Regional Forest Agreements Scientific Advisory Panel (SAP)

Scientific Advice to Support Regional Forest Agreement Negotiations

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Disclaimer

This report has been prepared with all due care and diligence, using the best information available at the time of publication; however, the Scientific Advisory Panel holds no responsibility for any errors or omissions. Any decisions made by other parties based on this report are solely the responsibility of those parties. The information contained in this report does not necessarily represent government policy.

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Abbreviations

CAR reserve system	Comprehensive, Adequate and Representative reserve system
DELWP	Department of Environment, Land, Water and Planning (Victoria)
DJPR	Department of Jobs, Precincts and Regions
EMS	Environmental Management System
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERF	Emissions Reduction Fund
ESFM	Ecologically Sustainable Forest Management
EVC	Ecological Vegetation Class
FFG Act	*Fauna and Flora Guarantee Act 1988* (Vic.)
GCM	Global Climate Model
IFM	Intensive Forest Management
IUCN	International Union for Conservation of Nature
JANIS	Joint ANZECC/MCFFA NFPS Implementation Sub-Committee
MIS	Managed Investment Schemes
MNES	Matters of National Environmental Significance
PVA	Population Viability Analysis
RCF	Representative Climate Futures
RFA	Regional Forest Agreement
RFA Act	*Regional Forest Agreements Act 2002* (Cth)
RFA-RG	Regional Forest Agreements Reference Group
SAP	RFA Scientific Advisory Panel
SDM	Species Distribution Model
TSSC	Threatened Species Scientific Committee
VFMP	Victorian Forest Monitoring Program
VROTS	Victorian Rare or Threatened Species

Executive Summary

The Department of Environment, Land, Water and Planning (DELWP) has appointed a Scientific Advisory Panel (SAP) to provide advice on current scientific knowledge in relation to the modernisation of the Regional Forest Agreements (RFAs) and the Victorian forest management system.

This report provides advice and recommendations on the following matters in relation to the modernisation of the RFAs:

- Improvement of the management of Matters of National Environmental Significance (MNES) in the RFA system
- Refinement and better management of the Comprehensive, Adequate and Representative (CAR) reserve system
- Implications of climate change for the full suite of forest values and potential improvements to the RFAs to ensure appropriate management
- Active management of forests to support a range of outcomes
- A strategic approach to the development of new plantations
- Development and implementation of a more adaptive forest management system.

The SAP recommends that the following commitments should be made in the RFAs to enable improved management of Victoria's forests in relation to the abovementioned matters.

1. Improved management of Matters of National Environmental Significance (MNES)

1.1 Commit to the following actions in the RFAs to enable MNES established under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) to be more effectively dealt with in the forest management framework:

- Provision of resources for the design, establishment and maintenance of a MNES system within the RFA framework. The system would:
    - Establish and maintain a list of forest-related MNES and mapping overlays for the forest-dependent MNES
    - Incorporate the forest-related MNES list and mapping overlays into the forest planning and approval processes.
- Require the review and updating of the forest-related MNES list and overlays whenever the MNES lists under the EPBC Act are changed, or on a regular review cycle (suggested every 3 years).
- Require that the forest-related MNES list and mapping overlays be applied in the planning, management and evaluation of the CAR reserve system.
- Require that any Recovery Plans produced under the EPBC Act and any Action Statements produced under the *Flora and Fauna Guarantee Act 1988* (Vic) (FFG Act) for forest-related MNES are implemented and that their effectiveness is reported under the RFAs, noting that some Recovery Plans and Action Statements have already proven inadequate. There should be a regular review cycle to ensure that the latest versions of the Action Statements and Recovery Plans are incorporated into the RFA system.
- Establish an agency or unit within DELWP to manage, curate and report on the MNES system.

- Require that compliance of forestry practices with MNES requirements is monitored by an independent body, such as the Commissioner for Environmental Sustainability, including the provision of sufficient resources for adequate assessment of on-ground activities.

2. Refinement and better management of the Comprehensive, Adequate and Representative (CAR) reserve system

2.1 Review the *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia* (JANIS criteria).[a] This would be timely given advances in forest conservation science over the past 20 years.

2.2 Review the spatial extent and configuration of the CAR reserve system:

- Assess the representation, adequacy and comprehensiveness of the areal representation of habitats and vegetation communities, based on the JANIS criteria.
- Evaluate the utility of other spatial measures of the entire forest estate including the CAR reserve system such as levels of forest fragmentation, and the extent of edge effects and other spatial metrics of disturbance by human activities and wildfire.

2.3 Commit to a detailed assessment of the adequacy of current habitat for forest-associated species. This could be achieved through mapping analyses and targeted Population Viability Analysis (PVA) to determine adequacy of reserves to promote long-term species persistence.

2.4 Commit to the following actions in relation to old-growth forests:

- Develop appropriate updated definitions of old-growth forest, and apply these to provide updated maps of the extent of old growth
- Determine priority targets for old growth protection and management, including identification of areas where maturing forests can be managed to provide new cohorts of old growth in the future. See Recommendation 3 for further details relevant to potential impacts of climate change.

2.5 Require the development and implementation of new management plans for the CAR reserve system in each RFA region. Such plans should provide coordinated cross-tenure management of the full CAR reserve system. The plans should be consistent with adaptive approaches to management (see Recommendation 6) including strategies for managing current and emerging threats such as climate change (see Recommendation 3). Accountability for plan development and implementation needs to be clear.

2.6 Establish monitoring and review requirements for the CAR reserve system that provide sufficient flexibility to adapt management arrangements within much shorter intervals than a 5-yearly RFA review.

2.7 Undertake sensitivity analyses of the adequacy of the CAR reserve system and management plans under a range of climate change scenarios.

3. Create an adaptive capacity to deal with climate change

[a] ANZECC/MCFFA (1997) National Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. Australian and New Zealand Environment and Conservation Council & Ministerial Council on Forestry, Fisheries and Aquaculture. Canberra, Australia.

3.1 Commit to the establishment and implementation of an adaptive approach to forest management that includes clear goals for managing climate change impacts on the full suite of forest values.

An adaptive approach to management is recommended as the primary mechanism for dealing with the highly uncertain but potentially major effects of climate change on many important forest values. The following important issues should be explicitly addressed when assessing climate-change impacts and solutions in the adaptive approach:

- Clearly defined conceptual models that articulate current understanding of climate change impacts on the full suite of forest values, and on ecosystem responses and feedbacks. Such models would describe relationships between forest attributes and processes for climate-change impacts at a range of scales and provide a strong basis for setting goals, measurable outcomes and associated monitoring strategies.
- Clearly stated and, where possible, quantifiable management goals for environmental outcomes relevant to the full suite of forest values under climate change. Such goals should be regularly revisited and refined in response to new evidence relating to climate-change effects, and to the ranking of the relative importance of forest values to society. This will most likely require prioritising some forest values over others, requiring inevitable trade-offs.
- Explicit recognition of the need to manage forests for climate change mitigation, e.g. to maintain or enhance forest carbon stocks. This could involve embedding carbon accounts into decisions about management practices, including uncertainties around how carbon additionality and permanence attributed to changed management will be influenced by climate change.
- Well-designed and implemented monitoring systems that make it possible to assess performance against goals, including the specification of indicators (including early-warning indicators), sample sizes and sampling designs for detecting change in the full suite of forest values (see Recommendation 6).
- Built-in mechanisms to test alternative, innovative management practices, including evaluation of climate change adaptation and mitigation practices.
- Regular re-evaluation of the results of monitoring and other scientific evidence to assess system predictions and management strategies, noting that the current provision for five-yearly reviews of RFA achievements may be too long to take effective adaptive-management responses for many forest values under climate change, and that a shorter review cycle (say 3 years) would be preferable.
- Identifying and defining climate-change related triggers for review of forest management goals and practices under the RFA.
- Research capacity will need to be strengthened to address knowledge gaps associated with considerable uncertainties relating to the future climate, especially the nature of rainfall (total amount, season and intensity), the biological responses of forests, dynamic and interactive effects among multiple potential stressors, and the ability of managers to deal with increasing fire risks. There is also major uncertainty relating to the effectiveness of altered management to mitigate or adapt to climate change.

3.2 Commit to the development of a cross-tenure approach to managing forests.

Effective responses to the many climate-change effects on multiple forest values will require coordinated management across tenures. Cross-tenure adaptive approaches to forest

planning and management will be challenging but are essential to addressing the threats posed by climate change. This will require strong co-operation between agencies, articulation of clear goals and significant investment in monitoring and evaluation processes that underpin adaptive responses (see Recommendation 6).

3.3 Commit to the implementation of pre-emptive management actions to mitigate the impacts of climate change on forest ecosystems.

There are considerable uncertainties around the impacts of climate change on multiple forest values and around the potential for management actions to mitigate those impacts. Nevertheless, the SAP identified the following actions as consistent with a precautionary approach to mitigating climate change impacts by reducing landscape-scale threats, and focusing on vulnerable forest elements:

- Continued active management that aims for appropriate fire regimes, which will likely require enhanced investment in bushfire detection and suppression activity to reduce the extent, severity and frequency of severe bushfires in many forest types.
- Identification and protection of those species and ecosystems most vulnerable to climate change as indicated by a range of representative climate futures, including identification of those at risk both within and outside existing reserves.
- Identification of climate refugia for key species and protection of these refugia from key threatening processes (including multiple threats).
- Support further improvements in spatial assessments of risks from soil erosion and mass movement after both management burns and wildfire; and addressing such risks in fire management planning and wildfire recovery plans.
- Strengthening capacity to reliably model both the direct and indirect effects of climate change on water yield from forest catchments.
- Identification, monitoring and management of the most threatening invasive plant and animal species under climate change.
- Active management of threatened fauna (e.g. faunal translocations, captive breeding programs), noting that there are significant risks associated with this approach.
- Active management of threatened plant species (e.g. ex situ seed banking, assessment of seed availability for obligate-seeder species before planned burning and effective monitoring of post-disturbance regeneration including re-seeding/ planting to ensure population persistence).
- Enhanced protection of remaining old-growth forests and identification of areas of forest to protect and grow through to ecological maturity.
- Greater buffering and compliance with existing requirements of patches of rainforest.

3.4 Commit to working with industry to identify how wood supply can be more flexibly managed under a changing climate

Climate change presents many challenges to the certainty of wood supply, particularly from native forests. It will be critical to work with the forest industry to address these challenges and to find workable solutions. Key considerations include:

- Development of an Integrated Wood Supply Strategy (See Recommendation 5) that considers both native forest and plantation wood sources and includes evaluation of how wood supply from both sources will be influenced by climate change and of alternative supply options as necessary.

- Explicit recognition in the RFAs and the Integrated Wood Supply Strategy of the uncertainties around the ongoing wood supply, which preclude commitments to fixed long-term availability of wood. This will necessitate quantification and clear communication of the probabilities of future wood supply that explicitly account for predicted climate-change impacts, particularly changed fire regimes.
- Investment/ co-investment in technological solutions and skills development to support the development of alternative wood products and to ameliorate anticipated changes in wood supply including new species mixes, log quality and reduced log size.

4. More active management of forests across tenures to deal with threats, uncertainties and new community goals

4.1 The SAP advocates use of a broad definition of 'active management', acknowledging the need to deal with threats, uncertainties and changing community goals, similar to that published by the American Society of Foresters.[b] Examples of such active management include the following practices (noting that many are currently implemented in some form in Victoria):

- Timber harvesting, tree planting, thinning, fertiliser use
- Control of invasive species (e.g. deer)
- Weed control
- Fire management – including fire suppression and planned burning
- Road and track management and maintenance, including construction or removal, as well as management of access including seasonal and permanent road closures.

4.2 When applying active management practices, particularly those which are 'new' and for which there is limited experience and/or empirical evidence, both potential benefits as well as risks should be carefully considered. Currently, the knowledge base in relation to active management is variable, and there have been few rigorous scientific studies to support evidence-based decision making in relation to some active-management practices. The SAP did not reach consensus on the potential implementation of some active-management practices, notably, intensive management of native forests for accelerated sawlog production[c].

4.3. If new active management measures are introduced, these should be undertaken using a rigorous adaptive management approach. This would include the development of conceptual models and hypotheses regarding the proposed intervention and its effects

[b] Society of American Foresters, Sustainable Forest Management Requires Active Forest Management. A Joint Position Statement of the Inland Empire Society of American Foresters and the Montana Society of American Foresters. http://www.cfc.umt.edu/saf/files/Active%20Forest%20Management.pdf

[c] Dr John Raison made the following recommendation (not endorsed by all other panel members), supporting detail is provided in Attachment 2: *Thinning, fertiliser addition and partial harvesting approaches should be further explored as a suite of silvicultural tools for accelerating sawlog production in regrowth stands in state forest, however a range of risks across the full suite of forest values would need to be addressed. An adaptive management approach would provide a means of managing these risks. Intensive management of a carefully selected, limited portion of regrowth may provide benefits for both sawlog production as well as increase the area of forest available for conservation. The scale and location of intensively managed areas should be determined as part of the regional forest management planning process, which takes account of both regional wood production and forest conservation goals.*

across the whole suite of forest values, implementation on a trial basis and monitoring, evaluation and reporting on the trial.

4.4 The RFA should commit to the review and evaluation of innovative management practices that actively address and anticipate the main threats posed to Victoria's forests, including mitigation and adaptation practices for addressing the threats associated with climate change. This will require considerable resources, especially for quantitative research and extensive monitoring.

5. A strategic approach to the development of new plantations

5.1 The RFAs should provide for improved coordination of planning and management arrangements between native forests and plantations, including development of a Victorian Integrated Wood Supply Strategy:

- A state-wide strategy that sits above a set of regional strategies is recommended to ensure that timber requirements and supply are planned with regard to state-wide as well as regional considerations.
- The strategy requires a mix of top-down (policy related) and bottom-up (biophysical, ecological, social and economic) considerations.
- Potential opportunities for onshore processing of the large amounts of eucalypt woodchips currently exported from the south-west of the state should be explored as part of the strategy, noting the spatial distribution of existing demand and the lead times required for the establishment of new plantations.

5.2. The SAP notes the government's proposed plantation expansion program and recommends that clear goals and objectives be established and articulated for the program.

Possible goals include:

- Increase the softwood estate – primary purpose to increase sawn timber, with the pulpwood by-products used for paper making.
- Increase the short-rotation hardwood estate – increased supply of pulpwood for domestic processing.
- Increase the hardwood sawlog estate – primary purpose to increase the amount and security of supply of sawlogs, with pulpwood by-products used for paper making.
- More trees in the landscape for multiple benefits – providing a combination of economic, environmental and social benefits. The relative balance between these benefits will depend on 'local' context and land-holder goals.

Objectives should be established with reference to the location, area, species, products and markets that additional plantations in Victoria would seek to deliver, noting the timeframes required for plantation establishment and risks to the various objectives.

5.3 The RFA should commit to the preparation of Regional Plantation Development Plans.

The Regional Plantation Development Plans should be consistent with the Victorian Integrated Wood Supply Strategy.

The plans should take account of opportunities and challenges posed by factors such as land availability (including assessment of social resistance to conversion of farmland to plantations as well as biophysical factors), climate change and impacts on water security.

The plans should have the capacity to manage complex issues such as the 600 mm rainfall 'rule' by ensuring water security is not compromised at local scales.

5.4 Victoria should consider lessons learned from the plantation and industry development strategies that have already been developed in other states across Australia.

6. Develop and implement a more adaptive forest management system

6.1 The RFAs should make a strong commitment to building an adaptive approach to forest management across all forests and outline a time frame for achieving this. Such an approach is the only realistic way in which future major uncertainties, including those relating to both the direct and indirect effects of climate change, can be managed. A significant increase in resourcing for planning, monitoring, evaluation of outcomes against planning goals and for underpinning research will be required as part of the commitment in order to implement the adaptive approach.

6.2 An adaptive approach should be applied to the RFAs. If the RFAs contain clear objectives, performance measures and procedures for evaluation of progress, then RFA reviews will be more effective and lead to greater improvements in forest management. Appropriate measures and targets should be specified for each goal/commitment specified in the RFAs. Current RFAs lack such a structure, making it difficult to determine if they have met their original objectives.

6.3 To facilitate improved adaptive cross-tenure management of forests, the Victorian and Federal governments should collaborate to develop an integrated forest information system. This would build upon existing remote-sensing coverages, ground-based monitoring, vegetation and fauna surveys, and spatial modelling. The Federal government would contribute national data sets including the multi-temporal Landsat coverages which extend back to 1972, and which are invaluable in creating a 'wall to wall' and consistent forest disturbance history. Two decades of work underpin these spatially and temporally consistent coverages, which are used for National Greenhouse Gas reporting. The institutional arrangements for establishing and maintaining the cross-tenure forest information system need to be clearly specified in the RFA.

6.4 Victoria should commit to developing an improved forest monitoring program that is better targeted to supporting adaptive forest management. An independent external review of the Victorian Forest Monitoring Program (VFMP) is required as part of a gap analysis that examines the monitoring requirements for all public forests. In designing improved systems, new approaches to effectively linking ground observations with remotely sensed data to enable reliable estimation of temporal change in forest values should be explored.

6.5 New cross-tenure regional forest management plans that are being proposed should be structured using an adaptive management model (as described above), with strong emphasis given to multi-stakeholder planning, specifying performance indicators, monitoring and evaluation and reporting processes.

1 Introduction

1.1 Background and Scope

'Regional Forest Agreements' (RFAs) are 20-year plans for the sustainable management and conservation of Australia's native forests.[1] They are bilateral agreements between the Commonwealth and state governments, pursuant to the *Regional Forest Agreements Act 2002* (Cth) 'RFA Act'. The purpose of the RFAs is to ensure that Commonwealth government responsibilities are adequately addressed in state forest management systems. The RFAs provide exemptions from some requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) 'EPBC Act' and *Export Control Act 1982* (Cth).

Victoria has five RFAs, which were signed over the period 1997 to 2000.[2] They are due for renewal by March 2020. Victoria is seeking to modernise the RFAs in the course of the renewal process.

The Department of Environment, Land, Water and Planning (DELWP) has appointed a Scientific Advisory Panel (SAP) to provide advice on current scientific knowledge in relation to the RFA modernisation, as well as in relation to the modernisation of Victorian forest management system. This report focuses on matters directly relevant to the RFA modernisation.

1.2 Aim and Objectives

DELWP has requested the SAP to provide written advice on the following topics to information the RFA modernisation:

1. Matters of National Environmental Significance (MNES)
    a. Do the RFAs provide equivalent or greater protection for MNES than would be afforded by the EPBC Act?
    b. If not, how could the RFAs achieve this?
2. CAR Reserve System
    a. Is the CAR Reserve System adequate, and considering the vulnerability of populations, species and communities to climate change will it be adequate in the future?
    b. How could the adequacy of the CAR reserve system be improved?
3. Climate change
    a. What are the projected impacts of climate change on the full suite of forest values?
    b. What improvements could be made to the RFAs to ensure these impacts are appropriately managed?
4. Active management
    a. How could active management of forests (to support a range of outcomes) be incorporated into the RFAs as a management tool?
    b. How can the productive capacity of forests be improved to support a range of forest industries (including high quality sawlogs, plantation timber, water, honey, carbon sequestration etc.)?
5. Plantations
    a. How could new plantations contribute to an integrated wood supply strategy?
    b. What are the key opportunities and barriers for expansion of the plantation estate, and how could they be addressed?

[1] Department of Agriculture 'Regional Forest Agreements', http://www.agriculture.gov.au/forestry/policies/rfa, July 2017
[2] East Gippsland RFA 1997; Central Highlands RFA 1998; North East RFA 1999; Gippsland RFA 2000; West Victoria RFA 2000

6. Adaptive management
    a. How could the RFAs and the associated forest management system incorporate best practice adaptive processes in order to improve and monitor their effectiveness?

1.3 Approach

1.3.1 Scientific Advisory Panel

The SAP was appointed through a public expression of interest process, managed by the Royal Society of Victoria. The Panel members were selected to cover a cross-section of environmental, economic and social science expertise. Panel members and their areas of expertise are:

- Dr Sandra Brizga – Chair, geomorphology, hydrology, environmental science, environmental planning and management
- Dr John Raison – Deputy chair, forest ecology and management, greenhouse gas accounting, sustainability assessment
- Associate Professor Lauren Bennett – ecosystem processes, forest carbon, forest ecology, fire impacts
- Dr Lyndall Bull – forest science
- Dr David Cheal – forest ecology, fire ecology, environmental weeds, phytosociology and rare species (especially of plants)
- Professor David Lindenmayer – conservation biology, wildlife biology, forest ecology, fire ecology, plantation design and management, reserve design, environmental and economic accounting, long-term monitoring and adaptive management, vegetation restoration

1.3.2 Methodology

The SAP advice was developed by workshopping the questions outlined in Section 1.2. Comprehensive literature reviews were outside the scope of the process, but targeted reviews of literature were undertaken where relevant.

The results of the literature reviews are presented in Table 1 (potential impacts of climate change on a range of biophysical forest values in Victoria), Attachments 1 and 2, and citations of key references throughout the report. Attachments 1 and 2 were prepared by Dr John Raison and are not endorsed by all SAP members.

As indicated in Section 1.3.1, the SAP membership is diverse and covers a wide range of expertise and scientific disciplines. The SAP members were not in full agreement on all matters discussed in this report. Divergences in opinion are indicated in the report where relevant. Professor David Lindenmayer has also provided separate advice to DEWLP on forest management and plantations in relation to the RFAs.[3]

The SAP interacted with the RFA Reference Group (RFA-RG) via the Chairs. The Chair of the SAP attended meetings of the RFA-RG and vice versa.

Traditional owner knowledge and practices are not within the SAP's expertise nor the scope of the SAP's brief. The SAP recognises the importance of traditional owner knowledge; however, it is

[3] Lindenmayer, D.B. (2019) *Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria.* Fenner School of Environment & Society, The Australian National University, Canberra. Lindenmayer, D.B. (2019) *Modernising Regional Forest Agreements in Victoria: Recommendations for management and conservation.* Fenner School of Environment & Society, The Australian National University, Canberra.

understood that the Victorian government will undertake other processes with the intention to capture this knowledge and bring it into the RFA modernisation process.

1.4 Report Outline

The report is structured into chapters, each of which addresses one of the six (6) key questions outlined in Section 1.2. These chapters present the consolidated SAP advice. Additional reviews prepared by Dr John Raison are presented as separate attachments as described above (Attachments 1 and 2).

2 Matters of National Environmental Significance (MNES)

2.1 Summary and Recommendations

2.1.1 Summary

The SAP was requested to provide advice on the following questions:

- Do the RFAs provide equivalent or greater protection for MNES than would be afforded by the EPBC Act?
- If not, how could the RFAs achieve this?

The SAP concluded that the RFAs in their current form do not provide equivalent or greater protection for MNES than would be afforded by the EPBC Act. It recommended the establishment of a system for managing MNES within the RFA framework.

2.1.2 Recommendations

The SAP recommends that the following commitments should be made in the RFAs to enable improved management of MNES:

1. Provision of resources for the design, establishment and maintenance of a MNES system within the RFA framework.

    - The system would:
        - Establish and maintain a list of forest-related MNES and mapping overlays for the forest-related MNES
        - Incorporate the forest-related MNES list and mapping overlays into the forest planning and approval processes.
    - Require the review and updating of the forest-related MNES list and overlays whenever the MNES lists under the EPBC Act are changed, or on a regular review cycle (suggested every 3 years).
    - Require that the forest-related MNES list and mapping overlays be applied in the planning, management and evaluation of the CAR reserve system.
    - Require that any Recovery Plans produced under the EPBC Act and any Action Statements produced under the *Flora and Fauna Guarantee Act 1988* (Vic) (FFG Act) for forest-related MNES are implemented and that their effectiveness is reported under the RFAs, noting that some Recovery Plans and Action Statements have already proven inadequate. There should be a regular review cycle to ensure that the latest versions of the Action Statements and Recovery Plans are incorporated into the RFA system.
    - Establish an agency or unit within DELWP to manage, curate and report on the MNES system.
    - Require that compliance of forestry practices with MNES requirements is monitored by an independent body, such as the Commissioner for Environmental Sustainability, including the provision of sufficient resources for adequate assessment of on-ground activities.

The SAP recommends that it would be desirable for the system outlined above for forest-related MNES to also include forest-related species and ecosystems listed under the FFG Act, so as to provide a single streamlined system for addressing rare and threatened species and ecosystems in forest planning and management.

2.2 Changes Since the Establishment of the RFAs

2.2.1 Legal and Policy Context

Australia is party to many international agreements dealing with environmental and biodiversity conservation.[4] The EPBC Act gives effect to Australia's international obligations in relation to biodiversity as well as protecting values and assets of national importance. Victoria also has state legislation and policies relating to biodiversity conservation.

EPBC Act

The EPBC Act provides a legal framework to protect and manage MNES, which include flora, fauna and ecological communities that are nationally and/or internationally important. There are nine MNES:

- World heritage properties
- National heritage places
- Wetlands of international importance listed under the Ramsar Convention
- Listed threatened species and ecological communities
- Migratory species protected under international agreements
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mines)
- A water resource, in relation to coal seam gas development and large coal mining development.

Actions that have, or are likely to have, a significant impact on MNES presumptively require approval from the Australian Government's Minister for the Environment. The MNES of most relevance to the RFAs is 'listed threatened species and ecological communities'.

The EPBC Act also enables the Australian Government's Minister for the Environment to make Recovery Plans for threatened species and ecological communities.

RFAs and the EPBC Act

The EPBC Act came into force on 16 July 2000, after the five existing Victorian RFAs were signed. The EPBC Act is not mentioned in the Central Highlands, East Gippsland nor North East RFAs. The Gippsland and West Victoria RFAs make provision for forestry operations in these RFA regions to be undertaken without approval under the EPBC Act.[5]

> *The Commonwealth undertakes to use its best endeavours to secure the enactment of legislation which amends the Environment Protection and Biodiversity Conservation Act 1999 (Cwth) by inserting definitions of 'Forestry Operations', 'RFA Forestry Operations' and 'RFA' or 'Regional Forest Agreement' identical to those contained in the Regional Forest Agreements Bill (Cwth) and introduce such legislation into the Parliament of the Commonwealth by 30 June 2000. The purpose of these amendments is to give effect to the Commonwealth Government's intention that Forestry Operations in RFA regions may be undertaken without approval under the Environment Protection and Biodiversity Conservation Act 1999 (Cwth).*[6]

[4] Department of Environment and Energy, *Australia's international role in conserving biodiversity* https://www.environment.gov.au/biodiversity/international-activities, viewed 15/7/2019
[5] Gippsland RFA s 26; West Victoria RFA s 26
[6] Gippsland RFA s 26

The East Gippsland and West Victoria RFAs both also include provisions in regard to World Heritage assessment as part of an Australia-wide Eucalypt theme.[7]

The RFAs include references to the protection of rare or threatened flora and fauna species and ecological communities under the FFG Act and the *Endangered Species Protection Act 1992* (Cth).[8] The *Endangered Species Protection Act 1992* (Cth) was repealed by the *Environmental Reform (Consequential Provisions) Act 1999* (Cth) and is no longer in force. The FFG Act is part of the Victorian forest management system.

The RFA Exemption

The EPBC Act provides that the requirements for environmental approvals in Part 3 of the EPBC Act do not apply to forestry operations undertaken in accordance with an RFA.[9] The exemption includes listed threatened species and communities, migratory species and National Heritage places. However, the exemption does not apply to properties included in the World Heritage List, wetlands listed under the Ramsar Convention nor forestry operations incidental to another action whose primary purpose does not relate to forestry.[10]

The RFA exemption was made on the basis that:

> *… in each RFA region a comprehensive assessment is being, or has been, undertaken to address the environmental, economic and social impacts of forestry operations. In particular, environmental assessments are being conducted in accordance with the Environment Protection (Impact of Proposals) Act 1974 … The objectives of the RFA scheme as a whole include the establishment of a comprehensive, adequate and representative reserve system and the implementation of ecologically sustainable forest management. These objectives are being pursued in relation to each region. The objects of this Act will be met through the RFA process for each region and, accordingly, the Act does not apply to forestry operations in RFA regions.*[11]

From this wording, it is clear that the RFA exemption relies on the objects of the EPBC Act being met through the RFA process. However, the RFAs in their current form do not specify how compliance with this provision will be ensured nor require this to occur.

Victorian Forest Management System (VFMS)

The VFMS is defined by a legal framework including:

- RFAs
- *Forest Act 1958* (Vic)
- *Sustainable Forests (Timber) Act 2004* (Vic)
- FFG Act

The FFG Act operates alongside the RFAs. It provides a framework for listing species and ecological communities in a state of decline or otherwise threatened in a way that places those species and ecological communities at risk of extinction. Once an item is listed, the FFG Act requires the production of an 'Action Statement', which is a summary of the actions required to be implemented to arrest the decline or otherwise reduce the extinction threat. Some species and ecological communities are listed under both the EPBC and FFG Acts.

[7] Gippsland RFA ss 27– 31; West Victoria RFA ss 27–31
[8] E.g. Central Highlands Regional Forests Agreement para 54
[9] EPBC Act s 38
[10] EPBC Act s 42
[11] Environment Protection and Biodiversity Conservation Bill Explanatory Memorandum 1998, para 113

DELWP also maintains threatened species Advisory Lists of Vulnerable, Rare or Threatened Species (VROTS). These lists do not have legal requirements nor consequences, although they are afforded some protection through Victoria's Native Vegetation Management Framework. Some of the species on the Advisory Lists are also listed as threatened under the FFG Act and/or the EPBC Act.

2.2.2 Changes in Scientific Knowledge

There is a rapid and ongoing decline in biodiversity worldwide.[12] This decline is also evident throughout Australia, including in remote, uninhabited and protected areas[13]. Australia has been isolated from the other continents for over 60 million years and much of its biodiversity is unique. Few species are shared with elsewhere; for example, 87% of Australian terrestrial mammal species are endemic.[14]

The EPBC and FFG Acts operate by:

- Listing threatened species and ecological communities, then
- Developing Recovery Plans (EPBC Act) or Action Statements (FFG Act) that will enable the species' recovery, then
- Implementing these management plans and procedures.

This has required the establishment of systems and processes to collect and manage information about rare and threatened species and ecological communities.

In addition to these statutory processes, DELWP publishes lists of rare and threatened species of flora and fauna, known as the VROTS 'Advisory Lists', as noted above. Based on these data, 41 species of vascular plants and 24 species of terrestrial vertebrates are extinct in Victoria (not including the one animal species that is only present in captivity, viz. *Perameles gunnii* Eastern Barred Bandicoot).[15] For vascular plants overall, a further 350 species are Endangered, 498 species are Vulnerable and 822 species Rare (i.e. in low numbers but not necessarily threatened), with 232 species too poorly known to categorise. For non-marine vertebrates, a further 50 species are Critically Endangered, 59 species are Endangered, 84 species are Vulnerable, with 13 species too poorly known to categorise. These high numbers of threatened species are the end result of a broad variety of processes associated with European settlement, including direct exploitation, habitat destruction (principally for agriculture), the introduction of exotic competitors and feral pests.[16]

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[12] Ceballos, Ehrlich & Dirzo (2017) Biological annihilation via the ongoing sixth mass extinction signalled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences* 114, E6089-E6096; IPBES (2019) IPBES Global Assessment Summary for Policymakers. Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), United Nations; Maxwell, Fuller, Brooks & Watson (2016) Biodiversity: the ravages of guns, nets and bulldozers. *Nature* 536,143-145.

[13] Woinarski, Burbidge & Harrison (2015) Ongoing unravelling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Science of the United States of America* 112(15), 4521-4540

[14] Woinarski, Burbidge & Harrison (2015) Ongoing unravelling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Science of the United States of America* 112(15), 4521-4540

[15] see https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/50448/Advisory-List-of-Rare-or-Threatened-Plants-in-Victoria-2014.pdf for vascular plants and https://www.environment.vic.gov.au/__data/assets/pdf_file/0014/50450/Advisory-List-of-Threatened-Vertebrate-Fauna_FINAL-2013.pdf for non-marine vertebrates (accessed 9 July 2019)

[16] Attiwill P & Wilson B (eds) 2006 *Ecology: an Australian perspective* (Oxford Uni Press); Foreman DB & Walsh NG (eds.) 1993 Flora of Victoria Vol. 1 (Inkata Press); Johnson C (2006) *Australia's Mammal Extinctions* (Cambridge University Press); Woinarski, J.C.Z., Braby, M.F., Burbidge, A.A., Coates, D., Garnett, S.T., Fensham, R.J., Legge, S.M., McKenzie, N.L., Silcock,

By far the majority of threatened species have disappeared from agricultural landscapes and from native vegetation outside the scope of the RFAs.[17] When compared with the agricultural, semi-arid and non-RFA forests, the RFA forested landscape has far fewer threatened species. Nevertheless, there are many species (around 70) that can reasonably be described as 'forest-dependent' that are also threatened in the wild and in forests encompassed within the various RFAs.[18]

From the DELWP lists and reports, there are 46 forest-dependent species that are considered to be rare or threatened in Victoria[19], most of which are vascular plant species. No forest-dependent plant taxa have had their (Victorian) threat status reduced since the RFAs were established.[20] These forest-dependent plant species are neither regularly nor frequently surveyed so their current status is uncertain.

Volunteer groups have been active in monitoring some parts of the Victorian flora, e.g. the regular monitoring of some orchid species by the Australian Native Orchid Society and the regular monitoring of post-fire vegetation plots in Wilsons Promontory National Park by *Prom'n'aides*[21]. However, these efforts have largely concentrated outside forests subject to commercial exploitation.

Former DELWP-managed monitoring projects for plant species (such as VROTPop) have not been sustained. Relatively recently, DELWP announced a new monitoring project (the Forest Protection Survey Program[22]) which has a prioritised list of 75 target species of flora and fauna likely to be found in forests and adversely affected by forestry operations. Whilst a considerable improvement over the Victorian Forest Monitoring Program (VFMP)[23] in intensity of survey effort and the targeting of likely affected species, there are nevertheless limitations in survey methods and knowledge of species' ecology that will hamper (but not prevent) implementation of effective conservation efforts.

Forest-dependent invertebrates are generally too poorly known or too infrequently surveyed for them to be useful indicators of forest condition. However, the various species of Spiny Crayfish (*Euastacus* spp), many of which are threatened, may prove useful indicator species.[24]

The latest Advisory List for non-marine vertebrates was published in 2013. During the periods of the various Victorian RFAs the total number of forest-dependent vertebrate species considered to be rare or threatened decreased by two species. The conservation status of 18% of rare and threatened

J.L. and Murphy, B.P., 2019. Reading the black book: The number, timing, distribution and causes of listed extinctions in Australia. *Biological Conservation*, *239*, p.108261.

[17] Woinarski, Burbidge & Harrison (2015) Ongoing unravelling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Science of the United States of America* 112(15), 4521-4540

[18] Taylor, C. and Lindenmayer, D.B. (2019). The adequacy of Victoria's protected areas for conserving its forest-dependent fauna. Austral Ecology, 44, 1076-1090.

[19] Victoria's State of the Forests Report 2013 https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0019/52705/VIC_SFR2013_lowres.pdf

[20] https://engage.vic.gov.au/review-flora-and-fauna-guarantee-act-1988 (accessed 12 July 2019)

[21] Ellis, Norden & Rowe (2019) An exploration of the capacity of a database generated by post-fire vegetation monitoring to yield useful information about responses of individual species to fire. *Victorian Naturalist* 136(3), 100-108.

[22] DELWP, Forest Protection Survey Program, https://www.forestsandreserves.vic.gov.au/forest-management/forest-protection-survey-program (October 2019)

[23] DELWP, Victorian Forest Monitoring Program, https://www.forestsandreserves.vic.gov.au/forest-management/victorian-forest-monitoring-program, May 2019 (accessed 11 July 2019)

[24] Morgan (1986) Freshwater crayfish of the genus *Euastacus* Clark (Decapoda: Parastacidae) from Victoria. *Memoirs of Museum Victoria* 47(1), 1-57.

forest-dependent vertebrate species changed between the earlier and the most recent Advisory Lists – 4% became less threatened and 14% became more threatened.[25]

The Forest Protection Survey Program includes targeted surveys of forest-dependent fauna and flora species and clear implementation procedures for conservation efforts once such species are detected within areas affected by proposed forestry operations. The survey methods for forest-dependent vertebrates have developed greatly over recent decades and reliable records can now be readily collected.

Monitoring has not been, and is not, restricted to DELWP-managed projects. In particular, studies have been conducted by universities, and researchers from ANU have recently modelled trajectories for a larger number of forest-dependent species.[26] The report by Keith *et al.* (2017) (and associated publications) also includes lists of forest-dependent species and changes in their listing status since the establishment of the RFAs.

The forest-dependent species that has received most attention and is a particularly valuable indicator for other biodiversity elements is the Victorian endemic Leadbeater's Possum *Gymnobelideus leadbeateri*.[27] Its prospects remain uncertain, despite this wealth of detailed ecological knowledge and understanding of habitat requirements.[28]

As noted above, threatened ecological communities can be listed for protection under the EPBC and the FFG Acts, and some have been listed under each or both. DELWP maintains the only comprehensive state-wide database of ecological communities for Victoria, the Ecological Vegetation Class (EVC) data layer.[29]

The SAP notes that the EVC mapping has been suitable for some applications[30] but has limitations that constrain its usefulness for implementing EPBC Act requirements in relation to threatened ecological communities. In particular, the base unit (EVC) is undefined, the recognition of novel EVCs is idiosyncratic, the mapping reliability is variable, and the database is poorly curated (so that corrections and reassignments cannot be readily incorporated). Furthermore, mapping has been reliant on recognition of mapping units (EVCs) from aerial photography. Vegetation communities that lack a distinct signature on air photos have proven difficult to map reliably in the EVC data layer (although other bases for mapping can informatively map such communities).[31] In addition, the coarse resolution of EVC maps leads to poor spatial differentiation of communities, particularly ecotones, which could be better mapped using advances in remotely sensed spatial data (e.g. LiDAR

[25] Victoria's State of the Forests Report 2013, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0019/52705/VIC_SFR2013_lowres.pdf

[26] E.g. Keith *et al.* (2017) Experimental Ecosystem Accounts for the Central Highlands of Victoria. version 2, pub. ANU, Canberra

[27] Lindenmayer and Sato (2018) Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. *Proceedings of the National Academy of Sciences* 115, 5181-5186; Lindenmayer, Blair, McBurney, Banks, Stein, Hobbs, Likens and Franklin (2013) Principles and practices for biodiversity conservation and restoration forestry; a 30-year case study on the Victorian montane ash forests and the critically endangered Leadbeater's Possum. *Australian Zoologist* 36, 441-460.

[28] Lindenmayer, Blair, McBurney, Banks & Bowd Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest *Australian Zoologist* (in press)

[29] DELWP, Native Vegetation Information Management (NVIM), https://www.environment.vic.gov.au/native-vegetation/native-vegetation-information-management (accessed 12 July 2019)

[30] Mac Nally *et al.* (2002) How Well Do Ecosystem-based Planning Units Represent Different Components of Biodiversity? *Ecological Applications* 12(3), 900-912.

[31] Cheal *et al.* (2011) *The Vegetation of East Gippsland – III* used a different approach to vegetation community mapping (i.e. mapping of environmental envelopes) which has advantages over mapping based on air photos, including the ability to map the former vegetation of cleared land and the ability to distinguish units that lack a distinctive aerial signature).

data) and spatial modelling techniques.[32] Finally, the database has assumed that EVCs cannot change to other ecological communities or be altered by fire, management practices or otherwise. As a result, this static data layer has little value for monitoring. Perhaps the easiest way to devise monitoring schema for ecological communities would be to rely on monitoring either keystone, dominant or narrowly faithful species of the target ecological communities.

2.3 How Well are MNES Currently Addressed in the RFAs?

The EPBC Bill Explanatory Memorandum indicates that it is assumed that the other assessments required by the RFAs would be sufficient to meet the needs of the EPBC Act.[33] The RFAs currently provide exemptions from certain environmental requirements under the EPBC Act but do not specifically require assessment of MNES.

The exemptions under the RFA process for environmental assessments under the EPBC Act do not provide exemptions from the requirements of the FFG Act, which have some overlap with the requirements of the EPBC Act but do not ensure that MNES are fully addressed.

As discussed in Chapter 3 (CAR Reserve system), few forest-dependent fauna species have become less threatened in areas covered by the existing RFAs and considerably more fauna species have become more threatened.[34] Furthermore, no forest-dependent plant species has had its threat status downgraded (i.e. been designated less threatened) in the Victorian Advisory Lists. Forest-dependent owls (not listed under the EPBC Act) have been the recipient of specific restrictions in Victoria's Forest Management System (e.g. the designation of Special Protection Zones) yet all such species retain the threat status they had before the implementation of the RFAs. The Leadbeater's Possum (EPBC listing 'critically endangered'), remains highly threatened and modelling indicates that it is in danger of imminent extinction.[35] The (forest-dependent) Greater Glider *Petauroides volans* has been recently listed as 'Vulnerable' under the EPBC Act[36] and 'vulnerable' in Victoria[37]. Site occupancy by Greater Gliders in the Central Highlands of Victoria has declined by more than 80% between 1997 and 2017.[38] During spotlight surveys in East Gippsland forests in the 1980s, preparatory to a Land Conservation Council assessment and report, Greater Gliders were the most frequently reported mammal species.[39]

The current RFAs have not ensured the survival of threatened species and many species have become more threatened in areas and periods of time covered by the RFAs. This does not necessarily mean that forest operations covered by the RFAs were the sole or principal cause for the threat status of all species. There may be adverse factors operating other than or in addition to

[32] Fedrigo *et al.* (2019) Predictive ecosystem mapping of southeast Australian temperate forests using lidar-derived structural profiles and species distribution models. *Remote Sensing* 11, 93.
[33] Environment Protection and Biodiversity Conservation Bill Explanatory Memorandum 1998, para 113
[34] Victoria's State of the Forests Report 2013, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0019/52705/VIC_SFR2013_lowres.pdf
[35] Blair, McBurney and Lindenmayer (2018) Failing to conserve Leadbeater's Possum and its Mountain Ash forest habitat. *Australian Zoologist* 39,443-448.
[36] TSSC, Conservation Advice, *Petauroides Volans*, greater glider, http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-05052016.pdf (accessed 12 July 2019)
[37] DELWP, Threatened species advisory lists, https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists (accessed 12 July 2019)
[38] Lindenmayer & Sato (2018) Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. *Proc. National Acad. Sci.* 115, 5181-5186
[39] VEAC, East Gippsland Area Review (LCC, 1986), http://www.veac.vic.gov.au/investigation/east-gippsland-area-review-lcc- (accessed 20 July 2019)

forestry operations.[40] Targeted studies (similar to those already under way and completed for Leadbeater's Possum) are required to separate and attribute explanations for the threat statuses.

