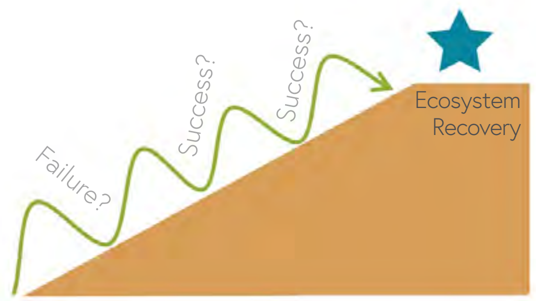
Ecological restoration is step-based and follows a logical progression

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.



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

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.

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).

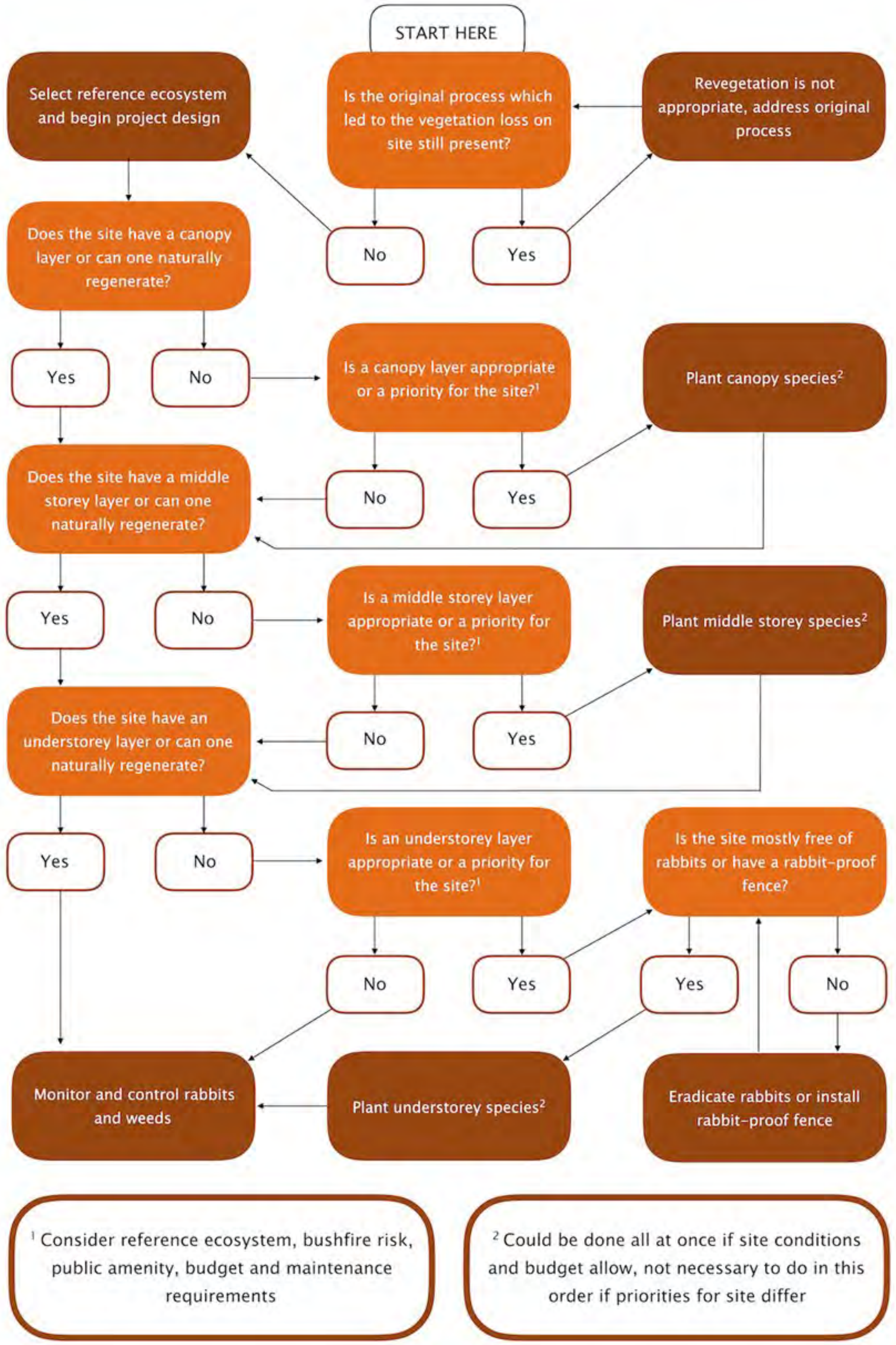


Figure 6. Decision tree for revegetation project design. Please note that this decision tree is intended to facilitate thinking and is not prescriptive.

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 
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).

