Partner aspirations for a healthy Wombat Forest

An exploration of manager values and objectives

B. Farmilo, K. Batpurev, J.L. Moore and S.J. Sinclair

August 2024

Arthur Rylah Institute for Environmental Research
Technical Report Series No. 381

Arthur Rylah Institute for environmental research

VICTORIA State Government | Energy, Environment and Climate Action

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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Citation: Farmilo, B., Batpurev, K., Moore, J. and Sinclair, S. (2024). Partner aspirations for a healthy Wombat Forest: An exploration of manager values and objectives. Arthur Rylah Institute for Environmental Research Technical Report Series No. 381. Department of Energy, Environment and Climate Action, Heidelberg, Victoria.

Front cover photo: Herb-rich foothill forest in the Wombat Forest (Joslin Moore).

Edited by Fox Writing Services

ISSN 1835-3827 (print)
ISSN 1835-3835 (pdf))
ISBN 978-1-76136-324-5 (pdf/online/MS word)

Accessibility

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Partner aspirations for a healthy Wombat Forest

An exploration of manager values and objectives

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Acknowledgements

The authors would like to thank Charlie Tack and Jon Rofe from the Department of Energy, Environment and Climate Action (DEECA; Forest Management Planning, Grampians Region) for the opportunity to be involved in this project.

We would like to thanks the numerous partners who contributed to meetings, workshops and field days: Mark Costello, Caleb Dunolly-Lee, Jackson Dunolly-Lee, Sophia Jackson, Pete McCurley, Oli Moraes, Tony O'Loughlin (Dja Dja Wurrung Clans Aboriginal Corporation); Chase Aghan, Greg Belden, Kelly Ann Blake, Michael Cook, Sarah Eccles, Chris Fagan, Tammy Gilson, Blair Gilson, Claire Mennen (Wadawurrung Traditional Owners Aboriginal Corporation); Brian Earl, Deltalucille Freedman, Sean Hunter, Jesse Pottage (Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation); Peter Field, Andrew Harris, Tom Miller (Central Highlands Water); Bridget Clarke (Country Fire Authority); Stephan Curwood, Mick Dunne, Kylie McLennan (Coliban Water); Brian Bainbridge, Lauren Linke, Bruce Lucas (Hepburn Shire Council); Tanya Loos, Karen Muscat, Maria Loriente (Macedon Ranges Shire Council); Adam Barber, Jesse Riordan (Melbourne Water); Liam Harley, Rory Thomson-Ball, Amanda Western (Moorabool Shire Council); Tess Grieves (North Central Catch Management Authority); Sarah Canham, Marie Keatley, Patrick Pigott, Siobhan Rogan, Belinda Seivers, Fiona Smith (Parks Victoria). In addition, Charlie Tack and Nate Perry (DEECA; Forest Management Planning, Grampians) provided valuable project support.

We would also like to that numerous staff from the Arthur Rylah Institute for Environmental Research for their assistance with this project: Maddison Miller (assistance with workshops), Dave Bryant (assistance with field days), Tracey Regan, Matt Bruce, Matt White and Josephine MacHunter (informing approach to elicitations).

The authors would like to acknowledge and pay respects to Wadawurrung, Dja Dja Wurrung and Wurundjeri Woi Wurrung Elders, both past and present, for their invaluable contributions in preserving and nurturing the cultural heritage of the Wombat Forest. Their commitment and dedication have ensured the continuation of rich traditions and knowledge for generations to come.

This report has undergone review by the Arthur Rylah Institute for Environmental Research, and we appreciate the efforts of Tracey Regan and Cindy Hauser who were involved in this process.

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Context:

The Wombat State Forest, between Daylesford and Bacchus Marsh, is set to become a new National Park (Wombat-Lerderderg National Park), with some areas of Regional and State Park. The area will likely be co-managed by Parks Victoria and three Registered Aboriginal Parties (Dja Dja Wurrung Clans Aboriginal Corporation, Wadawurrung Traditional Owners Aboriginal Corporation and Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation).

This transition is profound. Across large areas, it requires a shift from the narrow focus of forestry to the broad and complex management needed for a co-managed park system to cater for many community and nature conservation needs. This project seeks to assist the early stages of that transition by facilitating the development of a shared vision of the Wombat Forest with relevant partners (i.e. stakeholders and rightsholders).

Aims:

This project aimed to bring together all potential co-managers and management agencies with responsibilities for the future Wombat Forest parks (hereafter 'partners', acknowledging that there are other partners without management responsibilities, including the myriad of forest users) to:

- describe a shared vision for a healthy Wombat Forest
- systematically document the specific values and objectives that each partner group holds
- describe the current health of the Wombat Forest, with reference to these objectives
- systematically document the actions that each partner group believes will be necessary to create a healthy Wombat Forest, including an assessment of their likely impacts on the objectives
- describe potential targets and methods for monitoring, to track progress against the objectives,
- show how the objectives, management options and monitoring approaches are expressed and interpreted at a range of locations, using field visits with partners to case study areas
- present a literature review that provides an overview of forest management approaches. ARI was asked to give particular emphasis to the ideas of 'active forest management' and 'adaptive management'.

In parallel, ARI were also requested to develop a preliminary watchlist of high-risk environmental weeds for the Wombat Forest following a severe windstorm in June 2021.

Methods:

We consulted partners to identify values and objectives. We elicited the benefit or harm of multiple on-ground or administrative actions on those values. We undertook field visits to case study sites with partners to discuss forest values, objectives and management. Discussions were informed by strategic documents from partners, including Country Plans.

The methodology for developing the environmental weed watchlists and the watchlists are presented in Appendix 1. HTML maps showing known locations of high-risk species have also been provided.

Results:

Together, we defined a Vision that represents the aspirations of the partners:

The Wombat Forest is actively cared for by the Dja Dja Wurrung, Wadawurrung and Wurundjeri Woi Wurrung people in co-operation with the Victorian Government and the wider community, and is on a path to becoming a healthy forest with vibrant and rich ecological and cultural (i.e. biocultural) communities which preserve its cultural identity.

To support this vision, partners defined specific values and objectives that ranged widely to include ecological factors such as forest structure, the richness of native species, soil and waterway health and the

abundance of pests; along with social factors such as the safekeeping and practice of cultural knowledge, appropriate community access to land, and good governance. Most of the objectives were set with reference to past conditions, demonstrating that the partners wanted to repair damage and restore a value that was present in the past, but is now lost or under threat.

The partners often looked to innovation, new technology and new thinking when considering actions to improve the values, or how changes in values should be monitored.

The Wombat Forest currently falls short on many of these objectives. Different places carry the legacies of gold mining, extensive timber extraction, weed invasion and severe storm damage. We present several case studies, resulting from field visits, that show how the partners interpret the values, objectives, management decisions and monitoring approaches at these specific sites.

Conclusions and implications:

We provide a record of the partners' aspirations at a crucial juncture for the Wombat Forest. By documenting objectives that are broad in coverage and specific in intent, this work provides a good basis for 'active forest management' and 'adaptive management'; models of forest governance which emphasise participation from all partners and community engagement and the use of keen observation and monitoring to continually improve management. This report is accompanied by a shorter, less technical document, which provides only the key content relevant to partners and the public.

1 Introduction

1.1 Project context

The Wombat Forest lies in central Victoria, about 75 km north-west of Melbourne, and supports over 50,000 ha of native forest. The area is diverse, covering hills and valleys, with the relatively moist conditions in its western portion (880 mm annual rainfall near Daylesford), supporting tall forests of Messmate (*Eucalyptus obliqua*) and Peppermint (*E. radiata* and *E. dives*), and the much drier conditions to the east supporting lower, more open forests (505 mm annual rainfall near Bacchus Marsh).

First Nations people have cared for this area for tens of thousands of years. Following European invasion in the mid-1800s, the Wombat Forest was heavily impacted by gold mining in the 1850s and subsequent decades, and since the declaration of the Wombat State Forest in 1871, by large scale timber harvesting (Figure 1).

Figure 1. A typical scene of timber cutters in the Wombat Forest (date unknown). The stumps reveal the large size of the original trees (image source: Taylor 1998).

The impacts have resulted in many changes to the forest, most of which are now interpreted as degradation. These include the loss of old growth trees, extensive soil disturbance, weed and pest invasions, and declines in native biodiversity (Lindenmayer et al. 2000; Ough 2001; Loyn 2004). The changes have led local First Nations groups to describe the forest as ‘upside-down Country’, meaning the processes that underpin a functioning environment for people and nature have been fundamentally ruptured (Dja Dja Wurrung Clans Aboriginal Corporation 2014). The condition and management of the Wombat Forest have long been controversial, and the focus of much community debate (Matthews and Missingham 2009). Much of the controversy and debate centred on forest conservation versus timber production.

In 2019, the Victorian Environment Assessment Council (VEAC 2019) recommended that the Wombat State Forest become a mix of National Park and Regional Park, which was accepted by the Victorian State Government. Also in 2019, the Victorian Government announced that timber harvesting in Victoria would cease in December 2023.

These changes to the reservation status of the Wombat Forest come while Victoria is making the transition to co-management of public land with First Nations, and in the context of support for First Nations self-determination via the Department of Energy, Environment and Climate Action's (DEECA's) Aboriginal Self-Determination Reform Strategy (Pupangarli Marnmarnepu 'Owning our Future'; 2020–2025; DELWP 2019). Registered Aboriginal Parties are beginning to reach Settlement Agreements under the *Traditional Owner Settlement Act* (2010). In the case of the Wombat Forest, this has already occurred for the Dja Dja Wurrung Clans Aboriginal Corporation (in 2013). This move to joint management necessitates a new way of understanding land management, with new objectives, new priorities and new actors. Following their Settlement Agreement, the Dja Dja Wurrung Clans Aboriginal Corporation have already begun to make their aspirations and priorities clear, through publications such as their Country Plan (Dja Dja Wurrung Clans Aboriginal Corporation 2014), Forest Gardening Strategy (Dja Dja Wurrung Clans Aboriginal Corporation 2022) and Climate Change Strategy (Dja Dja Wurrung Clans Aboriginal Corporation 2023).

The changes also come alongside a severe windstorm in 2021, that caused extensive and widely publicised treefall (Crook 2021), and which has led to further controversies about forest management, particularly with regard to salvage logging of fallen trees (Kirkham 2023).

This combination of decisions, disturbances and strategies all impact on the future health of the Wombat Forest. Now that so much is up for redefinition and negotiation, it is timely to (re)-imagine the future of the Wombat Forest. Given the depth of the changes, this re-imagining must start at the most basic level. This will include gaining a broad and fresh understanding of:

- the values that people see in the forest, and their objectives for its future
- how the values are arranged or concentrated across the Wombat Forest (i.e. spatially)
- the approaches to land management and governance that may bring diverse partners with different priorities together, and which will result in effective and adaptive management
- the practical actions that people believe will achieve the objectives
- the approaches to track change, to ensure that managers learn and adapt.

The Arthur Rylah Institute (ARI) was contracted by DEECA's Forest, Fire and Regions Division to document and explore these issues, through consultation with partners. In this report, the term "partner" is employed to encompass all agencies and corporations who will have a direct and formal role managing the Wombat Forest. However, it is crucial to recognise that Traditional Owners transcend the conventional definition of partners; they are the custodians of the land, with profound connections and responsibilities that extend far beyond the partner label. Partners are listed (in alphabetical order) below:

- Country Fire Authority (CFA) (responsibilities under the Country Fire Authority Act 1958 and Bushfire Management Act 2009)
- Coliban Water (responsibilities under the Water Act 1989 and Catchment and Land Protection Act 1994)
- DEECA (responsibilities under The Forest Act 1958, The Flora and Fauna Guarantee Act 1988 and Environment Protection Act 1970)
- Dja Dja Wurrung Clans Aboriginal Corporation (hereafter DJAARA; responsibilities under the Aboriginal Heritage Act 2006 and Traditional Owner Settlement Act 2010, and under the current Settlement Agreement (Dja Dja Wurrung Clans Aboriginal Corporation and the State of Victoria 2013))
- Hepburn Shire Council (responsibilities under the Local Government Act 2020)
- Macedon Ranges Shire Council (responsibilities under the Local Government Act 2020)
- Melbourne Water (responsibilities under the Water Act 1989 and Catchment and Land Protection Act 1994)
- Moorabool Shire Council (responsibilities under the Local Government Act 2020)
- North Central Catchment Management Authority (CMA; responsibilities under the Catchment and Land Protection Act 1994)

- Parks Victoria (responsibilities under the Environment Protection Act 1970 and Parks Victoria Act 2018)
- Wadawurrung Traditional Owners Aboriginal Corporation (hereafter Wadawurrung; responsibilities under the Aboriginal Heritage Act 2006 and Traditional Owner Settlement Act 2010)
- Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation (hereafter Wurundjeri; responsibilities under the Aboriginal Heritage Act 2006 and Traditional Owner Settlement Act 2010).

It is important to acknowledge that there are other partners not included here, because they lack legislated or formal roles in managing the Wombat Forest. These other partners include local conservation groups (the most prominent of which is Wombat Forestcare Inc. – a registered charity established in 2006), local residents, and recreational users of the Wombat Forest. Some of these partner groups have important and longstanding relationships with the forest that will remain relevant as the reservation status of the Wombat Forest changes. Consequently, we assume that the current work forms the first part of a more extensive consultation and engagement process.

The information gathered in this project will best assist the future management of the Wombat Forest if it is incorporated into effective governance structures and good approaches to land management. These must acknowledge and utilise the fact that the Wombat Forest is a complex socio-ecological system, with many partners who use, care for, manage and love the forest in different ways, with different knowledge, responsibilities and capacities. Good management must also recognise that there is much to learn about management in the Wombat Forest, and that our approaches to management will need to adapt over time.

In this report, we highlight two complementary models of forest management that will foster good management. Briefly, they are:

- *Active Forest Management (AFM)*; where decision-makers and partners work together, implement bold management actions to conserve and restore the cultural, biological and social values of the Wombat Forest, using both Traditional and 'western' methods where they are appropriate; using regular monitoring, and applying the best data and analytical approaches to learn (Carey 2006; Bolte et al. 2009; Jackson et al. 2021)
- *Adaptive Management*, involving a continuous cycle of implementing management actions in ways that generate new knowledge, monitoring their results carefully, and changing our management in light of new knowledge (Gregory et al. 2006; Jackson et al. 2021).

Both of these approaches acknowledge that we must be thoughtful and mindful of the cultural, social and ecological history of the Wombat Forest before important decisions are made, but they also allow for bold and ambitious actions to take place without complete certainty of the outcomes. It's now a matter of 'learning by doing' (Walters and Holling 1990).

1.2 Introduction to the Wombat Forest

This report deals with the proposed Wombat-Lerderderg National Park (49,553 ha) and Wombat Regional Park (13,789 ha) proposed by VEAC (2019; Figure 2). This area is located ~50 – 100 km north-west of Melbourne, between Bacchus Marsh, Woodend, Kyneton, Newstead and Ballarat. It protects a range of forests, and the headwaters of several prominent rivers, including the Loddon, the Coliban and the Campaspe flowing northwards to the Murray basin; and the Werribee River which flows southward to Port Phillip.

The Wombat Forest intersects three First Nations groups whose boundaries are defined by the waterways (Wadawurrung to the west of Werribee River, Wurundjeri to the east) and ranges (Dja Dja Wurrung to the north of the Great Dividing Range, and Wadawurrung and Wurundjeri to south; Registered Aboriginal Party boundaries shown on Figure 2).

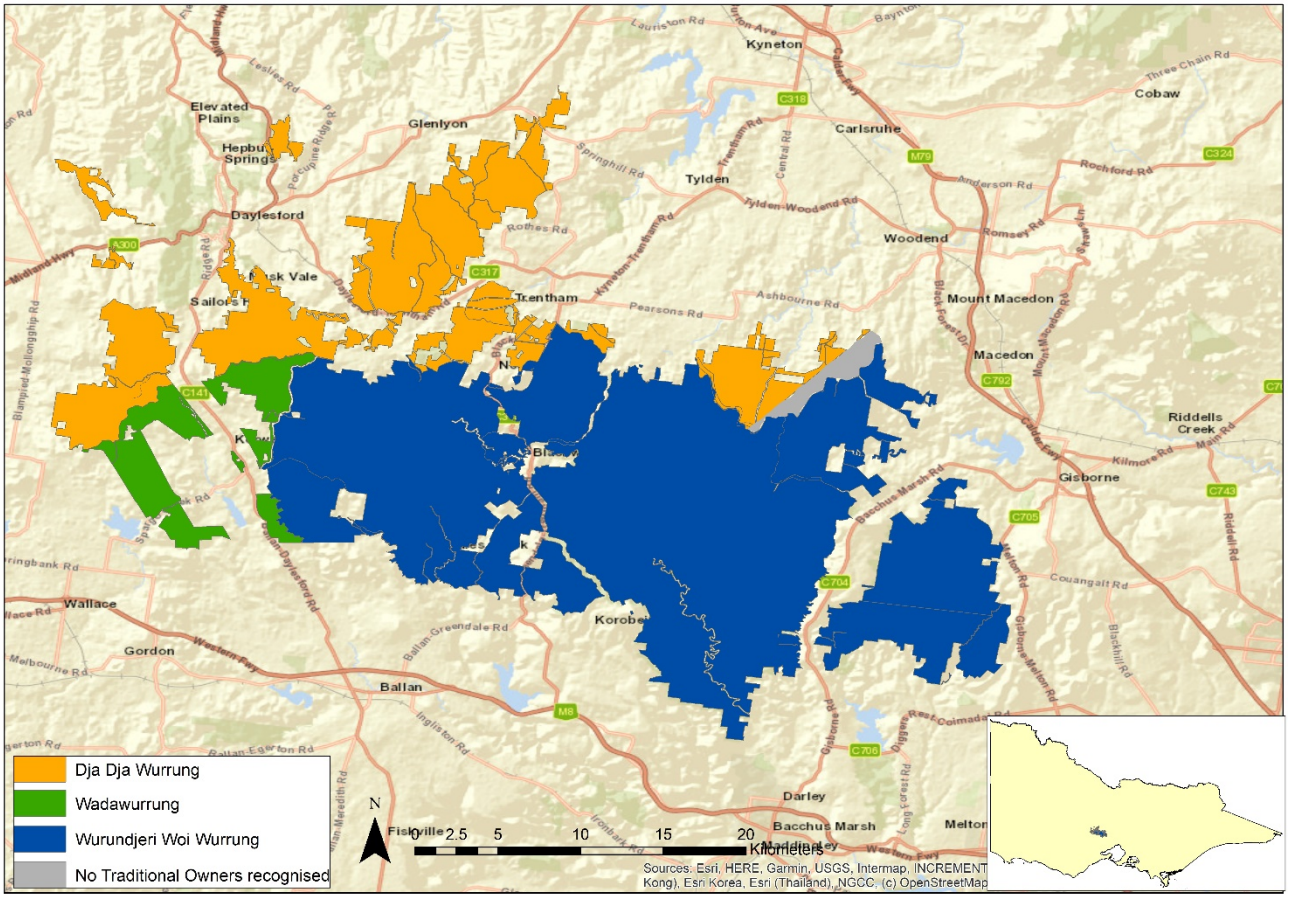

Figure 2. Footprint of the area under investigation in this report (i.e. proposed Wombat-Lerderderg National Park including broader regional parks and reserves) coloured to reflect Registered Aboriginal Party boundaries.

Currently, the majority of the public land in the central and western portions of the Wombat Forest are State Forests. These areas are relatively productive, mostly occupying undulating hills and valleys, and produce large trees that are merchantable, notably Messmate Stringybark (*Eucalyptus obliqua*), Narrow- and Broad-leaved Peppermint (*Eucalyptus radiata* and *Eucalyptus dives*), Manna Gum (*Eucalyptus viminalis*) and a range of other trees. These areas have been subject to timber harvesting, mostly between 1871 and 2008 (for images and further details, see case studies in Section 3.3).

The eastern portion of the area is mostly within the current Lerderderg State Park. This area protects Country that is more dissected, steep and of lower productivity (e.g. Pyrete Range). These areas support smaller trees, including the species mentioned in the previous paragraph along with trees of drier conditions such as Red Stringybark (*Eucalyptus macrorhyncha*) and Red Ironbark (*Eucalyptus tricarpa*), and have generally not been subject to recent logging.

Most areas of the Wombat Forest have been impacted by gold mining, mostly in the mid-nineteenth century, with some areas suffering extensive upheaval of the soil layer (Figure 3).

Figure 3. 'Bird's-eye view of Ballarat' (area ~25 kms west of the Wombat Forest) during the goldrush, 1858 by George Rowe (source State Library NSW; https://collection.sl.nsw.gov.au/record/Yr8RXdNn). This painting illustrates the degree of timber cutting and the substantial impacts to waterways and soils caused by gold seekers.

The Wombat Forest conserves a number of plants and animals of conservation significance (Matthews and Missingham 2009), including the Nationally Endangered Greater Glider (*Petauroides volans*) and two plants which occur only in the Wombat Forest (Wombat Bossiaea, *Bossiaea vombata*; and Wombat Bush-Pea, *Pultenaea reflexifolia*).

This report focusses mostly on the areas that are currently State Forest within the Wombat-Macedon block (VEAC 2019), because these areas are subject to most controversy, the most complex history of prior management and degradation, and will undergo the largest shift in management priorities. The former Lerderderg State Park is not considered in specific detail.

1.3 Literature review: Overview of approaches to forest management

"The worldview of a society is often written more truthfully on the land than in its documents" (Kimmerer and Lake 2001)

1.3.1 Background and scope

Forests are complex systems, often of great beauty and cultural significance (Ribe 2002; Trigger and Mulcock 2005; Ormsby and Bhagwat 2010; Ford et al. 2014). They also offer many tangible services and products to people and nature, including timber, carbon sequestration, soil stabilisation, water filtration, habitat for plants and animals, and places for recreation (Byrnes et al. 2014; Mastrangelo et al. 2014; Binder et al. 2017).

Managing forests for the provision of multiple forest services often requires trade-offs (Fernández-Manjarrés et al. 2021; Lu et al. 2021). Consequently, there is the need to manage, to make decisions, to share, to compromise and to resolve disputes (Kanowski 2017). There are vastly different ways to approach management from structural and attitudinal points-of-view: from the spiritual to the scientific.

Given the imminent changes to the management of the Wombat Forest noted above, it is timely and appropriate to re-think forest management. We conducted a literature review on approaches to forest management, with particular focus on the concepts of AFM and 'adaptive management'. This section presents that review.

competing interests and change? How do we act when we do not fully understand the consequences? We do not address the details of on-ground management practices such as clear felling and timber harvesting, nor the details of administrative or governance arrangements.

1.3.2 Clashing approaches: Traditional management and colonisation

Many different approaches to forest management have emerged in different places and eras (Nocentini et al. 2020). Two of the most fundamentally divergent approaches are both relevant to the Wombat Forest. Following the literature, these can be designated as the 'Traditional approach', which operated for millennia before invasion; and the 'western approach', which abruptly supplanted the Traditional approach after colonisation. Like other colonised regions, Australia's forest landscape bears the overlapping legacies of this varied history (Kimmerer and Wake 2014).

Traditional management conducted by First Nations people operated in the Wombat Forest for tens-of-thousands of years, up until colonisation. Unfortunately, traditional management is not well documented for the Wombat Forest area. However, there are sources of information that provide some insight. The first is the extensive literature on land management conducted by First Nations people elsewhere across Australia, as seen through the eyes of western scientists, anthropologists and historians, and *occasionally* in collaboration with First Nations authors. Some examples with different emphases include: Pyne (1991), Gott (2005, 2008), Gammage (2011), Pascoe (2014), Cahir et al. (2016), Jones and Clarke (2018), Foreman (2020), Jurskis (2020) and Sutton and Walshe (2021). From these disparate and sometimes conflicting sources, it is possible to build up a picture of some basic themes and structures which applied widely across Australia, and likely applied to the Wombat Forest.

Under Traditional management, land management is integrated into the spheres of social, economic, cultural and religious life. There are no clear demarcations between these spheres. Society is seen as inter-connected with the land, and land management involved balancing ecological, social and spiritual forces to achieve utilitarian (food, fibre), social and religious outcomes (which may not be differentiated at all) (Sutton and Walshe 2021). Different people in society fulfil different management roles (Pascoe 2014; Sutton and Walshe 2021). It is important to note that spiritual motivations for land management do not imply inward-looking or small-scale management aspirations, nor a lack of measurement or efficiency in resource use. On the contrary, management by First Nations people was often planned, extensive, impactful, sophisticated and far from haphazard.

The other main sources of information are the knowledge, memories and values retained by First Nations people today, and the cultural heritage retained in the land (e.g. scar trees and artefacts). This information is sometimes shared via the western literature (e.g. O'Brien and Watson 2014). In Victoria, contemporary understandings of approaches to land management are summarised and expressed publicly by the 'Country Plans' of some First Nations groups (e.g. DJAARA 2014; Wadawurrung Traditional Owners Aboriginal Corporation 2019). These documents emphasise the inter-relationship between people and Country: that healthy Country needs healthy people to care for it, and the people need healthy Country to be healthy themselves. This concept of reciprocity and interconnection, driven by attentive observation, respect and positive feedbacks, is present in many First Nations cultures throughout Australia and overseas (Kimmerer and Wake 2014).

These approaches collided with a very different worldview in the 1800s which was imported from Europe with British colonists. By the 18th century, forest management in Britain and Europe emphasised quantification and systemisation as key virtues, serving a single-minded objective of maximising wood production. Good forest management was seen as that which was regimented and efficient, and which could go on producing high timber yields. The idea of sustainable yield was first discussed in the 18th century (Spindler 2013). In the service of efficiency and consistency, many forests were pushed towards being even-aged monocultures over large areas (Lowood 1990; Johann 2006). This approach to forest management reveals assumptions that now appear naïve. These include that forest dynamics are consistent and predictable extensively across time and space, and that the single goal of timber production is what matters.

These assumptions were frequently questioned by the mid-19th century, from two quite different angles. First, the recognition that forests hold values other than timber production; ideas that formed part of the 'Romantic movement' (La Freniere 1990; Brand 2010). Second, that nature was subtle and complex and not always amenable to regimented management (Thoreau 1854; Lowood 1990).

By the early 20th century, it was widely recognised that there was value in retaining multi-aged stands, and working with natural regeneration, by using techniques such as selective harvesting and the retention of seed trees (Meffe and Carroll 1997, Johann 2006; Nocentini et al. 2020). These approaches were less rigid and naïve than those of the 18th century, but still pursued timber production as the primary aim of management.

1.3.3 Moving on from European forestry models

In the second half of the 20th century, attitudes changed rapidly, and many new views on land management emerged. A spur to this change was Aldo Leopold's 'Sand County Almanac' (Leopold 1966; Kimmins 2002), which advocated an ethical and ecologically-informed attitude to land management. By the 1980s, various approaches to 'ecosystem management' had emerged (Kimmins 2003). Some of the key realisations that characterised them are set out below.

