Protecting and Connecting EPBC species in the Yarra Ranges

An Ecological Character Description for the lowland Leadbeater's Possum and the Helmeted Honeyeater

Australian Government

Port Phillip & Westernport CMA

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Summary

This project builds on the restoration works undertaken by the Yarra4Life program coordinated by the Port Phillip and Westernport Catchment Management Authority (PPWCMA), while focussing on planning and restoration objectives for two key threatened species in the upper and middle Yarra catchment (Helmeted Honeyeater *Lichenostomus melanops cassidix* and the lowland Leadbeater's Possum *Gymnobelideus leadbeateri*). A recognised shortfall in uptake of earlier habitat protection and conservation works by private landholders led to trialling the different, adaptive approach described in this report.

The project aimed to strengthen linkages between participants, gather together relevant past and current rehabilitation actions and distil current scientific information in an easy-to-understand form. A simplified conceptual model (diagram) was developed to visually summarise this information so that it could be meaningful to a broad audience.

A range of scientists, managers and stakeholders involved in managing and restoring the ecosystem in the Yellingbo area, within the Yarra catchment, were brought together in a series of workshops. The intention was to develop an Ecological Character Description (ECD). An Ecological Character Description (ECD) is a conceptual planning tool that attempts to synthesise both scientific and practical sources of knowledge to capture the 'essence' or 'character' of a particular ecosystem (or species) to help guide its restoration. This ECD approach involved gathering together what is known of the key ecological and societal attributes in this ecosystem, and what stressors may modify those attributes. This information in the form of past actions, successes (provided by participants of the workshops) and literature from a review was then compiled in a diagrammatic model and used to inform further analysis of suitable restoration sites, the spatial Zonation model, and future actions in the Action Plan.

The Action Plan guides more specific locations, project planning and implementation, documentation and monitoring of priority rehabilitation actions.

An associated social research project (Stamation and Hames 2014) has assessed community acceptance, value and likely use of the ECD, as well as community value of the ECD-development process. It has also made recommendations on how to engage the broader Yarra Ranges community in the upcoming implementation phase of the project.

1. Introduction

The Yarra4Life program, coordinated by the Port Phillip and Westernport Catchment Management Authority (PPWCMA), is designed to be a large scale, practical response to pressures such as increasing population, habitat fragmentation and changes to natural flows in rivers and creeks in the Yarra Valley. The program is creating new partnerships and delivering on-ground improvements (PPWCMA 2013). A variety of community groups, environmental programs, and conservation-focused land owners, managers and schools are active in the local landscape and have participated in Yarra4Life.

A review of the earlier 'Habitat Protection and Conservation' project (RMCG 2013) associated with Yarra4Life indicated that there is still a gap in the uptake of restoration projects within the community. To reddress this shortfall, an adaptive approach was planned where conceptual restoration models and actions would be developed through a workshop series to bring together scientists, managers and stakeholders, as recommended by Harvey and Sklar (2006).

To this end, the PPWCMA obtained a grant from the Australian Government to deliver the 'Protecting and Connecting EPBC species (Helmeted Honeyeater *Lichenostomus melanops cassidix* and the lowland Leadbeater's Possum *Gymnobelideus leadbeateri*) in the Yarra Ranges' project throughout 2013-2018. The project will be delivered in two phases: (1) planning and (2) implementation.

The Department of Environment and Primary Industries (DEPI) and Arthur Rylah Institute (ARI) were commissioned to carry out works associated with the planning phase, including this Ecological Character Description (ECD), an associated Action Plan (DEPI 2014b), and a social research report (Stamation and Hames 2014). The social research project evaluated the ECD-development process and assessed community acceptance, value and likely use of the ECD product. It also provides recommendations on how to engage the broader Yarra Ranges community in restoration activities.

This document firstly details the ECD development method then looks at ecological and societal attributes, stressors and desired ecological outcomes (long term outcomes rather than on-ground actions) for the study area. These are presented in terms of a) what is the problem, b) why is it a problem and c) how can we respond. This approach informs the proposed actions that could be undertaken to reduce threats to the Helmeted Honeyeater and lowland Leadbeater's Possum, which are further described in the associated Action Plan (DEPI 2014b).

Project Objectives

The objective of this project is to provide a framework for directing and prioritising habitat connectivity revegetation works between existing, past and potential habitat for Helmeted Honeyeater and the lowland form of Leadbeater's Possum, in the vicinity of the proposed Victorian Fauna Emblems National Park. These species are referred to as the project icon species throughout this document.

This objective broadly aligns with the objectives within the National Recovery Plans for both the Leadbeater's Possum (McFarlane et al.1997) and Helmeted Honeyeater (Menkhorst 2008), in terms of maintaining and enhancing habitat and improving habitat management. An Ecological Character Description (ECD) approach is trialled through this project.

What is meant by 'Restoration?'

At the centre of the project is the restoration of habitat for the lowland Leadbeater's Possum and the Helmeted Honeyeater. Restoration can mean many things to a variety of people, and in the case of this project, numerous groups have contributed to the knowledge used and will be implementing the Action Plan. The term 'restoration' is defined below for the context of this project.

Revegetation, weed control, habitat supplementation, habitat protection are all components of ecological restoration activities. The definition used by the Society of Ecological Restoration International for ecological restoration is: "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004). Knowing when recovery has occurred or is occurring requires knowledge of the attributes that contribute to recovery. An abridged form of nine attributes considered to contribute to recovery by the SER (2004) is provided below:

1. The restored ecosystem contains a characteristic assemblage of species that occur in the reference ecosystem
2. The restored ecosystem contains indigenous species
3. All functional groups of the reference ecosystem are present or have the potential to naturally recolonise
4. The ecosystem is capable of sustaining reproducing populations of the desired species
5. The restored ecosystem appears to function normally
6. The restored ecosystem is integrated into a larger ecological landscape
7. Potential threats to the ecosystem have been eliminated or at least reduced
8. The restored ecosystem is sufficiently resilient to endure normal periodic stresses
9. The restored ecosystem is self-sustaining to the same degree of the reference ecosystem

Specific attributes for restoration of lowland Leadbeater's Possum and Helmeted Honeyeater habitat have been gathered from workshops, a review of past projects and existing literature. The ecological and societal attributes for this project, which are discussed in the following section, aim to incorporate the sentiments of SER (2004).

2. ECD Approach

An Ecological Character Description (ECD) is a conceptual planning tool that attempts to synthesise both scientific and practical sources of knowledge to capture the 'essence' or 'character' of a particular ecosystem (or species) to help guide its restoration. It outlines what we know of an ecological system in terms of pressures and threats and uses diagrams (referred to as conceptual models) to help explain ecological concepts and collective knowledge (DEWHA 2008). The aim of using the ECD approach is to close the gap between theoretical discussions of restoration efforts and the practicality of establishing and operating such initiatives (Fitzsimons *et al*. 2013; Ogden *et al*. 2005).

The ECD needed to incorporate both scientific and practical (i.e. on-ground, practitioner) knowledge. The main methods for information gathering were both a scientific literature review and a series of workshops. The results of the first workshop can be found in an un-published technical report (DEPI 2014). These two methods were used to obtain information about:

a. Key ecological and societal 'Attributes' we wish to target for restoration
b. 'Stressors' that are currently exerting pressure on these attributes
c. Restoration 'Actions' that could negate these stressors
d. The desired ecological 'Outcomes' we want to result from these actions

A conceptual diagrammatic model was developed to encapsulate the information gathered as part of the steps 'a to d' above. The desired outcomes are long-term aspirations with a timeframe greater than 20 years. They will influence monitoring methods in the Action Plan.

A spatial model was developed by experts at Arthur Rylah Institute (ARI) to identify top priority areas to focus restoration actions. The following steps were used:

1. A Species Distribution Model (SDM) was developed for the HeHo. This effectively shows where suitable HeHo habitat would have been prior to European settlement.
2. The SDM was refined based on factors influencing present-day habitat suitability. A list of potential factors related to the attributes and stressors identified earlier was compiled. Only factors with available GIS layers could be included.

3. The final spatial model was created using Zonation software.

The Action Plan will combine information from the conceptual model and spatial model to provide details on what activities should occur where. The outcomes of the Social Research (conducted by ARI in conjunction with the ECD workshops) will also feed in to the final Action Plans as a complementary but separate source of information to the ECD.

The following subsection details the specific method used during this project and depicted in Figure 1.

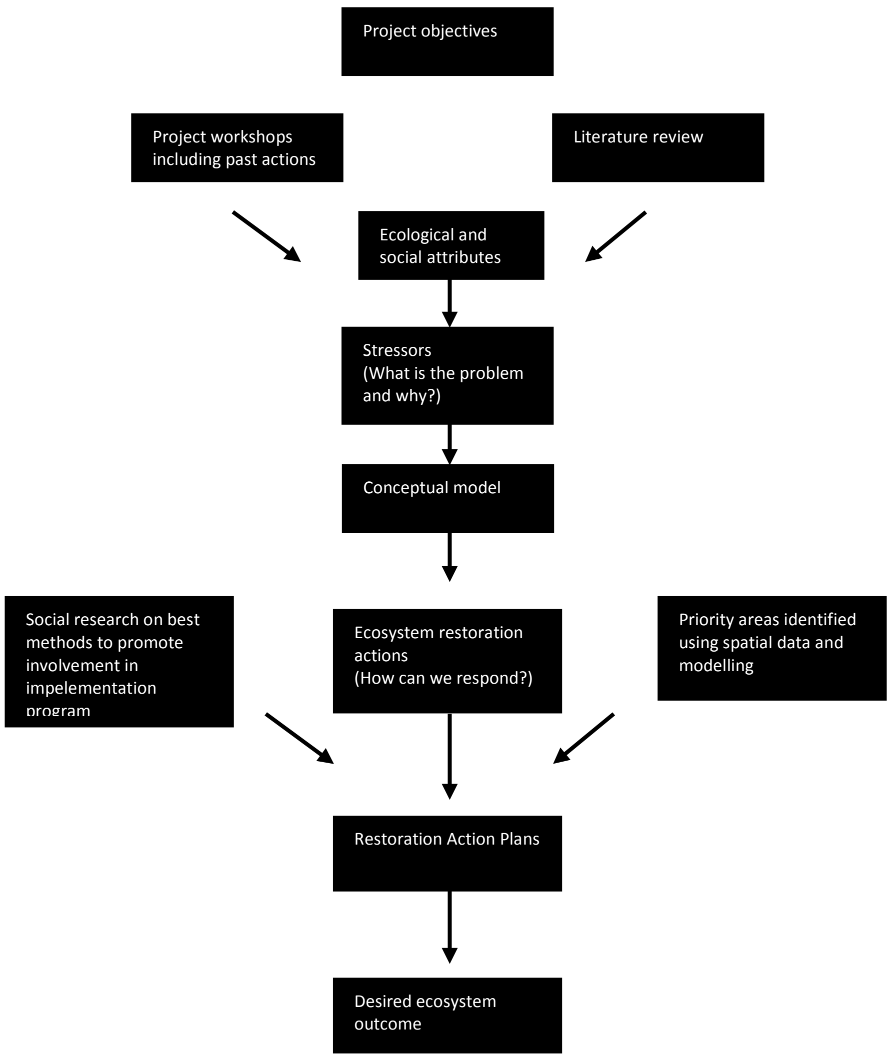

Figure 1: Generalised approach undertaken during the planning phase of the 'Protecting and Connecting EPBC Species' project ECD development.

Project Method

The method used in this project included:

1. Scoping of the appropriate format for the Ecological Character Description approach
2. Preparation of a briefing paper for Workshop 1, outlining a method to obtain information on past restoration experiences within the study area
3. Workshop 1 - information gathering and identification of key attributes to guide restoration for lowland Leadbeater's Possum and Helmeted Honeyeater

4. Modelling of locations suitable for habitat restoration activities for lowland Leadbeater's Possum and Helmeted Honeyeater
5. Brief literature review of desired ecological outcomes, ecological stressors, and possible actions to inform restoration efforts of habitat for lowland Leadbeater's Possum and Helmeted Honeyeater
6. Preparation of conceptual models that capture information from Point 5
7. Workshop 2 - practical review of conceptual models
8. Synthesis of literature review, outcomes from workshops and refined models to form an Ecological Character Description
9. Analysis of proposed actions to achieve objectives
10. Workshop 3 - presentation of results of mapping priority areas, final discussions on terminology used within the report, use of diagrams and models, and proposed actions
11. Development of Action Plans associated with the Ecological Character Description

The majority of workshop participants also participated in a social research project involving surveys after each workshop to refine the emphasis of the project, refine the subsequent workshops style, and gauge if participants would participate in Phase Two (implementation of the grant program). Recommendations from the social research conducted during the formation of the ECD are presented as a separate report (Stamation and Hames 2014). It is the authors understanding that the PPWPCMA will be undertaking further social research during Phase Two as part of the adaptive approach. The second phase will involve funding on-ground implementation of recommended actions at priority locations.