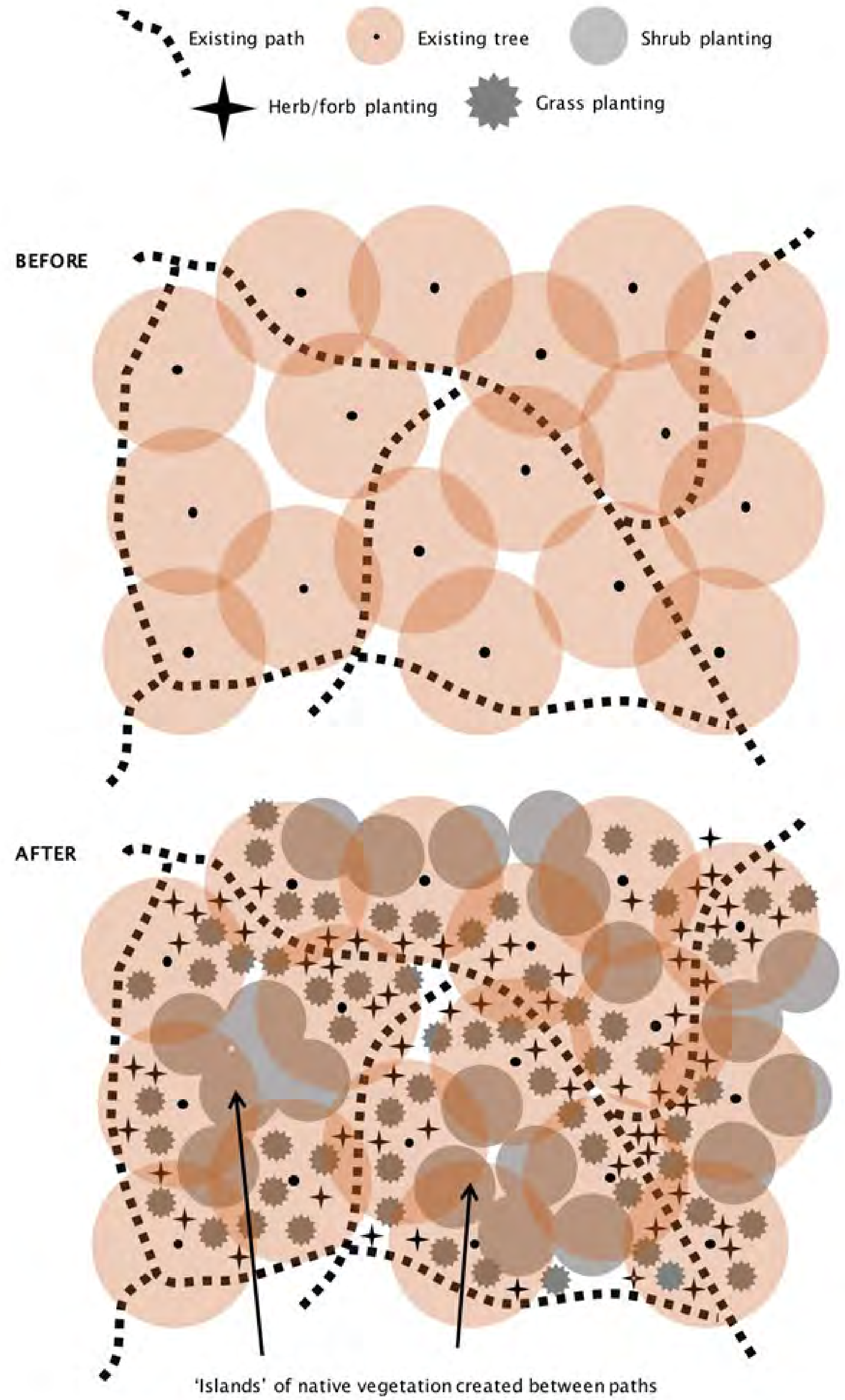


Figure 7. Potential design of native vegetation 'islands' among paths.