- Forests are social-ecological systems (SES). This idea emphasises that human societies and natural systems are interlinked. It was formalised in a theoretical framework in the 1990s (Ostrom 1990; Costanza 1991; Berkes and Folke 1998). Studies of SES emphasise the links and flows of resources between the different social and ecological elements, the feedback loops and non-linear interactions between them, and the capacities of such systems to adapt and change (Gunderson and Holling 2002; Berkes et al. 2008; McGinnis and Ostrom 2014).
- Human health and wellbeing are interdependent, with forest health, with the forest affecting people, and people affecting the forest (Kimmerer and Lake 2001; IUCN 2020; WWF 2020).
- Forests have many values other than timber. These include biodiversity (Lindenmayer and Franklin 2002), recreation (Zandersen and Tol 2009), carbon sequestration (Roxburgh et al. 2006), hydrological function (Lane et al. 2010), cultural values (Feary et al. 2010) and the intrinsic values of nature (Ciancio and Nocentini 2000; Ford 2013). In some places, non-human values have now been codified into legal rights for nature (Borràs et al. 2016), and consideration has been given to codify environmental ethics into forestry codes (Franklin 1989). This idea has come relatively recently to much of the forestry literature, but has been understood elsewhere for millennia.
- Forest ecosystems have many interacting parts and feedbacks, and suffer numerous disturbances; such that their dynamics are complex and difficult to predict. These dynamics include 'shocks' such as major wild-fires, disease outbreaks or storms (Collins et al. 2021), and 'tipping points' (Adams 2013; Messier et al. 2016). This means that forests may appear stable, but then undergo sudden change when they are pushed beyond a threshold. (This realisation has led to the conceptualisation of 'resilience', which is discussed below).
- Forest dynamics are related to scale and spatial context, with different processes operating across larger or smaller areas, interacting with other places and processes across patches and edges (Bradshaw 1992; de Mello et al. 2020).
- Forests differ from one another. They have different histories, composed of past natural disturbances and human acts of management and mismanagement (Hermy and Verheyen 2007; Bowd et al. 2021). History also involves time-lags, and the interaction of fast (e.g. storms) and slow (e.g. species range expansion and contraction) processes (Fernández-Manjarrés et al. 2021). In colonised nations such as Australia and the US, this history often includes thousands of years of management by First Nations people, followed by a dramatic imposition of colonial management (Kimmerer and Lake 2001). Simple assumptions or models based on one forest do not necessarily reflect other forests (O'Hara and Nagel 2013).
- Knowledge about forests is incomplete and uncertain (Regan et al. 2002; Kanowski 2017). Knowledge is contested, polarised and politicised, sometimes bitterly. In Australia, this applies particularly to the role of fire in forests, including the pre-colonial use of fire, the impacts of bushfire and the use of prescribed burning. Even when empirical evidence exists, there is much argument about the implications of experimental methods, and how far results can be extrapolated (e.g. see Adams 2013).
- Well-selected models, such as state-and-transition models, can be useful for understanding and communicating the complex dynamics of forests, and analysing how management can promote specific outcomes. State-and-transition models describe different 'states' that a forest may take. Which state is present at a given location depends on what has previously happened at the site. The

forest at a given location may change from one state to another. It may undergo a 'transition' if the system is disturbed in some way that causes a threshold to be crossed (Westoby et al. 1989). Transitions may include natural disturbance events such as storms; natural patterns of recovery such as growth and succession; or management actions such as logging, weed removal or planting. These models can show many complex pathways of change and interaction. They also show how land use legacies constrain future land use, or present opportunities for change (e.g. Wilkinson et al. 2005).

- Human values, preferences and aesthetics matter, should be taken seriously, and can be measured (Gobster 1999; O'Brien 2003; Ford et al. 2014). Values differ among different individuals and groups, and are often contested. Different partners have fundamentally different beliefs about what is important (e.g. timber, recreation, cultural heritage, wilderness), and how they can be traded off (O'Brien 2003). This has been explicitly explored in the Wombat Forest, where these issues are well-documented (Ford 2013).
- Governance structures and administrative processes matter. Poor processes can lead to inefficiency and inertia. Administrative processes are slow to change, due both to the genuinely complex nature of environmental change but also because of human behaviour and psychology, with people often reluctant to change (e.g. the so called 'Status quo trap', Kahneman et al. 1991; Fernández-Manjarrés et al. 2021). Kanowski (2017) noted that when change does occur, it is often in response to 'shocks' (such as COVID 19, the great depression, wars, etc.).
- As forest management concerns people, it also concerns justice. Poor governance can cause or exacerbate injustice, particularly if First Nations, local or minority interests are excluded from participation (Klooster 2002; Feary 2008; Lindenmayer 2018). There is often a tension between top-down management (e.g. government command and control) and bottom-up management (i.e. community action) (Fernández-Manjarrés et al. 2021). The exclusion of First Nations people from management, from the mid-1800s until very recently, is a major theme in the history of the Wombat Forest area.

1.3.4 Recent Forest management frameworks

The realisations that characterised ecosystem management since the 1980s have resulted in a struggle of ideas in the forest management literature, which have resolved into distinct themes and discourses. The most prominent are:

- Sustainability: The idea that systems should be able to continue into the future without exhausting their resources. In the words of the World Commission on Environment and Development (UN 1987) our activities should meet "the needs of the present without compromising the ability of future generations to meet their own needs". This concept has been deeply held by people for millennia, and the term (in German) was used as early as 1713 in the context of forestry (Spindler 2013). It emerged as a driving principle for economic development and environmental policy in the late 1970s (Spindler 2013).
- Resilience: The study of how systems respond to disturbances or shocks, and what factors encourage them to 'bounce back' or retain their essence, rather than shifting to an alternate state, or collapsing or dissociating (MacArthur 1955; Curtin and Parker 2014). A resilient system has a high capacity to rebound and reorganise. The idea of resilience can be applied to ecological systems, but also to social-ecological systems at larger scales (Messier et al. 2016, 2019; Jackson et al. 2021).
- Traditional land management and values: Recognition that Traditional values and land management techniques offer valuable contributions to land management came late to western forest management (Lynch et al. 2010). It emerged largely in the 1990s, in Australia and a range of other countries (Kimmerer and Lake 2001). In many cases, the main land management issue was the use of fire, versus the suppression of fire. This remains a contested space. There are still relatively few examples of good integration between traditional management and modern approaches to management (Klooster 2002).
- Forest or ecosystem 'health' (similar to the concepts of ecological 'condition', 'quality' or 'integrity'): Aldo Leopold described the idea of ecological 'health' in the 1960s (Leopold 1966), likening it to human health by analogy. Leopold noted that, like animal bodies, forests can have their vital functions degraded or lost so that they lose their ability to regenerate and grow as they once did. First Nations people also use the idea of health to express ideas of sick or damaged landscapes and waterways (DJAARA 2014; Wadawurrung Traditional Owners Aboriginal Corporation 2020). Since the 1980s, there has been much discussion of the idea of ecological 'health' in the ecological

literature (Schaefer et al. 1988; Rapport 1989), with an emphasis on ways to measure it and use it to track degradation and restoration. 'Health' is not easy to measure because it is a complex idea that blends many factors, some of which are subjective. This complexity and subjectivity have led some to suggest that the idea of 'ecosystem health' is flawed and misleading, and should be avoided in favour of measuring more tangible things (Suter 1993). Despite these difficulties, we embrace the term here. We note that it powerfully communicates complex ideas, and that it assists in the mediation of trade-offs between different values in decisions (Sinclair et al. 2015).

- Conservation planning: The systematic allocation of land areas to different uses or management zones, in recognition that there are spatial trade-offs to be made when managing landscapes (Pressey 1998; Margules and Pressey 2000; Bottrill and Pressey 2012). Conservation planning considers several interacting problems: a) the balance between diffusion of impacts across the landscape, versus partitioning impacts away from protected areas (the so-called 'Spare or share' debate; Stevenson et al. 2013; Kanowski 2017; Royer-Tardif et al. 2021); b) balancing patch size and patch number: Is it better to have many small reserves, or a few larger ones? (the so-called 'SLOSS' (single large or several small) debate; Diamond 1975; Simberloff and Abele 1976; Lindenmayer et al. 2015); and c) the management of patch area versus perimeter (Laurance 1991; Baker et al. 2007; Pryke and Samways 2012; Hatfield et al. 2020). Overall, conservation planning in Australia generally attempts to create a system of reservation and/or land management that is 'comprehensive, adequate and representative' with respect to biodiversity values (JANIS 1997). Interestingly, the regional forest agreements (RFAs) in Australia were one of the earliest examples of systematic Conservation Planning in the world.
- Adaptive management (AM): A systematic approach for the adjustment of management based on regular monitoring of outcomes; sometimes termed 'learning by doing'. Adaptive management exists in many forms in many domains under a variety of names (e.g. 'reflective practice' in medicine (Mamede and Schmidt 2004), 'inquiry cycle' in education (Pedaste et al. 2015)). While the basic concept is 'common sense', rigorous frameworks for implementing AM emerged in the 1980s and 1990s (Walters 1986; Walters and Holling 1990; Halbert 1993; Lee 1999). They tend to include a) the delineation of measurable goals, b) modelling or consultation to determine promising management strategies, c) the implementation of multiple management strategies, d) monitoring, and e) adjustment of management in response to monitoring. Different AM schemes vary in how they trade off learning with achievement. Some schemes prefer experimental approaches that quickly answer questions, even if many resources go towards management that fails, while others are cautious about outcomes, and suggest regular adjustment and abandonment of failing approaches (McCarthy and Possingham 2007; Williams 2011).

These ideas have been variously combined into management frameworks and schemes, including the following, which are named and described in the literature:

- 'Nature based forestry' (Johann 2006; Messier et al. 2019), which emphasises a 'living community', recognising natural ecological complexities, the need to understand and work with disturbance ecology, and the need to maintain diversity. Nature based forestry has been a major theme of discussion in forestry for over a century now.
- 'Pathways to sustainability approach' (Leach et al. 2010); which emphasises incomplete knowledge and different kinds of stressors.
- 'Systematic silviculture' (Nocentini et al. 2017); which emphasises intrinsic natural values and the 'land ethic'.
- 'Community (or Collaborative) forest management' (CFM; the name varies; Petheram et al. 2004; Matthews and Missingham 2009; Ford 2013), a model that emphasises community participation in decision-making among diverse partners. It may represent long-standing arrangements that have evolved over centuries (Jeanrenaud 2001), or it may be deliberately imposed to resolve conflict (Petheram et al. 2004). This model was explicitly attempted – with limited success – in the Wombat Forest in the 1990s (Nelson and Petit 2004; Matthews and Missingham 2009; Ford 2013).
- 'Active forest management' (Jackson et al. 2019), an Australian-focussed variation of CFM, which focusses on collaborative governance and adaptive management. It was noted as a suitable model by DEECA at the commencement of this project, and its discussion was mandated in the project brief for ARI. It is discussed further below.

Each of these approaches address forest management from different angles. They are not mutually exclusive, and can potentially work together.

1.4 Recent and current management of the Wombat Forest

1.4.1 Implementation of Regional Forests Agreements

In 1992, the National Forest Policy Statement ('the Statement'; Commonwealth of Australia 1992a) was released, as a guiding document for Forestry in Australia. It presents aspirations for forest management, and includes many of the ideas and trends outlined above. Since 1992, it has been augmented several times, to recognise traditional management (DAFF 2005), climate change (Department of the Environment 2014a, b), and wildfire (Forest Fire Management Group 2014; Kanowski 2017).

Regional forest agreements (RFAs) between state and federal governments are the instruments which facilitate implementation of the Statement (Davey 2018). RFAs were based on an assessment of the spatial distribution of the timber resource, native vegetation types, old growth stands, threatened species, cultural values and wilderness areas, and use reservation and zoning to balance the needs of production with conservation and other needs. Despite their far-reaching aspirations, RFAs have had mixed results (Jackson 2019) and have been much criticised for failing to achieve their aims (Lindenmayer 2018). Jackson et al. (2021) note that RFAs have "not provided an effective or enduring mechanism for presenting and addressing trade-offs between values or for engaging the broader public in managing those trade-offs and providing assurance that different values are being properly considered."

1.4.2 Community Forest Management

In 2002, the Victorian Government released a policy statement *Our Forests Our Future* (DNRE 2002) to improve the management and conservation of Victorian forests. Developing community participation in forest management was seen as a key to meeting this objective. The Wombat Forest was selected to trial a Community Forest Management model (Petheram et al. 2004). From the outset, the Community Forest Management initiative was embedded into a community that was both suspicious of how the initiative might impact local people, but also optimistic that better outcomes for the forest and the community might be realised (Nelson and Pettit 2004). Following a worldwide review of case studies applying Community Forest Management (Petheram et al. 2004) it was decided that local people should be asked to develop their own process and institutional structures suited to the local context (Matthews and Missingham 2009). The final structure included a Council of Stewards with a representative from each of 11 working groups tasked with managing different forest values (e.g. timber, cultural heritage and biodiversity; Ford 2013). However, due to: (1) poor representation of the community; (2) partners becoming frustrated and doubts of the government's intentions; (3) a lack of ongoing support and flexibility; (4) a lack of adequate and trustworthy leadership; and (5) ambiguity in the purpose, goals and authority of the Community Forest Management process, Community Forest Management in the Wombat Forest failed and was abandoned after its first few years (Matthews and Missingham 2009). It is important to note that this attempt at Community Forest Management for the Wombat Forest did not include significant representation from First Nations.

1.4.3 Conservation advocacy in the Wombat Forest

Advocacy for biodiversity conservation in the Wombat Forest has been persistent and strong for decades. This is evident from numerous reports (e.g. Macak et al. 2010; Macak 2012; Ralph 2017; Cally et al. 2023), articles (e.g. Roberts 2012; Pouliot 2012; Connelly 2017; Blair 2019), student theses (e.g. Golding 1979; Manderson 1979;) and scientific papers (e.g. Loyn and McNabb 2015). A Wombat Biodiversity Working Group was created as part of the trial of Community Forest Management, which eventually disbanded, but contributed to the formation of Wombat Forestcare Inc.

Wombat Forestcare Inc. is a prominent advocacy group for environmental values of the Wombat Forest (and adjoining areas). The community group opposes anthropogenic threats to environmental values (e.g. poorly planned and implemented planned burning, logging, mining, trail bikes, car rallies) and campaigned for the Wombat Forest to become part of a conservation reserve system well prior to the VEAC (2019) report. The group produces a quarterly newsletter (2006 – current), which provides news of recent activities (e.g. protests, monitoring events, walks, annual general meetings, forums, workshops and festivals) and links to outputs (e.g. videos, hosted talks, reports, field guides, media releases, letters to minister) of which they are often a provider or partner.

1.4.4 Recreational users of the Wombat Forest

Recreation and tourism are now the major uses of the Wombat Forest (VEAC 2019). The Wombat Forest provides many recreational opportunities for the local community and tourists and the demand for these opportunities is expected to increase, especially as the population of Melbourne and regional cities and towns grow (VEAC 2019). Residents and tourists currently pursue a wide range of recreational activities including nature observation, bushwalking, camping, four-wheel driving, trail bike and bicycle riding, hunting, prospecting, firewood collection, apiculture, dog walking, horse riding and attending car rallies. Many of these recreational uses are expected to continue in the Wombat Forest national park (e.g. bushwalking, hunting, DELWP 2021), while others (e.g. car rallies, firewood collecting, dog walking, firewood collecting and prospecting) may be constrained to the regional parks around the proposed national park (VEAC 2019). Recreational users are an important part of the social fabric that makes up the Wombat Forest, and they should form part of any consultation with broader partner groups.

1.4.5 Current development of the State Forest Management Planning Framework

Currently, the Victorian Government is developing a new approach to strategic planning for State forests: the 'State Forest Management Planning Framework (SFMPF)' (DEECA 2024). Given it deals with State Forest, this framework does not apply to the future Wombat-Lerderderg National Park. However, it deals with many of the same themes and issues, and is therefore highly relevant.

The SFMPF draws on many of the principles and ideas discussed above.

- It deals with multiple objectives, and is explicitly values-based. It sets out the relevant values under clear categories (healthy Country, culture and communities; Biodiversity; Human life and safety; historic heritage; livelihoods and economy; natural resources; community enjoyment). These values are complemented with an objectives hierarchy. We note that they are similar to those presented below for the Wombat forest.
- It seeks to foster decisions, which are evidence based, drawing on multiple sources and forms of knowledge.
- It recognises the importance of participation in decision-making as a key part of Aboriginal self-determination.
- It recognises the importance of clear governance, and it sets out the responsibilities of various agencies and partners.
- It recognises the importance of specific places, each with differing values and threats. It deals with this variation through a system of zones, where different activities are allowed or required. While it provides the logic for thinking about the needs of different places, it does not deal with any specific place.
- It seeks to be adaptive, to ensure that new information can be integrated into improved practices.

The current work seeks to be consistent with these principles of the SFMPF. It differs where necessary because it deals with future National Park rather than a State Forest. Importantly, the current work also differs from the SFMPF because it is about a specific place with specific values, needs and partners, rather than being a general state-wide framework.

1.5 An optimistic view to the future

Now is the time for change in the Wombat Forest. Now that commercial timber production has essentially ended, it is important to think beyond 'forestry', to include land management for multiple purposes, including biodiversity, and the promotion of healthy human culture and communities.

We must learn from past attempts at Community Forest Management. In that case, collaboration was attempted between groups with different pre-existing objectives (the government, the timber industry and conservation groups). Now that the fundamental dispute over logging practices is largely over, there is no reason to expect that partners cannot reach more lasting agreement on goals and objectives. Indeed, experiences in other countries show that success is possible. For example, in the Canadian Great Bear Rainforest Land Use Agreement, partner groups and First Nations people took leadership roles and worked together to propose solutions to forest management within a model centred on ecosystem-based management (Price et al. 2009; Moore and Tjornbo 2012). The collaborative process has persisted, and the

agreement was legalised in 2016 (final agreement signed and the Great Bear Rainforest Act introduced; Curran 2017; Henry et al. 2022).

The process of change is a process of management in itself. Just as there are many theories of forest management, so too are there many theories and models explaining how institutional and community change occurs, and how it can be managed (Kusel 2001; Lyon and Parkins 2013). Just as Adaptive Management can be used to manage natural resources, the adaptive cycle can also be used to help communities change and become stronger and more resilient (Emery and Flora 2006).

Here, after discussion with DEECA's Forest Management Planning group, we discuss one promising model of management for the Wombat Forest.

1.5.1 Active Forest Management: A possible way forward for the Wombat Forest

One recent model for the management of forest lands, that builds on many of the ideas developed in the Statement and RFAs, and many of the themes outlined above, is 'AFM' (described by Jackson et al. 2021). It may well provide a good template for management in the Wombat Forest.

AFM has three broad aims:

- Good on-ground land management, with clear goals set out for multiple objectives, including biodiversity and culture.
- Sustainable economic and management models (circular and renewable).
- Resilient and healthy forests, conceived as social and ecological systems, which support human communities, and are in turn sustained.

To achieve these broad aims, it sets out three key strategic areas:

- Governance models that are fair, genuinely collaborative, transparent, and monitored. They should bring together government agencies, First Nations people, western scientists, the private sector and civil society.
- Management that is active (bold and interventionist where it needs to be) and truly adaptive. This depends on the clear statement of goals (above) and meaningful monitoring and evaluation.
- The development of integrated knowledge systems, which allow management to be based on evidence that utilises the best technological and analytical capabilities, and which consider traditional and scientific knowledge. Such knowledge systems should be freely accessible to all partners.

This project represents one step in the shift towards this type of model. Specifically, it signifies the start of the process of partner consultation, and the collaborative development of clear goals that define a healthy Wombat Forest.

1.5.2 Applying Active Forest Management in the Wombat Forest

The implementation of AFM in the Wombat Forest could be a significant step toward enhancing multiple forest values and improving the health of the Wombat Forest. As the name suggests, AFM requires that people be engaged with the forest and that management actions are being implemented to improve the overall health of the Wombat Forest.

AFM was first designed for timber-production forests, but it can apply just as well to the safeguarding and management of cultural and ecological values; and is consistent with the participation of multiple engaged partner groups, each with their own aspirations and focus.

AFM can foster collaboration between agencies and First Nations people. Trust building is the first step in starting this process and addressing any past or potential future conflicts. By clearly documenting the values and objectives of the partners, we hope the current work will assist in developing trust.

Implementation of AFM at the Wombat Forest is likely to follow the following steps; or something similar:

1. Document and mutually understand the values and objectives for the Wombat Forest, as held by each partner group (this project, for those partners with management responsibilities).
2. Establish governance structure(s) that promote collaboration among all partners. The structure(s) should: (a) include representatives from government agencies, First Nations corporations, environmental organisations, and recreational users; (b) seek to balance the need for the autonomy

of different partners, and the need to work together; and (c) ensure that diverse perspectives are considered in decision-making processes.

3. Define models of resourcing, support, and responsibility that are practical, efficient and fair. These may include a diversity of arrangements, from the funded responsibilities of government agencies and Registered Aboriginal Parties, to the ability of First Nations (e.g. cultural and economic harvests) or members of the public (e.g. deer hunting) to extract resources from the forest.
4. Define which values should be monitored, and what techniques and protocols should be employed for each. This will require the use of a wide range of approaches to research, including ecological science and social research.
5. Establish a knowledge framework that makes it clear who are the custodians of different elements of knowledge and data, how this is best stored, how it may be shared or kept confidential, and how data should be analysed and published.
6. Generate a comprehensive baseline understanding of the status of the Wombat Forest. Effort should be focussed on the values of most importance to all partners (including those identified in this project). For those values that are physical aspects of the forest, it is important that they are measured across the spectrum of past land uses (i.e. areas degraded in different ways should be included).
7. Develop an Adaptive Management plan that accounts for the dynamic nature of the ecosystem and the evolving needs of all partners. This plan should define management targets for each key value, that are measurable, and consider relevant timelines and capture the desired direction of change. Aids for thinking about complex interactions could be incorporated (such as the use of state-and-transition models). It should be clear how the data will be analysed, and who is empowered to make adaptive changes to management. It should be co-owned by all of the key managers.
8. Implement the Adaptive Management plan, including on-ground management actions, monitoring to check on progress, updating of management actions and regular collaboration between all partners in accordance with the governance structures and knowledge framework noted above.
9. Engage with the public and local communities to foster a sense of ownership and stewardship for the Wombat Forest. Conduct educational programs and outreach initiatives to raise awareness about the importance of conservation and cultural values. This would include promoting sustainable recreational activities within the Wombat Forest.

2 Methods

2.1 Study area

This report deals with the proposed Wombat-Lerderderg National Park (49,553 ha) and Wombat Regional Park (13,789 ha) proposed by VEAC (2019; Figure 2). As noted above, it focusses on those areas that were once used for forestry.

2.2 Partner engagement to describe values, objectives, actions and consequences

2.2.1 Consultation

We engaged with the First Nations groups and management agencies who will co-manage the future parks (First Nations groups are currently collaborating with the State to develop a co-management model that will secure their future rights and aspirations; Table 1). Each First Nations group was consulted separately, while the various agency partners were engaged as a single group. We conducted two workshops for each group (i.e. eight workshops in total). Each was attended by an average of ~6 participants (Table 1). Workshop participants were experts in forest management and/or forest cultural practices.

The First Nations groups requested that the information they provided not be consolidated with other groups' values and objectives. We present the views of each First Nations groups separately throughout this report, except for the 'vision statement', where all partners agreed on a single statement (see 3.1.1 below). All workshops were facilitated by ARI (Figure 4).

Table 1. Representation from each partner group and the number of attendees at each workshop.

Partner group	Representative agencies	Workshop #1	Workshop #2	Overlapping attendees at both workshops
DJAARA	Dja Dja Wurrung Traditional Owner Aboriginal Corporation	4	4	3
Wadawurrung	Wadawurrung Traditional Owner Aboriginal Corporation	3	6	3
Wurundjeri	Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation	4	9*	3
Agency partners	Melbourne Water Parks Victoria Hepburn Shire Council Macedon Ranges Shire Council CFA Coliban Water North Central CMA Moorabool Shire Council	11	9	4

* Shortened workshop, no ranking of objectives or elicitation of actions.

2.2.2 Workshop 1: Values and objectives

The first workshop opened with an introductory exercise conducted in the forest, designed to encourage participants to use all their senses to perceive the forest surroundings, to think about what they valued in the forest; what was 'right' for a 'healthy forest', what (if anything) was 'not right' in the forest they were experiencing, and what they felt should change. Participants discussed their perceptions, the values they perceived at the site, and what they would like to experience if the forest was as healthy as it could be. We did not record any information from this informal exercise.

The first workshop then focussed on identifying the values held by the partners for the Wombat Forest, and appropriate objectives for management.

We define values as the things people care about, and objectives as descriptions of people's aspirations about those values.

As a starting point, we used the values and objectives already stated in the strategic documents published by each of the partner groups (e.g. Country Plans and other strategic documents), which identify biological (i.e. Healthy Country) and social (i.e. Healthy People) values and objectives held by each partner group across their Country or jurisdiction. We acknowledge that these documents represent a substantial and important body of prior work, but note that they apply to larger areas than the Wombat Forest. We displayed these values and objectives and asked the participants to consider the following:

- What are specific examples of how these values and objectives apply in the case of the Wombat Forest? (e.g. places, species, practices)
- Are there any listed values or objectives that don't apply to the Wombat Forest?
- Are there any values or objectives that are not listed in the documents, but which are relevant to the Wombat Forest?

Participants were given the freedom to consider values and objectives, which could be place-based, species-based, region-wide, or applicable to human communities. Participants could consider strategic, fundamental, means, and process objectives, but were not instructed to identify the objective type, because it can be difficult to disentangle means from fundamental objectives in a workshop context (Runge and Walshe 2014). We prioritised the free flow of ideas in the time allocated to workshops, rather than a detailed classification of objectives. We discussed which objectives were nested subsets of other, broader objectives, and arranged them into a 3-level objectives hierarchy (Level 1 overarching objectives, Level 2 intermediate objectives, Level 3 detailed and specific objectives) for each group, consisting of 50–70 nested objectives. This was done partly in the workshop, and partly out of session by the project team. After the first workshop, all participants were given an opportunity to comment on the objectives hierarchy produced for their organisations, and to consult with people within their organisation who were unable to attend the workshop. They were asked to review, make edits, or redact any sensitive information. We incorporated these changes into all subsequent representation of the objectives hierarchy. Once all groups' hierarchies were finalised, we tabulated them together, showing instances where the same objectives emerged from different groups, but keeping each group's responses separate (Appendix 2).

Figure 4. Elicitation workshop with agency partners facilitated by Khorloo Batpurev.

2.2.3 Workshop 2: From objectives to actions and consequences

The second workshop focussed on: (i) scoring the relative importance of a subset of high-order objectives, (ii) identifying a suite of actions that partners believe will realise the objectives over the next 10–20 years, and (iii) quantifying the likely benefit (or harm) attributable to each of these target actions on the target objectives.

To this end, individuals were asked to consider the objectives for their group, and rank their importance (1 to *n* for *n* objectives). We used the 'level 2' objectives from Workshop 1. In some cases, it was agreed in the workshop to include a Level 1 objective in this process, The ranks from all participants were averaged for each objective (i.e. with equal weight for every person), and the results presented back to the participants in the workshop, who were asked to consider and discuss the results as a group, and make any changes if necessary. No groups opted to change the rankings.

We then elicited desirable management actions. We asked the partners to look over the objectives hierarchy (Workshop 1) and define actions that would help realise the objectives. We also displayed and considered any management actions that were mentioned during Workshop 1. Importantly, management actions were conceived broadly, and could include on-ground actions (e.g. weed control), but also administrative or social actions (e.g. education).

All actions were elicited and discussed as a group. Several very broad or 'higher-level' actions that did not relate closely to the particular case of the Wombat Forest (e.g. 'combat climate change', 'seek funding for organisation') were removed from consideration. Although actions could be arranged into a hierarchy like objectives (e.g. 'Produce fact sheets' and 'conduct tours' could be arranged under 'Education'), we decided to produce only a single-tiered list for each group.

Once the action list was defined, we considered the consequences that each action would have on each objective, over a period of 10–20 years of appropriate and competent application. This was done via group discussion. We concede that open consensus processes can be susceptible to bias, power dynamics, pressure to conform and groupthink (Singh et al. 2017); but this approach was preferred by the partners, and was applied consistently across all partner groups we engaged with. We did not provide any background data to the partners, other than regional maps to guide discussion. We relied on the knowledge and judgements of the partners in our workshops. We prompted discussion and encouraged all participants to give their judgements.

We quantified the likely consequences on a 7-point scale ranging from -3 (very negative consequences), through 0 (no impact, or net impact judged to be neutral) to +3 (very positive consequences). Upper and lower bounds (on the same scale) could also be included to represent uncertainty due to a lack of knowledge, and/or disagreement between participants. When uncertainty is present, we assume the best estimate occurs at the mid-point of the interval (i.e. error distribution follows a normal distribution). We also allowed the partners to record 'consequences not known', in cases where no participant was able to make a meaningful prediction. This was treated in our analysis as if no response was recorded.

Where possible, each combination of an objective and an action were scored. Where time was constrained, the partners were asked to focus on judgements pairing (i) land management actions and Healthy Country objectives, and (ii) administrative actions and Healthy People objectives, as these combinations were deemed most likely to produce substantial positive consequences (i.e. we assumed that tree density is more likely to be affected strongly and clearly by on-ground actions such as thinning or fire, rather than by administrative actions such as education or governance).

Ranking of objectives or elicitation of actions was not completed for Wurundjeri, because the workshop time available was less than for other groups.

To identify the most important knowledge gaps, we took those objectives that ranked highly, and had wide uncertainty for the consequences of actions.