2.4 Options for Improvement

The RFAs would provide greater assurance that the requirements of the EPBC Act are fully met through the RFA process if they were to include specific requirements in relation to MNES.

One option would be to require MNES assessments to be undertaken under the RFA system in the same way as the assessments under the EPBC system. This would undermine the purpose of the EPBC exemption in the RFAs.

The RFAs provide the opportunity to develop streamlined regional frameworks for the management of forestry operations and the CAR Reserve system with regard to MNES. The Victorian planning system uses zones to define land uses, and then overlays to identify particular issues that need to be addressed in specific areas. It would be feasible to develop a system of MNES overlays that could be used in conjunction with the existing system of forest zonings, in a similar way to the Victorian planning system.

The SAP has contemplated a system of MNES overlays that involves the following elements:

- Develop and maintain a list of MNES that that are known or likely to be associated with forests in the region (e.g. forest ecosystems, forest-dependent flora and fauna, opportunistic forest-associated species)
- Develop and maintain a set of map overlays that shows the distribution of each forest-related MNES (places where they have been recorded or are likely to occur, e.g. as determined from modeling)
- Incorporate EPBC Recovery Plans and FFG Action Statements[41] into the overlays to provide management directions to maintain the MNES (actions under these plans will then be incorporated into the RFAs)
- Apply the forest-associated MNES overlays to determine priority areas that could be considered for extensions to the conservation estate – including the CAR reserve system and protected private land (e.g. Trust for Nature covenants)
- Apply the forest-related MNES overlays to the CAR reserve system to assist in developing management plans consistent with EPBC Recovery Plans for threatened species.
- Apply the forest-related MNES overlays to assist in forest planning and management outside of the CAR reserve system, including a risk-based system for desktop assessment of MNES for potential logging coupes
- Define accountability for implementation of MNES arrangements, including the establishment of the overlay system, incorporation into forest planning and management, and outcomes for MNES.

The SAP considers that a system of MNES overlays would have the following advantages over the current arrangements:

- Consistency with the intent of the RFA exemption

[40] E.g. Woinarski, Burbidge & Harrison (2015) Ongoing unravelling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Science of the United States of America* 112(15), 4521-4540

[41] The SAP recognises that RFAs are agreements between the Federal and respective state governments and make no specific mention of requirements under state-based legislation. However, a great deal of scientific research and understanding has gone into the (state-based) Action Statements and this knowledge should be incorporated into the RFAs.

- Environmental benefits resulting from a formal requirement for the available information regarding MNES to be incorporated into the forest planning and management process
- Enabling the EPBC Recovery Plans and FFG Action Statements (for EPBC-listed species and communities) to be integrally incorporated into forest planning and management

A system that covers all forest-associated species listed under the EPBC Act and/or the FFG Act across each RFA region would provide an efficient means of addressing both state and Commonwealth requirements in a single system, thus reducing costs and eliminating duplication.

The SAP notes the following issues that would need to be addressed to establish and maintain a system of MNES overlays within the RFA framework:

- Establishment costs for the new system or modification costs for the existing Victorian Biodiversity Atlas, including the facility to utilise new data layers or modifications to existing data layers following methodological improvements (e.g. recognition of ecological communities from remotely-sensed data)
- Inadequacies in the EVC data layer (this could potentially be addressed by monitoring keystone or narrowly faithful species of the target ecological communities)
- Ongoing requirement to maintain lists of forest-related MNES and overlay maps - updating would be required if new species /communities are added to EPBC lists and if new research or survey significantly affects proposed management actions for the MNES or changes the designated threat status.

List of Forest-related MNES

It is important to note is that not all MNES are forest-dependent or associated with forests. The RFA MNES system should focus on MNES that are forest-dependent or associated with forests.

A list of MNES that are relevant to the forests in the Victorian RFA regions (e.g. forest ecosystems, forest-related flora and fauna, other forest-associated species) does not currently exist and would need to be developed and curated.

Curation of the list is critical for maintaining its accuracy and currency. It involves adding or deleting to the list as research furthers our understanding of the nature of the ecological relationships of the MNES. It also includes tags or links to published ecological research that can inform the implementation of management compatible with the conservation status of the species.

Forest-related MNES Map Overlays

A set of map overlays should be developed and maintained that shows the distribution of each forest-related MNES, including places where they have been recorded or are likely to occur. Information to populate these overlays can be obtained from published research, unpublished research, surveys (both departmental and external, including *Vicforests*), existing databases (such as the Victorian Biodiversity Atlas, records of the National Herbarium of Victoria and the Victoria Museum) and other authoritative sources.

The entity responsible for developing and maintaining the forest-related MNES overlays should also be responsible for curating (updating, correcting) the overlays and contingent data. The reasons for this include efficiency and reduced risk of inconsistencies. The MNES overlays should be tenure-blind.

Application to Forest Management

The forest-related MNES overlays would assist in forest planning and management outside of the CAR reserve system, including a risk-based system for desktop assessment of MNES for potential logging coupes.

Application to CAR Reserve System

The forest-related MNES overlays could be used to determine areas that could be considered for extensions to the conservation estate, including the CAR reserve system and protected private land (e.g. Trust for Nature covenants and revolving fund purchases).

The forest-related MNES overlays would also be of assistance in developing management or stewardship plans for forests in the CAR reserve system (including public land and private land), to ensure consistency with best available knowledge for the relevant MNES.

Accountability

The SAP considers it is important for the RFAs to provide for accountability for the establishment, maintenance and application of the forest-related MNES overlay system consistent with the provisions that would be set out in the RFA. Ideally this would be an independent entity (such as the Commissioner for Environmental Sustainability or the Chief Conservation Regulator). It would be inappropriate for an industry body (e.g. VicForests) to have this role.

The importance of accountability is highlighted by existing shortcomings in the existing implementation of FFG Act requirements in forest management. For example, over recent decades, extensive information and ecological understanding has been accumulated in relation to Leadbeater's Possum and its habitat requirements. However, the results of this scientific work (including population viability analyses and modelling) have not been fully incorporated into broader forest management and coupe management plans and strategies. Furthermore, information that should affect forest management actions and strategies and is summarised in the FFG Action Statements (and in EPBC Recovery Plans) is given perfunctory consideration in forest and coupe management plans, despite legislation and government pronouncements that commit government agencies to fully incorporating this information.

3 Comprehensive, Adequate and Representative (CAR) Reserve System

3.1 Summary and Recommendations

3.1.1 Summary

The SAP was requested to provide advice on the following questions:

- Is the CAR reserve system adequate, and considering the vulnerability of populations, species and communities to climate change will it be adequate in the future?
- How could the adequacy of the CAR reserve system be improved?

All SAP members agreed that the CAR reserve system has not adequately protected biodiversity, and under current management arrangements, will not provide adequate protection in the future.

There were divergent views amongst SAP members regarding the measures required to improve the adequacy of the CAR reserve system. All SAP members agreed that there is a need for improved management of forests within the CAR reserve system. Some re-configuration of the CAR reserve system may also be required. However, there was disagreement as to whether or not it is necessary to increase the areal extent of the CAR reserve system to provide better protection for biodiversity

Professor David Lindenmayer has provided additional information relating to the adequacy of the CAR reserve system from the viewpoint of conservation biology in a separate report.[42]

3.1.2 Recommendations

The SAP recommends that the following commitments should be made in the RFAs to enable refinement and better management of the CAR reserve system:

1. Review of the JANIS criteria would be timely, given advances in forest conservation science over the past 20 years.

2. Review the spatial extent and configuration of the CAR reserve system:

    - assess the representation, adequacy and comprehensiveness of the areal representation of habitats and vegetation communities, based on the JANIS criteria.
    - evaluate the utility of other spatial measures of the entire forest estate including the CAR reserve system such as levels of forest fragmentation, and the extent of edge effects and other spatial metrics of disturbance by human activities and wildfire.

3. Commit to a detailed assessment of the adequacy of current habitat for forest-associated species. This could be achieved through mapping analyses and targeted Population Viability Analysis (PVA) to determine adequacy of reserves to promote long-term species persistence.

4. Commit to the following actions in relation to old-growth forests:

    - Develop appropriate updated definitions of old-growth forest, and apply these to provide updated maps of the extent of old growth
    - Determine priority targets for old growth protection and management, including identification of areas where maturing forests can be managed to provide new cohorts

[42] Lindenmayer, D.B. (2019) *Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria.* Fenner School of Environment & Society, The Australian National University, Canberra.

of old growth in the future. See Chapter 4 for further details relevant to potential impacts of climate change.

5. Require the development and implementation of new management plans for the CAR reserve system in each RFA region. Such plans should provide coordinated cross-tenure management of the full CAR reserve system. The plans should be consistent with adaptive approaches to management (see Chapter 7) including strategies for managing current and emerging threats such as climate change (see Chapter 4). Accountability for plan development and implementation needs to be clear.

6. Establish monitoring and review requirements for the CAR reserve system that provide sufficient flexibility to adapt management arrangements within much shorter intervals than a 5-yearly RFA review.

7. Undertake sensitivity analyses of the adequacy of the CAR reserve system and management plans under a range of climate change scenarios.

3.2 Changes Since the Establishment of the RFAs

3.2.1 Changes in Policy Context

Protected areas are accepted to be a key part of ecologically sustainable forest management in Australia. The National Forest Policy Statement stated that:

> *It is important that Australia has a comprehensive, adequate and representative network of dedicated and secure nature conservation reserves for forests and reserves for protecting wilderness.*[43]

RFAs are required to provide for the establishment of a CAR reserve system.[44] The terms 'comprehensive', 'adequate' and 'representative' are not defined in the RFA Act, but the *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia* (JANIS criteria) give the following definitions:

- Comprehensive - inclusion of the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels
- Adequate - maintenance of ecological viability and integrity of populations, species and communities
- Representative – inclusion of sample areas of forest that reasonably reflect the biotic diversity of the communities they represent.[45]

The objectives of the CAR reserve system are to:

- Maintain ecological processes and the dynamics of forest ecosystems in their landscape context
- Maintain viable examples of forest ecosystems throughout their natural ranges
- Maintain viable populations of native forest species throughout their natural ranges
- Maintain the genetic diversity of native forest species

[43] National Forest Policy Statement. A New Focus for Australia's Forests (1992, second edition 1995) p. 8, http://www.agriculture.gov.au/SiteCollectionDocuments/forestry/australias-forest-policies/nat_nfps.pdf
[44] RFA Act s 4
[45] ANZECC/MCFFA (1997) National Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. Australian and New Zealand Environment and Conservation Council & Ministerial Council on Forestry, Fisheries and Aquaculture. Canberra, Australia, pp 5–6.

- Protect old-growth forest and forested wilderness
- Safeguard endangered and vulnerable species and ecosystems.[46]

The JANIS criteria include quantitative criteria but emphasise the need for flexibility in their application:

> *As a general criterion, 15% of the pre-1750 distribution of each forest ecosystem should be protected in the CAR reserve system …*
>
> *Where forest ecosystems are recognised as vulnerable, then at least 60% of their remaining extent should be reserved …*
>
> *All remaining occurrences of rare and endangered forest ecosystems should be reserved or protected by other means as far as is practicable*[47]

The Victorian system of EVCs has been used as the basis for CAR reserve design in Victoria. At the time the RFAs were established, it was acknowledged that the areas of some EVCs in the CAR reserve system did not meet the areal targets set out in the Janis criteria due to the legacy of historical land clearing and limited representation of some EVCs in the public land estate. In addition, the EVC approach is a state-based system and not a nationwide one; hence, EVCs are not suitable for a rigorous assessment of the 'comprehensive' component of the CAR reserve system (see Chapter 2 for additional limitations of EVCs).

The Victorian government's biodiversity strategy (2017) states that the Victorian government seeks to 'maintain and improve a world class reserve system'.[48] It states:

> *To ensure that Victoria's reserve system on public and private land is as effective as possible, formally protected areas need to be well managed and well connected.* [49]

It proposes that the Victorian government will:

> *Review the extent, representativeness and adequacy of the reserve system to identify key gaps and additional complementary measures required to improve the reserve system on public and private land.* [50]

Consistent with the Victorian government's overall policy on climate change (see climate change policy overview in Chapter 4), the biodiversity strategy states that:

> *The impacts of climate change, and the uncertainty it brings, will be considered in all conservation decisions*[51]

[46] ANZECC/MCFFA (1997) National Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. Australian and New Zealand Environment and Conservation Council & Ministerial Council on Forestry, Fisheries and Aquaculture. Canberra, Australia, p 2
[47] ANZECC/MCFFA (1997) National Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. Australian and New Zealand Environment and Conservation Council & Ministerial Council on Forestry, Fisheries and Aquaculture. Canberra, Australia, pp 12-13
[48] *Protecting Victoria's Environment: Biodiversity 2037* (2017), Department of Environment, Land, Water and Planning.
[49] *Protecting Victoria's Environment: Biodiversity 2037* (2017), Department of Environment, Land, Water and Planning, p 49
[50] *Protecting Victoria's Environment: Biodiversity 2037* (2017), Department of Environment, Land, Water and Planning, p 49
[51] *Protecting Victoria's Environment: Biodiversity 2037* (2017), Department of Environment, Land, Water and Planning, p 12

3.2.2 Changes in Scientific Knowledge

In the time that has elapsed since the establishment of the RFAs, the International Union for Conservation of Nature (IUCN) has established global standards for identifying and defining key areas for biodiversity.[52] The JANIS criteria should be assessed in relation to their congruence with these standards.

3.2.3 Environmental Change

Many studies have highlighted the rapid decline of biodiversity worldwide. Research and monitoring (as summarised in Chapter 2, and below) has revealed ongoing decline in some of Victoria's forest-associated flora and fauna over recent decades,[53] raising questions about the adequacy of the CAR reserve system in terms of meeting its objectives.

Jackson in his independent consultation paper to the RFAs reported that:

> *More effort is needed to stop the overall decline of forest-dependent threatened species and improve the extent and condition of forest habitats …*[54]

Jackson indicated that his conclusion was based on a review of published sources but did not cite any specific examples or publications in support of this conclusion. He reported that a range of threats to forest health are recognised, including:

- Invasive species
- Changed fire regime – increased frequency of landscape fires
- Loss of hollow-bearing trees
- Risks associated with future climate change – including exacerbation of existing threats and introduction of new threats – raising a need to consider the adequacy of CAR reserve system in relation to climate change.

3.3 How Well Does the Existing CAR Reserve System Protect Biodiversity?

This question is examined in relation to six objectives for the CAR reserve system that were outlined as part of the JANIS criteria.

The JANIS criteria set out four objectives of biodiversity conservation for forests:

- to maintain ecological processes and the dynamics of forest ecosystems in their landscape context
- to maintain viable examples of forest ecosystems throughout their natural ranges
- to maintain viable populations of native forest species throughout their natural ranges
- to maintain the genetic diversity of native forest species.

In addition, the JANIS criteria identify the following two additional objectives for the CAR reserve system:

- to protect old-growth forest and forested wilderness

[52] IUCN. 2016. A Global Standard for the Identification of Key Biodiversity Areas. IUCN, Gland, Switzerland; Visconti, P., S. Butchart, T. M. Brooks, P. F. Langhammer, D. Marnewick, S. Vergara, A. Yanosky, and J. E. Watson. 2019. Protected area targets post-2020. Science 364:239-241.

[53] Lindenmayer, D. B., and C. Sato. 2018. Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. Proceedings of the National Academy of Sciences 115:5181-5186.

[54] Jackson, W. Independent Consultation Paper - Modernisation of the Victorian Regional Forest Agreements. May 2019 pp 7–8 https://www2.delwp.vic.gov.au/__data/assets/pdf_file/0029/417818/Independent-Consultation-Paper-Modernisation-of-the-Victorian-RFAs-May-2019.pdf

- to safeguard endangered and vulnerable species and ecosystems

3.3.1 Objective: Maintain Viable Examples of Forest Ecosystems Throughout Their Natural Ranges

The RFAs only specify performance requirements for the CAR reserve system based on areal extent and representativeness – in particular minimum areas for each forest EVC found in the RFA region. It appears to have been assumed that if this requirement is met, the other objectives of the JANIS criteria would follow. Other formal processes now exist to assess the conservation status of particular ecosystems, including in forests. This includes the IUCN's Red Listed Ecosystems process, which has been completed for the Mountain Ash ecosystem in the Central Highlands of Victoria.[55] It is noted that the application of this process in Victoria has been challenged.[56]

At the time the CAR reserve system was established, it was accepted that some vegetation communities had lower representation in the CAR reserve system than the JANIS criteria due to land availability and land tenure constraints. The SAP is not aware of any subsequent changes to the CAR reserve system to address this shortcoming.

The existing CAR reserve system was designed without consideration of potential future climate change. Climate change could change the range and distribution of key species,[57] key processes underlying species persistence,[58] as well as various forest ecological communities, which form the basis of the CAR reserve system. Hence, changes in the boundaries of the existing CAR reserve system may be required to maintain, let alone improve, representativeness of the CAR reserve system. Where, and to what degree, boundaries might need to be changed in response to climate change is currently highly uncertain (see Chapter 4). Further work is required to model the effects of climate change in relation to the current boundaries of the CAR reserve system.

Areal Extent

Targets for reserves based on areal extent are important but rather arbitrary, and not sufficient. They can be misleading because of a bias toward low productivity areas (that remain intact because they were not useful for other human uses such as agriculture, forestry and urban development)[59] and which have relatively limited values for some elements of biodiversity.[60]

[55] Burns, E. L., D. B. Lindenmayer, J. Stein, W. Blanchard, L. McBurney, D. Blair, and S. C. Banks. 2015. Ecosystem assessment of mountain ash forest in the Central Highlands of Victoria, south-eastern Australia. Austral Ecology 40:386-399.

[56] Poynter, M. and M. Ryan (2018). Leadbeater's possum and Victoria's central Highlands' forests: flawed science and environmental activism as drivers of forest management change. Australian Forestry 81**:** 250-272

[57] Lindenmayer, D. B., H. A. Nix, J. P. McMahon, M. F. Hutchinson, and M. T. Tanton. 1991. The conservation of Leadbeater's Possum, *Gymnobelideus leadbeateri* (McCoy): a case study of the use of bioclimatic modelling. Journal of Biogeography **18**:371-383; Brereton, R., S. Bennett, and I. Mansergh. 1995. Enhanced greenhouse climate change and its potential effect on selected fauna of south-eastern Australia: a trend analysis. Biological Conservation **72**:339-354; Steffen, W., A. Burbidge, L. Hughes, R. Kitching, D. B. Lindenmayer, W. Musgrave, M. Stafford-Smith, and P. Werner. 2009. Australia's Biodiversity and Climate Change. CSIRO Publishing, Melbourne.

[58] Mok, H.-F., S. K. Arndt, and C. R. Nitschke. 2012. Modelling the potential impact of climate variability and change on species regeneration potential in the temperate forests of South-Eastern Australia. Global Change Biology **18**:1053-1072.

[59] Taylor, M. F., J. A. Fitzsimons, and P. S. Sattler. 2014b. Building Nature's Safety Net 2014: A decade of protected area achievements in Australia. WWF-Australia, Sydney; Venter, O., A. Magrach, N. Outram, C. J. Klein, H. P. Possingham, M. D. Di Marco, and J. E. Watson. 2018. Bias in protected-area location and its effects on long-term aspirations of biodiversity conventions. Conservation Biology **32**:127-134.

[60] Visconti, P., S. Butchart, T. M. Brooks, P. F. Langhammer, D. Marnewick, S. Vergara, A. Yanosky, and J. E. Watson. 2019. Protected area targets post-2020. Science 364:239-241.

Simple areal extent is also misleading where threat levels are very high, or the remaining area of a given ecosystem is very small. This may require that most or all the remaining area of a given ecosystem be protected. This can be very controversial if it indicates that a large area of forest should be protected, particularly if that forest also has high values for timber production.

For example, recently published work indicates that proposed ongoing logging operations will have significant and likely highly negative impacts on threatened forest-dependent species, including species such as Leadbeater's Possum and the Greater Glider.[61] The conservation advice from the Threatened Species Scientific Committee (TSSC) for Leadbeater's Possum (*Gymnobelideus leadbeateri*) recommended that all of the remaining Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*E. delegatensis*) forests of the Central Highlands of Victoria should be protected to secure the survival of this species. However, the SAP is also aware of a critique by the Institute of Foresters of Australia (IFA) of the decision by the TSSC to maintain the listing of Leadbeater's possum as critically endangered.[62] Whilst the SAP has not had time to critically review the arguments provided by the IFA, this new material could be considered during the RFA negotiation process.

The criterion for areal extent in the JANIS criteria assumes that the areal coverage of the various forest ecosystems will remain static. However, impacts from increasing wildfires mean that the areal coverage of various forest ecosystems in the CAR reserve systems, and the habitat value they provide for forest-associated species, have not remained constant through time.[63] In addition, the structure and composition of the vegetation within a given ecosystem is likely to change over time.[64] Hence, the areal extent of a given ecosystem, vegetation community or other entity may not equate with the condition and habitat quality of that ecosystem.[65]

Representativeness

The Victorian system of EVCs has been used to assess the reserve system in Victoria. Recent analyses demonstrate that some EVCs are not well protected within Victoria's reserve system.[66] Furthermore, the range of age classes or growth stages is poorly represented within the reserve system in Victoria.[67] This has likely occurred for a range of reasons, such as land clearing and/or logging of more productive sites, together with recurrent wildfires.[68] The amount of young forest has increased in recent decades because of wildfire and logging, while the total area of old-growth Mountain Ash forest in the Central Highlands RFA is just 1.16% of the extent of the ecosystem. In the case of the

[61] Taylor, C. and Lindenmayer, D.B. (2019). The adequacy of Victoria's protected areas for conserving its forest-dependent fauna. Austral Ecology, 44, 1076-1090.

[62] Institute of Foresters of Australia (August, 2019). Concerns about the Threatened Species Scientific Committee's Conservation Advice (dated 22 June 2019) retaining the 'Critically Endangered' listing for Leadbeater's Possum (*Gymnobelideus leadbeateri*). [Document submitted to the Federal minister for the Environment].

[63] Bowman, D. M. J. S., B. P. Murphy, D. L. J. Neyland, G. J. Williamson, and L. D. Prior. 2014. Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. Global Change Biology **20**:1008-1015.

[64] Fairman, T. A., L. T. Bennett, S. Tupper, and C. R. Nitschke. 2017. Frequent wildfires erode tree persistence and alter stand structure and initial composition in a fire-tolerant sub-alpine forest. Journal of Vegetation Science **28**:1151-1165; Fairman, T. A., L. T. Bennett, and C. R. Nitschke. 2019. Short-interval wildfires increase likelihood of resprouting failure in fire-tolerant trees. Journal of Environmental Management **231**:59-65; Lindenmayer, D. B., W. Blanchard, L. McBurney, D. Blair, S. Banks, G. E. Likens, J. F. Franklin, J. Stein, and P. Gibbons. 2012. Interacting factors driving a major loss of large trees with cavities in a forest ecosystem. PLOS One **7**:e41864.

[65] Lindenmayer, D. B. 2019a. Integrating forest biodiversity conservation and restoration ecology principles to recover natural forest ecosystems. New Forests **50**:169-181.

[66] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna. Austral Ecology 44, 1076-1090.

[67] Cheal, D. 2010. Growth stages and tolerable fire intervals for Victoria's native vegetation data sets. Report No. 84. Department of Sustainability and Environment, Melbourne, Victoria.

[68] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna. Austral Ecology 44, 1076-1090.

Alpine Ash forest, old growth comprises 0.47% of the entire extent of the ecosystem in the Central Highlands RFA.[69] Due to the very limited extent of old growth and its ecological significance, all remaining old growth should be protected.[70]

Forest Fragmentation and Edge Effects

The configuration of conservation reserves can have a significant impact on their conservation values and viability, e.g. via edge effects and fragmentation/connectivity, particularly if adjacent areas are highly disturbed. Differences in spatial characteristics are important, given that they can have major landscape-level effects on other measures of forest condition, such as the rate at which keystone structures such as large old trees are likely to decay and collapse.[71]

The SAP is not aware of any comprehensive assessments of the configuration of the Victorian CAR reserve system in forests in terms of edge effects or connectivity. Some ecosystems have been subject to detailed analysis, such as the Wet Forest and Damp Forest EVCs and the Dry Forest group of EVCs, which were studied by Taylor and Lindenmayer (2019).[72] Taylor and Lindenmayer's (2019) analysis underscored the highly disturbed nature of off-reserve wood production forests. For the Wet and Damp Forests EVC Group, the median distance for a random point inside the dedicated reserve network to a boundary (representing a disturbed 'edge') was 1700 m. In comparison, the median distance to a boundary for informal protected areas was 71 m. For the Dry Forest group of EVCs, the median distance was 1232 m for a random point inside the formal protected area network to a boundary. The equivalent median distance across the informal protected area network was 180 m.[73]

As outlined above, there are major differences in spatial patterns of forest cover between reserve and off-reserve forest areas, including the distance to (and length of) intact forest and disturbance boundaries.[74] This can lead to problems such as edge effects in fragmented forests (e.g. wind throw and tree collapse[75]) as well as the potential for impaired functional connectivity.

SAP members provided divergent opinions as to whether off-reserve management is currently providing a sufficient complementary contribution to the reserve system, with some SAP members considering it inadequate for some key elements of the biota such as arboreal marsupials and forest birds.[76]

Edge effects can be minimised in a number of different ways, including:

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[69] Lindenmayer, D.B., Blanchard, W., Blair, D., Westgate, M.J., and Scheele, B.C. (2019). Spatio-temporal effects of logging and fire on tall, wet temperate eucalypt forest birds. Ecological Applications, https://doi.org/10.1002/eap.1999.

[70] Lindenmayer, D.B., Blair, D., McBurney, L., Banks, S., and Bowd, E. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. (*Australian Zoologist*) (in press).

[71] Lindenmayer, D. B., W. Blanchard, D. Blair, L. McBurney, J. Stein, and S. C. Banks. 2018b. Empirical relationships between tree fall and landscape-level amounts of logging and fire PLOS One 13(2):e0193132.

[72] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna? Austral Ecology 44 1076-1090.

[73] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna? Austral Ecology 44 1076-1090.

[74] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna? Austral Ecology 44 1076-1090.

[75] Lindenmayer, D. B., R. B. Cunningham, and C. F. Donnelly. 1997. Decay and collapse of trees with hollows in eastern Australian forests: impacts on arboreal marsupials. Ecological Applications **7**:625-641.

[76] Taylor, C. and Lindenmayer, D.B.(2019). The adequacy of Victoria's protected areas for conserving its forest-dependent fauna. Austral Ecology, 44, 1076-1090; Taylor, C., Cadenhead, N., Lindenmayer, D.B. and Wintle, B.A. (2017). Improving the design of a conservation reserve for a critically endangered species. PLOS One, 12(1), e0169629; Todd, C.R., Lindenmayer, D.B., Stamation, K., Acevedo-Catteneo, S., Smih, S. and Lumsden, L.F. (2016). Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling, 338, 90-100.

- Conserving larger consolidated areas rather than smaller fragmented areas
- Complementary management of adjacent 'off-reserve' areas

Further work would be required to determine the extent to which changes would need to be made to current forest management arrangements and tenures to address impacts arising from edge effects.

Climate Change Implications for Natural Ranges

Climate change is expected to alter the spatial distribution of some forest types and some forest-dependent species,[77] but the degree to which this will occur is very uncertain (Chapter 4). This has implications for the adequacy of a CAR reserve system based on the spatial distribution of EVCs as they existed in the 1990s or earlier (when the EVC mapping was largely done). Moreover, the component species within communities and other categorisations such as EVCs may disassemble and reassemble in unpredictable ways as a result of climate change.[78]

Extensive analyses of the effectiveness of the CAR reserve system should be completed, including under a range of Representative Climate Futures (RCFs), *sensu* Whetton *et al.*[79] This should include assessments of the surrogates used for analysing reserve effectiveness such as EVCs, particularly under key drivers of change such as altered fire regimes (e.g. fires of increased severity, frequency and interaction with other stressors such as drought and logging).[80] Other key aspects of climate change and their impacts on ecosystems and forest-dependent taxa should also be examined, such as elevated temperatures, reduced rainfall, more frequent frosts, prolonged droughts and events such as windstorms. A more detailed discussion of the implications of climate change for RFAs is provided in Chapter 4.

3.3.2 Objective: Maintain Viable Populations of Native Forest Species Throughout Their Natural Ranges

National and global level studies suggest that some of Australia's forest-dependent threatened species have distributions that do not overlap with the protected areas network.[81] Recent research by Lindenmayer and his colleagues has indicated that at a regional level (e.g. in the Central Highlands

[77] Dunlop, M., D. W. Hilbert, S. Ferrier, A. House, A. Liedloff, S. M. Prober, A. Smyth, T. G. Martin, T. Harwood, K. J. Williams, C. Fletcher, and H. Murphy. 2012. The implications of climate change for biodiversity conservation and the National Reserve System: Final synthesis CSIRO Climate Adaptation Facility, Canberra; Lindenmayer, D. B., W. Steffen, A. Burbidge, L. Hughes, R. L. Kitching, W. Musgrave, M. Stafford-Smith, and P. Werner. 2010. Conservation strategies in response to rapid climate change: Australia as a case study. Biological Conservation **143** 1587-1593.

[78] Hamann, A., and T. L. Wang, 2006. 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. Ecology **87**:2773-2786.

[79] Whetton, P., K. Hennessy, J. Clarke, K. McInnes, and D. Kent. 2012. Use of Representative Climate Futures in impact and adaptation assessment. Climatic Change **115**:433-442.

[80] Cary, G. J., R. A. Bradstock, A. M. Gill, and R. J. Williams. 2012. Global change and fire regimes in Australia. Pages 149-169 *in* R. A. Bradstock, A. M. Gill, and R. J. Williams, editors. Flammable Australia. Fire Regimes, Biodiversity and Ecosystems in a Changing World. Melbourne, CSIRO Publishing.

[81] Watson, J. E., M. C. Evans, J. Carwardine, R. A. Fuller, L. N. Joseph, D. B. Segan, M. F. J. Taylor, R. J. Fensham, and H. P. Possingham. 2010. The capacity of Australia's protected-area system to represent threatened species. Conservation Biology **25**:324-332.

of Victoria), the existing reserve system does not support viable populations of some species,[82] thereby failing to meet the Adequacy criterion in the CAR reserve system principles.[83]

There is evidence for species declines in some forest types and in some reserve systems. The best evidence comes from the ash-type eucalypt forests of the Central Highlands of Victoria and it is based on robust field data gathered on an array of long-term monitoring sites established in wood production sites and protected areas. Those data indicate there have been strong declines in mammals (such as Leadbeater's Possum and the Greater Glider) as well as a suite of bird species.[84] These declines have occurred in reserves and off-reserve areas but are more pronounced in unprotected forests. Another example is based on information associated with the recent conservation uplisting of the Greater Glider, there is evidence of declines in the species in forest types outside of the Central Highlands of Victoria.[85]

Two sets of detailed analyses suggest that the existing reserve system in the Central Highlands of Victoria is not adequate for the conservation of arboreal marsupials such as the Greater Glider, Leadbeater's Possum and some species of large forest owls.[86] Some of these species are associated with old-growth forest or old-growth structures such as large old trees, which are increasingly uncommon, especially in wood production ash-type forests.[87] This is particularly problematic in the event of future wildfires and is especially relevant in forest types in high demand for wood production such as the ash-type forests of the Central Highlands of Victoria, which have been extensively burnt in recent decades. One option would be for the protected area network to be larger than the extent of forest that would be typically subject to large-scale disturbances such as wildfires),[88] to increase resilience/options of the habitat for the subject species. However, some reserved areas have also been extensively burned and it is important for there to be improved management across the whole of the forest estate.

3.3.3 Objective: Protect Old-growth Forest and Forested Wilderness

The extent of old-growth forest can be critically important for a range of species, e.g. many species of forest birds.[89] Larger patches of old-growth forests (e.g. those dating from before 1900 in ash-type forests) are generally excluded from timber harvesting, although formerly this was not the case.

[82] Todd, C. R., D. B. Lindenmayer, K. Stamation, S. Acevedo-Catteneo, S. Smih, and L. F. Lumsden. 2016. Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling **338**:90-100; Taylor, C., N. Cadenhead, D. B. Lindenmayer, and B. A. Wintle. 2017. Improving the design of a conservation reserve for a critically endangered species. PLOS One 12:e0169629.

[83] Taylor, C. and Lindenmayer, D.B. (2019). The adequacy of Victoria's protected areas for conserving its forest-dependent fauna. Austral Ecology, 44, 1076-1090.

[84] Lindenmayer, D.B. and Sato, C. (2018). Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. Proceedings of the National Academy of Sciences, 115, 5181-5186.

[85] DELWP, Threatened species advisory lists, https://www.environment.vic.gov.au/conserving-threatened-species/threatened-species-advisory-lists (accessed 12 July 2019)

[86] Todd, C. R., D. B. Lindenmayer, K. Stamation, S. Acevedo-Catteneo, S. Smih, and L. F. Lumsden. 2016. Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling 338:90-100; Taylor, C., N. Cadenhead, D. B. Lindenmayer, and B. A. Wintle. 2017. Improving the design of a conservation reserve for a critically endangered species. PLOS One 12:e0169629.

[87] Lindenmayer, D. B., W. Blanchard, D. Blair, and L. McBurney. 2018a. The road to oblivion – quantifying pathways in the decline of large old trees Forest Ecology and Management 430:259-264.

[88] Baker, W. L. 1992. The landscape ecology of large disturbances in the design and management of nature reserves. Landscape Ecology 7:181-194; McKenzie, D., C. Miller, and D. A. Falk, editors. 2011. The landscape ecology of fire. Springer, Dordrecht.

[89] Lindenmayer, D.B. and Sato, C. (2018). Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. Proceedings of the National Academy of Sciences, 115, 5181-5186; Lindenmayer, D.B., Blanchard, W., Blair, D., Westgate, M.J., and Scheele, B.C. (2019). Spatio-temporal effects of logging and fire on tall, wet temperate eucalypt forest birds. Ecological Applications, https://doi.org/10.1002/eap.1999.

Indeed, reserve boundaries often excluded old-growth forest or provision was made for 'once-only logging' in forests earmarked for future reservation. A key priority should be to develop a strategy for protecting all existing old-growth forest, and to plan for creating significantly more old-growth forest.[90]

The definition of old-growth forest in the ecological literature has recently been modified to encompass only stands greater than 250 years old (see review by Blair *et al.,* 2018[91]). The definition of 'old-growth' in the RFAs needs to be re-examined to provide a clear basis for setting targets in relation to old-growth forest. Functional definitions should be established that are appropriate for particular forest ecosystems, tree species, vegetation communities and threatened forest-dependent species. This is consistent with a principle in the JANIS document that data relevant to the structural, floristic, and functional qualities of old-growth should be used to assess the significance of disturbance effects on old-growth forests, and is particularly relevant in fire-tolerant forests, in which the dominant trees typically survive most fires so that time-since-last-wildfire is not a clear indication of forest 'age'.

While not based on an exhaustive review of all RFA data, evidence in the Central Highlands RFA (Table 2 in that document) indicated that representative conservation of old growth in the CAR reserve system roughly met the JANIS criteria of protecting all viable examples of rare and depleted old-growth forest (<10% of the extant distribution) and 60% of old growth in other forest ecosystems. However, the percentage of EVC areas as old growth in the Central Highlands RFA was frequently low (<1% for 11 of 16 EVCs), so that the overall area of old-growth forest in CAR reserves was also low compared with other growth stages when the CAR reserve system was established.

It remains unclear if the JANIS criteria for old-growth forests are ecologically meaningful targets and/or how they compare with historical percentage distributions by growth stage. In addition, the spatial extent of old-growth forest in some forest types has declined markedly in the past 20 years, especially following major wildfires such as those in 2009[92] but also in the preceding decades. For example, in ash-type eucalypt forests in the Central Highlands region, old-growth Mountain Ash forest currently comprises 1.16% of the total Mountain Ash forest estate and old-growth Alpine Ash forest constitutes 0.47% of the total Alpine Ash forest estate.[93]

Given the importance of old-growth forest, or old-growth forest structures, and its paucity as a growth stage in some vegetation types (e.g. see Cheal 2010[94]), we recommend that a re-assessment of the amount and spatial distribution of old growth be completed as part of the RFA modernisation process. Such an assessment might also make recommendations as to the locations of key areas to be reserved for future recruitment of new cohorts of forest that could grow on to create old-growth forest in the future.

[90] Lindenmayer, D.B. (2019). Integrating forest biodiversity conservation and restoration ecology principles to recover natural forest ecosystems. New Forests, 50, 169-181.

[91] Blair, D., L. McBurney, and D. B. Lindenmayer. 2018. Failing to conserve Leadbeater's Possum and its Mountain Ash forest habitat. Australian Zoologist **39**:443-448.

[92] Lindenmayer, D.B., Blair, D., McBurney, L., Banks, S., and Bowd, E. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. (*Australian Zoologist*) (in press).

[93] Lindenmayer, D.B. and Sato, C. (2018). Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. Proceedings of the National Academy of Sciences, 115, 5181-5186; Lindenmayer, D. B., D. Blair, L. McBurney, S. Banks, and E. Bowd. 2019. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. Australian Zoologist in press.

[94] Cheal, D. (2010) *Growth stages and tolerable fire intervals for Victoria's native vegetation data sets Report no. 84 Fire and adaptive management* Department of Sustainability and Environment, East Melbourne, Victoria. 244 pp. (available online at <https://www.ffm.vic.gov.au/__data/assets/pdf_file/0008/21113/Report-84-REDUCED-SIZE-Growth-Stages-and-Tolerable-Fire-Intervals-For-Victorias-Native-Vegetation-Data-Se.pdf>).

A key component in modernising the RFAs should be to re-assess the status of forest wilderness areas in Victoria. There are 'Wilderness Zones' within management plans developed by Parks Victoria, and these are currently distinct from the designated 'Wilderness Areas'. Some work is needed to harmonise these definitions and to work across tenures on forest wilderness and where it is located, its current status, and which forest types, forest ecosystems and vegetation communities occur in such areas. The designation of Wilderness Areas also has implications for active management because the definition and specifications for 'Wilderness Areas' largely preclude active management.

3.3.4 Objective: Maintain Ecological Processes and the Dynamics of Forest Ecosystems in Their Landscape Context

Forest Condition within the CAR Reserve System

There is evidence for marked declines in keystone structures in some Victorian forest ecosystem types such as ash-type eucalypt forests of the Central Highlands of Victoria. Keystone structures are components of vegetation cover or landscapes which have a disproportionately high value for biodiversity and/or ecosystem processes relative to the size of the area that they occupy.[95] Examples include large old trees and rocky outcrops.

Recent research by Lindenmayer and his colleagues has shown declines in populations of both large living and large dead old trees in Victorian ash-type eucalypt forests over the past two decades (from 1997) and particularly in wood production areas.[96] These trees provide habitat for a wide range of species[97]) and also provide long-term stores of carbon,[98] although their current importance as carbon stores in this regard is limited by the existing low numbers of such trees. The abundance of large old trees and of old growth is higher in the CAR reserve system for ash forests than it is outside the reserve system in those same forest types, although there has been an overall decline in the abundance of large old trees across all tenures, but the decline is slower and less pronounced within reserves.[99] This research has also indicated that as forest landscapes are increasingly subject to logging operations, the rate of collapse of large old trees increases.[100]

Stressors

Some areas of forests within the CAR reserve system were previously logged but are now protected from timber harvesting. However, they are not necessarily protected from other stressors. Some of these stressors include (among others):

[95] Tews, J., U. Brose, V. Grimm, K. Tielborger, M. Wilchmann, M. Schwager, and F. Jeltsch. 2004. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of Biogeography **31**:79-92.
[96] Lindenmayer, D.B., Blanchard, W., Blair, D. and McBurney, L. (2018). The road to oblivion – quantifying pathways in the decline of large old trees. Forest Ecology and Management, 430, 259-264; Lindenmayer, D.B., Blanchard, W., Blair, D., McBurney, L. and Banks, S. (2016). Environmental and human drivers of large old tree abundance in Australian wet forests. Forest Ecology and Management, 372, 226-235; Lindenmayer, D.B., Blanchard, W., Blair, D., McBurney, L., Stein, J. and Banks, S.C. (2018). Empirical relationships between tree fall and landscape-level amounts of logging and fire. PLOS One, 13(2), e0193132.
[97] Lindenmayer, D. B., and W. Laurance. 2017. The ecology, distribution, conservation and management of large old trees. Biological Reviews **92**:1434-1458.
[98] Keith, H., B. G. Mackey, and D. B. Lindenmayer. 2009. Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests. Proceedings of the National Academy of Sciences **106**:11635-11640.
[99]Lindenmayer, D. B., W. Blanchard, D. Blair, L. McBurney, and S. C. Banks. 2016. Environmental and human drivers of large old tree abundance in Australian wet forests. Forest Ecology and Management **372**:266-235.
[100] Lindenmayer, D. B., W. Blanchard, D. Blair, L. McBurney, J. Stein, and S. C. Banks. 2018. Empirical relationships between tree fall and landscape-level amounts of logging and fire PLOS One 13(2):e0193132.