Study area

The area of land within the upper and middle Yarra catchment and of focus for the VEAC Yellingbo study area surrounds the Yellingbo Nature Conservation Reserve (NCR) to the East of Melbourne. This area is of considerable focus for dedicated community groups and State and Local government. The study area (Appendix 1) approximates the VEAC Yellingbo study area (VEAC 2013). The areas targeted for restoration works within the broad study area are those that would support habitat for Helmeted Honeyeater and the lowland Leadbeater's Possum, now and potentially into the future.

Relevant complementary projects and programs

There are several State and Local Government strategies and projects and local community group activities relevant to this ECD. These are outlined below:

State focus

The Victorian Environmental Assessment Council (VEAC) released an investigation in to recommendations for appropriate management arrangements to conserve and enhance the biodiversity and ecological values in the Yellingbo area in 2013 (VEAC 2013). The VEAC study area approximates the study area of this report as no defined boundaries are prescribed as part of the Ecological Character Description. Native vegetation in the VEAC study area is highly fragmented, although remaining areas retain significant biodiversity values. Yellingbo Nature Conservation Reserve (NCR), Coranderrk NCR, Sassafras NCR, Warramate Hills, lower Hoddles Creek and Wet Lead Creek contain significant biodiversity values. VEAC recommended these areas be included a State Emblems Conservation Area (VEAC 2013). The VEAC report also recommends rectifying some planning issues around stream frontages and other public land.

The Port Phillip and Westernport Catchment Management Authority (PPWCMA) have been very active in the Yarra area evident through their coordination of a host of programs including the Habitat Protection and Conservation (HPAC) program and Yarra4Life.

HPAC concluded in June 2013 and had an aim to protect and reduce threats to wildlife habitat sites as well as increase community awareness and understanding of the importance of wildlife habitat sites and how to protect them. Further information can be found at the following link: http://www.ppwcma.vic.gov.au/our-projects/major-environmental-projects/habitat-protection-and-conservation-project.aspx

Yarra4Life is another successful example of integrated catchment planning undertaken by the PPWCMA. Yarra4Life commenced in 2006 with a focus on: a healthy Yarra River; sustainable food production; potential for the 'Great Yarra Trail'; and biodiversity and enhanced biodiversity values (PPWCMA 2013). This ECD builds on the work undertaken as part of HPAC and Yarra4Life.

Local Government focus

The majority of the study area is within the Yarra Ranges municipality. The Yarra Ranges Shire Council is currently preparing its Environment Strategy, which will provide further advice on priority actions (Yarra Ranges 2014).

Community Group focus

The community in the Upper and Middle Yarra catchment are very active in undertaking conservation works and have a passion for the natural environment. Workshop 1 of this ECD captured information on 120 conservation or environmental based projects (summarised in Section 3 – Engagement of Community). Information from the workshop series was used to build and guide this ECD.

3. Ecological and Social Attributes

This section provides a commentary from the literature and workshop participants on the ecological and social attributes within the study area that may influence the restoration of habitat for Helmeted Honeyeater and lowland Leadbeater's Possum. The information presented here is used to inform the conceptual model and Zonation spatial model that prioritises areas for restoration works.

Ecological and social attributes were identified from key restoration themes highlighted by Workshop 1 participants and distilled from a list of projects compiled during the workshop. These were developed in the context of protecting and connecting EPBC listed species in the upper and middle Yarra Catchment through restoration activities. The two key species are included in these attributes, given they are the focus of this project.

The five key attributes are:

- Habitat connectivity
- Habitat presence, extent and condition
- Habitat structure
- Threatened species intrinsic and social values
- Community engagement

The five attributes are further defined in this section and then incorporated within a conceptual model.

Habitat connectivity

The remnant native vegetation in the upper and middle Yarra Catchment is largely fragmented outside of State Parks and Nature Conservation Reserves. In general, there are limited connections between reserves via some narrow remnant strips of vegetation, including along waterways. In the broad study area there are approximately 127 creeks and waterways. The riparian vegetation along these waterways provides many of the current and future vegetation connections in this landscape. Connecting the public land reserves has been an emphasis for many community groups and local government, with programs such as Melbourne Water's stream frontage program offering small grants to land holders to protect water ways. Appendix 2 outlines the State land and proposed State Emblems Conservation Area.

Physically connecting patches of native vegetation requires corridors across a variety of land tenures and land uses (Fitzsimons *et al.* 2013). Connectivity does not require physically establishing areas of native vegetation along each possible corridor. In some instances competing land uses means it is not possible to establish native vegetation corridors. This is a real concern for some industries operating with the Yarra Valley (Fisher 2005) and must be accounted for during the implementation phase of this program. Implementation in areas of seemingly incompatible land uses may be achieved through restoration actions being undertaken in accordance with relevant on farm Environmental Management Systems (Fisher 2005; Medhurst 2004). Connectivity does require a greater sharing of conservation management accountabilities and empowering of communities and individuals (Fitzsimons *et al.* 2013; DSEWPC 2012).

Any assessment of the value of existing remnant vegetation as habitat corridors for the two icon species needs to consider the species' ecological requirements (e.g. size of their territories, their mobility and behaviour and the presence of key habitat features).

Habitat connectivity is a significant factor in the conservation of both icon species, through reducing isolation of colonies, enabling gene flow and potentially increasing the total area of available habitat.

Habitat presence, extent and condition

The presence, extent and condition of habitat for the lowland Leadbeater's Possum and Helmeted Honeyeater provides a starting location for future restoration works and for works to support existing colonies that may be subject to diminished habitat features such as hollows. These starting points provide our reference ecosystems, although in some cases they are also degraded. Based on the Yellingbo Investigation (VEAC 2013), the study area is approximately 51,370 ha of which there is approximately 24,600 ha of remaining native vegetation. Not all of the 24,600 ha is suitable for lowland Leadbeater's Possum or Helmeted Honeyeater and conversely the modelled suitable habitat for these species in Appendix 3 and Appendix 4 does not contain purely native vegetation.

Given the specific habitat requirements of both icon species, habitat presence, extent and condition must all be taken into account when identifying suitable habitat to protect, as well as enhance. Recognition of key habitat features and existing knowledge can help guide prioritisation, while being mindful of limitations in availability of mapping information. In particular, information on habitat condition must largely come from local knowledge and site visits.

Habitat structure

Habitat structure is an important attribute due to the nesting, denning and foraging specificity of lowland Leadbeater's Possum. Helmeted Honeyeaters also use specific habitat components for nesting and foraging and there is evidence of variation in suitability of habitat based on structural features (Pearce and Minchin 2001). Moysey (1997) found male and female Helmeted Honeyeaters partition resources in the vertical plane, highlighting the need for restoration programs to include not only *Eucalyptus camphora* but also tea-tree thickets needed for nesting.

Reference areas and the last stronghold of these species in the study area within Yellingbo NCR are undergoing degradation. Essential habitat elements for the lowland Leadbeater's Possum of overstorey tree longevity and recruitment and hollow retention and formation (Lindenmayer *et al.* 2012) are declining in forest systems in general and in the reserve. A comparison of historical and current aerial images shows a degradation line encroaching through the Reserve. Repairing these habitat structure elements within the reserve is a priority for land managers, along with providing these attributes in future restoration corridors connecting the reserve.

The importance of structural complexity is often underestimated in revegetation and restoration projects. Tolsma (2014) notes that re-establishing structural complexity of remnant vegetation should be a key aim of restoration programs, since there is evidence that birds, for example, may respond more to plant structure than species richness.

Threatened species intrinsic and social values

The species of focus are Victoria's fauna emblem, Leadbeater's Possum, and bird emblem, Helmeted Honeyeater. Both species are listed under the Federal *Environment Protection and Biodiversity Conservation Act 1999* as Endangered. In Victoria the Leadbeater's Possum is classified as Endangered and the Helmeted Honeyeater as Critically Endangered under the Victorian *Flora and Fauna Guarantee Act* 1988 (DEPI 2013). Both are reliant on sedge-rich *Eucalyptus camphora* Swamp community that predominantly exists within Yellingbo NCR, other smaller reserves and in isolated patches along waterways in the study area. This community is also recognised as threatened and listed under the Victorian *Flora and Fauna Guarantee Act* 1988.

The study area also contains a wide range of rare or threatened species including 108 plant and 62 animal species. Of these the DEPI Actions for Biodiversity Conservation (ABC) database identifies the following species listed on the Federal *EPBC Act* 1999, in addition to Leadbeater's Possum and Helmeted Honeyeater:

- Barred Galaxias (*Galaxias fuscus*)
- Smoky Mouse (*Pseudomys fumeus*)
- Spot-tailed Quoll (*Dasyurus maculatus*)
- Buxton Gum (*Eucalyptus crenulata*)
- Tall Astelia (*Astelia Australiana*)
- Shiny Nematolepis (*Nematolepis wilsonii*)
- Green-striped Greenhood (*Pterostylis chlorogramma*)

Although these species are not the focus of this ECD, restoration actions that include consideration of these species can have additional positive impacts for conservation.

Community engagement

Community groups are involved with both restoration of habitat for lowland Leadbeater's Possum and Helmeted Honeyeater and active management of the species through monitoring, translocation or supplementary feeding (VEAC 2012). Many of the recovery efforts would not occur without the dedication of such groups as the Friends of Helmeted Honeyeater (VEAC 2012). The enthusiasm and dedication of the community within the study area, be it for conservation or effective land management, significantly contributes to the conservation of both icon species. The community should be commended for such efforts. Collaborative partnerships between community groups and government can strengthen efforts towards assisting the recovery of threatened species (Simmons 2013), particularly in times of limited resources and competing needs.

A side benefit of this project was to take a snapshot of conservation activities in the study area so groups can benefit from seeing what each group or government agency is doing, and potentially join forces to achieve a landscape-scale biodiversity benefit. During the workshops, participants provided extensive information on 120 existing and past projects. In summary, while these projects range in size, duration and purpose, some valuable general points can be made:

- 63% of projects were on private land
- Locational information ranged from very specific to very broad
- 41% of works were undertaken on an unknown area of land
- 49% included weed control works, 45% revegetation, 20% fencing, 5% animal control/management, 4% ecological burns/fire management, 8% research monitoring, with the remainder targeted actions for the icon species (e.g. supplementary feeding, nest box establishment), and flood mitigation, erosion control and engineering works
- 60% of works had no ongoing monitoring occurring
- 43% of projects response for "What worked in the restoration effort?" was unknown. The remainder included broad comment on levels of success effective weed control and revegetation, and community engagement
- Participants included private landholders, Landcare groups, DEPI, Parks Victoria, Yarra Ranges Council, Melbourne University, several Friends groups (Helmeted Honeyeater, Sherbrooke Forest, Wrights Forest, Hoddles Creek, and Kurth Kiln), Melbourne Water, the Country Fire Authority, PPWCMA, Friends of and the Lyrebird Survey Group.

There is value in ensuring this collated information is accessible to managers, stakeholders and the general public. It may also be worthwhile considering the potential value and effort involved in mapping past and current on ground works and monitoring their effectiveness.

4. Stressors (What is the problem and why?)

This section outlines the problems that influence our desired 'attributes' from the following section. Once the problems are known, they can be targeted by actions at priority locations. This targeted approach is used to develop the associated Action Plan of this project.

Five key stressors were identified during the workshop series that exert pressure on the societal and ecological attributes in the upper and middle Yarra Catchment. This section briefly describes the main stressors relevant to restoration efforts, which link clearly with the key attributes.

Physical disturbance (Habitat loss, isolation and degradation)

Native vegetation plays a fundamental role in sustaining environmental functions and processes, including binding and nourishing soils, cleansing the air, filtering streams and wetlands and buffering impacts of variable climates (COAG 2012). The potential consequences of loss and degradation of native vegetation can include decline in biodiversity, dryland salinity, declines in river and wetland health, reduced water quality and quantity, difficulty in flood control, increased erosion, increased greenhouse gas emissions, reduced ecosystem functioning, decline in ecosystem resilience and reduced productivity (COAG 2012).

Physical disturbance includes habitat removal through changes in land use practices or habitat degradation from secondary impacts associated with land use change or land and infrastructure maintenance. This can result in isolation of remnants which become unsuitable to the icon species.