2.2.4 Site visits to case study locations

Some partners communicated to us that the indoor location of Workshops 1 and 2 had limited the discussion, and that being 'in the bush' or 'on Country' would be less abstract, and would prompt new ideas to emerge and better enable specific examples to be discussed on site while looking at the issues. We agreed, and in response, we met with some of the partners at a series of case study sites for further discussion (Parks Victoria, DJAARA, Wadawurrung).

Partners were asked to nominate sites that they knew demonstrated something they wished to discuss (value, legacy, threat, management action, form of degradation or monitoring approach). If sites were

nominated, we visited them. In some cases, groups did not nominate sites, so ARI located sites that exemplified common issues for the Wombat Forest, and these were visited.

At each site, the partners led a free-ranging discussion. In a small number of cases, new objectives emerged from these discussions, and these were added to the outputs of Workshop 1. These additions were all at the lower levels of the hierarchy (i.e. details), and so did not affect the outcomes of the exercises in Workshop 2.

We documented these field discussions and present them as a series of case studies below. Their purpose is to demonstrate how the listed values, objectives and actions apply in specific instances.

2.2.5 Creation of a vision statement and consolidated objectives hierarchy

Following consultation, we took the information in the objectives hierarchies, and synthesised it into a single 'vision statement' that encapsulated the collective vision for the future of the Wombat Forest. We circulated this statement to the partners and modified it until all agreed that it represented their values and aspirations.

2.3 Understanding the current condition of the Wombat Forest

The ARI project team was initially asked to provide an overview of the current condition of the Wombat Forest, including a mapped representation of how conditions varied across the forest, based on the values we elicited from the partners. It soon become clear that most values were not well-enough defined or understood to allow us to quantify and map them. Instead, it was decided, to focus more on the elicitation of values, actions and consequences (described above), and represent condition much more simply, via a series of narratives applied to areas within the forest that had experienced a certain land-use history.

2.3.1 Spatial stratification to determine the extent of different land-use history scenarios

We conducted a spatial stratification of Wombat Forest's vegetation that summarised different combinations of underlying ecological differences, and past land use and disturbance history. We intended the results to guide:

- our discussion of current forest values and condition
- the distribution of future forest monitoring efforts.

We combined five spatial layers to create the strata (Table 2), using ArcGIS (ESRI). The resultant combinations should reveal the extent of each combination of land use (and hence impact and degradation).

Table 3 summarises the most extensive land-use history combinations.

Table 2. Details of the layers used to create the spatial stratification.

Layer name	Source	Purpose	Value range
Broad habitat types	State-wide Habitat Condition (ARI)	To describe forest structure broadly	1=Wet Mountain Forest 2=Damp Foothill Forest 3=Dry Foothill Forest 4=Wooded Plains 5=Grassland
Last logged	State-wide Habitat Condition (ARI)	To account for past logging-related disturbances	Continuous values between year 1965 to 2012
Last burnt	State-wide Habitat Condition (ARI)	To account for past bushfire-related disturbances and changes	Continuous values between year 1962 to 2020
Storm damage	Remotely sensed data (DEECA)	To account for storm-related damages and disturbances	0=not damaged 1=storm damage (all intensity categories)
Registered Aboriginal Party (RAP) boundary	RAP layer available on CDSL	To identify the First Nations group	1=Wadawurrung 2=DJAARA 3=Wurundjeri
VEAC Park	VEAC recommendation; Corporate layer published on CDSL	To delineate future conservation areas from other crown land	1=Conservation areas 2=Regional parks and other crown land

Table 3. The most widespread land-use history units in the Wombat Forest, based on 2023 spatial layers of disturbance, specific to each First Nations group.

Only those strata covering >1% of the area are shown. Narratives (#) relate to those descriptions in Section 3.2.1 below.

Location on Country of scenario described	Most recent logging	Most recent fire	Storm damage	Percent of study area	Represented as a 'narrative' in results
Wurundjeri	None recorded	5–20 years	None	27	Yes (#1)
Wurundjeri	None recorded	20–50 years	None	23	Yes (#2)
Wurundjeri	None recorded	None recorded	None	8	Yes (#2)
Dja Dja Wurrung	None recorded	5–20 years	None	5	Yes (#1)
Dja Dja Wurrung	None recorded	20–50 years	None	5	
Dja Dja Wurrung	None recorded	None recorded	None	3	Yes (#2)
Dja Dja Wurrung	> 50 years	5–20 years	None	3	Yes (#1)
Wurundjeri	> 50 years	20–50 years	None	2	
Wurundjeri	> 50 years	None recorded	None	2	Yes (#2)
Wurundjeri	> 50 years	5–20 years	None	2	Yes (#1)
Dja Dja Wurrung	40–50 years	5–20 years	None	1	Yes (#1)
Wurundjeri	< 20 years	20–50 years	None	1	Yes (#4)

From field visits and examination of aerial imagery, we believe that the ‘Last logged’ layer significantly under-represents the extent of past logging. Across the study area, including the current Lerderderg State Park (which has long been un-logged), the data suggest that 76% of the forest has no logging at all, only 6% was logged between 1965 and 1980, and only 5% between 1980 and 2000, and 5% since 2000. This is clearly inconsistent with our field observations. Consequently, we do not show the data as a map, to avoid potential confusion.

2.3.2 Narratives to describe current conditions

In lieu of a spatial condition assessment, we took some of the more common land-use history scenarios, and considered the ways in which their histories have impacted the way partners value this land today. These are presented as short narratives designed to give a sense of how, where and to what general extent the values have been impacted across the study area.

3 Results

3.1 The values and objectives of partners

3.1.1 Vision statement and high-level objectives

The vision statement below (Figure 5) emerged from our workshops and site visits with partners.

Beneath it, we show the highest level (Level 1) in the objectives hierarchy, which describes the values (paraphrased for brevity) shared by the partners, and which collectively reveal a shared vision that is broad and varied.

All groups agreed that it was useful to distinguish ‘Healthy Country’ values (things about the bush) and ‘Healthy People’ values (things about our human communities) for the sake of this project. Nonetheless, all groups emphasised the links and inter-dependencies between Country and people, and that neither can be considered alone.

Within these values, each partner group had different specific interests and priorities (expressed as different Level 2 objectives). This nuance is explored in detail in the sections below. Table A2.1 presents the full objectives hierarchy elicited from each partner group.

Figure 5. Vision and values (simplified from objectives in Appendix 2) for a healthy Wombat Forest.

3.1.2 Objective ranking

Each partner group considered the many Level 2 objectives expressed by their own group, selected the top 13–16 that were most important, and then ranked their importance (Wurundjeri did not conduct this exercise).

Although different, there were many commonalities in the rankings: more than half (56%) of the many objectives were selected and ranked by at least two partner groups (Table 4). Healthy Country objectives had more alignment between partners than Healthy People objectives. This suggests that there is strong agreement regarding aspirations for the forest itself, but that each group has its own cultural and social concerns.

'Traditional knowledge and heritage is protected and continued' was the most important objective for DJAARA and Wadawurrung. Conversely, agency partners identified 'Vegetation structure is healthy' as the most important objective for a healthy Wombat Forest.

Based on the two highest ranked objectives, DJAARA considered Healthy People objectives as most important. Conversely, agency partners considered Healthy Country objectives as most important (Table 4). Whereas Wadawurrung included both Healthy Country and Healthy People objectives in the two highest ranked objectives (Table 4). All partner groups that conducted the elicitation ranked a broad range of objectives that captured the following themes: (1) the health of waterways, vegetation structure and soils; (2) the abundance and diversity of flora and fauna; (3) weeds and pests in the forest; (4) generating, disseminating and storing information; and (5) cultural principles (Table 4).

Table 4. Ranked high-level objectives and values from the objectives hierarchy (Appendix 1) for each partner group (1 is the highest ranking). The colour of the text definitions distinguishes Country values (Orange) from People values (Blue). The colour ramp reflects the ranking for each partner group. Ranking of objectives or elicitation of actions was not completed for Wurundjeri, because the workshop time available was less than for other groups. TO – Traditional Owner.

Objective	Value (used in figures for brevity)	DJAARA	Wadawurrung	Agency
[P] Traditional knowledge and heritage is protected and continued	Knowledge (TOs)	1	1	
[C] Vegetation structure is healthy	Vegetation structure	5	8	1
[C] Waterways are protected and healthy	Waterways	7	2	3
[C] Native plant species richness and abundance is increasing	Native flora	12	9	2
[P] Traditional Owners are economically empowered	Jobs and economy (TOs)	2	12	
[C] Soil is protected and healthy	Soil	10	3	6
[C] Cultural landforms are protected and healthy	Cultural landforms	3		
[P] Traditional Owners are on Country regularly	TOs on Country	4		
[P] Cultural rights are practised on Country regularly	Cultural rights		4	
[C] Native fauna species richness and abundance is increasing	Native fauna			4
[C] Abundance of culturally significant fauna species is stable and increasing	Cultural fauna	8	5	
[P] Stewardship by the community increases	Community stewardship			5
[C] Culturally significant flora are stable and increasing	Cultural flora	6	6	7
[C] Forest is free of invasive plant species	Weed free	11	7	14
[C] Rare and threatened flora are stable and increasing	Rare native flora			8
[P] Information (new and old) is held, shared and updated appropriately	Knowledge (general)	9	13	15
[C] Native fungi species richness and abundance are increasing	Native fungi		14	9
[C] Forest is free of pest animals	Pest free	13	10	13
[P] Traditional culture is healthy	Knowledge (TOs)			10
[P] Forest resources benefit First Nations People	Resources (TOs)		11	11
[P] Forest provides job and opportunities	Jobs and economy (general)			12
[P] Recreational opportunities promote healthy people and Country	Recreation		15	
[P] Forest use and management is safe	Forest safety			16

[P] Healthy People values
[C] Healthy Country value

3.1.3 Actions

Partners identified on-ground and administrative actions that would likely realise the objectives of the Wombat Forest (Wurundjeri did not complete this exercise). Table 5 summarises the results. On-ground actions were similar across the partners and incorporated Traditional and western approaches to forest management. The planned use of fire (as a cultural action, for ecological benefits and/or for fire risk mitigation) was prominent. The partners also included weed control, pest control, species reintroduction, thinning and managing waterways (Table 5). All three partner groups identified educating the general public about the forest values and their management as an important action (Table 5).

Table 5. List of actions identified by the partners partitioned according to action type (on-ground actions and administrative actions). Ranking of objectives or elicitation of actions was not completed for Wurundjeri, because the workshop time available was less than for other groups.

Action	Action (shortened for figures)	DJAARA	Wadawurrung	Agency
On-ground actions				
Apply cultural/Traditional burning	Cultural burning	✓	✓	✓
Apply cultural flows	Cultural flows	✓	✓	
Apply cultural thinning	Cultural thinning	✓	✓	✓
Apply fuel reduction burning	Fuel reduction burning			✓
Conduct ecological restoration	Restoration		✓	
Conduct pest animal control	Pest animal control	✓	✓	✓
Conduct revegetation	Revegetation	✓		
Conduct weed control	Weed control	✓	✓	✓
Control soil erosion	Erosion control		✓	
Create tree hollows	Create tree hollows			✓
Manage waterways^	Waterways management^			✓
Protect old trees	Protect old trees			✓
Reintroduce absent native fauna	Reintroduction	✓	✓	✓
Remove mining contamination	Remove mining contamination	✓		
Remove waterway barriers	Remove waterway barriers	✓		
Administrative actions				
Conduct cultural tourism	Cultural tourism	✓	✓	
Create safe places for Traditional culture	Safe places for cultural practices		✓	
Document cultural values	Document cultural values		✓	
Educate general public	Educate general public	✓	✓	✓
Increase landholder partnerships	Increase landholder partnerships			✓
Practice cultural rights	Cultural rights practiced	✓		
Reserve culturally significant places	Reserve culturally significant places	✓	✓	

^ A broad action that generally relates to flow control, but could also incorporate other actions if applied strictly to waterways (e.g. revegetation, erosion control, remove waterway barriers, weed control).

3.1.4 The likely consequences of actions on objectives

Partners assessed the likely consequences of actions on a suite of values. All participating partner groups provided a relatively high level of certainty for their predictions (i.e. uncertainty range ≤1) for most of the elicitations provided (DJAARA 91%, Agency 84% and Wadawurrung 83%). Each partner group identified five actions that they expected to have strong benefit for all of the top-three ranked objectives (Table 6). While there was very little overlap between partner groups for most actions, weed control was identified as a beneficial action for at least one of the top-three ranked objectives for the partners (Table 6). DJAARA and agency partners identified five actions that are expected to have strong benefit for most objectives (≥ 80%), with thinning the only action identified across both groups.

Below, we present the results graphically, for each of the three partner groups that undertook this exercise. Each graph shows the selected objectives (vertical; written as values that align with Table 4, for brevity), set against the proposed actions (horizontal; ordered alphabetically). The coloured cells record the anticipated outcome of each action on each objective (from highly positive to highly negative). We present two graphs for each group – one representing the most positive anticipated outcome (upper), and the other the most negative (lower).

Table 6. Actions with strong benefit for either all top-three ranked objectives or most objectives for each partner group (benefit relates to upper end of uncertainty range; strong benefit equates to score of +3 in the elicitation). Ranking of objectives or elicitation of actions was not completed for Wurundjeri, because the workshop time available was less than for other groups.

	DJAARA	Wadawurrung	Agency
Actions with strong benefit for top-three ranked objectives			
Cultural rights practiced	✓		
Cultural thinning			✓
Cultural tourism	✓		
Erosion control		✓	
Fuel reduction burning			✓
Educate general public	✓		
Pest animal control		✓	
Protect old trees			✓
Reserve culturally significant places		✓	
Revegetation	✓		
Safe places for cultural practices		✓	
Waterways management			✓
Weed control	✓	✓	✓
Actions with strong benefit for most (≥ 80%) objectives			
Cultural burning			✓
Cultural rights practiced	✓		
Cultural thinning	✓		✓
Cultural tourism	✓		
Fuel reduction burning			✓
Educate general public	✓		
Protect old trees			✓
Revegetation	✓		
Tree hollow creation			✓^

^ Only affects a subset of values related to native fauna

DJAARA

DJAARA identified five actions ('Cultural rights practiced', 'Cultural thinning', 'Cultural tourism', 'General public informed and educated' and 'Revegetation') that are expected to have strong benefit (i.e. +3) for many of the objectives they were elicited against (Table 6; Figure A3.1, Figure A3.2). 'Cultural rights practiced' was the only action that is expected to have strong benefit with very high certainty across all the objectives in the elicitation (Figure A3.2).

Several actions ('Cultural rights practiced', 'Cultural tourism', 'General public informed and educated', 'Revegetation' and 'Weed control') are expected to have strong benefit for the top three ranked objectives (Traditional knowledge and heritage is protected and continued, Traditional Owners are economically empowered, and Cultural landforms are protected and healthy; Table 6; Figures A3.1, A3.2).

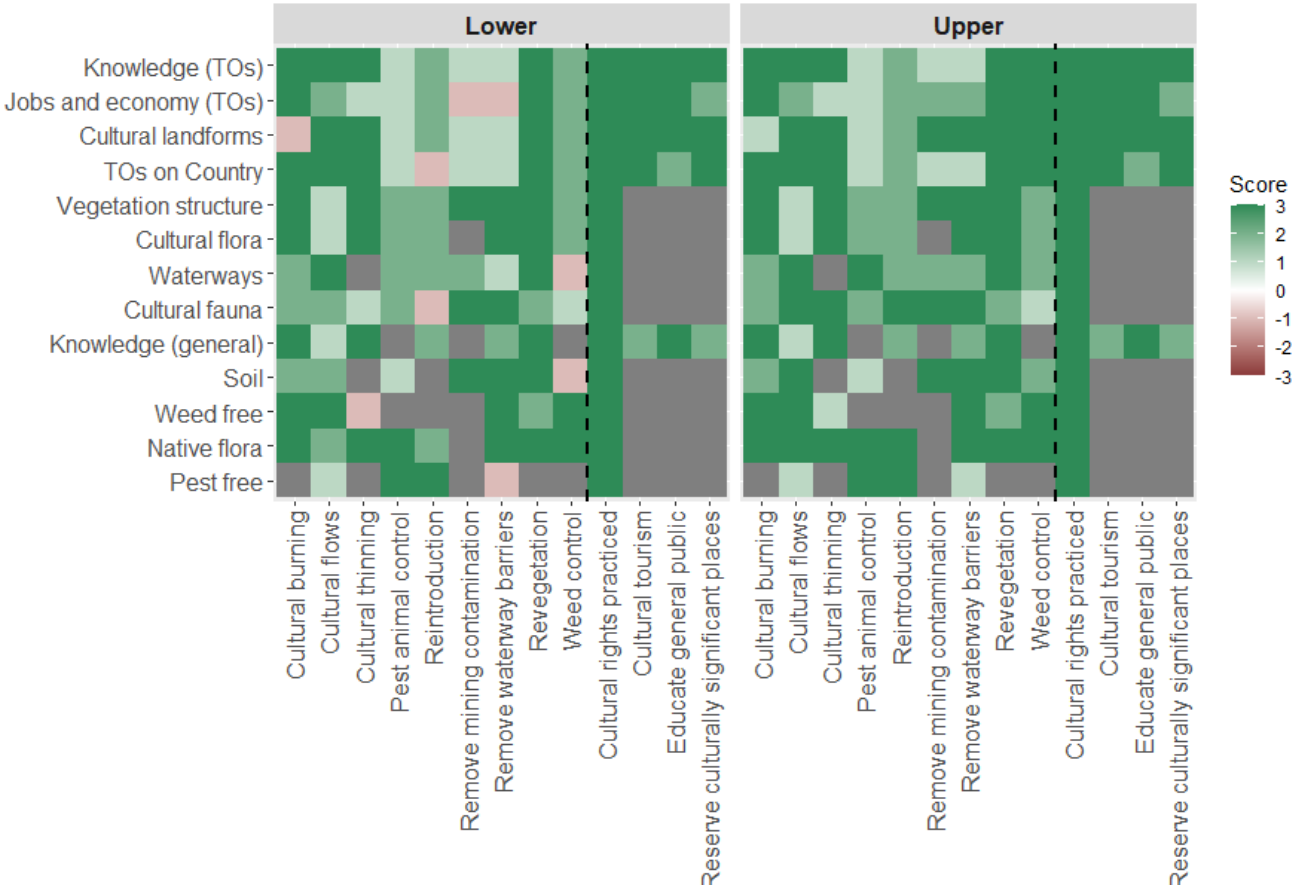

Figure 6. DJAARA elicitation of objectives (Y axis; written as values for brevity; see Table 4) and actions (X axis) displaying lower (left pane) and upper (right pane) end of the uncertainty range. Positive scores indicate benefit, negative scores indicate harm of the action for each objective. +3 indicates strong benefit, -3 indicates strong harm and 0 means neutral (neither beneficial nor harmful). Grey areas not elicited. Vertical dashed line demarcates on-ground actions (to the left) and administrative actions (to the right). TO – Traditional Owner.

Wadawurrung

Two actions ('Cultural burning' and 'Weed control') are expected to have strong benefit (i.e. +3) for more than half of the objectives (Figure A3.3). 'Cultural burning' was identified as less beneficial to objectives related to pest animals and recreation (Figure A3.3).

'Cultural thinning' impacts objectives in different ways. For instance, culturally significant flora and vegetation structure are expected to strongly benefit from cultural thinning with a high level of certainty, while Traditional knowledge and heritage are protected and continued (the top ranked objective), culturally significant fauna and the prevalence of weeds and pest animals could be benefitted or harmed by this action (Figure 7).

Wadawurrung identified several actions ('Erosion control', 'Culturally significant places reserved', 'Pest animal control', 'Safe places for cultural practices' and 'Weed control') that are expected to have strong benefit for the top three ranked objectives (Traditional knowledge and heritage is protected and continued, Waterways are protected and healthy, and Cultural landforms are protected and healthy; Table 6; Figures A3.3, A3.4).

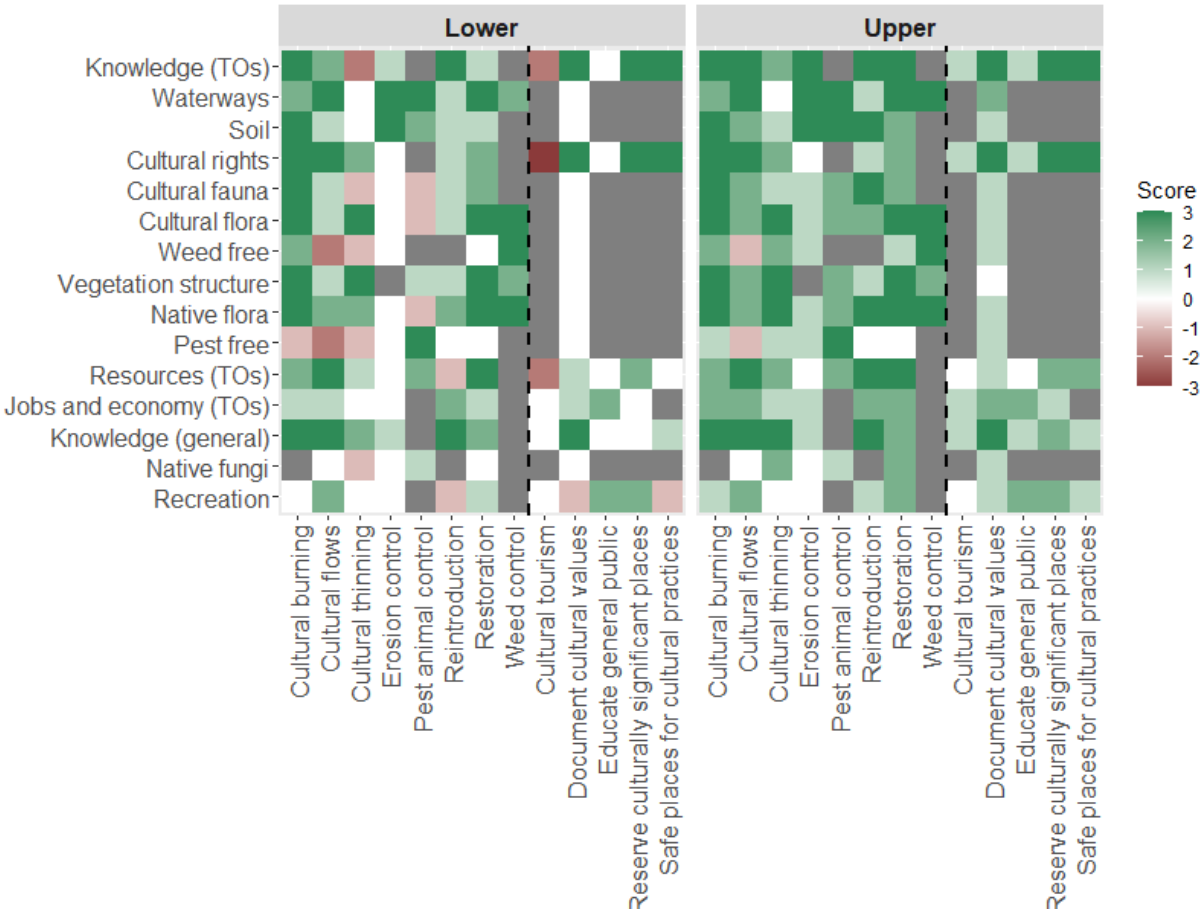

Figure 7. Wadawurrung elicitation of objectives (Y axis; written as values for brevity; see Table 4) and actions (X axis) displaying lower (left pane) and upper (right pane) end of the uncertainty range. Positive scores indicate benefit, negative scores indicate harm of the action for each objective. +3 indicates strong benefit, -3 indicates strong harm and 0 means neutral (neither beneficial nor harmful). Grey areas not elicited. Vertical dashed line demarcates on-ground actions (to the left) and administrative actions (to the right). TO – Traditional Owner.

Agency

Agency partners identified three actions ('Cultural burning', 'Cultural thinning', and 'Protect old trees') that are expected to have strong benefit (i.e. +3) for many the objectives (with minimal uncertainty; Figure A3.5). The benefit of 'Tree hollow creation' is only expected for objectives related to fauna and culturally significant flora, while all other objectives are expected to be unaffected by the action (Figure A3.5).

Agency partners identified several actions ('Cultural thinning', 'Fuel reduction burning', 'Protect old trees', 'Waterways management' and 'Weed control') that are expected to have strong benefit for the top three ranked objectives (Vegetation structure is healthy, Native plant richness and abundance is increasing, and Waterways are protected and healthy; Figures A3.5, A3.6). While the perceived benefit to an objective was certain for most actions, the impact of Fuel reduction burning spanned the entire uncertainty range for all objectives that were elicited on (Figures 8).

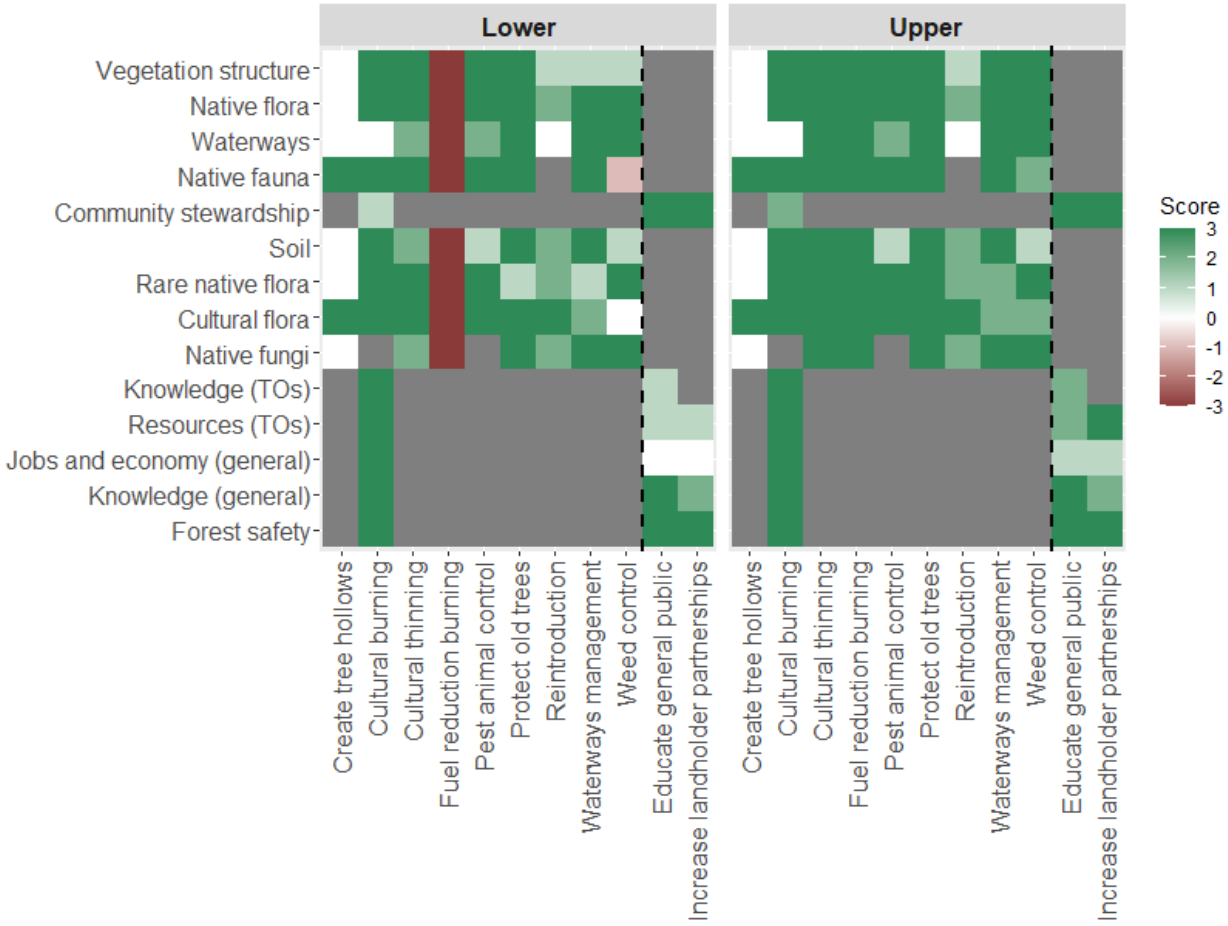

Figure 8. Agency elicitation of objectives (Y axis; written as values for brevity; see Table 4) and actions (X axis) displaying lower (left pane) and upper (right pane) end of the uncertainty range. Positive scores indicate benefit, negative scores indicate harm of the action for each objective. +3 indicates strong benefit, -3 indicates strong harm and 0 means neutral (neither beneficial nor harmful). Grey areas not elicited. Vertical dashed line demarcates on-ground actions (to the left) and administrative actions (to the right). TO – Traditional Owner.