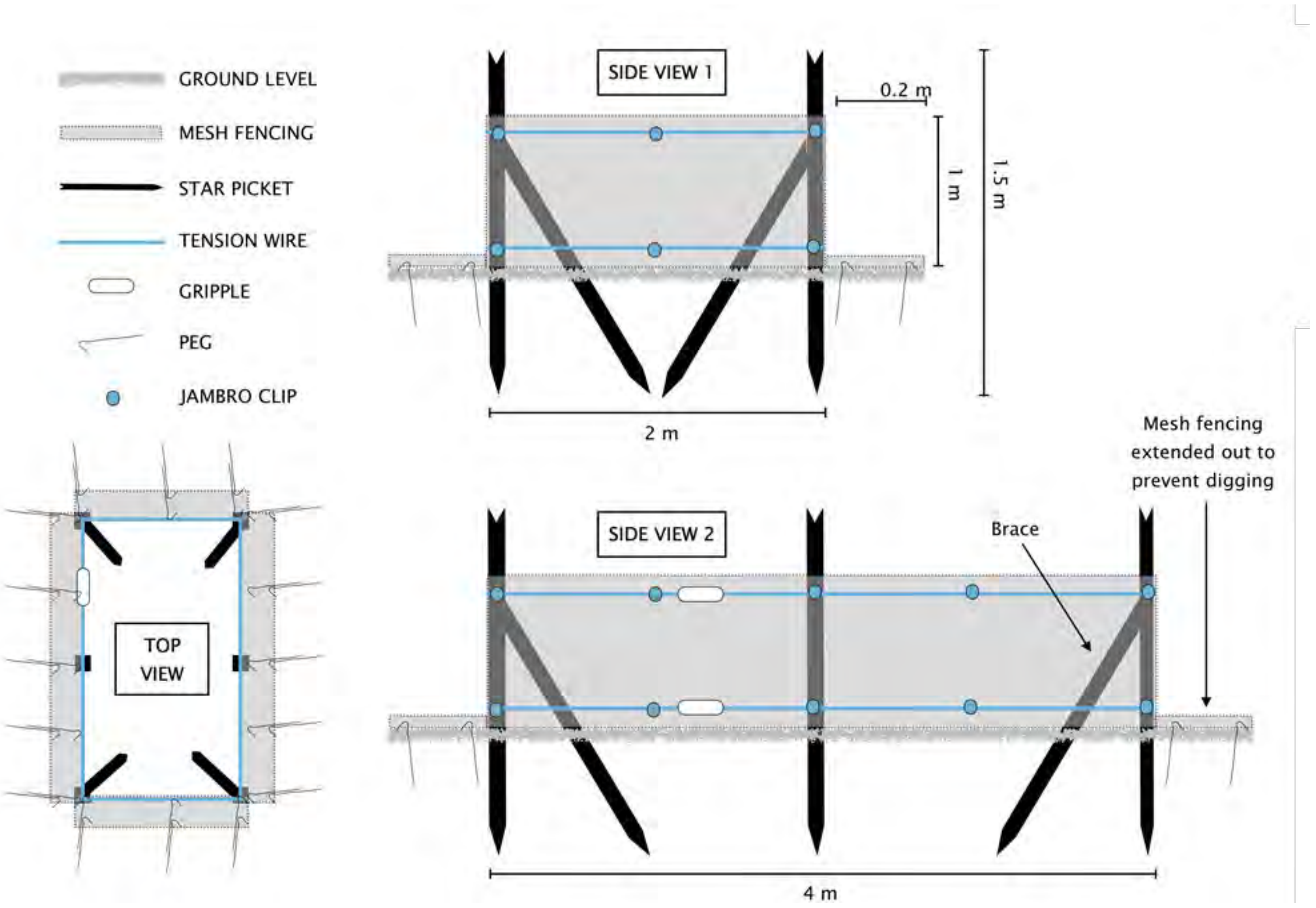


Figure 8. Potential design of rabbit-proof exclosures in which to establish ground-layer plantings and build the native seed bank while rabbit eradication is underway.

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.

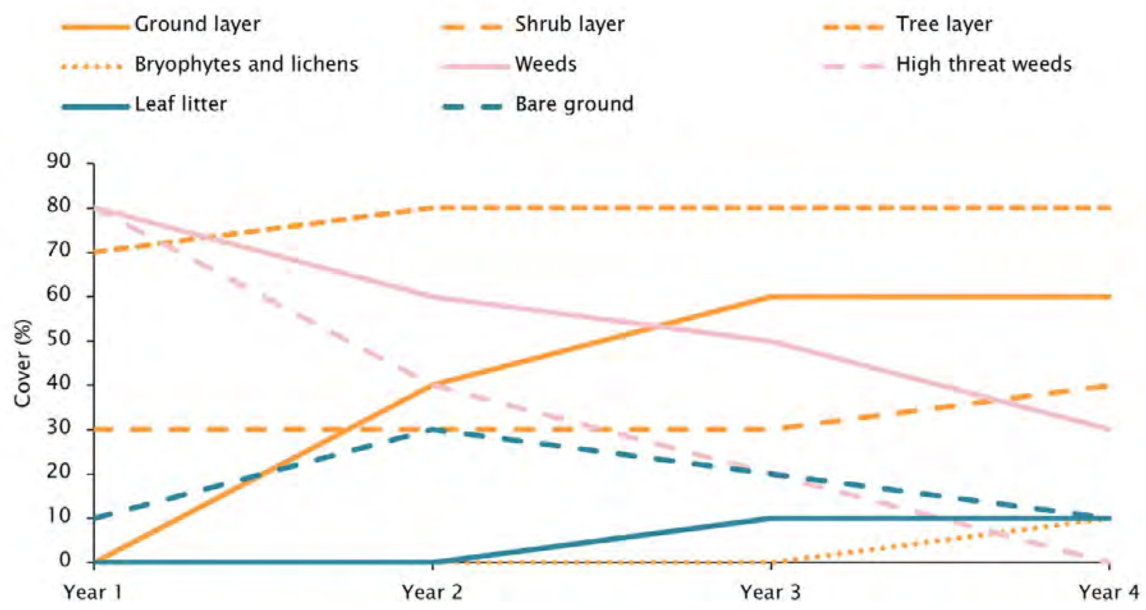


Figure 11. Theoretical representation of how to display vegetation cover data.

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.

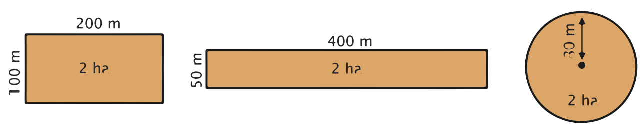
Control sites

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.

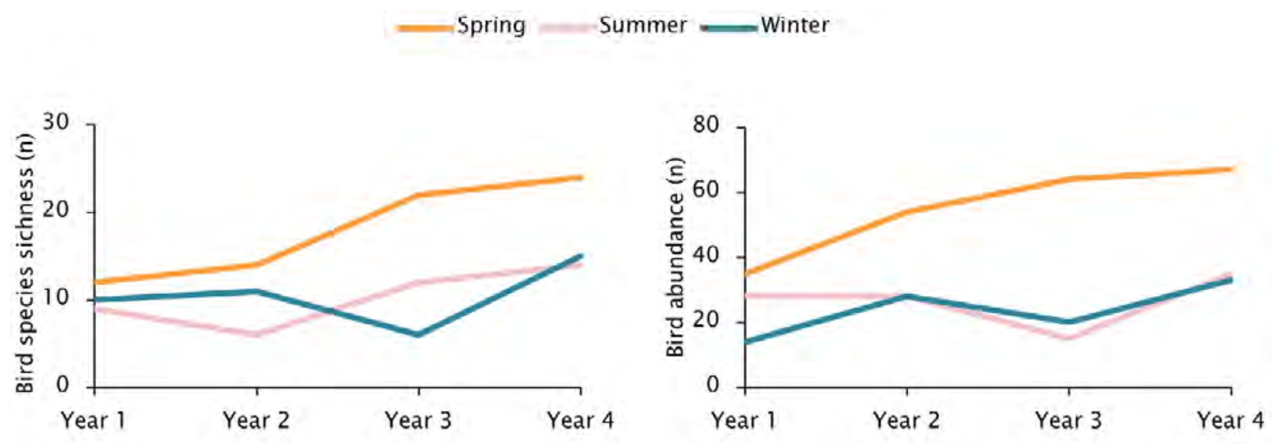


Figure 12. Theoretical representation of how to display bird monitoring data.

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?

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.