Both icon species have restricted distributions within the Yarra Catchment with a reliance on the *Eucalyptus camphora* swamp forest and particular habitat features. The dense thickets of *Melaleuca* and *Leptospermum* spp. provide a food source, nesting material and highly connected pathways for movement for Leadbeater's Possum (Harley *et al*. 2005). This species requires a predominance of smooth-barked eucalypts for feeding, hollow bearing trees which provide den sites and strongly connected vegetation within the mid storey and canopy. Leadbeater's Possums are more likely to occur in areas with higher densities of hollow bearing trees. Similarly, Helmeted Honeyeaters inhabit the same vegetation community, requiring decorticating bark, dense stands of eucalypts and shrubs for feeding, nesting and shelter (Menkhorst 2008).

The size and connectivity of habitat may also influence its suitability for both species. The lowland Leadbeater's Possum require territories between 1-3ha which should be at least 100m wide (Steve Smith, DEPI, pers. comm.). The lowland Leadbeater's Possum has poor dispersal capabilities (Harley 2007) and in the future there may be a need to move animals between sites due to this trait (Dan Harley, Zoos Victoria, pers. comm.). Helmeted Honeyeaters generally have territories of about 0.5ha which they rarely leave, although some birds may wander in the non-breeding season in search of food (Menkhorst 2008). It is suspected Helmeted Honeyeaters only disperse along stream corridors, and the minimum width of corridors required is unknown although likely to be small over short distances (Peter Menkhorst, DEPI, pers. comm.). Individual birds will fly out into cleared paddocks to visit isolated flowering trees and so are prepared to cross inhospitable areas. The current intention is to create clusters of sites supporting suitable habitat conditions allowing birds to undertake local movements between sites according to prevailing seasonal conditions (Dan Harley, Zoos Victoria, pers. comm.).

Growth stage of vegetation may also influence its value to both species, for feeding, nesting and denning. For example, while young stands of forest (e.g. 20-40 years) provide favourable foraging habitat for Leadbeater's Possums, hollow bearing trees required for nesting only develop in much older trees (Lindenmayer et al. 1996). Fortunately, provision of nesting boxes can ensure adequate den sites are available (Harley et al. 2005). The growth stage of vegetation required for Helmeted Honeyeaters is not well understood. Within Yellingbo, however, there is only one growth stage of *Eucalyptus camphora* swamp community, of approximately 60-80 years old (Peter Menkhorst, pers. comm.) The species requires decorticating bark, which probably only occurs on maturing trees. The patches of tall *Leptospermum* and *Melaleuca* species also used by the species, may also be 10 years and older.

Altered hydrology and sedimentation

Most catchments are regulated to some degree, with water extracted for agricultural use (domestic, stock and irrigation) and intercepted by catchment dams. Rivers and streams have experienced alterations of natural flow regimes including changes to amount and seasonality of flow, changes to the frequency, duration, size, timing, predictability and variability of flow events including floods, changes to surface and subsurface water levels, and changes to rates of rise and fall of water levels. Such changes impact the aquatic environment, riparian and floodplain habitats, and their associated flora and fauna.

Changes in flows in catchments such as Woori Yallock include interception by catchment dams, lack of passing flows from on-stream dams, changes in rainfall patterns and extraction of water for agricultural use (Melbourne Water 2012). Extensive historical drainage works have led to the channelization of Cockatoo Creek and its disconnection from the floodplain (Melbourne Water and SKM 2014). The presence of very shallow water tables within the Yellingbo Nature Conservation Reserve, and a water regime driven by sedimentation and erosion cycles is detrimental to the *Eucalyptus camphora* swamp forest habitat (Melbourne Water and SKM 2014). Gaps remain in understanding the exact influence of the current water regime on dieback of this vegetation.

The upper Yarra catchment mostly includes areas in State Parks. Streams are protected by buffers within State Parks but hydrology can be altered or modified through some Park uses such as timber harvesting, recreational uses and wildfire. The middle Yarra catchment is largely modified through removal of the physical form of bed and banks, and the associated remnant vegetation, and removal of native vegetation filtering strips that would have once buffered streams. These factors have altered the hydraulics of this section of the catchment, resulting in faster moving water flows, scouring of banks and possibly greater sediment and nutrient transport through the catchment to receiving waters.

Altered natural fire regimes

Changes in fire regimes (including fire frequency, seasonality, intensity and extent), can alter species composition, vegetation coverage and fuel load (COAG 2012). The interface of settlement with the natural environment places pressure on government bodies to reduce risks to the community. Risks from wildfire hazards can lead to increased prescribed burning in areas defined as asset protection zones. DEPI is subject to the guiding principles in the Code for Bushfire Management on Public land (DSE 2012).

Increased fire frequency within the landscape may influence the presence and density of foraging, nesting and denning habitat and movement pathways required by the icon species. Lindenmayer and Possingham (1995) note that frequent, extensive, high-intensity bushfires are a major threat to Leadbeater's Possum, resulting in deaths, destruction of food resources, changes to forest structure and loss of hollow-bearing trees. Lindenmayer et al. (2013) note the species' complex social organisation and need to gather food over a relatively large area. Fires, irrespective of severity, have significant negative effects on Leadbeater's Possum, with animals absent from all burned sites previously known to support the species (Lindenmayer et al. 2013). The time until animals recolonise burned areas is poorly understood, but is likely a function of what aged forest was burned (Todd et al. 2014, in prep.). Within the Central Highlands, when old growth forest of ash and shining gum are burnt, they will produce a pulse of large old dead and/or fire-scarred trees which provide den sites for Leadbeater's Possum (Lindenmayer 2009).

The restricted range of both icon species also makes them highly susceptible to loss through fire. There are gaps in knowledge of how both species respond to changes in fire frequency, seasonality, intensity and extent, within the Yarra catchment. The core vegetation currently occupied by Helmeted Honeyeater in Yellingbo has not been burnt. Captive bred birds released at Bunyip State Park moved several kilometres to occupy shrubby forest regenerating after fire (Peter Menkhorst, DEPI, pers. comm.).

DEPI has prepared a document outlining the range of tolerable fire intervals for a variety of vegetation types including those found in the study area (Cheal 2010). This work guide's fire planning within DEPI at the risk landscape and fire operation plan stages. The Code of Practice for Bushfire Management on Public Land (DSE 2012) identifies two primary objectives. The first objective is to minimise the impact of major bushfires on human life, communities, essential and community infrastructure, industries, the economy and the environment. Priority of human life is placed above all other considerations. This gives weight to prescribed burning of asset protection zones outside of their tolerable fire intervals. The second objective is to maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water, carbon storage and forest products.

Climate change

The State of the Environment 2014, prepared by the CSIRO and Bureau of Meteorology, provides a summary of observations of Australia's climate. Some key points are that Australia's climate has warmed by 0.9^{0}C since 1910; extreme fire weather has increased and fire season lengthened since the 1970s; Australian temperatures are projected to increase; and Australian rainfall in Eastern Australia is projected to decrease (CSIRO 2014). This will undoubtedly impact the icon species, given they are already clearly vulnerable to the existing stressors.

Pest animals and plants

Pest animals can threaten native species through competition, habitat destruction and predation. They can also act as reservoirs for diseases that affect native wildlife, stock and people. Pest animals cause significant damage to agriculture by damaging crops, preying on stock, competing for pasture, encouraging soil erosion (through soil compaction and reduced water infiltration), and increasing stream turbidity and spreading weeds (Commonwealth of Australia 2007). Stock can also contribute to higher soil fertility which can favour weeds.

Pest animals within the study area include foxes, rabbits, deer and cats. Helmeted Honeyeaters occasionally forage on the ground and nest at a low height in shrubs and thus a low level of predation by foxes and cats is possible (Bruce Quin, DEPI, pers. comm.).

The workshop 1 participants placed an emphasis on the damage deer cause to revegetation activities through browsing or destruction from trampling. Anecdotal reports suggest that many revegetation programs are lucky if plants grow higher than tree guards in the presence of deer. This can lead to the use of larger tree guards, posing the future problem of tree guard removal. Other efforts by the Friends of Helmeted Honeyeater include mass planting in exclusion plots to reduce the pressure and ongoing effect from deer grazing.

Native animals can potentially represent a threat through competition for resources. At Yellingbo competition from large Bell Miner colonies has reduced breeding success and habitat availability of Helmeted Honeyeaters in the past. Control of Bell Miner numbers has reduced their impact. Regular monitoring occurs to detect future influxes of Bell Miners into Helmeted Honeyeater areas and to determine when control programs are required (Bruce Quin, DEPI, pers. comm.).

Pest plants affect the structure and function of terrestrial and aquatic environments, and can displace native plants, harbour pest animals and diseases and create fuel loads for fire. They can also reduce the quantity and quality of agricultural, horticultural and forestry products. Many pest plants are also detrimental to human and animal health (Commonwealth of Australia 2007). A variety of pest plants occur in the Yellingbo area, including Phalaris, Willows, Blackberries, Ragwort and Honeysuckle. Within fragmented habitats, the edge effect can lead to greater prevalence of weeds. Edge effects are defined as "a diverse array of ecological changes occurring at and in the vicinity of the abrupt artificial margins of natural habitat and the linear clearing" (Goosem 2006).

Additional issues to consider

Consideration of the identified ecological and societal attributes, and the current and potential actions needed has enabled identification of several other issues, outlined below:

Lack of community engagement coordination regarding restoration efforts

This project recognises the importance of restoration activities undertaken by a variety of community groups, environmental programs, conservation focused land owners and managers and schools. There is an ongoing risk that local knowledge developed through conservation programs can be forgotten over time if not stored in a form and location that is accessible to Natural Resource Management practitioners and the general community. This stored, shared knowledge can then be used to inform landscape level conservation planning and action. This ECD is an attempt to redress this.

Knowledge gaps

While both icon species have been the focus of much research and monitoring, there remain gaps in our scientific knowledge of the ecological needs of Helmeted Honeyeaters and lowland Leadbeater's Possum, the impacts of these threats to the species and their habitats, and the effects of management actions. For example, the causes of dieback within Yellingbo are not fully understood and continue to be investigated.

The identification of stressors and suitable actions are, however, based on available evidence, expert scientific opinion and the important knowledge of local community, government and authorities. The precautionary approach must be applied where the lack of full scientific certainty should not be used to postpone measures to prevent environmental degradation.

Small population size

The current small population size of the Helmeted Honeyeater and the lowland Leadbeater's Possum within the Yarra catchment - and their concentration in restricted areas - means they are highly susceptible to the numerous threats outlined above, as well as genetic impacts (inbreeding, reduced genetic variability, reduced reproduction, increased mortality rates etc.) and those particularly difficult to control (e.g. wildfire, drought, disease).

Hansen *et al.* (2009) note that there have been both historic and recent declines in the Leadbeater's Possum. The marginal, isolated and inbred population at Yellingbo is considered highly genetically differentiated. Population viability analysis (PVA) has been used to determine key parameters impacting the Helmeted Honeyeater population demography and decline (Mitchell 2011). This has shown that the Helmeted Honeyeater population would not persist in the wild under current conditions, and that supplementation and management actions to promote survival of captive released birds should be the primary focus for management.

5. Conceptual Restoration Model

Information on 'attributes' and 'stressors' described in previous sections is now combined into a diagrammatic 'conceptual restoration model'. A conceptual restoration model can provide a key link between early planning and later implementation and evaluation (USACE 2006). Such approaches can simplify theories into a common language to enable better communication (Heemskerk et al. 2003). The conceptual model for this project incorporates the Helmeted Honeyeater and Lowland Leadbeater's Possum ecological attributes and the linked stressors (threats) and current restoration activities. A spatial Zonation model follows in Section 10. Priority ecological attributes such as soil wetness, proximity to water courses, and soil type are used as metadata (layers) in the spatial Zonation model analysis.

Conceptual model formation can be undertaken in a variety of ways depending upon purpose and audience (Trinity River Restoration Program, 2005; Henderson *et al*. 2007a; Henderson *et al.* 2007b; Hobbs and Suding 2009; Casper *et at.* 2009; Brooks et al. 2013). Morris and Pappas (2012) provide an approach for restoration activities for government agencies. That approach is refined for use in this project. Refinement included: consideration of priorities from Workshop 1; practicalities and limitation of volunteer-run projects inherently have a focus on the 'doing rather than the planning'; and an awareness of the need for a series of action plans for groups to use when applying for grants and project planning.