- Wildfires. Extensive areas within CAR reserve system have been burned in recent landscape-scale fires, with implications for change in age-class structure and loss of large trees and areas of old-growth forest.
- Invasive species. There has been an apparent rapid increase in populations of invasive deer species in large parts of the forest estate in Victoria.[101] This is a key emerging problem that warrants urgent attention.
- Edge effects and forest fragmentation effects. Parts of the CAR reserve system are subject to disturbance from timber harvesting in adjacent areas. For example, increasing amounts of logging in forest landscapes elevate rates of tree fall in adjacent unlogged areas[102].

Other stressors may pose a risk to the CAR reserve system. These include drought/insect interactions such as psyllid outbreaks that periodically occur in ash-type forests.[103] Some of these stressors may require active intervention to limit a potential decline in the condition of CAR reserve forests.

3.3.5 Objective: Safeguard Endangered and Vulnerable Species and Ecosystems

The RFAs currently provide exemptions from certain EPBC Act approval requirements but no alternative processes to address them. (The SAP has discussed this issue in Chapter 2 on MNES). The FFG Act applies to the CAR reserve system, but no special management or measures are applied in RFA regions, other than general FFG Act operation.

The management of CAR reserves is currently not adequate to protect species from key threatening processes, including the abovementioned stressors. For example, wildfire is one of the key threats to the survival of montane ash forests and some forest-dependent fauna such as Leadbeater's Possum.[104]

The question of reserve design and management in relation to wildfires is complex and controversial. General reserve design principles suggest that protected areas should be larger than the size of major disturbance events like wildfires, including catastrophic large-scale conflagrations.[105] This implies a need for the existing CAR reserve system to be assessed to appraise its adequacy in relation to large-scale recurrent disturbances such as wildfires,[106] especially given the likelihood of such major fire impacts as part of climate change.[107]

[101] Forsyth, D. M., P. Caley, N. E. Davis, A. D. M. Latham, A. P. Woolnough, L. P. Woodford, K. A. Stamation, P. D. Moloney, and C. Pascoe. 2018b. Functional responses of an apex predator and a mesopredator to an invading ungulate: dingoes, red foxes and sambar deer in south-east Australia. Austral Ecology, in press.
[102] Lindenmayer, D.B., Blanchard, W., Blair, D., McBurney, L., Stein, J. and Banks, S.C. (2018). Empirical relationships between tree fall and landscape-level amounts of logging and fire. PLOS One, 13(2), e0193132.
[103] Coy, R., and J. Burgess. 1994. Psyllids in Mountain Ash forests. Department of Conservation and Natural Resources, Melbourne.
[104] Lindenmayer, D.B., Blair, D., McBurney, L., Banks, S., and Bowd, E. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. (*Australian Zoologist*) (in press).
[105] Lindenmayer, D. B., and J. F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach. Island Press, Washington DC.
[106] Todd, C. R., D. B. Lindenmayer, K. Stamation, S. Acevedo-Catteneo, S. Smih, and L. F. Lumsden. 2016. Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling 338:90-100.
[107] Williams, R. J., R. A. Bradstock, G. J. Cary, N. J. Enright, A. M. Gill, A. C. Liedloff, C. Lucas, R. J. Whelan, A. N. Andersen, D. J. Bowman, P. J. Clarke, G. D. Cook, K. J. Hennessy, and A. York. 2009. Interactions between Climate Change, Fire Regimes and Biodiversity in Australia. A Preliminary Assessment. Department of Climate Change and Department of the Environment, Water, Heritage and the Arts, Canberra.

The effect of logging on the susceptibility of forests to wildfire is controversial.[108] This is relevant to the management of the CAR reserve system because of the potential spread of fire from other areas. Research led by the University of Melbourne and the University of Wollongong, has indicated that fire interacts with other disturbances such as logging, which can make some forest types more prone to subsequent crown-scorching fires.[109] However, Attiwell *et al*. (2014) argued that fire management plays a more important role. [110]

The risk of landscape-scale fires is increasing due to extreme weather and climate change, as discussed in Chapter 4. An effective fire-suppression capability is important for mitigating this risk, including skilled and experienced personnel with good local knowledge.[111] Roads and tracks have potential benefits and risks – they provide access for fire control but also for arson, with areas close to roads more likely to be subject to direct human fire ignitions.[112]

3.3.6 Objective: Maintain the Genetic Diversity of Native Forest Species

The JANIS criteria specify the need for the CAR reserve system to maintain the genetic diversity of forest-dependent species. There are few data to determine if this has occurred. Whilst there is a small number of studies of genetic variability of some forest-dependent taxa,[113] there have been no studies comparing patterns of genetic variability among populations within and outside CAR reserves. This indicates a need for further investigations of the inter-relationships between genetic variability, reserve design and medium to long-term population viability.

3.4 Options for Improvement

A range of different options for improving the CAR reserve system in relation to the objectives of the JANIS criteria are discussed in this section, including the following:

- Increase the areal extent of under-represented major forest types and vegetation communities in the CAR reserve system
- Assess the effectiveness of the CAR reserve system and identify opportunities for improvement
- Assess the adequacy of the CAR reserve system for species protection

[108] For example, compare Attiwell *et al*. (2014) with Zylstra (2018) and Taylor *et al*. (2014). Attiwill, P.M., Ryan, M.F., Burrows, N., Cheney, N.P., McCaw L., Neyland, M.and S. Read 2014. Timber harvesting does not increase fire risk and severity in wet eucalypt forests of southern Australia. Conservation Letters 7**:**341-354. Zylstra, P., 2018.Flammability dynamics in the Australian Alps. *Austral Ecology* 10.1111/aec.12594; Taylor, C., McCarthy, M. A. and Lindenmayer, D. B., 2014. Non-linear effects of stand age on fire severity. *Conservation Letters* **7:** 355-370. 10.1111/conl.12122

[109] Zylstra, P., 2018.Flammability dynamics in the Australian Alps. *Austral Ecology* 10.1111/aec.12594; Taylor, C., McCarthy, M. A. and Lindenmayer, D. B., 2014. Non-linear effects of stand age on fire severity. *Conservation Letters* **7:** 355-370. 10.1111/conl.12122

[110] Attiwill, P.M., Ryan, M.F., Burrows, N., Cheney, N.P., McCaw L., Neyland, M.and S. Read 2014. Timber harvesting does not increase fire risk and severity in wet eucalypt forests of southern Australia. Conservation Letters 7**:**341-354.

[111] Attiwill, P.M., Ryan, M.F., Burrows, N., Cheney, N.P., McCaw L., Neyland, M.and S. Read 2014. Timber harvesting does not increase fire risk and severity in wet eucalypt forests of southern Australia. Conservation Letters 7**:**341-354.

[112] Collins, K. M., O. Price, and T. Penman. 2015. Spatial patterns of wildfire ignitions in south-eastern Australia. International Journal of Wildland Fire **24**:1098-1108; Serra, L., M. Saez, J. Mateu, D. Varga, P. Juan, C. Díaz-Ávalos, and H. Rue. 2014. Spatio-temporal log-Gaussian Cox processes for modelling wildfire occurrence: the case of Catalonia, 1994–2008. Environmental and Ecological Statistics **21**:531-563.

[113] Banks, S. C., L. McBurney, D. Blair, I. D. Davies, and D. B. Lindenmayer. 2017. Where do animals come from during post-fire population recovery? Implications for ecological and genetic patterns in post-fire landscapes. Ecography **40**:1325-1338; Blyton, M. D. J., S. C. Banks, R. Peakall, D. B. Lindenmayer, and D. M. Gordon. 2014. Not all types of host contacts are equal when it comes to E. coli transmission. Ecology Letters **17**:970-978; Hansen, B. D., D. K. P. Harley, D. B. Lindenmayer, and A. C. Taylor. 2009. Population genetic analysis reveals a long-term decline of a threatened endemic Australian marsupial. Molecular Ecology **18**:3346-3362; von Takach Dukai, B., C. Jack, J. Borevitz, D. B. Lindenmayer, and S. C. Banks. 2019. Pervasive admixture between eucalypt species has consequences for conservation and assisted migration. Evolutionary Applications **12**:845-860.

- Refine goals for restoration of suitable levels of old-growth forest cover
- Evaluate the adequacy of the CAR reserve system in response to climate change
- Better management of the CAR reserve system
- Complementary management of adjacent areas (buffer zones)
- Active forest management
- Monitoring and adaptive management

Increase the Areal Extent of Under-represented Major Forest Types and Vegetation Communities in the CAR Reserve System

At the time the CAR reserve system was established, it was known that some vegetation communities (including EVCs) had inadequate representation in the CAR reserve system due to land availability and land tenure constraints. The SAP considers it appropriate for there to be a detailed re-assessment of the 'comprehensiveness, adequacy and representativeness' of the existing forest reserve system in Victoria. This assessment should seek opportunities for increasing representation of under-represented vegetation communities and habitats.

SAP members provided divergent opinions regarding the need for the areal extent of the CAR reserve system to be expanded. Based on evidence from conservation biology, some SAP members argued that substantial expansion in the reserve system is necessary to protect the viability of some threatened arboreal marsupials including Leadbeater's Possum.[114] This is consistent with recommendations from the TSSC.

However, the following concerns were raised by some SAP members about expanding the areal extent of the CAR reserve system:

- Expansion of the CAR reserve system will not necessarily secure the target populations.
- Better management of the CAR Reserve system is required, and this would be expected to lead to improved conservation outcomes within the footprint of the existing CAR Reserve System. Some SAP members consider that improving the management of the existing reserve system is a higher priority than expanding it.
- Some SAP members consider that the loss of access, equipment and experienced people working in harvested forests resulting from expansion of the CAR Reserve system may reduce the capacity for critical early stage suppression of wildfires.

Assess the Effectiveness of the CAR Reserve System and Identify Opportunities for Improvement

The SAP recommended further assessments be completed on:

- The spatial distribution of the CAR reserve system
- The adequacy of the current CAR reserve system, including with regard to reserve effectiveness for supporting viable populations of species and communities, and
- Forest configuration in relation to potential edge effects.

These assessments may include analyses of additional data describing vegetation structure and condition (such as the extent of old-growth forest, large old trees and other critical habitat features) as well as measures of spatial configuration (such as the size of patches of intact forest, the distance to tenure and disturbance boundaries). The SAP notes that some indices of fragmentation and

[114] Taylor, C., Cadenhead, N., Lindenmayer, D.B. and Wintle, B.A. (2017). Improving the design of a conservation reserve for a critically endangered species. PLOS One, 12(1), e0169629; Todd, C.R., Lindenmayer, D.B., Stamation, K., Acevedo-Catteneo, S., Smih, S. and Lumsden, L.F. (2016). Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling, 338, 90-100.

functional connectivity could be calculated utilising existing DELWP databases for comparison across forest tenures[115]), although this should be done within a broader evaluation framework.

- Updated and expanded assessments of the CAR reserve system could be used to:
- Identify strategic opportunities to improve the configuration of CAR reserves to reduce impacts of fragmentation/edge effects
- Identify priority areas for buffer zones to enhance complementary management
- Quantify the effectiveness of the existing reserve system relative to key international criteria such as the IUCN Standard for Key Biodiversity Areas[116]
- Determine the adequacy of the management of the entire forest system relative to the probability of persistence for key threatened forest-dependent biota.[117]

Assess the Adequacy of the CAR Reserve System for Species Protection

The EVCs mapped in Victorian forests were assumed to be biodiversity surrogates (*sensu* Caro[118] and Lindenmayer *et al.*[119]) and it was assumed that by including samples from the full range of EVCs in the protected area estate, this would also protect forest-associated species. Evidence of success or not in terms of meeting many of CAR reserve objectives is scant for the majority of forest-associated species. However, evidence in relation to some species in some forest types, such as arboreal marsupials and birds in montane ash forests of the Central Highlands of Victoria suggests the CAR reserve system, and its management are inadequate. On this basis, the adequacy of the CAR reserve system should be assessed in relation to the viability of populations of forest-associated species, including species of conservation significance identified in lists under the EPBC Act, FFG Act and the VROTS advisory lists, as well as other species that are forest-dependent. The decline of the Greater Glider (Chapter 2) provides an illustration of how a formerly non-threatened species can become subject to decline.[120]

The assessment of adequacy should include:

- Map-based assessments to examine forest-associated species distributions relative to the CAR reserve footprint, and the occurrence of required or preferred habitats for particular species within the CAR reserve system
- Assessment of the adequacy of management plans and implementation guidelines for the CAR reserve system in relation to the various forest-associated species. This includes assessments of the medium and long-term viability of threatened species as well as the adequacy of resources need for best practice reserve management.

[115] Taylor, C., and D. B. Lindenmayer. 2019. The adequacy of Victoria's protected areas to conserve its forest-dependent fauna? Austral Ecology 44 1076-1090.
[116] IUCN. 2016. A Global Standard for the Identification of Key Biodiversity Areas. IUCN, Gland, Switzerland.
[117] Taylor, C., Cadenhead, N., Lindenmayer, D.B. and Wintle, B.A. (2017). Improving the design of a conservation reserve for a critically endangered species. PLOS One, 12(1), e0169629; Todd, C.R., Lindenmayer, D.B., Stamation, K., Acevedo-Catteneo, S., Smih, S. and Lumsden, L.F. (2016). Assessing reserve effectiveness: Application to a threatened species in a dynamic fire prone forest landscape. Ecological Modelling, 338, 90-100.
[118] Caro, T. 2010. Conservation by Proxy. Indicator, Umbrella, Keystone, Flagship, and Other Surrogate Species. Island Press, Washington D.C.
[119] Lindenmayer, D. B., D. P. Blair, L. McBurney, and S. C. Banks. 2015b. Mountain Ash: Fire, Logging and the Future of Victoria's Giant Forests. CSIRO Publishing, Melbourne.
[120] Lindenmayer, D. B., J. T. Wood, L. McBurney, C. MacGregor, K. Youngentob, and S. C. Banks. 2011. How to make a common species rare: A case against conservation complacency. Biological Conservation 144:1663-1672; Lindenmayer, DB, and Sato C. (2018). Hidden collapse is driven by fire and logging in a socioecological forest ecosystem. *Proceedings of the National Academy of Sciences*, 115, 5181-86

The assessment of reserve adequacy is particularly apt in the context of increasing fire extent and risk in Victoria[121] and how this is managed. This assessment would provide the basis for determining requirements in relation to:

- Potential expansion of the CAR reserve system to increase areal representation for key forest-associated species. Priority could be given to rare and threatened forest-dependent species in the first instance. DELWP has identified 70 of these species and created Species Distribution Models (SDMs) for these taxa[122]
- Key risks to forest-associated species (e.g. loss of suitable habitat through wildfire)
- Improvements in management arrangements in the CAR reserve system to support viable populations of forest-associated species, including opportunities for mitigating key risks.

Refine Goals for Restoration of Suitable Levels of Old-growth Forest Cover

The spatial extent of the old-growth estate has been severely depleted in many forest ecosystems across Victoria and its current spatial extent will need to be expanded in some forest types such as the montane ash forests of the Central Highlands RFA.[123] Old growth needs to be defined with reference to a given ecosystem, but typically relates to areas with limited evidence of relatively recent direct human disturbance (e.g. in the past 100 years).[124] The Victorian Government has recently altered the definition of old growth in some forest types (e.g. > 250 years for ash-type forests[125] and the ecological validity of such changes should be reviewed as part of the RFA process, particularly in terms of the implications for biodiversity conservation.

A key issue is to determine where the next cohorts of old-growth forest are most likely to develop in future (e.g. in climate refugia) and seek to limit human disturbances such as logging in these areas.[126]These will need to be carefully managed and protected from a wide range of pressures including wildfire to have any chance of becoming old growth. Environmental domain analyses represent one approach to help identify where these areas are likely to occur in the landscape. Such an environmental domain approach has been taken in the past with respect to both old growth and rainforest cover in the Central Highlands RFA area.[127]

A second key issue for old growth conservation and management is to set forest-type specific goals for old-growth cover. Lindenmayer and his colleagues proposed a target of 30% old-growth cover for

[121] Williams, R. J., R. A. Bradstock, G. J. Cary, N. J. Enright, A. M. Gill, A. C. Liedloff, C. Lucas, R. J. Whelan, A. N. Andersen, D. J. Bowman, P. J. Clarke, G. D. Cook, K. J. Hennessy, and A. York. 2009; Cary, G. J., R. A. Bradstock, A. M. Gill, and R. J. Williams. 2012. Global change and fire regimes in Australia. Pages 149-169 *in* R. A. Bradstock, A. M. Gill, and R. J. Williams, editors. Flammable Australia. Fire Regimes, Biodiversity and Ecosystems in a Changing World. Melbourne, CSIRO Publishing.

[122] Taylor, C. and Lindenmayer, D.B.(2019). The adequacy of Victoria's protected areas for conserving its forest-dependent fauna. Austral Ecology, 44, 1076-1090.

[123] Lindenmayer, D.B., Blair, D., McBurney, L., Banks, S., and Bowd, E. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. (*Australian Zoologist*) (in press).

[124] Burgman, M. A., and D. B. Lindenmayer. 1998. Conservation Biology for the Australian Environment. Surrey Beatty and Sons, Chipping Norton, Sydney; Woodgate, P. W., B. D. Peel, J. E. Coram, S. J. Farrell, K. T. Ritman, and A. Lewis. 1996. Old-growth forest studies in Victoria, Australia. Concepts and principles. Forest Ecology and Management **85**:79–84.

[125] Blair, D., McBurney, L. and Lindenmayer, D.B. (2018). Failing to conserve Leadbeater's Possum and its Mountain Ash forest habitat. Australian Zoologist, 39, 443-448

[126] Mackey, B., S. Berry, S. Hugh, S. Ferrier, T. D. Harwood, and K. J. Williams. 2012. Ecosystem greenspots: identifying potential drought, fire, and climate-change micro-refuges. Ecological Applications **22**:1852-1864.

[127] Mackey, B., D. B. Lindenmayer, A. M. Gill, M. A. McCarthy, and J. A. Lindesay. 2002. Wildlife, Fire and Future Climate: A Forest Ecosystem Analysis. CSIRO Publishing, Melbourne.

the ash-type forests of the Central Highlands of Victoria.[128] This value was based on the likely historical extent of old-growth cover in ash-type forests prior to extensive human disturbance. They proposed that because of recurrent disturbances, a considerably larger area of forest should be set aside (> 50% of ecosystem cover) as they considered this necessary to have any hope of reaching that goal.[129] However, the SAP recognises such goals for old-growth cover may be challenging to meet given a range of factors including: the low percentage areas of old growth currently in the CAR reserve system, the projected increased in frequency and severity of wildfires in Victorian forests and the cost of long-term management of the forests to provide old-growth cover for biodiversity.

Evaluate the Adequacy of the CAR Reserve System in Response to Climate Change

- Conduct thorough testing of the sensitivity of the CAR reserve system to various scenarios for climate change (e.g. using an RCF approach[130]).
- Based on the results of current analyses and further sensitivity testing, consider re-configuring the CAR reserve system and/or improving the level of protection and management of the CAR reserve system to ensure it can best withstand the pressures associated with climate change.

The SAP considered three potential approaches to enhancing the effectiveness of the CAR reserve system in relation to potential impacts of climate change.

- Add a margin to JANIS criteria percentage areas. This was rejected because there is no clear defensible basis for percentages (they are simple rules of thumb). In addition, this approach does not account for variations in sensitivity of different forest types to climate change, nor for processes by which climate change will affect forests.
- Use climate futures scenario modelling (e.g. RCFs) to develop maps predicting the future extent and relative stability of the various forest communities and habitats under a range of climate change scenarios. This approach could help determine the adequacy of the CAR reserve system such as by assessments based on areal extent relative to the JANIS criteria percentages. It could also help identify priority areas for re-configuration of CAR reserves to maintain representative spatial coverage. This exercise could be restricted to vegetation communities that have been reliably mapped and/or are considered particularly vulnerable to climate change (such as ash-type forests and rainforests). This approach could be integrated with PVA (including multi-species PVA) to assess the probability of persistence of particular species within reserves and in response to climate change. However, the uncertainties may be too high to base future planning on this approach.
- Monitor change and be responsive to future needs. This includes continuing to monitor the CAR reserve system, and where evidence indicates failures in the CAR reserve system, then implement measures to address these failures. This approach assumes that failures in management and failures in reserve adequacy are reversible, which may not necessarily be the case. It also assumes that robust and responsive monitoring programs are in place.

[128] Lindenmayer, D. B., D. Blair, L. McBurney, S. C. Banks, J. A. R. Stein, R. J. Hobbs, G. E. Likens, and J. F. Franklin. 2013. Principles and practices for biodiversity conservation and restoration forestry: a 30 year case study on the Victorian montane ash forests and the critically endangered Leadbeater's Possum. Australian Zoologist **36**:441-460.
[129] Lindenmayer, D.B. (2019). Integrating forest biodiversity conservation and restoration ecology principles to recover natural forest ecosystems. New Forests, 50, 169-181
[130] Whetton, P., K. Hennessy, J. Clarke, K. McInnes, and D. Kent. 2012. Use of Representative Climate Futures in impact and adaptation assessment. Climatic Change **115**:433-442.

Better Management of the CAR Reserve System

Better management of the CAR reserve system (which must be supported by adequate resourcing) is strongly advocated. Some key areas where improved management should be directed include:

- Control of populations of exotic herbivores, notably Sambar Deer which are currently undergoing rapid expansion within and outside Victorian forests. [131]
- Improved fire management to better protect all forests from inappropriate fire regimes. This is important given the extent of recent wildfires in forest types subject to stand-replacing disturbances such as forests dominated by Alpine Ash[132] and Mountain Ash,[133] but also those where repeated fires at short intervals can affect fire-tolerant eucalypts.[134] Depending on previous fire intervals, this may include application of prescribed fire over increased areas in dry and mixed species forest types to protect adjacent fire-sensitive ash-type forests.
- Reduction in human population pressures on parts of the CAR reserve system such as limiting arson, littering, the establishment of invasive weeds (e.g. around roads[135]) and illegal firewood collection.
- Well designed and appropriately resourced monitoring to assess the effectiveness of the CAR reserve system as well as to adaptive approaches to forest management. An adaptive approach would assist forest managers to respond in a rapid and timely way to emerging threats and evidence of deficiencies in management and conservation effectiveness. A more detailed discussion of Adaptive Management and adaptive approaches is provided in Chapter 7.
- Carefully manage areas adjacent to reserves and where possible create buffers of unlogged forest at the boundaries of protected areas. Logging close to reserve boundaries can generate edge effects such as increased windthrow that can accelerate the rate of collapse of keystone structures such as large old trees.[136]

The RFAs should require the development and implementation of improved management plans for the CAR reserve system (to ensure that it is managed in accordance with the JANIS criteria objectives). This would include defining accountability for development, implementation and review of management plans.

Complementary Management of Adjacent Areas (Buffer Zones)

Off-reserve management is currently deficient for protecting key elements of biodiversity and keystone structures like large old trees in some forest ecosystems.[137] Existing scientific information could be used to create strengthened prescriptions for improved off-reserve management.[138] This would provide enhanced protection, and recruitment, of new cohorts of keystone structures such as

[131] Forsyth, D. M., P. Caley, N. E. Davis, A. D. M. Latham, A. P. Woolnough, L. P. Woodford, K. A. Stamation, P. D. Moloney, and C. Pascoe. 2018. Functional responses of an apex predator and a mesopredator to an invading ungulate: dingoes, red foxes and sambar deer in south-east Australia. Austral Ecology in press

[132] Bowman, D. M. J. S., B. P. Murphy, D. L. J. Neyland, G. J. Williamson, and L. D. Prior. 2014. Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. Global Change Biology **20**:1008-1015.

[133] Lindenmayer, D. B., D. Blair, L. McBurney, S. Banks, and E. Bowd. 2019. Ten years on – a decade of intensive biodiversity research after the 2009 Black Saturday fires in Victoria's Mountain Ash forest. Australian Zoologist **in press**.

[134] Fairman, T. A., L. T. Bennett, and C. R. Nitschke. 2019. Short-interval wildfires increase likelihood of resprouting failure in fire-tolerant trees. . Journal of Environmental Management **231**:59-65.

[135] Wace, N. 1977. Assessment of dispersal of plant species - the car borne flora of Canberra. Pages 166-186 *in* Exotic Species in Australia - Their Establishment and Success, Proceedings of the Ecological Society of Australia 10.

[136] Lindenmayer, D. B., W. Blanchard, D. Blair, L. McBurney, J. Stein, and S. C. Banks. 2018. Empirical relationships between tree fall and landscape-level amounts of logging and fire PLOS One 13(2):e0193132.

[137] Lindenmayer, D.B., Blanchard, W., Blair, D., McBurney, L., Stein, J. and Banks, S.C. (2018). Empirical relationships between tree fall and landscape-level amounts of logging and fire. PLOS One, 13(2), e0193132.

[138] Lindenmayer, D.B. (2019). Integrating forest biodiversity conservation and restoration ecology principles to recover natural forest ecosystems. New Forests, 50, 169-181.

large old trees. Strengthened prescriptions could also include limitations to further fragmentation of remaining areas of intact forest, thereby enhancing the ability of area outside the reserve system to make greater complementary contributions to forest biodiversity conservation.

The RFAs could require that the management plans for the CAR reserve system include recommendations for the management of adjacent buffer zones. These requirements might include:

- The development of scientifically-based principles for buffer zone establishment (e.g. to reduce edge effects and protect viable local populations of species)
- Mapping to designate the location of appropriately sized and located buffer zones to protect particular species, forest structures and vegetation.

Active Forest Management

Some key aspects of active forest management will be essential in the context of the CAR reserve system and RFAs. For example, there will be a need for forest restoration and active management of some forest values. This includes the long-term restoration of old growth through the protection of younger aged forests that would eventually grow through to become old growth.[139] There may need to be re-seeding of ash-type forests which are subject to repeated fire at short intervals (with such activities subject to monitoring, so that success or otherwise can be evaluated). There is a need to manage current and emerging threats (e.g. invasive species such as Sambar Deer).

Monitoring and Adaptive Management

The effectiveness of management arrangements for reserve and off-reserve areas for conservation demands rigorous, cross-tenure monitoring programs. Adaptive management is discussed in Chapter 7.

Although there have been recent innovations in DELWP monitoring, there are few monitoring programs at an appropriate spatial scale and across tenures for forests in Victoria. An exception is the DELWP and Parks Victoria-supported long-term monitoring program in the ash-type eucalypt forests of the Central Highlands of Victoria run by the Australian National University. The long-term sites in this research and monitoring program provide evidence of temporal trends in biodiversity and ecosystem condition as well as the responses to some kinds of management (including reservation and protection of forest). RFA modernisation provides an opportunity to address the deficiency in monitoring capability (including adequate resourcing) across all forest types in Victoria (see Chapter 7).

[139] Lindenmayer, D.B. (2019). Integrating forest biodiversity conservation and restoration ecology principles to recover natural forest ecosystems. New Forests, 50, 169-181.

4 Climate Change

4.1 Summary and Recommendations

4.1.1 Summary

The SAP was requested to provide advice on the following questions:

- What are the projected impacts of climate change on the full suite of forest values?
- What improvements could be made to the RFAs to ensure these impacts are appropriately managed?

The SAP concluded that the impacts of climate change on the full set of forest values (as specified by the Montréal Process Criteria) are likely to be significant for Victoria's forests. The dynamics of climate change effects including interactions and feedbacks associated with changing fire regimes, forest conditions (and associated flammability), soil and land stability, species assemblages (including invasive species) and management practices (planned burning, timber harvesting) makes prediction of these effects difficult, leading to considerable uncertainty that needs to be acknowledged, quantified, and planned for through a responsive, flexible management framework.

4.1.2 Recommendations

The SAP recommends that the following commitments should be made in the RFAs to create an adaptive capacity to deal with climate change:

1. Commit to the establishment and implementation of an adaptive approach to forest management that includes clear goals for managing climate change impacts on the full suite of forest values.

   An adaptive approach to management is recommended as the primary mechanism for dealing with the highly uncertain but potentially major effects of climate change on many important forest values. The following important issues should be explicitly addressed when assessing climate-change impacts and solutions in the adaptive approach:

   - Clearly defined conceptual models that articulate current understanding of climate change impacts on the full suite of forest values, and on ecosystem responses and feedbacks. Such models would describe relationships between forest attributes and processes for climate-change impacts at a range of scales, and provide a strong basis for setting goals, measurable outcomes and associated monitoring strategies.
   - Clearly stated and, where possible, quantifiable management goals for environmental outcomes relevant to the full suite of forest values under climate change. Such goals should be regularly revisited and refined in response to new evidence relating to climate-change effects, and to the ranking of the relative importance of forest values to society. This will most likely require prioritising some forest values over others, requiring inevitable trade-offs.
   - Explicit recognition of the need to manage forests for climate change mitigation, e.g. to maintain or enhance forest carbon stocks. This could involve embedding carbon accounts into decisions about management practices, including uncertainties around how carbon additionality and permanence attributed to changed management will be influenced by climate change.
   - Well designed and implemented monitoring systems that make it possible to assess performance against goals, including the specification of indicators (including early-

warning indicators), sample sizes and sampling designs for detecting change in the full suite of forest values (see Chapter 7).

- Built-in mechanisms to test alternative, innovative management practices, including evaluation of climate change adaptation and mitigation practices.
- Regular re-evaluation of the results of monitoring and other scientific evidence to assess system predictions and management strategies, noting that the current provision for five-yearly reviews of RFA achievements may be too long to take effective adaptive-management responses for many forest values under climate change, and that a shorter review cycle (say 3 years) would be preferable.
- Identifying and defining climate-change related triggers for review of forest management goals and practices under the RFA.
- Research capacity will need to be strengthened to address knowledge gaps associated with considerable uncertainties relating to the future climate, especially the nature of rainfall (total amount, season and intensity), the biological responses of forests, dynamic and interactive effects among multiple potential stressors, and the ability of managers to deal with increasing fire risks. There is also major uncertainty relating to the effectiveness of altered management to mitigate or adapt to climate change.

2. Commit to the development of a cross-tenure approach to managing forests.

   Effective responses to the many climate-change effects on multiple forest values will require coordinated management across tenures. Cross-tenure adaptive approaches to forest planning and management will be challenging but are essential to addressing the threats posed by climate change. This will require strong co-operation between agencies, articulation of clear goals and significant investment in monitoring and evaluation processes that underpin adaptive responses (see Chapter7).

3. Commit to the implementation of pre-emptive management actions to mitigate the impacts of climate change on forest ecosystems.

   There are considerable uncertainties around the impacts of climate change on multiple forest values and around the potential for management actions to mitigate those impacts. Nevertheless, the SAP identified the following actions as consistent with a precautionary approach to mitigating climate change impacts by reducing landscape-scale threats, and focusing on vulnerable forest elements:

   - Continued active management that aims for appropriate fire regimes, which will likely require enhanced investment in bushfire detection and suppression activity to reduce the extent, severity and frequency of severe bushfires in many forest types.
   - Identification and protection of those species and ecosystems most vulnerable to climate change as indicated by a range of representative climate futures, including identification of those at risk both within and outside existing reserves.
   - Identification of climate refugia for key species and protection of these refugia from key threatening processes (including multiple threats).
   - Support further improvements in spatial assessments of risks from soil erosion and mass movement after both management burns and wildfire; and addressing such risks in fire management planning and wildfire recovery plans.
   - Strengthening capacity to reliably model both the direct and indirect effects of climate change on water yield from forest catchments.

- Identification, monitoring and management of the most threatening invasive plant and animal species under climate change.
- Active management of threatened fauna (e.g. faunal translocations, captive breeding programs), noting that there are significant risks associated with this approach.
- Active management of threatened plant species (e.g. ex situ seed banking, assessment of seed availability for obligate-seeders before planned burning, effective monitoring of post-disturbance regeneration including re-seeding/ planting to ensure population persistence).
- Enhanced protection of remaining old-growth forests and identification of areas of forest to protect and grow through to ecological maturity.
- Greater buffering and compliance with existing requirements of patches of rainforest.

4. Commit to working with industry to identify how wood supply can be more flexibly managed under a changing climate

   Climate change presents many challenges to the certainty of wood supply, particularly from native forests. It will be critical to work with the forest industry to address these challenges and to find workable solutions. Key considerations include:

   - Development of an Integrated Wood Supply Strategy (See Chapter 6) that considers both native forest and plantation wood sources, and includes evaluation of how wood supply from both sources will be influenced by climate change, and of alternative supply options as necessary.
   - Explicit recognition in the RFAs and the Integrated Wood Supply Strategy of the uncertainties around the ongoing wood supply, which preclude commitments to fixed long-term availability of wood. This will necessitate quantification and clear communication of the probabilities of future wood supply that explicitly account for predicted climate-change impacts, particularly wildfire.
   - Investment/ co-investment in technological solutions and skills development to support the development of alternative wood products and to ameliorate anticipated changes in wood supply including new species mixes, log quality, and reduced log size.

4.2 Climate Change and Victoria's Forests

Decades of climate data provide clear evidence that Victoria's climate has been changing. As summarised by Australia's *State of the Climate 2018* report,[140] key changes relevant to Victoria's forests have been:

- Higher temperatures, in all seasons, both day and night
- Increases in the frequency of extreme heat events
- Drier conditions including unprecedented drying in recent decades, which has been most pronounced during April to October (~ 11% rainfall decrease since the late 1990s)
- Increases in the number of dangerous fire weather days in spring, and in the length of the fire season.

[140] Commonwealth of Australia (2018) State of the Climate 2018. Bureau of Meteorology & CSIRO, www.csiro.au/state-of-the-climate

Each of these changes is projected to persist or intensify in coming decades, leading to more hot days, more time in drought and more short-duration extreme rainfall events.[141] In addition, more frequent and more severe fire weather is predicted for much of southeastern Australia in coming decades.[142]

The impacts of climate change on Victoria's forests will be direct – through effects of changing temperatures, changing water availability and increased CO_2 concentrations on productivity – and indirect through interactions with changing disturbance regimes including bushfires and pest outbreaks. There remains considerable uncertainty about the magnitude, distribution and timing of both direct and indirect effects of climate change on Victoria's forest estate.

Victoria's forests and forest sector are also part of the solution to mitigating climate change. The carbon stored in Victoria's forests is an important component of the global forest carbon stocks and Australia has made international commitments to report changes in those stocks. In addition, wood-based products offer market-substitution opportunities for more energy-intensive products. While the data available to estimate carbon stocks in the full range of Victoria's forest types are improving, much remains unknown about the potential impacts of climate change and changing disturbance regimes on the carbon balance over time, on the relative effects of management practices and on the emerging opportunities provided by carbon markets.

4.3 Changes in Policy Context Since the Establishment of the RFAs

The Victorian Government is committed to addressing climate change. The *Climate Change Act 2017* (Vic) indicates that the Victorian Government:

> *will endeavour to ensure that any decision made by the Government and any policy, program or process developed or implemented by the Government appropriately takes account of climate change if it is relevant*[143]

The policy objectives are to:

- Reduce greenhouse gas emissions
- Promote and support the transition to a net zero greenhouse gas emissions economy
- Build resilience through effective adaptation and disaster preparedness
- Manage natural resources, ecosystems and biodiversity to promote resilience
- Support vulnerable communities and promote social justice and intergenerational equity.[144]

The *Climate Change Act 2017* sets out provisions in relation to carbon sequestration on Crown land.[145] It also establishes a system of forestry rights, carbon sequestration rights and soil carbon rights on private land.[146]

Climate change is an important theme in *Protecting Victoria's Environment – Biodiversity 2037*, which recognises:

- Potential impacts of climate change on biodiversity and habitats

[141] Ibid
[142] Clarke, H.G., Smith, P.L., Pitman, A.J., 2011. Regional signatures of future fire weather over eastern Australia from global climate models. International Journal of Wildland Fire 20(4), 550-562.
[143] *Climate Change Act 2017* (Vic) s 20
[144] *Climate Change Act 2017* (Vic) s 22
[145] *Climate Change Act 2017* (Vic) Part 8
[146] *Climate Change Act 2017* (Vic) Part 7

- The role of the natural environment in helping reduce the impacts of climate change.

The RFA Act and the East Gippsland, Central Highlands and North East RFAs are silent in relation to climate change. The Gippsland and West Victoria RFAs list 'Refugia from Climate Change' as one of the National Estate values on public land.[147]

Minister D'Ambrosio has indicated that the Victorian Government wishes to ensure that climate change is addressed in the revised RFAs, consistent with the *Climate Change Act 2017* (Vic).

4.4 What is the Scientific Understanding of the Projected Impacts of Climate Change on the Full Suite of Forest Values?

4.4.1 Climate Change Scenarios

There is significant uncertainty regarding the nature, magnitude and timing of future climate change in Victoria. Continuation and intensification of trends observed to date is widely considered to be a significant possibility. However, there is a need to consider a range of projected climate change scenarios based on multiple Global Climate Models (GCMs). While GCMs largely agree on projected temperature increases under the respective Representative Concentration Pathways (RCPs), projected changes in rainfall vary between GCMs and regions. One way of capturing a range of projections is through the RCF method.[148] This approach addresses uncertainties in climate change predictions and provides a basis for sensitivity analysis on alternative climate change possibilities. A set of RCFs can be used across a given region to describe plausible future climates.[149] Based on selected climate variables, the RCF consists of a multi-purpose decision-support tool to assist in the application of climate change projections for impact assessment and adaptation planning.[150] The RCF approach allows consideration of low likelihood, but high impact, future regional climates that can be significant for adaptation planning.

4.4.2 Full Suite of Forest Values

The Montréal Process framework was developed to characterise the essential components of sustainable forest management for Temperate and Boreal Forests. It consists of seven criteria and 54 indicators, which are intended to measure maintenance of the broad range of forest values in perpetuity. On the basis of this framework, and information on current values and uses of Victorian forests, a simplified list of forest values was used to address the question of incorporation of climate change considerations in the RFA (see below). In particular, the SAP focused on the following important values, all of which could be markedly affected by climate change:

- Biodiversity
- Soil and water resources
- Carbon
- Wood production.

The relative economic and non-economic value of these values to society can vary with time, and water and carbon in particular might increase in value as climate change intensifies (i.e. as the environment becomes drier, and as the need for reliable carbon stores increases). Environmental-

[147] Gippsland RFA, Table 1; West Victoria RFA, Table 1
[148] Whetton P., Hennessy K., Clarke J., McInnes K. and Kent D., 2012. Use of Representative Climate Futures in impact and adaptation assessment, Climatic Change 115, 433–442.
[149] Ibid
[150] Ibid

Economic Accounting frameworks like those noted in *Protecting Victoria's Environment – Biodiversity 2037* should consider the potential for climate change to influence the public priorities for forest values in coming decades. Lindenmayer and his colleagues used the SEEA approach in Victoria's Central Highlands forests.[151]

Other values and uses are acknowledged, including cultural, experiential and setting values,[152] and other product types (e.g. apiary, tree-ferns, firewood etc.). All these values and uses will potentially be affected by climate change; however, it is outside the scope of this report to provide detailed consideration as to how they might be affected.

4.4.3 Scientific Assessments of Climate Change Implications

Climate change has been studied across the forest-related sciences in a wide range of ways:

- Modelling – e.g. projected changes in runoff and water yield resulting from altered rainfall patterns
- Process studies – e.g. observations of forest processes, such as soil erosion, in response to climate-related disturbances such as bushfires
- Studies of past environmental changes – e.g. Quaternary science, historical geomorphology
- Space-for-time substitution – comparison of different areas at a single point in time.

The information from published literature across the various disciplines and types of studies has been used as a basis for compiling a summary of potential implications of future climate change for Victoria's forests in Table 1. Some of the impacts of climate change in Table 1 are based on local Victorian studies. Others are extrapolated from interstate or international literature, taking into account the particular characteristics of Victorian forests.

Based on the evidence summarised in Table 1 (refer to this Table for key references), and noting considerable uncertainty, the main climate-change impacts on Victoria's forest-associated biodiversity will potentially be:

- Reduced range, distribution and population sizes of key species, altered key ecological processes underlying species persistence such as the quality of food resources, altered timing of breeding events, asynchrony between prey and predator species, and disrupted mutualisms and other co-dependencies (e.g. flowering of host plants and pollinators)
- Increased potential for local extinction and/or contracted distributions of woody plants, particularly obligate-seeder species, due to decreasing seed recruitment and recruitment events under a drier, hotter climate, combined with decreased intervals between bushfires
- Changed interactions between native and non-native plant species, including increased risks of spread of invasive plant species.

Based on the evidence summarised in Table 1 (refer to this Table for key references), and noting considerable uncertainty, the main climate-change impacts on Victoria's forest soil and water resources will potentially be:

[151] Keith, H., M. Vardon, J. A. R. Stein, J. L. Stein, and D. B. Lindenmayer. 2017. Ecosystem accounts define explicit and spatial trade-offs for managing natural resources. Nature Ecology and Evolution 1:1683-1692; Vardon, M., Keith, H. and Lindenmayer, D.B. (2019). Accounting and valuing the ecosystem services related to water supply in the Central Highlands of Victoria, Australia. Ecosystems Services, 39, 101-114.