3.2 Overview of forest health: Values and landscape history

For an efficient program of management and monitoring, managers need to understand the current spatial patterns of 'health'. We do not currently have the data to address this in any detail. However,

to provide a preliminary picture of how health varies across the forest, we have considered the ways in which some of the major threats and impacts have acted across the Wombat Forest:

- The fire history data recorded extensive fires (e.g. in 1983), and show a wide range of burning histories across the forest. The most recent fire was within 5 years for 2% of the forest, 5–10 years ago for 17% of the forest, 10–20 years ago for 27%, 20–40 years ago for 34% of the forest, and greater than 40 years ago for 20% of the forest.
- Storm damage in 2021 covered slightly less than 0.5% of the study area.
- The logging history data available to us revealed that 76% of the forest had no logging recorded, 6% was logged between 1965 and 1980, 5% between 1980 and 2000, and 5% since 2000. As noted in our Methods, we believe this is inaccurate, and that far more of the forest has been logged in recent decades.
- Several other major disturbances are not covered by spatial data. These include the legacies of mining, and invasion of introduced species (but see Appendix 1 for a preliminary assessment of plant invasion status and a watchlist of high risk species).

The patterns of overlap among these disturbances allow us to delineate portions of the landscape ('strata') with common disturbance histories. Below we describe a few of these strata, providing a brief narrative for each that describes how the documented disturbance history is likely to have affected the values (underlined).

The information presented here is gleaned from the elicitation with the partners, our field visits to case study sites (see below), and from the literature. It is important to note that the brief narratives presented below cover only some of the more widespread issues. Their coverage is not comprehensive. What is presented below remains preliminary and imperfect and should be treated as a starting point that can be checked and tracked by monitoring. We recommend that this information be used to help position and prioritise monitoring efforts for each of the values.

3.2.1 Narratives

The forest areas described below correspond to the major disturbances that are widespread and visible. It is important to note that many of the threats and land-use legacies affecting the Wombat Forest are highly localised and idiosyncratic (e.g. damage from tracks), not well mapped (e.g. degradation by weeds), not clearly visible (e.g. pathogens, invertebrate or fungal communities), or may affect the whole socio-economic system, and not be amenable to summary via spatial stratification. The latter are particularly important and pervasive, and include a range of social and economic factors, such as the long-term exclusion of First Nations people from the forest.

1. Country burnt 5–20 years ago, without recent logging (within past 20 years) or storm damage

The spatial analysis suggested that such areas are very widespread on Wurundjeri and Dja Dja Wurrung Country; however, field observation suggests that many such areas have also been logged, and so it is likely that these areas are in fact rare in the landscape.

Reasonably recently burnt areas without recent logging or storm damage are among the most intact in the Wombat Forest. They are characterised by a relatively heterogeneous Vegetation structure, with a mix of small and moderate sized Eucalypt trees, with occasional larger trees bearing hollows that are used by Native fauna. In some places, mid-storey species such as Blackwood (*Acacia melanoxylon*) occur. Given the time that has elapsed since fire, these areas of forest are adolescent or mature with respect to their post-fire under- and mid-storey growth (Cheal 2010). Canopy cover is high, and many of the shrubs that germinate or re-shoot after fire are mature, flowering and seeding, and actively adding to the seed bank. Coarse woody debris are often present, having accumulated after fire, providing habitat for Native fauna. Waterways within or near these areas are likely to be relatively intact. Soils and Cultural landforms such as artifact scatters and scar trees are present in many places. These will require assessment.

2. Country without recent fire (within the past 20 years), logging (within the past 20 years) or storm damage

Like those above, these areas are likely rare in the Wombat Forest (even though the spatial data suggests they are quite common, i.e. 11% forest area; Table 3). They are characterised by a mix of small and moderate-sized Eucalypt trees, with occasional larger trees bearing hollows that are used by Native fauna. In places, mid-storey species such as Blackwood occur. Given the long time that has elapsed since fire, these areas of forest are likely to be in a state of 'stasis' or even 'senescence', with characteristic understorey Vegetation structure (Cheal 2010). Shrub cover is likely to be low, with many shrubs having retreated to a soil seedbank post fire. Grasses may be common in places where there is sufficient light for them to prosper. Litter and debris are likely to be abundant and deep, and being actively incorporated into the Soil. Coarse woody debris is often present, having accumulated since fire, providing habitat for Native fauna. Waterways within or near these areas are likely to be relatively intact. Soils and Cultural landforms, such as artifact scatters and scar trees, are present in many places. These will require assessment. Case study site 1 corresponds to this type.

3. Storm damaged forest country

The area of this stratum is small, ~ 0.5% across the entire forest. These areas are characterised by recent tree falls from storm-winds, which occurred in 2021. The Vegetation structure is now poor, with a discontinuous tree canopy and large spaces between trees, a lack of large old trees, and large quantities of logs on the forest floor. Waterways nearby may be impacted by increased sediment flows, as a result of soil disturbance from uprooted trees. Native plant species richness is likely to be high, and may even have been elevated by soil disturbance and canopy gaps. Cultural landforms, such as artifact scatters and scar trees, may have been damaged by tree fall, or may remain intact among the fallen trees. These will require assessment. Some Native fauna may be in decline due to a loss of tree hollows and canopy cover (Cally et al. 2023), while other animals may be benefitting from increased log and litter cover. Some Invasive plant species are likely to have increased, especially those species able to disperse widely and rapidly, and to take advantage of newly-available resources due to the tree fall (e.g. thistles). Some Rare or threatened flora may have been impacted by the storm damage, but others may have benefitted, including those species with a long-lived seed bank that may be stimulated by disturbance, such as Wombat Bush-Pea.

Some of the storm damaged areas have been made available for domestic timber collection. In these areas, soil compaction and the patchy accumulation of saw dust and litter have further impacted the understorey. Some other storm damaged areas have been subject to salvage logging, which has resulted in reduced densities of logs, but more soil disturbance.

4. Recently (within the past 20 years) logged forest country

These areas occur extensively in the current Wombat State Forest, across Dja Dja Wurrung, Wadawurrung, and Wurundjeri Woi Wurrung Country. They are one of the most extensive impact types, although the forest harvest data we accessed are incomplete (only 12% of the total area apparently fits this type), and it is difficult to quantify its extent precisely.

This impact type is characterised by its Vegetation structure, with densely-packed, even-aged trees with relatively small trunks. Beneath these, the vegetation is sparse, dominated by species tolerant of past disturbance, shade and high competition from the trees. The most common species include Bracken (*Pteridium esculentum*) and Common Tussock Grass (*Poa sieberiana*). The Soil is likely compacted and modified by logging operations (Bowd et al. 2019), and the forest floor is usually covered by a thick layer of leaf litter. Native plant species richness and cover is low, although many species persist at low abundance, and some species may persist in the seed bank. Some Cultural landforms, such as scar trees, may have been removed or damaged by past logging, but other cultural aspects, such as artefact scatters, may remain partially intact.

5. Previously mine-affected and recently (within past 20 years) logged forest country

Areas of intense mining activity from the 19th century gold rush are scattered across the Wombat Forest. Many remain un-mapped. These areas are characterised by extensive Soil disturbance and compaction to the extent than many such sites can be described without exaggeration as 'upside-down country' (Kellas et al. 1988). Evidence remains of shafts, tunnels, waste heaps, aqueducts, stream diversions, puddling areas and subsequent gully erosion. The Soils and Waterways may be unstable and subject to erosion (Rab 1994; Shakesby et al. 2007) and affected by contaminants left over from mining operations, particularly arsenic and mercury (Abraham et al. 2018). Mining sites were generally cleared of timber, and many were subsequently logged; adversely affecting Vegetation structure and Native fauna habitat, even a century or more after mining ceased. Most now support small, poorly-formed trees, and a depauperate understorey similar to recently logged country (above). Many Cultural landforms have been destroyed, degraded or displaced.

3.3 Case studies

We conducted a series of field days on Country, one with each partner group, to discuss forest values, objectives and management. In some cases, these days enabled the partners to share the depth of their local knowledge and the complexity of the issues confronting the forest. In other cases, they enabled partners who lacked direct experience in some areas of the forest to gain a greater appreciation of the variety of forest types in the Wombat Forest and build on the knowledge generated in the workshops.

We visited sites that captured a wide variety of management histories and forest health issues, as described above. At each site, we discussed values, objectives, threats and potential monitoring and management approaches. We documented these discussions, and present them below. Our purpose is to demonstrate how the objectives and actions we describe above apply in specific places with complex histories and needs.

Case study 1: Forest springs, Korweinguboora, Wadawurrung Country

Partner visitors:

- Parks Victoria
- Wadawurrung Traditional Owners Aboriginal Corporation

Site description:

- Herb-rich foothill forest, selectively logged in the past, with scattered large old trees retained.
- Diverse grassy understorey.
- Network of spring-fed soaks containing *Sphagnum* moss and large sedges, shaded by stands of Blackwood (*Acacia melanoxylon*) (Figure 9).

Figure 9. Photographs taken from the case study site showing vegetation structure, old trees, Sphagnum moss, floristic diversity (pictured *Almaleea subumbellata* and *Pterostylis melagramma*) and point-intercept monitoring.

Partner reactions:

"The site is calling us" (Wadawurrung representative).

"Hugely important site ecologically…. a special place" (Parks Victoria partner).

Prominent values and objectives noted by partners:

Wadawurrung and Parks Victoria partners noted the diverse and abundant bird fauna with complex song-scape (i.e. bird calls), along with healthy mature trees.

Wadawurrung – The understorey vegetation is diverse. Many species present offer resources such as fibre (particularly the large sedge and Mat-rush species; *Lomandra longifolia*, *Gahnia sieberiana*), and are important for practicing and teaching culture. The spring-soak areas beneath large Blackwood trees provided important cultural values. As well as being sources of water, they are shady and welcoming places for people to congregate.

Parks Victoria – Mature Blackwood provide important resources to fauna. The spring-soak area provides important ecological values and functions.

Threats and degradation noted by partners:

Wadawurrung –The volume of coarse woody debris adjacent to site (partly caused by minor storm damage) poses a fire threat to sensitive spring-soak. Climate change and reduced rainfall may threaten the hydrology of the spring-soak. The volume of small trees is excessive, suppressing the understorey, and diminishing the appearance of, and visibility through, the forest.

Parks Victoria – Climate change and reduced rainfall may threaten the hydrology of the spring-soak. Weeds (Blackberry and Pine wildlings) and pest animals (e.g. deer and pigs) threaten the site, particularly the sensitive Sphagnum beds. Firewood collection and Phytophthora present risks to the vegetation. The volume of coarse woody debris (partly caused by minor storm damage) is excessive and a fire hazard. Forest fragmentation by nearby pine plantations potentially hampers forest processes.

Actions noted by partners:

Wadawurrung – Cultural burning away from the soaks to protect the soaks and clean up the understorey. Cultural thinning of some small Eucalypt trees to open the site and protect old trees via reduced competition. Coarse woody debris removal to avoid burn hotspots and allow cultural burning to take place.

Parks Victoria – Burning (cultural ideally). Seed collection for reintroduction to other sites. Weed and pest control and/or protective fencing.

Suggestions for monitoring:

Wadawurrung – Acoustic monitoring to monitor fauna (birds, frogs etc.). Accurate monitoring of plant species cover (preferably using methods such as point-intercept plots), to track change in understorey (native and exotic) and ground cover. Drone imagery to map vegetation – notably the extent of the spring soaks – and for use as a communication aid.

Parks Victoria – Acoustic and camera monitoring to monitor fauna (mammals, birds, frogs etc.), as well as timed counts for birds. Map extent of soak to track resilience to future climate change and warming.

Case study 2: Maturing forest, upper Loddon, Dja Dja Wurrung Country

Partner visitors:

- Dja Dja Wurrung Clans Aboriginal Corporation

Site description:

- Herb-rich foothill forest on west-facing aspect with some larger trees retained.
- Litter and grass dominated understorey (Figure 10).

Figure 10. Photographs taken from the case study site showing vegetation structure, coarse woody debris, and grass-dominated understorey.

Prominent values and objectives noted by DJAARA:

The song-scape and understorey vegetation is diverse. Healthy older trees were present with hollows forming (particularly in Manna Gum). Few weeds. A site with great potential for recovery of pre-colonial ecological and cultural values.

Threats and degradation noted by DJAARA:

Tree stem density too thick, which could be a fire hazard.

Actions noted by DJAARA:

The site prompted broader discussions around strategy of action, rather than how to act at this particular site (e.g. cultural thinning to reduce stem density). A site like this might be a candidate for action if it were considered a 'special place' by Dja Dja Wurrung (Djaara) people, and action could be irrespective of quality. Actions at this site would follow the principles of Forest Gardening and might entail 'tending' to the site and applying a 'light touch'. To determine if the site was a candidate for Forest Gardening would require a better understanding of the biocultural values across the landscape.

Suggestions for monitoring:

Monitoring was not discussed at this site.

Case study 3: Post-logging regeneration, Barkstead, Wadawurrung Country

Partner visitors:

- Parks Victoria
- Wadawurrung Traditional Owners Aboriginal Corporation

Site description:

- Herb-rich foothill forest with extensive mining activity (i.e. 'upside-down Country'), including obvious and extensive soil disturbance and old mine shafts.
- Extensive 'old' Eucalypt regeneration post logging.
- Litter dominated understorey (Figure 11).

Figure 11. Photographs taken from the case study site showing vegetation structure, stumps of mature trees and litter dominated understorey.

Partner reactions:

"The site is dark and not appealing" (Wadawurrung representative).

"The forest at this site is comprised of small trees at high density where resources are locked up… needs management" (Parks Victoria partner).

Prominent values and objectives noted by partners:

Wadawurrung – The site is free of weeds. Native understorey species are present, but in very low abundance and small in stature. The wattles present in the midstory could provide useful cultural tools.

Parks Victoria – The site provides interesting topographic relief and is peaceful with dappled light. The site appears stable and dominated by native plant species.

Threats and degradation noted by partners:

Wadawurrung – The site has a strong legacy of past logging and mining resulting in high density of eucalypt stems. Due to the altered structure and lack of resources, the site lacks bird diversity or native animal sign. However, deer signs were present at the site. Litter cover too high, which can make implementing burning difficult.

Parks Victoria – There is an obvious lack of mature trees and the disturbance history (i.e. logging and mining) has resulted in dense regeneration of trees that are unable to grow into large trees due to competition. The site is too quiet, which is likely the result of diminished flower or invertebrate resources for fauna.

Actions noted by partners:

Wadawurrung – Cultural thinning to reduce tree density and allow trees to escape competition. Cultural burning could be difficult given the litter layer and the risk of baking the ground. Burning may require different approaches at small-scale (i.e. raking and burning). Deer control should be considered to allow understorey plants to grow and reproduce. This site has lots of problems, but it is now stable, and when considered alongside other sites, it may not be a priority for any action at all.

Parks Victoria – Thinning (with a focus on removing coppiced trees) should be conducted to release trees from competition, which should produce better vegetation structure. Some thinned trees should be retained on site as coarse woody debris to provide habitat for fauna and microsites for native plant germination.

Suggestions for monitoring:

Wadawurrung – Acoustic monitoring could be used to monitor bird recovery in response to tree thinning. Camera monitoring could also be employed to track deer abundance and detect recovery of native fauna. Monitoring understorey could be used to track long-term changes in understorey and ground cover. No specific understorey monitoring methods were discussed.

Parks Victoria – Monitoring should focus on tree structure by monitoring tree size (i.e. diameter at breast height) and density. Monitoring should also assess long-term changes in understorey plant composition and ground cover. No specific understorey monitoring methods were discussed.

Case study 4: Post-logging regeneration, Leonard's Hill, Dja Dja Wurrung Country

Partner visitors:

- Dja Dja Wurrung Clans Aboriginal Corporation

Site description:

- Shrubby dry forest with Eucalypt regeneration following shelter wood cut in 1996.
- Some large trees have been retained.
- Diverse. Patchy and sometimes sparse native understorey with patches of Gorse invasion (*Ulex europaeus*; Figure 12).

Figure 12. Photographs taken from the case study site showing vegetation structure and large old tree.

Partner reactions:

"The site would have been high quality prior to shelter wood cut, as it wasn't logged since horses were used to log forests" (DJAARA representative).

Prominent values and objectives noted by DJAARA:

The site has a diverse native understorey with minimal herbaceous weeds. Some old trees have been retained and are in good health.

Threats and degradation noted by DJAARA:

The legacy of past logging has resulted in very dense eucalypt regeneration. The site has poor visibility, and a Djaara person would not be able to successfully throw a spear if hunting. The site has patches of Gorse invasion.

Actions noted by DJAARA:

The forest remnant is a trial site for cultural thinning. No thinning has been conducted, but it is anticipated that the amount of thinning would be 'light'. Some consideration was given to using goats to target Gorse invasion, because goats may prefer Gorse over other species due to the high protein content of foliage.

Suggestions for monitoring:

Baseline monitoring has begun at the site. Transects and plots have been established that monitor understory species diversity, tree density and fauna.

Case study 5: Storm damage, Barkstead, Wadawurrung Country

Partner visitors:

- Parks Victoria

Site description:

- Herb-rich foothill forest with extensive storm damage.
- Understory is dominated by native grasses.
- The storm has increased the amount of leaf litter and coarse woody debris.
- Following the storm, legal firewood collection has been permitted (Figure 13).

Figure 13. The storm damaged site showing vegetation structure with epicormic growth, firewood collection and grassy understorey; and satellite image of the site showing storm damage and the location where partners met (yellow dot).

Partner reactions:

"The loss of trees is dramatic… but mother nature will repair the site over time. Importantly we can help at the edges. Depending on what we are prepared to commit, recovery may be quick." (Parks Victoria partner; paraphrased)

Prominent values and objectives noted by Parks Victoria:

Bird activity was high, which could be due to differing forest types (e.g. intact forest and riparian areas) and forest uses (e.g. pine plantation) adjacent to the site. Tree age-classes and density were more representative of healthy forest.

Threats and degradation noted by Parks Victoria:

The site could easily be invaded by weeds (Gorse, Broom and Pines) due to increased light, soil disturbance and proximity to weeds. Soil erosion and soil disturbance from tree roots being lifted could cause nutrient depletion, soil erosion, and changes in micro-geography.

Actions noted by Parks Victoria:

The removal of wood (as firewood) is a big step change for Parks Victoria who typically do not engage with such activities. Weed control may be one of the first actions required at the site. It was discussed that this site may well recover a desirable forest structure sooner than it

would have without the storm damage. The storm damage can be used to our advantage, provided we create the conditions for recovery.

Suggestions for monitoring:

The recovering vegetation will require monitoring of tree density and soil loss/erosion. Tree recovery could be monitored using drone flights over time. Point intercepts could be used to monitor changes in understorey vegetation and weed invasion. In addition, gaining a greater understanding of how birds, reptiles and fungi respond to forest recovery over time with comparison to benchmark sites would be beneficial. Any actions that are implemented should be monitored to ensure the local community and land managers are well informed, given the level of attention focussed on storm damaged areas.

Case study 6: Storm damage, Loddon River, Dja Dja Wurrung Country

Partner visitors:

- Dja Dja Wurrung Clans Aboriginal Corporation

Site description:

- Herb-rich foothill forest with extensive storm damage.
- Native understorey is comprised mainly of grasses with high cover (Figure 14).

Figure 14. The storm damaged site showing vegetation structure with epicormic growth and grassy understorey; and satellite image of the site showing storm damage and the location where partners assessed the site (yellow dot).

Partner reactions:

"The storm and the subsequent impacts to the forest may present an opportunity for the forest to naturally open up" (DJAARA representative)

"Emu used to occupy these forests. This could be used to inform tree spacing" (DJAARA representative)

Prominent values and objectives noted by DJAARA:

The grassy understorey has likely increased in response to the opening of the tree canopy. Bird activity is prominent, potentially influenced by nearby Loddon River. Tree density after the storm damage is more appropriate for the forest, compared to what it was before the storm. Storm damage might fast-track hollow creation in standing large trees.

Threats and degradation noted by DJAARA:

The excess coarse woody debris caused by the storm increases risk of bushfire. The midstory (i.e. wattles) are missing from the site. Soil erosion from tree roots could threaten the water quality of the nearby Loddon River.

Actions noted by DJAARA:

Removal of some coarse woody debris should be considered in order to prepare the site for cultural fire. Some debris should be retained at site to provide habitat, while some removed debris could be used to improve the health of the nearby Loddon River (e.g. snags). (Re)-

Introduction of woody species (e.g. wattles, she oak and banksia) could help fast-track post-storm recovery and improve the forest midstory.

Suggestions for monitoring:

The recovering vegetation will require monitoring of tree density and soil loss/erosion. Nuanced information about tree density will be required to assist DJAARA, who is developing thinning guidelines and determining benchmarks.

Case study 7: Riparian forest, Loddon River, Dja Dja Wurrung Country

Partner visitors:

- Dja Dja Wurrung Clans Aboriginal Corporation

Site description:

- Riparian forest on the upper Loddon River with extensive storm damage on adjacent north-facing slope.
- In-stream and fringing vegetation is largely native and diverse, with some weed invasion (Figure 15).
- A few large Manna Gums are present, but most trees are small regrowth.

Figure 15. The riparian forest site (adjacent to a storm damaged site) showing vegetation structure with stream fringe vegetation and aquatic plants.

Partner reactions:

"The Loddon River is important for navigation and has a rich cultural history" (DJAARA representative)

Prominent values and objectives noted by DJAARA:

Water ribbons (*Cycnogeton* spp.) are important cultural plants (both food and textiles). The river flow is permanent and was flowing during the site visit.

Threats and degradation noted by DJAARA:

Overall quality of the water was low. Potential soil erosion from the adjacent storm damaged forest could deteriorate the water quality further. Partners suspect the river no longer supports platypus or turtle populations (platypus and short-necked turtles are important species for Djaara).

Actions noted by DJAARA:

Some of the debris from adjacent storm damaged forest could be used to improve the health of the nearby Loddon River by reinstating snags. (Re)-introduction of tree species (e.g. River Red Gum (*Eucalyptus camaldulensis*)) could help restore the species in the riparian areas where it once occurred. Improvements to the quality of riparian vegetation could also help improve water quality.

Suggestions for monitoring:

Aboriginal Water Assessments (AWAs) could be a useful tool to quantify water quality and track change over time. These assessments are being used by DJAARA (and other First Nations groups) and help inform decision making for both First Nations groups and government agencies (e.g. Catchment Management Authorities). Environmental DNA (eDNA) sampling could also be a useful tool for detecting cryptic aquatic species (e.g. platypus and turtles).

Case study 8: Weed invaded forest, Spargo Creek, Wadawurrung Country

Partner visitors:

- Parks Victoria

Site description:

- Herb-rich foothill forest with a very diverse native understorey.
- A prominent patch of Gorse has invaded the site.
- The site is small and positioned between a sealed road and a powerline easement (Figure 16).

Figure 16. The weed invaded site showing the vegetation structure with its grassy understorey and Gorse invasion; and satellite image of the site showing the fragmented nature of the site and the location where partners met (yellow dot).

Prominent values and objectives noted by Parks Victoria:

The site has a grassy native understorey with limited herbaceous weeds.

Threats and degradation noted by Parks Victoria:

The Gorse invasion is extensive with some pine wildlings, which have likely invaded from an adjacent plantation. The site is also fragmented and small so will likely have prominent edge effects, which could affect the capacity of the site to resist weed invasion and other pervasive threats.

Actions noted by Parks Victoria:

Gorse and pine wildlings could be removed using mechanical and herbicide control methods ('Eco-blade' mentioned). Goats could be considered as a potential way of weed control given the small size of the site. Fire could be used as a tool to express the Gorse seedbank before control. Alternatively, the site could be protected from fire to ensure the Gorse seedbank isn't expressed. However, this approach assumes fire can be prevented, which could be unlikely as Gorse seed dormancy can exceed 50 years. The replanting of native plant species should follow weed removal.

Suggestions for monitoring:

The recovering understorey vegetation will require monitoring to fill knowledge gaps about Gorse control methods and native species recovery. No specific monitoring methods were mentioned.

Case study 9: Large old tree, Babbingtons Hill, Dja Dja Wurrung Country

Partner visitors:

- Dja Dja Wurrung Clans Aboriginal Corporation

Site description:

- Herb-rich foothill forest with extensive eucalypt regrowth.
- One very large old tree (*Eucalyptus obliqua*) remains (Figure 17).

Figure 17. One of very few old growth eucalypts in the proposed Wombat-Lerderderg National Park showing tree form and health, with adjacent eucalypt regrowth in the background.

Prominent values and objectives noted by DJAARA:

A large mature tree, which is rare in the landscape. The tree appears in good health.

Threats and degradation noted by DJAARA:

Other than negligent acts (i.e. damage or removal) or intense bushfire, no immediate threats were proposed because the value of focus was the single large old tree.

Actions noted by DJAARA:

Maintenance and care of the large old tree should be paramount given the rarity of trees of this size in the landscape. This should involve protection from anthropogenic disturbances and monitoring to ensure disease and parasites do not kill the tree.

Suggestions for monitoring:

No specific monitoring approaches were mentioned. The tree will be regularly visited to track its overall health using tree canopy observations as the prominent source of information.

4 Discussion

This project resulted in several tangible outcomes that will assist future forest management:

- a clear vision statement for the Wombat Forest, which considers the forest and its people, that is endorsed by all partners
- a detailed objectives hierarchy that expresses the values and objectives of each of the partners, and highlights the different priorities of each group
- a list of the main actions that partners believe will achieve their objectives
- data on the cross-relationships between actions and objectives
- a set of case studies that show the detail and complexity of how values, objectives, threats, actions and monitoring apply to specific locations
- a preliminary description of current forest health.

We believe that the collaborative and flexible approach used by this project also resulted in a number of less tangible benefits; notably positive engagement and constructive dialogue with future co-managers.

It is clear that the Wombat Forest is valued for a wide range of reasons, and much-loved by many. It is also clear that the Forest has suffered a long history of disturbance and harm that has left it damaged and vulnerable. These started in the 1840s, with the exclusion of the forest's First Nations custodians (Fletcher et al. 2021) and continued through the gold rush of the 19th century, with a long history of forestry that is only now coming to a close. The future looks very different, and this project is one step towards making sure that the future is bright.

We see this project as the first step in a process of collaborative management, guided by the principles of AFM, and working from the objectives presented here.

4.1 Shared vision for co-management

This project revealed that all partners shared a common vision for the Wombat Forest. A long-term shared vision is an excellent basis for future co-management, particularly when it emerges from partners themselves, rather than being imposed from outside, as it can unite partners and build trust (Vangansbeke et al. 2015).

Underneath this shared vision, however, partners hold very different priorities in some areas, and are focussed on different things. These differences are most prominent for cultural and social concerns. Agency partners focussed relatively little on cultural aspects. In contrast, First Nations partners are very strongly focussed on the continuation and safeguarding of their cultural practices, and see these as essential for future forest health. A similar pattern was identified by Lee and Kant (2006) in Canada. Their study revealed that First Nations people ranked First Nations heritage, identity, livelihood and spirit higher than other values (i.e. economy, environment, recreation, tourism and education), while other partners representing environmental non-government organisations and the natural resources sector ranked these issues low (Lee and Kant 2006).

This disparity may seem troubling at first, because it may suggest the potential for conflict. However, we believe it is appropriate and to be expected, given the responsibilities of each partner group. Each First Nations group represents its People and Country, and the agencies represent the environmental interests of the wider Victorian public and have specific legislative responsibilities. We believe that the disparities only show that each group knows its own remit very well. Importantly, no group at any stage was disparaging or dismissive of any of the objectives held by another group; for that could herald conflict.

These differences represent a clear starting point. All partners must recognise how their own agenda, responsibilities and constraints differ from those of their co-managers, and this can inform discussions about management. AFM (or a similar collaborative model) can accommodate this, by requiring that co-managers be well represented, and the objectives of any management action are made clear. Indeed, it has been suggested that involving partners representing a range of viewpoints better reflects the reality of complex socio-ecological systems, and should lead to better management outcomes (Schultz et al. 2011).

