Independent Forestry Panel

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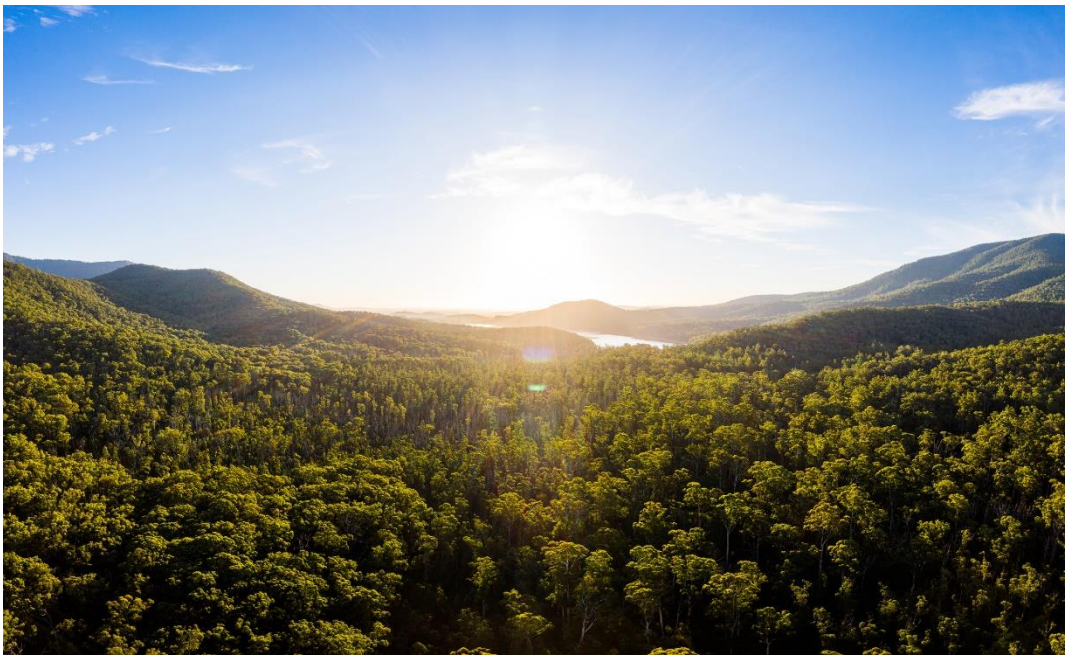
SUBMISSION TO THE NSW INDEPENDENT FORESTRY PANEL ON THE FORESTRY INDUSTRY ACTION PLAN

13 October 2024

Submission by
The Institute of Foresters of Australia (IFA) trading as
Forestry Australia



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A submission from Forestry Australia to:
The NSW Independent Forestry Panel:
Peter Duncan AM (Chair), Professor Mary O'Kane AC, and the Hon. Mick Veitch.

About Forestry Australia:
Forestry Australia is a not-for-profit, independent professional association with over 1,000 members. Our members are scientists, professionals and farm forest growers who manage, study and care for our forests. Our members are individuals who operate across all aspects of forest, fire and land management, farm forestry and tree growing throughout Australia. They have high levels of scientific expertise and extensive operational experience in forest, fire and landscape management.

Our members are committed to supporting healthy and resilient forests through evidence-based practice and the principles of active, adaptive and sustainable forest management. Our members apply these principles to generate appropriate environmental, economic, cultural and social outcomes in all types of forests.

1. Introduction

Forestry Australia contends that maintaining healthy and resilient forests based on ecologically sustainable forest management principles should be the primary objective for managing all forests regardless of land tenure. The balance of economic, social, cultural and environmental values from any given forest should be determined by the management objectives of that forest.

Under ecologically sustainable forest management, active and adaptive management practices are required to maintain and restore resilient and healthy forests that can withstand the impacts of threats including bushfires, invasive species and climate change. Guided by Aboriginal knowledge and forestry professionals, silvicultural practices, which may include sustainable timber harvesting and ecological thinning of forests where appropriate, can enhance forest resilience and reduce the impacts of identified threats while maintaining water yield and productivity as well as conserving biodiversity.

Active and adaptative management can provide a solution to many of the challenges that Australia faces including by helping to:

- combat climate change, through carbon capture and storage in trees and wood products, thereby reducing Australia's reliance on emissions-intensive alternatives;
- support biodiversity conservation through on-ground action, including forest restoration, and comprehensive forest monitoring;
- meet the growing local demand for wood, including for housing and specialty timbers some of which cannot readily be sourced from plantations or without dependence on imports; and
- contribute to an effective fire management capability by maintaining a regionally based workforce with skills and experience in forest and plantation fire management, supported by experienced contractors with appropriate equipment.

Setting aside native forests in formally protected and conserved areas with few resources to monitor and maintain the values that led to their reservation can be contrary to the principles of ecologically sustainable forest management. Tenure boundaries do not guarantee protection of biodiversity, particularly from the broader threats of bushfires, invasive species, and climate change. Where natural ecosystems have been disturbed, or are at risk of anthropogenic impacts, active forest management is required to maintain or restore structural forest diversity and resilience and a capacity to recover from this range of threats.

In considering the future of NSW forests and the benefits they deliver, Forestry Australia advocates for evidence-based decision making, long-term strategic thinking and the application of good governance principles. Good policy needs to be based on sound evidence and quality assessments.

2. Sustainability of current and future forestry operations in NSW

New South Wales (NSW) has 20.2 million hectares of native forest, of which 5.6 million hectares is formally protected within conservation reserves.

Forestry Corporation of New South Wales (FCNSW) manages around two million hectares of State forests. These forests include approximately 1.8 million hectares of native, or naturally occurring, forests as well as approximately 225,000 hectares of softwood timber plantations and just under 35,000 hectares of hardwood timber plantations (FCNSW, 2024).

In 2022-2023 Forestry Corporation NSW reported that it harvested approximately 11,700 hectares, including Redgum and Cypress, across all of its native forest estate (FCNSW, 2024).

The management of public native forests in NSW appears to be guided by two assumptions, both of which are questionable.

The first assumption is that forestry operations, and in particular forest harvesting represents a threat to biodiversity. Whilst unregulated and poorly implemented forest harvesting can create adverse pressure on environmental values, forestry operations in NSW are required to comply with strict legislation, regulations and Codes of Practice. In addition, they are guided by strategic and operational management plans and verified by independent third-party forest certification schemes all of which provides assurance that harvesting practices are managed sustainably.

Forestry Australia has a **position statement on sustainable forest harvesting**, which is linked below[1] for reference by the NSW Independent Forestry Panel (hereafter, 'the Panel').

The impacts of native forest harvesting on biodiversity have been studied extensively but much work remains to be done to fully understand the responses of different plant and animal groups (Davey 2018 a, b). Australia's State of the Forests Report 2013 observes that forestry operations pose a minor threat to nationally listed threatened forest-dwelling fauna and flora species compared with other identified threats (Department of Agriculture 2014). This finding deserves further consideration as it runs counter to the claims made by some civil society groups and the popular press that forestry operations are a major threat to forest-dwelling species.

The second assumption is that forest biodiversity is effectively conserved within the formal conservation reserves. Whilst protected areas theoretically provide the foundation of conservation action, whether they do this in practice depends on how effectively they are managed.

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[1] Forestry Australia (2023) *Position Statement on Sustainable Forest Harvesting*. Available online: https://www.forestry.org.au/wp-content/uploads/2023/07/Sustainable-Forest-Harvesting-June-2023.pdf

The fact that large areas of forest, both State forests and protected areas in NSW were severely burnt during the 2019/20 Black Summer bushfires (NSW Bushfire Inquiry 2020), raises concerns about the effectiveness of forest and fire management across all tenures.

Catastrophic fires and unnatural fire regimes present a threat to forest biodiversity and people. Other major contributors to biodiversity loss include invasive species (feral cats, dogs, deer, weeds) and land clearing resulting from agriculture, mining and urban expansion (Department of Agriculture, Water and Environment 2021).

One key challenge to understanding sustainability of forestry operations in NSW is that forest harvesting is often misunderstood or misinterpreted in the public discourse as being deforestation.

The Food and Agriculture Organization of the United Nations (FAO) defines deforestation as *the conversion of forest to other land use independently of whether human-induced or not* (FAO 2022). FAO notes that the term specifically excludes areas where the trees have been removed as a result of harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures.

Similarly, WWF defines deforestation as (Pacheco et al. 2021):

> *"The permanent conversion of forest to another land use or significant long-term reduction of tree canopy cover. This includes conversion of natural forest to tree plantations, agriculture, pasture, water reservoirs and urban areas; but excludes logging areas where the forest is managed to regenerate naturally or with the aid of silvicultural measures."*

Timber harvesting in NSW native forests is not deforestation because harvested forest is regenerated deliberately with the objective of restoring forest cover and species composition (Forestry Corporation NSW 2023).

In seeking to answer question regarding the sustainability of current and future forestry operations in NSW, one needs to consider the concept of sustainability from two perspectives, firstly the sustainability of forest biodiversity and flows of ecosystem services and secondly from a broader societal view of sustainability.

Forestry operations in NSW public forests are managed by FCNSW under arrangements described in the Overview of the New South Wales Forest Management Framework (NSW Government 2021). Sustainable forest management goes beyond timber production and involves balancing ecological, economic, cultural and social values.

Management of State forests is certified to Australian Standard for Sustainable Forest Management under the Responsible Wood Certification System. This standard is recognised by the international Programme for Endorsement of Certification Scheme (PEFC), which guarantees that timber has been grown and harvested from a sustainable forest.

Forest certification is subject to independent auditing of compliance and provides an additional layer of surety to consumers that harvesting is undertaken sustainably and in line with agreed best-practice standards.

In public native forests covered by Regional Forest Agreements, the Comprehensive, Adequate and Representative (CAR) reserve system is the mechanism jointly agreed by Commonwealth and State governments to protect biodiversity, old growth, and wilderness values. Biodiversity values are highly regulated and strategically identified and protected within formally protected and conserved areas of forest and in public native forests available for timber harvesting. Conservation and heritage values are protected through complementary measures such as management zoning systems, regulatory prescriptions, and other voluntary and site-specific measures. This multi-layered approach provides for conservation and representation of key forest types and biologically important areas across the landscape.

However, the RFAs have not clearly provided long-term stability of forests and forest industries as reductions in the area available for harvest from native forests have not been matched by increases in plantation. One possible risk to the sustainability of forestry operations is the periodic downward adjustments to designated wood production areas, and the transfer of State forest to conservation reserves. This may generate pressure to shorten forest harvesting cycles to meet contractual agreements to supply wood processing businesses.

A sustained approach to forestry operations in native forests requires active and adaptive management over long time frames.

Sustainable forest harvesting using appropriate silviculture promotes forest health and positive environmental outcomes. For example, thinning in regrowth forests enables trees to grow bigger quicker, making them more resistant to fire and supporting carbon capture and storage, helping to increase water yields, and mitigate fire risk in some forest types. Forestry Australia has a **position statement on the role of thinning in increasing the health and resilience of forests**, which is linked below[2] for reference by the Panel.

The sustainability of future forestry operations in NSW also deserves consideration from a broader assessment of sustainability. One critical consequence of reducing sustainable forest harvesting is an increased reliance on imports. Australia already has a growing balance of trade deficit in forest products, and this has been exacerbated with the decisions of state governments in Victoria and Western Australia to withdraw from timber harvesting in public native forests. An increasing reliance on imported timber can generate biosecurity risks, lead to increased costs, price volatility and sovereign risk resulting from disruptions in global shipping, conflict and rising freight costs.