[152] Ford, R.M., Anderson, N.M., Nitschke, C.R., Bennett, L.T., Williams, K.J.H., 2017. Psychological values and cues as a basis for developing socially relevant criteria and indicators for forest management. Forest Policy and Economics 78, 141-150.

- Increased likelihood of soil mass movements (rock falls, soil creep, landslides, debris flows), and of soil erosion by water and wind, which might be exacerbated by management practices (timber harvesting, planned burning; see Attachment 1)
- Drying landscapes leading to decreasing and more variable water yields, which will also be influenced by high-severity fires and timber harvesting although predictions of the interactive effects of climate and disturbance on forest water yields come with very wide confidence intervals that indicate a high degree of uncertainty (Attachment 1)
- Increased likelihood of events leading to sediment influx to waterways (i.e. deterioration in water quality).

Based on the evidence summarised in Table 1 (refer to this Table for key references), and noting considerable uncertainty, the main climate-change impacts on Victoria's forest carbon resource will potentially be:

- Decreased carbon sequestration through reduced tree growth and increased tree mortality associated with drying (chronic and acute), warming (chronic and acute), more frequent and severe bushfires, and the interactions of these effects as compound events
- Increased carbon emissions associated with more frequent and severe bushfires
- Increased carbon losses due to increased ecosystem respiration in response to warmer temperatures and extreme heat events
- Decreased likelihood of forest landscapes acting as reliable carbon stores (stocks), with flow-on implications for management leverage of carbon stocks and carbon market opportunities.

Based on the evidence summarised in Table 1 (refer to this Table for key references), and noting considerable uncertainty, the main climate-change impacts on Victoria's wood production will potentially be:

- Longer rotation times for D+ sawlogs due to decreased tree growth rates and/or decreased probability of reaching required rotation lengths for D+ sawlogs due to decreased bushfire intervals. This will have flow-on effects to industry including the need to accommodate shorter rotations and smaller-diameter sawlogs
- Changed nature of available wood products including changed mixes of species, wood properties and products
- Less predictable environmental conditions for entire rotations (e.g. increased likelihood of fire, heat and/or water stress) and flow-on effects to costs and risks associated with managing and producing wood products.

Overall, the impacts of climate change on the full set of forest values (as specified by the Montréal Process Criteria) are likely to be significant for Victoria's forests. The dynamics of climate change effects including interactions and feedbacks associated with changing fire regimes, forest conditions (and associated flammability), soil and land stability, species assemblages (including invasive species) and management practices (planned burning, timber harvesting) makes prediction of these effects difficult, leading to considerable uncertainty that needs to be acknowledged, quantified and planned for through a responsive, flexible management framework.

Table 1 Summary of the potential impacts of climate change on a range of biophysical forest values in Victoria.

The anticipated changes (both relating to climate and fire regimes) relevant to Victoria's forest landscapes are as indicated by trends in recent decades and projections (CoA 2018); abbreviations: D, drying; DRE, drought events; STE, storm events; W, warming; HE, extreme heat events; FS, severe bushfire events; FI, decreased bushfire intervals; FSE extended bushfire season.

Value	Changes	Potential impacts [a]	Supporting evidence[a]	Key knowledge gaps
Biodiversity	D, DRE, HE, FS, FSE	↓ range of individual animal species	Lindenmayer *et al.*, 1991; Brereton *et al.* 1995, Steffen *et al.*, 2009	• Potential for range shifts, locations of key climate refugia in the landscape
	W, HE	↓palatability of food resources	Kanowski 2001	• Effects of increased concentrations of GHG on leaf chemistry
	D, DRE, W, HE	↓of key habitat elements such as large old trees for cavity-dependent fauna	Rubsamen *et al.* 1983, Pahl, 1984, Lindenmayer *et al.* 2011	• Impacts of increasing night-time temperatures
	D, DRE, HR	↑heat stress on temperature-sensitive species	Rubsamen *et al.* 1983, Pahl, 1984, Lindenmayer *et al.* 2011	• Impacts of increasing night-time temperatures
	FS, FI, FSE	Recurrent wildfire that directly kills animals and/or removes key elements of suitable habitat	Lindenmayer *et al.* 2019	• Understanding of tolerable fire intervals and ability to recover repeatedly post-fire
	D+W	↓ regeneration niche of dominant tree species (↓ distribution)	Mok *et al.* 2012	• Effects of extreme events • Feedback effects to fire regimes
	FI (+D+W)	↑recruitment failure of obligate-seeder plants; changed understorey composition	Bowman *et al.*2014; Enright *et al*. 2015; Fairman *et al.* 2017	• Impacts on resprouter plants • Fuel limitations and feedback effects to fire regimes

Value	Changes	Potential impacts [a]	Supporting evidence[a]	Key knowledge gaps
	D+W	↑ distribution of invasive plant species	Wan &Wang 2019	• Changed interactions between native and invasive plants
Soil and water resources	STE + FS (+DR)	↑ mass movements (landslides etc.); ↑ sediment influx to waterways	Rutherfurd *et al.* 1994; Nyman *et al.* 2015, 2019; see also Attachment 1	• Post-landslide recovery processes and trajectories • Cumulative impacts of multiple landslides on forests
	FS (+STE, +FI)	↑ soil erosion by water; ↑ stream erosion (exposure due to burning of vegetation); changed soil nutrient concentrations and stocks	Bowd *et al.* 2019; Nyman *et al.* 2015, 2019; Fairman *et al.* under review; see also Attachment 1	• Soil type susceptibility to erosion • Effects on soil nutrient stocks at depth • Long-term implications for sediment and nutrient export from forests
	D, DR (+STE, +FS)	↑ soil erosion by wind; destabilisation of dunes; increased spread of dust and contaminants	Whicker *et al.* 2006 (USA)	• Post-wildfire wind erosion has been identified as a potentially important but little-studied process (e.g. Shakesby 2011) • Assessment of potential susceptibility of Victorian forests to wind erosion
	D, DR	↓ water yield,	CoA 2018, Zhou *et al*. 2015; see also Attachment 1	• Feedback effects of changed tree water use (e.g. Hawthorne *et al.* 2018)
	D, DR (+STE, +FS)	↑ soil water repellence (↓ tree growth, ↑ soil erosion)	Mao *et a*l. 2019; Noske *et al*. 2016; Sheridan *et al*. 2016; Van der Sant *et al.* 2018	• Landscape-scale distribution of soil erosion potential by forest type and topography

Value	Changes	Potential impacts [a]	Supporting evidence[a]	Key knowledge gaps
	FS	Variable effects on water yield (dependent on main forest type, pre-fire forest age, and prevailing dryness)	Feikema *et al.* 2013; Taylor *et al*. 2019; Zhou *et al*. 2015;	
	FS, FI	↑ soil erosion, ↓ water quality	Nunes *et al*. 2018	• Systematic frameworks for assessing risk of post-fire water contamination
Carbon sequestration & storage	D	↓ tree growth (↓ seq.)	Flexas *et al*. 2006; Landsberg & Waring 2016; Hinko-Najera *et al*. 2019	• Species-specific growth responses to decreasing water availability
	DR	↓ tree growth, ↑ susceptibility to pests and pathogens (↑ tree mortality)	Desprez-Loustau *et al*. 2006; Keith *et al*. 2012	• Drought effects on frequency of pest and pathogen outbreaks
	DR + HE	↑ tree mortality (↓ seq., ↓ storage), ↑ susceptibility to pests and pathogens, ↓ regeneration	Booth *et al*. 2015;	• Climatic thresholds leading to tree death (and variation among species) • Intrinsic climate adaptability of tree species
	W, HE	↓ tree growth, ↑ respirational losses (↓ storage)	Griebel *et al*. under review;	• Compound effects of extreme heat and drought or drying on tree growth and mortality
	FS	↑ carbon emissions (↓ storage), ↑ tree mortality	Keith *et al.* 2014; Bennett *et al*. 2016, 2017; Fairman *et al*. 2016	• Carbon emissions associated with decomposition of fire-killed stems • Fire-severity effects on post-fire tree growth in fire-tolerant forests

Value	Changes	Potential impacts [a]	Supporting evidence[a]	Key knowledge gaps
	FI	↑ tree mortality, ↓ tree growth, ↓ regeneration, changed forest states (↓ seq., ↓ storage)	Bowman *et al.* 2014; Fairman *et al*. 2016, 2017, 2019;	• Variable fire-interval effects in mixed-species eucalypt forests, including uncertainties re changed states (Collins in press) • Effects of changed stand structure after short-interval bushfire (e.g. more open) on competition-released growth of remaining stems, and on future flammability (i.e. feedbacks)
Timber products	D, W, HE, FI	↓ yield (via ↓ tree growth, as above), ↑ rotation length for D+ sawlogs, ↓ probability of realising rotation length for sawlogs, ↑ disruptions to wood supply	Keenan & Nitschke 2016; Baker *et al.* 2017; Cary *et al*. under review	• Probability-based approaches to estimating total merchantable volumes (multiple sources of uncertainty)
	DR, FS, FS+DR, FI	Changed species/ product mixes (via ↑tree mortality, as above), and wood properties	Keenan & Nitschke 2016; Keenan 2017	• Nature of changes to product mixes and properties
	DRE, HE, FS, FSE	Changed costs of providing forest products	Keenan & Nitschke 2016; Keenan 2017	• Nature of changes to forest operations and to wood processing, and associated adaptation options and adaptive capacity of the forest sector

[a]Time constraints precluded a detailed literature review; the anticipated impacts are those understood to be the main ones based on the panel's understanding, and selected papers based on local studies where possible and/or the broader scientific literature as cited in the supporting evidence column (full reference list below).

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4.5 How Well is Climate Change Currently Addressed in the RFAs?

Climate change is not addressed in detail in the existing RFAs. As mentioned above, the RFA Act and the East Gippsland, Central Highlands and North East RFAs are silent in relation to climate change, and the Gippsland and West Victoria RFAs list 'Refugia from Climate Change' as one of the National Estate values on public land.

4.6 Options for Improvement

The RFAs are long-term (20-year) agreements, but there is a need for management actions to be taken now in response to current knowledge about likely and potential climate change and its impacts, and for provisions to be included for management responses to be undertaken in the future as climate change impacts occur.

As discussed above, there are considerable uncertainties regarding:

- the nature, magnitude and timing of future climate change
- the response of the forest systems to climate change, including dynamic interactions and feedbacks between various biotic and abiotic components
- the implications of these various interactive impacts for the full suite of forest values.

Management responses to the challenges posed by climate change will need to be part of an overarching adaptive approach to management (see Chapter 7). A key point in relation to the RFA response to climate change is the acknowledgement of uncertainty and the need to accommodate uncertainty in the Victorian Forest Management System. Scenario-based evaluation of climate-change effects will aid with the transparent accommodation of uncertainty in decision processes, e.g. by offering scope to present modelled impacts as probability distributions. Risk management

frameworks, including probabilistic risk analyses, are increasingly being used in climate science, and can provide a structured way to account for climate uncertainty.

Management responses to ameliorate climate change impacts should be coordinated at landscape- to regional scales, and across tenures. This requires, for example, considering forest structural and compositional configurations that increase the potential for persistence of animal and plant meta-populations, and also provide for other forest values. It is generally understood that configurations involving multiple structural and compositional types are better than more simplified landscapes for biodiversity.[153] Methods exist to evaluate optimal growth-stage distributions for a range of flora and fauna species,[154] but how such distributions deliver or detract from positive outcomes for multiple forest values including carbon sequestration, potable water and forest products is a key knowledge gap.

Management practices applied to mitigate and adapt to climate change at stand scales must be guided by clear management goals. Management options could include (depending on the location and forest type) reforestation, harvest exclusion, bushfire hazard reduction, fertiliser applications, thinning (e.g. to improve water status of retained trees in drier forests), regeneration/ restoration interventions including active seeding and adaptive planting and post-fire remediation measures to, for example, mitigate soil erosion (Chapter 5). The evidence base relating to such practices in specific forest types should be strengthened, including potential barriers to their broadscale-implementation (e.g. availability of seed; perverse outcomes/ trade-offs with other values).

In relation to key biophysical values, management options to consider could be:

Biodiversity – a key approach to enhancing the resilience of Victoria's forests will be to limit the number of (potentially interacting) ecosystem stressors within the existing CAR reserve system. This will require active management and associated resourcing, to in particular control invasive species and to manage compounded events like multiple short-interval bushfires.

As discussed in Chapter 3, an associated activity could be a risk-based reconfiguration of the CAR reserve system which, under the auspices of the RFA, could involve extending Special Protection Zones to increase the reserved area of under-represented or particularly vulnerable biodiversity elements (e.g. old growth and rainforests) and associated buffer zones. There is a substantial body of scientific literature indicating the need to expand reserve systems under conditions of rapid climate change.[155] This is particularly important when climate change interacts with other drivers of change such as large-scale bushfires.[156]

A key part of conservation strategies in a rapidly changing climate will be to identify climate refugia for key species and other biotic entities that could be a priority for inclusion in the reserve system

[153] Di Stefano, J., York, A., 2012. Relationships between disturbance regimes and biodiversity: background issues and approaches for monitoring, Department of Sustainability and Environment, East Melbourne, Victoria.

[154] Di Stefano, J., McCarthy, M.A., York, A., Duff, T.J., Slingo, J., Christie, F., 2013. Defining vegetation age class distributions for multispecies conservation in fire-prone landscapes. Biological Conservation 166, 111-117.

[155] Steffen, W., A. Burbidge, L. Hughes, R. Kitching, D. B. Lindenmayer, W. Musgrave, M. Stafford-Smith, and P. Werner. 2009. Australia's Biodiversity and Climate Change. CSIRO Publishing, Melbourne; Ackerly , D. D., S. R. Loarie, W. K. Cornwell, S. B. Weiss, H. Hamilton, R. Branciforte, and N. J. Kraft. 2010. The geography of climate change: implications for conservation biogeography. Diversity and Distributions 16:476-487.

[156] Williams, R. J., R. A. Bradstock, G. J. Cary, N. J. Enright, A. M. Gill, A. C. Liedloff, C. Lucas, R. J. Whelan, A. N. Andersen, D. J. Bowman, P. J. Clarke, G. D. Cook, K. J. Hennessy, and A. York. 2009. Interactions between Climate Change, Fire Regimes and Biodiversity in Australia. A Preliminary Assessment. Department of Climate Change and Department of the Environment, Water, Heritage and the Arts, Canberra; Cary, G. J., R. A. Bradstock, A. M. Gill, and R. J. Williams. 2012. Global change and fire regimes in Australia. Pages 149-169 *in* R. A. Bradstock, A. M. Gill, and R. J. Williams, editors. Flammable Australia. Fire Regimes, Biodiversity and Ecosystems in a Changing World. Melbourne, CSIRO Publishing.

and may require targeted management. An associated activity should be to identify those species most at risk from climate change across a range of representative climate futures, including those at risk both within and beyond existing reserves.

Any changes to the CAR reserve system might involve revisiting the JANIS criteria by, for example, making more precautionary percentage requirements for inclusion in the CAR reserve system and/or examining the effectiveness of existing JANIS criteria in conserving forest-ecosystem distributions under a range of potential future climate-change scenarios. The SAP notes however that changing JANIS criteria percentages at this time would be highly arbitrary and that evidence based on modelled projections will be highly uncertain (i.e. dependent on modelling assumptions, including baseline information, forest responses, and dynamic future climates).

Soil and geomorphology – there are opportunities to be proactive in terms of taking measures to minimise the effects of planned burns on soil erosion (Attachment 1), and other stressors that contribute to erosion/sediment movement – e.g. bushfires, roads, vehicles, over-browsing and trampling by, for example, deer. In many instances, this will require capacity to respond quickly – e.g. installation of sediment traps in priority areas to protect streams – particularly after trigger events (as below).

Quaternary science has shown that past changes in climate have been associated with landscape-scale changes in geomorphological processes. Drier conditions with greater rainfall variability have been linked to increased sediment influx to rivers and increased movement and deposition of aeolian (wind-blown) sediment. A sound risk-based understanding of potential geomorphological impacts of future climate change and the likely effectiveness of potential responses is necessary to determine an appropriate forest management regime.

Water resources – The SAP notes that considerable advances have been made in recent years in relation to the operational prediction of extreme soil erosion events that threaten water quality after bushfires in Victoria; for example, hydrologic risk assessments, underpinned by robust science,[157] have been routinely used by Melbourne Water and by DELWP's Bushfire Rapid Risk Assessment Teams to predict fire hazards to water quality. Similar proactive risk-based approaches will be required to adaptively manage forest water yields both in response to trigger events (as below) and over longer time frames under a drying climate. This will require acknowledgement and accommodation of considerable uncertainties in relation to the timing, magnitude and dynamics of climate change effects (direct and indirect, chronic and acute) on water yields from forest landscapes.

Carbon storage – Ongoing carbon storage in Victoria's forests will require maintaining both carbon stocks (predominantly in large live trees and soils) and carbon sequestration (dependent on healthy, growing forests). As per the evidence summarised above, climate change poses a serious threat to both Victoria's forest carbon stocks and sequestration potential now and in coming decades. This threat will need to be actively managed, including adaptive management approaches that explore and evaluate adaptation and mitigation practices, as listed above.

Wood production – climate change effects increase uncertainties around future availability of wood, so an adaptive rather than fixed approach to setting wood allocations is advised for the RFAs, particularly given that past experience has shown previous RFA sawlog commitments could not be met. Management options to ameliorate climate change impacts on wood supply could include changing practices along the supply chain associated with harvesting (e.g. longer and/or flexible

[157] Nyman, P., Smith, H.G., Sherwin, C.B., Langhans, C., Lane, P.N.J., Sheridan, G.J., 2015. Predicting sediment delivery from debris flows after bushfire. Geomorphology 250, 173-186.

rotation times), processing, product types and marketing, acknowledging the need to accommodate potentially new species mixes/ quality/ size specifications. Such innovation will require committed investment to technological innovation and skills development. Management options to ameliorate climate change impacts on timber products might also include shifts in, or expansion of, the resource base, including increased reliance on plantation wood. As suggested in Chapter 6, such options should be considered in an Integrated Regional Wood Supply Strategy, including an evaluation of the risks posed by climate change to the resource base from both native forests (e.g. decreasing opportunities for long rotation times due to more frequent bushfire) and from plantations (e.g. changing climate envelope for plantations, impacts on catchment water yields).

The SAP also noted the need to identify climate-change related triggers for review of forest management goals and practices under the RFA (as part of an adaptive approach to forest management). Such triggers could lead to landscape-scale real or anticipated changes in forest condition (e.g. widespread mortality and/or decreased productivity, major reduction to water yields, widespread soil erosion and decreased water quality), and could include:

- Landscape-scale bushfire(s): particularly a single widespread high-severity bushfire, and/or short-interval bushfires of medium to high severity
- Widespread drought event(s): particularly if associated with landscape-scale bushfires
- Widespread pest outbreaks: particularly if compounded by drought and/or bushfire
- Medium- to large-scale soil erosion events.

5 Active Management of Native Forests

5.1 Summary and Recommendations

5.1.1 Summary

The SAP was requested to provide advice on the following questions:

- How could active management of forests (to support a range of outcomes) be incorporated into the RFAs as a management tool?
- How can the productive capacity of forests be improved to support a range of forest industries, including high quality sawlogs, plantation timber, water, honey, carbon sequestration etc)?

The question of active management of forests was highly controversial. Some of the range of views is illustrated by the papers by Dr John Raison and Professor David Lindenmayer:

- Dr Raison's paper outlines the potential benefits in terms of timber production that could be provided by more active management of selected areas of native forests (Attachment 2)
- Professor Lindenmayer's report outlines potential risks to forest ecosystems and biota that could arise from active management[158]

5.1.2 Recommendations

The SAP provides the following advice in regard to the modification of the RFAs to enable more active management of forests across tenures to deal with threats, uncertainties and new community goals:

1. The SAP advocates use of a broad definition of 'active management', acknowledging the need to deal with threats, uncertainties and changing community goals, similar to that published by the American Society of Foresters.[159] Examples of such active management include the following practices (noting that many are currently implemented in some form in Victoria):

    - Timber harvesting, tree planting, thinning, fertiliser use
    - Control of invasive species (e.g. deer)
    - Weed control
    - Fire management – including fire suppression and planned burning
    - Road and track management and maintenance, including construction or removal, as well as management of access including seasonal and permanent road closures.

2. When applying active management practices, particularly those which are 'new' and for which there is limited experience and/or empirical evidence, both potential benefits as well as risks should be carefully considered. Currently, the knowledge base in relation to active management is variable, and there have been few rigorous scientific studies to support evidence-based decision making in relation to some active-management practices. The SAP did not reach consensus on the potential implementation of some active-management

[158] Lindenmayer, D.B. (2019) *Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria.* Fenner School of Environment & Society, The Australian National University, Canberra.
[159] Society of American Foresters, Sustainable Forest Management Requires Active Forest Management. A Joint Position Statement of the Inland Empire Society of American Foresters and the Montana Society of American Foresters. http://www.cfc.umt.edu/saf/files/Active%20Forest%20Management.pdf

practices, notably, intensive management of native forests for accelerated sawlog production.[160]

3. If new active management measures are introduced, these should be undertaken using a rigorous adaptive management approach. This would include the development of conceptual models and hypotheses regarding the proposed intervention and its effects across the whole suite of forest values, implementation on a trial basis and monitoring, evaluation and reporting on the trial.

4. The RFA should commit to the review and evaluation of innovative management practices that actively address and anticipate the main threats posed to Victoria's forests, including mitigation and adaptation practices for addressing the threats associated with climate change. This will require considerable resources, especially for quantitative research and extensive monitoring.

5.2 What is Active Management?

The first step in considering the application of active management to Victoria's forests is to define the term 'active management'. The SAP agreed that a broad definition of 'active management' is relevant in the context of managing the current and potential future challenges to Victoria's forests through the modernisation of the RFAs.

The American Society of American Foresters definition of 'active management' provides an example of a suitably broad definition:

> *Active management is attaining desired forest objectives and future conditions using cultural operations and forest management practices. These may include timber harvesting, tree planting, thinning, fertilisation, grazing, weed control, and other activities for improving wildlife habitat and watersheds, such as erosion control, and also fire suppression, restoration-based fuel treatment, and prescribed fire. Active management also involves road and trail maintenance, including and construction, reconstruction, or deconstruction, as well as activities and practices for improving recreation areas and trails, including road closures to manage access.*[161]

In an Australian context, examples of such active management include the following practices:

- Timber harvesting, tree planting, thinning, fertiliser use
- Control of invasive species (e.g. deer)
- Weed control
- Fire management – including fire suppression and planned burning

[160] Dr John Raison made the following recommendation (not endorsed by all other panel members), supporting details are provided in Attachment 2: *Thinning, fertiliser addition and partial harvesting approaches should be further explored as a suite of silvicultural tools for accelerating sawlog production in regrowth stands in state forest, however a range of risks across the full suite of forest values would need to be addressed. An adaptive management approach would provide a means of managing these risks. Intensive management of a carefully selected, limited portion of regrowth may provide benefits for both sawlog production as well as increase the area of forest available for conservation. The scale and location of intensively managed areas should be determined as part of the regional forest management planning process, which takes account of both regional wood production and forest conservation goals.*

[161] Society of American Foresters, Sustainable Forest Management Requires Active Forest Management. A Joint Position Statement of the Inland Empire Society of American Foresters and the Montana Society of American Foresters. http://www.cfc.umt.edu/saf/files/Active%20Forest%20Management.pdf

- Road and track management and maintenance, including construction or removal, as well as management of access including seasonal and permanent road closures.

Many of these are currently implemented in some form in Victoria.

5.3 Changes Since the Establishment of the RFAs

5.3.1 Changes in Policy Context

Reviews by the SAP and others have identified concerns that the Victorian forest management system under the existing RFAs is not meeting community expectations for a wide range of forest values. For example:

- The SAP's discussion on the adequacy of the CAR reserve system (Chapter 3) identified concerns about the condition of the forests within the reserved areas, including a dominance of younger age classes following major wildfires during the last 15 years.
- The SAP's discussion of climate change (Chapter 4) identified a need to better address the potential risks to the full suite for forest values arising from climate change
- There is an increasing gap between the demand for wood products and supply of these products from Victoria's forests.[162]

This raises questions regarding the scope for further investigation and application of active forest management (including fire management and other measures) to improve outcomes for a wide range of forest values, including biodiversity, water, and sawlog production. How can provision be made in the updated RFAs to accommodate or encourage this?

5.3.2 Changes in Scientific Knowledge

The question of applying active management has been explored in the scientific and environment management literature in relation to a range of forest values.

From the viewpoint of sawlog production, new research provides guidance on how selected parts of the native forest can be more intensively managed (by control of initial stocking, thinning and fertiliser addition) to accelerate production of sawlogs. Better ways to protect valuable wood production forests from wildfire have also been developed. (This is further discussed in Attachment 2, prepared by Dr John Raison).

There has also been discussion of the application and implications of active management in relation to other forest values, including biodiversity conservation and restoration[163] and water resources (yield and quality).[164] The scientific knowledge base for evaluating the effects of active management of forests on a range of forest values has advanced over the past two decades. This ranges from increased knowledge of forest biota and ecosystems to improved capacity for modelling the effects of forest management (e.g. harvesting, thinning, afforestation) on catchment water yield (see Attachment 1). Despite this, considerable uncertainties remain.

[162] Jackson, W. Independent Consultation Paper - Modernisation of the Victorian Regional Forest Agreements. May 2019. https://www2.delwp.vic.gov.au/__data/assets/pdf_file/0029/417818/Independent-Consultation-Paper-Modernisation-of-the-Victorian-RFAs-May-2019.pdf

[163] Bernes *et al.* What is the impact of active management on biodiversity in forests set aside for conservation or restoration? A systematic review protocol, Environmental Evidence 2014, 3:22, http://www.environmentalevidencejournal.org/content/3/1/2

[164] Vose JM Forest and Water in the 21st Century: A Global Perspective,J. For. 117(1):80–85

5.3.3 Environmental Change

Environmental changes have already occurred in Victoria's forests. For example, more frequent intense fires have resulted in major soil erosion, damage to riparian ecosystems, loss of timber, loss of biodiversity, and creation of large swathes of younger forest. Further changes are likely to occur as a result of climate change. Climate change is predicted to create warmer and more arid conditions and more extreme events such as drought and wildfire (as reviewed in Chapter 4). This raises the question of the potential role of 'active management' in maintaining the current values of forests or transitioning to a new state and set of values. What degree of intervention is appropriate and feasible?

Examples where such questions arise include:

- Impacts of reduced interval between fires for biodiversity – e.g. Lake Mountain – conversion of *E. delegatensis* forest to *Acacia* spp. forest as a result of repeated fires in close succession before eucalypts produce adequate seed crops. Should there be intervention to re-establish Alpine Ash forest and is it likely to succeed?
- Impacts of more frequent fires on timber production – younger forest, smaller sawlogs. Should there be more intensive management to promote more rapid growth of larger trees, and investment to enable sawing of smaller diameter logs?
- Impacts on water yield – should there be manipulation of forests to increase water yield (or mitigate reductions in water yield due to change in forest age structure or reductions in rainfall (see Attachment 1)?

5.4 How Well is Active Management of Native Forests Currently Addressed in the RFAs?

In their current form, the Victorian RFAs refer to the introduction of new technology and thinning of regrowth forests in relation to enhancement of opportunities for further growth and development of forest-based industries.

5.5 Options for Improvement

In broad terms, active management measures fall into two major categories:

- Management of stressors
- Direct intervention / manipulation of the forest

Other chapters of this report include discussion on the management of stressors, such as invasive species and changed wildfire regimes, in the context of the CAR reserve system (Chapter 3) and climate change (Chapter 4).

Direct intervention/manipulation of the forest (apart from low-intensity prescribed burning) is less common in Victorian native forests and is more controversial.

When applying active management practices, particularly those which are 'new' and for which there is limited experience and/or empirical evidence, both potential benefits as well as risks should be carefully considered. Currently, the knowledge base in relation to active management is variable, and there have been few rigorous scientific studies to support evidence-based decision making in relation to some active-management practices. The SAP did not reach consensus on the potential

implementation of some active-management practices, notably, intensive management of native forests for accelerated sawlog production.[165]

If new active management measures are introduced, these should be undertaken using a rigorous adaptive management approach. This would include the development of conceptual models and hypotheses regarding the proposed intervention and its effects across the whole suite of forest values, implementation on a trial basis and monitoring, evaluation and reporting on the trial.

The RFA should commit to the review and evaluation of innovative management practices that actively address and anticipate the main threats posed to Victoria's forests, including mitigation and adaptation practices for addressing the threats associated with climate change. This will require considerable resources, especially for quantitative research and extensive monitoring.

[165] Dr John Raison made the following recommendation (not endorsed by all other panel members), details are provided in Attachment 2: *Thinning, fertiliser addition and partial harvesting approaches should be further explored as a suite of silvicultural tools for accelerating sawlog production in regrowth stands in state forest, however a range of risks across the full suite of forest values would need to be addressed. An adaptive management approach would provide a means of managing these risks. Intensive management of a carefully selected, limited portion of regrowth may provide benefits for both sawlog production as well as increase the area of forest available for conservation. The scale and location of intensively managed areas should be determined as part of the regional forest management planning process, which takes account of both regional wood production and forest conservation goals.*

6 Plantations

6.1 Summary and Recommendations

6.1.1 Summary

The SAP was requested to provide advice on the following questions:

- How could new plantations contribute to an integrated wood supply strategy?
- What are the key opportunities and barriers for expansion of the plantation estate, and how could they be addressed?

The SAP concluded that a strategic approach to expansion of the plantation sector is required.

There were differences in opinion regarding the need for new plantations, including the potential use of plantations as a replacement for native timber, as well as the extent of opportunities for expanding the plantation estate and the scope to influence the management of the existing plantation sector through government policy. Professor David Lindenmayer has provided additional comments on plantations in a separate paper.[166]

Potential options for the plantation expansion include:

- Increasing the productivity of the current plantation estate
- Conversion of rural land to plantations; and
- Partnerships with landowners to increase the area of commercial trees

Opportunities and barriers relating to plantation expansion include:

- Increased domestic processing of plantation wood
- Social barriers to expanding the plantation estate
- Socio-economic benefits of the plantation sector
- Benefits of trees in the landscape
- Generating income from environmental services
- Effects of plantations on water resources (yield and quality)
- Markets for forest products
- Impacts of new wood technologies on forest products
- Investments barriers
- Potential government incentive to stimulate private sector investment in plantations.

6.1.2 Recommendations

The SAP made the following recommendation in relation to improved management of the plantation sector through the RFAs:

1. The RFAs should provide for improved coordination of planning and management arrangements between native forests and plantations, including development of a Victorian Integrated Wood Supply Strategy:

    - A state-wide strategy that sits above a set of regional strategies is recommended to ensure that timber requirements and supply are planned with regard to state-wide as well as regional considerations.

[166] Lindenmayer, D.B. (2019) *Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria.* Fenner School of Environment & Society, The Australian National University, Canberra.

- The strategy requires a mix of top-down (policy-related) and bottom-up (biophysical, ecological, social and economic) considerations.
- Potential opportunities for on-shore processing of the large amounts of eucalypt woodchips currently exported from the south-west of the state should be explored as part of the strategy, noting the spatial distribution of existing demand and the lead times required for the establishment of new plantations.

2. The SAP notes the government's proposed plantation expansion program and recommends that clear goals and objectives be established and articulated for the program.

   Possible goals include:

   - Increase the softwood estate – primary purpose to increase sawn timber, with the pulpwood by-products used for paper making.
   - Increase the short-rotation hardwood estate – increased supply of pulpwood for domestic processing.
   - Increase the hardwood sawlog estate – primary purpose to increase the amount and security of supply of sawlogs, with pulpwood by-products used for paper making.
   - More trees in the landscape for multiple benefits – providing a combination of economic, environmental and social benefits. The relative balance between these benefits will depend on 'local' context and land-holder goals.

   Objectives should be established with reference to the location, area, species, products and markets that additional plantations in Victoria would seek to deliver, noting the timeframes required for plantation establishment and risks to the various objectives.

3. The RFAs should commit to the preparation of Regional Plantation Development Plans.

   The Regional Plantation Development Plans should be consistent with the Victorian Integrated Wood Supply Strategy.

   The plans should take account of opportunities and challenges posed by factors such as land availability (including assessment of social resistance to conversion of farmland to plantations as well as biophysical factors), climate change and impacts on water security. The plans should have the capacity to manage complex issues such as the 600mm rainfall 'rule' by ensuring water security is not compromised at local scales.

4. Victoria should consider lessons learned from the plantation and industry development strategies that have already been developed in other states across Australia.

6.2 Changes Since the Establishment of the RFAs

6.2.1 Changes in Policy Context

The sustainable expansion of plantation timber resources is a key objective of a number of overarching forestry policies including *Plantations for Australia: The 2020 Vision, National Forest Policy Statement* and RFAs.[167]

The *Plantations for Australia: The 2020 Vision*[168] strategy was developed for the purpose of enhancing regional wealth creation and competitiveness, through 'a sustainable increase in

[167] Agriculture Victoria. 2018. Plantations and farm forestry. http://www.agriculture.gov.au/forestry/australias-forests/plantation-farm-forestry viewed July 2019

[168] Ministerial Council on Forestry, Fisheries and Aquaculture. 2002. Plantations for Australia: The 2020 Vision

Australia's plantation resources, based on a notional target of trebling the area of commercial tree crops by 2020'. Overall this strategy has fallen well short of delivering its 'notional target'.

The National Forest Policy Statement[169] details the commitment by the Commonwealth, State and Territory governments to the sustainable management of all forests in Australia. The statement covers the use of public and private land for timber production and provides for the expansion of Australia's commercial softwood and hardwood plantations. RFAs were a key outcome of this statement, which establish the framework for the management of forests in a designated RFA region. Victorian RFAs (particularly Central, Gippsland, North East and West Victoria), have included provisions that promote and encourage plantation development/expansion. Victorian RFAs provide an exemption from export controls on unprocessed wood sourced from Victorian plantations.

The Commonwealth policy, *Growing a Better Australia: A Billion Trees for Jobs and Growth*[170] was released in 2018, pledging support for the growth of a billion new plantation trees over the next decade, through the creation of regional forestry hubs.

In its 2017-18 budget, the Victorian Government committed $110 million for the establishment of new plantations in the La Trobe Valley, to support the long term environmental and economic sustainability of the timber harvesting industry. The Department of Jobs, Precincts and Regions (DJPR) is currently developing a *Plantation Investment Strategy* to implement this commitment. This work has investigated potential barriers to greenfield plantation development, revealing that:

- Low internal rates of return are impeding new investment in plantation establishment.
- Land cost is the stand-out feasibility factor impeding investment but monetising the value of carbon sequestered by new plantations may help to reduce this constraint.
- Streamlining of the processes for compliance with the Emissions Reduction Fund (ERF) '600 mm rainfall rule' is required to enable new plantations to participate in the ERF.
- There is a poor perception of Victoria as a plantation investment environment due to perceived negative Government attitude to forestry, regulatory complexity and infrastructure shortcomings.

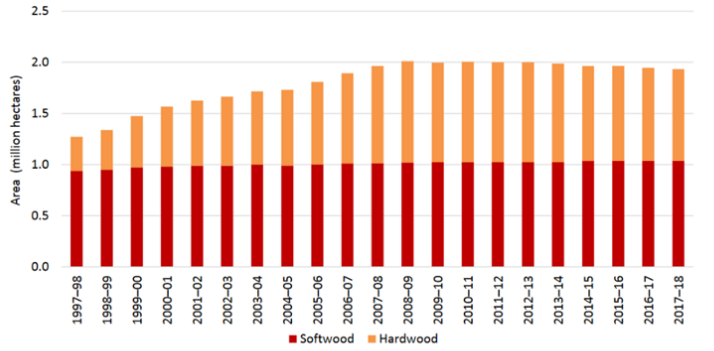
This suggests that supportive policy/regulatory action from government will be required to underpin investor confidence to participate in any new plantation investment program.

6.2.2 The Australian and Victorian Plantation Estate

To meet future wood demand, the global area of tree plantations may need to double by 2050.[171] Domestically, a growing population and increasing use of wood in construction for design and environmental benefits are driving increased demand for wood products.

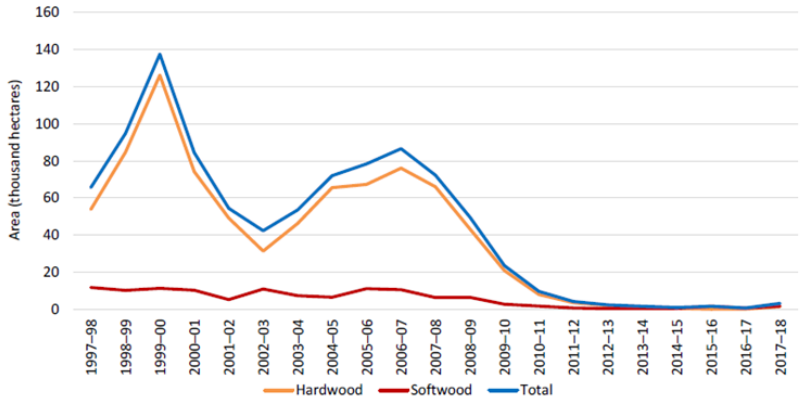
In 2017–18 Australia's total commercial plantation area was 1 942 700 hectares (Figure 1). This is comprised of 1 037 000 hectares of softwood plantations and 896 000 hectares of hardwood plantations.[172] Plantation development has been in decline in Australia since the mid-2000s (Figure 2).

[169] Commonwealth of Australia. 1995. National Forest Policy Statement (Second edition)
[170] Department of Agriculture and Water Resources 2018, Growing a better Australia – A billion trees for jobs and growth, Canberra. CC BY 4.0. ISBN 978-1-76003-174-9
[171] Barua, S.K., Lehtonen, P. and Pahkasalo, T., 2014. Plantation vision: potentials, challenges and policy options for global industrial forest plantation development. International Forestry Review, 16(2): 117-127.
[172] R. Downham, and Gavran, M. 2019. Australian plantation statistics update. *ABARES*.



Note: Data for 1997–98 to 2004–05 are for calendar years representing 1997 to 2005; data for 2005–06 to 2017–18 are for financial years. 'Other' category plantations are not included.

Figure 1 The Australian plantation estate 1997-98 – 2017-18[173]



Note: Data for 1997–98 to 2004–05 are for calendar years representing 1997 to 2005; data for 2005–06 to 2017–18 are for financial years.
Source: ABARES

Figure 2 New plantations, by type, 1997-98 – 2017-18[174]

Victoria has Australia's largest commercial plantation estate, currently comprised of approximately 223 400 ha in softwood and 196 300 in hardwood.[175] Until the early 2000s, softwood was sourced primarily from plantations, while hardwood was drawn largely from native forests. Changes in Commonwealth Government policy, particularly in relation to export controls in 1996 and the introduction of tax subsidies through Managed Investment Schemes (MISs) in 1998, saw a substantial increase in hardwood plantation estate in Victoria. However, this growth has had a negligible impact on contributing to integrated wood supply and enhancing Victorian processing, with the overwhelming majority of this hardwood resource exported. Following the global financial crisis, a number of major forestry businesses collapsed, and institutional investors acquired a large proportion of the hardwood estate.

It is important to note that the overwhelming majority of the growth in the hardwood plantation estate has been short-rotation pulpwood plantations, mainly blue gum. There is generally a lack of investment appetite for long rotation hardwood plantations, given the extended time horizons (at least 25-35 years). Perceived insecurity of harvest is also an issue, with risks that long rotation

[173] Downham, R & Gavran, M 2019, Australian plantation statistics 2019 update, ABARES technical report 19.2, Canberra, May. CCBY4.0
[174] Downham, R & Gavran, M 2019, Australian plantation statistics 2019 update, ABARES technical report 19.2, Canberra, May. CCBY4.0
[175] R. Downham, and Gavran, M. 2019. Australian plantation statistics update. ABARES.

hardwood plantations can develop 'native vegetation' characteristics (e.g. as has occurred in areas of the Strzelecki Ranges) and/or can be potentially impeded by native wildlife management protocols.

Victoria's commercial timber plantation estate has experienced a decrease over recent years, due to a lack of investment in greenfield plantations and some reversion of former MIS plantation land to non-forestry uses. Data from ABARES indicates that between 2012-13 and 2017-18, Victoria experienced a decrease in its plantation estate of 14,000 ha. This constrains future wood supply to domestic and international markets. Significant work has been progressing on a strategic and operational level, for the sustainable expansion of plantation resources to address this supply shortfall.

Today, plantations supply more than 80% of wood for the timber industry in Australia. This is dominated by softwood. Despite increasing demand and rising timber prices, investment in new plantations is at a standstill (Figure 2). An estimated 500 000 ha of new softwood plantations is required to meet domestic timber demand for housing by 2045[176].

Policy (e.g. *Growing a Better Australia: A Billion Trees for Jobs and Growth)* is also driving demand for more trees in rural landscapes to sequester carbon, improve water quality, reduce soil erosion and provide biodiversity habitat.

6.2.3 Impact of Climate Change on the Plantation Estate

Climate change provides threats and opportunities for the Victorian plantation sector.[177] These are examined here in relation to three issues:

- Growth of the estate
- Fire, pests and diseases
- Potential economic benefits

Growth of the Estate

The implications of climate change for growth rates of forest plantations are expected to be variable. Blue gum plantations established in the drier parts of Western Victoria are susceptible to reductions in average growth rates, and to mortality during drought.[178] In cooler highland areas growth rates may increase. The effects of climate change on growth rates for much of Australia's plantation estate is very uncertain because of uncertainty about future increase in atmospheric CO_2 levels and how forests will respond to this.[179] Nutrient availability constrains responses to elevated CO_2, but fertiliser additions could remove much of this constraint in some plantations. Pest risk may increase under climate change, especially in eucalypt plantations[180].