4.2 Forest restoration: Views from the past and an eye to the future

Most of the objectives identified, regardless of how they were differently emphasised, were about the past. All partners wanted to repair damage in one way or another, and restore a forest value that was present in the past, but is now lost or under threat. This applies to biological objectives such as the restoration of a pre-impact forest structure, the removal of weeds and the protection of species that have become depleted. It also applies to cultural practices, with a very strong focus on safeguarding and re-enlivening traditional cultural practices. There is a strong belief that reinvigorating the past will result in a stronger and more resilient future. No-one wanted a radically transformed future. No-one viewed the Wombat Forest as a lost cause or a blank slate that should be fundamentally re-invented. In other words, the objectives for the forest were seen to reside in its historic character and identity.

Interestingly, carbon sequestration was not raised by any partners as an important value, despite the well-publicised evidence of its global importance, and the knowledge that well-managed, diverse and mature forests can store large quantities of carbon (Knops and Tilman 2000; Yapp et al. 2010; Berendse et al. 2015). However, some partners did aspire to a future Wombat Forest that is resilient to current and future climate change, and climate change adaptation was considered a process action as part of the elicitation.

In contrast, partners often looked to innovation, new technology and new thinking when actions to achieve the objectives were considered. This included cultural thinning protocols that bind together traditional cultural practices with the post-colonial need to reduce tree densities. When monitoring was considered, emerging technologies were suggested, including environmental DNA detection for aquatic organisms (eDNA; Beng and Corlett 2020) and passive acoustic monitoring for birds and insects (Ross et al. 2023). While the objectives were about history and tradition, the view of future management was broad, forward looking and deeply creative.

The management actions that were suggested by partners were generally aligned with the management and ecological literature. For example, the focus on weed and pest control actions aligns with studies about their positive impacts. Effective weed control can safeguard plant diversity and encourage native species regeneration (Sher et al. 2018), while effective pest animal management can effectively mitigate predation pressures on native fauna (Doherty et al. 2016).

4.3 The critical role of fire in future Wombat Forest management

Some of the interactions between ecosystems and people are likely to be central to future management in the Wombat Forest. The use of fire is of particular prominence. All partners agreed that fire was an important tool for management, but its ramifications are complex and unresolved. How fire is applied is crucial because its use affects so many other things of value. It matters how and why fires are planned, and who decides to burn. It matters when and where a fire burns. It also matters how a burn is implemented and by whom.

In recent decades, fire has been used extensively in the Wombat Forest by management agencies for fuel reduction (Attiwill and Adams 2013), despite ongoing debate about its effectiveness in preventing catastrophic fires (Morgan et al. 2020). In a survey of Wombat Forest community members, Bell and Oliveras (2006) showed that more than 50% of respondents believed prescribed burning in the Wombat Forest was highly effective at reducing wildfire, and many have demanded more fuel

reduction burning (Binskin et al. 2022). However, when prompted, many people suggested “no amount of prescribed burning will prevent a big wildfire” (Bell and Oliveras 2006).

Fire is also used by agency managers to promote species richness and manage vegetation structure for ecological reasons. Too much (Penman et al. 2008 a and b) or too little fire (Freestone et al. 2015) can be detrimental, but most managers and ecologists lack the detailed knowledge to manage fire with the nuance required to optimise its effects (Foster et al. 2018). This sentiment was captured in our elicitation with agency partners where the anticipated effect of fuel reduction burning on the objectives spanned the entire possible uncertainty range.

First Nations people used fire to manage and shape the landscape for millennia, well before control by western land management agencies. With co-management arrangements coming into effect, the use of fire by First Nations people is re-emerging. While the use of fire by First Nations people may have similar ecological (DJAAR 2022) and fuel reduction (Whitehead et al. 2008) objectives to agency partners, it has additional dimensions of cultural importance. For this reason, the use of fire is often referred to as ‘Cultural burning’, to express the fact that it is done by First Nations people in line with cultural outcomes, and to express the fact that its practice affects people. Cultural burning can yield positive outcomes for First Nations communities because it is part of active cultural practice, and it can foster community pride, confidence, and the maintenance of expertise (Patterson and Hunt 2012).

It is notable that, in our elicitation, agency partners recorded high uncertainty in relation to fuel reduction burning (this action was not elicited from First Nations partners). However, all partner groups recorded the use of cultural fire as unequivocally positive, with little uncertainty. Therefore, the type of fire that is applied requires care and tact to ensure the benefits to forest values can be maximised, and the risks to values are minimised.

These results imply that poor governance could lead to poor outcomes with the use of fire. Burning planned by agency managers alone could have negative ecological consequences if poorly timed or implemented; but also, negative social consequences if First Nations groups are alienated from important cultural practices and opportunities. Conversely, while burning by First Nations groups is likely to have more positive cultural outcomes, it should not be assumed that handing over the responsibility of fire management is a panacea, or will have instant benefits. There remain many barriers to successful cultural burning, including regulatory environments that hamper it (Williamson 2021), too many demands on too few people, some loss of Traditional knowledge, a reluctance to share retained knowledge with agencies, and changed conditions (weeds and climate change) that mean some Traditional practices may need to be adjusted for the modern world. Instead, we suggest that a successful burning program will emerge over time out of dialogue and trust among partners. The conversation should consider the values and objectives of all partners, and all the cultural and ecological ramifications of a decision.

4.4 Interconnectedness of objectives and actions

We elicited each of the objectives and management actions as separate items for the sake of clarity, but we must recognise that they are profoundly inter-linked by ecological and social interactions and feedbacks. This point was made by many partners during the elicitation workshops.

These interactions may be ecological. A very simple example is that protection of old trees and the manipulation of forest structure (themselves values and objectives) benefits many hollow-dependent fauna such as Phascogales and bats, which are in turn singled-out as values (Lefroy et al. 1993; Lindenmayer et al. 2014; Gibbons and Lindenmayer 2022). These relationships extend further, with complex links between vegetation structure, fire, soils, water, ecosystem stability and human health. For example, forests provide intact vegetation structure and soils enhance water quality through filtration, temperature regulation and pollutant removal (Johnson and Jones 2000), and provide flood mitigation, erosion control and diverse habitats that support aquatic (Horwitz et al. 2008) and terrestrial (Steward et al. 2022) biodiversity. Diverse floristic communities can also enhance

ecosystem stability, nutrient cycling, and carbon sequestration (Berendse et al. 2015), which collectively contribute to the resilience and health of forest ecosystems (Stan and Sanchez-Azofeifa 2019). It is likely the effective management of these objectives will interact and reinforce each other (Keesstra et al. 2018).

These interactions may also be social, or between ecological and social elements. For instance, implementing burning not only reduces wildfire risk but also fosters community engagement and Traditional knowledge sharing (Lake et al. 2017). Also, watershed protection initiatives not only safeguard water quality and quantity, but also foster community cohesion through collaborative decision-making processes, and can promote aquatic recreational activities (e.g. swimming, kayaking, canoeing; Marques et al. 2021). Additionally, actions that improve forest health not only preserve biodiversity, but also promotes ecotourism, contributing to local livelihoods and cultural preservation (Jenkins et al. 2003). Forest health objectives often intertwine with social considerations, with management actions influencing both ecological and social dynamics (Fischer 2018).

4.5 Forest management frameworks

If committed to, funded and applied, AFM in the Wombat Forest will represent a significant step toward enhancing diverse forest values and bolstering the overall health of the Wombat Forest (for both ecosystem and the people who use it). AFM is appropriate for addressing the unique challenges faced by the Wombat Forest, extending beyond timber production to include cultural and ecological values more comprehensively. This approach advocates for collaborative efforts among various partners, including government agencies, First Nations corporations, environmental organisations, and recreational users.

We advocate that AFM in the Wombat Forest should begin. This would ensure the momentum and relationships generated in this project can be harnessed and maximised. Once a governance structure is established, partners should seek to develop a monitoring, evaluation and reporting (MER) framework that defines the values to be monitored, the methods that should be employed to quantify them, how often they should be monitored and the approaches to data analysis that should be employed to assess trends. This information should be documented and communicated to other partners. In addition, regular reporting of the findings should be planned to ensure the information can be used to advise the adaptive management cycle.

4.6 Conclusion

The interactions between objectives remind us that no action can be considered in isolation. There are trade-offs to be made, and opportunities for identifying win-win solutions. We did not consider these interactions when we elicited priorities. Taking account of all of these interactions and consequences is potentially bewildering and daunting. Dialogue, trust and good governance goes some way to making decision-making less daunting, but other tools are also likely to be necessary. These include Structured Decision Making (Regan et al. 2023), Adaptive Management and the processes of AFM.

Transitioning to AFM for the Wombat Forest involves prioritising on-ground land management, applying sustainable economic models, and ensuring the forest is healthy and resilient (Jackson et al. 2021). AFM's strategic areas, encompassing fair governance, active management, and integrated knowledge systems, echo the collaborative approach initiated by this project, emphasising a comprehensive and participatory process for effective forest management.

If the right governance structures are in place, the disparities in partner priorities identified in this project can be seen as an opportunity for informed and effective co-management. Recognising and respecting the diverse focuses of each partner group, particularly in cultural and social concerns, lays the groundwork for a collaborative approach guided by AFM principles. By ensuring well-represented

co-managers and transparent communication about management objectives, the potential for conflict is minimised, and the richness of perspectives contributes to better forest management.

References

Abraham, J., Dowling, K. and Florentine, S. (2018). Assessment of potentially toxic metal contamination in the soils of a legacy mine site in Central Victoria, Australia. *Chemosphere* **192**, 122–132.

Adams, M. A. (2013). Mega-fires, tipping points and ecosystem services: Managing forests and woodlands in an uncertain future. *Forest Ecology and Management* **294**, 250–261.

Attiwill, P.M. and Adams, M.A., 2013. Mega-fires, inquiries and politics in the eucalypt forests of Victoria, south-eastern Australia. *Forest Ecology and Management* **294**, 45–53.

Baker, S.C., Barmuta, L. A., McQuillan, P. B. and Richardson, A.M. (2007). Estimating edge effects on-ground-dwelling beetles at clearfelled non-riparian stand edges in Tasmanian wet eucalypt forest. *Forest Ecology and Management* **239**, 92–101.

Bell, T. and Oliveras, I. (2006). Perceptions of prescribed burning in a local forest community in Victoria, Australia. *Environmental Management* **38**, 867–878.

Beng, K.C. and Corlett, R.T. (2020). Applications of environmental DNA (eDNA) in ecology and conservation: Opportunities, challenges and prospects. *Biodiversity and Conservation* **29**, 2089–2121.

Berendse, F., van Ruijven, J., Jongejans, E. and Keesstra, S. (2015). Loss of plant species diversity reduces soil erosion resistance. *Ecosystems* **18**, 881–888.

Berkes, F. and Folke, C. (1998). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press, Cambridge, UK.

Berkes, F., Colding, J. and Folke, C. (2008). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.

Binskin, M., Bennett, A. and Macintosh, A. (2020). *Royal commission into national natural disaster arrangements report.* Commonwealth of Australia, Canberra.

Binder, S., Haight, R.G., Polasky, S., Warzniack, T., Mockrin, M.H., Deal, R.L. and Arthaud, G.J. (2017). *Assessment and valuation of forest ecosystem services: State of the science review*. US Forest Service, Newtown Square, USA.

Blair, S. (2019). The natural wonders of Wombat Forest. *Park Watch: June 2019* **277**, 19–21.

Bolte, A., Ammer, C., Löf, M., Madsen, P., Nabuurs, G.J., Schall, P., Spathelf, P. and Rock, J. (2009). Adaptive forest management in central Europe: Climate change impacts, strategies and integrative concept. *Scandinavian Journal of Forest Research* **24**, 473–482.

Borràs, S. (2016). New transitions from human rights to the environment to the rights of nature. *Transnational Environmental Law* **5**, 113–144.

Bottrill, M.C. and Pressey, R.L. (2012). The effectiveness and evaluation of conservation planning. *Conservation Letters* **5**, 407–420.

Bowd, E.J., Banks, S.C., Strong, C.L. and Lindenmayer, D.B. (2019). Long-term impacts of wildfire and logging on forest soils. *Nature Geoscience* **12**, 113–118.

Bowd, E.J., Blair, D.P. and Lindenmayer, D.B. (2021). Prior disturbance legacy effects on plant recovery post-high-severity wildfire. *Ecosphere* **12**, e03480.

Bradshaw, F.J. (1992). Quantifying edge effect and patch size for multiple-use silviculture—a discussion paper. *Forest Ecology and Management* **48**, 249–264.

Brand, K.W. (2010). German environmentalism: Still feeding on its romantic, anti-modern heritage? *Nature+ Culture* **5**, 209.

Byrnes, J.E., Gamfeldt, L., Isbell, F., Lefcheck, J.S., Griffin, J.N., Hector, A., Cardinale, B.J., Hooper, D.U., Dee, L.E. and Emmett Duffy, J. (2014). Investigating the relationship between biodiversity and ecosystem multifunctionality: Challenges and solutions. *Methods in Ecology and Evolution* **5**, 111–124.

Cahir, F., McMaster, S., Clark, I., Kerin, R. and Wright, W. (2016). Winda lingo parugoneit or why set the bush [on] fire? Fire and Victorian Aboriginal people on the colonial frontier. *Australian Historical Studies* **47**, 225–240.

Cally, J.G., Macak, P.V. and Ramsey, D.S. (2023). *Abundance of the Southern Greater Glider in Wombat State Forest. Impacts of habitat and the 2021 storms*. Unpublished Client Report for Forest and Fire Planning, Grampians Region. Arthur Rylah Institute for Environmental Research, Department of Energy, Environment and Climate Action, Heidelberg, Victoria.

Carey, A.B. (2006). Active and passive forest management for multiple values. *Northwestern Naturalist* **87**, 18–30.

Cheal, D. (2010) *Growth stages and tolerable fire intervals for Victoria's native vegetation data sets*. Fire and Adaptive management report No. 84. Department of Sustainability and Environment, East Melbourne, Victoria.

Ciancio, O. and Nocentini, S. (2000). Forest management from positivism to the culture of complexity. In: *Methods and Approaches in Forest History*. *Papers selected from a conference held in Florence, Italy in 1998*, pp. 47–58. CABI Publishing, Wallingford, UK.

Collins, L., Bradstock, R.A., Clarke, H., Clarke, M.F., Nolan, R.H. and Penman, T.D. (2021). The 2019/2020 mega-fires exposed Australian ecosystems to an unprecedented extent of high-severity fire. *Environmental Research Letters* **16**, 044029.

Commonwealth of Australia (1992). *National Forest Policy Statement: A new focus for Australia's forests.* Commonwealth of Australia, Canberra, ACT.

Connelly, C. (2017) Five years of NatureWatch in Wombat forest. *Park Watch: December 2017* **271**, 24–25.

Costanza, R. (1991). *Ecological Economics: The Science and Management of Sustainability*. Columbia University Press, New York, USA.

Crook, J. (2021). Wild winds and flattened forests. *Park Watch: June 2021* **286**, 22–23.

Curran, D. (2017). "Legalizing" the Great Bear Rainforest Agreements: Colonial adaptations toward reconciliation and conservation. *McGill Law Journal* **62**, 813–860.

Curtin, C.G. and Parker, J.P. (2014). Foundations of resilience thinking. *Conservation Biology* **28**, 912–923.

DAFF (Department of Agriculture, Fisheries and Forestry) (2005). *National Indigenous Forest Strategy*. Australian Government, Canberra, ACT.

Davey S.M. (2018). Regional forest agreements: Origins, development and contributions. *Australian Forestry* **81**, 64–88.

DEECA (Department of Energy, Environment and Climate Action) (2024). *State Forest Management Planning Framework: Approach to strategic planning for State forest management (v 8.0). Forest Fire Management, Victoria.* The State of Victoria, Department of Energy, Environment and Climate Action, East Melbourne, Victoria.

de Mello, N.G.R., Gulinck, H., Van den Broeck, P. and Parra, C. (2020). Social-ecological sustainability of non-timber forest products: A review and theoretical considerations for future research. *Forest Policy and Economics* **112**, 102109.

DELWP (Department of Environment, Land, Water and Planning) (2019). *Pupangarli Marnmarnepu 'Owning our Future': Aboriginal Self-determination Reform Strategy 2020–2025*. The State of Victoria Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

DELWP (Department of Environment, Land, Water and Planning) (2021) *Recreational hunting in the Central West Area* (Fact sheet). The State of Victoria Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

Department of the Environment (Australia) (2014a). *Emissions Reduction Fund*. http://www.environment.gov.au/climate-change/emissions-reduction-fund/about (accessed 14 August 2023).

Department of the Environment (Australia) (2014b). *Green Army*. http://www.environment.gov.au/land/greenarmy (accessed 14 August 2023).

Diamond, J.M. (1975). The island dilemma: Lessons of modern biogeographic studies for the design of natural reserves. *Biological Conservation* **7**, 129–146.

Dja Dja Wurrung Clans Aboriginal Corporation and the State of Victoria (2013) *Recognition and Settlement Agreement (Volumes 1 and 2) under the Traditional Owner Settlement Act 2010 (Vic).* Dja Dja Wurrung Clans Aboriginal Corporation and the State of Victoria, Melbourne, Victoria.

DJAARA (2014) *Dhelkunya Dja: Dja Dja Wurrung Country Plan, 2014–2034*. Dja Dja Wurrung Clans Aboriginal Corporation, Bendigo, Victoria.

DJAARA (2022) *Galk-galk dhelkunya: Forest gardening strategy, 2022–2034*. Dja Dja Wurrung Clans Aboriginal Corporation, Bendigo, Victoria.

DJAARA (2023) *Turning 'wrong way' climate 'right way': Dja Dja Wurrung Climate Change Strategy 2023–2024*. Dja Dja Wurrung Clans Aboriginal Corporation, Bendigo, Victoria.

DJPR (Department of Jobs, Precincts and Regions) (2021). *Victorian Forestry Plan*. Department of Jobs, Precincts and Regions, Melbourne, Victoria.

Doherty, T.S., Dickman, C.R., Johnson, C.N., Legge, S.M., Ritchie, E.G. and Woinarski, J.C. (2017). Impacts and management of feral cats *Felis catus* in Australia. *Mammal Review* **47**, 83–97.

Emery, M. and Flora, C. (2006). Spiraling-up: Mapping community transformation with Community Capitals Framework. *Community Development* **37,** 19–35.

Feary, S. (2008). Social justice in the forest: Aboriginal engagement with Australia's forest industries. *Transforming Cultures* **3**, 265–290.

Feary, S., Kanowski, P., Altman, J. and Baker, R. (2010). Managing forest country: Aboriginal Australians and the forest sector. *Australian Forestry* **73**, 126–134.

Fernández-Manjarrés, J.F., MacHunter, J. and Zavala, M.A. (2021). Forest management, conflict and social–ecological systems in a changing world. *Forests* **12**, 1459.

Fischer, A.P. (2018). Forest landscapes as social-ecological systems and implications for management. *Landscape and Urban Planning* **177**, 138–147.

Fletcher, M.S., Hall, T. and Alexandra, A.N. (2021). The loss of an indigenous constructed landscape following British invasion of Australia: An insight into the deep human imprint on the Australian landscape. *Ambio* **50**, 138–149.

Ford, R.M. (2013). Contested social values in decision-making for Australian native forests. *Australian Forestry* **76**, 37–49.

Ford, R.M., Williams, K.J., Smith, E.L. and Bishop, I.D. (2014). Beauty, belief, and trust: Toward a model of psychological processes in public acceptance of forest management. *Environment and Behaviour* **46**, 476–506.

Foreman, P. (2020). The 1840 Western Port journey and Aboriginal fire history in the grassy ecosystems of lowland, mesic south-eastern Australia. *Australian Journal of Botany* **68**, 320–332.

Forest Fire Management Group (2014). *National Bushfire Management Policy Statement for Forests and Rangelands*. The Council of Australia Governments, Canberra, ACT.

Foster, C.N., Barton, P.S., MacGregor, C.I., Catford, J.A., Blanchard, W. and Lindenmayer, D.B. (2018). Effects of fire regime on plant species richness and composition differ among forest, woodland and heath vegetation. *Applied Vegetation Science* **21**, 132–143.

Franklin, J.F. (1989). Toward a new forestry. *American Forests* **95**, 37–44

Freestone, M., Wills, T.J. and Read, J. (2015). Post-fire succession during the long-term absence of fire in coastal heathland and a test of the chronosequence survey method. *Australian Journal of Botany* **63**, 572–580.

Gammage, B. (2011) *The Biggest Estate on Earth, How Aborigines made Australia*. Allen and Unwin, Sydney, NSW.

Gibbons, P. and Lindenmayer, D. (2002). *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Collingwood, Victoria.

Gobster, P.H. (1999). An ecological aesthetic for forest landscape management. *Landscape Journal* **18**, 54–64.

Golding, B.G. (1979). *Use of artificial hollows by mammals and birds in the Wombat Forest, Daylesford, Victoria*. Masters Thesis, Monash University, Victoria.

Gott, B. (2005). Aboriginal fire management in south-eastern Australia: Aims and frequency. *Journal of Biogeography* **32**, 1203–1208.

Gott, B. (2008). Indigenous use of plants in south-eastern Australia. *Telopea* **12**, 215–226.

Gregory, R., Ohlson, D. and Arvai, J. (2006). Deconstructing adaptive management: Criteria for applications to environmental management. *Ecological Applications* **16**, 2411–2425.

Gunderson, L.H. and Holling C.S. (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington, USA.

Halbert C.L. (1993) How adaptive is adaptive management? Implementing adaptive management in Washington State and British Columbia. *Reviews in Fisheries Science* **1**, 261–283.

Hatfield, J.H., Barlow, J., Joly, C.A., Lees, A.C., Parruco, C.H.D.F., Tobias, J.A., Orme, C.D.L. and Banks-Leite, C. (2020). Mediation of area and edge effects in forest fragments by adjacent land use. *Conservation Biology* **34**, 395–404.

Henry, A., Hagerman, S. and Kozak, R. (2022). The effects of institutions on perceptions of legitimacy in the Great Bear Rainforest, British Columbia. *Canadian Journal of Forest Research* **52**, 11–18.

Hermy, M. and Verheyen, K. (2007). Legacies of the past in the present-day forest biodiversity: A review of past land-use effects on forest plant species composition and diversity. In: Nakashizuka, T. (Ed) *Sustainability and Diversity of Forest Ecosystems: An Interdisciplinary Approach*, pp. 361–371. Springer, Tokyo, Japan.

Horwitz, R.J., Johnson, T.E., Overbeck, P.F., O'Donnell, T.K., Hession, W.C. and Sweeney, B.W. (2008). Effects of riparian vegetation and watershed urbanization on fishes in streams of the Mid-Atlantic Piedmont (USA) 1. *Journal of the American Water Resources Association* **44**, 724–741.

Jackson, W. (2019). *Independent Consultation Paper-Modernisation of the Victorian Regional Forest Agreements*. Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

Jackson, W., Freeman, M., Freeman, B. and Parry-Husbands, H. (2021). Reshaping forest management in Australia to provide nature-based solutions to global challenges. *Australian Forestry* **84**, 50–58.

JANIS (Joint ANZECC / MCFFA National Forest Policy Statement Implementation Sub-committee) (1997). *Nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia*. Commonwealth of Australia, Canberra, ACT.

Jeanrenaud, S. (2001). *Communities and forest management in Western Europe: A regional profile of WG-CIFM the working group on community involvement in forest management*. IUCN, Switzerland.

Jenkins, J. and Wearing, S. (2003). Ecotourism and protected areas in Australia. In: Fennell, D.A and Dowling, R.K. (Eds) *Ecotourism Policy and Planning,* pp. 205–234. CABI Publishing, Cambridge, USA.

Johann, E. (2006). Historical development of nature-based forestry in Central Europe. In: Diaca, J. (Ed) *Nature-based forestry in Central Europe. Alternatives to Industrial Forestry and Strict Preservation*, pp.1–17. Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, Ljubljana, Slovenia.

Johnson, S.L. and Jones, J.A. (2000). Stream temperature responses to forest harvest and debris flows in western Cascades, Oregon. *Canadian Journal of Fisheries and Aquatic Sciences* **57**, 30–39.

Jones, D.S. and Clarke, P.A. (2018). Aboriginal culture and food-landscape relationships in Australia: Indigenous knowledge for country and landscape. In: Zeunert, J and Waterman, T. (Eds) *Routledge Handbook of Landscape and Food,* pp.41–60. Taylor and Francis, London, UK.

Jurskis, V., Underwood, R. and Burrows, N. (2020). How Australian Aborigines shaped and maintained fire regimes and the biota*. Evolutionary Biology* **5**, 164–172.

Kanowski P.J. (2017). Australia's forests: Contested past, tenure-driven present, uncertain future. *Forest Policy and Economics* **77**, 56–68.

Kahneman, D., Knetsch, J.L. and Thaler, R.H. (1991). Anomalies: The endowment effect, loss aversion, and status quo bias. *Journal of Economic Perspectives* **5**, 193–206.

Keesstra, S.D., Kondrlova, E., Czajka, A. and Seeger, M. (2012). Assessment of the impact of riparian and channel vegetation on water and sediment retardation using a catchment and channel scale model. *Netherland Journal for Geosciences* **91**, 245–256.

Kellas, J.D., Jarrett, R.G. and Morgan, B.J.T. (1988). Changes in species composition following recent shelterwood cutting in mixed eucalypt stands in the Wombat Forest, Victoria. *Australian Forestry* **51**, 112–118.

Kimmerer, R.W. and Lake, F.K. (2001). The role of indigenous burning in land management. *Journal of Forestry*, **99**, 36–41.

Kimmins, J.H. (2002). Future shock in forestry Where have we come from; where are we going; is there a" right way" to manage forests? Lessons from Thoreau, Leopold, Toffler, Botkin and Nature. *The Forestry Chronicle* **78**, 263–271.

Kimmins, J.P. (2003). *Forest Ecology (3rd edition).* Benjamin Cummings, San Francisco, USA.

Kirkham, R. (2023) *Supreme Court orders VicForests to halt salvage logging in Wombat State Forest coupe, ABC Ballarat.* https://www.abc.net.au/news/2023-09-26/vic-forests-court-order-stops-logging-wombat-state-forest/102889450 (accessed 31 October 2023).

Klooster, D.J. (2002). Toward adaptive community forest management: integrating local forest knowledge with scientific forestry. *Economic Geography* **78**, 43–70.

Knops, J.M. and Tilman, D. (2000). Dynamics of soil nitrogen and carbon accumulation for 61 years after agricultural abandonment. *Ecology* **81**, 88–98.

Kusel, J. (2001). Assessing well-being in forest dependent communities. *Journal of Sustainable Forestry* **13**, 359–384.

La Freniere, G.F. (1990). Rousseau and the European roots of environmentalism. *Environmental History Review* **14**, 41–72.

Lake, F.K., Wright, V., Morgan, P., McFadzen, M., McWethy, D. and Stevens-Rumann, C. (2017). Returning fire to the land: Celebrating traditional knowledge and fire. *Journal of Forestry* **115**, 343–353.

Lane, P.N., Feikema, P.M., Sherwin, C.B., Peel, M.C. and Freebairn, A.C. (2010). Modelling the long term water yield impact of wildfire and other forest disturbance in Eucalypt forests. *Environmental Modelling and Software* **25**, 467–478.

Laurance, W.F. (1991). Edge effects in tropical forest fragments: Application of a model for the design of nature reserves. *Biological Conservation* **57**, 205–219.

Lee K.N. (1999) Appraising adaptive management. In: Buck, L.E., Geisler, C.C., Schelhas, J., Wollenberg, E. (Eds) *Biological Diversity: Balancing Interests Through Adaptive Collaborative Management*, pp. 465–489. CRC Press, Boca Raton, USA.

Leach, M., Scoones, I. and Stirling, A. (2010). Governing epidemics in an age of complexity: Narratives, politics and pathways to sustainability. *Global Environmental Change* **20**, 369–377.

Lee, S. and Kant, S. (2006). Personal and group forest values and perceptions of groups' forest values in northwestern Ontario. *The Forestry Chronicle* **82**, 512–520.

Lefroy, E.C., Hobbs, R.J. and Scheltema, M. (1993). Reconciling agriculture and nature conservation: Toward a restoration strategy for the Western Australian wheatbelt. In: Saunders, D.A., Hobbs, R.J. and Ehrlich, P.R. (Eds), *Nature Conservation 3: Reconstruction of Fragmented Ecosystems*, pp. 243–257. Surrey Beattie and Sons, Chipping Norton, NSW.