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[2] Forestry Australia (2023) *Position Statement on Thinning of Native Forest*. Available online: https://www.forestry.org.au/wp-content/uploads/2023/10/14-Thinning-of-Native-Forest-Ocotber-2023.pdf

The closure of sustainable native forestry in NSW would weaken global climate change efforts by increasing demand for forest products from overseas countries, many with low environmental credentials.

The sustainability of future forestry operations in NSW, and indeed the sustainability of forests, will largely depend on the ability of forest managers to apply active and adaptive management that is appropriate to achieving management objectives.

Adaptive management of native forests and plantations is a key tool to addressing the twin challenges of climate change and biodiversity loss. Best practices, guided by codes of practice and ongoing research, help ensure that forest management strategies evolve with environmental conditions and the latest scientific understanding.

Active and adaptive management of forests can build forest resilience and sustainably contribute to environmental, economic, and social benefits for future generations, and complement the important role played by the formal conservation estate.

3. Environmental and cultural values of forests

The Intergovernmental Panel on Climate Change (IPCC, 2007) has consistently recognised the significant potential of ecologically sustainable forest management, and its capacity to maintain or increase forest carbon stocks and facilitate sustained yields of timber, fibre and energy from forests, will deliver the greatest climate change mitigation benefits. This position is reinforced by studies undertaken specifically in the context of NSW native forests (Ximenes et al. 2012).

In NSW, native forests and plantations are harvested and regenerated to provide forest products with multiple flow-on benefits that meet a range of societal needs. However, it is important to recognise that plantations and native forests provide different types of products and therefore both have a role to play, and both must be managed as part of a holistic forest products supply strategy.

Beyond the provision of wood products, sustainable forest harvesting in NSW provides a broad suite of important ecosystem values. These include supporting vibrant rural and regional communities and providing other socio-economic benefits, including road access for recreation, ecotourism and production of non-timber products.

Forests in NSW are rich in environmental and cultural significance, playing a critical role in both biodiversity conservation and the preservation of Aboriginal cultural heritage as well as supporting vibrant rural and regional communities and providing socio-economic benefits, including road access for recreation, ecotourism and production of non-timber products like honey.

Biodiversity and threatened species

NSW's native forests support a diverse range of plant and animal species, including threatened species. These forests are integral to biodiversity conservation, acting as vital habitats for wildlife.

In native forests, biodiversity values are strategically identified and protected within formally protected and conserved areas of forest. In forests that are designated as available for timber harvesting, conservation and heritage values are further protected through complementary measures including management zoning systems, regulatory prescriptions, and other voluntary and site-specific measures. This multi-layered approach provides for conservation and representation of key forest types and biologically important areas across the landscape.

The list of threatened species at risk of extinction continues to grow because of multiple threatening processes including invasive species, land clearing, climate change, and changes in both fire regimes and land management practices. Most threatened species have complex habitat needs, which are not yet fully understood. Further research across different land tenures and at a landscape scale is required to inform future decisions.

Forestry Australia has a **position statement on the conservation of threatened species in forests**, which is linked below[3] for reference by the Panel.

Fire Management

Fire has been part of the Australian environment for millennia. It is an essential element of many forest types from which it cannot be removed or altered without ecological consequences. Aboriginal people developed appropriate fire management practices to maintain their culture and Country.

Australia has experienced an increased occurrence of severe bushfires, which result in substantial impacts on life, property, forest biodiversity, water quality and quantity, forest products and uses as well as on the health and resilience of forest ecosystems. Australia's knowledge and systems of forest fire management are based on decades of bushfire research and lessons from previous bushfire inquiries. The COAG-endorsed National Bushfire Management Policy Statement for Forests and Rangelands brings this knowledge together to provide appropriate goals and strategies for reducing the occurrence, severity, and impacts of bushfires as well as for enhancing the resilience of forest and rangeland ecosystems.

Forestry Australia has a **position statement on the key requirements for an effective forest fire management program**, which is linked below[4] for reference by the Panel.

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[3] Forestry Australia (2023) *Position Statement on the Conservation of Threatened Species*. Available online: https://www.forestry.org.au/wp-content/uploads/2023/10/15-Conservtion-of-Threatened-Species-FINAL.pdf

[4] Forestry Australia (2023) *Position Statement on Forest Fire Management*. Available online: https://www.forestry.org.au/wp-content/uploads/2023/07/Forest-Fire-Management-June-2023.pdf

Over the past 25-years, the decline of the native forest timber industry has coincided with a shift from pre-season fire mitigation measures to a less balanced fire management approach dominated by in-season emergency fire suppression, which is increasingly reliant on the use of very expensive tools and technology, such as aerial water bombers, fire suppression chemicals, and computer modelling.

Rapid and aggressive ground-based fire control using experienced and well-trained personnel including timber harvesting crews skilled in using vital plant and equipment are essential to NSW forest fire management strategies. Forest fire risk is better managed with experienced forestry personnel that are familiar with the forest and are experienced at working with forest fire.

Maintaining a strong native forest and plantation workforce is an integral part of the solution to the recent increase in frequency and magnitude of forest fires.

Australia's experience with large-scale wildfires, particularly during the 2019-2020 bushfire season, underscores the need for active forest management.

Excluding timber production from native forests does not guarantee the protection of biodiversity from catastrophic fires. In contrast, sustainable and adaptive forest management, including the use of prescribed fire, is essential for reducing fire risks and maintaining forest resilience. Fire management strategies should align with broader land management goals, protecting both ecological assets, cultural values and communities.

Water quality and supply

NSW State forests help regulate water cycles and supply clean water. Naturally forested catchments maintain the ecological integrity of riverine systems and can produce high quality drinking water. However, water yield and quality can be adversely affected by high intensity wildfires or poorly planned and regulated forestry practices. Sustainable native forest management offers flexibility to maintain or enhance water quality and quantity.

Water quality in timber harvesting areas is maintained through the strict application of streamside reserves that consider the size of the stream, topography, soil type and adjacent land use. Strategies, such as limiting the area harvested in any one year and dispersing harvested areas in space and time are used to minimise impacts on water yields from water-supply catchments. Additionally, management practices such as forest thinning, implementing longer timeframes between timber harvesting events, and prescribed burning are used to maintain or enhance water yield in domestic water-supply catchments.

Aboriginal Cultural values

For Aboriginal People, forests hold deep cultural and spiritual significance, having been actively and sustainably managed by Indigenous communities for thousands of years (Fletcher et al. 2021). Clearly, forest managers and policy makers must recognise and

respect the culture, knowledge and rights of Aboriginal and Torres Strait Islander peoples. In some locations this is already happening with Aboriginal rangers and cultural heritage officers demonstrating leadership in forest management.

Public native forests in NSW provide an opportunity for Aboriginal Peoples to take on leadership roles where they choose to do so. Bringing together traditional knowledge and western science to guide forest management has considerable potential to improve environmental outcomes, maintain cultural heritage, and build resilience in the face of climate change.

Social values

State forests provide vital social benefits, offering spaces for recreation, eco-tourism, and education. Accessible to the public, they enhance mental and physical well-being and promote community engagement with nature. Additionally, state-managed forestry operations maintain infrastructure such as roads, which improves accessibility for recreational and fire management purposes. State forests offer a range of recreational opportunities, including horse riding, motor bikes and 4WDing, that are often restricted in the conservation estate.

Ecosystem services valuation

Forestry Australia encourages the Panel to consider the extent to which an ecosystems services valuation model can help test and validate various forest management options, and to provide decision makers with sound cost-benefit valuation evidence.

The management of native forests can provide a broad range of ecosystem services, which are the benefits (goods and services) derived by humans from the environment. Ecosystem services are often categorised into three main types:

- *Regulating services*: services that ecosystems provide by acting as regulators, such as such as carbon sequestration and water filtration
- *Provisioning services*: the material or energy outputs from ecosystems, such as timber and honey production and pollination services.
- *Social and cultural services*: services experienced by humans, such as recreation and tourism and cultural values.

These categories can be used to prepare an ecosystem services model that considers how the generation of these values and the consequent changes in the flow of benefits changes depending on the approach taken to forest management.

An ecosystem services model can enable cost benefit analysis of various forest management options and comparison of net benefits between those options. These models have already been widely used internationally based on the internationally accepted standard of the System of Environmental-Economic Accounting (SEEA) framework, developed under the auspices of the United Nations, which includes a set of

accounting principles that can help recognise the interdependence of societies, economies and the environment (United Nation, n.d.)

Without the use of an ecosystem services valuation model, there is a risk that forest management options are assessed with limited insight and appreciation of the net impacts, especially where the value of some ecosystem services are overlooked or undervalued.

In this context, a recent assessment of the net benefits of multiple use native forest management in southeast Queensland observed that multiple use forests support and maintain a broad range of ecosystem services, including biodiversity conservation, extensive recreation opportunities, and carbon sequestration and storage, as well as provisioning services (South + Central Queensland Regional Forestry Hub, 2022). The study noted that the scope for maintaining the flow of these ecosystem services is broader under State forest management that under protected forest tenures. Furthermore, it concluded that the cessation of timber harvesting, and transfer from multiple use forests to national parks and conservation reserves, may result in lower net social benefits over the longer term.

4. Demand for timber products

Timber supply is essential for Australia's housing and building industries, with demand for timber products in NSW ever increasing. The NSW Government has forecast that by 2041, the state population will reach almost 10 million people, and NSW will need an additional 904,000 homes over the next 20 years to house this growing population (NSW Government Department of Planning, 2024). In addition, there is an increase in demand for mass-timber buildings and carbon-negative buildings. This increase in demand is placing significant pressure on NSW timber supplies.

While demand is increasing, Australia's timber production has decreased over the past decade, especially in the reduction of sawlogs from native forests (ABARES, 2024). Furthermore, Australia is a net-importer of wood products, with approximately $6.9 bn of imported wood products compared to $2.8 bn of exported wood products in 2022-23. Paper and paperboard products account for a large proportion of these imports, however, wood-based panel imports totalled over $900 million and sawn wood product imports totalled almost $600 million (*ibid*). Historical under-investment in plantations has resulted in a significant timber shortage, increasing the cost of building and presenting challenges for future supply.

Ongoing contraction in the total area of the hardwood plantation estate and the end of native forest harvesting in Victoria, coupled with limited development of new softwood plantations, means that Australia is struggling to meet the increasing demands for wood products from a growing population. In addition, the devastating bushfires of 2019–2020 severely impacted NSW's plantations, further exacerbating timber supply challenges.

NSW faces a real risk of increased dependency on imports and the likelihood that more energy intensive products will be substituted for wood within the construction sector. Therefore, NSW is at a critical juncture in determining how to meet the growing demand for wood products in the face of a potentially diminishing domestic supply.

5. The future for hardwood and softwood plantations

Softwood plantations, especially *Pinus radiata* (pine) plantations in southeast Australia, are fundamental to Australia's timber industry, particularly for housing and construction. Softwood provides the structural timber for building homes, and as demand for housing continues to surge, particularly in NSW, these plantations will need to expand to meet the need for affordable and sustainable materials. Currently, this is not happening. Over the past two decades, the expansion of softwood plantations has lagged behind demand.