6

Appendices

6.1

Appendix 1

Complexity and recovery models in International Restoration Standards

NUMBER OF STARS	SUMMARY OF RECOVERY OUTCOME
★	Ongoing deterioration prevented. Substrates remediated (physically and chemically). Some level of native biota present; future recruitment niches not negated by biotic or abiotic characteristics. Future improvements for all attributes planned and future site management secured.
★★	Threats from adjacent areas starting to be managed or mitigated. Site has a small subset of characteristic native species and low threat from undesirable species onsite. Improved connectivity arranged with adjacent property holders.
★★★	Adjacent threats being managed or mitigated and very low threat from undesirable species onsite. A moderate subset of characteristic native species is established and there is some evidence of ecosystem function commencing. Improved connectivity at the landscape scale is in evidence.
★★★★	A substantial subset of characteristic biota present (representing all species groupings), providing evidence of developing community structure and of ecosystem processes. Improved connectivity established and surrounding threats being managed or miti-gated.
★★★★★	Establishment of a characteristic assemblage of biota to a point where structural and trophic complexity to a level of very high similarity to the reference ecosystem is likely to develop with minimal further restoration interventions. Appropriate cross-boundary flows are enabled and commencing and resilience is restored with return of appropriate disturbance regimes. Long-term management arrangements in place.

ATTRIBUTE	★	★★	★★★	★★★★	★★★★★
Absence of threats	Further deterioration discontinued, and site has tenure and management secured.	Threats from adjacent areas beginning to be managed or mitigated.	All adjacent threats managed or mitigated to a low extent.	All adjacent threats managed or mitigated to an intermediate extent.	All threats managed or mitigated to high extent.
Physical conditions	Gross physical and chemical problems remediated (e.g., excess nitrogen, altered pH, high salinity, contamination or other damage to soil or water).	Substrate chemical and physical properties on track	Substrate stabilized within natural range and supporting growth of characteristic native biota.	Substrate securely maintaining conditions suitable for ongoing growth and recruitment of characteristic native biota.	Substrate exhibiting physical and chemical characteristics highly similar to that of the reference ecosystem with evidence they can indefinitely sustain species and processes.
Species composition	Some colonizing native species present (e.g., ~2% of species in the reference ecosystem). Moderate onsite threat from nonnative invasive or undesirable species. Regeneration niches available.	A small subset of characteristic native species establishing (e.g., ~10% of reference). Low to moderate onsite threat from nonnative invasive or undesirable species.	A subset of key native species (e.g., ~25% of reference) establishing over substantial proportions of the site. Very low onsite threat from nonnative invasive or undesirable species.	Substantial diversity of characteristic native biota (e.g., ~60% of reference) present across the site and representing a wide diversity of species groups. Very low onsite threat from nonnative invasive or undesirable species.	High diversity of characteristic native species present (e.g., >80% of reference), with high similarity to the reference ecosystem; improved potential for colonization of more native species over time. No known onsite threat from undesirable species.
Structural diversity	One or fewer biological strata present and no spatial patterning or community trophic complexity relative to reference ecosystem.	More strata present but low spatial patterning and trophic complexity, relative to reference ecosystem.	Most strata present and some spatial patterning and trophic complexity relative to reference site.	All strata present. Spatial patterning evident and substantial trophic complexity developing relative to the reference ecosystem.	All strata present and spatial patterning and trophic complexity high. Further complexity and spatial patterning able to self-organize to highly resemble reference ecosystem.
Ecosystem function	Substrates and hydrology are at a foundational stage only, capable of future development of functions similar to the reference.	Substrates and hydrology show increased potential for a wider range of functions including nutrient cycling, and provision of habitats and resources for other species.	Evidence of functions commencing (e.g., nutrient cycling, water filtration, and provision of habitat and resources for a range of species).	Substantial evidence of key functions and processes commencing including reproduction, dispersal, and recruitment of native species.	Considerable evidence of functions and processes on a secure trajectory towards that of the reference and evidence of ecosystem resilience, tested by reinstatement of appropriate disturbance regimes.
External exchanges	Potential for exchanges (e.g., of species, genes, water, fire) with surrounding landscape or aquatic environment identified.	Connectivity for enhanced positive (and minimized negative) exchanges arranged through cooperation with stakeholders. Linkages being reinstated.	Positive exchanges between site and external environment becoming evident (e.g., more species, gene flows, etc.).	High level of positive exchanges with other native ecosystems established; control of undesirable species and disturbances.	Evidence that external exchanges are highly similar to reference, and long-term integrated management arrangements with broader landscape in place and operative.

Baseline *10 years later*

Figure 4. *The Ecological Recovery Wheel is a tool for conveying progress of recovery of ecosystem attributes compared to those of a reference model. In this example, the first wheel represents the condition of each attribute assessed during the baseline inventory stage of the project. The second wheel depicts a 10-year-old restoration project, where over half its attributes have attained a 4-star condition. Practitioners familiar with the project goals, objectives, site-specific indicators, and recovery levels achieved to date can shade the segments for each sub-attribute after formal or informal evaluation. Blank templates for the diagram and its accompanying form are in Appendix 2. Sub-attribute labels can be added or modified to best represent a particular project. For symmetry of design, three sub-attributes are used in this example, but there may be more, or fewer, needed depending on the project.*

6.2 Appendix 2

Planting palettes

The planting palettes categorises plants into the following four groups, explained in detail in Box 1:

1. Tree Layer broken down into:
   - Canopy Trees; and
   - Sub-canopy Trees.
2. Climbers.
3. Shrub Layer broken down into:
   - Large Shrubs; and
   - Small-medium Shrubs.
4. Ground-layer broken down into:
   - Grasses;
   - Rushes and Sedges;
   - Ferns;
   - Herbs and Forbs (excluding grasses, rushes and sedges, and ferns which are technically herbaceous, though for the purpose of the planting palettes are better categorised otherwise); and
   - Prostrate Shrubs.

These palettes are not considered to be exhaustive, due to the extreme diversity of both vegetation communities and species found throughout the study area of the Yarra River. These planting palettes contain the most common and indicative species of their respective vegetation communities, and it is possible to include other species in revegetation projects by using the below methodology or similar.