Leopold, A. (1966). *A Sand County Almanac. With Essays on Conservation from Round River*. Oxford University Press, New York, USA.

Lindenmayer, D.B., Margules, C.R. and Botkin, D. (2000). Indicators of forest sustainability biodiversity: The selection of forest indicator species. *Conservation Biology*, **14,** 941–950.

Lindenmayer, D.B. and Franklin, J.F. (2002). *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island press, Washington, USA.

Lindenmayer, D.B., Laurance, W.F., Franklin, J.F., Likens, G.E., Banks, S.C., Blanchard, W., Gibbons, P., Ikin, K., Blair, D., McBurney, L. and Manning, A.D. (2014). New policies for old trees: Averting a global crisis in a keystone ecological structure. *Conservation Letters* **7**, 61–69.

Lindenmayer, D.B., Wood, J., McBurney, L., Blair, D. and Banks, S.C. (2015). Single large versus several small: The SLOSS debate in the context of bird responses to a variable retention logging experiment. *Forest Ecology and Management* **339**, 1–10.

Lindenmayer, D.B. (2018). Flawed forest policy: Flawed regional forest agreements. *Australasian Journal of Environmental Management* **25**, 258–266.

Lowood, H.E. (1990). The calculating forester: Quantification, cameral science, and the emergence of scientific forestry management in Germany. In: Frangsmyr, T., Heilbron, J.L. and Rider, R.E. (Eds) *The Quantifying Spirit of the Eighteenth Century*, pp. 315–342. University of California Press, Berkeley and Los Angeles, USA.

Loyn, R.H. (2004). Research for ecologically sustainable forest management in Victorian eucalypt forests. In: Lunney, D. (Ed). *The Conservation of Australia's Forest Fauna*. Second Edition pp. 783–806. Royal Zoological Society of New South Wales, Mosman, NSW.

Loyn, R.H. and McNabb, E.G. (2015). Bird population responses to wildfire and planned burns in foothill forests of Victoria, Australia. *Journal of Ornithology* **156**, 263–273.

Lu, N., Liu, L., Yu, D., and Fu, B. (2021). Navigating trade-offs in the social-ecological systems. *Current Opinion in Environmental Sustainability* **48**, 77–84.

Lynch, A. J. J., Fell, D. G. and McIntyre-Tamwoy, S. (2010). Incorporating Indigenous values with 'Western' conservation values in sustainable biodiversity management. *Australasian Journal of Environmental Management* **17**, 244–255.

Lyon, C. and Parkins, J. R. (2013). Toward a social theory of resilience: Social systems, cultural systems, and collective action in transitioning forest-based communities. *Rural Sociology* **78**, 528–549.

MacArthur, R. (1955). Fluctuations of animal populations and a measure of community stability. *Ecology* **36**, 533–536.

Macak, P.V., Chick, R.R. and Loyn, R.H. (2010) *Arboreal mammal habitat associations in Wombat State Forest.* Arthur Rylah Institute for Environmental Research Unpublished client report to the Wombat Biodiversity Working Group/Wombat Forestcare Inc. Department of Sustainability and Environment, Heidelberg, Victoria.

Macak, P.V. (2012) *Small ground mammal habitat associations in Wombat State Forest*. Arthur Rylah Institute for Environmental Research Unpublished client report to the Wombat Biodiversity Working Group/Wombat Forest Care Inc. Department of Sustainability and Environment, Heidelberg, Victoria.

Mamede, S. and Schmidt, H.G. (2004). The structure of reflective practice in medicine. *Medical Education* **38**, 1302–1308.

Manderson, A.D. (1979) *Aspects of forest management for natural hollow in the Wombat State Forest.* Masters thesis, Monash University, Clayton, Victoria.

Margules, C.R. and Pressey, R.L. (2000). Systematic conservation planning. *Nature* **405(6783)**, 243–253.

Marques, M., Reynolds, K.M., Marto, M., Lakicevic, M., Caldas, C., Murphy, P.J. and Borges, J.G. (2021). Multicriteria decision analysis and group decision-making to select stand-level forest management models and support landscape-level collaborative planning. *Forests* **12**, 399.

Mastrangelo, M.E., Weyland, F., Villarino, S.H., Barral, M.P., Nahuelhual, L., and Laterra, P. (2014). Concepts and methods for landscape multifunctionality and a unifying framework based on ecosystem services. *Landscape Ecology* **29**, 345–358.

Matthews, N. and Missingham, B. (2009) Social accountability and community forest management: The failure of collaborative governance in the Wombat Forest. *Development in Practice* **19**, 1052–1063.

McCarthy, M.A. and Possingham, H.P. (2007). Active adaptive management for conservation. *Conservation Biology* **21**, 956–963.

McGinnis, M.D., and Ostrom, E. (2014). Social-ecological system framework: Initial changes and continuing challenges. *Ecology and Society* **19**, 30.

Meffe, G.K. and Carroll, C.R. (1994). *Principles of Conservation Biology*. Sinauer Associates, Sunderland, USA.

Messier, C., Puettmann, K., Filotas, E. and Coates, D. (2016) Dealing with non-linearity and uncertainty in forest management. *Current Forestry Reports* **2**, 150–161.

Messier, C., Bauhus, J., Doyon, F., Maure, F., Sousa-Silva, R., Nolet, P., Mina, M., Aquilué, N., Fortin, M.J. and Puettmann, K. (2019). The functional complex network approach to foster forest resilience to global changes. *Forest Ecosystems* **6**, 1–16.

Moore, M.L. and Tjornbo, O. (2012). From coastal timber supply area to Great Bear Rainforest: Exploring power in a social–ecological governance innovation. *Ecology and Society* **17**, 26–37.

Morgan, G.W., Tolhurst, K.G., Poynter, M.W., Cooper, N., McGuffog, T., Ryan, R., Wouters, M.A., Stephens, N., Black, P., Sheehan, D. and Leeson, P. (2020). Prescribed burning in south-eastern Australia: History and future directions. *Australian Forestry* **83**, 4–28.

Nelson, A. and Pettit, C. (2004). Effective community engagement for sustainability: Wombat community forest management case study. *Australian Geographer* **35**, 301–315.

Nocentini, S., Buttoud, G., Ciancio, O. and Corona, P. (2017). Managing forests in a changing world: The need for a systemic approach. A review. *Forest Systems* **26**, eR01.

DNRE (Department of Natural Resources and Environment) (2002) *Our Forests our Future: Victorian Government Statement on Forests*. Department of Natural Resources and Environment, Melbourne, Victoria.

O'Brien, E.A. (2003). Human values and their importance to the development of forestry policy in Britain: A literature review. *Forestry* **76**, 3–17.

O'Brien, L. and Watson, I. (2014). In conversation with Uncle Lewis: Bushfires, weather-makers, collective management. *AlterNative: An International Journal of Indigenous Peoples* **10**, 450–461.

O'Hara, K.L. and Nagel, L.M. (2013). The stand: Revisiting a central concept in forestry. *Journal of Forestry* **111**, 335–340.

Ormsby, A.A. and Bhagwat, S.A. (2010). Sacred forests of India: A strong tradition of community-based natural resource management. *Environmental Conservation* **37**, 320–326.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, Cambridge, UK.

Ough, K. (2001). Regeneration of Wet Forest flora a decade after clear-felling or wildfire – is there a difference? *Australian Journal of Botany* **49**, 645–664.

Pascoe, B. (2014) *Dark Emu, Black seeds: Agriculture or Accident?* Magabala Books Aboriginal Corporation, Broome, Western Australia.

Patterson, T. and Hunt, J. (2012). Reconnecting with culture for future generations. In: Altman, J.C. and Kerins, S. (Eds.) *People on Country: Vital Landscapes, Indigenous Futures*, pp. 202–212. The Federation Press, Alexandria, NSW.

Pedaste, M., Mäeots, M., Siiman, L.A., De Jong, T., Van Riesen, S.A., Kamp, E.T., Manoli, C.C., Zacharia, Z.C. and Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review* **14**, 47–61.

Penman, T.D., Binns, D.L. and Kavanagh, R.P. (2008a). Quantifying successional changes in response to forest disturbances. *Applied Vegetation Science* **11**, 261–268.

Penman, T.D., Binns, D.L., Shiels, R.J., Allen, R.M. and Kavanagh, R.P. (2008b). Changes in understorey plant species richness following logging and prescribed burning in shrubby dry sclerophyll forests of south-eastern Australia. *Austral Ecology* **33**, 197–210.

Petheram, R.J., Stephen, P. and Gilmour, D. (2004) Collaborative forest management: A review. *Australian Forestry* **67**, 137–146.

Pouliot, A. (2012) Fungi and biodiversity conservation. *Park Watch: June 2013* **253**, 26–27.

Pressey, R.L. (1998). Algorithms, politics and timber: an example of the role of science in a public, political negotiation process over new conservation areas in production forests. In: Wills, R.T. and Hobbs, R.J. (Eds.) *Ecology for Everyone: Communicating Ecology to Scientists, the Public and the Politicians,* pp. 73–87. Surrey Beatty and Sons, Chipping Norton, NSW.

Price, K., Roburn, A. and MacKinnon, A. (2009). Ecosystem-based management in the Great Bear Rainforest. *Forest Ecology and Management* **258**, 495–503.

Pryke, J.S. and Samways, M.J. (2012). Conservation management of complex natural forest and plantation edge effects. *Landscape Ecology* ***27***, 73–85.

Pyne, S.J. (1991). Fire down under: How the First Australians put a continent to the torch. *The Sciences* **31**, 39–45.

Rab, M.A. (1994). Changes in physical properties of a soil associated with logging of *Eucalyptus regnans* forest in southeastern Australia. *Forest Ecology and Management* **70**, 215–229.

Ralph, M. (2017) Conservation values of the Wombat Forest and Macedon Region, Wombat Forestcare Inc, Melbourne, Victoria.

Rapport, D.J. (1989). What constitutes ecosystem health? *Perspectives in Biology and Medicine* **33**, 120–132.

Regan, H.M., Colyvan, M. and Burgman, M.A. (2002). A taxonomy and treatment of uncertainty for ecology and conservation biology. *Ecological Applications* **12**, 618–628.

Regan, T.J., MacHunter, J., Sinclair, S.J., Bruce, M.J., Neil, J., Parker, E. and Nam, B. (2023). Structured decision making to navigate trade-offs between multiple conservation values in threatened grasslands. *Conservation Science and Practice* **5***,* e12953.

Ribe, R. (2002). Is scenic beauty a proxy for acceptable management? The influence of environmental attitudes on landscape preferences. *Environment and Behaviour* **34**, 757–780.

Roberts, N. (2012) Mining threat to wombat forest. *Park Watch: September 2012* **250**, 10–11.

Ross, S. R. J., O'Connell, D. P., Deichmann, J. L., Desjonquères, C., Gasc, A., Phillips, J. N., Sethi, S.S., Wood, C.M. and Burivalova, Z. (2023). Passive acoustic monitoring provides a fresh perspective on fundamental ecological questions. *Functional Ecology* **37**, 959–975.

Roxburgh, S.H., Wood, S.W., Mackey, B.G., Woldendorp, G. and Gibbons, P. (2006). Assessing the carbon sequestration potential of managed forests: A case study from temperate Australia. *Journal of Applied Ecology* **43**, 1149–1159.

Royer-Tardif, S., Bauhus, J., Doyon, F., Nolet, P., Thiffault, N. and Aubin, I. (2021). Revisiting the functional zoning concept under climate change to expand the portfolio of adaptation options. *Forests* **12**, 273.

Runge, M.C. and Walshe, T. (2014). Identifying objectives and alternative actions to frame a decision problem. In: Guntenspergen, G.R. (Ed) *Application of Threshold Concepts in Natural Resource Decision Making,* pp. 29–43. Springer, New York, USA.

Schaeffer, D.J., Herricks, E.E. and Kerster, H.W. (1988). Ecosystem health: I. Measuring ecosystem health. *Environmental Management* **12**, 445–455.

Schultz, L., Duit, A. and Folke, C. (2011). Participation, adaptive co-management, and management performance in the world network of biosphere reserves. *World Development* **39**, 662–671.

Sher, A.A., El Waer, H., González, E., Anderson, R., Henry, A.L., Biedron, R. and Yue, P. (2018). Native species recovery after reduction of an invasive tree by biological control with and without active removal. *Ecological Engineering* **111**, 167–175.

Shakesby, R.A., Wallbrink, P.J., Doerr, S.H., English, P.M., Chafer, C.J., Humphreys, G.S., Blake, W.H. and Tomkins, K.M. (2007). Distinctiveness of wildfire effects on soil erosion in south-east Australian eucalypt forests assessed in a global context*. Forest Ecology and Management* **238**, 347–364.

Simberloff, D.S., and Abele, L.G. (1976). Island biogeography theory and conservation practice. *Science* **191(4224)**, 285–286.

Sinclair, S.J., Griffioen, P., Duncan, D.H., Millet-Riley, J.E. and White, M.D. (2015). Quantifying ecosystem quality by modeling multi-attribute expert opinion. *Ecological Applications* **25**, 1463–1477.

Singh, G.G., Sinner, J., Ellis, J., Kandlikar, M., Halpern, B.S., Satterfield, T. and Chan, K. (2017). Group elicitations yield more consistent, yet more uncertain experts in understanding risks to ecosystem services in New Zealand bays. *PloS one* **12**, e0182233.

Spindler, E.A. (2013). The history of sustainability the origins and effects of a popular concept. In: Jenkins, I. and Schröder. R. (Eds) *Sustainability in Tourism: A Multidisciplinary Approach*, pp. 9–31. Springer, Wiesbaden, Germany.

Stan, K. and Sanchez-Azofeifa, A. (2019). Tropical dry forest diversity, climatic response, and resilience in a changing climate. *Forests* **10**, 443.

Stevenson, J.R., Villoria, N., Byerlee, D., Kelley, T. and Maredia, M. (2013). Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production. *Proceedings of the National Academy of Sciences* **110**, 8363–8368.

Steward, A.L., Datry, T. and Langhans, S.D. (2022). The terrestrial and semi-aquatic invertebrates of intermittent rivers and ephemeral streams. *Biological Reviews* **97**, 1408–1425.

Suter, G.W. (1993). A critique of ecosystem health concepts and indexes. *Environmental Toxicology and Chemistry: An International Journal* **12**, 1533–1539.

Sutton, P. and Walshe, K. (2021) *Farmers or Hunter-gatherers? The Dark Emu Debate.* Melbourne University Press, Carlton, Victoria.

Taylor, A. (1998). *A Forester's Log: The Story of John La Gerche and the Ballarat-Creswick State Forest, 1882–1897*. Melbourne University Press, Carlton South, Victoria

Thoreau, H.D. (1854) *Walden; or, Life in the Woods*. Ticknor and Fields, Boston, USA.

Trigger, D. and Mulcock, J. (2005). Forests as spiritually significant places: Nature, culture and Belonging ‘in Australia. *The Australian Journal of Anthropology* **16**, 306–320.

UN (United Nations) (1987) *Report of the World Commission on Environment and Development: Our Common Future (the "Brundtland Report").* United Nations Department of Public Information.

Vangansbeke, P., Gorissen, L., Nevens, F. and Verheyen, K. (2015). Towards co-ownership in forest management: Analysis of a pioneering case 'Bosland' (Flanders, Belgium) through transition lenses. *Forest Policy and Economics* **50**, 98–109.

VEAC (2019) *Central West Investigation, Final report*. Victorian Environment Assessment Council (VEAC), Melbourne, Victoria.

Wadawurrung Traditional Owners Aboriginal Corporation (2020) *Paleert Tjaara Dja: Let's Make Country Good Together 2020–2030*. Wadawurrung Country Plan. WTOAC, Ballarat, Victoria.

Walters C.J. (1986) *Adaptive Management of Renewable Resources*. MacMillan, New York, USA.

Walters C.J. and Holling C.S. (1990). Large-scale management experiments and learning by doing. *Ecology* **71**, 2060–2068.

Westoby, M., Walker, B. and Noy-Meir, I. (1989). Opportunistic management for rangelands not at equilibrium. *Journal of Range Management* **42**, 266–274.

Whitehead, P.J., Purdon, P., Russell-Smith, J., Cooke, P.M. and Sutton, S. (2008). The management of climate change through prescribed savanna burning: Emerging contributions of indigenous people in northern Australia. *Public Administration and Development: the International Journal of Management Research and Practice* **28**, 374–385.

Wilkinson, S.R., Naeth, M.A. and Schmiegelow, F.K.A. (2005). Tropical forest restoration within Galapagos National Park: Application of a state-transition model. *Ecology and Society* **10**, 28.

Williams, B.K. (2011). Passive and active adaptive management: Approaches and an example. *Journal of Environmental Management* **92**, 1371–1378.

Williamson, B. (2021). *Cultural Burning in NSW: Challenges and Opportunities for Policy Makers and Aboriginal Peoples*. ANU Press, Canberra, ACT.

WWF (World Wildlife Fund). (2020*). Living planet report 2020 – Bending the Curve of Biodiversity Loss*. World Wildlife Fund, Gland, Switzerland.

Yapp, G., Walker, J. and Thackway, R. (2010). Linking vegetation type and condition to ecosystem goods and services. *Ecological Complexity* **7**, 292_301.

Zandersen, M. and Tol, R.S. (2009). A meta-analysis of forest recreation values in Europe. *Journal of Forest Economics* **15**, 109–130.

Appendices

Appendix 1 – A watchlist of high-risk environmental weeds for the Wombat Forest

Summary

Context: Recent storms have resulted in widespread disturbance within the Wombat State Forest increasing opportunities for environmental weeds to establish or spread. Creating a watchlist of high-risk taxa is a simple yet effective approach for concentrating surveillance and response effort towards the highest risk weeds.

Aims: The aim of this study was to develop a watchlist of high-risk environmental weeds for the Wombat State Forest.

Methods: We created a list of candidate weed taxa by identifying all introduced or taxa with uncertain provenance in the Flora of Victoria, in the eight Local Government Areas that are within 10 km of the Wombat State Forest. We then downloaded all the records for these taxa from the Atlas of Living Australia recorded within the study extent (the rectangular area within ~10 km of the Wombat State Forest). We also looked up the risk ratings of the candidate weed taxa in the two recently completed state-wide weed risk assessments: the Advisory List of Environmental Weeds and the Environmental Weed Risk Database. We identified a watchlist of high-risk emerging weeds as those taxa that had not been recorded in the study extent until 2010 or later and having a risk rating of very high and with a maximum score for spread potential (consistent with a newly arrived taxa) in the advisory list or high on the weed risk assessment. In addition, we identified a watchlist of high-risk established weeds as those taxa that had been recorded within the Wombat State Forests at least once since 1970 and had an advisory list risk rating of very high or a weed risk assessment rating of high risk.

Results: We identified 539 taxa that had Atlas of Living Australia records within the study extent and had been assessed by at least one of the state-wide weed risk assessments. We applied the rules to this checklist to create the two watchlists (as well as some long watchlists with less strict criteria). A further 12 taxa were assessed manually, with one taxon added to the watchlist of emerging weeds. We identified 22 taxa that met the criteria for the emerging weed watchlist, and 28 taxa that met the criteria for the established watchlist. A further 8 taxa did not have a risk rating and will need to be assessed in the future.

Conclusions and implications: The watchlists created here are predominantly based on state-wide risk assessments, but restricted to taxa occurring within the Wombat State Forest (established) or nearby the forest and recorded since 2010 (emerging). They have identified environmental weeds with high spread potential and high impact. However, impact has been assessed at a state-wide level and therefore may not necessarily occur within the Wombat State Forest.

The watchlists could be further refined by assessing the degree to which impacts might be considered to affect the environmental values of the Wombat State Forest in particular. This could be assessed using a combination of literature review and expert assessment.

Furthermore, the watchlists do not account for the benefit, feasibility or cost-effectiveness of any eradication or management effort. The watchlists identify a manageable number of high-risk species on which to target surveillance and management efforts, and provide a useful first cut of weed priorities. However, it is likely that watchlists accounting for benefit, feasibility or cost-effectiveness would contain some different weed taxa to those on these watchlists.

Introduction

Environmental weeds (invasive plant species that invade natural ecosystems) can pose a risk to biodiversity. Watchlists are a simple method that can be used to communicate which weeds to look out for in a specific area. Watchlists of environmental weeds have been developed at national, regional, and local scales (Frey 2017; Moshobane et al. 2019; Osunkoya et al. 2019) for a range of applications. Broadly, a watchlist aims to identify high risk or high impact species that are a priority for intervention. When considering a specific locality, a regional or national list might be too general and result in irrelevant taxa on the watchlist or miss locally high threat species (Koch et al. 2016). However, resources to undertake detailed risk assessments at a local scale are rarely available. One common approach to address this situation is to use local information on distribution and environmental conditions to adapt a national or regional list to a more specific location (Frey 2017; Blood et al. 2019; Osunkoya et al. 2019).

In forests, disturbances that create gaps in the canopy provide recruitment opportunities for weed invasion if propagules are present. The major windstorms in 2021 resulted in substantial areas of fallen trees and debris across the Wombat State Forest. This substantial disturbance event will stimulate recruitment of forest plants including environmental weeds. In addition, the subsequent clean-up and safety works associated with the wind-throw areas may create an additional level of disturbance as well as the possibility of introducing invasive species propagules. Therefore, it is timely to create a watchlist of high risk introduced plant species that can be used to focus environmental weed surveillance across the forest during the clean-up and recovery phase.

The aim of this study is to generate watchlists of:

- emerging environmental weeds that pose a high risk to the forest should they become established
- established high impact environmental weeds that might threaten biodiversity without management intervention.

The approach taken was to create a checklist of introduced species known to occur within ~10 km of the Wombat State Forest using the Flora of Victoria and the Atlas of Living Australia (ALA). We then filtered this checklist using a combination of state-wide risk ratings, distribution within the study region and expert judgement to produce a watchlist for emerging weeds and a watchlist for established weeds.

Methods

Compilation of checklist for the Wombat State Forest

The first step was to create a checklist of introduced plant species that have been recorded as occurring within the region and so have the opportunity to invade the Wombat State Forest. The polygons defining the Wombat State Forest were downloaded from the DataVic layer CROWNLAND_PLM25_STATE_FOREST (via the R package VicmapR, accessed 29 September 2022). This area was selected to ensure the advice provided in this report was relevant to weed control decisions being made in real time, rather than in relation to the proposed Wombat-Lerderderg Nation Park, which is yet to be instated (VEAC 2019). A rectangular box that defined the extent of these polygons was created (WSF extent). A second box ~ 10 km wider in each direction (10 km extent) was used as the definition of the study region for the purpose of creating the checklist of species and identifying records from the ALA (Figure A1.1).

Candidate taxa

The study extent intersected with eight Local Government Areas (LGA; Hepburn, Macedon Ranges, Moorabool, Mount Alexander, Melton, Hume, Ballarat, Central Goldfields). The Flora of Victoria website (accessed 28–29 September 2022) was used to identify a list of all species with establishment means classified as either ‘introduced’ (1024 taxa) or ‘uncertain’ (37 taxa). The

uncertain taxa were reviewed by ARI, and a subset of the taxa (13/37) were included for consideration in the checklist. Taxa with 'Occurrence Status' listed as 'extinct' or 'excluded' in the Flora of Victoria were excluded from further analysis, resulting in a final list of 987 taxa for further consideration.

The ALA was then searched (using the galah R package) for records of all species on the checklist located within the 10 km extent (accessed 9 November 2022). Each observation was classified as occurring in either the WSF polygons, the WSF extent or the 10 km extent using the sf package in R. The observation dataset was used to create the checklist of introduced species.

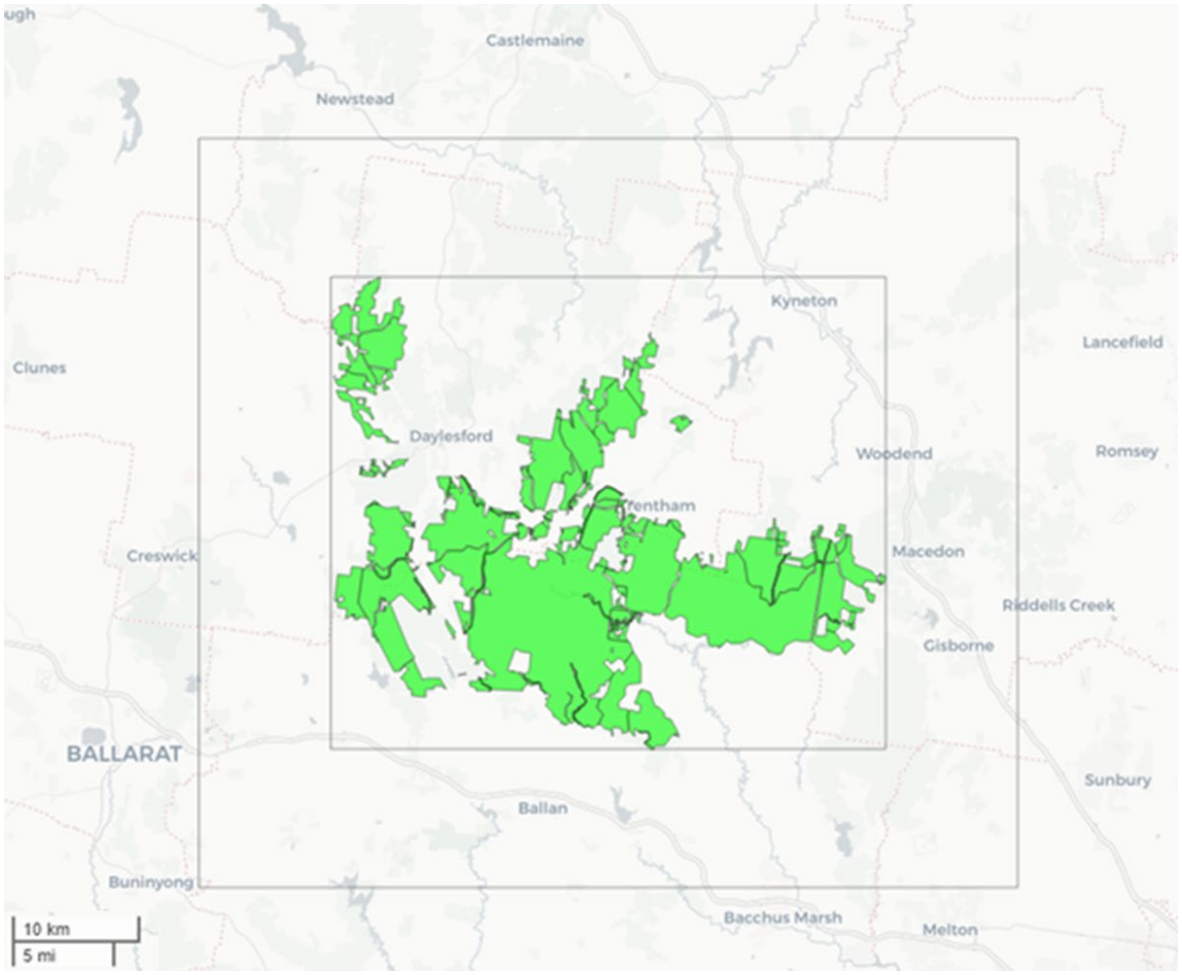

Figure A1.1. The Wombat State Forest and study region. Green polygons are the Wombat State Forest, the inner box is the Wombat State Forest extent, and the outer box is the extent of the study region and is 10 km wider than the Wombat State Forest extent.

Risk ratings

The risk ranking for species in the Advisory List of Environmental Weeds (White et al. 2022) and the weed risk assessments contained in the WESI Project Victorian Environmental Weed Risk Database V10_27Feb2019 (Blood et al. 2018) were used assess the weed risk of the candidate taxa. The weed risk database provides scores using a version of the Australian Weed Risk Assessment adapted for environmental weeds (excluding some of the more agricultural questions).

The weed risk assessment scores weed risk using information on species traits, invasion history elsewhere and potential distribution (when available) from the literature. The overall score combines scores for invasiveness and impact and varies from 0–1, with a threshold of 0.32868 identified to separate high risk weeds in the weed risk database. The weeds risk database provides scores for 574 taxa.