Though hardwood plantations are smaller in scale than softwoods, they are crucial to Australia's timber sector. Hardwood plantations cannot currently produce sawlogs in the quantity and quality obtained from Australia's sustainably managed native forests.

Farm forestry and private native forestry provide critical supplements to the supply of hardwood timber produced in public forests. Whilst the size and scale of farm forestry and private native forestry is modest, they do, nevertheless, offer economic opportunities (including from the sale of wood and non-wood products and via carbon market opportunities) while delivering Landcare, and conservation benefits for landowners.

When considering the future for hardwood and softwood plantations in timber supply, it should be noted that *not all timber products are the same*. Wood products harvested from native forests and plantations have different physical characteristics and are used for different purposes and are not readily interchangeable.

Proposals to transition timber production from native forests to plantations typically gloss over the challenges and costs of obtaining a cleared farmland base of sufficient size, and the investment risks of waiting decades before plantations provide a capital return.

Future timber supply from domestic sources will depend on a combined strategy of expanding softwood and hardwood plantations while supporting farm forestry and private native forestry, as well as maintaining some level of harvesting in public forests.

For NSW to create a larger, more diversified and resilient timber supply through the expansion of plantations requires a long-time horizon and collaborative efforts to overcome significant barriers including the cost and availability of appropriate land, the lack of policy certainty, and the need for significant investment. In addition, the expansion of the plantation estate will require a highly skilled workforce and effective community engagement to address social license issues (Parliament of Australia, 2018)

Expansion of the plantation estate needs to start today but the benefits for NSW timber supply will be decades from being realised.

6. Opportunities to realise carbon and biodiversity benefits

In relation to opportunities to realise carbon benefits specifically, ahead of further consideration of biodiversity benefits, Forestry Australia is pleased to share the following perspectives.

Globally, it is well recognised that forests, including avoided deforestation, play a critical role in mitigating the effects of climate change through carbon capture and storage. Across Australia, forests are an important carbon sink, and when appropriately protected and managed sustainably, they can absorb more carbon than is emitted from a range of forest management activities. Sustainably harvested wood products are renewable and can serve as a long-lived carbon store, as well as replace fossil fuel usage as a more environmentally friendly energy source.

In Australia, the value of forests in mitigating climate change is recognised through existing and proposed carbon credit markets and emission reduction incentives. To generate Australian carbon credit units (ACCUs), projects can be developed to apply an approved methodology under the ACCU Scheme (formerly the Emissions Reduction Fund (ERF)). The integrity of carbon projects is crucial to the carbon market. Approved methods work to create real and quantifiable levels of greenhouse gas abatement that would not occur without the carbon project.

In this context, Forestry Australia recently submitted a carbon method proposal to the Australian Government, under the title of '*Enhancing Native Forest Resilience*'. The proposal presents the scope for conducting a broad range of restorative forestry practices, improved utilisation of harvested wood products, and active forest management focused on improving habitat values, carbon stocks and resilience to droughts and wildfires.

Forest restoration practices, such as assisted regeneration in degraded areas, cultural and prescribed fire, thinning for ecological and cultural values, protecting old and big trees, weed and feral animal control can be used to restore forests across all tenures, including State forests, private forests, areas managed by Traditional Owners and, potentially, protected areas.

The proposed suite of forest management practices in Forestry Australia's proposal is consistent with the stated position of the Intergovernmental Panel on Climate Change (IPCC), in their latest report (2021):

> *"Sustainable forest management can help to manage some of these vulnerabilities [to climate change], while in some cases it can increase and maintain forest sinks through*

harvest, transfer of carbon to wood products and their use to store carbon and substitute emissions-intensive construction materials".

There are also precedent examples of improved forest management methods in the US and Canada, which encompass the capacity to conduct silvicultural treatments such as reducing competition and thinning, as well as rehabilitating harvesting access areas, increasing rotation age and reducing harvesting.

Forestry Australia recommends the Panel consider this new carbon method proposal, as guidance to opportunities to realise carbon and biodiversity benefits, while enhancing native forest resilience and maintaining a broad range of other forest values. The proposed method has been developed by a body of forest scientists based on extensive academic and applied research, and strongly aligns with approaches identified as carbon positive by the IPCC and used in other countries. Carbon investment has driven a significant improvement in the way forests and fire are managed in northern Australia. If implemented, this carbon method can provide opportunities for people to actively engage with forests across the country to improve carbon stocks and the long-term health of forests and communities.

7. Conclusions

Forestry Australia welcomes the NSW Government's initiative to establish the Independent Forestry Panel to engage with stakeholders to inform the development of the Forestry Industry Action Plan for NSW.

As the national association representing over 1,000 members comprising forest scientists, professionals and farm forest growers who manage, study and care for our forests, we stand ready to assist the Panel with its inquiries and would be pleased to engage further.

Forestry Australia is committed to supporting healthy and resilient forests through evidence-based practice and the principles of active, adaptive and sustainable forest management. Our members apply these principles to generate appropriate environmental, economic, cultural and social outcomes in all types of forests.

Furthermore, Forestry Australia is strongly of the view that we need develop a new shared vision for the management of public native forests in Australia. We need more holistic approaches that encompass all forest values across the landscape, rather than the current approach of dividing public forest management up across different government agencies (Jackson et al. 2022), with the overly simplistic notion that transferring State forests to national parks will protect them and address society needs.

Recent bushfires in Australia have heightened concerns that the management of public forest lands has largely failed to ensure the health of forest ecosystems, build resilience, and secure a promised balance between economic, social and environmental values across these tenures.

Therefore, Forestry Australia calls on the Panel to recognise the **timely opportunity to establish new governance models for ecologically sustainable forest management in NSW** – and envisage and adopt new ways of forest management to promote forest health, restore degraded forests and support resilient and sustainable communities.

These new models for native forest management in NSW can be based on prioritising a **'nature positive' agenda, especially through forest restoration**, in areas impacted by major shocks or stresses such as large-scale bushfires, invasive species or land use change. Forestry Australia advocates for active and adaptive forest management practices Bennett et al. 2024) to maintain resilient and healthy forests that can withstand the impacts of threats and disturbances over time. Guided by Aboriginal and Torres Strait Islander People and forestry professionals, silvicultural practices, which may include sustainable timber harvesting and ecological thinning of forests, can enhance forest resilience, restore degraded forests and reduce the impacts of threats while adapting to climate change and conserving biodiversity.

Forestry Australia calls on the Panel to **recognise the importance of maintaining options and capacity for active and adaptive management** across public native forest tenures in NSW, especially in the face of the considerable uncertainty presented by climate change and related impacts.

While national parks and other conservation reserves have been established to protect the best sites, or 'world-class natural and cultural values', with primacy on biodiversity conservation, the tenure status and regulatory framework for these protected areas can constrain the capacity of managers to conduct forest restoration, as well as appropriate fire management and silvicultural works to enhance the health and resilience of these forests. Compared to protected areas, State forests generally provide a broader range of ecosystem services, including selective timber harvesting, honey production, and active recreation and tourism, including horse riding or use of motorised vehicles, while also conserving biodiversity and addressing climate change.

The formal conservation reserve system and State forests provide complementary outcomes. However, this complementarity is dependent upon the effective management across all public forest tenures, with adequate resourcing to support the planning and implementation requirements to realise the differing management objectives.

Ceasing timber harvesting in State forests, and transferring State forests to National parks, is not the panacea for forest health and resilience in NSW. Instead, it risks reducing options for future adaptation and increases dependency on imports and less sustainable alternatives for construction. Unfortunately, simple solutions such as ceasing native forest harvesting do not address the increasing threats to forests from catastrophic wildfires, weeds and feral animals and other factors exacerbated by climate change.

While it may afford an increased area under protected status, it will not inherently provide additional conservation of NSW forests, nor enable options for the Government to adapt forest management to conserve biodiversity and maintain flows of ecosystem services.

Forestry Australia considers the way forward is to **establish new shared governance models** that bring together government agencies with Indigenous Australians and actors from the private sector and civil society. Forestry Australia encourages the NSW Government to focus on supporting the integration of traditional knowledge with scientific evidence and innovative technologies to enable more effective and timely monitoring of forest health and to inform adaptive management approaches.

Forestry Australia supports the scope for maintaining capacity for some level of sustainable timber harvesting from native forests to meet a range of society's needs, while seeking to expand the plantation estate, farm forestry and private native forestry.

Forestry Australia would welcome further discussion on any of the points raised in this submission.

We can provide further information, evidence and background upon request. Please feel free to contact us via:

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Active management: a definition and considerations for implementation in forests of temperate Australia

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ABSTRACT

Active management is often mentioned but rarely defined in current policies and strategies for native forests of temperate Australia. Lack of clarity about active management could mean that policies to support forest health and human involvement with forests are not fit for purpose. In this paper, we summarise the policy context for active management in Victoria (as a case study for temperate Australia) and review representations of active management in the broader temperate-forest literature, including its place in relation to associated concepts like adaptive management. Based on the review, we provide a definition of active management that focuses on human activities in forests – deliberate practices for diverse purposes and goals – situated within broader operational approaches (e.g. adaptive management frameworks) that enact the overarching philosophy and paradigm(s) of forest management. Our definition acknowledges multiple potential framings of active management that encompass diverse philosophies and sociocultural relationships with forests and require governance structures that foster inclusive understandings. Additional considerations for implementing active management in Australia's temperate forests include refreshed visions for forest management, clearly stated goals for active management, criteria for choosing among practices under uncertainty, revised operational guidelines for diverse practices, and commitment to building the evidence base for active management through iterative learning and targeted experiments within an adaptive management or analogous framework.

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adaptation; adaptation pathway; adaptive management; forest practices; passive management; sustainable forest management; temperate Australia

Introduction

Active management is often mentioned in relation to Australia's temperate native forests. Recent examples are available from Western Australia (DBCA 2022), Tasmania (Sustainable Timber Tasmania 2024) and New South Wales (DPI 2021). However, for introductory context, we focus on active management in policy documents for Victoria's forests – as a case study representing many of the challenges facing forest management in temperate Australia, including those posed by shifting societal expectations and changing climate and disturbance regimes.

Active management has increasingly been used in policies and strategies relevant to Victoria's native forests. The term first appeared in Australia's National Forest Policy Statement (Commonwealth of Australia 1995; Figure 1). Policy references relevant to Victoria's forests were few in the early 2000s (except for the Sustainability Charter for Victoria's State Forests; DSE 2006) but increased sharply from the late 2010s (Figure 1). For example, in 2017, the Victorian Government's Biodiversity 2037 plan (DELWP 2017) stated a vision of biodiversity that is 'actively cared for' and noted that 'active and adaptive' management is consistent with Traditional Owner approaches for maintaining healthy landscapes. In the same year, active management was referred to in the Country Plan of the Dja Dja Wurrung Clans Aboriginal Corporation (2017) in Central Victoria. Thereafter, active management was recommended in multiple clauses in the 2020 variation of Victoria's Regional Forest Agreements (RFAs; State of Victoria 2020), as well as in an independent major review following severe bushfires (Sparkes et al. 2022) and various policy documents relating to threatened species decline (LCEPC 2021), climate change (DELWP 2021b) and First Nations cultural landscapes (FVTOC 2021).