Adapting to climate change, in terms of timber production, may be easier in plantations than in native forests because management is more focused (the major objective is wood production), rotations are shorter, there is some opportunity to change the land base (e.g. not to replant very

[176] Zed P. (2017). Implications of wood fibre supply dynamics in Australia. Presentation to FWPA / DANA Insights and Outlook Conference 5th October 2017, Melbourne.
[177] Pinkard, E (2017a). Climate change: threat or opportunity? Australian Forestry 80, 195-6.
[178] Battaglia, M and J. Bruce (2017). Direct climate change impacts on growth and drought risk in blue gum (Eucalyptus globulus) plantations in Australia. Australian Forestry 80, 216-227.
[179] Battaglia, M and J. Bruce (2017). Direct climate change impacts on growth and drought risk in blue gum (Eucalyptus globulus) plantations in Australia. Australian Forestry 80, 216-227.
[180] Pinkard, E (2017b). Climate change and pest risk in temperate eucalypt and radiata pine plantations: a review. Australian Forestry 80, 228-241

drought-prone sites) and silvicultural input (e.g. thinning, fertiliser application) can be more intensive and flexible.[181]

Fire, Pests and Diseases

It is commonly accepted that under a changing climate fires will become more intense and more frequent. Reduced rainfall and increased dry period length may impact plantations as much through fire losses as by reduced growth rates.[182] Opportunities for pests and diseases to take hold may also increase through the availability of fresh coppice leaves and/or their capacity to impact on stressed trees.

Potential Economic Benefits

Planting trees for the offsetting of fossil carbon emissions can also form a component of climate change mitigation strategies for landholders, industries and the country. Afforestation projects are a common component of carbon offset trading schemes and are recognised within Australian's Carbon Farming Initiative (e.g. the Plantation Forestry Methodology Determination 2017[183]). Afforestation is also often promoted as a potential new economic opportunity for private landholders.[184]

6.3 How Well are Plantations Currently Addressed in the RFAs?

There was a clear intention in the existing RFAs to support plantation expansion. Plantations are recognised in the following sections of the Central Highlands RFA:

Item 69 *The Parties acknowledge that the forest-based industries in the Central Highlands make a significant contribution to both the regional and State economies and are an essential component of many communities in the region. The Parties intend that this Agreement will enhance opportunities for further growth and development of forest-based industries in the Central Highlands and provide long-term stability for these industries. The Parties therefore acknowledge that this Agreement must provide enhanced security of access to resources on forested land for the life of the Agreement. This in turn will facilitate industry development through:*

> *New investment, plantation development, reforestation, downstream processing, value-adding and jobs growth in forests-based industries*

Item 76 *The parties recognise that export controls have been removed from unprocessed wood and woodchips sourced from Victorian plantations in accordance with the Export Control (Unprocessed Wood) Regulations*

The Gippsland and West Victoria RFAs (both finalised in 2000) included more detailed provisions relating to plantations. For example, The Gippsland RFA stated that:

[181] Keenan, RJ (2017). Climate change and Australian production forests: impacts and adaptation. Australian Forestry 80, 197-207.

[182] Battaglia, M., Bruce, J., Brack, C., Baker, T. 2009, Climate Change and Australia's plantation estate: analysis of vulnerability and preliminary investigation of adaptation options. Project No: PNC068-0708. Forest and Wood Products Victoria.

[183] Department of the Environment and Energy, Plantation Forestry, https://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/plantation-forestry, viewed July 2019

[184] Schirmer, J., Bull, L. 2014. *'Assessing the likelihood of widespread landholder adoption of afforestation and reforestation projects.'* Global Environmental Change 24:306 - 320

Item 81 *Parties agree that a significant expansion in the extent of hardwood and softwood plantations on previously cleared land in the Gippsland Region, consistent with environment and heritage objectives, would be desirable …*

Item 82 *Parties agree that the current extent of hardwood sawlog plantations is not sufficient to provide an alternative source of supply to native forest hardwood sawlog resources in the Gippsland Region. Governments recognise the need to facilitate product diversification in the plantation sector.*

Plantation expansion occurred during the RFA time period but was largely the result of tax benefits realised under MISs. This expansion mainly occurred in the west of the State and was typically short-rotation hardwoods.

6.4 Plantation Development Options and Considerations

6.4.1 Plantation Expansion Options

The Next Generation Forest Plantation Investment Project (see: https://blogs.unimelb.edu.au/nextgenplantations) identified three ways that future wood supply from plantations could be increased[185]:

- increase the productivity of the current plantation estate;
- buy rural land for new plantations; or
- adopt and increase partnerships with landowners to increase the area of commercial trees.

All options require new investment, and all have challenges. For example, increasing the productivity of plantations will require funding research and development to develop new tree growing technologies, new genotypes, fertiliser, or other productivity improvers. Land purchase requires a large capital outlay and depends on suitable land being on the market at an appropriate price (such land has been almost impossible to secure in recent years). Partnerships with landowners can require lower initial capital outlay but higher transactions costs in engaging and maintaining relationships with landowners, and would result in more dispersed plantings which affects future harvest and haulage costs.

Lessons might also be learned from plantation development efforts in other states and jurisdictions. In Tasmania, for example, major planting of eucalypts for sawlogs commenced by converting native forest almost 20 years ago as part of a future sawlog supply strategy under the RFA[186]. These were mostly *E. globulus* and *E. nitens* and have been pruned and thinned to help improve sawlog quality. It is important to note that these plantations are owned by the State and were established under a very different economic model to that now proposed for private sector development in Victoria

The Next Generation Forest Plantation Investment Project identified considerable suitable privately-owned land in the Colac-Otway and Gippsland regions of Victoria[187]. Plantation establishment on this land will require partnerships with landowners and depends on matching landowner and industry needs, and meeting investor returns. Landowners differ widely in their interest and motivation for

[185] Keenan, R.J., Anderson, N., Bull, L., Dembek, K., Kostanski., and Patterson, S. (2019) 'Designing business models for commercial tree growing partnerships in rural land: A guide for the Victorian forest industry' A publication of the Next Generation Plantation Investment Project. University of Melbourne. In Press

[186] M.J. Wood, M.L. McLarin, P.W. Volker and M. Syme (2009). Management of eucalypt plantations for profitable sawlog production in Tasmania, Australia. TasForests 18, 117-130.

[187] Next Generational Forest Plantation Investment, Key Messages and Insights, February 2019. See: https://blogs.unimelb.edu.au/nextgenplantations/#tab187

growing trees on their properties. Their decisions depend on their beliefs about tree growing, perceived capacity as growers, partnership designs and the on-farm benefits and monetary returns from growing trees.

To successfully grow, plantations must be well established and managed to achieve the high growth rates required for economically viability. Site selection is critical to avoid significant soil constraints to growth[188] and to generally provide > 800 mm annual rainfall. Like any crop, trees established in low rainfall areas will have slower growth and are generally of lower quality. This impact is compounded on lower fertility soils.

Nolan *et al.*[189] concluded that to be profitable, eucalypt plantations for sawn wood needed to be highly productive (wood production of at least 25 cubic m/ha/yr at age 10 yr), and to produce logs of very high quality (mostly appearance grade clear wood which requires a large investment in pruning and thinning). Rotation lengths must be short to reduce compounding the high initial financial investment in land and silviculture.

6.4.2 Increasing Domestic Processing of the Plantation Estate

As previously mentioned, the bulk of the plantation expansion that has taken place in Victoria in the last 20 years has been an increase in the hardwood plantation estate, largely in the south-west of the State. Development of short rotation hardwood plantations in this region is a reflection of land availability, price and suitability as well as access to an export port.

As access to native forest pulpwood becomes increasingly constrained, guaranteed, long-term supply for the Maryvale Mill in Gippsland has become less certain. The hardwood plantations grown in the west of the state could provide suitable feedstock for the Maryvale mill located in Gippsland. However, haulage to Maryvale has not been economically viable and export markets have proved to be lucrative for these privately-owned plantations.

If plantation wood from the south-west of the State were to be used at the Maryvale site, it is likely that government assistance would be required to make this an economically viable proposition for the plantation owners.

The Victorian softwood estate is largely processed domestically.

6.4.3 Social Barriers to Expanding the Plantation Estate

The Next Generation Forest Plantation Investment Project identified a range of social barriers and social licence considerations that have the potential to impact on the capacity to significantly expand the plantation estate in Victoria.[190] These can be broadly divided into the following categories:

- Resistance from landowners to plant trees on their land for a broad range of reasons including past bad experiences with plantations or having no experience nor knowledge of trees on farms

[188]Bennett, L.T., Weston, C.J., Attiwill, M. 1997. *Biomass, Nutrient Content and Growth Response to Fertilisers of Six-year-old Eucalyptus globulus Plantations at Three Contrasting Sites in Gippsland, Victoria.* Australian Journal of Botany. 45, 103–121

[189] Nolan, G., R. Washusen, S. Jennings, B. Greaves and M. Parsons (2005). Eucalypt plantations for solid wood products in Australia – A review, 'If you don't prune it, we can't use it'. Project No. PN 04.3002, 130pp. Forest and Wood Products Research and Development Corporation, Melbourne.

[190] Anderson, N. 2018. 'Integrating trees in rural landscapes: What do landholders think?'. Research summary report. University of Melbourne. Available at: https://blogs.unimelb.edu.au/nextgenplantations/#tab187; Keenan, R.J., Anderson, N., Bull, L., Dembek, K., Kostanski., and Patterson, S. (2019) 'Designing business models for commercial tree growing partnerships in rural land: A guide for the Victorian forest industry' A publication of the Next Generation Plantation Investment Project. University of Melbourne. In Press

- Resistance from communities to increased trees in the landscape due to concerns about:
    - Landscape aesthetics
    - Employment impacts
    - Increased heavy vehicle traffic
    - Increased fire risks
    - Perceived threats to water supply
    - Reduced capacity for food production.

These concerns must not be underestimated. If the sector cannot engage with landowners and rural communities appropriately, its capacity to develop greenfield plantations will be limited.

6.4.4 Socio-Economic Benefits of the Plantation Sector in Victoria

Plantations and the primary processing of wood make significant socio-economic contributions, particularly in rural and regional Victoria. Schirmer et al[191] reported the following statistics (see Table 2):

Table 2 Socio-economic contributions of the plantation sector in Victoria

	Softwood plantations	Hardwood plantations
Direct jobs (2017)	2,437	457
Indirect jobs (direct plus production and consumption induced jobs)	7,577	1808
Direct value output ($m)	$778	$187
Next expenditure ($m)	$666	$175
Gross regional production ($m)	$291	$48
Value of output ($m)	$2,358	$609

6.4.5 Benefits of Trees in the Landscape

Tree planting offers a range of benefits beyond that of producing timber and financial returns. The Next Generation Forest Plantation Investment Project cites a range of benefits at the landowner, regional, national and global scale[192]. These are outlined in Table 3.

Table 3 Economic, environmental and social benefits of integrating tree plantations on rural land for the landowner and wider community

Landowner	Regional	National and global
• Additional and more diverse sources of income, including from timber or environmental payments, e.g. carbon, ecosystem services • Productivity increases on farm, e.g. shelter, pasture and livestock, reduced livestock mortality, improved animal welfare	• Enhanced rural landscape aesthetics • Biodiversity habitat conservation • Improved air and water quality • Increased local employment	• National and global carbon markets • Export markets – pulp and solid wood biomass • Carbon sequestration – contribute to climate adaptation and mitigation • Decreased reliance on natural forests

[191] Schirmer, J., Mylek, M., Magnusson, A., Yabsley, B. and Morison, J. 2018. 'Socio-economic impacts of the forest industry in Victoria.' Forest and Wood Products Australia, University of Canberra and econsearch.

[192] Keenan, R.J., Anderson, N., Bull, L., Dembek, K., Kostanski., and Patterson, S. (2019) 'Designing business models for commercial tree growing partnerships in rural land: A guide for the Victorian forest industry' A publication of the Next Generation Plantation Investment Project. University of Melbourne. In Press

• Improved on-farm aesthetics and amenity • Biodiversity and habitat conservation— e.g. integrated pest management, pollination services • Soil conservation—e.g. reduced wind erosion, improved nutrient cycling • Water management—e.g. reducing dry-land salinity and waterlogging • Management of excess nutrients and water quality		• Renewable resource –energy and fibre (pulp and solid wood)

6.4.6 Generating Income from Environmental Services

Offsets for farm greenhouse gas emissions, or income from environmental services such as carbon sequestration, water quality or wildlife habitat, have the capacity to increase the financial viability of new plantation developments. There is also increasing desire for the agricultural sector to meet carbon neutrality targets (e.g. the red meat industry's target to be carbon neutral by 2030[193]).

Currently, however, commercial plantations established in areas with > 600 mm rainfall are not eligible to participate in Federal government carbon funding schemes.[194] This is a significant impediment to the economic viability of new plantings. Even when new plantings meet this rainfall criterion, they are also required to not have undesirable impacts on agricultural production (as determined by the Federal minister for Agriculture). Efforts are under way at Federal-State government level to find a way of dealing with the potential impacts of new plantations on water security and agricultural production at landscape scales. These issues need to be resolved if the expansion of plantations is to be facilitated in the higher rainfall zone in Victoria.

6.4.7 Plantations and water

Plantations use more water than grassland, and pines more than eucalypts.[195] Importantly, afforestation has more effect on 'low' (summer) flows when water is most limiting for both the environment and for human use. Effects on catchment water yield depends on both the proportion of the catchment planted, but also on where trees are planted. Impacts on water yield are greatest from planting in the wetter parts of the catchment near streams, but these are also the areas where the benefits of afforestation for water quality are often the greatest. An analysis (at an appropriate catchment scale) of likely impacts on water security should be a key input to planning any major expansion of plantation area and such an analysis needs to consider possible significant reductions in rainfall under climate change.

[193] E.g. Mayberry, D., Bartlett, H., Moss, J., Wiedemann., S. and Herrero, M. 2018. 'Greenhouse Gas mitigation potential of the Australian red meat production and processing sectors.' Meat and Livestock Australia and CSIRO. Project code: B.CCH.7714.

[194] Smith, H. F., F. A. Ximenes and N. O'Brien (2017). New greenhouse gas abatement methodology: potential value to the plantation forestry sector. Australian Forestry 80, 273-4.

[195] Kathleen A. Farley, Esteban G. Jobbágy and Robert B. Jackson (2005). Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology 11,1565-76; Zhang L., Vertessy R., Walker G., Gilfedder M. and Hairsine P. (2007). Afforestation in a catchment context: understanding the impacts on water yield and salinity. Industry report 1/07. CSIRO Land and Water, Canberra and eWater CRC, Melbourne, Australia. ISBN 1876810 09 2.

6.4.8 Markets for Forest Products

When considering plantation development, it is essential that the products have a viable market.[196] With respect to the domestic market, transport distances are a critical component of economic viability, with haulage distances limited to about 100 kilometres a general rule of thumb. Table 4 provides an overview of current markets for plantations in Victoria.

Table 4 Markets for Victorian plantations

Plantation type	Market overview
Hardwood	There is a reasonably substantial hardwood plantation estate in the west of Victoria which at present is sold into the export woodchip market. This has been a very lucrative market in recent years and there have been no economically viable domestic processing options that have progressed. It is possible that alternative options for this estate could be considered including new technologies (See Table 5). While there may be a desire to use this estate as a replacement for native forest pulp wood for the Maryvale mill, it has not been economically viable to haul the logs across the state.
Softwood	At present there is adequate softwood processing capacity for the existing resource. If additional resource was to be located in a region that is not within an economically viable haul distance of existing processors, it is important that the resource created is of adequate size to support a new processing facility so as not to build a stranded resource. The capacity to ensure this is likely is dependent on land availability as described earlier.

6.4.9 Plantations as a Replacement for Native Timber

It has been suggested that plantation timber could replace the supply that is currently sourced from the native forest estate.[197] While there is potential for some aspects of the supply chain to be substituted (i.e. native woodchips for plantation woodchips for paper production) other products are not as straightforward. For example, the products that are developed from high quality sawlogs from native forests are typically used for high value uses such as flooring, decking and furniture. There are several barriers as to why production of these products from plantations is problematic:

- Timber produced from plantations typically has very different sawing, strength and quality characteristics to that produced from native forests. Thus, direct substitution is not possible. Victorian processors are currently not equipped for substituting plantation hardwood logs (which are smaller and more difficult to process) for native grown timber;
- There is a substantial time lag (> 25 years) between the planting and harvesting of a hardwood sawlog plantation;
- As discussed previously, hardwood sawlog plantations need to be grown on very productive land and require intensive thinning and pruning. Hardwood sawlog regimes have faced both financial and other risk management issues thus acting as a significant disincentive to establishment. Land that might be made available to plantation establishment is therefore more likely to be made available to established softwood regimes that face fewer risks; and

[196] Jenkin, B, Keenan, JR and Bull, L 2019. 'Tree plantation investment and partnerships in Australia: an analysis of past experiences.' University of Melbourne School of Ecosystem and Forest Sciences. 2019. ISBN: 978 0 7340 5515

[197] Lindenmayer, D.B. (2019) *Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria.* Fenner School of Environment & Society, The Australian National University, Canberra.

- Over time some hardwood plantations in Australia have taken on characteristics of native forests. While this is beneficial from a biodiversity perspective it can be problematic from a social licence risk and right to harvest perspective.

Considering the above points, establishment of new hardwood plantations for sawlogs is likely to require significant government subsidies to reach the private sector's economic hurdle rates and, given their risks, it is difficult to see why the private sector would invest in such plantations, even with subsidies, rather than in species and regimes that are known to pose fewer social and economic barriers.

Should a decision be made to go down the path of establishing hardwood sawlog plantations, clear policies and guidance should be provided with respect to the implementation of the EPBC Act. Operational and policy decisions that should be considered include:

- What happens if an EPBC-listed species moves in and occupies a plantation?
- What if the plantation becomes a stronghold of natural habitat lost (e.g. in a major bushfire)?

In both cases:

- Should the plantation owner be allowed to harvest as of right?
- Should compensation be paid if a plantation cannot be harvested at maturity for ecological reasons?

Native and exotic plantations have the capacity to deliver both positive and negative biodiversity, fire, greenhouse gas mitigation and social outcomes[198]. As such policy makers need to make careful decisions about the placement and design of new plantations to ensure that their likely impacts (both positive and negative) are well understood.

6.5 Investment Barriers

Low returns on investment limit the attractiveness of new investment in tree growing, and this is a major reason why plantation establishment rates have stalled. Some degree of 'subsidy is likely to be needed to overcome economic hurdles, [199] which will likely be greater for long rotation hardwood plantations than for softwoods. Subsidies have played an important role in plantation development across the world. Jenkin (2018) provided an up to date analysis of the role of policy and incentives in plantation development. [200]

6.6 Technology and Forest Products

The Australian Government's recent policy statement, *Growing a Better Australia, a billion trees for jobs and growth*,[201] sets out the aim of growing Australia's plantation estate to establish a sustainable and secure supply of wood-based products. Central to this objective is the role of new

[198] Lindenmayer, D.B. (2009). Large-Scale Landscape Experiments. Lessons from Tumut. Cambridge University Press, Cambridge. 287 pp; Lindenmayer, D.B., Blanchard, W., Westgate, M.J., Foster, C., Banks, S.C., Barton, P.S., Crane, M., Ikin. K. and Scheele, B.C. (2019). Novel bird responses to successive, large-scale, landscape transformations. Ecological Monographs, doi:10.1002/ecm.1362

[199] Enters, T. and Durst, P.B., 2004. What does it take? The role of incentives in forest plantation development in Asia and the Pacific, UN Food and Agriculture Organisation, Bangkok.

[200] Jenkin, B. 2018. 'Benchmarking Analysis: Part 1 Australia's history of plantation development, policy and incentives' Next Generation Forest Plantation Investment Project. The University of Melbourne;
Jenkin, B. 2019 'Benchmarking analysis: Part 2 An international perspective of the history of plantation development, policy and incentives.'

[201] Department of Agriculture and Water Resources 2018, Growing a better Australia – A billion trees for jobs and growth, Canberra. CC BY 4.0. ISBN 978-1-76003-174-9

technologies and products in driving investment in plantations, and the need to establish more trees on farms in collaborative arrangements between landholders and industry.

> *Changes in markets and product development are important determinants of plantation viability. New technologies create new uses for existing products as well as new wood-based materials, which can impact on plantations by creating added value for lower quality products and processing residues or by increasing demand for existing products.*[202]

Table 5 summarises the impact that a range of new wood product technologies may have on plantation development. There are clearly major uncertainties about if, when and how much these developments will impact on future development of plantations.

Table 5 Assessment of how product innovations could affect plantation development (adapted from Piper, 2018)

Product innovation	**Input product or material**	**Specificity of input requirements** [1]	**Location and transportation** [2]	**Key influencing markets** [3]	**Type of market** [4]	**Cost of adoption** [5]
CLT and mass timber	Timber	High	Existing processing region	Domestic	Mainstream	High
Bioenergy and wood pellet production	Residues	Low	Existing processing region	International	Mainstream	High
Plywood from spindle-less lathes	Logs	Medium	New processing location	International	Mainstream	Low
Bio-plastics using wood residues	Residues	Low	Existing processing region	Domestic	Mainstream	High
WPC for building materials	Residues	Low	Existing processing region	Domestic	Mainstream	High

Notes:
1 – The degree of specific product requirements at the point of processing (using a scale of High, Medium, Low)
2 – The geographical location where products could be manufactured (either in an Existing processing region or a New processing location)
3 – The key markets that could drive the development and uptake of the product (either International or Domestic)
4 – The type of market that the identified products would be sold in (Mainstream or Niche)
5 – The cost of adoption of the identified product (using a scale of High, Medium, Low)

6.7 Potential Government Incentives to Stimulate Private Sector Investment in Plantations

Governments play a critical role in supporting increased tree-growing in rural landscapes. This includes clear policy and planning frameworks, political support, financial incentives, and enabling the implementation of policies regarding information provision, research and education[203].

[202] Piper, Andrew. Trends in forest product development. 2018. Next Generation Forest Plantation Investment Project. The University of Melbourne. See: https://blogs.unimelb.edu.au/nextgenplantations/#tab187
[203] Jenkin, B, Keenan, JR and Bull, L 2019. 'Tree plantation investment and partnerships in Australia: an analysis of past experiences.' University of Melbourne School of Ecosystem and Forest Sciences. 2019. ISBN: 978 0 7340 5515

The Next Generation Forest Plantation project has identified a comprehensive suite of recommendations[204] that policy makers at both the State and Commonwealth levels of government could adopt to support expansion of the plantation sector. These are provided in Appendix A of this chapter. A key over-arching conclusion of the Next Generation Forest Plantation project is that plantation expansion should be supported by detailed regional strategic plans that take account of opportunities and act to minimise potential adverse social, and environmental impacts. Wood flows from plantations should be considered together with those from native forests as part of a regional wood supply strategy to support industry development.

6.8 RFA Options for Improvement

6.8.1 Development of Victorian Integrated Wood Supply Strategy

The RFA should commit to the development of a comprehensive Victorian Integrated Wood Supply Strategy. Such a Strategy would ensure that the right trees are planted in the right place at the right scale for the right market and that plantation development aims to complement wood supply from native forests in each wood supply region. The Strategy will require a mix of top-down (policy related) and bottom-up (biophysical, social and economic) considerations. Figure 3 summarises important factors to consider when creating a Plantation Expansion Program, Regional Plantation Development Plans and, ultimately, a Victorian Integrated Wood Supply Strategy. The Victorian Integrated Wood Supply Strategy might also consider wood sourced from outside of Victoria, as well as alternative products and technologies.

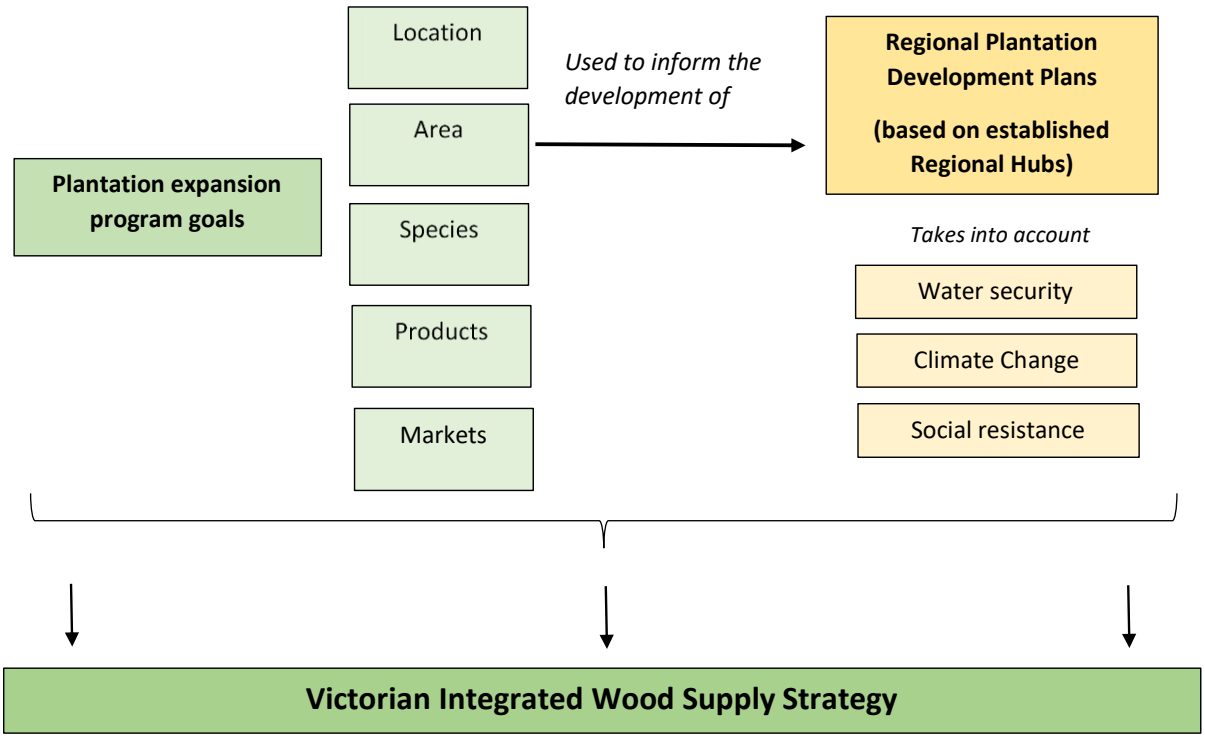


Figure 3 Important inputs to the development of Regional Plantation Development Plans. Such plans also need to take account of potential wood availability from native forests in each region. Such plans inform the development of a Victorian Integrated Wood Supply Strategy

[204] Keenan RJ, Anderson N, Bull L, Dembek K, Kostanski and Patterson S (2019) 'Designing business models for commercial tree growing partnerships in rural land: A guide for the Victorian forest industry' A publication of the Next Generation Plantation Investment Project. University of Melbourne. In Press

6.8.2 Clear Goals for the Proposed Government Plantation Expansion Program

The RFAs should describe clear goals for the proposed government plantation expansion program. The goals should provide clear guidance to the development of a plantation development expansion program and form the basis for objectives that will outline the location, area, species, products and markets that additional plantations in Victoria would seek to deliver. Possible goals are summarised in Table 6.

Table 6 Possible goals of a government plantation expansion program

Plantation Goal	**Strategic intent**
Increase softwood estate	Primary purpose to increase sawn timber, with the pulpwood by-products used for paper making
Increase short-rotation hardwood estate	Increased supply of pulpwood for domestic processing
Increase hardwood sawlog estate	Primary purpose is to increase the amount and security of supply of sawlogs, with pulpwood by-products used for paper making
More trees in the landscape for multiple benefits	A combination of economic, environmental and social benefits. The relative balance between these benefits will depend on 'local' context, and farmer goals

An Integrated Wood Supply Strategy is likely to be a composite of multiple goals. It could be based on a 'dispersed' production model where many farmers contribute to wood supply, a model relying on fewer, more 'consolidated', areas of plantation, or a combination of both models. Potential opportunities for on-shore processing of the large amounts of eucalypt woodchips currently exported from the south west of the State could also be explored. Victoria should review and consider lessons learned from the plantation and industry development strategies that have already been developed in other states across Australia (e.g. New South Wales, Western Australia and South Australia).

6.8.3 Regional Plantation Development Plans

The RFAs should commit to the preparation of Regional Plantation Development Plans. Plantation expansion should be guided by detailed Regional Plantation Development Plans that take account of opportunities as well as challenges posed by factors such as impacts on water security, climate change and social resistance to conversion of farmland to plantations. The Regional Plantation Development Plans should be consistent with the Victorian Integrated Wood Supply Strategy and contribute to the implementation of the strategy at regional and local scales. Regional Plantation Development Plans have the capacity for managing the 600 mm rainfall limitation by ensuring water security is not compromised at local scales.

Appendix A – Policy Actions Identified by the Next Generation Forest Plantation Investment Project

The Next Generation Forest Plantation project has identified a comprehensive suite of recommendations that policy makers at both the Commonwealth and State levels of government could adopt to support expansion of the plantation sector.

Commonwealth Government Actions

Policy and Planning Framework

1. Integrate plantation forestry and farm trees into agricultural policies and programs, not only into forest policy.

2. Develop a long-term national plan for trees in rural landscapes coordinated with state, territory and local governments. Build bipartisan political support, e.g. the New Zealand government's One Billion Trees Programme, launched in 2018, aims to plant an additional 2.4 million ha of trees, bringing the level of trees on agricultural land to 30%, for commercial, on-farm and public good outcomes.

3. Define desired public good outcomes from trees in rural landscapes and develop mechanisms to monitor and quantify to support incentive programs.

4. Develop a Regional Planning Framework in conjunction with industry, state governments and other stakeholders. Use supporting spatial information on biophysical potential and land suitability for agriculture and commercial forestry and specify the infrastructure requirements in each region to meet industry needs as tree-growing increases.

5. Integrate planning with other regional industries with similar infrastructure or service requirements, such as agriculture, transport or tourism to strengthen the case for investment and upgraded infrastructure.

6. Design spatial planning and policy mechanisms to minimise potential adverse outcomes on agricultural production or conservation, heritage or other values.

7. Ensure regular review of policies and plans. Learn through actions and allow policies to evolve with the changing scale of afforestation, timber market conditions and changes in agricultural production. For example, after 20 years, Forest Law of Uruguay was amended in 2005 to revoke taxation benefits for investment in short rotation trees but maintained it 'for production of quality wood' in plantations targeting sawlogs and veneer logs on rotations longer than 15 years.

Financial Incentives

1. Develop a portfolio of incentives linked to Regional Plantation Development Plans. A combination of grants and low-interest loans has worked in past programs in Australia and other countries. Grants have been more successful where designed to target specific locations and land units for afforestation, and specify the species planted and other project attributes.

2. For example, in New Zealand, the One Billion Trees Programme includes a variety of finance options, including lease and joint venture projects on suitable land 200 ha in size or larger. Landowners participate through leases and direct payments. Other parties can participate via limited partnerships, syndicates and joint ventures. Investment facilitators work with landowners and partners to organise afforestation projects.

3. Low interest loans are most appealing to corporate investors. Individual farmers prefer grants. Grant programs need to be flexible with payments linked to desired long-term outcomes. This can be achieved through new types of investment vehicles to leverage private finance

4. Funding allocated for grants or loans needs to be aligned with the size of the resource required. This can be linked to an industry commitment to buy wood at a given future price.

5. Underwrite market or biophysical risks to facilitate investment, as this provides assurances to investors and landowners and stimulates private investment in landowner partnerships.

6. Specific payments can be targeted at providing environmental services such as water quality and erosion control. Integrated incentive programs can be developed to provide for native forest restoration and protection in conjunction with commercial planting for pollination or wildlife habitat outcomes.

7. Work with State Governments to ensure alignment of incentives and communication of benefits of commercial tree plantations on farms.

8. Planted trees for harvest on cleared land increase landscape carbon stock. Clear and simple methodologies and rules for tree plantations in carbon farming regulations can support investment. For example, the New Zealand Emissions Trading Scheme (ETS) has a simple credit process for plantation forests that stimulates more investment as the price of credits increases.

9. Design taxation incentives to support appropriate investments in commercial tree plantations in appropriate places. These would define targeted investment zones and allow offsets against other income for plantation establishment costs or allow investment of tax liabilities back into afforestation. Postponing the deduction of expenses until harvest is a disincentive to afforestation. Income-averaging for harvest returns over a 5–10-year period can address a longer-term investor concern.

Enabling and Facilitating Policies

1. Develop and communicate information on the synergies of trees with agriculture, commercial tree-growing options and the role of trees in rural landscapes in conjunction with Australian Forest Growers (AFG) and the Institute of Foresters of Australia (IFA), AFPA and the NFF.

2. Continue technical and financial support for inventory of tree plantations and trees on farms, timber prices, timber harvest projections and other planning tools to provide a clear picture of the current plantation industry and market status in each state and territory.

3. Support research and development in trees on farms and commercial forestry options for different regions. Support innovation in markets and product development.

4. Support education and training to build professional capacity in the industry, understanding of farm tree-growing options in tertiary education agriculture, forestry and ecosystem management programs, and build mentoring capacity and networks between landowners.

5. Support cooperation along supply chains, including with farm advisors and others who influence farmers' decisions.

6. Support training and capacity-building among farmers to build knowledge and familiarity of plantation options.

State Government Actions

Policy and Planning

1. Integrate policy for plantation forestry and commercial farm trees with agricultural policies and programs.

2. Define desired public good outcomes from trees in rural landscapes and develop mechanisms to monitor and quantify to support incentive programs.

3. Work with the Federal Government to develop a Regional Planning Framework in conjunction with industry, local governments and other stakeholders. Use supporting spatial information and analysis on biophysical potential and land suitability for commercial forestry and the infrastructure requirements in each region to meet industry needs as tree-growing increases.

4. Support local governments to ensure coordinated planning for plantations. Provide information regarding the potential benefits of commercial trees, and how these can contribute to regional development objectives. Ensure local governments in the program have trained staff, information and resources to implement state policies and plans. Provide guidance on planning scheme arrangements that support integration of commercial trees with agriculture.

5. Support CMAs to develop spatial information for desired planting locations and sites and an understanding of how to integrate commercial tree-growing with other catchment objectives.

Financial Incentives

1. Develop an integrated portfolio of financial incentives for tree-growing linked to Australian Government policies and regional plans. Work with the Australian Government to ensure that taxation arrangements effectively support commercial tree planting objectives.

2. Develop investment vehicles that enable public and private co-investment trees in rural landscapes at sufficient scale to make a difference.

3. Develop a framework and funding mechanism for payments for environmental services for trees in rural landscapes, including commercial trees.

Enabling Policies

1. Develop, and increase access to, information regarding the synergies of trees with agriculture, commercial tree-growing options and the role of trees in rural landscapes, in conjunction with the Australian Government, AFG, IFA, AFPA and VFF.

2. Provide technical and financial support for inventory of plantations and trees on farms, and information on timber prices, timber harvest projections and other planning tools to give a clear picture of the current plantation resource, and industry and market status in Victoria.

3. Provide support for investment partnerships, including development of standard legal agreements, offtake agreements, and other relevant administration.

4. Support education and training to build professional capacity in the industry, understanding of farm tree-growing options in tertiary education agriculture, forestry and ecosystem management programs, and build mentoring capacity and networks between landowners.

5. Support research and development in tree plantations on farms and commercial forestry options for different regions. Support innovation in markets and product development.

7 Adaptive Management

7.1 Summary and Recommendations

7.1.1 Summary

The SAP was requested to provide advice on the following question:

- How could the RFAs and the associated forest management system incorporate best practice adaptive processes in order to improve and monitor their effectiveness?

The SAP noted that 'adaptive management' has a wide spectrum of definitions, ranging from: management systems that incorporate monitoring, review and improvement, to management research methods. The Victorian RFAs in their current form do not incorporate adaptive management. All SAP members agreed that an adaptive approach to forest management would be desirable. There were debates about the benefit/cost and practicality of varying levels of rigour in the application of adaptive management.

7.1.2 Recommendations

The SAP recommends that the following commitments should be made in the RFAs to enable the development and implementation of a more adaptive forest management system:

1. The RFAs should make a strong commitment to building an adaptive approach to forest management across all forests and outline a time frame for achieving this. Such an approach is the only realistic way in which future major uncertainties, including those relating to both the direct and indirect effects of climate change, can be managed. A significant increase in resourcing for planning, monitoring, evaluation of outcomes against planning goals and for underpinning research will be required as part of the commitment in order to implement the adaptive approach.

2. An adaptive approach should be applied to the RFAs. If the RFAs contain clear objectives, performance measures and procedures for evaluation of progress, then RFA reviews will be more effective and lead to greater improvements in forest management. Appropriate measures and targets should be specified for each goal/commitment specified in the RFAs. Current RFAs lack such a structure, making it difficult to determine if they have met their original objectives.

3. To facilitate improved adaptive cross-tenure management of forests, the Victorian and Federal governments should collaborate to develop an integrated forest information system. This would build upon existing remote-sensing coverages, ground-based monitoring, vegetation and fauna surveys, and spatial modelling. The Federal government would contribute national data sets including the multi-temporal Landsat coverages which extend back to 1972, and which are invaluable in creating a 'wall to wall' and consistent forest disturbance history. Two decades of work underpin these spatially and temporally consistent coverages, which are used for National Greenhouse Gas reporting. The institutional arrangements for establishing and maintaining the cross-tenure forest information system need to be clearly specified in the RFA.

4. Victoria should commit to developing an improved forest monitoring program that is better targeted to supporting adaptive forest management. An independent external review of the VFMP is required as part of a gap analysis that examines the monitoring requirements for all public forests. In designing improved systems, new approaches to effectively linking ground

observations with remotely sensed data to enable reliable estimation of temporal change in forest values should be explored.

5. New cross-tenure regional forest management plans that are being proposed should be structured using an adaptive management model (as described above), with strong emphasis given to multi-stakeholder planning, specifying performance indicators, monitoring and evaluation and reporting processes.

7.2 What is 'Adaptive Management'?

Adaptive management is 'learning by doing'. There is a large body of literature on adaptive management. The concept of adaptive management has a wide spectrum of definitions, ranging:

- From: management systems that incorporate monitoring, review and improvement[205]
- To: management research methods that include development of conceptual models, setting up formal hypotheses, development of quantitative models, application of management as areal world experiment, monitoring, and then using the information obtained to test the hypotheses and refine the conceptual and numerical models.[206]

At the 'experimental' end of the spectrum, issues are raised about the ethical considerations arising from using a true experimental approach, where management approaches that may be considered suboptimal are applied as part of the experimental design for comparative purposes.

Conversely, at the 'managerial' end of the spectrum, there are concerns about the lack of scientific rigour from bias towards a preferred management approach and using a suboptimal experimental design.

As discussed in earlier chapters of this report, Victoria's forests are subject to ongoing environmental change, including climate change, and cannot be assumed to be in dynamic equilibrium. This should be taken into account when establishing requirements in relation to adaptive management in the RFAs.

7.3 Changes Since the Establishment of the RFAs

7.3.1 Changes in Policy Context

The Victorian Government has begun to embrace the principles of adaptive management in many aspects of natural resource management. Adaptive management can be applied in differing ways, with major consequences for costs and practicality. Below we briefly discuss these issues and then recommend a simple, management-based approach.