Methodology

In order to create planting palettes for each of the reference ecosystems/vegetation communities identified in Section 3.2, a number of sources were used. First, Oates and Taranto (2001), *Flora of Melbourne* (Bull 2014), and DELWP *EVC Benchmarks* (DELWP 2020) to identify species which are indicative of each vegetation community. Subsequently, distribution mapping from VICFLORA (Royal Botanic Gardens Victoria 2018) was consulted to identify if these species were found within or near the study area of the Yarra River. If species were indicative of the vegetation communities, and distributed near the Yarra, then in combination with some knowledge of the species' habitat and ecology, they were included in the planting palette.

Modifying palettes for social/practical/safety reasons

While the inclusion of all vegetation components (tree, shrub, and ground-layers) belonging to each community is always desirable from an ecological perspective, it may be necessary to omit one for other reasons such as:

High foot-traffic Aaeas which will continue to be used by the public could have the ground-layer species omitted to allow the continued passage of pedestrians;

Sites with high weed cover or with a low maintenance budget could only include hardy species;

Bushfire-risk areas could have the shrub layer omitted to reduce fuel loads; or

Area near electrical assets could have the canopy tree layer omitted to reduce the need for pruning.

Image 41. The Yarra at Westerfolds Park. Anthony Despotellis.

Tree Layer

Hardiness key	Community key
Hardy species	**Plant Species is typical of vegetation community** Notes
Moderately hardy species	Plant Species is somewhat typical of vegetation community Notes
Less hardy species	Plant Species is not typical of vegetation community Notes

Layer	Notes	Common Name	Genus	Species	Box-Ironbark Forest	Creekline Grassy Woodland	Creekline Herb-rich Woodland	Escarpment Shrubland	Floodplain Riparian Woodland	Floodplain Wetland Aggregate	Grassy Dry Forest	Grassy Woodland	Plains Grassy Woodland	Riparian Forest	Riparian Woodland	Stream Bank Shrubland	Swamp Scrub
Tree Layer – Canopy		**River Red Gum**	***Eucalyptus***	***camaldulensis***				5									
Tree Layer – Canopy		Bundy	*Eucalyptus*	*goniocalyx*				5									
Tree Layer – Canopy		Yellow Gum	*Eucalyptus*	*leucoxylon* subsp. *connata*				5									
Tree Layer – Canopy		Red Stringybark	*Eucalyptus*	*macrorhyncha*				5									
Tree Layer – Canopy		Yellow Box	*Eucalyptus*	*melliodora*				5									
Tree Layer – Canopy		Swamp Gum	*Eucalyptus*	*ovata*													
Tree Layer – Canopy		Red Box	*Eucalyptus*	*polyanthemos* subsp. *vestita*													
Tree Layer – Canopy		Narrow-leaf Peppermint	*Eucalyptus*	*radiata*													
Tree Layer – Canopy		Red Ironbark	*Eucalyptus*	*tricarpa*													
Tree Layer – Canopy		Manna Gum	*Eucalyptus*	*viminalis*				5									
Tree Layer – Canopy		Yarra Gum	*Eucalyptus*	*yarraensis*													
Tree Layer – Subcanopy		Silver Wattle	*Acacia*	*dealbata*													
Tree Layer – Subcanopy		Lightwood	*Acacia*	*implexa*													
Tree Layer – Subcanopy		Black Wattle	*Acacia*	*mearnsii*													
Tree Layer – Subcanopy		Blackwood	*Acacia*	*melanoxylon*													
Tree Layer – Subcanopy		Golden Wattle	*Acacia*	*pycnantha*				5									
Tree Layer – Subcanopy		Black Sheoak	*Allocasuarina*	*littoralis*				5									
Tree Layer – Subcanopy		Drooping Sheoak	*Allocasuarina*	*verticillata*				3,4									
Tree Layer – Subcanopy	2	Cherry Ballart	*Exocarpos*	*cupressiformis*													
Tree Layer – Subcanopy	1	Woolly Tea-tree	*Leptospermum*	*lanigerum*													1
Tree Layer – Subcanopy	1	Swamp Paperbark	*Melaleuca*	*ericifolia*													1

Climber Layer

Notes	Common Name	Genus	Species	Box-Ironbark Forest	Creekline Grassy Woodland	Creekline Herb-rich Woodland	Escarpment Shrubland	Floodplain Riparian Woodland	Floodplain Wetland Aggregate	Grassy Dry Forest	Grassy Woodland	Plains Grassy Woodland	Riparian Forest	Riparian Woodland	Stream Bank Shrubland	Swamp Scrub
	Small-leaved Clematis	***Clematis***	***microphylla***													
	Purple Coral-pea	*Hardenbergia*	*violacea*													

Shrub Layer

Hardy species
Moderately hardy species
Less hardy species

Plant Species is typical of vegetation community	Notes
Plant Species is somewhat typical of vegetation community	Notes
Plant Species is not typical of vegetation community	Notes