Participants at Workshop 2 were provided one diagrammatic model including a summary of attributes, threats and actions and a series of more detailed linear models describing the five key attributes. Workshop participants were asked to comment on the threats to Helmeted Honeyeater and lowland Leadbeater's Possum related to those attributes. Information was also collated regarding the many ecological restoration projects that have been in operation within the study area. These past and current projects provide guidance on how threats can be addressed.

There were detailed discussions in both Workshop 2 and 3, to consider the most appropriate method to summarise the attributes, threats and actions for these species. Various iterations of diagrammatic models were developed and discussed. Workshop 2 participants found the linear model format to be too simplified in structure. Participants also suggested that the diagrammatic model be presented as one model for the attributes, one model for the threats and one model for the actions. Models were produced, although participants did not consider the icons chosen to be visually appealing. They also felt the placement of the icons over the map of the study area was misleading. It was agreed that there would be some value in having a designer produce suitable maps.

Discussions eventually led to the conclusion that developing one diagram which visually summarised attributes, threats and actions would be most effective (see Figure 2). While initially there was an intention to have separate diagrams for each icon species, it was recognised that the significant overlap in issues would be repetitive, and so one diagram which identified issues specific to each icon species was deemed most appropriate. Participants also preferred the use of layman language, to most clearly explain what the situation was and what needed to be done: Agreement was reached to use the following terms within the diagram:

- What is the problem?
- Why is it a problem?
- How can we respond?

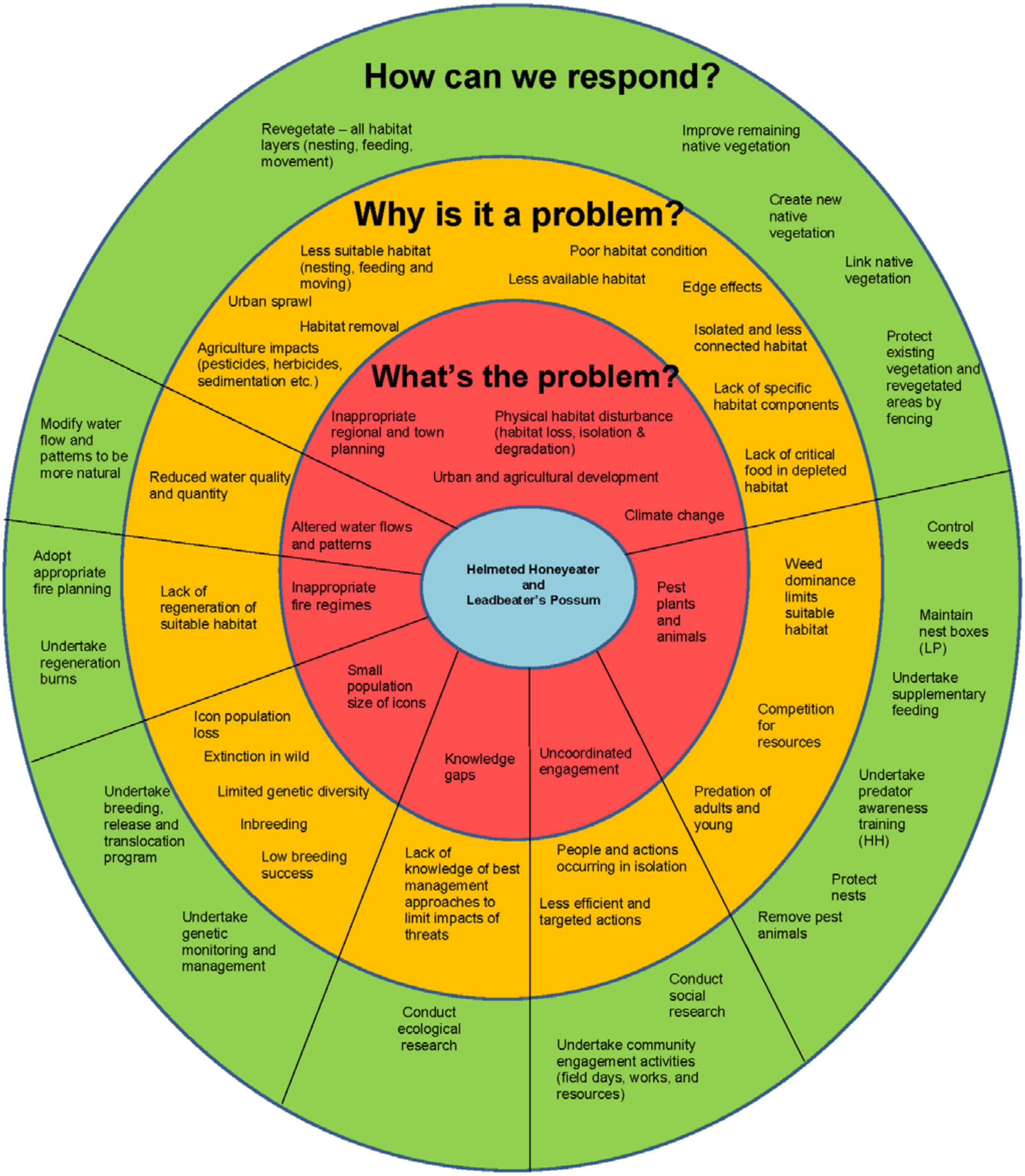

Figure 2: Conceptual model - A summary of issues, problems and what can be done to restore habitat for the Helmeted Honeyeater and lowland Leadbeater's Possum in the Yarra Catchment

6. Actions – How can we respond?

This section briefly outlines tangible actions that address the ‘stressors’ outlined previously. These future restoration actions were developed in response to the conceptual model, which in tern is informed by the past restoration actions. They directly inform the Actin Plan (DEPI 2014b). This section should be referred to for guiding principles on how actions should be implemented when developing site specific Action Plans (as guided by the Action Plan document).

The tangible actions will be assessed for suitability for funding through Phase two of this project. The intention is to focus effort within priority areas. Focusing efforts will require on-ground assessment of properties to determine feasibility of undertaking works and the specific types of works required. The Action Plan will describe this process in more detail.

Habitat – protection, enhancement and restoration

All actions must focus on enhancing habitat connectivity, structure, extent and condition to benefit the two icon species.

Protection of existing habitat and restoration works

It is generally recognised that protection of existing vegetation has a greater ecological value compared to that of a revegetated area (Tolsma 2014). Protection of existing vegetation may be achieved through legislative means on public and private land, incentives to private landholders as well as educational and engagement schemes which promote the environmental and economic value of such vegetation.

Legislative protection includes establishing covenants on private land, although this may not always be possible or appropriate. Past studies and the Yarra Valley Environmental Management System (Fisher 2005) have highlighted concerns by agriculturalists around protection of planted native vegetation in areas of a farm that may be needed for future farming activities. Planning of farm design and consultation with DEPI can help maximise the value of existing or planted native vegetation so that it does not interfere with future land requirements.

Physical protection includes guarding tube stock and fencing remnants or revegetation sites to combat against browsing damage by pest and native animals. A key theme from the workshops is that protection must be suited to the objective. If the objective is to stop deer entering a revegetation area on a flood plain, then the fence must be strong enough to withstand pressures from deer and from flood water.

Habitat enhancement

The icon species have specialised habitat requirements for breeding, foraging and movement. Habitat enhancement therefore can potentially encompass provision of required elements on multiple temporal scales. For example, provision of breeding habitat for lowland Leadbeater’s Possums in the short term can be achieved through installation and maintenance of nesting boxes whereas in the longer term, planting vegetation that forms hollows is required. Helmeted Honeyeaters require reinstatement of dense stands of eucalypts to supply decorticating bark, as well as specific shrub habitats to provide both food and nesting resource. Infill planting of shrubby layers within existing habitat may have potential benefits to enhance habitat value for the icon species.

Any habitat enhancement and reinstatement actions should ensure they focus on provision of key habitat elements required by the icon species. Consideration of species composition and richness, community structure and planting density should be guided by the EVC description of the *Eucalyptus camphora* swamp community, expert advice and previous learnings of the results of enhancement works.

Habitat restoration

In comparison to protection of existing vegetation, revegetation tends to be a less favoured management option for multiple reasons including: it is expensive; there is a long time lag to provide required resources; inferiority for many native species; potential legacy for weed and nutrient issues; potential high failure rate, low species diversity, lower resilience etc. (Tolsma 2014). There may however be some value in restoring habitat to connect high priority areas. As is the case above for habitat enhancement, any habitat restoration activities should consider appropriate species composition and richness, community structure and planting density based on the

EVC description of the *Eucalyptus camphora* swamp community, expert advice and previous learnings of the results of restoration works.

Harley et al. (2005) emphasised the importance of focusing revegetation efforts on creating core breeding habitat for the lowland Leadbeater's Possum within the Yellingbo area, establishing both canopy and mid storey.

Management of existing habitat and restoration works (i.e. manipulation of fire and hydrological regimes)

Management of habitat and restoration is triggered when the system is out of balance. For example, if native vegetation biomass becomes too thick and old (senescent) resulting in reduced capacity to flower and set seed and ultimately leading to the death of the plant. In such cases ecological burns or use of well managed grazing regimes may be required to stimulate desired plant growth. Burning can sometimes be used to reduce weeds and promote germination of native seed, although results can be variable and can depend on timing of burns and ecosystem characteristics including composition of existing seed banks (Tolsma 2014). There may be potential to trial burning as a habitat regeneration technique in the area. Limited investigations have so far been undertaken to determine the potential influence of fire on habitat suitability e.g. data from the Bunyip Ridge Wildfire of Black Saturday, which burnt similar habitat in Bunyip State Park, resulted in a flush growth of eucalypt and Myrtaceae shrub seedlings but generally they were out-competed by sedge and grass re-growth (Bruce Quin, DEPI, pers. comm.). At Yellingbo small area burns were conducted to reduce the biomass of Phalaris to allow native plant germination. Results found that the burn did not reach the lower roots of the Phalaris and so it re-grew, and spraying with herbicide was required (Bruce Quin, DEPI, pers. comm.).

The system can also be out of balance due to soil stability issues or water logging. A current example is the dieback of eucalyptus species within Yellingbo Nature Conservation Reserve. Melbourne Water, Parks Victoria, DEPI and Zoos Victoria all form part of a Yellingbo Restoration Group looking into the causes of die back in Yellingbo. Melbourne Water has commissioned the former SKM (SinclairKnight Mertz) to prepare a hydro and hydraulic ecosystem model of Cockatoo Swamp to help explain the problem and recommend possible solutions. This investigation noted that anecdotal and historical information suggests prolonged inundation and subsequent increases in groundwater levels cause permanent soil waterlogging. It is suggested that managing the water regime of the swamp, specifically avoiding prolonged periods of shallow groundwater may help reduce the occurrence of future dieback events. A proposed water regime also suggests recreating a wetting and drying sequence, increasing the extent of flooding, reducing channel peak flow, erosion and siltation (Melbourne Water and SKM 2014).

Melbourne Water has also been preparing stream flow management plans for priority catchments throughout the Yarra River basin, including several within the study area. A Stream flow Management Plan for the Woori Yallock Creek Water Supply Protection Area (Melbourne Water 2012) has been developed which identifies flow recommendations to meet environmental objectives.

Pest plant control

Weeds can reduce emergence of native plants as well as limit the growth of seedlings (Tolsma 2014). Controlling weeds within remnant patches of native vegetation - prior to and during restoration projects is critical, although it can be challenging. In revegetation programs adequate time and effort is needed to minimise weed recruitment since weed species can dominate seed banks and germinate faster than native species. Consideration must be given to how many weed treatments will be required to be effective for particular sites and for particular target weeds.

Participants of Workshop 1 consistently highlighted weed control as an issue during restoration programs. Current and previous weed control programs by Parks Victoria and volunteers have provided valuable experience in effective techniques. Separating weed control into various target species based on their height is useful for streamlining control measures.

Multiple treatments and a combination of burning, herbicide application and physical removal can be effective to control weeds (Tolsma 2014). Woody weed control can be targeted at tree removal or at shrub removal. Different levels of effort and techniques are required for controlling the two life forms, but the principles are similar; physical removal of the vegetation, control of the root mass and control of seedling emergence.

Ground layer weed control can be very difficult due to the invasion potential and growth rate of grassy and herbaceous weeds. Such weeds directly compete with tube stock and direct seeding restoration efforts. The use of herbicides without off-target kill and contamination of waterways and soils is difficult. Low rates of herbicide application targeting weeds while they are susceptible can be used to reduce competition. Physical removal via soil disturbance or smothering is also an option and if maintained, can keep weed competition at a low enough level to allow desired plants to grow.

Successful revegetation will be less likely in sites with heavy weed infestations. Site assessments can enable consideration of the potential for effective weed control.