There is a need for the Victorian government to take a more adaptive approach to forest management planning and practice to help deal with the major uncertainties that will always exist when managing the large, diverse and complex native forest estate. Adaptability will also be required to enable response to changing circumstances, and to incorporate new knowledge as it is

[205] Jackson, W. Independent Consultation Paper - Modernisation of the Victorian Regional Forest Agreements. May 2019. https://www2.delwp.vic.gov.au/__data/assets/pdf_file/0029/417818/Independent-Consultation-Paper-Modernisation-of-the-Victorian-RFAs-May-2019.pdf

[206] Westgate, M.J., Likens, G.E. and Lindenmayer, D.B. (2013). Adaptive management of biological systems: A review. Biological Conservation, 158, 128-139; Lindenmayer, D.B. (2018). Difficulties in fitting an adaptive management approach to threatened species monitoring. In: Legge, S.M., Lindenmayer, D.B., Robinson, N.M., Scheele, B.C., Southwell, D.M. and Wintle, B.A. (Editors). Monitoring Threatened Species and Ecological Communities. CSIRO Publishing, Melbourne. pp. 397-406; Lindenmayer, D.B. and Likens, G.E. (2009). Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution, 24, 482-486.

acquired. This is particularly important in relation to the impacts of major wildfires that have occurred since the establishment of the RFAs, and to future climate change. Jackson advocated a proactive, adaptive approach to identifying and managing risks including:

- Identifying thresholds in environmental states that may trigger management responses
- Using the best available evidence of the current state and trends of pressures on forests and assessments of likely future impacts.[207]

7.3.2 Changes in Scientific Knowledge

Ecologically Sustainable Forest Management (ESFM)

Sustainability science has advanced greatly during the last several decades, including its application to forests.[208] Part of this has been the improved development and application of the principles of ESFM, which were still in the early phases of development when the RFA process was commencing 20 years ago.[209] Various definitions of ESFM have been proposed. A useful definition is as follows:

> *Ecologically sustainable forest management perpetuates ecosystem integrity while continuing to provide wood and non-wood values; where ecosystem integrity means the maintenance of forest structure, species composition, and the rate of ecological processes and functions with the bounds of normal disturbance regimes* [210]

Experience during the last few decades shows that the following are key concepts embodied within the ESFM framework:

- ESFM can involve all forests (native forests and plantations, irrespective of tenure), in which the management intent ranges markedly from conservation (in reserves) to intensive management with an emphasis on wood production (plantations, and the Intensive Forest Management [IFM] zones in multiple-use state forests).
- ESFM should consider the full suite of forest values (e.g. as reflected by the Montréal Process Criteria, which have been adopted for reporting at State and Federal level in Australia). These criteria are comprehensive and cover social, economic and environmental aspects of forest management, as well as the legal and institutional framework that is essential to support good forest management. However, as discussed below, the indicators used for higher-level 'State of the Forest' reporting are often not useful for supporting adaptive forest management at finer scales.
- ESFM can only be delivered by a forest management system that delivers effectively on the ground. Thus, specifying the management system is critical in the RFA because the RFA accredits

[207] Jackson, W. Independent Consultation Paper - Modernisation of the Victorian Regional Forest Agreements. May 2019. https://www2.delwp.vic.gov.au/__data/assets/pdf_file/0029/417818/Independent-Consultation-Paper-Modernisation-of-the-Victorian-RFAs-May-2019.pdf

[208] Raison, R.J., Brown, A.G. and Flinn, D.W. (Editors) (2001). Criteria and Indicators for Sustainable Forest Management. IUFRO Research Series, No. 7. CABI, Wallingford, UK. pp.443; David B. Lindenmayer and Gene E. Likens (2009). Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology & Evolution, 24, 482-486; Deborah O'Connell, John Raison, Steve Hatfield-Dodds, Andrew Braid, Annette Cowie, Anna Littleboy, Thomas Wiedmann, Megan Clark (2013). Designing for Action: Principles of Effective Sustainability Measurement. Summary Report Prepared by the Commonwealth Scientific and Industrial Research Organisation for the World Economic Forum Global Agenda Council on Measuring Sustainability. Available at http://www3.weforum.org/docs/GAC/2013/WEF_GAC_MeasuringSustainability__PrinciplesEffectiveSustainabilityMeasurement_SummaryReport_2013.

[209] Davey, S. M. (2018). Regional forest agreements: origins, development and contributions. Australian Forestry 81, 64-88.

[210] Lindenmayer DB and Franklin JF. (2002). *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island Press, Washington DC. 351 pp, p 6

the system and provides exemption from key Commonwealth legislation (EPBC Act, Export Control Act).

- ESFM requires a well-designed and adequately resourced monitoring system
- ESFM aims to support the long-term stability of forests and forest industries. Thus, the desired goal of ESFM is to ensure that the full suite of forest values (including services) is maintained over time. This is problematic in the context of environmental change, including climate change, where maintenance of stability may require ever increasing intervention to resist changes in forest ecosystems and values in response to environmental change. An adaptive approach to forest management (see below) can help to deal with the inevitable future uncertainties that will result from managing a large and complex native forest ecosystem, that will also be impacted by the direct and indirect effects of climate change. An adaptive approach is highly demanding in terms of resources when applied at fine scales on the ground. So far, forest managers have relied more on applying 'good' practices that are then assumed to work, rather than on actually assessing outcomes. Thus, adaptive forest management remains more of an aspirational goal rather than a practical reality.
- Planning and forest management requires both a knowledge of the current state of the forest (e.g. age-class distributions reflecting prior disturbance from fire and harvesting, species distributions), and crucially, a capacity to forecast future forest dynamics. An understanding of forest dynamics makes it possible to estimate future habitat, biodiversity values, wood flow, water yields, carbon stocks, and associated social implications. A capacity to forecast forest dynamics and associated forest values must be a central plank of the forest management system.
- ESFM is only meaningful when framed by clear management intent and the set of objectives (goals) that this encompasses. The RFA must determine these objectives at a higher level, and this will require negotiation regarding the relative priorities for biodiversity, wood flow, water yield, tourism and other factors that stakeholders deem to be important across the total native forest estate. Regional forest management plans will reflect more local issues.
- There are very few absolutes in ESFM, and there is almost always a need for some trade-off between forest values. It is clearly not possible to have the same forest values, in all places, at all times. The negotiated trade-offs will be reflected, regionally, in forest zoning, and the associated differing management practices within each of those management zones. The relative priority given to a specific forest management outcome is very regionally specific (e.g. in locations where water is critically limiting it will assume greater significance in negotiations; where species are threatened, management to reduce threats will be a priority).

Adaptive Management

Adaptive forest management in its simplest form is essentially 'learning by doing'. The topic has been subject to deep and wide-ranging discussion.[211]

Adaptive management is based on a critical set of generic linked components. These include:

- Multi-stakeholder input to planning
- Development of conceptual models and hypotheses regarding the effects of the proposed management regime
- Operational guidelines to implement the plans (e.g. Codes of Practice, silvicultural prescriptions)

[211] Westgate, Martin, Likens, Gene E. and Lindenmayer, David. (2013). Adaptive management of biological systems: A review. Biological Conservation 158, 128–139. 10.1016/j.biocon.2012.08.016; Julian Di Stefano and Alan York (2012). Relationships between disturbance regimes and biodiversity: background, issues and approaches for monitoring. Fire and adaptive management report no. 91, Victorian Department of Sustainability and Environment, Melbourne. 44pp.

- Monitoring of the costs and outcomes of forest management, using indicators or direct measures
- Robust evaluation processes (to evaluate actual outcomes against specified agreed outcomes contained in plans) to decide if the management approach (including plans or operational guidelines) needs to be changed
- Reporting to the public.

Research has a pivotal role in improving all aspects of the adaptive management system, particularly in evaluating alternative practices and in providing science-based options for improvement.

A distinction has been drawn in the scientific literature between 'active' and 'passive' adaptive management: [212]

- Active adaptive management includes comparison of several management strategies in a systematic way, thus potentially leading to more rapid improvements
- Passive adaptive management involves carefully designing, monitoring and evaluating a single management strategy. A well-designed research program is required to support this approach.

7.4 How Well is Adaptive Management Currently Addressed in the RFAs?

The Victorian RFAs in their current form do not incorporate adaptive management. They provide for 5-yearly reviews, which are intended to monitor progress in relation to the milestones established in the RFA. The RFAs clearly indicate that the reviews will not open up the entire RFAs to re-negotiation, but they do provide scope for the Parties to agree to modifications to enable incorporation of the findings of the review.

7.5 Options for Improvement

The RFAs provide the opportunity to establish a more adaptive approach to forest management in Victoria. Rigorous adaptive approaches are more complex and expensive, and compete for limited resources available for implementing current 'good practice' management. For Victoria, which is at an early stage in implementing adaptive approaches, we recommend a simple, management focused approach outlined in Figure 4, but with development of stronger supporting research.

For each of the key steps required to effectively implement adaptive forest management, the following elements are very important.

1. **Legislative and policy context** – this is established by the RFAs and the Victorian forest management system.
2. **Conceptual models**. Conceptual models are required to develop and explain hypotheses about the potential effects of the proposed management regime. The conceptual models can be used to refine the proposed management regime, explain the expected effects of management to stakeholders and to assist in the design of monitoring program (e.g. development of hypotheses and indicators). This process is used to identify science-based management prescriptions.
3. **Management Planning.** To help define clear management goals for ESFM, a linked suite of plans is required that cascade down from:

[212] Julian Di Stefano and Alan York (2012). Relationships between disturbance regimes and biodiversity: background, issues and approaches for monitoring. Fire and adaptive management report no. 91, Victorian Department of Sustainability and Environment, Melbourne. 44pp.

- Commonwealth and State level plans that reflect broad government goals and policies (e.g. targets for conservation, targets for GHG emissions reduction), to
- Regional-level plans (reflected in the RFAs) that consider the regional context and define the regional contribution to higher level goals, to
- Finer-sale forest management plans that specify how forests are managed consistent with sustainability principles, taking account of forest condition, landscape and social context, and employing a range of implementation guidance such as Codes of Practice for timber harvesting and fire management, silvicultural prescriptions etc.

Effective stakeholder input to the management planning process is critical for the development of shared goals and for deciding on monitoring approaches (indicators/data to be collected), what are appropriate performance measures and how the evaluation step is conducted.

Design of the monitoring program should be an integral part of management planning.

4. **Implementation.** This step relates to how forest management goals are translated into actions on the ground. Management guidelines or prescriptions are used, and they should incorporate current science and experience, and thus represent 'best practice' management. A major challenge is to know how to adapt the guidelines to deal with local 'risks' to forest values and to know whether desired outcomes are actually achieved.

5. **Monitoring**. Design of the monitoring program should be an integral part of management planning. The monitoring program should be implemented in parallel with the management program. Monitoring data should be regularly reported.

   Well- targeted and adaptive monitoring is a critical component of an adaptive forest management system. There are several types of monitoring,[213] the main ones being:

   - Broadscale passive or 'surveillance' monitoring which aims to act as an early warning system for unexpected change in forest condition
   - Mandated, broadscale monitoring to assess broad trends without much focus on the processes driving change, and
   - 'Targeted' question-driven monitoring that aims to measure progress towards a clearly stated objective.

   Often monitoring is based on the use of indicators.[214] Indicators need to be appropriate for the spatial scale of assessment, sufficiently sensitive to be able to detect relevant change in forest values and cost-effective when applied at an operational scale. In addition to data, modelled interpolations or projections are also used to inform decision making.

[213]David B Lindenmayer and Gene E Likens. (2010) The science and application of ecological monitoring. Biological Conservation, 143, 1317-1328.

[214]Lindenmayer, D.B., Pierson, J., Barton, P.,Beger, M.,Branquinho, C., Calhoun, A., Caro, T., Greig, H., Gross, J., Heino, J., Hunter, M., Lane, P., Longo, C., Martin, K., McDowell, W.H., Mellin, C., Salo, H., Tulloch, A. and Westgate, M. (2015). A new framework for selecting environmental surrogates. Science of the Total Environment, 538, 1029-1038; Lindenmayer, D.B., Barton, P. and Pierson, J.C. (Editors) (2015). Indicators and Surrogates of Biodiversity and Environmental Change. CSIRO Publishing, Melbourne. CRC Press, London. 206 pp.

Lindenmayer and Likens pointed out why many monitoring systems fail and described the requirements for an 'adaptive' monitoring program that can, importantly, evolve over time as needs of the monitoring system change.[215]

The cost-effectiveness of monitoring can be improved using a linked tiered approach. For an example relating to the effects of forest harvesting on important soil properties affecting forest growth, see Raison and Rab.[216] The linked tiered approach encompasses:

- Wall to wall remote sensing (e.g. multi-temporal Landsat) with sub-sampling using higher resolution remote sensing (e.g. LiDAR)
- Monitoring of compliance with management guidelines (e.g. the Code of Practice for Timber Harvesting) across the total forest
- Detailed monitoring at a subset of sites (with emphasis being on selection of sites deemed to be of highest risk to adverse change as well as relevant control sites) to determine the operational effectiveness of management guidelines
- Detailed long-term research at replicated key representative sites to validate or improve the management guidelines. Ideally statistical analysis would be undertaken, and this would require a sufficient number of sites to be included to provide sufficient statistical power to determine trends, particularly when there are interactions between the driving factors.

The broad goal is to integrate remotely sensed and land-based observations to improve cost-effectiveness.[217] However, risks and limitations to this approach should be considered, such as over- or under-estimation by models compared with on-ground measurements.[218]

The Victorian government established the VFMP in 2011.[219] It aims to observe broadscale, long-term trends in forest condition, and would need modification to be able to assess the effects of management interventions.[220] Based on a brief review, the SAP have identified the following limitations of the VFMP in terms of its ability to support adaptive forest management:

- This is a passive monitoring program and there are no key questions or strong conceptual models to guide how monitoring is done
- The design makes it difficult to identify the cause of any change detected
- Plots are too small to allow effective sampling of the overstorey in most forest types
- There are too few plots in important forest types such as mountain ash

[215] David B Lindenmayer and Gene E Likens (2009). Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology & Evolution, 24, 482-486; David B Lindenmayer and Gene E Likens (2018). Effective Ecological Monitoring. CSIRO Publishing, Melbourne. 224pp.

[216] Raison, R.J. and Rab, M.A. (2001). Guiding concepts for the application of indicators to interpret change in soil properties and processes in forests. p. 231-258. In: Raison, R.J., Brown, A.G. and Flinn, D.W. (eds.) Criteria and Indicators for Sustainable Forest Management. IUFRO Research Series, No. 7. CABI, Wallingford, UK.

[217] Penman, J. *et al.* (2014). Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative. Published by Group on Earth Observations, Geneva, Switzerland. 156 pp.

[218] Keith, H., Lindenmayer, D.B., Mackey, B.G., Blair, D., Carter, L., McBurney, L., Okada, S. and Konishi-Nagano, T. (2014). Accounting for biomass carbon stock change due to wildfire in temperate forest landscapes in Australia. PLOS One, 9, e107126.

[219] Haywood, Andrew; Thrum, Kristen; Mellor, Andrew and Christine Stone. (2017). Monitoring Victoria's public forests: implementation of the Victorian Forest Monitoring Program. Southern Forests: a journal of forest science 80, 185-194.

[220] Victorian State of the Forests report (2018).

- Statistical power is low for detecting temporal change, especially for spatially variable components such as soils
- Although remote sensing is used to facilitate spatial scaling, it is not clear how effective this has been.

The SAP recommends that a detailed external review of the VFMP be undertaken to establish how it could be improved to better support adaptive forest management.

The SAP expects that the review will demonstrate the need for significantly increased investment in monitoring. In addition to surveillance monitoring, long-term robustly-designed and replicated monitoring is required to support adaptive management.[221]

6. **Evaluation.** This step interprets the meaning or value of data collected in relation to stated management goals, and thus informs learning and adaptive processes. Details of when and how the evaluation process should be conducted, as well as performance measures, targets and thresholds, should form part of forest management plans.
7. **Responses**. Changes may be made to management plans and/or to management practices. A commitment to long-term field research that explores the effects of management options on forest values is needed to provide confidence that any adaptive changes to the management system are likely to achieve their objectives.
8. **Reporting**. Reporting on an agreed timeline is important in building stakeholder confidence, and thus in building 'social licence' for the forest management system.

If the RFAs are going to commit to a more adaptive approach to forest management in the future, they need to specify how it will deal with these essential requirements.

A critical aspect is specifying triggers for review of progress against management goals. Reviews may be initiated based on time elapsed since the establishment of the management system or completion of a previous review, or a major disturbance such as bushfire which impacts on timber stocks, or a major drought which is limiting water security. The triggers for review should be clearly articulated in forest management plans, and in the RFA itself. The Forest Management System, which is accredited as part of the RFA, needs to be structured to be consistent with the adaptive forest management framework summarised below, and will be most effective if embedded within an Environmental Management System (EMS).

[221] David B Lindenmayer and Gene E Likens (2018). Effective Ecological Monitoring. CSIRO Publishing, Melbourne. 224pp.

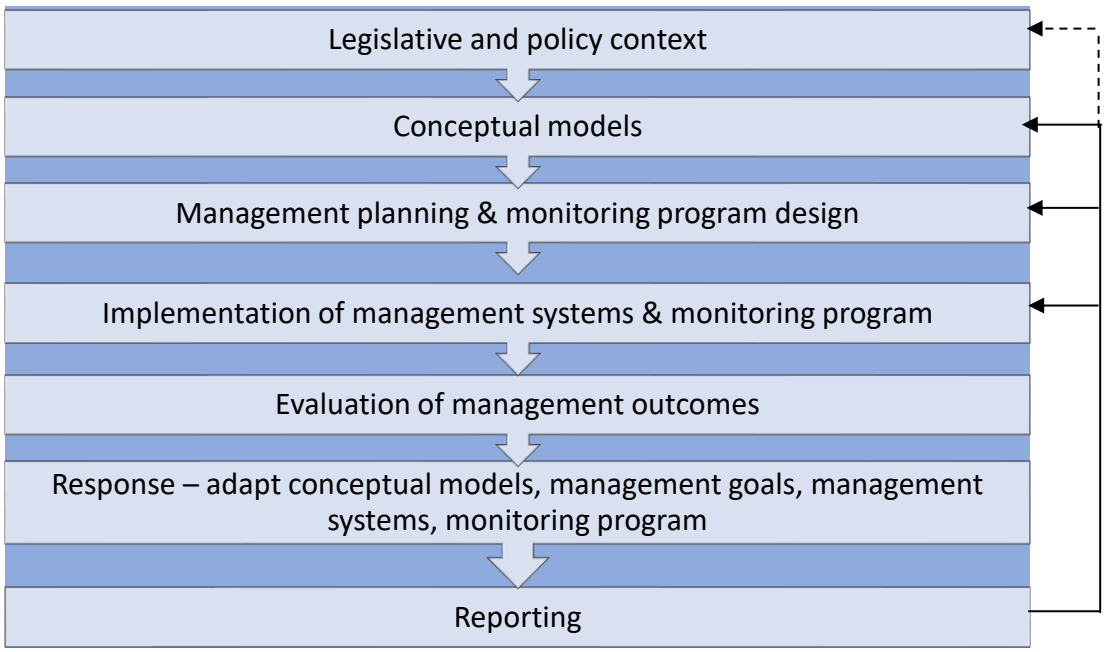


Figure 4 Key steps in an adaptive management approach

Attachment 1 - Papers on Critical Issues (prepared by Dr John Raison)

Not endorsed by all SAP members

(a) Estimating the effects of forest age on water yield from Mountain Ash catchments

Prepared July 2019

The 'Kuczera' curve (Kuczera, 1987) is often used to estimate the effects of varying age of stands of Mountain Ash forest on annual catchment water yield. The curve is a composite derived from studies in different catchments varying in age of recovery after the extensive 1939 wildfires. It was based on data covering a 5-15-year pre-burn period and a 40-year post-burn period (Eamus, 2009). The curve has been generalised to represent a 'regional average' and extended to cover up to 160 years after fire (Kuczera, 1987).

Vertessy (1998) calculated the 95% confidence limits around the curve, and showed that uncertainties are very high, especially for the period 50-120 years as ash forest begins to mature. They also make a critical point that whilst the curve estimates a water yield of 1200 mm/yr from old-growth forests, observations from such forests growing under differing site conditions vary in yield from 250-1500 mm/yr. Clearly caution should be taken when applying the curve across variable landscapes.

Detailed process modelling by Vertessy *et al.* (1998, 2001) showed that whilst water use did decline with forest age (over the period 15 to 240 years), the difference between a 15-year-old forest and a 240-year-old forest that they modelled was 460mm/year or about 75% of that estimated by the Kuczera curve. Analyses such as those recently reported by Taylor *et al.* (2019) that apply a single Kuczera curve (with a high maximum yield reduction of 600mm/year) across entire catchments, are likely to overestimate the impacts of forest disturbance on future water yields.

A critical question is what effect will reductions in rainfall under climate change have on differences in water use between young and older forests? One might expect that differences will reduce in absolute terms (i.e. the Kucera curve would become much flatter) because with reduced soil moisture young forests will be more constrained in their use of water, whilst older forests may be able to use most of the water available. Fiekema *et al.* (2013) concluded that under lower than average rainfall, the effects of forest age are reduced, and that rainfall is the main factor affecting post-fire change in catchment water yield. The reduction in water yield caused by conversion of older (120 year) forest to regrowth was less (a maximum of about 200mm/year) in the drier Picaninny catchment which forms part of the Coranderrk experimental area (Bren *et al.*, 2010; R Benyon, University of Melbourne, pers. comm., 2019). A further possibility is that with reduced rainfall and drought, the rate of self-thinning will increase in regrowth ash stands, thus accelerating the transition to a forest structure with lower water use (i.e. there will be accelerated movement along the Kucera curve). Clearly, further work is needed to clarify these important issues.

Conclusions

Whilst the effects of reduced rainfall on catchment water yields is clear and very significant (e.g. flows into Melbourne's reservoirs declined by about 40 % during the Millennium drought, Feikema *et al.*, 2013), logging and fire disturbance is likely to have less, but still important, effects on long-term water yield (e.g. Lane *et al.*, 2010; Feikema *et al.*, 2013; Zhou *et al*., 2015). The magnitude of reductions in water yields at landscape scales caused by creation of younger forests following

harvesting or wildfire is a critical area of uncertainty, especially under a drying climate where both the variability (seasonality and intensity e.g. Pendergrass *et al*., 2017) as well as total rainfall are expected to change. This is a crucial issue for future water security, and a priority area for further detailed study that will enable much better spatial resolution of impacts on catchment water yield that take better account of soils, aspect, forest condition and local rainfall distributions. An excellent conceptual framework, models such as Macaque, and capacity to use remotely-sensed data for spatial scaling already exist to underpin future work (e.g. Benyon *et al*., 2015; Fowler *et al*., 2018).

Hydrologic responses to forest disturbance are quite different in drier mixed-species forests (e.g. Webb and Jarrett, 2013; Nolan *et al.*, 2015), and are also complex. Catchments dominated by such forests are important for regional water supply in Victoria.

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(b) Natural and human disturbance can accelerate soil erosion and have highly negative impacts on Victoria's forests

Prepared July 2019

Forest disturbance by wild or planned fire, harvesting, or grazing can increase rates of soil erosion which then negatively impact on a wide range of values, but especially soil fertility and vegetation growth, water quality, and aquatic and terrestrial habit and biodiversity.

Timber harvesting

Risks to soil and water values from timber harvesting are addressed in Victoria via a range of actions (e.g. slope limits, barring and drainage of snig tracks, cessation of operations in wet weather, use of filter and buffer strips along drainage features) under the Code of Practice for Timber Harvesting (2014). Detailed guidance is contained within the 'Management Standards and Procedures', including region-specific instructions, but the Code does not specify how these can be sourced (but they are referenced in the Victorian State of the Forests report, 2014). The Management Standards and Procedures provide a very approximate (methods are not specified) scoring approach to assessing soil erosion hazard and risks to water values at the logging coupe-scale. Whilst a useful approach, currently only compliance with implementation of the Code is independently audited and reported, but outcomes are not systematically assessed (Victorian State of the Forests Report, 2018). The effectiveness of mitigation measures needs to be assessed visually on all logging coupes and on streams leaving the coupe. This will provide valuable information to inform the on-going improvement in implementing the Code to deal with local differences in erosion risk resulting from the interaction between degree of site disturbance and soil type/terrain/aspect/other environmental conditions.

Fire

Fire impacts forest ecosystems by changing many important soil and plant processes. In nutrient-poor systems such as most Australian native forests, effects on nutrient budgets and cycling processes are important, and soil erosion which is often increased by fire and which results in loss of nutrient-rich ash and surface soil, can be a rapid and major agent of change (e.g. Raison *et al*., 2009).

Wildfire can cause catastrophic rates of soil erosion in Victorian forests (e.g. Dunkerley *et al*., 2009; Nyman *et al*., 2011), and have significant impacts on water yield and quality (Lane *et al*., 2010; Smith *et al*., 2011). Further, debris flows in the initial years following wildfire can threaten the water supply system (Nyman *et al*., 2015) – such as occurred after the 2003 Canberra fires. After wildfire, sheet erosion can be high even under rainfall of moderate intensity, and hillslope sediment transport can continue for several years, especially after a subsequent fire or intense rainfall (Dunkerley *et al.*, 2009). Deposits of sediment either near to, or within, the stream network can also be re-immobilised over time. Efforts to control wildfires, such as construction of control lines, also render the landscape more prone to erosion. During the 2003 wildfires, about 9000 km of control lines were constructed, many using heavy machinery and being up to 60 m wide. Much rehabilitation was undertaken, but this is very expensive and often only partly successful (Dunkerley, 2009).

Low-intensity (prescribed) burns used for purposes of fuel reduction and reducing the subsequent risk of wildfire can also increase soil erosion rates in Victoria (e.g. Cawson *et al*., 2013). Potential increase in erosion from management burns is a significant issue because such burns are applied over large areas (often 100-250 thousand hectares per year), and over several months, thus increasing the chance that some burns will soon be followed by intense rainfall. Cawson *et al.* (2013) suggested that in conducting such burns that streams need to be protected, and that a mosaic of unburnt patches creating strips > 10 m wide be created to reduce erosion connectivity. Victoria uses a Code of Practice for Bushfire Management on Public Land (2012) to guide prescribed burning

activities. The Code itself does not contain guidance on how planning and implementation of management burns take erosion risk into account. The Code states that the operational detail for how bushfire goals are achieved 'will be specified in bushfire management manuals and guidelines, which will be publicly available and consistent with this Code'. We were informed by DELWP staff that guidance for how planners assess and mitigate soil erosion risk is currently not well developed. Thus, this is an area requiring significant improvement for the reasons outlined above. The Code also commits to developing a framework for monitoring, evaluating, and reporting on the environmental impacts of its bushfire management program. The SAP have not been able to evaluate progress in this area, but it clearly is an important area to progress as mentioned in other SAP chapters providing advice to the RFA negotiations.

Spatial variation in erosion is high (Dunkerley, 2009; Cawson *et al.*, 2012), but the reasons for this are becoming better understood (e.g. Noske *et al.*, 2016). Recent work has demonstrated a positive relationship between an Aridity Index (AI, a function of long-term rainfall and net radiation experienced at a site) and the rate of infiltration to the soil after fire (Sheridan *et al*., 2016; Sant *et al.*, 2018). The AI can be mapped with high spatial resolution, and thus offers a way to assess erosion risk after fire.

Conclusions

Potential for accelerated soil erosion after forest disturbance poses a major risk to many important values in Victoria's native forests. A clearer description of how to determine erosion risk at the coupe-level, and to manage to mitigate it is needed in the Code of Practice for Timber Harvesting. The Code of Practice for Bushfire Fire Management needs to provide clear guidance on how to take soil erosion risk into account when planning and implementing broad-scale prescribed burning for fuel reduction.

Research that leads to better capacity to spatially predict soil erosion rates across forested landscapes following disturbance will be of great value to forest managers, and thus is of high priority. The practical application of site Aridity Index (Sant *et al*., 2018) in planning to mitigate erosion after timber harvesting and fire should be further evaluated. Greater emphasis is needed on monitoring the effectiveness of erosion mitigation activities as part of a broader adaptive forest management system (see Question 7).

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Attachment 2 - Active Management of Native Forests: intensified management to accelerate sawlog production (paper by Dr John Raison).

Not endorsed by all SAP members

Changes Since the Establishment of the RFAs

Changes in Policy Context

A major challenge for those managing native forests for sawlog production is to maintain supply during the transition from harvesting mature forests to reliance on younger regrowth forests. In recent decades this challenge has been magnified by increases in the reservation of productive areas of native forest, damage by extensive wildfires, and adoption of variable retention harvest techniques as an alternative to clearfelling. In Tasmania where these factors impacted on future sawlog availability, an Intensive Forest Management (IFM) program was introduced as a supplement to the RFA (Commonwealth of Australia, State of Tasmania, 2005). The IFM program involved establishment of new plantations, the thinning, pruning and fertilisation of existing hardwood sawlog plantations, and the thinning of suitable stands of native even-aged regrowth. Most emphasis and expenditure was directed towards plantations. Regrowth thinning was mostly commercial, thus requiring little new funding.

Research during recent decades can underpin a strategy to accelerate the growth of sawlogs in selected areas of regrowth forests and thus contribute to the supply of high quality sawlogs (e.g. Kerruish and Rawlins, 1991;CSIRO 1991, 1993; Forestry Tasmania, 2001; Connell *et al*., 2001; Ryan, 2013).

Changes in Scientific Knowledge

Victoria has large areas of even-aged regrowth native eucalypt forest originating from earlier clearfall harvesting, and from wildfires (Ryan, 2013). Such forests are concentrated in the central highlands and in East Gippsland. Of the hardwood sawlogs available for processing over the next 30 years, almost all will need to come from regrowth forests because any new plantations will still be too young for harvest. To help maintain flows of sawn timber, appropriate silvicultural systems (such as commercial thinning and fertilisation), can be applied to regrowth stands to increase growth of sawlog trees, and improve the wood quality and recovery of sawn timber from smaller fast grown logs (e.g. Connell *et al*., 2001).

Raison *et al.* (1997) summarised extensive research studies in coastal mixed species regrowth forests in East Gippsland and argued that managing a small portion of the regrowth more intensively can result in benefits for both conservation and wood production. They provided an example in which managing 10% of the forest intensively could result in a 25% increase in the area available for reservation, whilst also increasing wood production by a similar amount.

As part of a national conference on 'Intensive management of regrowth forest for wood production in Australia', Fagg and Thomson (2001) summarised the potential for greater adoption of such practices in Victoria. However, subsequent rates of adoption have been modest, and largely confined to commercial thinning in mixed-species stands with about 600ha/yr commercially thinned in East Gippsland (VicForests, 2012). Lesser areas are thinned annually in mountain ash and alpine ash forests in the Central Highlands.

The knowledge basis underpinning thinning operations includes a review by the University of Melbourne (2006) on the effects of commercial thinning on a wide range of forest values for VicForests. Thinning guidelines have been produced for mixed-species forests (Siebre and Fagg, 1997) and ash forest (Fagg, 2006). A prescribed burning guide for thinned mixed-species forests in East Gippsland is also available. The effects of thinning on wood quality and solid wood product recovery has been reported for regrowth in the Central Highlands and in Eastern Victoria (Washusen *et al.*, 2008, 2009). Ryan (2013) provided an analysis of the opportunities for adaptive silviculture in regrowth eucalypt forests in Victoria for water, wood, wildlife and wildfire.

A need for initial financial investment to enable non-commercial thinning or fertiliser application to younger stands is a major impediment, even if the long-term benefits are well worthwhile (Raison *et al.*, 1995). Thus, most thinning has been confined to older (pole-age) stands if there is a market for the thinnings so that the operation can be at least cost-neutral.

Thinning provides a critical early opportunity to select the best potential sawlog trees. Diameter, form, bole length, and branching characteristics determine sawlog potential. Adopting practices that minimise stem damage during the thinning operation is crucial because stem defect lowers potential sawlog quality and sawn product recovery (see Old and Wardlaw, 2001). Likewise, there is a need to carefully manage fire risk which is increased for a period after thinning – prescribed burning guides have been developed to reduce thinning slash without damaging remaining stems (e.g. McCaw *et al.*, 2001).

Commercial thinning of pole age regrowth can markedly reduce sawlog rotation times, especially for low and medium site quality stands. The largest 50 trees ha-1 in thinned forest maintain at least co-dominance and will be the first trees in the stand to reach economic sawlog sizes. Harvest of this cohort of trees will provide early economic returns from both sawlog and pulpwood products, as well as increasing the growth rate of retained future sawlogs. Use of such partial harvest silviculture can be profitable (Connell *et al.*, unpublished). They used discounted cash-flow analysis to show that the economic performance of regrowth managed for sawlog can be increased by commercial thinning at pole-age (26yrs) and further increased if followed by a partial harvesting of sawlogs when the first 50 logs have reached >60 cm DBHOB (as early as 50 years in high quality forest). A more intense partial harvest (largest 70 trees at age 50) can further increase the economic benefits.

Partial harvesting warrants more detailed investigation as an option for reducing predicted sawlog deficits in the next 30 years and for improving economic returns from the public forest estate. Careful management of both un-thinned and thinned regrowth over the next few decades has the potential to reduce projected sawlog deficits and assist sustainable supply until larger areas of regrowth reach harvestable age, or until a suitable plantation resource becomes available.

The growth rate of young regenerating forest can be greatly increased by silvicultural intervention, especially on nutrient limited soils such as occur over extensive areas of East Gippsland (CSIRO, 1991; 1993; Raison *et al.*, 2009). Early growth rates of eucalypts can be tripled with addition of very small amounts of P fertiliser, and the biomass of N-fixing understorey increased 10-fold. There are clearly major implications for increasing long-term growth of trees and for changes in habitat quality. Early spacing (non-commercial thinning) is also a benefit to future crops trees but is expensive if undertaken manually – but it may be possible to produce more optimal initial stocking by varying seeding rates in silver top ash forests (Raison *et al.*, 1995). As stated earlier, extra costs of silvicultural inputs at the start of the rotation are a constraint to the widescale adoption of these practices even though there may be large long-term benefits.

Thinning and fertiliser additions also impact on other forest values such as understorey biodiversity (e.g. Bauhus *et al.*, 2001) and hydrology, and can also increase fire risk. However, many of these effects are transient, or can be managed (such as fire risk by burning to remove the more flammable components of thinning slash) at both the site-level and landscape scales (e.g. Peacock, 2008, Connell *et al.*, 2001; Ryan, 2013). Clearly, in selected areas of regrowth managed for wood production as a priority, there will need to be some trade-off of other values. Clearly wood production components of native forests must be integrated into the broader forested landscape, including conservation forests and plantations. This can be achieved as part of the regional forest management planning process. More intensively managed portions of the native forest form a continuum of forest management activities and must be located and managed in a manner that is consistent with regional forest conservation and wood production goals (Raison *et al.*, 2001).

Recommendations for the RFAs

1. Thinning, fertiliser addition and partial harvesting approaches should be further explored as a suite of silvicultural tools for accelerating sawlog production in regrowth stands in state forest, however a range of risks across the full suite of forest values would need to be addressed. An adaptive management approach would provide a means of managing these risks. Intensive management of a carefully selected, limited portion of regrowth may provide benefits for both sawlog production as well as increase the area of forest available for conservation. The scale and location of intensively managed areas should be determined as part of the regional forest management planning process, which takes account of both regional wood production and forest conservation goals.

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Modernising Regional Forest Agreements in Victoria

Recommendations for management and conservation

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Cover photo: A logging coupe near Matlock in Alpine Ash forest in the Victorian Central Highlands, 30 July 2019. (Photo by C. Taylor)

Introduction

This document contains recommendations for tackling some of the key issues associated with a science-based and an economics-based approach to the modernization of the Regional Forest Agreements in Victoria. It addresses four key topics:

- **The importance of plantations and the need to transition the forest industry into a plantation-only industry.**
  Such a transition will result in a move toward managing natural assets for the best and highest value. That is, plantations for timber production, and native forests for water, carbon and tourism. A transition to a plantation-only industry is especially important for providing resource security for the forest industry. This is because recurrent wildfire, past overcutting, conflict over water security, other environmental conflicts, as well as declining social licence, will all further undermine resource security from native forests. Thus, a transition to plantation-only forest industry will be critical to address key issues associated not only with timber security but also with water security and the enhanced conservation of forest biodiversity. It is best if this is a planned transition rather than one based on the rapid collapse in the native forest sector. There are valuable lessons on forest industry transitions from other parts of Australia (and overseas) as well as transitions in other industries nationally and globally. Much can be gained from examining these transitions to produce the best possible outcomes for the Victorian economy and Victorian regional communities. There are well identified approaches for best practice plantation establishment and management, and Victoria should look toward the implementation of these practices so that plantations can work toward FSC certification.

- **The urgent need to significantly expand the CAR reserve system.**
  The current protected area network is deficient, especially around the Adequacy component of the CAR principles. Expansion of the reserve system will also be important to increase its resilience to climate change. Allied with reserve expansion, there is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans – with all of these plans based on robust, peer-reviewed science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management. The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative. The RFAs should not be re-signed until these maps of the CAR reserve system have been created. A part of an commitment to an expanded CAR reserve system, the Government of Victoria must undertake a thorough re-assessment of sustained yields from native forests that take into account: (a) the risks of recurrent future wildfire; (b) the extent of past disturbance (both fire and logging) in the existing forest estate; (c) the need to exclude timber harvesting from water catchments because of negative effects on water security for Melbourne (and regional centres north of the Divide); and (d) the conservation of threatened forest-dependent species.

- **The need for active management of forests.**
  Some key forms of active management of native forests are currently needed, such as the control of invasive plants and animals. In addition, if Victoria were to embrace carbon markets (and native forests are managed as major and secure long-term stores of carbon), then active management of that carbon stock will be required, including enhanced fire-fighting, and the control of populations of exotic herbivores that can affect forests (e.g. sambar deer, which

damage young regenerating forests). There may also be a need for changes in institutional arrangements, such as restructuring VicForests to become a new body (e.g. VicCarbon).

- **The need for more robust forest monitoring programs, including better monitoring to underpin Adaptive Management programs.**
  A greater commitment to monitoring will provide greater insights into what management interventions are (and are not) effective and provide the best returns on investments in resource management.

An important caveat is that the recommendations made in this report are not exhaustive, nor is the supporting literature always cited to support the recommendations. The report is relatively brief and somewhat skewed toward issues associated with plantations. This is because the native forest sector: (a) is largely producing low value product, (b) suffering from low levels of investment, (c) characterized by shrinking levels of employment, (d) subject to high levels of resource conflict (e.g. between water and wood), and (e) characterized low levels of community support.

1. Plantations

It is well understood that some of the recommendations made below have already been implemented. There are, however, some suggestions that are new (at least in part) within the context of plantation establishment and design in a Victorian context.

1.1. **The Victorian Government should embrace a policy of best and highest value for natural assets.**
Environmental and economic accounting work has shown that the best and highest value for plantations is timber production. The best and highest value for Victoria's native forests is water production, tourism, and carbon [1, 2].

1.2. **Review and update the Plantations 2020 Vision to establish an up-to-date and well-articulated vision for the size of the plantation industry that is desired.**
This should include a horizon-scanning process (*sensu* [3]) to explore potential future demand over medium to long-term timeframes (e.g. 15-40 years) as well as possible disruptions to plantation industry development. The review would examine the size and location of plantation resources at regional and national scales to determine potential domestic and international markets, linking this to options for value added processing to reduce the levels of raw product (logs) or low value products (chips and pulp) being exported from Victoria. The Plantations 2020 Vision prioritised those aims as a way of decreasing trade deficits. Due to the time lag between plantation establishment and harvest, it is critical such reviews and actions are conducted rapidly. Victoria has established few new plantations since 2003. Such review processes are undertaken routinely in other resource-based industries such as mining.

1.3. **Complete a thorough stocktake of the existing plantation estate in Victoria, coupled with land capability mapping of suitability for plantation expansion (including different types of plantation with different end products).**
It has long been understood there are substantial areas of south-eastern Australia suitable for plantation establishment (e.g. [4]) and it is assumed suitable areas were identified in the Latrobe Valley prior to the 2017 Victorian Government budget announcement of $110m for plantation establishment. The implications of climate change for the suitability of plantation establishment and subsequent tree growth need to be quantified.

1.4. **Identify approaches to overcome financial and social disincentives to establish new plantations.**
This includes reviewing case studies and experience from other jurisdictions in Australia (e.g. southern NSW; see Stanley, 2006) as well as those places overseas with dynamic plantation sectors (e.g. New Zealand). Unfortunately, Managed Investment Schemes did significant damage to the long term expansion of the plantation sector, and the goal of the Plantations 2020 Vision of establishing 3m ha was not reached (in 2017/2018 Australia supported 1.94m ha of plantations) [5]. The financing of wood production in Victoria needs to be reviewed to find incentives for the plantation industry, some of which may be achieved through a more 'level playing field' between the plantation and native forest sectors, such as would come through reviewing the *Forests (Wood Pulp Agreement) Act 1996* (among other policies and subsidies).

1.5. **Seek approaches to overcome disincentives to processing eucalypt plantation feedstock within Victoria.**
The vast majority of eucalypt plantation timber is exported, and thus processing jobs are also sent off-shore [6]. The Plantations 2020 Vision called for additional local processing with the goal of turning the trade deficit around to a net surplus in this sector. Examination of transport and other impediments to in-State processing of plantation timber is urgently required.

1.6. **Quantify the carbon, water, tourism, employment and biodiversity benefits as well as the general economic benefits of a rapid transition out of native forest logging and into plantations.**
Environmental and Economic Accounting using the United Nations SEEA Framework [7] has quantified the trade-offs involved in ceasing native forest harvesting in the Central Highlands RFA area [1, 2]. The economic gains from ceasing native forest harvesting are substantial [1, 2] and are likely to be even larger at a Statewide level given that native forest logging operations in areas such as East Gippsland have been uneconomic for some time [8]. Notably, the State of the Forests report indicated a need to adopt accounting practices more broadly – including environmental and economic accounting for carbon in forests [9].

1.7. **Develop key insights from examining other industry transitions. There have been rapid transitions in resource-based industries worldwide.**
Case studies of the economic and social benefits of these transitions have been well documented (e.g. [10]). Important lessons for Victoria can be learned from these transitions. For example, a rapid transition to a plantation-only forest industry in New Zealand has proved to be successful in terms of industry growth and conservation benefits. Experience from other industries (such as the restructuring of the cod industry in Norway versus the collapse of the fishery that occurred in maritime Canada) highlight the benefits of early intervention and a rapid reset of harvest levels to limit negative social and economic impacts [11]. Again, there are potentially important lessons for industry transition, the creation of new employment opportunities, and approaches to creating an appropriate social safety net for workers.

1.8. **Prepare appropriate institutional and other arrangements associated with a rapid transition to a plantation-based economy for wood production in Victoria.**
If wood production in Victoria is to be extensively based around plantation forests and native forests are to become key to carbon storage (and water production), then the institutional

arrangements for bodies such as VicForests will need to be considered. One option is to re-purpose the function of that agency to become a carbon manager (and rebadge that entity; e.g. as "VicCarbon"). VicCarbon would then have responsibility for the management of a valuable carbon asset and, accordingly, seek ways to maintain and build that asset. Activities may include (among others) fire suppression, control of invasive species that can affect forest growth (such as sambar deer), fully restoring areas of forest where there has been regeneration failure, and debuilding parts of the currently very extensive road and track network (covering many thousands of kilometres; see [12]) where tree growth is impaired [13]. Of course, development of appropriate carbon methodologies will be central to realizing the economic benefits of carbon storage both from the conservation of native forests and the expansion of the tree plantation estate.