Layer	Group	Notes	Common Name	Scientific Name: Genus	Scientific Name: Species	Box-Ironbark Forest	Creekline Grassy Woodland	Creekline Herb-rich Woodland	Escarpment Shrubland	Floodplain Riparian Woodland	Floodplain Wetland Aggregate	Grassy Dry Forest	Grassy Woodland	Plains Grassy Woodland	Riparian Forest	Riparian Woodland	Stream Bank Shrubland	Swamp Scrub
Shrub layer	Large shrubs		Gold-dust Wattle	*Acacia*	*acinacea*													
Shrub layer	Large shrubs		Hedge Wattle	*Acacia*	*paradoxa*													
Shrub layer	Large shrubs		Sweet Bursaria	*Bursaria*	*spinosa*				4								7	
Shrub layer	Large shrubs		River Bottlebrush	*Callistemon*	*sieberi*												6	
Shrub layer	Large shrubs		Shiny Cassinia	*Cassinia*	*longifolia*				5								7	
Shrub layer	Large shrubs		Sticky Hop-bush	*Dodonaea*	*viscosa*				4								7	
Shrub layer	Large shrubs		Hemp Bush	*Gynatrix*	*pulchella*													
Shrub layer	Large shrubs		Prickly Tea-tree	*Leptospermum*	*continentale*				4									
Shrub layer	Large shrubs	1	Wooly Tea-tree	*Leptospermum*	*lanigerum*												6	
Shrub layer	Large shrubs	1	Swamp Paperbark	*Melaleuca*	*ericifolia*													
Shrub layer	Large shrubs		Tree Violet	*Melicytus (Hymenanthera)*	*dentatus (dentata)*												7	
Shrub layer	Large shrubs		Sticky Boobialla	*Myoporum*	*petiolatum*				4									
Shrub layer	Large shrubs		Snow Daisy-bush	*Olearia*	*lirata*													
Shrub layer	Large shrubs		Tree Everlasting	*Ozothamnus*	*ferrugineus*				5									
Shrub layer	Large shrubs		Hazel Pomaderris	*Pomaderris*	*aspera*													
Shrub layer	Large shrubs		Prunus Pomaderris	*Pomaderris*	*prunifolia*				5									
Shrub layer	Large shrubs		Victorian Christmas-bush	*Prostanthera*	*lasianthos*													
Shrub layer	Small - Medium shrubs		Rock Correa	*Correa*	*glabra*				4									
Shrub layer	Small - Medium shrubs		Grey Parrot-pea	*Dillwynia*	*cinerascens*													
Shrub layer	Small - Medium shrubs		Common Heath	*Epacris*	*impressa*													
Shrub layer	Small - Medium shrubs		Hop Goodenia	*Goodenia*	*ovata*												7	
Shrub layer	Small - Medium shrubs		Rosemary Grevillea	*Grevillea*	*rosmarinifolia*				4									
Shrub layer	Small - Medium shrubs		Grey Everlasting	*Ozothamnus*	*obcordatus*													
Shrub layer	Small - Medium shrubs		Common Flat-pea	*Platylobium*	*obtusangulum*													
Shrub layer	Small - Medium shrubs		Cranberry Heath	*Styphelia (Astroloma)*	*humifusa (humifusum)*													

Ground-layer

Grasses and Rushes and Sedges

Layer	Group	Notes	Common Name	Genus	Species	Box-Ironbark Forest	Creekline Grassy Woodland	Creekline Herb-rich Woodland	Escarpment Shrubland	Floodplain Riparian Woodland	Floodplain Wetland Aggregate	Grassy Dry Forest	Grassy Woodland	Plains Grassy Woodland	Riparian Forest	Riparian Woodland	Stream Bank Shrubland	Swamp Scrub
Ground layer	Grasses		**Common Blown-grass**	***Agrostis***	***avenacea***													
			Veined Spear-grass	*Austrostipa*	*rudis*													
			Common Plume-grass	*Dichelachne*	*rara*													
			Common Wheat-grass	*Elymus*	*scabra*													
			Weeping Grass	*Microlaena*	*stipoides* var. *stipoides*													8
			Sword Tussock-grass	*Poa*	*ensiformis*													
			Common Tussock-grass	*Poa*	*labillardierei*													8
			Soft Tussock-grass	*Poa*	*morrisii*													
			Grey Tussock-grass	*Poa*	*sieberiana*													
			Slender Tussock-grass	*Poa*	*tenera*													8
			Kneed Wallaby-grass	*Rytidosperma*	*geniculatum*													
			Silvertop Wallaby-grass	*Rytidosperma*	*pallidum*													
			Striped Wallaby-grass	*Rytidosperma*	*racemosum*													
			Bristly Wallaby-grass	*Rytidosperma*	*setaceum*													
			Purplish Wallaby-grass	*Rytidosperma*	*tenuius*													
			Kangaroo Grass	*Themeda*	*triandra*													
	Rushes and Sedges		Marsh Club-sedge	*Bolboschoenus*	*medianus*													
			Tall Sedge	*Carex*	*appressa*													
			Rush Sedge	*Carex*	*tereticaulis*													
			Common Spike-sedge	*Eleocharis*	*acuta*													
			Tall Spike-sedge	*Eleocharis*	*sphacelata*													
			Thatch Saw-sedge	*Gahnia*	*radula*													
			Nodding Club-sedge	*Isolepis*	*cernua*													
			Swamp Club-sedge	*Isolepis*	*inundata*													
			Hollow Rush	*Juncus*	*amabilis*													
				Juncus	*australis*													
			Green Rush	*Juncus*	*gregiflorus*													
				Juncus	*gregiflorus*													
			Joint-leaf Rush	*Juncus*	*holoschoenus*													
			Sea Rush	*Juncus*	*kraussii* subsp. *australiensis*													
				Juncus	*pallidus*													
			Loose-flower Rush	*Juncus*	*pauciflorus*													
			Tall Rush	*Juncus*	*procerus*													
			Broom Rush	***Juncus***	***sarophorus***													
			Common Rush	*Juncus*	*usitatus*													
			Variable Saw-sedge	*Lepidosperma*	*laterale*				5									
			Wattle Mat-rush	*Lomandra*	*filiformis*													
			Spiny-headed Mat-rush	*Lomandra*	*longifolia* subs.. *longifolia*				5									
			Common Reed	*Phragmites*	*australis*													
			River Club-sedge	*Schoenoplectus*	*validus*													
			Water Ribbons	*Triglochin*	*procerum*													
			Cumbungi	*Typha*	*orientalis*													