The desired outcomes of active management in these policies and plans for Victoria's forests are diverse and wide-ranging. The National Forest Policy Statement from the 1990s indicated that active management was needed to balance wood production and nature conservation in private native forests (Commonwealth of Australia 1995). In comparison, the emphasis in the Sustainability Charter for Victoria's State Forests (DSE 2006) was for active management to 'promote healthy forests' by minimising the negative impacts of both 'natural and human induced' disturbances. This emphasis is consistent with more recent aspirations in Victoria's 2020 RFAs for active management to 'build resilience and diversity' and control processes that threaten listed species and communities (State of Victoria 2020). The RFAs also state that active management is needed to 'reduce bushfire risk and support the recovery of forests' and to 'support a range of forest values and uses, including forest industries' (State of Victoria 2020).

Wide-ranging aspirations for active management in Victoria's forests are reiterated in the Major Event Review of the 2019–2020 Bushfires (Sparkes et al. 2022) and are consistent with those conveyed in Victoria's Climate Change

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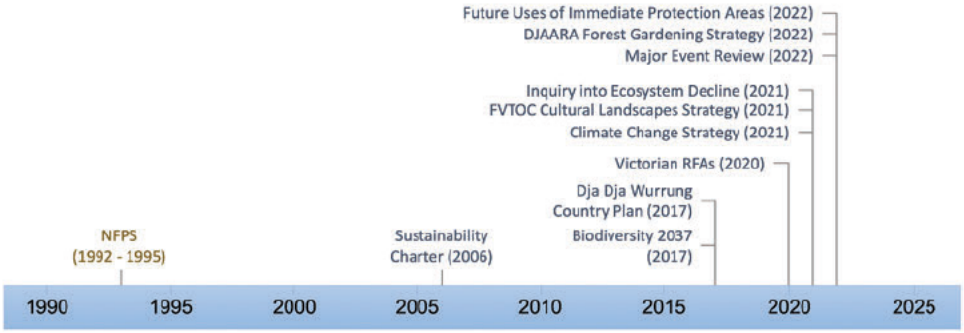

Figure 1. Timeline of when and where active management has been mentioned in policies, agreements and strategy documents in the context of Victoria's native forests, including (in brown) the National Forest Policy Statement (Commonwealth of Australia 1995)

Strategy that active management can help to 'balance sometimes competing values and uses' (DELWP 2021b). The National Forest Policy Statement suggested that such balance was principally achieved by protecting high conservation values in reserves and confining active management to private land (Commonwealth of Australia 1995). However, more recent documents acknowledge the importance of active management of all tenures, including parks and reserves (LCEPC 2021) and new reserves that were created to protect forests of high conservation value in a first step towards the cessation of commercial harvesting in Victoria's state forests (DELWP 2022).

Despite the increasing use of the term 'active management' in policy documents for Victoria's forests, the mechanisms for achieving the diverse desired outcomes are not entirely clear. Active management has not been clearly defined in these policy documents but has been variously identified as a 'proactive measure' (State of Victoria 2020) and 'strategies' (Sparkes et al. 2022). Limited elaboration about the form of active management indicates that it involves the implementation of practices, including pest, weed or disease control (DSE 2006; State of Victoria 2020); reseeding or revegetation (State of Victoria 2020; LCEPC 2021); prescribed burning (DSE 2006; Sparkes et al. 2022); and 'silviculture practices to improve the forest's structure and condition' (State of Victoria 2020). Active management has also been described in recent government documents as the 'application of Traditional Owner knowledge and practice' (DELWP 2022). This is consistent with calls by Traditional Owners to lead the healing of Country through 'active management such as forest thinning, cultural water flows and cultural fire' (FVTOC 2021), with the important distinction that Indigenous active management is not new but is long-standing and based in worldviews and traditions that have been disrupted by colonisation and associated laws (FVTOC 2021; DJAARA 2022).

Addressing ambiguities about the active management of forests is timely, given the changing context of native forest management in Australia. Recent substantive changes include the end of commercial timber harvesting of public native forests in Victoria (DEECA 2022) and Western Australia (DBCA 2022) and an impending end in southeast Queensland (DAF 2023). These changes are consistent with contemporary societal values and priorities, with wood production rated less important by the public in southeastern Australia than experiential and cultural forest attributes (Anderson et al. 2018). They also reflect increasing recognition of diverse relationships with forests, including those based in Indigenous knowledge and culture (Fletcher, Romano et al. 2021) and roles like environmental volunteering, which combines experiencing, caring for and learning about forests (Reid et al. 2011). Shifting societal priorities, coupled with a rapidly changing climate and associated disturbance regimes (CSIRO and BoM 2022), provide a challenging setting for forest management in temperate Australia and highlight the pressing need for clarity about active management – what is it, and how can it best be implemented?

In this review, we examine understandings and applications of active management of forests. We summarise general definitions of active management in relation to forests and conduct a systematic review of active management understandings and implementation in an unbiased sample of published papers relating to temperate forests. For purposes of clarity, we also examine the positioning of active management in relation to associated concepts, including adaptive management. Our aim is to provide a clear definition of active management and to present different framings and considerations relevant to diverse aspirations for its implementation in the forests of temperate Australia.

Defining active management

General definitions

There have been very few explicit definitions of active management in the broad forest literature, with the handful that do exist varying in scope and simplicity. Concise definitions of active management focus on the implementation of actions. For example, active management was defined by Götmark (2013) as 'manipulation/treatment of habitats and/or species' and by Carey (2007) as occurring 'anytime silvicultural practices are implemented'. These framings are broadly consistent with an early interpretation in relation to Australian forests that active management 'logically includes logging' (Brown 1996). Such concise definitions contrast with others that link actions to wide-ranging goals for active management. For example, noting the absence of a standard definition, the Society of American Foresters (2003) defined active management as: ' ... attaining desired forest objectives and future conditions using cultural operations and forest management practices', where cultural operations are defined as vegetation manipulations to meet stand composition or structure objectives and forest management as 'practical application' of a range of principles to meet goals for diverse values from 'aesthetics, fish, [and] recreation' to 'wilderness, wildlife, [and] wood products'. Likewise, in relation to Australian forests,

Jackson et al. (2021) defined active management as: 'a preparedness to conduct interventions that will conserve and restore biological diversity, ecological functions and evolutionary processes at multiple spatial and temporal scales'.

Reflecting these varied scopes, such definitions of active management point to a range of understandings about the possible practices that might be included. While some definitions indicate that forest active management has a focus on silvicultural practices – either as simply 'logging' (Brown 1996) or as a diverse suite of harvesting, tree tending and regeneration techniques (Carey 2007) – others provide a more expansive list, also including fertiliser addition, weed control, grazing, erosion control, road building and maintenance, recreation management, and fire management practices, including suppression, fuel treatment and prescribed burning (Society of American Foresters 2003). Of the latter, Jackson et al. (2021) recognised 'Aboriginal land management and cultural burning' in their definition of active management for Australian forests, which is consistent with Götmark's (2013) characterisation of active management as involving 'strong human/cultural influence' on forests.

Active management is also defined by what it is not. For example, the alternative 'passive management' of forests is defined by Carey (2007) as 'the choice … not to intervene in any way except to reduce or exclude human activities', and by the Society of American Foresters (2003) as allowing 'forests to evolve with minimal human intervention'. More general contrasts to active management have included 'benign neglect' (Brown 1996; Carey 2006a), 'leaving nature to takes its course' and the forest 'untouched' (Jackson et al. 2021), and a 'laissez faire' approach in which 'forests are not managed in any way except through the agencies of nature' (Brown 1996).

Consistent with its use in Australia's National Forest Policy Statement (Commonwealth of Australia 1995), papers that define active management often link it with resource-focused land uses like timber production, whereas passive contrasts are typically identified with reserves and protected zones (Brown 1996; Society of American Foresters 2003; Carey 2006a, 2006b). Nonetheless, some recognise that reserve-based passive management can include occasional 'appropriate' actions like 'fire threat reduction and restoration activities' (Carey 2007). Similarly, while some present active management as a better option than strictly passive approaches to forest management (Brown 1996; Society of American Foresters 2003), others argue that passive management is needed in at least some parts of the landscape to achieve goals like the 'protection of old-growth forest' (Carey 2007).

Active management representation in temperate-forest literature

Approach

To examine understandings of active management in temperate forests, we took a systematic approach to compile and evaluate relevant published peer-reviewed papers in Australia and worldwide. Our searches (see Appendix for details) were intended to provide an unbiased 'sample' of how active management is understood in temperate-forest literature. One search used the Web of Science database, which only includes journals that meet recognised standards of quality and allows for exhaustive searches of published papers based on search terms present in paper titles, abstracts, author keywords and/or 'keywords plus'. The second search used Google Scholar, with the aim of sourcing more accessible papers that might better capture a broader range of understandings of active management. Searches in Google Scholar are restricted to either the paper title (too restrictive) or include the entire article (too generous, given, for example, that papers can be returned based on words included in their reference list). Papers chosen from the Google Scholar search were thus restricted to the 20 'most relevant' reviews, as ranked by Google Scholar.

The searches returned a total of 70 papers (listed in Appendix), which we evaluated with a focus on the representation of active management. This involved whether explicit definitions of active management were provided, the stated or implied understandings of active management (e.g. high-level aspiration and/or implementation of practices), the form of implementation (e.g. part of a broader management framework, temporal and spatial scales), and the types of active management goals and practices (if mentioned). These summaries provided an objective basis for evaluating the breadth of usage and understanding of active management in temperate forests around the world and for highlighting inconsistencies, limitations and knowledge gaps.

Understandings of active management in temperate-forest literature

Reflecting mixed general definitions, the term 'active management' has been used in a variety of ways in relation to temperate forests throughout the world. Of the 70 reviewed papers, most focused on forests in Europe (26), followed by the United States (16) and Australia (6), with 17 considering temperate forests across multiple continents. The earliest mentions of active management in the reviewed papers date from the mid-1990s (e.g. Gurnell et al. 1995; Brown 1996), with the majority (46) published between 2010 and 2019. This timing is consistent with observations from an earlier temperate-forest review (Götmark 2013) and reflects lags between the emergence of new paradigms for forest management in the early 1990s (highlighting the need to balance active management with 'non-intervention' approaches for a range of conservation- and production-focused goals), and the evaluation of associated practices in the scientific literature (Bernes et al. 2015). Nonetheless, despite nearly 30 years of use, the concept of active management itself has had very little evaluation and development in the context of temperate forests, with, for example, just 2 of the 70 papers providing a definition of it (Brown 1996; Götmark 2013; see 'General definitions').

The use of the term 'active management' is inexplicit in several of the 70 reviewed papers. Some papers make only passing mention of active management without clear application (e.g. McMahon et al. 2015; Kristensen et al. 2015; Sing et al. 2018; Mölder et al. 2019), and others use the term to refer to a broad type of management without specifications (e.g. Lucas et al. 2011, Węgiel et al. 2019; Loeb and Powell 2020; Mayer et al. 2020). Also in a general sense, the term active management is used to highlight the need to do something – to respond to potential threats and degradation (Millar and Stephenson 2015; Bennett et al. 2017) or to restore threatened or fragmented forests (Lindenmayer et al. 2010; Allek et al. 2023; Havrdová et al. 2023; Pedley et al. 2023; Mantero et al. 2024) – rather than to rely on non-intervention

or non-assisted ecosystem processes to ensure forest persistence.