Pest animal control

A suite of established pest animals occur in the area including foxes, cats, rabbits, hares and deer. Pest and native animals can compete with and predate on both icon species, including adults and their young. Pest species can also significantly degrade habitats and limit successful revegetation programs.

Principles of established pest animal management include; that the benefits should exceed the costs; to address actual rather than perceived problems and to reduce impacts rather than simply pest numbers. Management also requires coordination across partners and land tenure (Commonwealth of Australia 2007).

A key problem highlighted by Workshop 1 participants is the presence of deer and their browsing on revegetation plants. Control programs such as shooting, baiting and mist netting have all been successfully used to control pest animals for the two icon species. However such programs often require permits and licensed operators and these requirements must be considered in project planning.

Regular monitoring within Yellingbo enables control programs to be undertaken for foxes and cats as well as Bell Miners as required (Bruce Quin, DEPI, pers. comm.).

Direct management of icon species

Direct management of icon species captures recovery efforts for the two icon species being undertaken by a host of groups including: Friends of Helmeted Honeyeater, Friends of Leadbeater's Possum, BirdLife Australia, Zoos Victoria, Parks Victoria, various universities and DEPI. The community contribute countless volunteer hours to these two recovery programs and are instrumental in keeping the programs effective.

Nest boxes and population monitoring (Leadbeater's Possum)

Zoos Victoria and Parks Victoria have an active Leadbeater's Possum nest box program within Yellingbo NCR. Nest boxes provide habitat in a degrading environment and are also used in monitoring activities.

Population monitoring of lowland Leadbeater's Possum occurs within Yellingbo to obtain long-term data on the population dynamics, demography, distribution and abundance of the species.

Captive breeding, release, monitoring and protection (Helmeted Honeyeater)

A captive breeding and wild release program has been the backbone of the Helmeted Honeyeater program for many years. This program requires supplementary feeding, which is labour intensive due to the regularity of supplying feed to the wild animals and the distance that feed must be distributed, often manually. DEPI and Zoos Victoria provides funds to this program where possible but a major effort in the actual distribution of feed is contributed by volunteers. Supplementary food has been provided for both the naturally occurring colonies as well as released birds.

Predictive habitat modelling has been undertaken to select future release sites. Current research includes investigation of factors influencing success of released birds including survivorship and breeding success. Nest protection is occasionally undertaken, and the success of this in Bunyip State Park is currently being investigated (Bruce Quin, DEPI, pers. comm.).

Community Engagement

Workshop participants indicated that a key to success was engagement with neighbours to restoration sites. This type of approach is supported by the Yarra Ranges Council Biodiversity Strategy, the Regional Catchment Strategy being developed by the PPWPCMA, and the Victorian Government Environmental Partnerships Program.

A key potential activity is joining farm managers with environmentalists to achieve wise use of the Yarra catchment. Wise use involves recognising the values and contribution to society farms within the Yarra Valley provide, along with the environmental values associated with remnant vegetation, Victoria's fauna and bird emblem, and other wildlife and threatened species.

Weed and pest animal control approaches are far more likely to succeed when they are part of an integrated, coordinated and large scale program with multiple partners across varying land tenures.

More work is needed to raise awareness in the broader Yarra ranges community of restoration programs such as Yarra4Life. Agencies like the PPWCMA need to undertake efforts to build trust and increase participation through sustained and targeted engagement (Stamation and Hames, 2014). These efforts need to be accompanied by evaluation tools that measure the success of these activities through the level of uptake and acceptance within the community.

7. Desired Ecological Outcomes

A desired ecological outcome in this context is some form of favoured biological response in the ecosystem as a result of a proposed restoration activity. The desired ecological outcomes were developed through the workshop series and in particular are informed from the objectives of past restoration actions and review of relevant literature indicating habitat preferences for the Helmeted Honeyeater and Lowland Leadbeater's Possum. It is expected the outcome would be achieved at a point in the distant future (greater than 20 years' time). This section and the concepts within should be used when planning individual projects and defining their long term goals.

At this point the reader is reminded of the Project Objectives that drive the desired ecological outcomes. The desired ecological outcomes for this project are summarised as:

- An increase in the number and size of biological links between areas of remnant vegetation.
- Cessation of tree dieback, within Yellingbo NCR and other affected waterways, linked to water logging of soil.
- Replacement of midstorey vegetative layer through revegetation activities and natural fire regimes within ecosystems lacking this layer.
- Replacement of canopy trees through revegetation activities in ecosystems with this layer removed.
- Replacement of hollows through naturally occurring processes of tree senescence (i.e. letting trees grow old) and artificial means (provision of nest boxes).
- Native vegetation emergence and growth to mature life stages to enable natural vegetation replacement e.g. appropriate planting design and protection from grazers.
- Long term native diversity of vegetation within remnant and planted ecosystems to add resilience.

These ecological outcomes influence the appropriate monitoring methods and performance criteria to be used. These are outlined in the Action Plan to enable project managers to track project success in a consistent way and to report back to project sponsors and grant providers.

8. Performance Measures

This section provides the background regarding how a restoration project should be monitored: before, during and after. When developing an Action Plan for a specific site as guided by the Action Plan document, this section should be referred to for guiding principles on how the action should be monitored.

There is a growing recognition for the need to report on the quantity and quality of outputs of management actions (Brooks et al. 2013). Reich et al. (2013) have commenced development of a monitoring framework to support evidence-based natural resource management in Victoria. This outlines DEPI's Monitoring Evaluation and Reporting (MER) Framework i.e. the need for: strategy and planning; implementation and monitoring; and evaluation and reporting. Developing a program logic (i.e. conceptual model) which outlines cause-and-effect relationships and assumptions regarding management actions, outcomes and condition change, can support project strategy and planning. Monitoring is important to document whether management actions are implemented and whether desired outcomes have been achieved.

Robust monitoring programs involve monitoring selected measures before and after outputs are applied (Reich et al. 2013). Many issues must be considered when designing, implementing and maintaining monitoring. This includes recognising the compromise of balancing the competing expenditure of learning (i.e. monitoring) and doing (i.e. intervention activities), recognising the importance of achieving outputs whilst ensuring these are not misguided (Reich et al. 2013). Reich et al. (2013) also emphasise the importance of monitoring over the longer term, clear roles and responsibilities between participants, and flexibility due to potential fluctuations in investment. Brooks et al. (2013) have identified conceptual models to support riparian MER in riparian systems, which are worthwhile considering in the context of this project. These recognise 'modifiers' which are factors that may influence outcomes from management outputs (see Figure 3).

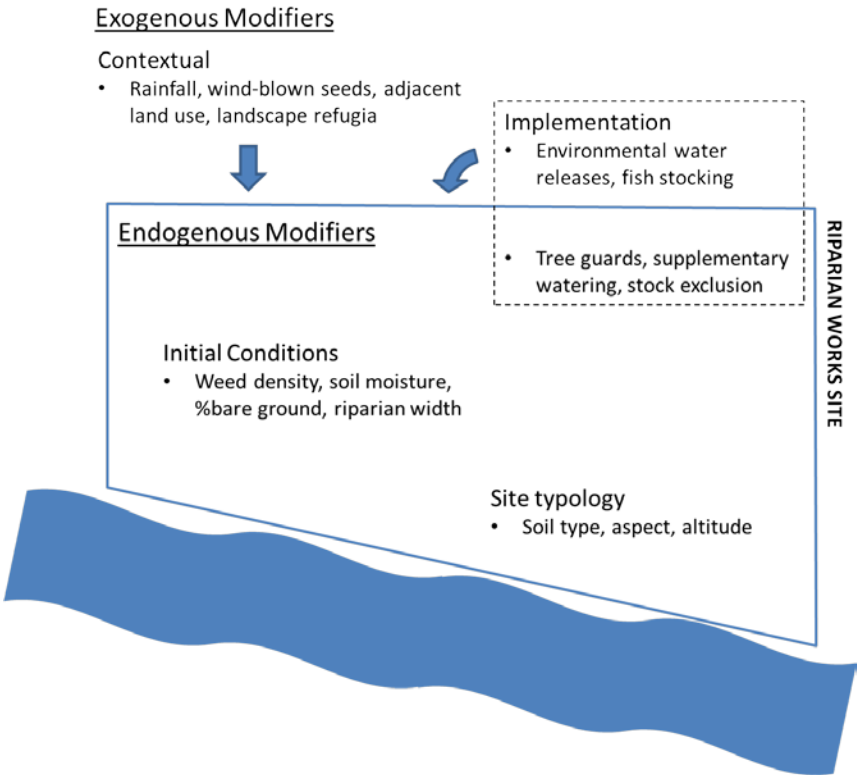

Figure 3: Classification of modifiers as endogenous (properties of the management site) or exogenous (external contextual modifiers). (Taken from Brooks *et al.* 2013)

Developing program logic can also be worthwhile – these outline the reasoning behind a project, cause and effect relationships between activities, outputs and intermediate outcomes and longer term desired outcomes (Brooks et al. 2013). A program logic may be a simple diagram or matrix that shows a series of consequences, not just events. It can express how change is expected to occur (Brooks et al. 2013) (See Figure 4 for an example).

Action Plans will seek to incorporate these important learnings. They will aim to be straightforward to fill out, seek only the key relevant information to demonstrate sound planning. The likelihood of future funding to undertake specific monitoring of the effectiveness of actions is unknown. However, provision of an adequate level of relevant information should maximise the potential for long term monitoring. The aim is to keep such monitoring of intervention conditions simple and measurable.

Action Plans will seek the following detail:

- the attribute, threat (stressor) it is addressing
- the site objectives and desired ecological outcome
- the current condition of the site (e.g. existing vegetation, weed cover etc.)
- action detail (e.g. techniques, size of area, site preparation, timing, frequency
- ongoing maintenance requirements

Clearly described site objectives and key evaluation questions provide the basis for maximising monitoring and evaluation (Morris et al. 2014, in draft). Indices can then be used in evaluations (e.g. % cover of native canopy, area of weed invasion; width of native vegetation area along waterway being restored; number of hollows (artificial and natural); height of vegetation layers in area being restored; and proportion of alive to dead mature canopy trees.).

Data management is also an important consideration, to provide accurate data regarding where, who, how and why. During the workshops, information was gathered in spreadsheets and on hard copy maps detailing past and current on ground rehabilitation actions in the general study area. These projects have been funded through different sources, with differing levels of documentation including mapping components. Over time and with inevitable staff changes, it can become difficult to collate and interpret such information in a broader context. Thus this project should aim to include consistent documentation, including mapping outputs, to maximise future value.