The advisory list risk rating score provides a nested ranking of species risk. Taxa are first ranked according to their potential impact and degree of spread (score can be 0, 10, 20 or 30), with taxa predicted to have a high impact and with substantial potential for future spread ranked highest. Within this ranking, taxa are then sorted by their invasiveness and capacity to disperse with fast spreading and far dispersing taxa ranked most highly (score options 0, 1, 2, 3). Finally, within this ranking, taxa are ranked according to the breadth of habitat types that the taxa can invade, with more generalist taxa scoring more highly (score options (0.0, 0.1, 0.2, 0.3). The minimum risk rating score is 0 and the maximum score is 33.3. The advisory list provides risk rating scores for 1810 taxa based on expert assessment of each taxon's attributes. These taxa were then classified into five risk categories (very high, high, moderately high, medium and low).

The taxa on each of the two weed lists were harmonised with the ALA taxonomy. In some cases, taxa in the weed lists resolved only to a genus level and were excluded from the analysis. There were also some taxa in the weed lists (e.g. sub-species, synonyms) that resolved to the same species in the ALA taxon concept but had different risk ratings. In these cases, the highest risk rating was assigned to the species and used in making the watchlists.

The risk ratings were then joined to the list of ALA observations of candidate taxa using the ALA scientific name to match the taxa. Not all of the candidate taxa had corresponding risk ratings from the advisory list and/or the weed risk assessment.

Checklist

The final checklist comprised the scientific name of each taxon along with the number of ALA records in the 10 km extent, the WSF polygons, the WRF extent and the WRF extent only (i.e. excluding records withing the WSF polygons), the year of the first and last observation for each taxon in the 10 km extent, the advisory list risk rating score (along with the values of each contributing component) and the impact, invasiveness and combined Weed Risk Assessment (WRA) score from the WESI database.

Creating the watchlists

The aim of this part of the analysis was to filter the checklist to compile some shorter lists of high-risk taxa on which agency staff could concentrate surveillance and/or management efforts (Figure A1.2).

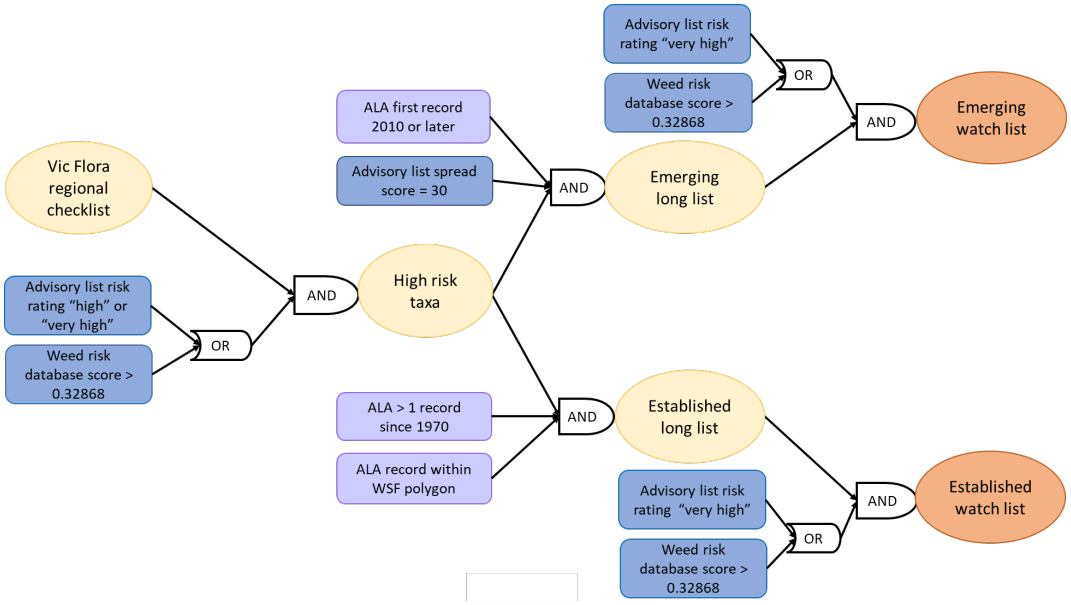

Figure A1.2. Process of filtering the initial checklist to produce the two watchlists. Lists are represented by ovals while rectangles indicate criteria based on state-wide risk assessments (blue) or Atlas of Living Australia (ALA) records (purple).

We aimed to identify high risk taxa separated into a list of emerging taxa, that might be in an early phase of invasion in the forest, and a second list of well-established taxa that it is also important to consider.

A long list of high-risk species was identified by filtering to include species that were ranked as high risk in either of the state-wide risk assessments. Taxa that had last been recorded prior to 1970 were excluded from the list. This list was then split into an emerging and established long list.

Emerging was defined as species that had an advisory list spread score of 30, because this indicates that a substantial portion of the taxa's potential range is not yet occupied (White et al. 2018) and have not been recorded in the study extent prior to 2010 (Figure A1.3). The established list was restricted to taxa with observations within the Wombat State Forest polygon.

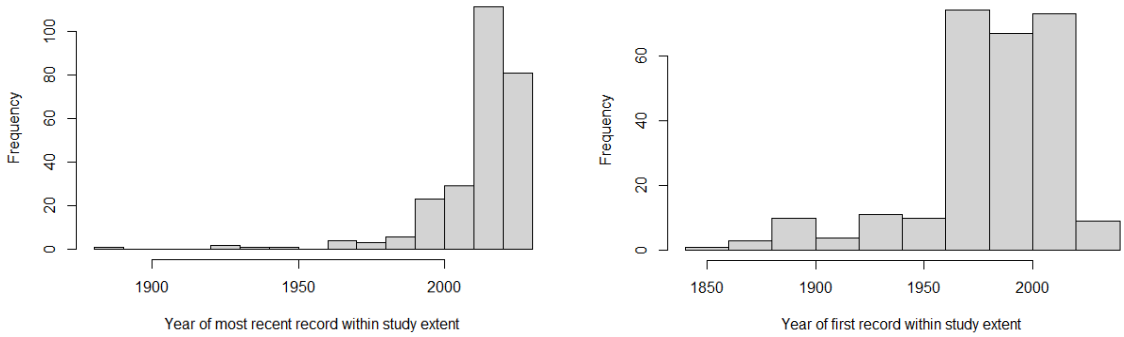

Figure A1.3. Year of last record (a) and first record (b) for the 264 taxa classified as high risk in either risk assessment.

The short watchlists for emerging and established species were created by filtering the long lists to include only those taxa rated as very high risk in the advisory list (weed risk score 31.3–33.3) or as high risk in the weed risk assessment (≥ 0.32868). Taxa that were not on either of the weed lists were assessed by ARI, with any considered as high risk by ARI also included on the watchlists.

Results

Wombat State Forest checklist

Candidate taxa

The Flora of Victoria identified 987 candidate taxa of interest based on checklists for the eight Local Government Regions that intersected with the 10 km extent. These 987 taxa were matched from the Flora of Victoria checklist to the ALA resulting in 952 species names – because the ALA did not recognise all of the sub-species and varieties included in the Flora of Victoria list as separate taxa. One taxon, *Hedera Hibernica* (Boston Ivy) was not matched in the ALA, returning a genus level name instead and was excluded from further analysis. However, in some treatments *Hedera Hibernica* is considered a synonym for *Hedera helix* (English Ivy), which was included on the list. The search returned 23,597 ALA observation records for 641 taxa within the study extent (the majority of records (21,214) were derived from the Victorian Biodiversity Atlas).

Risk ratings

Taxonomic harmonisation of the weed lists with the ALA taxonomy resulted in 1782 resolved taxa from the advisory list and 535 taxa from the weed risk database. A total of 67 taxa in the weed lists returned either no match (27 taxa) or were resolved to the genus level only (40 taxa) in the ALA and were excluded from further analysis. Some taxa resolved to the same ALA name but had different risk scores (12 pairs in advisory list, nine pairs in weed risk database). This meant that when the risk

scores were joined to the ALA observations of taxa within the study extent these taxa had multiple entries. When this occurred, the maximum risk score was used when creating the checklists.

Checklist

The checklist contained records for 634 taxa, but 65 of these did not have risk ratings. Of the 65 taxa that did not have risk ratings, 22 were taxonomic anomalies, 23 taxa were already on the checklist at a different taxonomic level (e.g. species, subspecies or variety), and 12 taxa had risk scores at a different taxonomic level that were not on the checklist. These taxa were assessed manually, with one taxon added to the emerging watchlist (*Phalaris arundinacea* or Reed Canary Grass*)*. Finally, eight taxa did not have a risk rating and will need to be assessed in the future. The final checklist used for ranking comprised the remaining 569 taxa that had risk ratings.

Watchlists

Of the 569 taxa in the checklist, 560 had a risk rating in the advisory list, including 247 that had an advisory list risk rating of high or very high (with 88 of these rated as having a very high risk). Many less taxa (133) had risk assessments in the weed risk database, and 124 of these also had a risk rating in the advisory list. There were 41 taxa classified as being high risk based on the weed risk assessment methodology. Overall, 262 taxa were included on the high risk list, of which nine had not been recorded in the study region since 1970. These were excluded from the analysis, resulting in a long list of 253 taxa.

High risk emerging species

Of the 253 taxa, 51 taxa were included in the emerging taxa long list, with 23 taxa on the emerging watchlist (including the manually added taxa) (Table A1.1).

High risk established species

The long list of high risk established taxa comprised the remaining 202 high risk taxa that were not classified as emerging. However, only 69 of these were recorded as occurring within the Wombat State Forest polygons and therefore included on the established taxa long list. The established watchlist (Table A1.2) comprised 28 taxa.

Table A1.1. Watchlist of emerging weeds.

ALA records is the number of records recorded within the study extent, Earliest record is the year of the first record, Latest record is the year of the last record, ALEW rating is the risk rating from the Advisory List of Environmental Weeds, ALEW score is the risk score from the Advisory List of Environmental Weeds, WRA score is the risk score from the Weed Risk Assessment Database (taxa with a score > 0.32868 are considered high risk in this assessment). Taxa are listed in alphabetical order.

Scientific name	Vernacular name	Family	ALA records	Earliest record	Latest record	ALEW risk rating	ALEW score	WRA score
Billardiera fusiformis	Bluebell Creeper	Pittosporaceae	12	2012	2022	Very high	33.3	NA
Coprosma repens	Looking-Glass Bush	Rubiaceae	6	2012	2020	Very high	33.1	0.324
Cotoneaster pannosus	Silverleaf Cotoneaster	Rosaceae	1	2015	2015	Very high	33.3	0.277
Crocosmia x crocosmiiflora	Montbretia	Iridaceae	3	2018	2021	Very high	32.3	0.414
Ficus carica	Brown Turkey Fig	Moraceae	2	2011	2022	High	23.1	0.362
Gazania rigens	Trailing Gazania	Asteraceae	1	2020	2020	Very high	32.3	0.209
Gleditsia triacanthos	Honey Locust	Fabaceae	1	2021	2021	Very high	31.3	0.386
Glyceria maxima	Reed Sweetgrass	Poaceae	1	2011	2011	Very high	32.1	0.323
Ixia polystachya	Variable Ixia	Iridaceae	3	2011	2011	Very high	32.2	NA
Juncus acutiflorus	Sharp-Flowered Rush	Juncaceae	3	2019	2019	Very high	32.1	NA
Juncus effusus	Common Rush	Juncaceae	1	2019	2019	Very high	33.1	NA
Leucanthemum x superbum	Shasta Daisy	Asteraceae	1	2013	2013	Very high	32.2	NA
Ligustrum lucidum	Large-Leaved Privet	Oleaceae	1	2015	2015	Very high	33.2	0.393
Lophopyrum ponticum	Tall Wheat-Grass	Poaceae	1	2018	2018	Very high	33.2	NA
Mesembryanthemum crystallinum	Crystalline Ice Plant	Aizoaceae	1	2021	2021	Very high	32.3	NA
Phalaris arundinacea	Reed Canary Grass	Poaceae	2	2012	2012	Very high	32.3	NA

Scientific name	Vernacular name	Family	ALA records	Earliest record	Latest record	ALEW risk rating	ALEW score	WRA score
Phalaris canariensis	Canary Grass	Poaceae	3	2011	2015	Very high	33.2	NA
Pinus nigra subsp. *laricio*	Corsican Pine	Pinaceae	1	2015	2015	Very high	32.2	NA
Pittosporum eugenioides	Tarata	Pittosporaceae	3	2012	2012	Very high	32.1	NA
Viola odorata	Sweet Violet	Violaceae	4	2011	2015	Very high	32.1	NA
Watsonia meriana var. *bulbillifera*	Bubil Watsonia	Iridaceae	4	2010	2018	Very high	32.2	0.199
Zantedeschia aethiopica	Arum Lily	Araceae	2	2021	2021	Very high	32.1	0.404

Table A1.2. Watchlist of established weeds.

ALA records is the number of records recorded within the study extent, Earliest record is the year of the first record, Latest record is the year of the last record, ALEW rating is the risk rating from the Advisory List of Environmental Weeds, ALEW score is the risk score from the Advisory List of Environmental Weeds, WRA score is the risk score from the Weed Risk Assessment Database (taxa with a score > 0.32868 are consider high risk in this assessment). Taxa are listed in alphabetical order.

Scientific name	Vernacular name	Family	ALA records	Earliest record	Latest record	ALEW risk rating	ALEW score	WRA score
Acer pseudoplatanus	Scottish Maple	Sapindaceae	17	1984	2022	Very high	32.2	0.319
Cenchrus clandestinus	Kikuyu	Poaceae	8	1980	2021	Very high	32.2	NA
Conium maculatum	Hemlock	Apiaceae	159	1975	2022	Moderately high	22.1	0.33
Cotoneaster glaucophyllus	Glaucous Cotoneaster	Rosaceae	14	1995	2013	Very high	33.2	0.328
Crataegus monogyna	Hawthorn	Rosaceae	330	1964	2022	High	23.2	0.368
Cytisus scoparius	English Broom	Fabaceae	364	1945	2022	High	22.3	0.396
Digitalis purpurea	Foxglove	Plantaginaceae	5	1980	2018	Moderately high	22.1	0.399
Erica lusitanica	Spanish Heath	Ericaceae	67	1980	2022	Very high	32.3	0.326
Genista monspessulana	Montpellier Broom	Fabaceae	580	1896	2022	Very high	32.2	0.318
Hakea salicifolia subsp. *salicifolia*	Willow-Leaved Hakea	Proteaceae	9	1882	2022	Very high	32.2	NA
Hedera helix	Ivy	Araliaceae	46	1980	2022	Very high	32.3	0.306
Ilex aquifolium	Holly	Aquifoliaceae	122	1973	2022	Very high	33.2	0.326
Leycesteria Formosa	Himalaya Honeysuckle	Caprifoliaceae	10	2004	2022	Very high	33.2	0.428
Lycium ferocissimum	African Box-Thorn	Solanaceae	198	1973	2022	High	23.3	0.344
Marrubium vulgare	Horehound	Lamiaceae	129	1964	2021	High	23.3	0.345
Nassella trichotoma	Nassella Tussock	Poaceae	1984	1970	2022	Very high	33.2	0.432
Oxalis pes-caprae	Oxalis/Soursob	Oxalidaceae	37	1980	2022	Very high	31.3	0.293
Oxalis purpurea	Large-Flower Wood-Sorrel	Oxalidaceae	17	1997	2022	High	31.2	0.336

Scientific name	Vernacular name	Family	ALA records	Earliest record	Latest record	ALEW risk rating	ALEW score	WRA score
Paspalum distichum	Water Couch	Poaceae	65	1964	2012	Very high	32.1	NA
Pinus radiata	Monterey Pine	Pinaceae	319	1973	2022	Very high	32.3	0.335
Prunus laurocerasus	Cherry Laurel	Rosaceae	13	1996	2022	High	31.1	0.346
Ranunculus repens	Creeping Buttercup	Ranunculaceae	34	1973	2020	Very high	33.2	NA
Rosa rubiginosa	Sweet Briar	Rosaceae	362	1964	2022	High	22.2	0.38
Salix alba	White Willow	Salicaceae	31	1980	2018	NA	NA	0.405
Salix cinerea	Grey Sallow	Salicaceae	53	1980	2015	NA	NA	0.484
Salix cinerea subsp. *cinerea*	Grey Sallow	Salicaceae	4	1997	2014	Very high	33.2	NA
Salix x fragilis	Crack Willow	Salicaceae	116	1991	2020	NA	NA	0.425
Ulex europaeus	Gorse	Fabaceae	1853	1973	2022	High	22.2	0.404

Comparison of the two risk assessments

There was a lot of variation in how the two different risk assessments scored the same taxa (Figure A1.4). For example, there were many taxa classified as very high risk on the advisory list (Figure A1.4, to the right of the dotted line) that were not considered high risk in the weed risk assessment (below the horizontal line) and vice versa. Likewise, there were many taxa classified as high risk in the weed assessment (above the horizontal line), but not considered very high risk in the advisory list (to the left of the dashed vertical line).

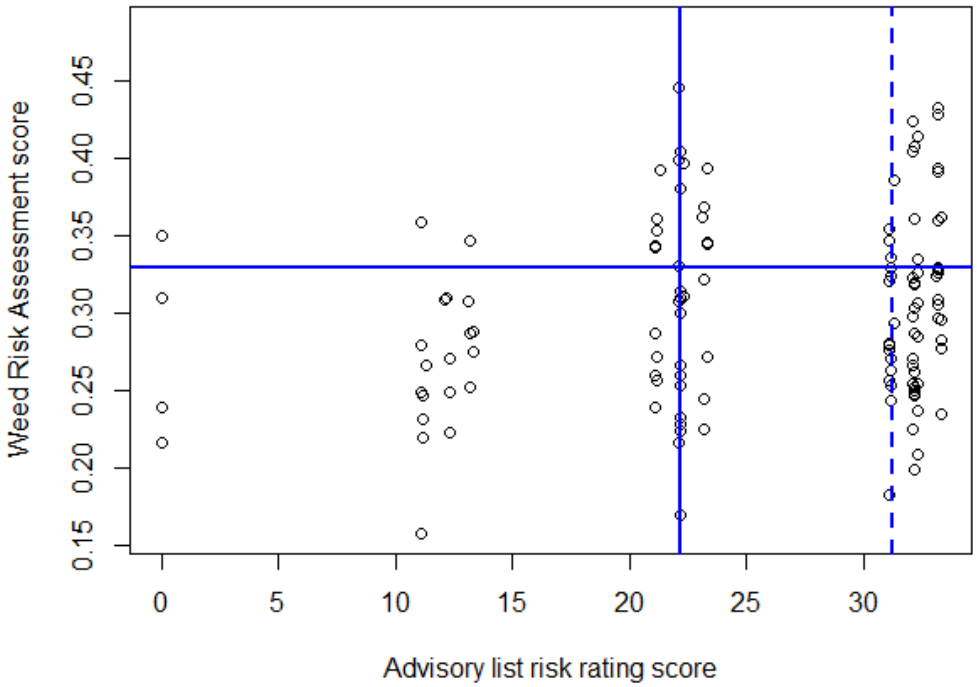

Figure A1.4. Plot of weed risk assessment versus advisory risk scores for the 125 taxa that were assessed using both methods. Species above the horizontal line are classified as high risk by the weed risk assessment. Species to the right of the solid vertical line are classified as 'high risk' in the advisory list and those to the right of the dashed line are classified as 'very high risk'.

Discussion

Watchlists can be a simple and effective way to concentrate agency efforts on key, high risk species (Frey 2017; Moshobane et al. 2019; Osunkoya et al. 2019). They are straightforward to communicate and understand and therefore the information can be readily disseminated throughout the community. However, if a list is too long, it can overwhelm users, reducing effectiveness (Reaser et al. 2020). When the number of candidate taxa is large, the challenge then lies in identifying a reliable and transparent way for creating a short list of priorities.

While risk provides a useful first cut, recent advances in invasive species prioritisation have highlighted that having clear objectives to underpin invasive species management (Tulloch et al. 2015) as well as considering the tractability of management, the benefit to biodiversity, and the cost of management can substantially improve management outcomes (Firn et al. 2015; Carwardine et al. 2019; Moore et al. 2021).

While resources for a full cost-benefit analysis may be unavailable at this time, it might be possible to elicit information regarding the specific biodiversity values likely to be impacted by different species and the tractability of management as part of the second round of workshops (see next steps below). This information could be used to derive an indicator of management benefit that could be used to rank the weeds to maximise overall benefit.

Limitations and caveats

Atlas records tend to be spatially biased towards frequently visited or easily visited locations, particularly if observations are contributed by members of the public. Furthermore, reporting of introduced taxa is likely much lower and done likely less frequently by the public, because these taxa are often overlooked unless they are part of a specific awareness program. Consequently, the observations are likely an incomplete record of environmental weeds in the region. In particular, we expect that the distributions of the weeds are more extensive than is recorded here. The final watchlist for established weeds is therefore likely to omit some weeds that are present in the forest because the list was restricted to taxa recorded within the Wombat State Forest polygons. It is for this reason that we will consult with local agency staff and existing weed lists to ensure that we have not overlooked any important established or emerging weeds before the watchlists are finalised.

Furthermore, incursions are often well established before they are first detected; consequently, it is possible that taxa identified as emerging have had populations present prior to 2010.

The two risk assessments were not always consistent in the ranking of taxa included in both methods. This is not surprising as the approaches taken were quite different. However, it is not obvious which of these assessments best aligns with the goals of the watchlists. This issue merits further consideration.

Next steps

The watchlists developed here could be improved if we included assessments of impact to the biodiversity of the Wombat State Forest and the tractability of management. Better targeted impact assessments could be derived through a combination of elicitation during workshops, as well as an assessment of invasive taxa preferred habitat.

Information regarding management feasibility could be generated using a combination of local knowledge, expert judgment and methods developed as part of the WESI approach for assessing the feasibility of management (Blood and James 2018). It is likely that feasibility assessments for many of the taxa considered here have been undertaken in other parts of Victoria and could be readily adapted.

Incorporating this additional information would likely change the composition of the watchlists, identifying taxa whose management will likely confer the most biodiversity benefit.

Finally, this list is very much for now in that we're just considering taxa that are nearby rather than trying to scan the horizon for threats into the future. Horizon scanning methods to identify future invasion risks have been developed (Kendig et al. 2022).

References

Blood, K. and James, R. (2018). *Managing weeds: Decide the response guide: A guide for determining the appropriate response to weeds at the early stage of invasion on public land in Victoria*. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Blood, K., James, R. and Panetta, F.D. (2018). *Managing weeds: Assess the risk guide: A guide for assessing the risk for weeds at the early stage of invasion on public land in Victoria*. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Blood, K., James, R., Panetta, F.D, Sheehan, M. Adair, R. and Gold, B. (2019). *Early invader manual: Managing early invader environmental weeds in Victoria*. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Carwardine, J., Martin, T.G., Firn, J., Reyes, R.P., Nicol, S., Reeson, A., Grantham, H.S., Stratford, D., Kehoe, L. and Chadès, I. (2019). Priority threat management for biodiversity conservation: A handbook. *Journal of Applied Ecology* **56**, 481–490.

Firn, J., Martin, T.G., Chadès, I., Walters, B., Hayes, J., Nicol, S. and Carwardine, J. (2015). Priority threat management of non-native plants to maintain ecosystem integrity across heterogeneous landscapes. *Journal of Applied Ecology* **52**, 1135–1144.

Frey, M. (2017). An invasive plant watch list for the National Capital Regional National Parks (USA). *Natural Areas Journal* **37**, 108–117.

Kendig, A.E., Canavan, S., Anderson, P.J., Flory, S.L., Gettys, L.A., Gordon, D.A., Iannone, B.V., Kunzer, J.M., Petri, T., Pfingsten, I.A. and Lieurance, D. (2022). Scanning the horizon for invasive plant threats using a data-driven approach. *NeoBiota* **74**, 129–154.

Koch, C., Jeschke, J.M., Overbeck, G.E. and Kollmann, J. (2016). Setting priorities for monitoring and managing non-native plants: Toward a practical approach. *Environmental Management* **58**,465–475.

Moore, J.L., Camaclang, A.E., Moore, A.L., Hauser, C.E., Runge, M.C., Picheny, V. and Rumpff, L. (2021). A framework for allocating conservation resources among multiple threats and actions. *Conservation Biology* **35**, 1639–1649.

Moshobane, M.C., Mukundamago, M., Adu-Acheampong, S. and Shackleton, R. (2019). Development of alien and invasive taxa lists for regulation of biological invasions in South Africa. *Bothalia* **49**, 1–11.

Osunkoya, O.O., Froese, J.G., Nicol, S., Perrett, C., Moore, K., Callander, J. and Campbell, S. (2019). A risk-based inventory of invasive plant species of Queensland, Australia: Regional, ecological and floristic insights. *Austral Ecology* **44**, 1123–1138.

Reaser, J.K., Frey, M. and Meyers, N.M. (2020). Invasive species watch lists: Guidance for development, communication, and application. *Biological Invasions* **22**, 47–51.

Tulloch, V.J.D., Tulloch, A.I.T, Visconti, P., Halpern, B.S., Watson, J.E.M., Evans, M.C., Auerbach, N.A., Barnes, M., Beger, M., Chadès, I., Giakoumi, S., McDonald-Madden, E., Murray, N.J., Ringma, J. and Possingham H.P. (2015). Why do we map threats? Linking threat mapping with actions to make better conservation decisions. *Frontiers in Ecology and the Environment* **13**, 91–99.

VEAC (2019). *Central West Investigation, Final report. Victorian Environment Assessment Council (VEAC)*, Melbourne, Victoria.

White, M., Cheal, D., Carr, G.W., Adair, R., Blood, K. and Meagher, D. (2018). *Advisory list of environmental weeds in Victoria*. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

White, M., Cheal, D., Carr, G.W., Adair, R., Blood, K., Muir, A. and Meagher, D. (2022). *Advisory list of environmental weeds in Victoria 2022*. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Appendix 2 – Objectives hierarchy

Table A2.1. Objectives hierarchy elicited from each of the four partner groups.

A tick (✓) shows that a given value came up prominently in consultation with a particular group. The lack of a tick does NOT imply that a given value is not important for any partner group.

Where higher-level values were not elicited specifically, these were included in the objective's hierarchy if lower-level values within a high-level were identified in the relevant workshop.