Many of the reviewed papers use a less-active contrast to convey their interpretation of active management in the context of temperate forests. Several papers contrast active management with the absence of intervention or management (Antos et al. 2008; Ishii et al. 2016; Baker et al. 2023; Havrdová et al. 2023; Spînu et al. 2023) and/or with conservation or protection in reserves (Battles et al. 2001; Killey et al. 2010; Nunery and Keeton 2010; Sebek et al. 2015; Zumr et al. 2021), which are occasionally equated to 'pristine' (Loeb and Powell 2020) or 'natural' states (Vance 2018). Consistent with this understanding of passive management as a lack of human intervention if not an untouched state, others equate active management with the re-establishment of historical management regimes after prolonged periods of 'neglect' (Buckley and Mills 2015). For example, active management is mentioned in relation to re-establishing European coppicing systems that were used for hundreds of years before abandonment in the twentieth century (Hedl et al. 2010; McMahon et al. 2015; Hamřík et al. 2023). This perspective suggests that active management involves regular and sustained tending (Buckley and Mills 2015; Sebek et al. 2015) rather than once-off intervention, which fits with interpretations that active management requires 'strategic repetition' (Wood et al. 2020) and 'years of ongoing' management (Larkin et al. 2014). Thus, while passive management can imply no human activity over extended periods, active management can involve regular activity, with one recent study equating more frequent and extensive silvicultural treatments with more intensive active management (Duan et al. 2023).

Implementation of active management in temperate-forest literature

Although expressed in a myriad of ways, active management in the reviewed papers is conveyed consistently as a form of human intervention. Of the 70 papers, 67 link active management – either clearly or through inference – to the use of forest practices that encompass a broad range of activities (Table 1), from tree felling and the manipulation of dead wood, species and grazing, to new plantings and fire management (see Table 1 for practice descriptions). Of all practices, active management is most frequently mentioned in relation to ecological thinning (15 papers) and prescribed burning (15), 'general silviculture' (i.e. practices broadly or collectively described as silviculture; 13), and removal of undesirable species (10). Also mentioned multiple times are general thinning (not ecological; 7), dead wood supplementation (7), grazing or mowing (7), uneven-aged harvesting (6), grazing or browsing reduction (5), and restoration practices either not specified (5) or relating to general revegetation (6) or to species mixes (5; Table 1). In some cases, active management is linked to an intervention to exclude a practice; for example, delaying harvesting to retain mature forest (Węgiel et al. 2019), or not removing dead wood (Zumr et al. 2021).

Rules for recognising practices as active management were not always clear in the reviewed papers. For example, although fire suppression clearly involves human intervention, it was identified as active management in just one paper (Bennett et al. 2017), whereas others presented suppression as a contrast to active management in the form of prescribed burning (Eales et al. 2018) or only included suppression in comparative scenarios that were not identified as active management (Battles et al. 2001; Halofsky et al. 2017). In a similar vein, recognition of traditional practices as active management was most often in the form of European coppicing systems (Hedl et al. 2010; Buckley and Mills 2015; McMahon et al. 2015; Roth et al. 2021; Hamřík et al. 2023) and rarely in the form of longer-term practices like Indigenous cultural burning (Götmark 2013), which were otherwise mentioned in relation to the historical context of forest condition rather than explicitly linked to active management (e.g. Brown 1996; Weston et al. 2022).

Practices could be linked to goals in most (67) of the reviewed papers, suggesting that active management involves intentional intervention. Reflecting the diversity of practices, the papers included a wide range of active management goals, which we have grouped into three types: biodiversity conservation, ecosystem function and ecosystem services (see Table 1 for goal descriptions). The most frequently mentioned goals related to biophysical complexity (i.e. heterogeneity to support biodiversity; 18 papers) and tree growth and development (including tree regeneration, survival and productivity; 15), followed equally by biodiversity in general (13), plant or animal diversity (13), and the provision of wood products (12). Less frequently, active management was also mentioned in the context of goals for the management of targeted species or ecosystems (10 papers) and to support forest resilience mostly in relation to threats posed by changing climate (10). The most frequent combinations of practices and goals (noting that a link here does not necessarily indicate practice efficacy towards the goal) were ecological thinning with biophysical complexity (6 papers) and plant or animal diversity (5), dead-wood supplementation or prescribed burning with general biodiversity (5 each), and general silviculture with the provision of wood products (5; Table 1).

Of the 70 reviewed papers, 23 explicitly tested practices relative to goals. Of these, the majority (19) examined practice effects at tree to stand scales, with just four evaluating active management practices in the context of landscape-scale configurations or modelled scenarios. Most evaluations (56%) involved multiple rather than single applications of a practice or practices, consistent with mentions of active management as cycles of practices (e.g. coppice system; Buckley and Mills 2015). Where practices were explicitly identified, they were sometimes combined (e.g. thinning with prescribed burning; Weston et al. 2022), including sets of prescriptions (e.g. silvicultural systems comprising harvesting and regeneration practices; Dey et al. 2019). Active management is also occasionally noted as involving strategic combinations of practices across landscapes (Brown 1996; Götmark 2013; Bernes et al. 2014) or responsive selections of practices from a suite, depending on the ongoing state of the ecosystem (Larkin et al. 2014). Nonetheless, the majority (66) of the 70 reviewed papers did not clearly identify active management as involving coordinated or strategic management across broad spatial and temporal scales.

Synopsis: active management in temperate-forest literature

Overall, the reviewed papers present active management in temperate forests as a mostly operational concept. That is, rather than an overarching philosophy or principle for forest management, active management is principally represented

Table 1. Goals and practices associated with active management in temperate-forest literature. Cell values represent the number of 70 review papers that mention a practice linked to a goal in the context of active management, without indicating the nature of the relationship between the two. Row and column values do not add up to the total number of papers by practice or goal where papers mentioned multiple practices and/or multiple goals

		Goal type[a]												
		NA	Biodiversity conservation				Function		Ecosystem services					
Practice type	Practice[b]	Not specified	Biodiversity general	Plant or animal diversity	Species/ ecosystem	Biophysical complexity	Tree growth/ development	Resilience	Aesthetics	Soil formation	Wood provision	Carbon storage	Disturbance regulation	**Total**
General	Not specified	1				1							1	**3**
	Restoration		2		3									**5**
	Landscape configuration		3											**3**
Tree felling	General silviculture	1	2	1	1	1	1	3		1	5			**13**
	Ecological thinning		3	5	3	6	4	1						**15**
	Thinning other		3			1	2	1			1	2		**7**
	Uneven-aged harvest		1	1	1		1	1	1		3	1		**6**
	Even-aged harvest						1	1			3	1		**4**
Dead wood	Retention					2	1							**3**
	Supplementation		5	2		1								**7**
	Tree girdling		2			1								**2**
New plantings	Revegetation general		1		1	1	2				1			**6**
	Species mixes			1		2		3						**5**
Species control	Re-introduction		2		1									**2**
	New introduction				1									**1**
	Removal		3	1	1	4	3			1				**10**
Cultural or traditional	General				1	1								**1**
	Coppice system	1	1	1		3					1			**5**
	General		1					1						**2**
Fire management	Prescribed burning		5	4	3	4		3			1		1	**15**
	Mechanical fuel management					1		2			1		1	**3**
	Suppression							1						**1**
Grazing control	Grazing or mowing		2	2	4		2							**7**
	Grazing/browsing reduction		1	2	1	1	3							**5**
Miscellaneous	Fertiliser runoff control				1									**1**
	Removal of understorey		1											**1**
	Litter/humus manipulation		1											**1**
	Hydrological manipulation		2											**2**
Total		**3**	**13**	**13**	**10**	**18**	**15**	**10**	**1**	**2**	**12**	**3**	**2**	

Note: [a]Goal types are based on goals that were mentioned in the 70 papers at least once (i.e. the list is not exhaustive of all potential goals for active management of temperate forests)

- Biodiversity conservation: goals mention diversity, composition and/or abundance of any organism
  - Biodiversity general: conservation of some or all organisms, including genetics and broad functional groups
  - Plant diversity: assemblage(s) of plant species, including interactions among plant species
  - Animal diversity: assemblage(s) of animal species, including interactions among animal species

- Species/ecosystem: individual species (plant or animal) or ecosystem type, including rare and threatened species or ecosystems, and keystone, umbrella, focal or flagship species
- Biophysical complexity: arrangement of biotic and abiotic elements explicitly linked to biodiversity conservation based on principles of complexity or habitat/niche provisioning (including desired forest states and landscape configurations as surrogates for biodiversity)

- Function: goals mention an ecosystems process or functional capacity
  - Tree growth/development: tree or woody plant regeneration, growth/productivity and/or development, including tree survival or mortality and development of large trees
  - Resilience: capacity to recover and/or persistence and/or adaptability of species or populations to external stress in general and/or in relation to climate change or disturbance regimes
- Ecosystem services: goals mention ecosystem services as listed.

[b]Practices and practice types are based on those mentioned in the 70 papers at least once (i.e. the list is not exhaustive of all potential active management practices in temperate forests)

- General: practices either not specified or aligned with a practice intention without specifics
- Tree felling
  - General silviculture: practices broadly or collectively identified as 'silviculture'
  - Ecological thinning: thinning mentioned in context of ecological objectives other than commercial wood production
  - Thinning other: thinning with a production focus or no explicit focus, including stand-density manipulation
  - Uneven-aged harvest: removal of stems using silvicultural regimes that lead to uneven-aged stands, including single tree selection, group selection, partial harvest and shelterwood harvesting
  - Even-aged harvest: removal of stems using silvicultural regimes that lead to even-aged stands, including clearfell and seedtree harvesting
- Dead wood
  - Retention: deliberate retention of fallen or standing dead wood, including protection from damaging agents like fire
  - Supplementation: deliberate introduction or creation of dead wood, either standing or fallen
  - Tree girdling: deliberate girdling of stems for intentions other than creation of dead wood
- New plantings
  - Revegetation general: including planting and seeding without specification and assisted natural regeneration
  - Species mixes: intentional management/planting/establishment of plant species mixes
- Species control
  - Re-introduction: Re-establishment or augmentation (including rewilding of apex predators)
  - New introduction: introduction of species new to an area
  - Removal: removal of undesirable plant and/or animal species, including weeds, pests and invasive species
- Cultural or traditional
  - General: individual practices or collections of practices identified by the paper's authors as cultural or traditional
  - Coppice system: management of coppice identified as traditional by the paper's authors, including coppice-with-standards
- Fire management: either mentioned generally or in relation to listed practices
- Grazing control
  - Grazing or mowing: use of either grazing animals or mechanical machinery for mowing
  - Grazing/browsing reduction: management of grazers/browsers including exclusion and culling
- Miscellaneous: as listed, hydrological manipulation includes flooding regimes and soil drainage.

as the implementation of practices to manipulate forest attributes (structure, composition, function) towards goals for diverse outcomes (e.g. forest biodiversity, function and/or ecosystem services). It can involve single or multiple practices applied once or in cycles through time, most commonly at tree to stand scales, with some consideration of spatial configuration of practices at larger scales. In this sense, active management involves the presence and influence of humans who are engaged in attentive, deliberate and coordinated activity in forests and forest landscapes. While providing some clarity about its scope, this synopsis nonetheless presents active management as a catch-all term for all human activity in forests. Whether it is a useful, stand-alone concept requires further examination, including where and how it fits with other concepts in forest management.