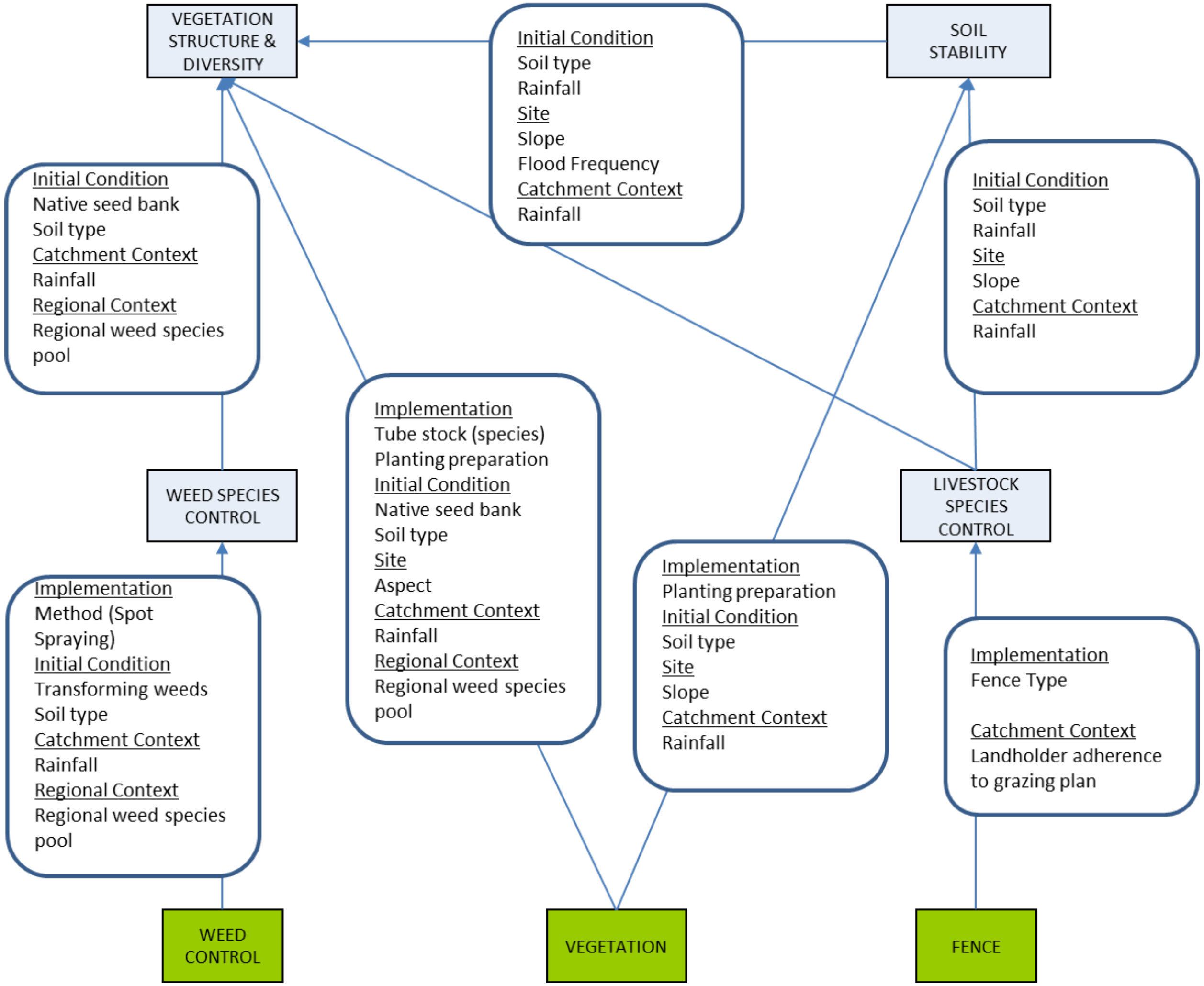

Figure 4: An example of a program logic model for DEPI standard outputs at "Example Creek Riparian Restoration Site" incorporating outcomes modifiers. Green = DEPI standard output, grey = expected outcomes. (Taken from Brooks *et al.* 2013)

9. Identification of Priority Areas for Restoration Effort

A spatial model was developed by experts at Arthur Rylah Institute (ARI) to identify top priority areas to focus restoration actions. The Action Plan will combine information from the conceptual model and spatial model to provide details on what activities should occur where.

The following steps were used to develop the spatial model:

1. A Species Distribution Model (SDM) was developed for the HeHo. This effectively shows where suitable HeHo habitat would have been prior to European settlement.
2. The SDM was refined based on factors influencing present-day habitat suitability. A list of potential factors related to the attributes and stressors identified earlier was compiled. Only factors with available GIS layers could be included.
3. The final spatial model was created using Zonation software.

Further detail on the development of the spatial model is provided below.

Species Distribution Model

Scrutiny of spatial data by the project team during the development of this ECD helped identify priority areas to undertake actions which could achieve the best benefits for both the Helmeted Honeyeater and lowland Leadbeater's Possum, based on the project objectives. Refined areas for restoration effort have been defined by modelling known habitat for Helmeted Honeyeater and extrapolating this to the broad study area. Habitat for Helmeted Honeyeaters has been used as a surrogate for lowland Leadbeater's Possum due to both species sharing a similar habitat and the lack of sufficient information for Lowland Leadbeater's Possum to enable sophisticated habitat modelling.

A Species Distribution Model (SDM) for the Helmeted Honeyeater was prepared as the first step to guide further refinements (Appendix 3). The SDM provides a broad understanding of habitat for the Helmeted Honeyeater and lowland Leadbeater's Possum prior to European settlement of the Yarra catchment. The SDM used various spatial layers to predict the most likely habitat for this species, including:

- records of known wild populations,
- historic recorded observations,
- 10 & 50-year flood data,
- rainfall data,
- height above stream and
- soil wetness index.

This SDM is effectively a pre-settlement model of the Helmeted Honeyeater and by inference the lowland Leadbeater's Possum. The SDM was then clipped to tree cover layers to provide a map of suitable habitat on public and private land for the Helmeted Honeyeater and lowland Leadbeater's Possum (Appendix 4).

Preferred Ecological Vegetation Classes (EVCs) were not modelled, under the assumption that the underlying abiotic factors that were modelled would automatically determine the vegetation type (i.e., the degree of correlation makes EVC status superfluous). Extant tree cover was also not used in the model, as the aim of the SDM was to identify all areas across the study region that would have provided suitable habitat prior to the land clearing that occurred after 1750. Barring major hydrological or edaphic changes in any areas, these modelled areas are assumed to represent the limits of where appropriate habitat might be restored or maintained in future.

No SDM was compiled for LBP, as there were insufficient data to support the modelling. We have assumed that its preferred habitat, which is similar to that of HH, will be adequately captured by the HH modelling.

The layers and modelled SDM was used in the Zonation model to inform the priority restoration areas.

Refinement of SDM to Current Conditions

The next step was to identify the important attributes for the icon species within the modelled habitat, and what relevant spatial parameters could help gauge their state. Potential indicators relevant to gauging the state of key attributes and the stressors that might impact on the habitat or desired ecological outcomes were identified using the information gathered during this project including through workshop participants views, relevant literature and expert opinion (LPAG 2014; Melbourne Water 2012; Peter Menkhorst, ARI, pers. comm.). Many potential attributes where considered and assessed according to their availability as a GIS layer, their importance to the species, and potential data limitations and gaps. Appendix 5 summarises the spatial data considered which could have potentially informed the identification of priority sites for management works. Attributes that were considered were grouped in the following way:

- Spatial data available (i.e. GIS layers)
- Already encompassed within the available spatial data
- Local knowledge to be considered, since no spatial data in usable form
- Potentially useful, but need more information/need to interpret information
- No accurate spatial data
- Too hard to incorporate and not closely relevant

Those attributes with available spatial data were then ranked as either high or moderate priority. These include ecological and management attributes.

Those of high priority included:

- the Helmeted Honeyeater SDM – included in Zonation model
- existing native vegetation – GIS layer Extant Native Vegetation (woody component) is available, assumed to be important to both species. Tree layer however does not provide information on the quality of the vegetation – included in Zonation model
- connection to Yellingbo – GIS layer Extant Native Vegetation. Yellingbo NCR represents the focal area and priority should be given to sites that abut this reserve - included in Zonation model
- Fire Management Zones & Risk Landscapes – Asset protection zones may be subject to a regime of prescribed burning that the icon species may not tolerate, and so should be excluded. Risk landscapes show areas of high risk to life and priority and should also be excluded. – None in Study area
- Neighbourhood value (total vegetation in landscape) – GIS layer Extant Native Vegetation. Landscape biodiversity outcomes may be better when total vegetation in the landscape around the site exceeds a threshold (around 10% of birds). It is calculated as the number of vegetation pixels/unit area. Tree layer however does not fully differentiate native from exotic vegetation - included in Zonation model
- Planning Zones – Planning Schemes – protected areas (e.g. covenants, Environmental Significance Overlays, Vegetation Protection Overlays) are considered higher priority - included in Zonation model
- Freehold Land – GIS layer Land Tenure. The Yarra4Life project primarily focusses on freehold land - included in Zonation model

Those of moderate priority included:

- Distance to remnants – GIS layer Extant Native Vegetation. Lowland Leadbeater's Possum has limited dispersal capacity - included in Zonation model
- Roads and tracks – GIS Road Layer. Roads, tracks and easements may reduce movement for Lowland Leadbeater's Possum if the canopy is not contiguous. Sites with fewer roads can be considered a priority - included in Zonation model
- Parcel size – GIS parcel or Vic Map property layer. Narrow or small blocks will have a more pronounced edge effect than wider larger blocks, and are thus a lower priority for restoration. Larger vegetated parcels may also be more capable for sustaining reproducing populations of species. There is however

potential to aggregate smaller parcels. While a lack of information available on preferred corridor for icon species, presumed to be at least 100m - included in Zonation model

- Density of parcel - GIS parcel or Vic Map property layer. Density of parcels can be a useful surrogate for quality since smaller parcels are presumed to be of lower quality. Higher density may mean little if parcels are still forested - included in Zonation model
- Proximity to urban areas – GIS layer Plan Zone. Areas closer to urban areas are likely to be of poorer quality with higher numbers of pest plants and animals - included in Zonation model
- Specific sites e.g. Melbourne Water sites, Trust for Nature, Land for Wildlife. Areas adjoining such sites could potentially be given a higher priority to build on and achieve synergies with existing works - included in Zonation model

Zonation Modelling

Only those attributes with available spatial data could be used within the final modelling. A software package called Zonation (an open source systematic conservation planning tool) was used to undertake a landscape prioritisation for actions towards the icon species' conservation. Zonation efficiently ranks all locations within a region on the basis of their relative contribution to specified instructions i.e. our broad conservation aims. The focus was on finding aggregated areas of suitable habitat and good prospects for habitat maintenance and restoration within the least fragmented landscape. Maps were produced with this Zonation analysis to identify the best 2.5% and best 10% of suitable restoration works area (Appendix 6 and 7). This product represents a highly valuable tool to focus restoration effort.

Interpretation of the Zonation Models

The Zonation models represent the priority areas to undertake habitat restoration works for the Helmeted Honeyeater and Lowland Leadbeater's Possum. The model assumes the two species were similarly distributed due to limited distribution data for Lowland Leadbeater's Possum.

The Zonation model in Appendix 6 represents the best 2.5% of land within the former distribution of both species for restoration. The darker pixels on the maps are a higher priority than the lighter pixels. These darker pixels should be focused on before the lighter coloured pixels. In anticipation that not all property owners within the darker pixel areas will be amenable to undertaking restoration works and broader model is provided in Appendix 7. This broader model highlights the best 10% of land within the former distribution of both species for restoration. This model can be used as part of Action Planning associated with this project or for other similar projects.

As with any generated model some form of ground truthing is required. Ground trothing such as feasibility to undertake actions, accessibility to sites and extent of treed vegetation need to be checked on the ground. The Action Plan (DEPI 2014b) outlines the approach to interpret and develop site specific action plans.

10. What happens next?

An Action Plan has been developed that includes a process on how works on priority restoration areas can be implemented (DEPI 2014b). The Action Plan also includes detailed maps of where restoration works should be undertaken and a template for establishing, monitoring and reporting on those works. The PPWCMA will implement the targeted grant program as outlined in the Action Plan. Implementation will involve Landcare in the study area to access landholders and skills associated with on-ground assessments.

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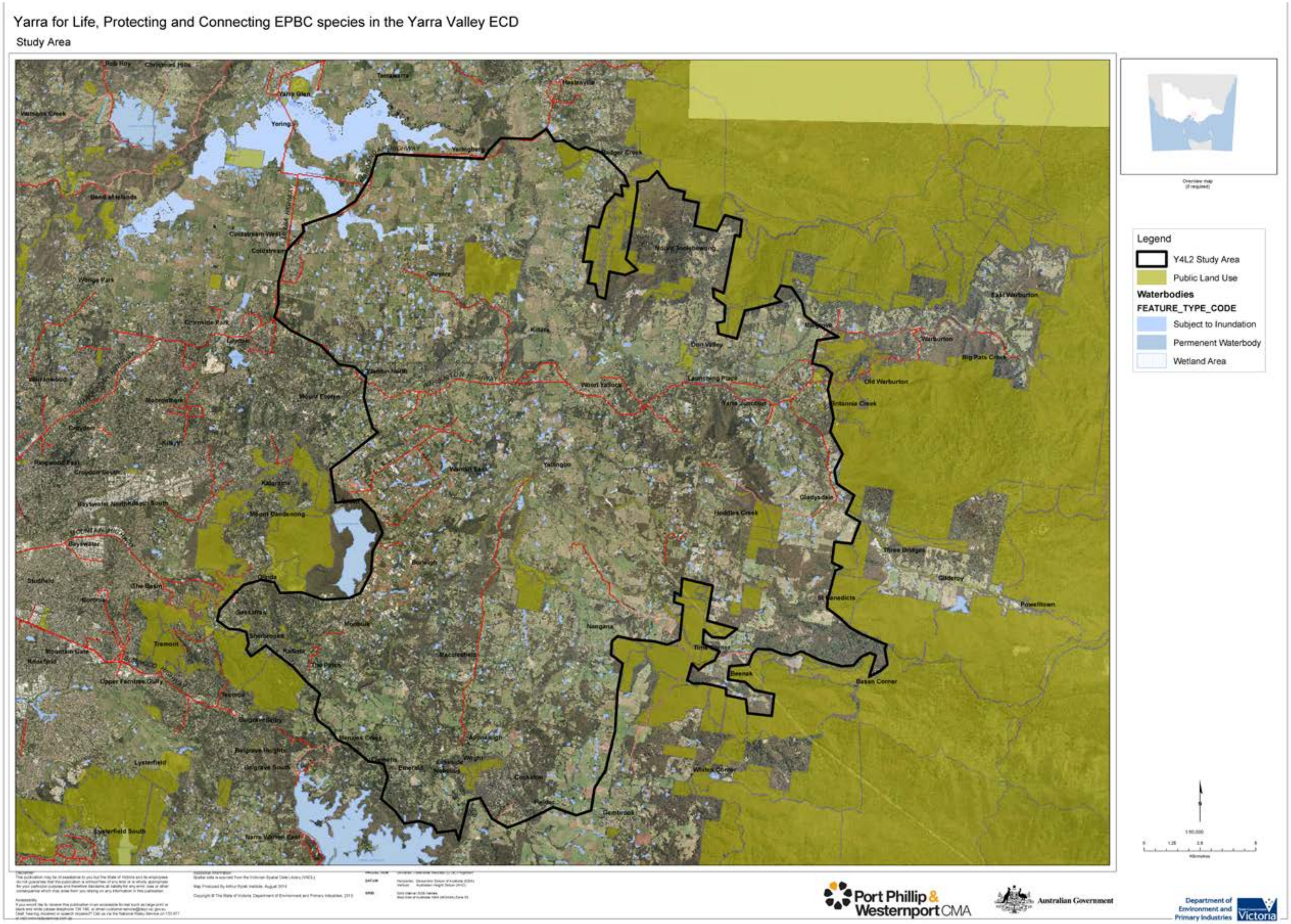
Appendices