Tree and Climber Layer

Ferns, Herbs and Forbs, and Prostrate Shrubs

		Notes	Common Name	Genus	Species	Box-Ironbark Forest	Creekline Grassy Woodland	Creekline Herb-rich Woodland	Escarpment Shrubland	Floodplain Riparian Woodland	Floodplain Wetland Aggregate	Grassy Dry Forest	Grassy Woodland	Plains Grassy Woodland	Riparian Forest	Riparian Woodland	Stream Bank Shrubland	Swamp Scrub
Ground layer	Ferns		Common Maidenhair	*Adiantum*	*aethiopicum*			●							●			
Ground layer	Ferns		Annual Fern	*Anogramma*	*leptophylla*				4									
Ground layer	Ferns		Necklace Fern	*Asplenium*	*flabellatum*				4									
Ground layer	Ferns		Sickle Fern	*Pellaea*	*falcata*				4									
Ground layer	Ferns		Austral Bracken	*Pteridium*	*esculentum*	●	●	●				●	●					8
Ground layer	Herbs and Forbs		Sheep's Burr	*Acaena*	*agnipila*	●						●	●	●				
Ground layer	Herbs and Forbs		Bidgee-widgee	*Acaena*	*novae-zelandiae*		●	●									●	8
Ground layer	Herbs and Forbs		Water Plantain	*Alisma*	*plantago-aquatica*					●	●							
Ground layer	Herbs and Forbs		Lesser Joyweed	*Alternanthera*	*denticulata*					●	●							
Ground layer	Herbs and Forbs		Sea Celery	*Apium*	*prostratum*					●	●							
Ground layer	Herbs and Forbs		Chocolate Lily	*Arthropodium*	*strictum*								●	●				
Ground layer	Herbs and Forbs		Shiny Everlasting	*Bracteantha*	*viscosa*				5									
Ground layer	Herbs and Forbs		Blue Pincushion	*Brunonia*	*australis*							●						
Ground layer	Herbs and Forbs		Bulbine Lily	*Bulbine*	*bulbosa*							●	●					
Ground layer	Herbs and Forbs		Milkmaids	*Burchardia*	*umbellata*								●					
Ground layer	Herbs and Forbs		Large Bindweed	*Calystegia*	*sepium*					●	●							
Ground layer	Herbs and Forbs		Centella	*Centella*	*cordifolia*		●	●									●	●
Ground layer	Herbs and Forbs		Pink Bindweed	*Convolvulus*	*erubescens*				5			●	●	●				
Ground layer	Herbs and Forbs		Swamp Crassula	*Crassula*	*helmsii*					●	●						●	
Ground layer	Herbs and Forbs		Black-anther Flax-lily	*Dianella*	*admixta*	●						●	●	●				
Ground layer	Herbs and Forbs		Kidney-weed	*Dichondra*	*repens*	●	●	●	4			●	●	●	●	●		
Ground layer	Herbs and Forbs		Prickfoot	*Eryngium*	*vesiculosum*		●	●										
Ground layer	Herbs and Forbs		Common Raspwort	*Gonocarpus*	*tetragynus*	●						●						
Ground layer	Herbs and Forbs		Lanky Goodenia	*Goodenia*	*elongata*		●	●										
Ground layer	Herbs and Forbs		Austral Brooklime	*Gratiola*	*peruviana*			●										●
Ground layer	Herbs and Forbs		Angled Lobelia	*Lobelia*	*anceps*		●	●		●	●							
Ground layer	Herbs and Forbs		Variable Stinkweed	*Opercularia*	*varia*	●						●						
Ground layer	Herbs and Forbs		Slender Knotweed	*Persicaria*	*decipiens*					●	●						●	
Ground layer	Herbs and Forbs		Common Rice-flower	*Pimelea*	*humilis*	●	●					●	●					
Ground layer	Herbs and Forbs		River Buttercup	*Ranunculus*	*inundatus*						●							
Ground layer	Herbs and Forbs		Shiny Swamp-mat	*Selliera*	*radicans*					●	●							
Ground layer	Herbs and Forbs		Shrubby Groundsel	*Senecio*	*minimus*					●	●					●		8
Ground layer	Herbs and Forbs		Prickly Starwort	*Stellaria*	*pungens*				5									
Ground layer	Herbs and Forbs		Grass Trigger Plant	*Stylidium*	*graminifolium*	●	●					●						
Ground layer	Herbs and Forbs		Twining Fringe-lily	*Thysanotus*	*patersonii*									●				
Ground layer	Herbs and Forbs		Yellow Rush-lily	*Tricoryne*	*elatior*								●	●				
Ground layer	Herbs and Forbs		Ivy-leaf Violet	*Veronica*	*hederacea* subsp. *hederacea*								●	●				
Ground layer	Herbs and Forbs		Trailing Speedwell	*Veronica*	*plebeia*											●		
Ground layer	Herbs and Forbs		Sprawling Bluebell	*Wahlenbergia*	*gracilis*	●	●					●	●					
Ground layer	Prostrate shrubs		Grey Parrot-pea	*Dillwynia*	*cinerascens*	●	●					●						
Ground layer	Prostrate shrubs		Saloop Saltbush	*Einadia*	*hastata*	●			●							●		
Ground layer	Prostrate shrubs		Nodding Saltbush	*Einadia*	*nutans*				5									
Ground layer	Prostrate shrubs		Common Wedge-pea	*Gompholobium*	*huegelii*							●						
Ground layer	Prostrate shrubs		Small-leaf Bramble	*Rubus*	*parvifolius*							●	●	●	●			8

6.3

Appendix 3

Yarra River 50-year Community Vision (Willip-gin Birrarung murron)

– Whole of river

"Our Yarra River, Birrarung, is recognised around the world as an iconic example of a nurturing relationship between a river and its community.

Flowing from source to sea, it is the resilient lifeblood of past, present and future generations of Victorians. It connects and enriches our flourishing city, suburbs, regions and beyond.

Our Yarra River, Birrarung, its essential role in our lives and its rich history, are respected, understood and protected. It has cared for us for thousands of years and will for thousands to come.