Positioning active management relative to associated concepts

Our review identified that active management is principally used in an operational context in temperate-forest literature. Here, we offer further insights into the nature of active management by presenting its position relative to other forest management concepts. Broadly, we suggest that active management is an implementation step embedded within an operational framework, which puts into effect the overarching vision and principles of forest management (consistent with active management as a 'technique' within a broader system of 'active intentional management'; Carey 2006b, 2007). To illustrate, we examine the place of active management in a conceptual 'instrumental' path (Figure 2), named to reflect planning approaches common in forest management (Sapkota et al. 2024) that involve instrumentalising policies set by management agencies through a series of 'rational, organised' steps, including defining the problem, setting goals, identifying options and actioning solutions (Leeuwis 2004). To avoid consideration of multiple potential models of forest management (see Lane and McDonald 2002), we have designed the instrumental path to be consistent with sustainable forest management (SFM) (Figure 2). This path is for illustration purposes only – it conveys just one way of seeing and thinking about human relationships with forests. Alternative paths – relevant to different philosophies, paradigms, frameworks and outcomes – could be developed (e.g. Figure 3), although we suggest that active management would maintain a similar relative position in those paths. This highlights that active management is an inclusive concept that need not be constrained by instrumental approaches but can be aligned with a range of different approaches and philosophies for forests.

Our example instrumental path (Figure 2) conveys a hierarchy of interconnected concepts, starting with an overarching philosophy of SFM that is ultimately linked to a broad outcome of healthy adaptive forests. This is not the only path that could be developed with SFM as the starting point because there are multiple alternative terms and embedded concepts that could be considered at each level (see Table 2). Our purpose in using this form of an instrumental path is to show the position of 'active management' relative to 'adaptive management' because the two concepts are often used together but are rarely distinctly defined. Since alternative paths – based on different philosophies, paradigms and frameworks – can be defined, our framing illustrates that active management will not always be planned with adaptive principles as a foremost priority; equally, not all adaptive management will be active (see below).

Placing SFM as the first link in our instrumental path is consistent with the stated overarching vision for 'ecologically sustainable management of Australia's forests' in the National Forest Policy Statement (Commonwealth of Australia 1995). 'Sustainable' in this context broadly requires maintenance of forest ecological processes and biodiversity, and optimisation of benefits derived from 'all uses within ecological constraints' (Commonwealth of

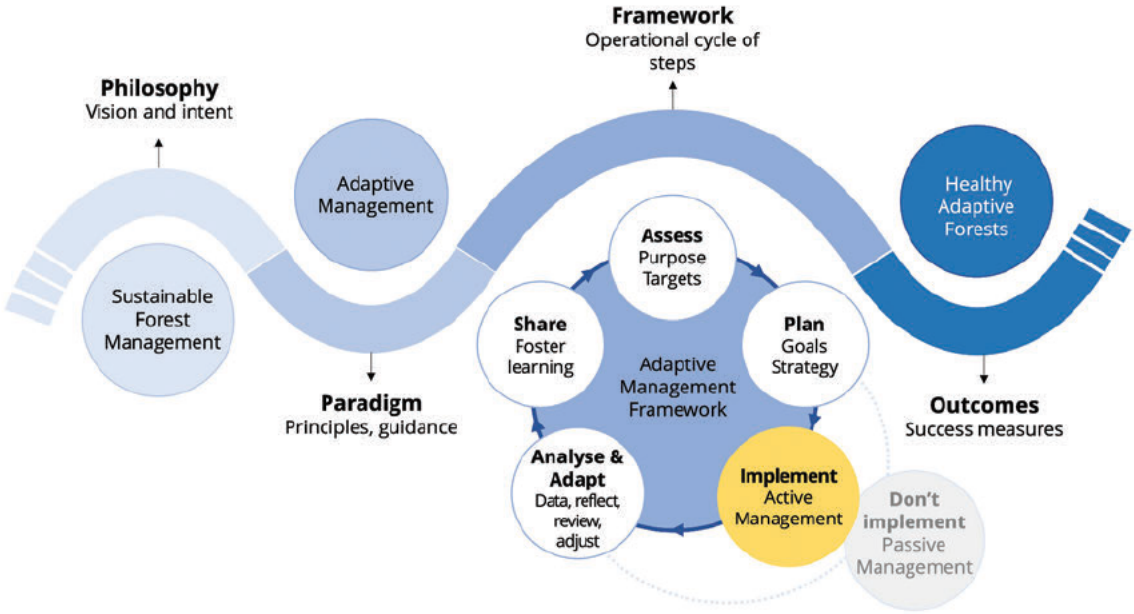

Figure 2. Example positioning of active management relative to associated concepts in an 'instrumental' path, which applies a philosophy of sustainable forest management and an adaptive management paradigm with the intended outcome of healthy adaptive forests. Active management (in yellow) involves the implementation of practices within an operational framework (in this case, an adaptive management framework, modified from CMP 2020). Decisions (based on assessment and planning) to not implement in-forest practices are consistent with the concept of passive management (grey), represented as an alternative to active management within an adaptive management cycle

Table 2. Additional concepts associated with active management. Concepts are listed by the levels or steps that precede active management in a hypothetical path (e.g. instrumental path; Figure 2) and are linked to comparable or embedded concepts, as described or applied in the cited references

Level	Attributes	Concept	Comparable or embedded concepts	References
Philosophy	High-level vision, intent	Sustainable forest management	Ecosystem management	Lane and McDonald (2002)
Paradigm	Principles, guidance	Adaptive management (general)	Resist, accept, direct (RAD) Resistance–resilience–transformation (RRT)	Lynch et al. (2021) Peterson St-Laurent et al. (2021)
			Ecological restoration Rewilding	Gann et al. (2019) Perino et al. (2019)
Framework	Operational network, interconnected steps	Adaptive management framework	RAD adaptive management framework Decision-support frameworks Ecological risk assessment	Lynch et al. (2022) Hemming et al. (2022) USEPA (1998)
Framework step: Assess	Purpose, targets, options	Adaptation options	Active adaptation, passive adaptation Autonomous, planned, assisted adaptation	Jandl et al. (2019) Doherty et al. (2017)
			Active resistance, passive resistance, resilience, autonomous transformation, directed transformation, accelerated transformation	Peterson St-Laurent et al. (2021)
Framework step: Plan	Goals, objectives, strategy	Adaptation pathways	Scenario modelling Decision pathways	Penman et al. (2022) Lane and McDonald (2002)

Australia 1995). As per the comparable concept of 'ecosystem management' (Lane and McDonald 2002; Table 2), SFM places importance on ecological processes to sustain the composition, structure and function of a forest and to meet society's diverse cultural, economic and political needs (Safford and Vallejo 2019).

As acknowledged in the National Forest Policy Statement (Commonwealth of Australia 1995), SFM needs to adapt to accommodate change. That is, the philosophy of SFM accommodates many of the management responses that will be required to maintain forest function under uncertainty, including climate change (Ogden and Innes 2008). This need to adapt describes 'adaptive management' in its broadest sense – being agile in response to unpredictable and changing conditions, learning through experience, and iteratively integrating learnings into ongoing management (Millar et al. 2007). Adaptive management at this broad paradigm level (Figure 2) provides principles that guide decision-making under uncertainty (Lane and McDonald 2002). At a comparable level (Table 2), the paradigm of ecological restoration provides principles that guide the process of assisting the recovery of a degraded ecosystem towards a reference model that describes the pre-degradation condition, typically informed by historical data (Murcia et al. 2014; Gann et al. 2019). However, other paradigms are premised on a wider range of potential adaptive responses that are less constrained by historical fidelity. For example, the resist–accept–direct (RAD) paradigm recognises that unprecedented environmental change is pushing many ecosystems beyond irreversible thresholds to novel states 'that diverge dramatically from prior structure and function' (Lynch et al. 2021). RAD allows managers to consider alternatives to *resisting* change (focusing on maintaining historical or current conditions) by presenting the possibility of *accepting* change trajectories that emerge without human intervention or of *directing* trajectories by intervening to deliberately shape ecosystem structure and function (Lynch et al. 2021; Schuurman et al. 2021). Clearly, although both ecological restoration and RAD are arguably consistent with SFM, commitment to one or the other as a guiding paradigm could lead to divergent decisions further down an instrumental path.

Although the term 'adaptive management' can be used in a general sense, it also refers to an operational framework, which in our example includes active management as an embedded step (Figure 2). At this level, adaptive management is a type of decision-support framework that aims to reduce uncertainty by using iterative learning to inform future decisions (Hemming et al. 2022). Our example comprises a cycle of assessment, planning, implementation, analysis and sharing steps (CMP 2020), with active management as the implementation step, which is informed by, and in turn informs, all other steps in the cycle (Figure 2). As previously indicated, alternative paradigms like ecological restoration and RAD could be chosen at the preceding level in the path because both can and should be implemented within an adaptive management framework (Gann et al. 2019; Lynch et al. 2022). Equally, alternative frameworks could be substituted at this level, including ecological risk assessment (USEPA 1998) and other decision-support frameworks (e.g. priority threat management and systematic conservation planning; Hemming et al. 2022). This illustrates that active management can be embedded in a different framework that might not be identified as adaptive.

Adaptive management frameworks can be described as either active or passive – providing a potential source of confusion in our 'active management' context. However, these qualifiers refer to whether implementation options in the adaptive management framework are examined and/or tested rather than the nature of those options. For example, passive adaptive management involves using a single best-response model based on current understandings to screen and choose practices, whereas active adaptive management involves the development and screening of a range of alternative response models to identify multiple practices that can be tested at the implementation step (Walters and Holling 1990). This evaluation (or not) of potential practices occurs at the 'assess' and 'plan' steps, which precede the active management step in our example adaptive management cycle (Figure 2). The 'assess' step, for example, defines the purpose, targets and potential options of a management program (CMP 2020), which, in our example, can be checked for alignment with the adaptive

management paradigm and overarching SFM philosophy. Potential adaptation options are available in a range of typologies (see Table 2), which – again potentially confusing in our active management context – can broadly be grouped under passive or active adaptation. Passive forms of management adaptation rely on the 'autonomous adaptation' (Doherty et al. 2017) of the forest ecosystem (without human intervention) to maintain current species and states (Peterson St-Laurent et al. 2021) by 'exert[ing] a dynamic self-regulation' based on 'inherent resilience' (Jandl et al. 2019). In contrast, active or 'planned' (Doherty et al. 2017) adaptation involves deliberate responses to changing conditions like those presented by the RAD framework (Lynch et al. 2021) and by the resistance–resilience–transformation six-point scale, including options designed to support the resilience of current states or to support ecosystem transformations that are autonomous, directed or accelerated (Peterson St-Laurent et al. 2021).

Ideally, before their implementation as active management, the expected long-term outcomes of different adaptation options would be conceptually or quantitatively modelled, including associated uncertainties (Walters and Holling 1990). In a rigorous planning step within the adaptive management cycle (Figure 2, Table 2), this could involve generating adaptation pathways that visualise and support current and future decisions in favour of desired forest states by identifying a sequence of aligned strategies and responses that are triggered by potential future changes in environmental and/or social conditions as they evolve (Barnett et al. 2014). This type of approach lends itself to scenario modelling based on spatial simulation models, like those often employed in risk assessment frameworks to support fire management (e.g. Penman et al. 2022).