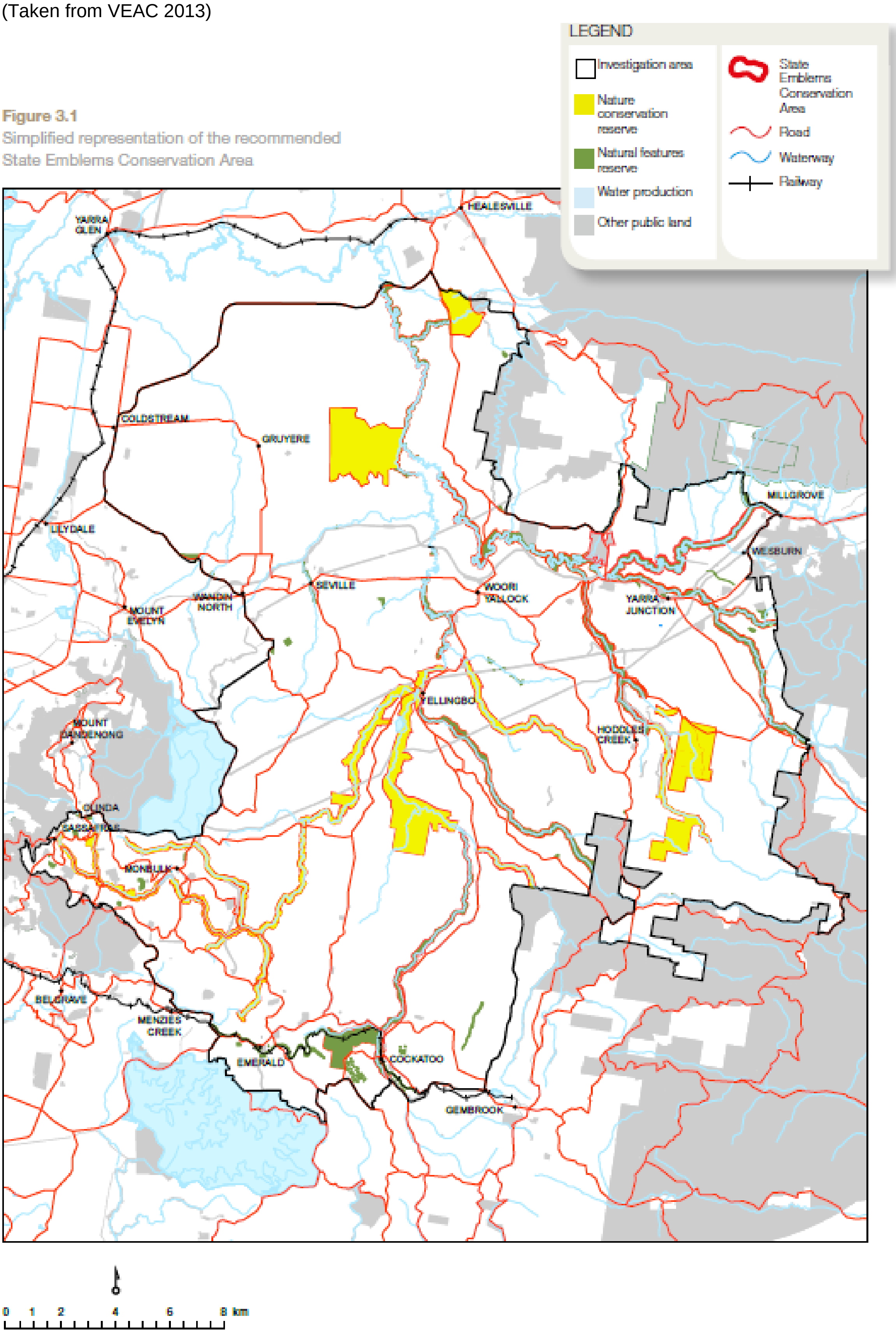
Appendix 1: Study Area



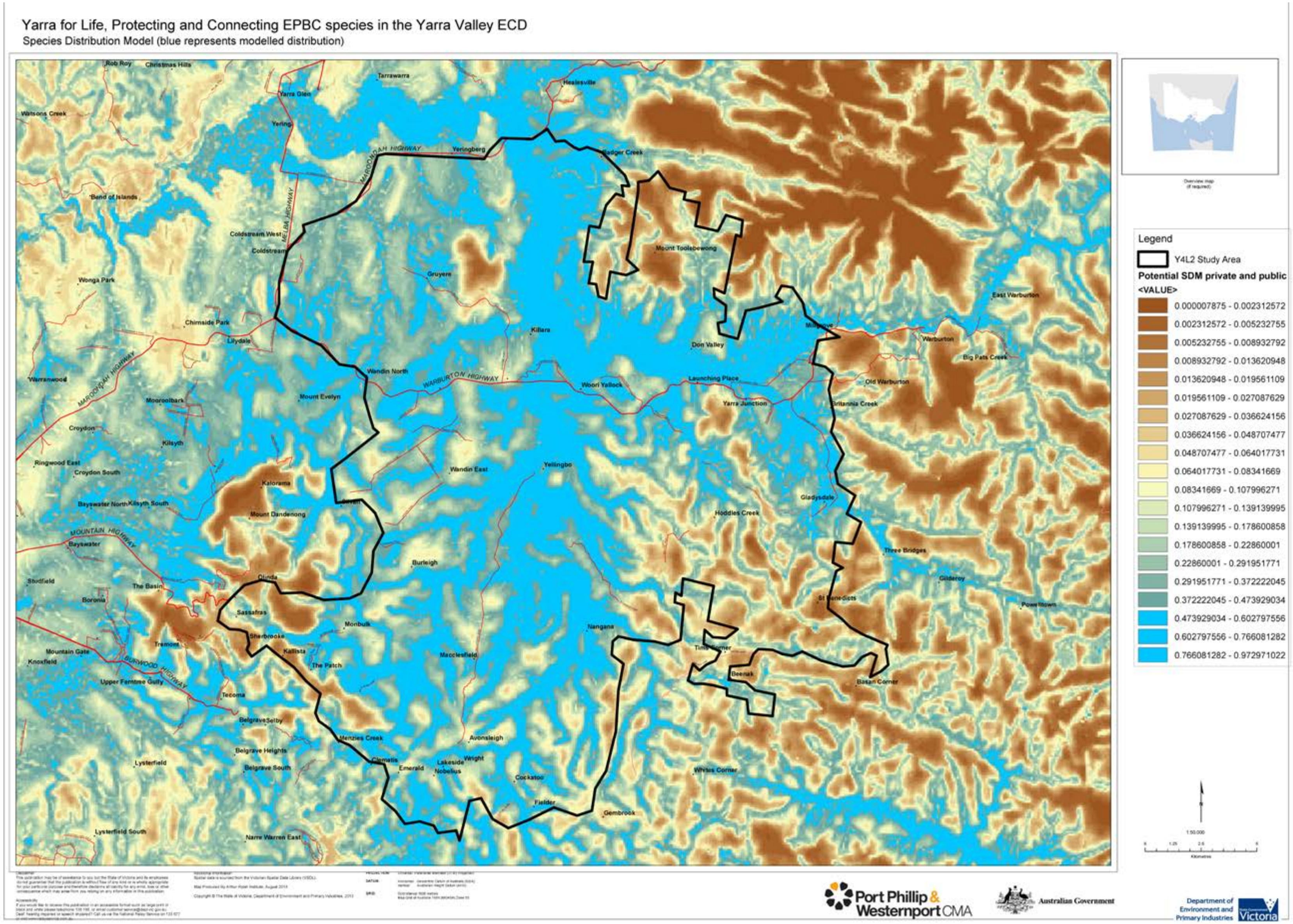
Appendix 2: State land and proposed State Emblems Conservation Area

(Taken from VEAC 2013)

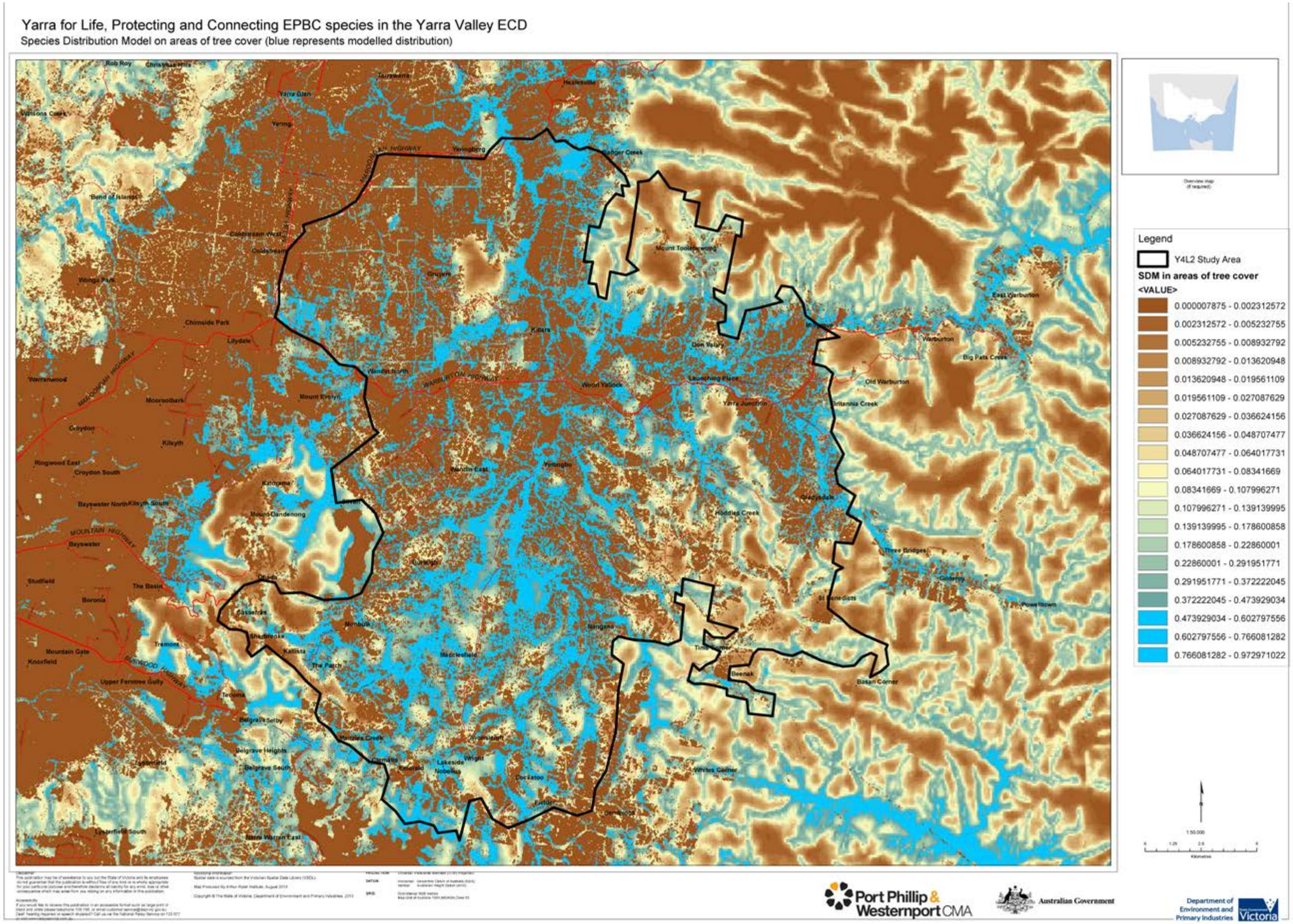
Figure 3.1
Simplified representation of the recommended State Emblems Conservation Area