1.9. **Ensure that the range of values of plantations are appropriately examined and accounted for.**

Plantations can be important for the sustainable intensification of wood production that provides offsets for enhanced conservation elsewhere [14-16]. Plantations also can store large amounts of carbon [17, 18]. Greenhouse Gas emissions from the land sector can be reduced when wood products are sourced from plantations rather than native forests [19]. Past work on plantations has suggested that ecological and social problems arise when land management is driven by too narrow a set of values [20]. One approach to enhance assessments of some of the range of values of plantations is to ensure they are included in environmental accounting (e.g. [1, 2]).

1.10. **Develop prescriptions for best practice plantation establishment and management (with the objective of gaining FSC certification)**.

There is a well-developed science around plantation establishment and design derived from empirical work in plantations elsewhere, such as in NSW [21, 22]. Issues include ensuring that key habitats like native grasslands are not destroyed through plantation establishment, patches of significant remnant vegetation (e.g. Grass Box-gum woodland) are not incorporated within the boundaries of plantation rather than cleared, and streamside areas are restored with native riparian vegetation [22].

1.11. **Design plantations in ways to limit potential impacts of disturbances such as wildfire.**

There are approaches to plantation management that may limit the risk of fire spread, including the strategic location of fire breaks between compartments. Notably, landscape-scale simulation of fire occurrence in landscapes with *Pinus radiata* plantations in southern New South Wales suggest that plantations may experience much longer intervals between fire in the future, even accounting for future shortening of intervals across all forest types [23].

1.12. **Develop strategies for appropriate actions when species of conservation concern occur in plantation areas.**

Plantations can sometimes have value for conservation, including greater value for some groups of biodiversity than the cleared pastures on which the plantations are established [24]. Plantations also can be valuable for some individual species of conservation concern [25]. Approaches need to be developed as part of codes of practice for plantation management when such species occur in plantations. Part of such approaches may include appropriate monitoring of parts of the plantation estate.

1.13. **Build on insights from farm forestry and the farmland vegetation literatures to inform new strategies for integrating tree plantation establishment and agriculture in agricultural landscapes.**
There have been significant efforts invested in farm forestry programs [26, 27], as well as revegetation programs on farmland in south-eastern Australia (e.g. [28-30]) that achieve a range of positive outcomes for landholders, not just providing wood volumes. There have been many key insights and learnings from these programs over the past three decades and these need to be brought together in ways that inform new efforts in plantation forestry on farmland.

2. The CAR reserve system

2.1. **The CAR reserve system must be expanded, particularly to meet the Adequacy requirement of the CAR criteria.**
A key part of the reserve expansion process must include not only the protection of viable populations of threatened forest-dependent taxa, but also ensure that forests are sufficiently well reserved to have both resilience and resistance to climate change (including being large enough to be bigger than the extent of major disturbance events like wildfires [31, 32]. Notably, almost all of some forest types, such as almost all of the Mountain Ash and Alpine Ash ecosystems, will need to be reserved to meet the Adequacy criterion of a CAR reserve system.

2.2. **Priority areas for reserve expansion urgently need to be identified.**
This is critical for several reasons. First, forests presently being targeted for logging under the Timber Release Plan have very high conservation value for the 70 species of threatened forest-dependent taxa in Victoria [33]. This means that further logging will have substantial negative impacts on threatened forest-dependent fauna. Second, the forests outside the existing reserve system are highly fragmented and further logging will only serve to significantly exacerbate this problem. As an example, [33] found that for the Wet and Damp Forests EVCs, the median distance for a random point inside the dedicated reserve network to a human disturbance boundary was 1700 metres. In comparison, the median distances to a boundary for informal protected areas outside the formal reserve system was 71 metres. For the Dry Forest group of EVCs, the median distance was 1232 metres for a random point inside the formal protected area network to a boundary. The equivalent median distance across the informal protected area network was 180 metres [33].

2.3. **The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative**.
The RFAs should not be re-signed until these maps of the CAR reserve system have been created and then reviewed by scientists with expertise in reserve design and the identification of robust networks of protected areas. Australia has several of the world's leading exponents of reserve design science and their expertise should be sought on this important matter.

2.4. **Key areas for inclusion in the reserve system should include those where there are high levels of resource conflict.**
Obvious areas for immediate forest reservation are water catchments where water

production values are high and impacts of logging on water yield are also high. The Thomson catchment is a clear example [33]. Other areas that are important for reservation include places where forest landscapes are relatively intact (e.g. the south face of Mt Baw Baw).

2.5. **Allied with reserve expansion, there is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans.**
All of these plans must be based on robust, peer-reviewed science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management.

2.6. **Protect areas of regrowth forest that will most rapidly become the next old growth forest.**
Some forest ecosystems have been so heavily and repeatedly disturbed that they support almost no old growth forest. This is a breach of the JANIS criteria. Urgent action is needed on a pathway for restoring old growth forest. For example, all areas of 1939 aged montane ash forest need to be protected in the Central Highlands of Victoria. This is because regrowth forests of this age are typically the oldest current cohort (outside of existing old growth) (and are therefore where the least time will be needed until those forests become old growth). In addition, reservation of all existing areas of 1939 aged forest is essential to meet future targets of 30% of the landscape as old growth forest [34]. Notably, this recommendation is congruent with the May 2019 recommendation of the Threatened Species Scientific Committee, that logging in the montane ash forests of the Central Highlands of Victoria should cease.

2.7. **There should be no once-only logging of currently intact forest before it is brought into an expanded reserve system.**

2.8. **An expanded reserve system must be well managed (with adequate resourcing) and subject to rigorous monitoring of key targeted entities (e.g. measures of forest condition, key species, and key ecological processes).**
Many reserve systems globally are chronically underfunded [35], despite their large economic benefits, including in Victoria [36]. The history of monitoring of reserves is poor and these deficiencies need to be rectified. Some of the entities targeted for monitoring should include variables that are also measured (in the same) off-reserve areas to facilitate cross-tenure comparisons in key forest metrics. The management of an expanded reserve system should include (among others): **(a)** the control of feral animals (e.g. deer) and weeds (e.g. blackberry in key areas subject to past logging operations), **(b)** debuilding of some parts of the road network (as roads can facilitate access to forested areas by foxes and cats and can be sites for arson (see [37, 38]), and, **(c)** the regeneration of failed logging coupes (including locations now in reserves but which were subject to once-only logging before being gazetted as protected areas).

2.9. **The multiple economic and other values of reserve systems need to be further quantified.**
Considerable effort has been dedicated to qualifying the economic values of reserve systems in Victoria [36]. The contribution to regional and State economies of an expanded reserve system should be further documented as part of building the case for greater levels of resourcing to improve the management of the protected area estate.

2.10. **The impacts of an expanded reserve system on sustained yields of timber must be quantified.**
An expanded reserve system will remove substantial parts of the wood production forest from harvest schedules. This underscores the need for a rapid transition to plantations as the

source of timber for the forest industry. Importantly, the plantation resource has a high degree of certainty for the forest industry.

3. Active management of forests

Some kind of active management will be required in all forests (and some plantations).

3.1. **Intensification of forestry operations in the native forest estate is inappropriate.**
High levels of intensification, such as through recurrent thinning are tantamount to a conversion of native forests to *de facto* plantations. This will have a wide range of negative environmental impacts and generate few benefits, including limited economic benefits. Plantations are already extensive across many parts of Victoria and are the places where intensive forestry operations are appropriate. Australia currently derives 85% of wood product value from plantations which occupy only 14% of land designated as wood production areas. Native forestry accounts for 86% of land but produces less than 15% of wood product value.

3.2. **Variable retention harvesting has fewer negative environmental effects relative to conventional clearfelling [39, 40]. However, it is inappropriate for application in some key forest types because of the current extent of human and natural disturbance.**
The extent of past logging, the amount of forest burned, the rapid decline in biodiversity, and other problems in forest types (such as those dominated by Mountain Ash and Alpine Ash) indicate they should not be subject to any more logging (using any harvesting method) [41]. This is entirely consistent with recommendations of the Threatened Species Scientific Committee that, to enhance the conservation of the Critically Endangered Leadbeater's Possum, there should be no further logging in the montane ash forests of the Central Highlands of Victoria. For example, all remaining areas of unlogged, unburned 1939-aged montane ash forest need to be excluded from harvesting because it is the next nearest old growth forest that must be set aside to grow through to ecological maturity [34, 42].

3.3. **A fundamental part of informed active management must include a recalculation of plausible and truly ecologically sustainable sustained yields of timber and pulpwood.**
It is well understood and widely recognized that sustained yields in Victoria forests have been set at levels that were (and still are) too high. More realistic and ecologically appropriate harvest levels need to be calculated. These calculations need to accommodate: **(a)** the impacts of fire on resources, including how climate change will increase fire frequency and reduce the inter-fire interval. Altered fire regimes will have major impacts on the probability of trees reaching a suitable age to be sawlogs (Cary et al., in review). And, **(b)** the need for a significantly expanded CAR reserve system.

3.4. **Active management should entail the direct expansion of the CAR reserve system.**
The CAR reserve system is currently inadequate in Victoria and a substantial expansion is required [33].

3.5. **A key part of active management is the removal or mitigation of some key stressors from forest ecosystems**.
Logging is a key stressor in some ecosystems, such as those dominated by montane ash forests [34, 43, 44]. Active management should therefore include the removal of logging from those ecosystems.

3.6. **Active management of any forests that continue to be broadly designated for wood production must include the establishment of a strengthened network of buffers and other measures to protect key natural assets.**
Buffers of unlogged forests should be implemented to protect all existing large old trees [45, 46] as well as other key biodiversity micro-hotspots such as patches of old growth forest and rocky outcrops. The size of buffers should be guided by an understanding of microclimate changes associated with disturbances such as logging (including the risks of windthrow) [42, 47]. Buffers to protect streamside areas may also need to be widened. This is because such places are where key natural assets like large old trees are most likely to occur [47]. Key natural assets that may need protection include areas that will be climate refuges under rapid climate change. Identifying where such refuges occur can demand detailed research (such as occurred in establishing the importance of old growth as refugia for climate change sensitive birds in western North America) [48].

3.7. **Active management should entail invasive animal and plant control.**
Invasive species have had substantial negative impacts on Australian biota and ecosystems. There are emerging invasive species issues in some forest ecosystems (e.g. sambar deer) as well as established long-term problems in these same system (e.g. cats, foxes and blackberry). There may also be interactions between invasive species and other drivers such as disturbance (e.g. increased foraging by feral predators in burned areas [49]) and deer browsing effects in areas of post-logging regeneration.

3.8. **Consider the ecological effectiveness and cost-effectiveness of highly interventionist actions such as the establishment of nest boxes and translocation of animals.**
Some actions are costly but can have significant benefits. For example, populations of some threatened species have been recovered through the establishment of nest boxes and other kinds of artificial nest sites. Chainsawing trees to create artificial hollows can provide forest-based employment options. However, it makes little sense to engage in such programs whilst the initial source of the problem (e.g. cutting down existing and potential nest trees) is continuing. In addition, there can be some negative impacts of establishing nest boxes, such as altering breeding and nesting behaviour [50], and homogenizing biotic communities (e.g. bats [51]). Other programs such as reintroductions and translocations of threatened species can be effective, although they are expensive and high risk [52-54]. A risk management framework is useful to guide these projects in terms of the factors which can influence their success [55]. These kinds of projects are often best implemented as experiments to maximize learning and assessment of effectiveness [53, 54].

3.9. **Debuild part of the road and track network.**
Roads can have a range of positive and negative effects [56, 57]. They provide access to areas to fight fires and to undertake activities like feral animal control. They also provide recreational opportunities. At the same time, they can be conduits for invasive plants and invasive animals. They also can lead to human access and subsequent arson attacks. Arsonists are more likely to light fires in easily accessible areas, close to roads and populated areas [37], and a greater distance from both urban areas and roads is associated with a decrease in the number of wildfires [38]. Roads can fragment forest landscapes and are known to act as barriers to movement of some species. The Victorian State of the Forests report has acknowledged that some forest types are very heavily fragmented by roads [9]. Removal of

some roads and tracks can be important for promoting a range of conservation outcomes in natural forests, particularly those where there is already an extensive network of roads [58].

3.10. **Assess the effectiveness of active forest management practices.**
The efficacy of some management interventions is poorly known, both in terms of ecological effectiveness and cost effectiveness. They need to be subject to rigorous monitoring and in some cases be targeted for Adaptive Management studies. The costs of conducting such work can be reduced where it is built on existing management practices. Assessments of the effectiveness of management interventions require that data are gathered on what actions were conducted where, when and how. Record keeping of this kind has not always been exemplary in the past, but it is essential for determining what actions have worked, what have not, and therefore what changes are required to achieve better management outcomes [59].

3.11. **Data that are gathered as part of active management as well as Adaptive Management and other kinds of monitoring should be collected in ways that allow it to be readily incorporated into standard accounting frameworks.**
These frameworks include the SEEA accounting framework developed by the United Nations and already employed for some forest types in the Central Highlands RFA region [1, 2].

3.12. **Review documents such as *Plantations for Australia: The 2020 Vision* to update the vision for the coming 20 years, and to ensure the continuing transition to a plantation-based wood products sector is well planned rather than precipitated by industry collapse.**

4. Adaptive management

4.1. **Develop an agreed definition of AM within and across appropriate agencies (including Parks Victoria) for the purposes of forest management.**

4.2. **Conduct a Statewide audit of, and spatial mapping exercise for, existing monitoring programs and long-term studies (within and outside government).**
This is an important step because rigorous monitoring, particularly question-driven monitoring [59], is an essential ingredient for AM. This would aim to document existing long-term studies (see Youngentob, et al. [60] for an example) and determine which ones might be best brought into an AM framework to fill gaps in existing government monitoring capability. Allied to this recommendation is the need to seek ways to significantly increase the quality of, and resources for, forest monitoring in Victorian forests (including forests in reserves) as well as monitoring of parts of the plantation estate (both hardwoods and softwoods). This includes exploring ways to strengthen existing monitoring initiatives such as the Victorian Forest Management Plan – a process of Adaptive Monitoring. A key part of strengthening monitoring programs must be to identify trigger points for action, so that timely interventions can be made if circumstances change (e.g. populations of a forest-dependent species begin to undergo a rapid decline) [61].

4.3. **Identify the ecosystems, species, processes and/or other entities that are best targeted for AM**.
True AM is hard to do and it is important to acknowledge that not all things can be managed and monitored using an AM framework. It is therefore appropriate to prioritize which entities are sufficiently important to warrant being part of AM. Notably, the costs and logistical inputs

required for AM can be reduced by piggy-backing AM programs on existing resource management activities and management interventions [62]. For example, the costs of the Variable Retention Harvesting experiment in Mountain Ash forests were curtailed by building it on the existing harvesting schedule.

4.4. **For those entities that are targeted for AM studies and are therefore part of monitoring programs (and where they are appropriate), ensure that AM activities occur across tenures (e.g. in reserves and off-reserve areas).**
This can be important for cross-tenure contrasts in, for example, aspects of forest condition, landscape pattern (such as road length and density), the prevalence of invasive species, and assessments of the effectiveness of particular management actions. This will demand the identification of a harmonized set of metrics measured across tenures.

4.5. **There is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans and ensure they are properly monitored, preferably within an Adaptive Management framework.**
All of these plans must be based on robust, peer-reviewed science and the monitoring must also be underpinned by robust science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management.

4.6. **Find ways to cut lag times in management responses to new knowledge. Adaptive Management generates new insights and understanding about, for example, resource management and biodiversity conservation.**
The time between new knowledge acquisition and modified on-the-ground management can be prolonged (sometimes exceeding years and even decades). A range of institutional and other actions can facilitate knowledge transfer [63, 64]. As an example, the Threatened Species Recovery Hub of the Australian Government's National Environmental Science Program has developed a targeted knowledge brokering program to facilitate knowledge exchange. This has an explicit remit of reducing lag times for knowledge adoption in enhanced policy.

4.7. **Agitate for more of the scientific community to engage in AM in Victorian forests**.
Too few scientists have partnered with State Government agencies to participate in AM studies. More engagement on the part of the scientific community is needed to create a greater body of targeted work and foster greater efficiency in the delivery of quality AM studies. The Government of Victoria might explore approaches to incentivize greater participation in AM studies by the scientific community.

4.8. **Develop rules of thumb for adequate resourcing of monitoring within given programs.**
Monitoring is nearly always the last activity funded and the first one cut in government and other programs. A more robust approach is needed to set aside suitable levels of resources to fund monitoring at the outset of the instigation of a program. A general rule of thumb is that 10% of the budget for an environmental initiative should be dedicated to supporting monitoring [59, 65], although this is, of course, context dependent.

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Recommendations for Forest Management and Plantations Relevant to the Regional Forest Agreements in Victoria

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Cover photo: A logging coupe near Matlock in Alpine Ash forest in the Victorian Central Highlands, 30 July 2019. (Photo by C. Taylor)

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Executive summary

This document contains brief recommendations for tackling some of the key issues associated with a science-based approach to the modernisation of the Regional Forest Agreements (RFAs) in Victoria. It addresses four key topics:

- **The importance of plantations and the need to transition the forest industry into a plantation-only industry.**
  Such a transition will result in a move toward managing natural assets for the best and highest value. That is, plantations for timber production, and native forests for water, carbon and tourism. A transition to a plantation-only industry is especially important for providing resource security for the forest industry. This is because recurrent wildfire, past overcutting, conflict over water security, other environmental conflicts, as well as declining social licence, will all further undermine resource security from native forests. Thus, a transition to plantation-only forest industry will be critical to address key issues associated not only with timber security but also with water security and the enhanced conservation of forest biodiversity. It is best if this is a planned transition rather than one based on the rapid collapse in the native forest sector. There are valuable lessons on forest industry transitions from other parts of Australia (and overseas) as well as transitions in other industries nationally and globally. Much can be gained from examining these transitions to produce the best possible outcomes for the Victorian economy and Victorian regional communities. There are well identified approaches for best practice plantation establishment and management, and Victoria should look toward the implementation of these practices so that plantations can work toward Forest Stewardship Council (FSC) certification.

- **The urgent need to significantly expand the Comprehensive Adequate and Representative (CAR) reserve system.**
  The current protected area network is deficient, especially around the Adequacy component of the CAR principles. Expansion of the reserve system will also be important to increase its resilience to climate change. Allied with reserve expansion, there is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans – with all of these plans based on robust, peer-reviewed science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management. The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative. The RFAs should not be re-signed until these maps of the CAR reserve system have been created. A part of an commitment to an expanded CAR reserve system, the Government of Victoria must undertake a thorough re-assessment of sustained yields from native forests that take into account: **(a)** the risks of recurrent future wildfire; **(b)** the extent of past disturbance (both fire and logging) in the existing forest estate; **(c)** the need to exclude timber harvesting from water catchments because of negative effects on water security for Melbourne (and regional centres north of the Divide); and **(d)** the conservation of threatened forest-dependent species.

- **The need for active management of forests.**
  Some key forms of active management of native forests are currently needed, such as the control of invasive plants and animals. In addition, if Victoria were to embrace carbon markets (and native forests are managed as major and secure long-term stores of carbon), then active management of that carbon stock will be required, including enhanced fire-fighting, and the control of populations of exotic herbivores that can affect forests (e.g. sambar deer, which

damage young regenerating forests). There may also be a need for changes in institutional arrangements, such as restructuring VicForests to become a new body (e.g. VicCarbon).

- **The need for more robust forest monitoring programs, including better monitoring to underpin Adaptive Management programs.**
  A greater commitment to monitoring will provide greater insights into what management interventions are (and are not) effective and provide the best returns on investments in resource management.

Introduction

This document contains recommendations for tackling some of the key issues associated with a science-based and an economics-based approach to the modernization of the RFAs in Victoria. Some of the material in this report expands upon topics and perspectives that were only partially addressed in chapters of the Scientific Advisory Panel RFA report. There is repetition in some themes between sections of this report. This is deliberate, as some readers may elect to focus only on particular sections.

An important caveat is that the recommendations made in this report are not exhaustive, nor is the supporting literature always cited to support the recommendations. The report is relatively brief and somewhat skewed toward issues associated with plantations. This is because the native forest sector: (a) is largely producing low value product, (b) suffering from low levels of investment, (c) characterized by shrinking levels of employment, (d) subject to high levels of resource conflict (e.g. between water and wood), and (e) characterized by low levels of community support.

The range of reasons for the focus on plantations is further outlined below.

- The plantation sector dominates the forest industry in Victoria, in terms of volumes of sawn timber, eucalypt pulplogs, employment, and economic value and returns [1-3].
- The RFAs are agnostic in terms of where wood is sourced to support the forest industry.
- Despite plantations providing over 85% of net value of the overall forest industry in Australia, they use only 14% of the area currently managed for forestry in the nation.
- **The Victorian Government should embrace a policy of best and highest value for natural assets.** Environmental and economic accounting work has shown that the best and highest value for plantations is timber production. Plantations can produce up to 14 times the wood volume per ha relative to native forests [4]. The best and highest value for Victoria's native forests for is water production, tourism, and carbon [1, 2]. Global analyses indicate that native forests are six times better than agroforestry and 40 times better than plantations at storing carbon [5]. There are likely to be significant job opportunities associated with managing native forests for carbon storage and increased tourism. There are also important opportunities for increased employment in the plantation sector if steps are taken to process more plantation wood within Victoria (see [3]). In-State processing meets with the aims of value-adding in the plantation sector.
- There is only limited social licence to continue widespread native forest logging [3]. Recent surveys by the Victorian Government indicate a strong desire on the part of the general public to protect native forests from timber harvesting [6].
- There are rapidly declining sawlog resources in native forests. This is a result of past overcutting due to efforts to maximise sustained yields, with levels being set at unsustainably high levels due to Woodstock and Stanley resource modelling failing to account for the effects of disturbances (such as recurrent wildfires) in sustained yield calculations [7].
- Past fires, high risks of repeated fire in the future, past overcutting, increasing environmental concerns (such as biodiversity conservation and water supply), and declining community support all strongly indicate there is little certainty for long-term access to timber from native forests. The only real certainty of future timber supply for the forest industry will come from plantations.

- The native forest sector is overwhelmingly dominated by the production of pulpwood and woodchips. More than 87% of the native forest harvested in Victoria is used for woodchips, pulp and paper.
- The large volumes of eucalypt plantation pulpwood could substitute for the native forest pulpwood that clearly dominates the wood derived from the native forest sector [8].
- The economic value of non-timber assets from native forests, such as water and carbon storage, are far higher than the timber and pulpwood values [1, 2]. This reinforces the increasing need to source timber from the plantation estate.
- There are high levels of resource conflict between water production and logging in water catchments and these conflicts will only be further magnified under climate change [9]. Again, this highlights a need to find alternative sources of feedstock to those from native forests to support processors such as Australian Paper.
- It has long been recognized that native forest logging has significant negative effects on water yield. This directly affects the security of the water supply for Melbourne [10-12] as well as rivers north of the divide which flow to the Murray catchment. Increasing challenges with water yield from water catchments in the face of climate change and fire, indicate an urgent need to remove logging from key catchments such as the Thomson catchment [9]. The first Legislative Supply Agreement for the provision of pulpwood was passed in 1936 and it required the exclusion of logging from the Thomson Catchment upon its designation as a catchment by 1967 [13]. However, a revision of this Agreement in 1961 removed this requirement, thereby committing the Thomson Catchment to supply pulplogs under successive Legislative Supply Agreements [14]. Ongoing logging of the Thomson catchment has major impacts on water yield, currently equivalent to water for 250 000 people (at 161 litres consumed per person per day) but set to rise to water for 600 000 people by 2060 [9].
- Recent water accounting research has indicated that the costs of the shortfall in water lost through logging of the Thomson Catchment is substantial; an estimated $1650 per MegaLitre [ML] (in 2017 dollars) [15]. Removing logging from water catchments will reduce the costs of supplying water to the people of Melbourne and communities north of the Great Divide.
- Montane ash is disproportionately represented in the native forest wood product volumes generated from the Central Highlands RFA region of Victoria. However, key elements of biodiversity such as the Critically Endangered Leadbeater's Possum are undergoing significant decline in montane ash forests [16, 17]. Conservation advice from the Australian Government's Threatened Species Scientific Committee recommended the cessation of logging of montane ash forests to increase the chance of persistence of the species. Of the montane ash forests, the Mountain Ash forest ecosystem is the most widespread and is currently subject to extensive clearfell logging. This ecosystem is classified as Critically Endangered under the International Union for the Conservation of Nature (IUCN) Red Listed Ecosystems criteria, and further logging may lead to ecosystem collapse [18]. These forests are located in the Forest Agreement Area that supplies the majority of native forest pulp logs allocated to Australian Paper under the *Forests (Wood Pulp Agreement) Act 1996*. Alternative sources of feedstock are therefore needed for processors including Australian Paper.
- Recent work based on species distribution models for 70 threatened forest-dependent species in Victoria suggests that the current reserve network does not meet Comprehensive Adequate and Representative (CAR) criteria [19]. The CAR reserve system therefore needs to

be expanded, particularly to meet the Adequacy criterion [19]. This further underscores the need to meet timber demands from plantations.

- Recent work has modelled relationships between climate change-driven increases in fire frequency and rotation times in wood production ash-type forests. The results of the modelling suggest a low likelihood of trees being able to reach an age where they can produce sawlogs (Cary et al., unpublished data). This is due to a contraction in fire return intervals (Cary et al., unpublished data). Plantation tree crops, harvested with shorter rotation lengths, have greater likelihood of successfully meeting timber demands than native forests. Moreover, other simulation modelling of some plantations suggests they may experience longer intervals between fire in the future, even accounting for future shortening of intervals across all forest types [20].
- Several studies led by different research groups have shown that ongoing native forest logging in native forests will increase the fire proneness of these forests, thereby adding significantly to the fire burden in these areas (and for adjacent human communities) for many decades to come [21, 22].

Beyond some discussion of plantation issues and their implications for RFAs, some commentary is also provided on the need for an expanded reserve system, Active Management of native forests, aspects of true Adaptive Management of native forests, and the importance of a much increased focus on robust monitoring programs across multiple tenures.

Additional key points

Finally, a number of other issues are raised below that were not examined by the RFA Scientific Advisory Panel committee and do not fit readily into the themes in this report. They are, however, important in the context of the modernization of RFAs.

1. **There is a need to resist the push for RFAs to be rolling agreements. Rolling agreements would be poor policy and not based on robust science.** This is because rolling agreements ignore the high level of uncertainty associated with native forest management, particularly with respect to: (a) the impacts of recurrent fire on depleting sawlog resources (Cary et al., unpublished data); (b) the effects of climate change on many key aspects of forest condition and ecological integrity, including the risks of forest ecosystem collapse [16]; (c) the combined effects of ongoing logging and climate change on water security for Melbourne and regional centres north of the Divide [9]; (d) the need to respond to the conservation needs of many elements of forest biodiversity including those that are currently undergoing rapid decline; and (e) the changing philosophical perspectives of the Victorian population reflecting the fact that ongoing native forest logging has limited social licence [3]. It is critical that the Government of Victoria retains the flexibility to make informed choices about the best and highest value of forest and plantation resources. Locking in rolling agreements eliminates that flexibility.

2. **There is a need to implement a more widespread effort around developing environmental and economic accounting of natural assets, including water, carbon, tourism, plantation timber and native forest timber.** Accounts provide a strong basis for rational decision making, particularly with respect to identifying which uses of natural assets generate the best and highest returns for Victoria [1, 2].

3. **There is a need for the Government of Victoria to meet is legal mandate to properly develop and effectively deliver key planning documents.** These include Action Statements,

Recovery Plans and Management Plans. These plans must be based on the best available and highest quality robust science. These plans also must be appropriately resourced and effectively implemented with regular reviews of progress (typically every 3 years). These plans will be effective only if they are linked to robust monitoring and, where possible, underpinned by true Adaptive Management (see section #4 of this report).

4. **There is a critical need for a far more responsive approach to RFAs. Environmental conditions are changing rapidly, as are forest resources and biodiversity.** Five-year reviews are too infrequent given the rate of environmental change. RFAs need to be reviewed on a 3-year basis or immediately after major disturbance events such as large-scale wildfires, drought, and the uplisting of key elements of biodiversity. This means that RFAs must have inbuilt triggers for action when major disturbance events occur and/or new problems are identified. The RFAs also need to have mechanisms for review when their objectives are not being met (such as ongoing declines in employment [3] or lack of industry profitability [23]).

5. **There is no scientifically rationale basis for RFAs to continue to overrule the EPBC Act on key matters of environmental importance.** The declines of some Critically Endangered forest-dependent species, in part as a result of ongoing logging operations, highlight the inherent problems with RFAs in regard to creating adequate conservation outcomes [24]. Indeed, the failings of RFAs and the Environmental Protection and Biodiversity Conservation (EPBC) Act highlight the importance of State-level legislation such as the Flora and Fauna Guarantee Act (should it be enacted appropriately). This also underscores the importance of complementarity between Federal and State Government legislation.

6. **There is a need to assess the relatively limited to the benefits of ongoing native forest harvesting relative to the high costs of adequate management, robust monitoring and other costs like the threat to water security resulting from the operation of RFAs in native forests.** This is again linked to the concept of best and highest value from natural assets. It is also connected with major (but presently missed), employment and other opportunities to: (a) value-add in the plantation sector; (b) build a vibrant jobs-rich forest-based tourism sector; (c) to create a carbon storage sector in native forests (with associated employment opportunities); and (d) reduce the costs associated with water production, especially through limiting the need for desalinated water.

1. Plantations

In a nutshell

The Victorian Government is to be commended for efforts to increase investment in plantations.

Despite plantations providing over 85% of net value of the overall forest industry in Australia, they use only 14% of the area currently managed for forestry in the nation.

Plantations dominate the forest industry in Victoria in terms of volumes of sawlogs, sawn timber, pulpwood, employment, and economic value.

The Government of Victoria should embrace a policy of best and highest value for natural assets. Environmental and economic accounting work has shown that the best and highest value for plantations is timber production. The best and highest value of native forests is water, tourism and potentially also carbon.

The vast majority of output from native forests is pulpwood and woodchips, both of which can be substituted by feedstock from plantations.

Wood supply from plantations has a high degree of certainty for industry, whereas wood supply from native forests does not (because of past human and natural disturbance, the high probability of future disturbance, the environmental impacts of native forest logging, and other factors like the low level of support from the community for continued native forest logging).

It is critical to overcome impediments for in-State processing of wood from the plantation sector. This will boost value-adding of that wood and be positive for growth in employment in the plantation sector.

There is a need for a well-managed and planned transition to a plantation-only wood production sector. Key lessons can be learned from transitions in forest industries that have made this change elsewhere (e.g. New Zealand) as well as from transitions in other industries nationally and globally.

The RFAs are agnostic in terms of the source of timber and pulpwood for use by the forest industry. Significant volumes of timber in Victoria are already derived from plantations and log volumes from native forests are falling. To compensate for the latter, the proportion of the forest industry that is based on plantations is likely to further increase over time. This is reflected in the significantly greater economic value of the plantation sector versus the native forest sector at a national level. Accounts produced by the Australian Bureau of Statistics on native and plantation timber resources for the whole of Australia, reported a net value of $11.6 billion in 2016–17. Of this, $9.9 billion was for plantation timber and $1.7 billion was native timber. Despite plantations providing over 85% of net value, they use only 14% of the area currently managed for forestry in Australia.

The importance of plantations in the forestry sector was recognised back in 1997 with the ‘Plantations for Australia: The 2020 Vision’ with an aim of trebling the national plantation estate.

Tree plantations can be broadly defined as:

> *Stands of trees of native or exotic species that are specifically created by the regular placement of cuttings, seedlings, or seed through human management. Tree plantations are managed for an economic purpose that may include the extraction of timber or timber-related products or the sequestration of carbon for future economic benefit. Plantations are typically comprised of one or a few fast-growing exotic tree species in even-aged and evenly spaced stands [25].*

Plantations can have a number of key benefits. These include: **(a)** generating large volumes of timber per unit area (up to 14 times the volume of wood per ha relative to native forests [4]), **(b)** storing significant amounts of carbon [26] although markedly less than native forests (see [5]), **(c)** providing an offset for enhanced conservation in one area through intensified production in another [27, 28], and **(d)** providing habitat for wildlife [29, 30].

Plantations can produce large amounts of timber from a relatively small area, with that timber generating less Greenhouse Gas emissions than timber cut from logging native forests. This has the additional benefit of conserving native forests for other key values such as long-term carbon storage and long-term water production [9, 31]. Indeed, with rapid changes in climate, the importance of secure long-term stores of carbon in native forests will likely increase significantly and hence sourcing wood products from plantations will be increasingly important [31].

There can be disadvantages of plantations such as removing habitat for native species, replacing key vegetation communities (such as grasslands or native forest), acting as a source of invasive species, displacing native biota, impairing water yields relative to cleared agricultural land, increasing levels of pesticide and herbicide use, and promoting fire risks (reviewed by [32]).

Data from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Plantation and Log Supply inventory report update (2019) show Victoria has the largest total area of forest plantations in Australia, with 420 600 hectares of commercial hardwood and softwood plantations in 2017–18. The area of pine plantations has remained consistent over 20 years, while hardwood plantations increased for a decade then declined slowly for the last decade (mainly due to the introduction, then failure of the Howard-era Managed Investment Schemes). The land area of Victoria is 22 744 400 ha [33]. The total plantation area in Victoria equates to 1.8% of its land area. By comparison, the area allocated to VicForests for wood production from native forests is 1 820 000 ha, equating to 8% of the area of Victoria.

The forest industry in Victoria is dominated by the plantation sector in terms of sawn timber, pulp logs, and overall employment. Eighty-eight per cent of all sawn timber in Victoria comes from the plantation estate [34]. Compared to even the most productive native forest region of Victoria – the Central Highlands RFA – the value-added value of the plantation sector is approximately three times that of the native forest sector [2].

The expansion of the Victorian hardwood plantation estate has resulted in significant growth in hardwood pulplog production, increasing from 76 500m^3 in 2001 to 3 900 000 m^3 in 2017 [34]. Most of this is exported as low value unprocessed product. Indeed, of the 3.9 m tonnes of hardwood eucalypt pulp logs produced in Victoria, 2.9 m tonnes was shipped out of state [34]. Schirmer, Mylek, Magnusson, Yabsley and Morison [3] suggest that such exports are leading to a major loss of processing jobs in Victoria. The injection of $110m in 2017-18 by the Victorian Government into hardwood plantation establishment in the Latrobe Valley is a welcome initiative given that new plantation establishment stalled in 2003, with few new plantations established since then. However, concerns remain over the slow pace at which trees are actually being planted.

There is considerable potential for the replacement of wood cut from native forests with plantation timber. Most of the wood harvested from Victorian native forests (87%) goes into the pulp and paper stream [32], including for paper manufacturing by Australian Paper. The potential for substitution of native forest timber by plantation timber has been extensively researched [8, 35, 36].

It is feasible to replace native forest wood for Australian Paper with plantation feedstock. A transition to 100% plantation wood for the Australian Paper Maryvale mills would require around 600 000 m^3 of native forest pulplogs to be replaced by hardwood plantation pulplogs to maintain current production capacity. Given the extent of Victoria's hardwood plantation estate and the

volume of eucalypt pulpwood logs that are produced, this transition has been deemed technically feasible for nearly a decade [8]. The recent announcement of $110m of funding for expansion of the plantation estate would assist with this transition. The previous owner of Maryvale Mill (in 2008, PaperlinX Ltd) publicly announced that it would phase out its procurement of native forest pulp logs by 2017. This transition never happened.

Much of the replacement hardwood plantation pulplog supply could currently be sourced from the Green Triangle region, where a comparatively small fraction of the pulplogs destined for export markets could be redirected to the Maryvale Mills for domestic processing. As more hardwood plantations are established in the Latrobe Valley, sourcing of pulp volume from this feedstock could occur. Potential options for redirection may reside with the Nippon Paper Group itself –in 2016, the Group exported 581 280 tonnes of woodchips from Australia, much of it sourced from plantations, including those in Victoria.

As the majority of hardwood plantation tree species to replace the native forest input to the Maryvale Mills would consist of Tasmanian Bluegum, there are increased processing benefits for a transition to hardwood plantations. Tasmanian Bluegum has a higher basic density (kg dry fibre/m^3) compared with the native forest ash species, which gives the pulplogs more 'dry tonnes' of weight (kg) per cubic metre of wood [8].

Recommendations

It is well understood that some of the recommendations made below have already been implemented. There are, however, some suggestions that are new (at least in part) within the context of plantation establishment and design in a Victorian context.

1.1. **The Victorian Government should embrace a policy of best and highest value for natural assets.** Environmental and economic accounting work has shown that the best and highest value for plantations is timber production. The best and highest value for Victoria's native forests is water production, tourism, and carbon [1, 2].

1.2. **Review and update the Plantations 2020 Vision to establish an up-to-date and well-articulated vision for the size of the plantation industry that is desired.** This should include a horizon-scanning process (*sensu* [37]) to explore potential future demand over medium to long-term timeframes (e.g. 15-40 years) as well as possible disruptions to plantation industry development. The review would examine the size and location of plantation resources at regional and national scales to determine potential domestic and international markets, linking this to options for value added processing to reduce the levels of raw product (logs) or low value products (chips and pulp) being exported from Victoria. The Plantations 2020 Vision prioritised those aims as a way of decreasing trade deficits. Due to the time lag between plantation establishment and harvest, it is critical such reviews and actions are conducted rapidly. Victoria has established few new plantations since 2003. Such review processes are undertaken routinely in other resource-based industries such as mining.

1.3. **Complete a thorough stocktake of the existing plantation estate in Victoria, coupled with land capability mapping of suitability for plantation expansion (including different types of plantation with different end products).** It has long been understood there are substantial areas of south-eastern Australia suitable for plantation establishment (e.g. [38]) and it is assumed suitable areas were identified in the Latrobe Valley prior to the 2017 Victorian Government budget announcement of $110m for plantation establishment. The implications of climate change for the suitability of plantation establishment and subsequent tree growth need to be quantified.

1.4. **Identify approaches to overcome financial and social disincentives to establish new plantations.** This includes reviewing case studies and experience from other jurisdictions in Australia (e.g. southern NSW; see Stanley, 2006) as well as those places overseas with dynamic plantation sectors (e.g. New Zealand). Unfortunately, Managed Investment Schemes did significant damage to the long term expansion of the plantation sector, and the goal of the Plantations 2020 Vision of establishing 3m ha was not reached (in 2017/2018 Australia supported 1.94m ha of plantations) [39]. The financing of wood production in Victoria needs to be reviewed to find incentives for the plantation industry, some of which may be achieved through a more 'level playing field' between the plantation and native forest sectors, such as would come through reviewing the *Forests (Wood Pulp Agreement) Act 1996* (among other policies and subsidies).

1.5. **Seek approaches to overcome disincentives to processing eucalypt plantation feedstock within Victoria.** The vast majority of eucalypt plantation timber is exported, and thus processing jobs are also sent off-shore [3]. The Plantations 2020 Vision called for additional local processing with the goal of turning the trade deficit around to a net surplus in this sector. Examination of transport and other impediments to in-State processing of plantation timber is urgently required.

1.6. **Quantify the carbon, water, tourism, employment and biodiversity benefits as well as the general economic benefits of a rapid transition out of native forest logging and into plantations.** Environmental and Economic Accounting using the United Nations SEEA Framework [40] has quantified the trade-offs involved in ceasing native forest harvesting in the Central Highlands RFA area [1, 2]. The economic gains from ceasing native forest harvesting are substantial [1, 2] and are likely to be even larger at a Statewide level given that native forest logging operations in areas such as East Gippsland have been uneconomic for some time [23]. Notably, the State of the Forests report indicated a need to adopt accounting practices more broadly – including environmental and economic accounting for carbon in forests [41].

1.7. **Develop key insights from examining other industry transitions. There have been rapid transitions in resource-based industries worldwide.** Case studies of the economic and social benefits of these transitions have been well documented (e.g. [42]). Important lessons for Victoria can be learned from these transitions. For example, a rapid transition to a plantation-only forest industry in New Zealand has proved to be successful in terms of industry growth and conservation benefits. Experience from other industries (such as the restructuring of the cod industry in Norway versus the collapse of the fishery that occurred in maritime Canada) highlight the benefits of early intervention and a rapid reset of harvest levels to limit negative social and economic impacts [43]. Again, there are potentially important lessons for industry transition, the creation of new employment opportunities, and approaches to creating an appropriate social safety net for workers.

1.8. **Prepare appropriate institutional and other arrangements associated with a rapid transition to a plantation-based economy for wood production in Victoria.** If wood production in Victoria is to be extensively based around plantation forests and native forests are to become key to carbon storage (and water production), then the institutional arrangements for bodies such as VicForests will need to be considered. One option is to re-purpose the function of that agency to become a carbon manager (and rebadge that entity; e.g. as "VicCarbon"). VicCarbon would then have responsibility for the management of a valuable carbon asset and, accordingly, seek ways to maintain and build that asset. Activities may include (among others) fire suppression, control of invasive species that can affect forest growth (such as sambar

deer), fully restoring areas of forest where there has been regeneration failure, and debuilding parts of the currently very extensive road and track network (covering many thousands of kilometres; see [44]) where tree growth is impaired [45]. Of course, development of appropriate carbon methodologies will be central to realizing the economic benefits of carbon storage both from the conservation of native forests and the expansion of the tree plantation estate.