The 'assess' and 'plan' steps in our adaptive management framework provide the rationale for the 'implement' step, which we equate to active management (Figure 2). That is, active management enacts the planning and decisions of preceding steps by implementing in-field practices, which can be selected from a diverse range (e.g. Table 1). Here, the decision can also be made to not implement practices, typically characterised as passive management (Figure 2). Like active management, passive management can be embedded within an adaptive management cycle and used to manage for forest conditions or states according to the rationale provided in the preceding steps (e.g. based on adaptation options and pathways evaluated against targets and goals). Subsequent monitoring and analysis are then used to foster learning and modify targets and goals in an iterative manner and with stronger understanding of uncertainties associated with incomplete knowledge (Schreiber et al. 2004). In this way, passive management is not equated to the complete absence of humans but more to a hiatus in human activity or a decision to not implement a practice for that adaptive management cycle. Alternatively, passive management could be abandoned as a redundant concept, replaced by concepts like 'minimal intervention' (Götmark 2013) that recognise low-intensity practices (e.g. human influences on ungulate densities and browsing pressure; Götmark 2013) on an active management spectrum. This framing captures the ubiquitous influence of humans on all forest landscapes and better acknowledges the functional roles of Indigenous place-based societies in forest ecosystems and their active long-term stewardship (Bliege and Nimmo 2018; Fletcher, Hamilton et al. 2021).

The outcome of our instrumental path is healthy adaptive forests (Figure 2). From a biophysical perspective, 'healthy' can be defined as the capacity of a forest ecosystem to maintain vigour and organisation through resilience to stress (Costanza 1992). However, a 'healthy' forest or forest landscape can have many interpretations, including those that better reflect the diversity and depth of human relationships with forests and the interconnectedness of human health and ecosystem health. In any case, that the forest is 'adaptive' rather than 'adapted' highlights both that adaptation remains an ongoing process and that a sustainable ecosystem (consistent with SFM) is a healthy one – it maintains its capacity to recover from shocks and disturbances through autogenic processes, which can include humans but does not require ongoing or intensive interventions (Chapin et al. 1996; Whisenant 1999).

Refined definition of active management of forests

Based on our review of its usage in temperate-forest literature and considering associated concepts, we provide the following definition of active management:

> Active management is deliberate human tending of a forest or forest landscape by implementing practices or sets of practices to maintain and modify composition, structure or function towards a diverse range of potential purposes and goals. Active management sits within broader frameworks or approaches, which enact the overarching philosophy, paradigm and desired outcomes of forest management.

We use the word 'tending' to reflect the need for ongoing attention and to evoke practices that are inclusive of a diverse range of human–forest relationships, including, for example, those within First Nations cultures that are often centred in caring rather than more instrumental values. Our definition also highlights that active management is a part of, rather than a type of, forest management, which in this context is a higher-level concept that also encompasses the principles, paradigms and frameworks or approaches of management.

Considerations for implementing active management

Our definition of active management highlights considerations for its effective implementation, including clear overarching visions (based on the philosophy, paradigms and desired outcomes of management) to guide directions and/or decisions, and an agreed approach or framework to enact the vision(s). The following subsections expand on these considerations and are roughly ordered to reflect their relative position on a conceptual path like our instrumental path (Figure 2).

Refreshed visions for forest management

Changing social and environmental contexts of Australia's temperate forests highlight the need for refreshed philosophies and visions to inform and guide the frameworks that support active management. The Sustainability Charter for Victoria's State Forests (DSE 2006), for example, includes a vision to 'protect the environment and promote social and economic development for all Victorians … [including] the

long-term future of our forests, regional communities and the timber industry … '. While elements of this vision remain relevant, commitment to the long-term future of the timber industry is now inconsistent with the 2024 cessation of commercial timber harvesting in Victoria's state forests. In addition, the Charter (DSE 2006) and the National Forest Policy Statement (Commonwealth of Australia 1995) make little to no mention of the challenges presented to Australia's temperate forests by changing climate and fire regimes (e.g. Fairman et al. 2016) – challenges that are posing threats to the biophysical health of temperate forests throughout the world (Millar and Stephenson 2015; Steel et al. 2023). The Charter and National Forest Policy Statement also predate the sharp increase in policy mentions of active management from the late 2010s (Figure 1) and do not consider related concepts like adaptive management, suggesting shifts in management thinking since their release.

The development of refreshed visions for Australia's temperate forests presents opportunities – within the constraints of regulatory requirements and societal expectations – for consideration of a range of paradigms and associated principles relevant to active management. Frequent mention of adaptive management in policy documents, for example, suggests scope to explore related concepts, including those described by paradigms like RAD (Lynch et al. 2021; Schuurman et al. 2021) and resistance–resilience–transformation (RRT; Peterson St-Laurent et al. 2021), which offer principles to guide management for diverse outcomes, including resilient current forest states or transformed states. Similarly, ecological restoration has clearly stated principles to 'explain, define, guide, and measure the activities and outcomes' of restoration practices, including principles for engaging stakeholders and drawing on different types of knowledge (Gann et al. 2019). Such principles are relevant to diverse forest contexts, offering scope to define cross-tenure visions that recognise the need for coordinated planning of active management across landscapes and that remove a persistent tenure-based dichotomy of active management only in production landscapes and passive management only in reserves and protected zones (see 'Understandings of active management in temperate-forest literature').

Inclusive understandings and governance structures

With reimagined paradigms come opportunities to establish inclusive understandings and governance structures for active management that recognise and enable diverse values and cultural relationships with forests. In our review, goals for active management were overwhelmingly focused on biophysical values (Table 1), with just one paper including a goal of 'aesthetic appeal' (Webster and Jensen 2007). There were also very few mentions of social or cultural forest practices in relation to active management – an exclusion that extended to Indigenous cultural burning (except for Jackson et al. 2021), despite recognition in temperate Australia of its importance in shaping forest landscapes (Brown 1996). This absence of social and cultural values from active management literature reflects a predominance of authoritative and managerial relationships in Australian forest management, as opposed to interactive and relational approaches, which have a stronger focus on community participation in decision-making and establishing trusting relationships (Sapkota et al. 2024). It also reflects a focus on biophysical components in SFM frameworks, which can fail to capture the full range of social values (Ford et al. 2017).

Our framing of active management allows for more inclusive approaches to its implementation. To illustrate, we have also developed a 'local communities' path (Figure 3), which has a focus on participation and relationship values and potentially expands the repertoire of active management by providing a place for community-based forest practices. However, while conceptually useful, establishing such a path requires several foundational steps, including investment in social capital, sustained support and resourcing, and collaborative design of agreed and clear governance structures, including processes for resolving conflicts (e.g. Matthews and Missingham 2009). Volunteer 'Friends' groups,

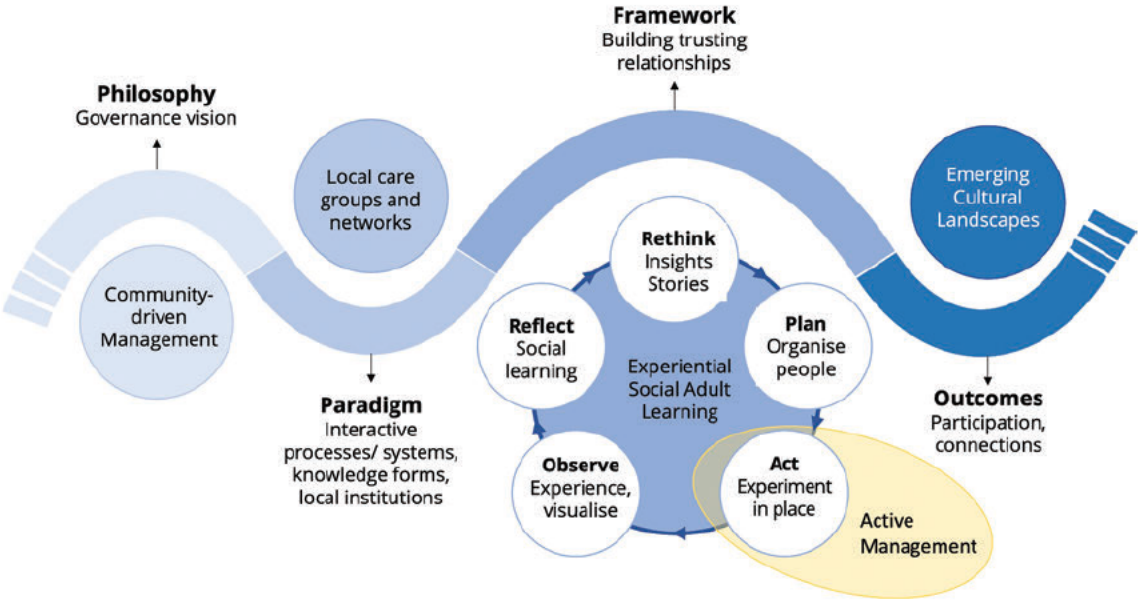

Figure 3. Example of a 'local communities' path applying a philosophy of community-driven management and a paradigm of interactive relationships with the intended outcome of emerging cultural landscapes. Active management is consistent with the 'act' step within a framework of experiential social adult learning

for example, can develop into strong institutions in partnership with government through their regular tending of places or species. In Victoria, Friends of Organ Pipes National Park have revegetated the park since the 1970s, guided by a vision of restored ecosystems. They learn through cycles of action, observation and reflection and share this knowledge as evolving shared stories (Kolb 1984; Reid et al. 2011). Over time, ecosystems have been restored towards desired outcomes alongside deep human connections with the landscape (Reid et al. 2011).

Cultural relationships with forests are situated in landscape elements, social connections and practices through time (Stephenson 2008). They provide a basis for alternative ways of considering active management based on different knowledge systems, including potential to develop further refined paths that involve 'cross-cultural, two-way or right-way work' (Ens and Turpin 2022) and steady co-learning journeys based on 'Two-Eyed Seeing' (Bartlett et al. 2012). Aboriginal ranger programs, for example, provide clear evidence of applying key principles in justice, culture and relationships for multiple benefits, including environmental conservation, human health, life satisfaction and well-being (Matthews et al. 2023). Of critical importance is equitable governance structures, including Traditional Owner-led initiatives that ensure 'Caring for Country' practices are enacted with 'relationality (centring community and their relationship to Country) and reciprocity (co-benefits for community and Country)' (Matthews et al. 2023). Such structures underpin recent Traditional Owner initiatives for forests in Victoria. For example, the Galk-galk Dhelkunya – Forest Gardening Strategy by Djaara (Dja Dja Wurrung People) articulates multiple key principles, including that 'Djaara knowledge, practice and connection with Country will define a cultural approach to planning and management, governance, decision making rights and intellectual sovereignty as the foundation for leading management' (DJAARA 2022). The Strategy's business case includes a request to lead the healing of Country, including resuming active management and developing associated long-term capabilities (DJAARA 2022). This emphasises a pressing need for an inclusive framing of active management that recognises and enables diverse values and cultural relationships with forests.

Decision-support frameworks

Our definition and example paths (Figures 1 and 2) highlight that active management sits within broader frameworks and approaches, which will enact the overarching visions and principles of forest management by providing the context and support for actions and ongoing learning. At least within an instrumental path (Figure 2), such operational approaches logically include decision-support frameworks (Hemming et al. 2022) like adaptive management frameworks, consistent with multiple mentions of adaptive management in several recent policy documents relevant to the temperate forests of Australia (State of Victoria 2020; FVTOC 2021; LCEPC 2021; Sparkes et al. 2022). As illustrated in Figure 2, adaptive management frameworks are generally described as a cycle of steps that provide rigorous structure to planning, collaboration, modelling and learning and support the identification of best-bet management strategies to meet goals despite uncertainties (e.g. Schreiber et al. 2004; Williams and Brown 2018; Lynch et al. 2022). Such structure and guidance is particularly useful where effects of active management practices are highly uncertain, high-risk or untested (see 'Active management practices under uncertainty').