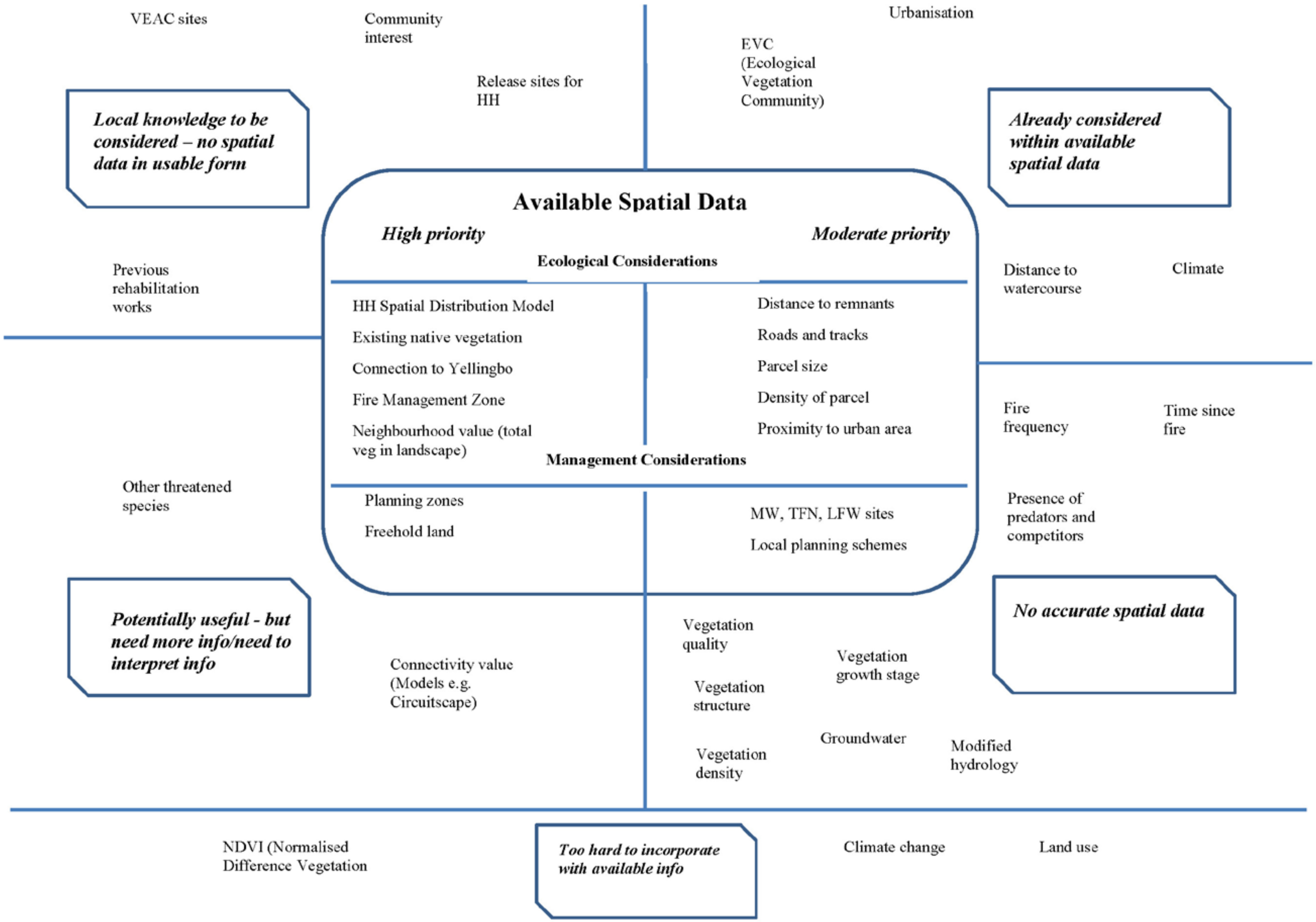
Appendix 3: Helmeted Honeyeater ideal species distribution model



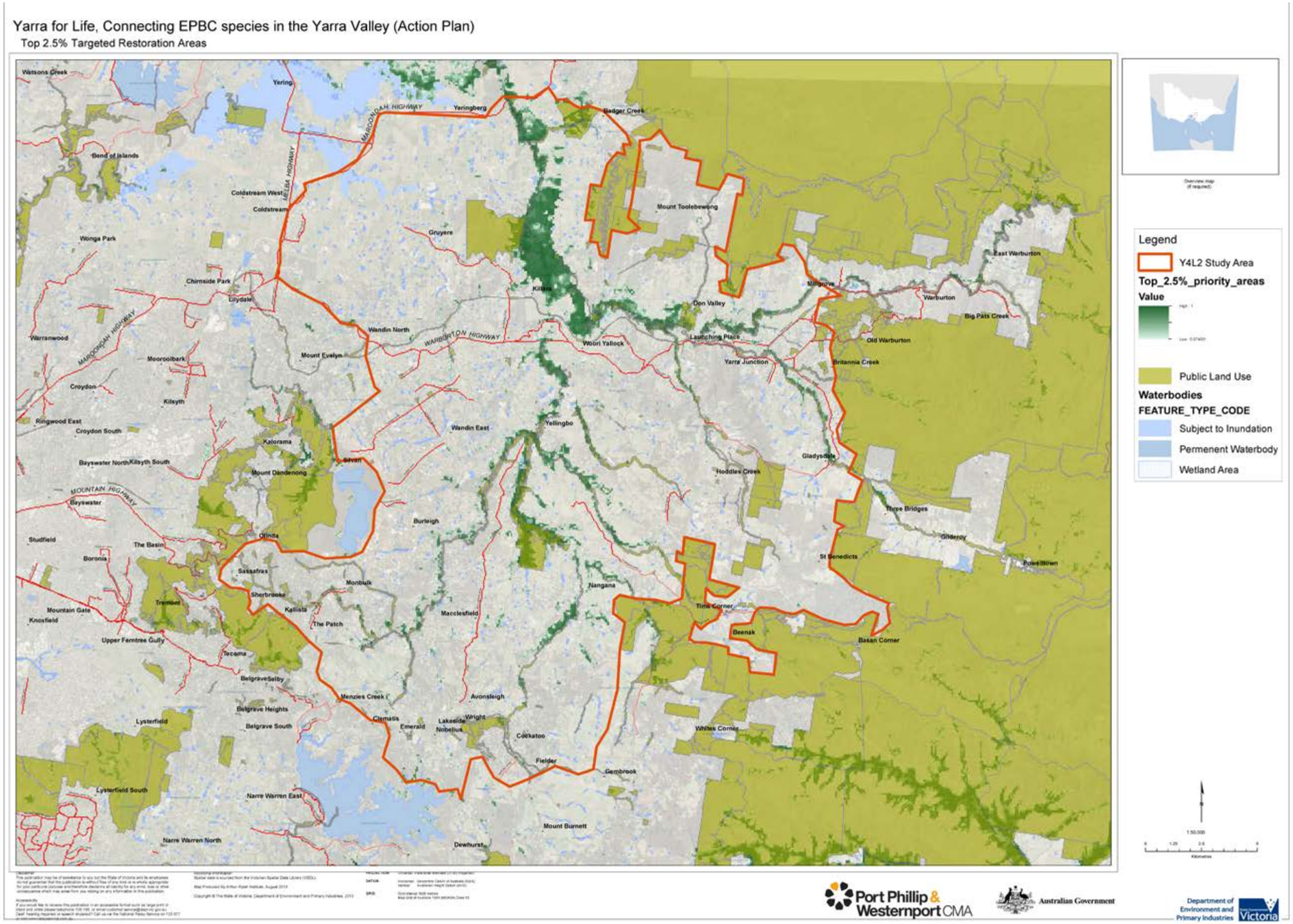
Appendix 4: Helmeted Honeyeater modelled distribution of suitable habitat on public and private land



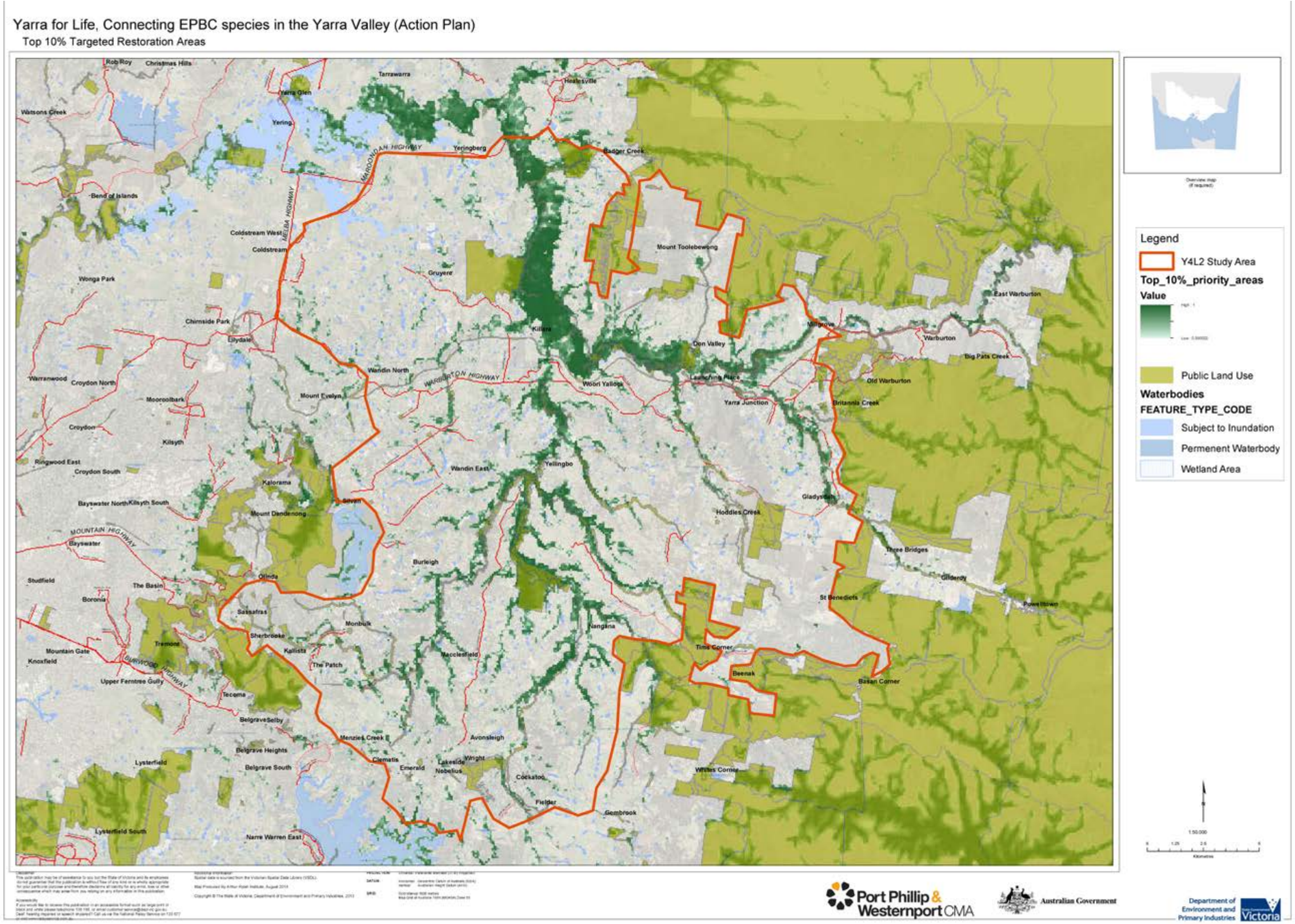
Appendix 5: Summary of spatial data used to inform identification of priority sites for rehabilitation works



Appendix 6: Top 2.5% of suitable restoration works area



Appendix 7: Top 10% of suitable restoration works area



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