The vital and continued role of Traditional Owners as custodians of the River, and its role in their culture, is recognised and celebrated.

Our Yarra River, Birrarung and its diverse surrounding landscapes provide a place of refuge, recreation, learning and livelihood. It brings communities together and supports sustainable local economies.

Its clean waters and connected network of thriving green spaces nurture biodiversity, and deepen the relationship between people and nature.

Our Yarra River, Birrarung is respected as a sacred natural living entity and everyone takes responsibility for its care. Its health and integrity are paramount and uncompromised.

What is good for the Yarra is good for all."

https://www.water.vic.gov.au/waterways-and-catchments/protecting-the-yarra/50-year-community-vision

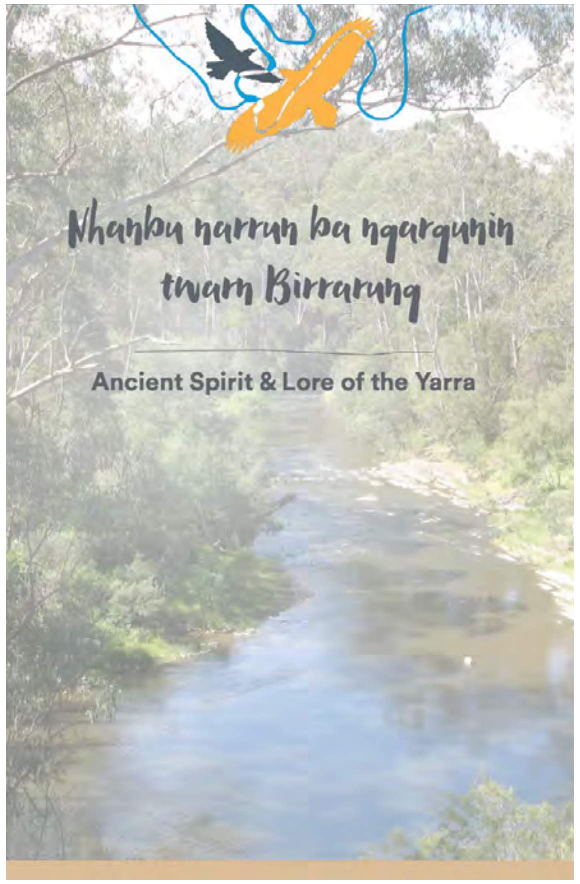


Image 42., 43 and 44, Three critical documents that inform our understanding of the Yarra.

6.3
References

Andik, B. & Sarang, A. (2017) *Daylighting buried rivers and streams in Tehran. Water Conservation and Management*, 1, pp. 01-04.

BirdLife Australia (2020) *Survey Techniques.* Available at: https//birdata.birdlife.org.au/survey-techniques.

Boroondara City Council (2018) *Recognising and managing environmental weeds.*

Bull, M. (2014) *Flora of Melbourne: a guide to the indigenous plants of the Greater Melbourne area*/Marilyn Bull; line drawings by George Stolfo. 4th edn. Hyland House Publishing Pty Ltd.

Cuvier, G. & Latreille, P. A. (1831) *The animal kingdom arranged in conformity with its organization.* G. & C. & H. Carvill.

Department of Mines (1959) *Geological Survey of Victoria, 1959. Melbourne & suburbs 40 chains to 1 inch, geological map.* Department of Mines, Victoria. Available at http://earthresources.efirst.com.au/product.asp?pID=725&cID=58&c=145659

DELWP (2020) *Bioregions and EVC Benchmarks.* Department of Environment, Land, Water and Planning, Government of Victoria. Accessed via: https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks

DELWP (2018) *NatureKit.* Department of Environment, Land, Water and Planning, Government of Victoria. Accessed at http://maps.biodiversity.vic.gov.au/viewer/?viewer=NatureKit

Foreman, D. (2004) *Rewilding North America: A Vision For Conservation In The 21St Century.* Island Press, Washington

Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Jonson J, Hallett JG, Eisenberg C, Guariguata MR, Liu J, Hua F, Echeverria C, Gonzalez E, Shaw N, Decleer K, Dixon KW. 2019. International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology* S1-S46 (Available at https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/ser_publications/ser_primer.pdf

George, K. & Erickson, S. (2007) *City of Banyule Yarra River Frontage Weed Action Plan.* Envirotechniques Pty Ltd, Eltham, Victoria.

Lacey, G. (2004) *Still Glides the Stream, The Natural History of the Yarra from Heidelberg to Yarra Bend.* Australian Scholarly Publishing, Melbourne.

Lindenmayer, D., Claridge, A., Hazell, D., Michael, D., Crane, M., MacGregor, C. & Cunningham, R. (2003) *Wildlife on Farms: How to conserve native animals.* CSIRO Publishing, Melbourne.

Melbourne Water (2010) *Constructed Wetland Guidelines.* Melbourne Water. Melbourne.

Monbiot, G (2013) Fe*ral: Searching for Enchantment on the Frontiers of Rewilding.*Penguin, London.

Oates, A. & Taranto, M. (2001) *Vegetation Mapping of the Port Phillip & Western Port Region.* Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Melbourne.

Presland, G. (2009) *The Place for a Village.* Second edition. Museum Victoria, Melbourne.

Royal Botanic Gardens Victoria (2018) V*icFlora – Flora of Victoria*,. Available at: http://data.rbg.vic.gov.au/vicflora

Standards Reference Group SERA (2017) *National Standards for the Practice of Ecological Restoration in Australia.* Second Edition. Society for Ecological Restoration Australasia. Available at:http://seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf

Tree, I (2018) *Wilding How a Farm Return of Nature to a British Farm.* Pan MacMillan, London.

Yarra Council (2013) *Removing Weeds in Yarra and Planting Indigenous Alternatives.* Yarra Council, Melbourne.

Image 43. Westerfolds park, Anthony Despotellis

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