Value	DJAARA	Wadawurrung	Wurundjeri	Agency
The Country is healthy	✓	✓	✓	✓
**Vegetation structure is healthy*	✓	✓	✓	✓
Forest stand structure (i.e. size-class distribution) is adequate	✓	✓	✓	✓
The balance between small and large trees is adequate	✓	✓	✓	✓
Visibility/mobility through the trees is appropriate	✓	✓	✓	
Forest has diversity of layers (trees/shrubs/forbs/grasses)				✓
Forest understorey structure is right (density, height, diversity)				✓
Vegetation structure varies from place to place, providing the best arrangement of habitats for animals and plants	✓	✓		✓
Logs are present, with appropriate abundance and size class distribution			✓	✓
Canopy trees are healthy	✓	✓	✓	✓
Large trees (often with hollows and wide canopies) are retained, abundant and healthy	✓	✓	✓	✓
Tree dieback (caused by lack of groundwater, herbivory, phytophthora, fire) is absent, declining or controlled				✓
Native animals are thriving	✓	✓	✓	✓
*Native fauna species richness and abundance are increasing		✓	✓	
*Abundance of culturally significant fauna species is stable and increasing	✓	✓	✓	✓
Wombat populations are increasing or maintained at an adequate level		✓		
Koala populations are increasing or maintained at an adequate level		✓		
Echidna populations are increasing or maintained at an adequate level		✓		✓
Platypus populations are increasing or maintained at an adequate level (also rare or threatened)		✓		✓
Quoll populations are increasing or maintained at an adequate level (also rare or threatened)	✓	✓	✓	✓
Bandicoot populations are reintroduced and maintained at a desired level (also rare or threatened)		✓		✓
Phascogale populations are increasing or maintained at an adequate level (also rare or threatened)		✓		✓
Dingo populations are reintroduced and maintained at a desired level (also rare or threatened)	✓	✓	✓	✓
Goanna populations are increasing or maintained at an adequate level	✓	✓		
Wedge-Tailed Eagle populations are increasing or maintained at an adequate level		✓		
Emu populations are reintroduced and maintained at a desired level	✓	✓	✓	✓
Butterfly and other insect (e.g. ants, spiders and bardi grubs) populations are increasing or maintained at an adequate level		✓		✓
Amphibians (e.g. frogs) are increasing or maintained at an adequate level		✓		
Reptiles (e.g. snakes) are increasing or maintained at an adequate level		✓		✓
Fish and eels are increasing or maintained at an adequate level	✓	✓		

Value	DJAARA	Wadawurrung	Wurundjeri	Agency
Crustaceans (e.g. yabbies) are increasing or maintained at an adequate level		✓		
Kangaroos/wallabies are available for hunting	✓	✓		✓
Birds (totem species) are increasing or maintained at an adequate level			✓	✓
Bats (totem species) are increasing or maintained at an adequate level			✓	✓
Bush rats and water rats (Rakali) are increasing or maintained at a desired level				✓
Rare and threatened fauna are thriving	✓	✓	✓	✓
Possum/glider populations are increasing or maintained at an adequate level	✓	✓	✓	✓
Antechinus are increasing or maintained at a desired level				✓
Leadbeater's Possum are reintroduced and maintained at a desired level				✓
Powerful Owl are increasing or maintained at a desired level				✓
Lyrebirds are reintroduced and maintained at a desired level				✓
Hollow-dependant fauna (e.g. birds, possums) are increasing or maintained at desirable level				✓
Animal species are moving and behaving according to the seasons	✓			
Native flora and fungi are thriving	✓	✓	✓	✓
*Native plant species richness and abundance are increasing	✓	✓	✓	✓
*Native fungi species richness and abundance are increasing	✓	✓	✓	✓
Native plants are green and growing, flowering or seeding, in the right seasons (right species, right places)	✓	✓		
*Culturally significant flora are stable and increasing	✓	✓	✓	✓
Grass Tree populations are increasing or maintained at an adequate level		✓		
Silver Banksia populations are increasing or maintained at an adequate level		✓		
Murnong and other tuber-plant populations (e.g. Nardoo) are increasing or maintained at an adequate level	✓	✓		
Populations of medicine plants are increasing or maintained at an adequate level	✓	✓		
Populations of fibre-producing plants (e.g. Lomandra) are increasing or maintained at an adequate level	✓	✓		
Populations of tool making plants (e.g. red gum, Buloke) are increasing or maintained at an adequate level	✓			
*Rare and threatened flora are stable and increasing				✓
Creeping Grevillea populations are increasing or maintained at a desired level				✓
Leafless Bossiaea populations are increasing or maintained at a desired level				✓
**Soil is protected and healthy*	✓	✓	✓	✓
Soil profile is stable and eroded areas are restored	✓	✓	✓	✓
Soil is free from contamination	✓		✓	
Soil nutrient status is at or approaching pre-agricultural levels	✓			
**Waterways are protected and healthy*	✓	✓	✓	✓
Forest streams have good water quality		✓	✓	✓
Ground and spring water quality and recharge level is adequate	✓		✓	✓
Creeks and floodplains are connected				✓
Water is free of waterborne pathogens (affecting both humans and livestock)				✓
Water regimes are appropriate				✓
Waterways are seen as living/changing entities				✓
Desirable ecological processes are occurring, with plants and animals playing their roles	✓	✓	✓	✓

Value	DJAARA	Wadawurrung	Wurundjeri	Agency
Native predators are regulating animal populations (sufficient to replace role played by exotic predators, once removed)	✓	✓		
Native pollinators are diverse, abundant and active (sufficient to replace role played by exotic honeybees, once removed)		✓		
Seed dispersal is adequate	✓	✓		✓
Native plants are producing adequate food resources for animals (e.g. seeds, fruits, foliage) (sufficient to replace roles played by weeds (e.g. pine seeds), once removed)	✓			
Small native mammals and birds are digging the soil		✓		✓
Organic decomposition is adequate				✓
Ecological threats are absent, declining or controlled	✓	✓	✓	✓
Pine plantations are absent, or their area is decreasing	✓	✓		
*Forest is free of invasive plant species	✓	✓		✓
Cover of weeds, measured collectively, is decreasing		✓		✓
Pine trees (exotic) are absent, declining or controlled		✓		✓
Gorse is absent, declining or controlled				✓
Blackberry is absent, declining or controlled				✓
Willow is absent, declining or controlled				✓
Broom (English, Cape) is absent, declining or controlled				✓
Pasture grasses are absent, declining or controlled				✓
Holly is absent, declining or controlled				✓
Laurel (Portuguese, Cherry) is absent, declining or controlled				✓
Periwinkle is absent, declining or controlled				✓
Hemlock (riparian areas) is absent, declining or controlled				✓
Thistle (perennial) is absent, declining or controlled				✓
Spanish Heath is absent, declining or controlled				✓
Invasive native Acacias (e.g. *A. howittii, A. floribunda, A. baileyana, A. pravissima*) are absent, declining or controlled				✓
Weed control is strategic		✓		✓
Herbicide use is minimised		✓		
Emerging and established weeds are mapped in the forest (particularly storm damage areas)				✓
*Forest is free of pest animals	✓	✓	✓	✓
Pest fishes (e.g. trout and carp) are absent, declining or controlled				✓
Introduced honeybees are absent, declining or controlled		✓		
Rabbits are absent, declining or controlled		✓	✓	✓
Foxes are absent, declining or controlled		✓	✓	✓
Cats are absent, declining or controlled		✓	✓	✓
Deer are absent, declining or controlled		✓	✓	✓
Goats are absent, declining or controlled			✓	✓
Pigs are absent or declining in the forest			✓	✓
Phytophthora impacts are absent, declining or controlled		✓		✓
Rubbish dumping does not occur, or is cleaned up appropriately		✓		
Firewood collection is appropriate or removed				✓
The forest gives the right sensations to people	✓			

Value	DJAARA	Wadawurrung	Wurundjeri	Agency
The forest has the right aroma for the right time (growth, flowers, animals, decay, fire)	✓			
The forest has the right sounds for the right time (birds, frogs, wind, people)	✓			
The forest has the right play of light and colour for the right time (grass, flowers, sun, shade)	✓			
The forest has the right feeling/touch for the right time (grass, flowers, sun, shade)	✓			
The forest is managed to maximise resilience and adaptation to change	✓	✓		✓
The forest is resilient to current and future climate change	✓			✓
The effects of forest fragmentation are prevented or reversed				✓
The forest is resilient to future storm damage	✓			✓
The forest is resilient to damage from windthrow	✓	✓		✓
The forest is resilient to uncontrolled canopy fires	✓	✓		
The People are healthy	✓	✓	✓	✓
Governance, collaboration, decision-making processes and access arrangements are appropriate and fair	✓	✓	✓	✓
First Nations People are involved appropriately in all management decisions	✓	✓		
Processes are in place which foster group decision-making processes within First Nations People groups (e.g. community EOI processes)	✓	✓		
Decisions are made on Country, where possible and appropriate	✓		✓	
Decision-making processes are appropriate, fair and empower those with the right knowledge	✓			
All structures and approaches to management foster self-determination for First Nations People	✓		✓	✓
First Nations People are consulted/supported in funding bids (i.e. scoping)			✓	
Partnerships with private landholders increase	✓			✓
Tension between people, biodiversity and forest use (e.g. timber production, 4WD recreation, firewood collection, prospecting) is resolved				✓
**Traditional culture is healthy*	✓	✓	✓	✓
*Cultural rights are practised on Country regularly	✓	✓	✓	
*First Nations People are on Country regularly, and have free access	✓	✓	✓	
*Cultural landforms are protected and healthy	✓	✓	✓	
Fire is used in the landscape to promote culture	✓	✓	✓	
Cultural objects are being made (using materials from the forest, and being used in the forest)	✓	✓		✓
Hunting is carried out	✓	✓		
Traditional seasonal calendars are used to plan management and describe changes in the forest	✓			
The land is actively tended in the right way	✓	✓		
Traditional stories are told (by the appropriate people, to the appropriate people, in the right time and place)	✓	✓		
New stories are created and told	✓			
Cultural heritage is visible (where appropriate; e.g. scarred trees)			✓	
Cultural sites are explored, recorded and studied by those with appropriate skills (e.g. archaeologists)		✓	✓	
There are safe places to carry out cultural practices (e.g. cultural reserves)		✓	✓	✓
Cultural landscapes are (re)identified	✓			
Water is used in the landscape to promote culture	✓	✓		✓

Value	DJAARA	Wadawurrung	Wurundjeri	Agency
**Forest provides jobs and opportunities*	✓	✓	✓	✓
*First Nations People are supported economically	✓		✓	✓
Cultural tourism is increasing	✓	✓		✓
*Forest resources benefit First Nations People	✓		✓	✓
Resources are available for identifying and documenting cultural sites	✓	✓		
**Information (new and old) is held, shared and updated appropriately*	✓	✓	✓	✓
*Traditional knowledge and heritage is protected and continued	✓	✓	✓	
Knowledge generated by adaptive management is exchanged fairly between all partners	✓	✓		✓
The intellectual property of First Nations People is respected	✓		✓	
The general public is interested in forest culture and biology (via appropriate education programs)	✓		✓	✓
New residents (around Wombat Forest) engage with First Nations People goals and aspirations				✓
**Recreational opportunities promote healthy people and Country*	✓	✓	✓	✓
Tracks and signs/art encourage connection to nature and responsible park usage (e.g. goldfields track)		✓	✓	✓
Culturally significant areas are formally reserved, and access controlled	✓	✓	✓	
Traditional names are used for locations and tracks, wherever appropriate		✓		✓
Forest is free of 4WD and motorbikes			✓	✓
The forest supports spirituality, wellbeing and creativity				✓
Use of mountain bikes and horses constrained to appropriate areas or removed				✓
Opportunities in the forest are targeted to diverse audiences (age, ability, ethnicity)				✓
Public facilities (e.g. toilets) are maintained and meet the needs of forest visitors				✓
Recreation activities (e.g. walking, riding, fishing) should promote low impact use and be excluded from sensitive/important areas				✓
The forest is used to inspire and educate people about nature				✓
Story of forest includes both pre- and post-invasion history				✓
**Forest use and management is safe*	✓	✓	✓	✓
Risk of falling trees is mitigated where appropriate				✓
Fire risk is minimised where possible				✓
Tracks are well maintained and safe			✓	✓
**Stewardship by the community increases*				✓

* indicates high-level values identified by partners for ranking in Workshop 2 (i.e. ranking and scoring actions)

Appendix 3 – Elicitation data

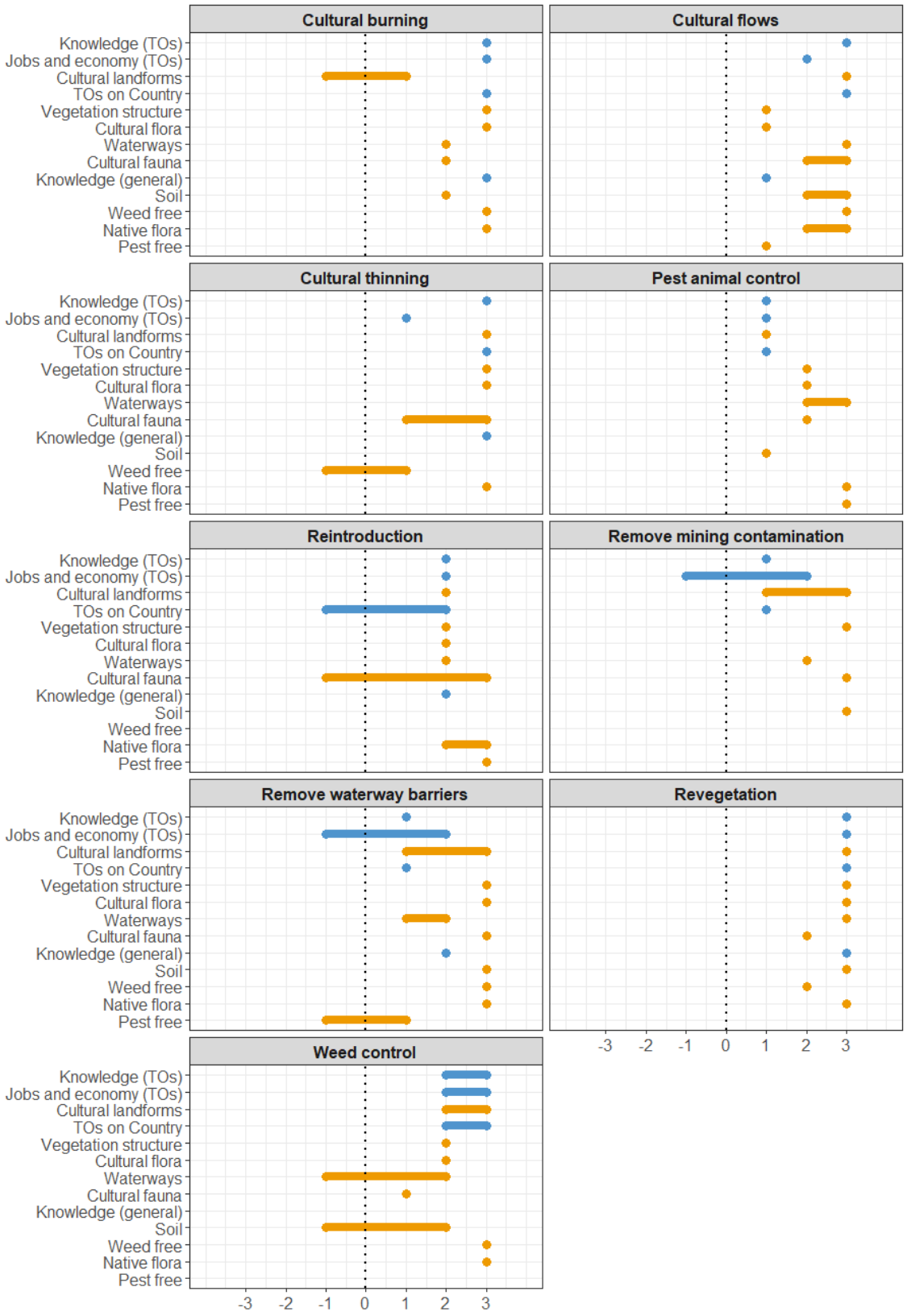

Figure A3.1. The elicited benefit (positive values) or harm (negative values) with uncertainty of on-ground actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the DJAARA workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

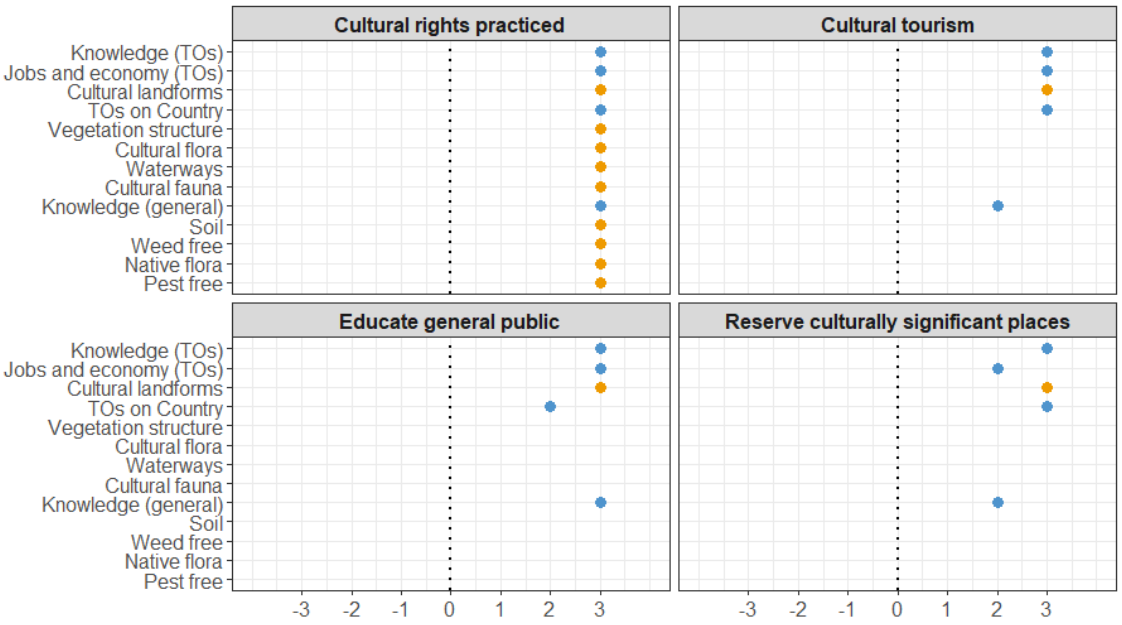

Figure A3.2. The elicited benefit (positive values) or harm (negative values; with uncertainty) of administrative actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the DJAARA workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

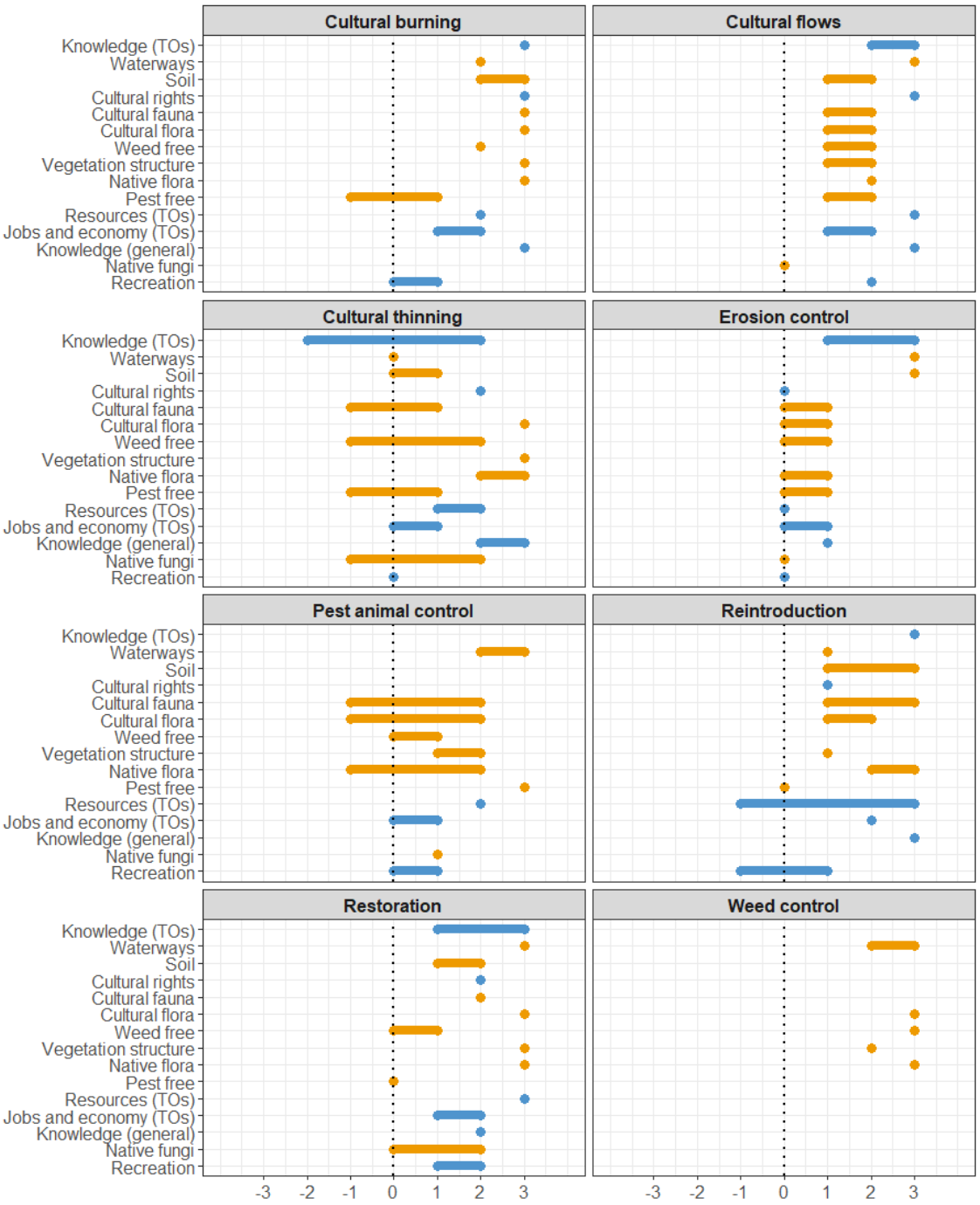

Figure A3.3. The elicited benefit (positive values) or harm (negative values; with uncertainty) of on-ground actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the Wadawurrung workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

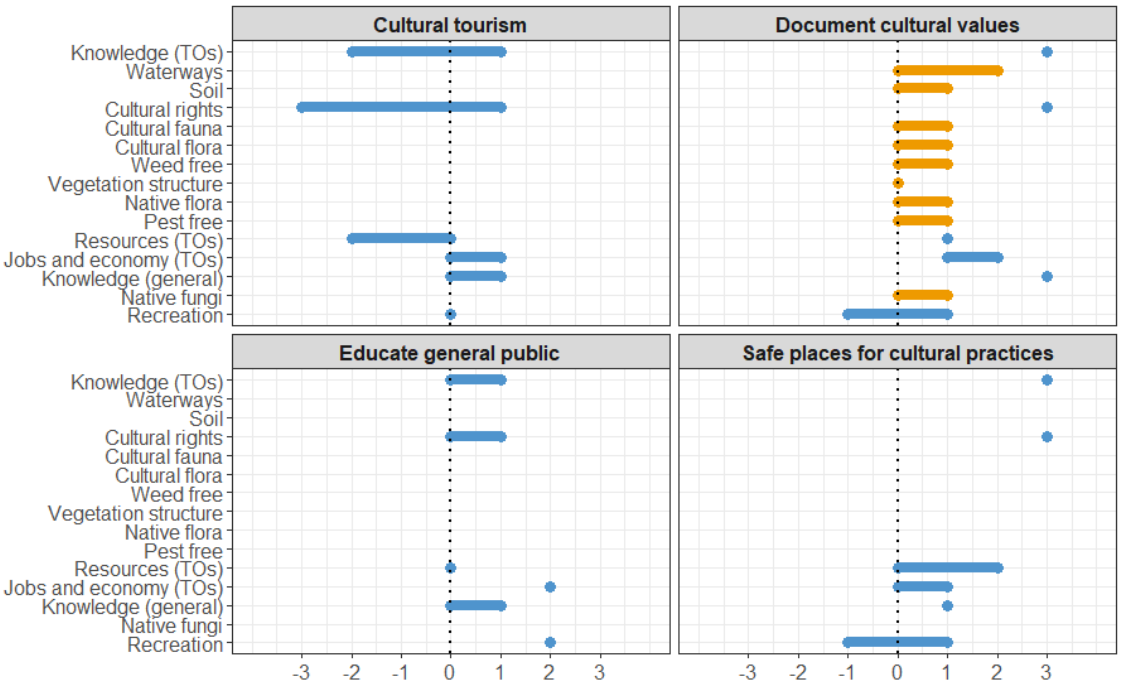

Figure A3.4. The elicited benefit (positive values) or harm (negative values; with uncertainty) of administrative actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the Wadawurrung workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

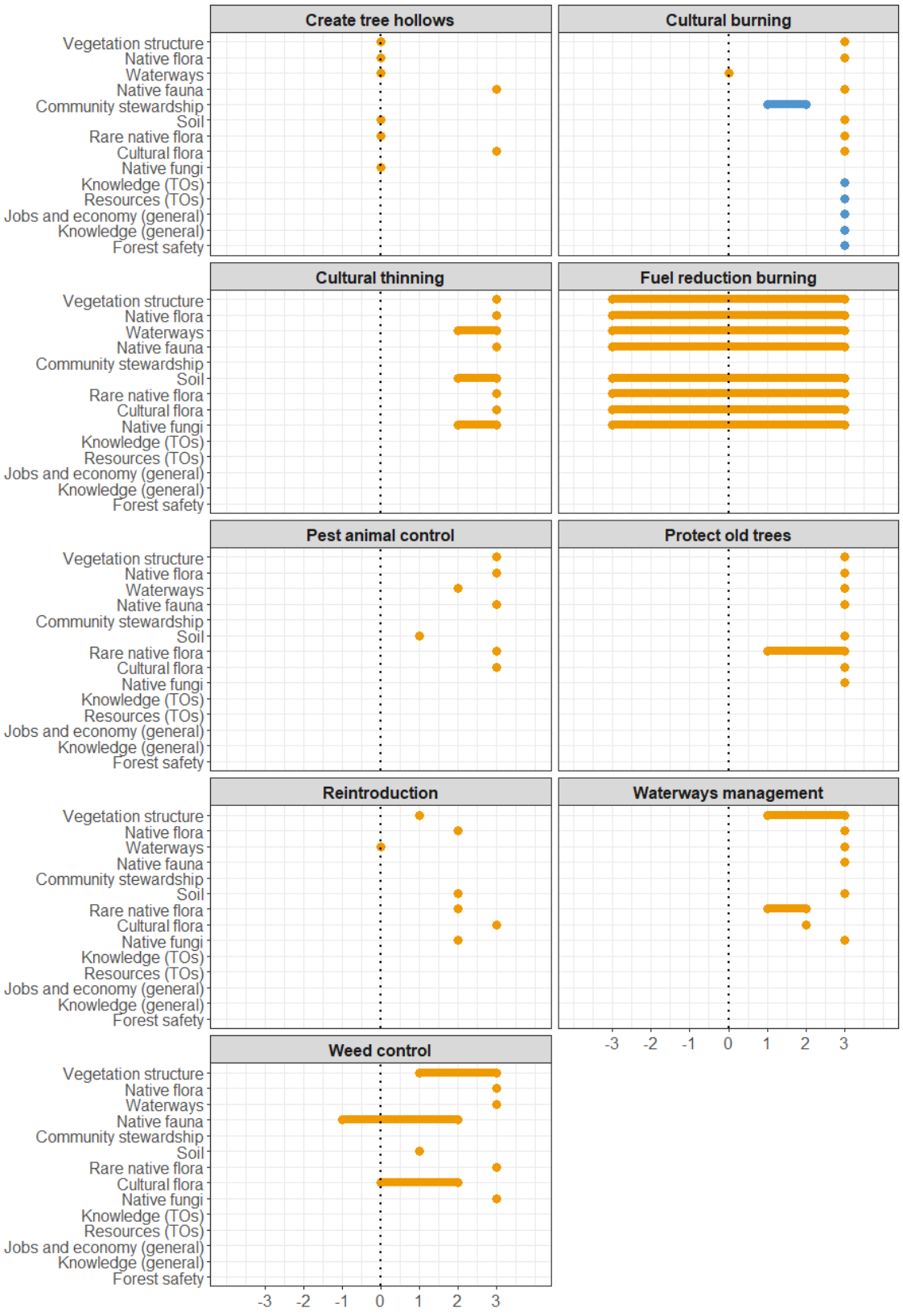

Figure A3.5. The elicited benefit (positive values) or harm (negative values; with uncertainty) of on-ground actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the agency workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

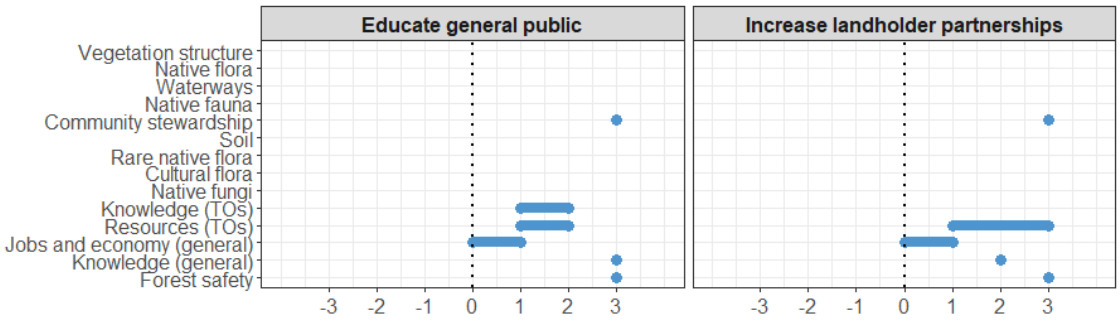

Figure A3.6. The elicited benefit (positive values) or harm (negative values; with uncertainty) of administrative actions for all values assessed (value ranked on the y-axis from highest ranked (top) to lowest (bottom)) in the agency workshop. Data coloured blue indicate Healthy People values and those coloured orange indicate Healthy Country values. Aside from data without uncertainty, best estimates were not elicited.

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