1.9. **Ensure that the range of values of plantations are appropriately examined and accounted for.** Plantations can be important for the sustainable intensification of wood production that provides offsets for enhanced conservation elsewhere [46-48]. Plantations also can store large amounts of carbon [26, 49]. Greenhouse Gas emissions from the land sector can be reduced when wood products are sourced from plantations rather than native forests [31]. Past work on plantations has suggested that ecological and social problems arise when land management is driven by too narrow a set of values [32]. One approach to enhance assessments of some of the range of values of plantations is to ensure they are included in environmental accounting (e.g. [1, 2]).

1.10. **Develop prescriptions for best practice plantation establishment and management (with the objective of gaining FSC certification)**. There is a well-developed science around plantation establishment and design derived from empirical work in plantations elsewhere, such as in NSW [29, 50]. Issues include ensuring that key habitats like native grasslands are not destroyed through plantation establishment, patches of significant remnant vegetation (e.g. Grass Box-gum woodland) are not incorporated within the boundaries of plantation rather than cleared, and streamside areas are restored with native riparian vegetation [50].

1.11. **Design plantations in ways to limit potential impacts of disturbances such as wildfire.** There are approaches to plantation management that may limit the risk of fire spread, including the strategic location of fire breaks between compartments. Notably, landscape-scale simulation of fire occurrence in landscapes with *Pinus radiata* plantations in southern New South Wales suggest that plantations may experience much longer intervals between fire in the future, even accounting for future shortening of intervals across all forest types [20].

1.12. **Develop strategies for appropriate actions when species of conservation concern occur in plantation areas.** Plantations can sometimes have value for conservation, including greater value for some groups of biodiversity than the cleared pastures on which the plantations are established [51]. Plantations also can be valuable for some individual species of conservation concern [30]. Approaches need to be developed as part of codes of practice for plantation management when such species occur in plantations. Part of such approaches may include appropriate monitoring of parts of the plantation estate.

1.13. **Build on insights from farm forestry and the farmland vegetation literatures to inform new strategies for integrating tree plantation establishment and agriculture in agricultural landscapes.** There have been significant efforts invested in farm forestry programs [4, 52], as well as revegetation programs on farmland in south-eastern Australia (e.g. [53-55]) that achieve a range of positive outcomes for landholders, not just providing wood volumes. There have been many key insights and learnings from these programs over the past three decades and these need to be brought together in ways that inform new efforts in plantation forestry on farmland.

2. The CAR reserve system

In a nutshell

A Comprehensive, Adequate and Representative reserve system is a fundamental tenet of all credible plans for ecologically sustainable forest management [56].

Several detailed empirical assessments of the current reserve system in Victoria shows that it is not Comprehensive, Adequate and Representative. In particular, the system fails to meet Adequacy criteria for a range of threatened forest-dependent species [19, 57, 58].

A significant expansion of the reserve system is required to make the forest reserve system a CAR reserve system. This is particularly important as new areas of forest targeted for logging under the current Timber Release Plan have high conservation value for biodiversity [19]. The expansion of the reserve system is also essential to build its resilience and resistance to future climate change.

The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative. These maps should be reviewed by scientists with expertise in reserve design and the identification of robust networks of protected areas. Australia has several of the world's leading exponents of reserve design science and their expertise should be sought on this important matter.

The Government of Victoria should not extend or re-sign RFAs until it has satisfied itself (based on the high quality reserve selection and design science) that the expanded reserve system is a scientifically robust CAR reserve system.

The expanded reserve system must be well managed with appropriate levels of resources to conduct that management.

There should be no once-only logging of currently intact forest before being brought into an expanded reserve system.

Many studies have highlighted the rapid decline of the world's biodiversity [59-61]. Human activities, including forestry operations are responsible for much of this decline [59]. Networks of protected areas are a key component of efforts to conserve biodiversity. For example, it has been estimated that approximately 25% of the world's bird biota has been saved from extinction due to conservation reserves [62].

A relatively detailed assessment of the CAR reserve system was presented in the main Scientific Advisory Panel report for the modernization of RFAs. A small amount of additional detail is presented here as some of it was unpalatable to some members of the SAP committee.

The JANIS criteria that underpins the National Forest Policy Statement, specifies a number of key characteristics of the reserve systems in native forests. It states (on page 8):

> *It is important that Australia has a comprehensive, adequate and representative network of dedicated and secure nature conservation reserves for forests and reserves for protecting wilderness.*
>
> *As a general criterion, 15% of the pre-1750 distribution of each forest ecosystem should be protected in the CAR reserve system …*
>
> *Where forest ecosystems are recognised as vulnerable, then at least 60% of their remaining extent should be reserved …*

All remaining occurrences of rare and endangered forest ecosystems should be reserved or protected by other means as far as is practicable.

Several studies, including those led by the Government of Victoria, have quite clearly indicated that the current reserve network does not meet these specifications including the Comprehensive Adequate and Representative (CAR) criteria. For example, the current reserve system does not meet Adequacy criteria for some species of threatened forest-dependent arboreal marsupials and birds [57, 58]. In addition, recent work based on species distribution models for 70 threatened forest-dependent species in Victoria suggests that the current reserve network does not meet Comprehensive Adequate and Representative (CAR) criteria [19]. Furthermore, the range of age classes or growth stages is poorly represented within the reserve system in Victoria [63]. For example, the total area of old growth Mountain Ash in the Central Highlands RFA is just 1.16% of the extent of this forest type; in the case of the Alpine Ash, old growth constitutes 0.47% of the entire extent of this forest type in the Central Highlands RFA region [17]. Finally, some forest ecosystems such as the Mountain Ash ecosystem have been formally assessed under IUCN Red Listed Ecosystem approach as being Critically Endangered [18].

Recommendations

2.1. **The CAR reserve system must be expanded, particularly to meet the Adequacy requirement of the CAR criteria.** A key part of the reserve expansion process must include not only the protection of viable populations of threatened forest-dependent taxa, but also ensure that forests are sufficiently well reserved to have both resilience and resistance to climate change (including being large enough to be bigger than the extent of major disturbance events like wildfires [64, 65]. Notably, almost all of some forest types, such as almost all of the Mountain Ash and Alpine Ash ecosystems, will need to be reserved to meet the Adequacy criterion of a CAR reserve system.

2.2. **Priority areas for reserve expansion urgently need to be identified.** This is critical for several reasons. First, forests presently being targeted for logging under the Timber Release Plan have very high conservation value for the 70 species of threatened forest-dependent taxa in Victoria [19]. This means that further logging will have substantial negative impacts on threatened forest-dependent fauna. Second, the forests outside the existing reserve system are highly fragmented and further logging will only serve to significantly exacerbate this problem. As an example, [19] found that for the Wet and Damp Forests EVCs, the median distance for a random point inside the dedicated reserve network to a human disturbance boundary was 1700 metres. In comparison, the median distances to a boundary for informal protected areas outside the formal reserve system was 71 metres. For the Dry Forest group of EVCs, the median distance was 1232 metres for a random point inside the formal protected area network to a boundary. The equivalent median distance across the informal protected area network was 180 metres [19].

2.3. **The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative**. The RFAs should not be re-signed until these maps of the CAR reserve system have been created and then reviewed by scientists with expertise in reserve design and the identification of robust networks of protected areas. Australia has several of the world's leading exponents of reserve design science and their expertise should be sought on this important matter.

2.4. **Key areas for inclusion in the reserve system should include those where there are high levels of resource conflict.** Obvious areas for immediate forest reservation are water catchments where water production values are high and impacts of logging on water yield are

also high. The Thomson catchment is a clear example [19]. Other areas that are important for reservation include places where forest landscapes are relatively intact (e.g. the south face of Mt Baw Baw).

2.5. **Allied with reserve expansion, there is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans.** All of these plans must be based on robust, peer-reviewed science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management (see section #4).

2.6. **Protect areas of regrowth forest that will most rapidly become the next old growth forest.** Some forest ecosystems have been so heavily and repeatedly disturbed that they support almost no old growth forest. This is a breach of the JANIS criteria. Urgent action is needed on a pathway for restoring old growth forest. For example, all areas of 1939 aged montane ash forest need to be protected in the Central Highlands of Victoria. This is because regrowth forests of this age are typically the oldest current cohort (outside of existing old growth) (and are therefore where the least time will be needed until those forests become old growth). In addition, reservation of all existing areas of 1939 aged forest is essential to meet future targets of 30% of the landscape as old growth forest [17]. Notably, this recommendation is congruent with the May 2019 recommendation of the Threatened Species Scientific Committee, that logging in the montane ash forests of the Central Highlands of Victoria should cease.

2.7. **There should be no once-only logging of currently intact forest before it is brought into an expanded reserve system.**

2.8. **An expanded reserve system must be well managed (with adequate resourcing) and subject to rigorous monitoring of key targeted entities (e.g. measures of forest condition, key species, and key ecological processes).** Many reserve systems globally are chronically underfunded [66], despite their large economic benefits, including in Victoria [67]. The history of monitoring of reserves is poor and these deficiencies need to be rectified. Some of the entities targeted for monitoring should include variables that are also measured (in the same) off-reserve areas to facilitate cross-tenure comparisons in key forest metrics. The management of an expanded reserve system should include (among others): **(a)** the control of feral animals (e.g. deer) and weeds (e.g. blackberry in key areas subject to past logging operations), **(b)** debuilding of some parts of the road network (as roads can facilitate access to forested areas by foxes and cats and can be sites for arson (see [68, 69]), and, **(c)** the regeneration of failed logging coupes (including locations now in reserves but which were subject to once-only logging before being gazetted as protected areas).

2.9. **The multiple economic and other values of reserve systems need to be further quantified.** Considerable effort has been dedicated to qualifying the economic values of reserve systems in Victoria [67]. The contribution to regional and State economies of an expanded reserve system should be further documented as part of building the case for greater levels of resourcing to improve the management of the protected area estate.

2.10. **The impacts of an expanded reserve system on sustained yields of timber must be quantified.** An expanded reserve system will remove substantial parts of the wood production forest from harvest schedules. This underscores the need for a rapid transition to plantations as the source of timber for the forest industry. Importantly, the plantation resource has a high degree of certainty for the forest industry.

3. Active management of forests

In a nutshell

All forests – both outside and inside reserves – will need some form of active management including invasive (animal and plant) species control.

A key part of active management is the removal or mitigation of some key stressors from forest ecosystems. Logging is a key stressor in some ecosystems, such as those dominated by montane ash forests. Active management should therefore include the removal of logging from those ecosystems.

Active management should include a significant expansion of the reserve system so that it meets CAR criteria.

Intensification of logging in native forests is inappropriate given the extent of human and natural disturbance that has already occurred there.

The application of Variable Retention Harvesting systems in some forest types such as those dominated by Mountain Ash and Alpine Ash is inappropriate. This is because these systems are already heavily degraded and fragmented as a result of past logging and recurrent wildfires. A key recommendations by the Australian Government's Threatened Species Scientific Committee is that there should be no more logging (of any form) in these montane ash forest types.

A fundamental part of any native forest logging that might be considered for ecosystems outside the montane ash forests (where all harvesting should be ceased) must be the recalculation of truly ecologically sustainable levels of sustained yield that accommodate the effects of past disturbance, the risk of future fire, and the impacts of climate change. It is likely that the high levels of uncertainty in timber supply that will result from these drivers will make it essential for a rapid transition to plantations.

Native forests (as well as plantations) will often require various forms of active management to ensure the maintenance or creation of key values. This is a vast topic that embodies a broad array of themes. It is well beyond the scope of this short report to discuss the numerous elements of active management of forests. Topics such as hazard reduction burning and targeted ecological burning are not examined, although they are clearly relevant to large parts of the forest estate in Victoria – both within and outside the formal reserve system. Some of the key issues around fire management include are touched on directly and/or indirectly in other parts of this report and they include (among others):

(a) The use of repeated and targeted prescribed fire to minimize the loss of property and infrastructure. Such activities are most effective in protecting human infrastructure when they are conducted frequently and close to that infrastructure [70].

(b) The range of effects of additional fires in ecosystems that have already been extensively disturbed by wildfire [71, 72]. This includes the susceptibility of ecosystems to collapse as a result of recurrent wildfire as well as other kinds of disturbances such as logging and the interactions of these drivers [16, 73, 74].

(c) The impacts of fire on key resources such as water yield from water catchments [9].

(d) The interaction of logging history and fire that can add to the fire burden in some forest types [21, 22].

(e) The impacts recurrent wildfire on the viability of populations of threatened biota [58].

(f) The impacts of post-fire management actions such as salvage logging on biodiversity and key ecosystem processes [75-78]. And,

(g) The impacts of fire on sawlog availability, especially under shortening inter-fire intervals (Cary et al., unpublished data).

In the remainder of this section, only a small subset of topics associated with active forest management are considered. Many of these relate specifically to the montane ash forests of the Central Highlands of Victoria. This is because recommendations for enhanced management prescriptions have been made for these forests in the past due to problems with the conservation of biodiversity in these ecosystems [79, 80].

Problems with forest intensification, including widespread stand thinning, as a part of active management

Victoria has significant areas of relatively young regrowth forest. For example, approximately 98% of the Mountain Ash ecosystem in the Central Highlands of Victoria is 80 years or younger with substantial areas of this forest type burned in 2009 or clearfelled in the last two decades [17]. In addition, large areas of Alpine Ash forest throughout Victoria have been subject to repeated fire in the past two decades [71].

It has been suggested by some forestry advocates that these areas be subject to thinning and other forms of intervention such as fertilizer application to promote sawlog production or for ecological reasons including hollow development and *Acacia* spp. regeneration. However, these suggestions are highly problematic for a range of key reasons.

- First, thinning can elevate fire risk by elevating fuel loads, drying the understorey, and increasing wind incursion [81, 82].
- Second, thinning can badly damage key elements of the understorey such as tree ferns and resprouting mesic shrubs) which can have important ecological roles in native forests.
- Third, thinning requires extensive roading (in an already highly roaded forest landscapes) or in landscapes that would require extensive additional road construction.
- Fourth, thinning is a high investment but low return activity in montane ash forests as the material removed from the forest is pulpwood.
- Fifth, even if thinning interventions were made in regrowth stands, it will be still be prolonged period before sawlog quality timber might be grown – but recent modelling work suggests that the risks of such stands being consumed by fire before that time are extremely high (Cary et al. unpublished data).
- Sixth, the places likely to be targeted for the intensification of forestry interventions would most likely be sites with high levels of site productivity; these are also places with high levels of species richness (see [83-85]) and which support high values for threatened forest-dependent species [19].

Some advocates of thinning has suggested that it will grow larger diameter trees more quickly and this may more quickly alleviate environmental problems due to a paucity of old growth trees. However, hollow development relates to internal decay which is, in part, time dependent [86]. That is, larger diameter trees do not necessarily equate with old growth trees, in terms of some of the key characteristics that are important for biodiversity such as the presence of cavities and deep, complex structured crowns [87].

Intensification of harvesting such as through widespread and recurrent thinning, will potentially shift native forest ecosystems toward being *de facto* plantations. This is inappropriate as: **(1)** There are already large areas of plantations in Victoria that are used for intensive timber production. Activities that are tantamount to the conversion of native forests to plantations are environmentally inappropriate. **(2)** The economic costs of widespread thinning will be large (e.g. through additional roading), but the returns will be limited (as almost all the product from such interventions will be pulplogs). **(3)** Many of the places that would be targeted for thinning have already been subject to repeated disturbances and recovery is dependent on limiting further disturbances rather than adding further major perturbations. And, **(4)** Agencies such as VicForests have been advocating a move toward lower intensity logging operations such as the Variable Retention Harvesting system (although this too has major problems – see below). This is the antithesis of harvest intensification.

In summary, the environmental and economic costs of thinning are likely to significantly outweigh the perceived benefits of intensification activities like thinning in the vast majority of forest ecosystems.

Active management and the problems of Variable Retention Harvesting systems

The application of silvicultural systems is a clear form of active management in native forests. Much has been written about the array of negative ecological impacts of some forms of logging such as clearfelling, particularly in the montane ash forests of the Central Highlands of Victoria (reviewed in [44]). It has long been suggested that alternative forms of harvesting to clearfelling are required in these (and other forests) [88]. One of these forms of logging is called Variable Retention Harvesting.

An international group of forest scientists defined Variable Retention as:

> *An approach to forest management based on the long-term retention of structures and organisms, such as live and dead trees and small areas of intact forest, at the time of harvest. These structures and organisms are not removed in future forest management operations and hence undergo natural processes of growth and decay. The aim is to achieve a significant level of continuity in forest structure, composition, and complexity that promotes maintenance of biodiversity and ecological functions at different spatial scales. Approaches and levels of retention, which take account of natural disturbance dynamics, differ depending on local context but the practice is appropriate for all types of silvicultural systems and forests.(after [89], p. 423).*

Importantly, under Variable Retention harvesting, retained structures are within the boundary of a logging coupe, not outside of that boundary [90].

A Variable Retention Harvesting experiment has been underway for more than 15 years in Mountain Ash forests. However, there are some major issues with the broad-scale implementation of this approach (reviewed in [91]). Some of these are set out below.

A. Despite having shown that Variable Retention Harvesting is operationally achievable in montane ash forests in Victoria and Tasmania for more than a dozen years [92, 93], only 3.9% of montane ash forest coupes in the Central Highlands region in the 2017 Timber Release Plan for the following five years are listed as to be cut using Variable Retention Harvesting [94].

B. Even within logging coupes that are currently claimed to be Variable Retention by VicForests, it appears unlikely that such operations actually meet the definition of such kinds of silvicultural systems (as per [as per 90, 91, 95]) and are, in fact, strongly reminiscent of conventional clearfelling operations (**see Figure 1**).

C. There has been major damage to retained islands resulting from high-intensity fires deliberately lit to promote the regeneration of stands subject to Variable Retention Harvesting. Entire islands are often fully engulfed during such burning operations [44] (**Figure 2**). This problem is, in part, linked with the high levels of logging slash generated by logging operations in Mountain Ash forests, sometimes exceeding 450 tonnes per ha [31]. However, the problem is also due to the lack of desire to bear the cost of two-stage burning where islands and coupe boundaries are burnt in more controlled ways in cooler fire conditions. Moreover, the smoke pollution generated from these logging burns can be substantial with subsequent negative impacts on air quality and human health [96].

D. Irrespective of the kinds of logging operations that occur, there is still considerable long-term damage to soil environments created by harvesting machinery, including soil compaction and losses of soil nutrients [77].

E. Forests ecosystems that have been the focus of logging operations such as Mountain Ash forests are already very highly disturbed (see Figure 3). Further disturbance in this ecosystem, including through logging, increases the risk of ecosystem collapse [16]. That is, the ecosystem is at risk of being characterized by impaired key ecosystem processes, depleted biodiversity, and a reduced capacity to generate important ecosystem services and products (e.g. water). For example, increasing the number of coupes in Mountain Ash landscapes has been found to elevate rates of collapse of large old trees in adjacent uncut areas [97]. The Mountain Ash ecosystem is classified as Critically Endangered under the IUCN Red Listed Ecosystem criterion [18]. Moreover, all remaining areas of unlogged, unburned 1939-aged montane ash forest needs to be excluded from harvesting because it is the next nearest old growth forest that must be set aside to grow through to ecological maturity [17, 98].

A further contextual issue for the implementation of Variable Retention Harvesting relates to timber availability and sustained yield. In the case of the Mountain Ash forests, widespread recent and past fires, coupled with extensive timber harvesting have severely depleted the amount of forest available for sawlog production. This, in part, arose after the 2009 wildfires where a substantial component of the timber resource was burned but successive governments then failed to reduce the sustained yield in response to the large amount of forest burned. A result of this was to concentrate harvesting into the remaining green (unburned) forest resulting in their overcutting [7]. Notably, logging operations in the Central Highlands Mountain Ash forests have consistently failed to achieve Forest Stewardship Council certification, in part, because the rate of harvesting is not deemed to be ecologically sustainable.

In summary, while the widespread implementation of Variable Retention Harvesting might seem to be a positive step, it would be unwise to do so without simultaneously implementing a major reduction in sustained yield. Failure to do so will result in a greater overall area affected by logging (as less timber is removed from each coupe subject to Variable Retention Harvesting, therefore more coupes are required to achieve the same volume) [44].

Figure 1: A logging coupe near Matlock in Alpine Ash forest. This cutblock is listed as being a Retention Harvest coupe on the Victorian Government's logging history layer. The coupe does not have any of the characteristic levels of retention typical of a Variable Retention Harvesting system logging coupe [99, 100] and fails to meet the formal definition of that type of logging operations (see text). (Photo by Chris Taylor taken on 30 July 2019.)

Figure 2: Fire damaged in a retained island in logged Mountain Ash forests. As of August 2019, the retained island was compromised only of dead trees. (Photo series by David Blair.).

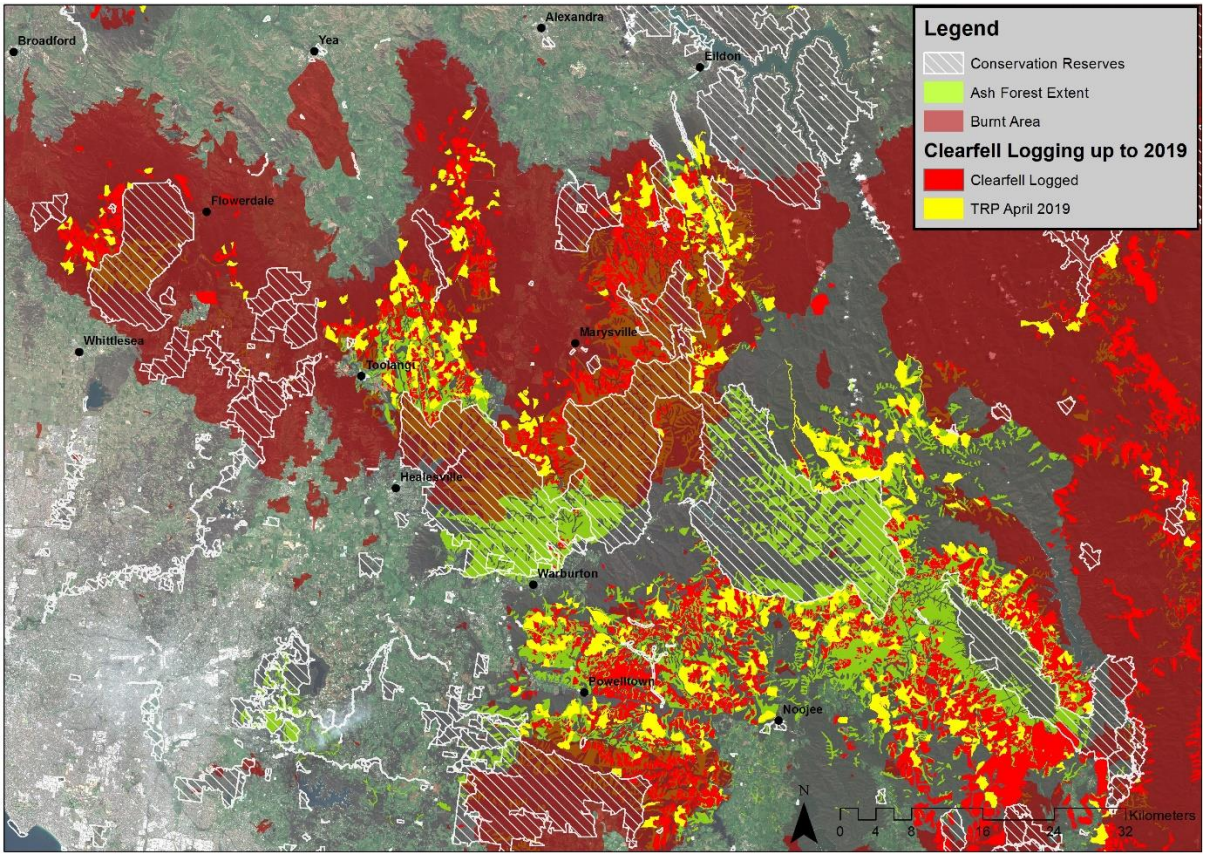

Figure 3: The extent of disturbance in the forests of the Central Highlands of Victoria. The map highlights the extent of fire and logging in ash-type eucalypt forests. (Map compiled by Chris Taylor using Government of Victoria data layers.)

Recommendations

Some kind of active management will be required in all forests (and some plantations).

3.1. **Intensification of forestry operations in the native forest estate is inappropriate.** High levels of intensification, such as through recurrent thinning are tantamount to a conversion of native forests to *de facto* plantations. This will have a wide range of negative environmental impacts and generate few benefits, including limited economic benefits. Plantations are already extensive across many parts of Victoria and are the places where intensive forestry operations are appropriate. Australia currently derives 85% of wood product value from plantations which occupy only 14% of land designated as wood production areas. Native forestry accounts for 86% of land but produces less than 15% of wood product value (see Section #1 on plantations).

3.2. **Variable retention harvesting has fewer negative environmental effects relative to conventional clearfelling [89, 100]. However, it is inappropriate for application in some key forest types because of the current extent of human and natural disturbance.** The extent of past logging, the amount of forest burned, the rapid decline in biodiversity, and other problems in forest types (such as those dominated by Mountain Ash and Alpine Ash) indicate they should not be subject to any more logging (using any harvesting method) [91]. This is entirely consistent with recommendations of the Threatened Species Scientific Committee that, to enhance the conservation of the Critically Endangered Leadbeater's Possum, there

should be no further logging in the montane ash forests of the Central Highlands of Victoria. For example, all remaining areas of unlogged, unburned 1939-aged montane ash forest need to be excluded from harvesting because it is the next nearest old growth forest that must be set aside to grow through to ecological maturity [17, 98].

3.3. **A fundamental part of informed active management must include a recalculation of plausible and truly ecologically sustainable sustained yields of timber and pulpwood.** It is well understood and widely recognized that sustained yields in Victoria forests have been set at levels that were (and still are) too high. More realistic and ecologically appropriate harvest levels need to be calculated. These calculations need to accommodate: **(a)** the impacts of fire on resources, including how climate change will increase fire frequency and reduce the inter-fire interval. Altered fire regimes will have major impacts on the probability of trees reaching a suitable age to be sawlogs (Cary et al., in review). And, **(b)** the need for a significantly expanded CAR reserve system (see Section #2 on reserves).

3.4. **Active management should entail the direct expansion of the CAR reserve system.** The CAR reserve system is currently inadequate in Victoria and a substantial expansion is required [19] (see Section #2 on reserves).

3.5. **A key part of active management is the removal or mitigation of some key stressors from forest ecosystems** [16, 73]. Logging is a key stressor in some ecosystems, such as those dominated by montane ash forests [16, 17, 73]. Active management should therefore include the removal of logging from those ecosystems.

3.6. **Active management of any forests that continue to be broadly designated for wood production must include the establishment of a strengthened network of buffers and other measures to protect key natural assets.** Buffers of unlogged forests should be implemented to protect all existing large old trees [80, 101] as well as other key biodiversity micro-hotspots such as patches of old growth forest and rocky outcrops. The size of buffers should be guided by an understanding of microclimate changes associated with disturbances such as logging (including the risks of windthrow) [79, 98]. Buffers to protect streamside areas may also need to be widened. This is because such places are where key natural assets like large old trees are most likely to occur [79]. Key natural assets that may need protection include areas that will be climate refuges under rapid climate change. Identifying where such refuges occur can demand detailed research (such as occurred in establishing the importance of old growth as refugia for climate change sensitive birds in western North America) [102].

3.7. **Active management should entail invasive animal and plant control.** Invasive species have had substantial negative impacts on Australian biota and ecosystems. There are emerging invasive species issues in some forest ecosystems (e.g. sambar deer) as well as established long-term problems in these same system (e.g. cats, foxes and blackberry). There may also be interactions between invasive species and other drivers such as disturbance (e.g. increased foraging by feral predators in burned areas [103]) and deer browsing effects in areas of post-logging regeneration.

3.8. **Consider the ecological effectiveness and cost-effectiveness of highly interventionist actions such as the establishment of nest boxes and translocation of animals.** Some actions are costly but can have significant benefits. For example, populations of some threatened species have been recovered through the establishment of nest boxes and other kinds of artificial nest sites. Chainsawing trees to create artificial hollows can provide forest-based employment options. However, it makes little sense to engage in such programs whilst the initial source of the problem (e.g. cutting down existing and potential nest trees) is continuing. In addition,

there can be some negative impacts of establishing nest boxes, such as altering breeding and nesting behaviour [104], and homogenizing biotic communities (e.g. bats [105]). Other programs such as reintroductions and translocations of threatened species can be effective, although they are expensive and high risk [106-108]. A risk management framework is useful to guide these projects in terms of the factors which can influence their success [109]. These kinds of projects are often best implemented as experiments to maximize learning and assessment of effectiveness [107, 108].

3.9. **Debuild part of the road and track network.** Roads can have a range of positive and negative effects [110, 111]. They provide access to areas to fight fires and to undertake activities like feral animal control. They also provide recreational opportunities. At the same time, they can be conduits for invasive plants and invasive animals. They also can lead to human access and subsequent arson attacks. Arsonists are more likely to light fires in easily accessible areas, close to roads and populated areas [68], and a greater distance from both urban areas and roads is associated with a decrease in the number of wildfires [69]. Roads can fragment forest landscapes and are known to act as barriers to movement of some species. The Victorian State of the Forests report has acknowledged that some forest types are very heavily fragmented by roads [41]. Removal of some roads and tracks can be important for promoting a range of conservation outcomes in natural forests, particularly those where there is already an extensive network of roads [56].

3.10. **Assess the effectiveness of active forest management practices.** The efficacy of some management interventions is poorly known, both in terms of ecological effectiveness and cost effectiveness. They need to be subject to rigorous monitoring and in some cases be targeted for Adaptive Management studies. As outlined in section #4 on Adaptive Management, the costs of conducting such work can be reduced where it is built on existing management practices. Assessments of the effectiveness of management interventions require that data are gathered on what actions were conducted where, when and how. Record keeping of this kind has not always been exemplary in the past, but it is essential for determining what actions have worked, what have not, and therefore what changes are required to achieve better management outcomes [112].

3.11. **Data that are gathered as part of active management as well as Adaptive Management (see section #4 below) and other kinds of monitoring should be collected in ways that allow it to be readily incorporated into standard accounting frameworks.** These frameworks include the System of Environmental and Economic Accounting (SEEA) framework developed by the United Nations and already employed for some forest types in the Central Highlands RFA region [1, 2].

3.12. **Review documents such as *Plantations for Australia: The 2020 Vision* to update the vision for the coming 20 years** (and as part of the RFA review) to ensure the continuing transition to a plantation-based wood products sector is well planned rather than precipitated by industry collapse.

4. Adaptive management

In a nutshell

The Victorian Government should be commended for committing to the adoption of Adaptive Management (AM).

There are numerous definitions of AM and confusion about what it entails. Government agencies need to agree on what definition is appropriate in the context of forest management, including the improved management of reserves.

There are some key steps in, and characteristics of, true AM but few programs could currently be considered to be AM programs. This should not preclude appropriate adaptive responses as part of improved management practices.

The Victorian Government needs to identify a subset of critically important programs that might be modified and improved in ways so that they meet AM principles. In particular, such modifications will demand strengthening approaches to monitoring.

Many existing programs might be strengthened through a thorough review aimed at improving monitoring. This would enable agencies and the general public to transparently assess program effectiveness and return on resource management investments.

There is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans. All of these plans based on robust, peer-reviewed science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management.

The concept of Adaptive Management is discussed widely in the scientific and 'grey' literatures. A commitment to Adaptive Management (AM) is written into native forest management policy in Victoria. This is a commendable commitment on the part of the Victorian Government.

There is a wide range of definitions of AM and the concept means different things to different people. A succinct definition of AM is given by Williams, et al. [113]:

> *Adaptive management is a systematic approach for improving resource management by learning from management outcomes.*

This general goal of AM can be implemented using a range of methods, as appropriate to any given study system. Although different authors provide different advice for how to implement AM, there is general agreement that the process typically involves several steps (reviewed by [114]):

1. Identification of management goal/s in collaboration with stakeholders.
2. Specification of multiple management options, one of which can be 'do nothing'.
3. Creation of a rigorous statistical process for interpreting how the system responds to management interventions. This stage typically involves creation of quantitative conceptual models and/or a rigorous experimental design for the target ecosystems.
4. Implementation of management action(s).
5. Monitoring of system response to management interventions (preferably on a regular basis).
6. Adjust management practice in response to results from monitoring, including modifying the monitoring program (Adaptive Monitoring; see [115]).

Despite the extraordinary literature on Adaptive Management (that spans many thousands of articles), there are, in fact, very few examples of true adaptive management globally, especially in

the biological sciences (reviewed by [114]). Some AM experiments have been established in Victorian forests such as a natural and artificial seeding and regeneration experiment through a partnership between DELWP and The Australian National University [116]. In other cases, experiments that might be broadly considered to be AM experiments and studies have been established. An example is the Variable Retention Harvesting Experiment that was established in partnership between DELWP and The Australian National University following an international, multi-stakeholder Forestry Roundtable meeting in 2002 [117] and which continues to be monitored to this day [91].

Variable Retention Harvesting has been known to be operational since 2007 [92] and positive environmental outcomes have been documented in a number of studies [75, 93, 118, 119]. However, VicForests has failed to implement Variable Retention Harvesting on a widespread basis, with an estimated 96.1% of all coupes on the current Timber Release Plan in montane ash forests slated for clearfelling [91]. The Variable Retention Harvesting experiment therefore does not quality as an AM experiment because the scientific knowledge on why it should be implemented has not been converted to altered on-the-ground practices [120].

Recommendations

4.1. **Develop an agreed definition of AM within and across appropriate agencies (including Parks Victoria) for the purposes of forest management.**

4.2. **Conduct a Statewide audit of, and spatial mapping exercise for, existing monitoring programs and long-term studies (within and outside government).** This is an important step because rigorous monitoring, particularly question-driven monitoring [112], is an essential ingredient for AM. This would aim to document existing long-term studies (see Youngentob, et al. [121] for an example) and determine which ones might be best brought into an AM framework to fill gaps in existing government monitoring capability. Allied to this recommendation is the need to seek ways to significantly increase the quality of, and resources for, forest monitoring in Victorian forests (including forests in reserves) as well as monitoring of parts of the plantation estate (both hardwoods and softwoods). This includes exploring ways to strengthen existing monitoring initiatives such as the Victorian Forest Management Plan – a process of Adaptive Monitoring. A key part of strengthening monitoring programs must be to identify trigger points for action, so that timely interventions can be made if circumstances change (e.g. populations of a forest-dependent species begin to undergo a rapid decline) [122].

4.3. **Identify the ecosystems, species, processes and/or other entities that are best targeted for AM**. True AM is hard to do and it is important to acknowledge that not all things can be managed and monitored using an AM framework. It is therefore appropriate to prioritize which entities are sufficiently important to warrant being part of AM. Notably, the costs and logistical inputs required for AM can be reduced by piggy-backing AM programs on existing resource management activities and management interventions [123]. For example, the costs of the Variable Retention Harvesting experiment in Mountain Ash forests were curtailed by building it on the existing harvesting schedule.

4.4. **For those entities that are targeted for AM studies and are therefore part of monitoring programs (and where they are appropriate), ensure that AM activities occur across tenures (e.g. in reserves and off-reserve areas).** This can be important for cross-tenure contrasts in, for example, aspects of forest condition, landscape pattern (such as road length and density), the prevalence of invasive species, and assessments of the effectiveness of particular

management actions. This will demand the identification of a harmonized set of metrics measured across tenures.

4.5. **There is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans and ensure they are properly monitored, preferably within an AM framework.** All of these plans must be based on robust, peer-reviewed science and the monitoring must also be underpinned by robust science. Having robust plans that are properly resourced and implemented is a key part of true Adaptive Management.

4.6. **Find ways to cut lag times in management responses to new knowledge. Adaptive Management generates new insights and understanding about, for example, resource management and biodiversity conservation.** The time between new knowledge acquisition and modified on-the-ground management can be prolonged (sometimes exceeding years and even decades – see the section on Variable Retention Harvesting in the Active Management section [#3]). A range of institutional and other actions can facilitate knowledge transfer [124, 125]. As an example, the Threatened Species Recovery Hub of the Australian Government's National Environmental Science Program has developed a targeted knowledge brokering program to facilitate knowledge exchange. This has an explicit remit of reducing lag times for knowledge adoption in enhanced policy.

4.7. **Agitate for more of the scientific community to engage in AM in Victorian forests**. Too few scientists have partnered with State Government agencies to participate in AM studies. More engagement on the part of the scientific community is needed to create a greater body of targeted work and foster greater efficiency in the delivery of quality AM studies. The Government of Victoria might explore approaches to incentivize greater participation in AM studies by the scientific community.

4.8. **Develop rules of thumb for adequate resourcing of monitoring within given programs.** Monitoring is nearly always the last activity funded and the first one cut in government and other programs. A more robust approach is needed to set aside suitable levels of resources to fund monitoring at the outset of the instigation of a program. A general rule of thumb is that 10 % of the budget for an environmental initiative should be dedicated to supporting monitoring [112, 126], although this is, of course, context dependent.

Consolidated list of recommendations

For details of each recommendation, see the relevant chapter of the text.

1. Plantations

1.1. The Victorian Government should embrace a policy of best and highest value for natural assets.

1.2. Review and update the Plantations 2020 Vision to establish an up-to-date and well-articulated vision for the size of the plantation industry that is desired.

1.3. Complete a thorough stocktake of the existing plantation estate in Victoria, coupled with land capability mapping of suitability for plantation expansion (including different types of plantation with different end products).

1.4. Identify approaches to overcome financial and social disincentives to establish new plantations.

1.5. Seek approaches to overcome disincentives to processing eucalypt plantation feedstock within Victoria.

1.6. Quantify the carbon, water, tourism, employment and biodiversity benefits as well as the general economic benefits of a rapid transition out of native forest logging and into plantations.

1.7. Develop key insights from examining other industry transitions. There have been rapid transitions in resource-based industries worldwide.

1.8. Prepare appropriate institutional and other arrangements associated with a rapid transition to a plantation-based economy for wood production in Victoria.

1.9. Ensure that the range of values of plantations are appropriately examined and accounted for.

1.10. Develop prescriptions for best practice plantation establishment and management (with the objective of gaining FSC certification).

1.11. Design plantations in ways to limit potential impacts of disturbances such as wildfire.

1.12. Develop strategies for appropriate actions when species of conservation concern occur in plantation areas.

1.13. Build on insights from farm forestry and the farmland vegetation literatures to inform new strategies for integrating tree plantation establishment and agriculture in agricultural landscapes.

2. The CAR reserve system

2.1. The CAR reserve system must be expanded, particularly to meet the Adequacy requirement of the CAR criteria.

2.2. Priority areas for reserve expansion urgently need to be identified.

2.3. The Government of Victoria should create maps of the expanded reserve system that is truly Comprehensive, Adequate and Representative.

2.4. Key areas for inclusion in the reserve system should include those where there are high levels of resource conflict.

2.5. Allied with reserve expansion, there is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans.

2.6. Protect areas of regrowth forest that will most rapidly become the next old growth forest.

2.7. There should be no once-only logging of currently intact forest before it is brought into an expanded reserve system.

2.8. An expanded reserve system must be well managed (with adequate resourcing) and subject to rigorous monitoring of key targeted entities (e.g. measures of forest condition, key species, and key ecological processes).

2.9. The multiple economic and other values of reserve systems need to be further quantified.

2.10. The impacts of an expanded reserve system on sustained yields of timber must be quantified.

3. Active management of forests

3.1. Intensification of forestry operations in the native forest estate is inappropriate.

3.2. Variable retention harvesting has fewer negative environmental effects relative to conventional clearfelling. However, it is inappropriate for application in some key forest types because of the current extent of human and natural disturbance.

3.3. A fundamental part of informed active management must include a recalculation of plausible and truly ecologically sustainable sustained yields of timber and pulpwood.

3.4. Active management should entail the direct expansion of the CAR reserve system.

3.5. A key part of active management is the removal or mitigation of some key stressors from forest ecosystems.

3.6. Active management of any forests that continue to be broadly designated for wood production must include the establishment of a strengthened network of buffers and other measures to protect key natural assets. f old growth as refugia for climate change sensitive birds in western North America) [102].

3.7. Active management should entail invasive animal and plant control.

3.8. Consider the ecological effectiveness and cost-effectiveness of highly interventionist actions such as the establishment of nest boxes and translocation of animals.

3.9. Debuild part of the road and track network.

3.10. Assess the effectiveness of active forest management practices.

3.11. Data that are gathered as part of active management as well as Adaptive Management (see section #4 below) and other kinds of monitoring should be collected in ways that allow it to be readily incorporated into standard accounting frameworks.

3.12. Review documents such as *Plantations for Australia: The 2020 Vision* to update the vision for the coming 20 years.

4. Adaptive management

4.1. Develop an agreed definition of AM within and across appropriate agencies (including Parks Victoria) for the purposes of forest management.

4.2. Conduct a Statewide audit of, and spatial mapping exercise for, existing monitoring programs and long-term studies (within and outside government).

4.3. Identify the ecosystems, species, processes and/or other entities that are best targeted for AM.

4.4. For those entities that are targeted for AM studies and are therefore part of monitoring programs (and where they are appropriate), ensure that AM activities occur across tenures (e.g. in reserves and off-reserve areas).

4.5. There is an urgent need to actually develop and fully implement Recovery Plans, Action Statements and Management Plans and ensure they are properly monitored, preferably within an Adaptive Management framework.

4.6. Find ways to cut lag times in management responses to new knowledge. Adaptive Management generates new insights and understanding about, for example, resource management and biodiversity conservation.

4.7. Agitate for more of the scientific community to engage in AM in Victorian forests.

4.8. Develop rules of thumb for adequate resourcing of monitoring within given programs.

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