Despite support for adaptive management, there are very few documented case studies of adaptive management cycles relating to Australian forests. Examples that formally identify as adaptive management programs include fox control in Victoria (Parkes et al. 2006) and variable-retention silviculture in Tasmania's wet forests (Baker and Read 2011; Scott et al. 2019). Less formally, studies that could provide knowledge relevant to adaptive management cycles include, in Victoria, long-term experiments testing silvicultural systems (Squire 1990), variable-retention harvesting (Lindenmayer et al. 2019) and prescribed fire treatments (Bennett et al. 2014), and, in Western Australia, biodiversity monitoring programs (Robinson et al. 2023). Each of these examples provides important learnings for establishing effective adaptive management frameworks to support the implementation of active management. They also highlight many potential challenges that have been acknowledged elsewhere, including very real constraints on large-scale experiments and the continuity of long-term research (Bennett and Adams 2004; Driscoll et al. 2010) that often limit inferences and learnings to short-term responses (Schreiber et al. 2004). Nonetheless, alternatives to formal adaptive management frameworks often involve *ad hoc* trial and error approaches that lack adequate planning and monitoring (Schreiber et al. 2004) and are inconsistent with more consultative relational approaches to forest management (Sapkota et al. 2024). This illustrates a potential tension in designing decision-support frameworks for implementing active management – balancing the time required to design shared goals for diverse values, choose among active management options, and monitor environmental outcomes in systems dominated by long-lived organisms (trees) with the agility required to respond to changing environmental conditions and potentially abrupt transitions in forest state (Millar and Stephenson 2015).

Goals for active management

Goals are part of the planning step in an adaptive management framework and their development will be critically important for effective active management, particularly within instrumental paths (e.g. Figure 2). For clarity, we adopt definitions from the field of ecological restoration in which goals are 'formal statements of the medium to long-term desired ecological or social condition' (Gann et al. 2019) that link targets (desired outcomes as, for example, a focus ecosystem type and associated attributes) and guide objectives ('changes and intermediate outcomes needed to attain the goals'; SERA 2021). That is, goals translate intentions into on-the-ground action (Stanturf et al. 2014) by articulating and enacting the overarching vision and principles for active management.

In acknowledging multiple aspirations and desired outcomes for forest management, goals for active management would ideally cater for diverse values. That is, an active management program will likely require multiple goals relevant to, for example, different biophysical attributes (species, structure, function) and social benefits (e.g. community well-being, engagement, knowledge enrichment; Gann et al. 2019). Such goals would arise ideally from inclusive,

transparent consultations with all interested parties, effectively providing statements of shared understandings. Given diverse views of forests in temperate Australia, and potential public unease about some active management practices (Ford et al. 2021), there will likely be several sources and forms of disagreement relating to goals of active management. Here, Williams and Brown (2018) recommended using structured approaches, including formal or informal surveys to elicit a range of feasible goals – at least some of which could be treated as working hypotheses within an adaptive management framework, including testing for impacts and feasibility with monitoring and/or experimental trials. Weights for individual goals within a set might also be considered based on resources, party agreement and available evidence (Williams and Brown 2018) and to minimise trade-offs and ensure complementary outcomes.

Goals for active management require clear understanding of target biophysical conditions, states, models and/or trajectories. Active management, using our definition, involves maintaining or modifying forest biophysical attributes (composition, structure or function). Thus, expression of goals for active management would be strengthened by improved understanding of the attributes that characterise desired outcomes (targets). A potential target for active management of a forest stand in Victoria could, for example, be based on the appropriate Ecological Vegetation Class (EVC) benchmark (DEECA 2023), which summarises the 'average characteristics of mature stands of native vegetation of the same community type in a natural or undisturbed condition' to represent vegetation or habitat of high 'quality' (Parkes et al. 2003). The concept is analogous to old-growth forest, which can act as an 'inspiring template' for active management of some forests (Jandl et al. 2019). A full evaluation of benchmark systems, including the utility of old-growth states, is outside the scope of this paper, other than to highlight that using long-undisturbed forests as targets is incongruous with elements of some paradigms not constrained by historical fidelity (e.g. RAD; Lynch et al. 2021). It is thus important that any active management project starts with shared understandings of desired forest targets that are consistent with the overarching philosophy and paradigm.

Ideally, goals for active management should be SMART (specific, measurable, achievable, reasonable, time-bound; SERA 2021). This includes goal and objective statements that are based on measurable ecosystem, socio-ecological and/or cultural indicators (e.g. Table 3). Such indicators are needed to assess progress towards goals and targets and to foster data capture and learnings required to complete an adaptive management (or analogous) cycle. As such, effective indicators need to be clearly linked to target attributes. For example, tree regeneration standards for Victoria's forests were developed with timber production in mind (i.e. strong yield and good tree form). However, such standards might be inconsistent with guidance on forest structure for biodiversity – for example the typically lower densities of large eucalypts in EVC benchmarks (DEECA 2023). More open forest states as desired outcomes are also evident in Traditional Owner strategies that include cultural thinning (e.g. DJAARA 2022), consistent with evidence of more open forest landscapes before colonisation (e.g. Howitt 1890). Designing revegetation or thinning practices to support more open forest states will thus require indicators of planting densities or retained basal area to develop goals and objectives towards the target open state. Alternatively, where attributes of desired targets are difficult to define or agree on, Matonis et al. (2016) highlighted the potential benefits of instead focusing on undesirable forest conditions to frame goals that better acknowledge ecosystem variability, risks and uncertainties.

Finally, goals for active management will necessarily encompass multiple temporal and spatial scales. Active management is 'tending', meaning potential cycles of single or sets of practices over a range of potential periods, from short- to long-term, as relevant. Environmental conditions and societal expectations of forests are constantly changing, the probabilities of damaging climate or fire events are highly uncertain, and there can be lags between practice implementation and desired or undesired outcomes. Active

Table 3. Hypothetical example of target, goals, objectives and indicators for active management of degraded snow-gum open forests in Victoria's subalpine region

Current condition	Snow-gum open forests (~3600 ha) burned by three short-interval wildfires between 2003 and 2013; assessed as degraded based on elevated tree mortality (50% of clumps dead), poor tree seedling recruitment, and greater abundance of grasses at the expense of shrubs compared with long-unburned comparable forests (Fairman et al. 2017)	
Target[a]	Snow-gum open forests restored to the extent of their pre-degradation distribution, with composition, structure and function within the envelope of variation defined by the agreed reference models	
Goal[b]	Objective[b]	Indicator(s)[b]
(1) 100% support by all stakeholders within 2 years	Engagement with all stakeholders and communicated restoration plan within 2 years	Documented engagement activities Restoration plan Communications plan
(2) Recovering populations of snow gums across the degraded area within 5 years	Regenerating seedlings or saplings of snow gum established at >75% of assessed sites at densities consistent with reference model trajectories within 5 years	Seedling and sapling densities
(3) Native shrub layer recovered across the degraded area within 10 years	Composition and cover of all native shrub functional groups consistent with reference model trajectories at >60% of assessed sites within 10 years	Shrub species presence/absence Shrub species cover Shrub functional groups
(4) Protection of the degraded area from further fire for at least the next 20 years	Extent of area burned by high-severity fire limited to <10% of the 3600 ha within the next 20 years	% extent of area burned by high-severity fire

Note: [a]The (hypothetical) target was developed after consultation with all interested parties, including development of a set of agreed reference models representing multiple potential successional trajectories based on a diversity of information sources, including assessment of non-degraded local sites and Indigenous knowledge systems (Gann et al. 2019); [b]goals and objectives are ideally specific, measurable, attainable, relevant and time-bound ('SMART'); goals indicate how the target status might be achieved, objectives state the shorter-term outcomes needed to achieve the goals, and indicators are the measures used to assess success (terminology after SERA 2021).

management goals thus need to cater for change over time by being stepwise or provisional and open to adjustment based on captured data, shared learnings and changed preferences and perspectives (i.e. as per the adaptive management cycle; Williams and Brown 2018). Equally, active management practices in forests involve a range of spatial scales, from individual species (e.g. *in situ* protection of rare species) and entities (e.g. protection of large trees) to locations or stands (e.g. revegetation, thinning, intensive fuel management), to landscapes (e.g. suppressing wildfires, protecting climate corridors, maintaining water quality and quantity; Tables 1 and 4). Because forest landscapes are composed of multiple stands, and stands are composed of species and entities, goals for active management should be integrated across scales, reflecting a network of interactions and patterns that underpin complexity and contribute to ecosystem- and landscape-level resilience (Hobbs and Cramer 2003).

Active management practices under uncertainty

Meeting targets and goals for active management requires robust planning involving criteria and tools to choose among practice types, intensities and configurations across scales. To be adaptive to uncertain futures, criteria for practice selection can be guided by broad principles relating to adaptation options (see Table 2) or more explicitly described and tested. Adaptation pathways, for example, provide a means to envision multiple possible futures, including identifying potential tipping points ('what is likely to change in the biophysical system?'), turning points ('what are the plausible game changers in the socioeconomic conditions or rules?') and trigger points ('the necessary lead time for action before a turning point is reached'; Bosomworth et al. 2015). Useful in the context of Australian temperate forests, adaptation pathways are designed to acknowledge uncertainty and change, providing alternative routes to achieving the same future goal, including immediate and contingency actions (Serrao-Neumann et al. 2015). Nonetheless, there are very few examples of adaptation pathways that have been developed to support forest management – although see Colloff et al. (2016) for a simple example relating to eucalypt ash forests.

Adaptation options and pathways recognise the potential complexities involved in selecting active management practices, including the need to consider diverse forest values, a range of temporal and spatial scales, and uncertain future climate and disturbance regimes. This complexity requires a diversity of approaches to support decisions, including identifying the 'issue type' – for example, those requiring 'judgement' (high uncertainty about the system and parties agree on the goals), 'inspiration' (high system uncertainty, parties disagree), 'bargaining' (low system uncertainty, parties disagree), or 'computation' (low system uncertainty, parties agree; Bosomworth et al. 2015). Of the latter, decision-support systems provide increasingly sophisticated software frameworks to integrate experiential knowledge with management systems and operational and analytical research models across forest landscapes (Nitschke et al. 2017). For example, by incorporating spatially explicit fire behaviour models, future climate projections and management effects (e.g. Penman et al. 2022), they offer a probabilistic way to explore adaptation pathways with quantified uncertainties for a range of forest values over time and across landscapes. They also provide a way to explore trade-offs and contested values or practices and to identify potential barriers to transformational change, including information gaps and social acceptance (Himes et al. 2023). Here, there remains considerable scope to develop and trial new approaches to test the waters before active management practices are implemented, including, for example, diagnostic problem-structuring methods that have been proposed for adaptation pathways (e.g. Bosomworth et al. 2017).

Guidelines for implementing active management practices

A range of new and revised guidelines to support in-field practice implementation will be required to cater for diverse goals of active management within decision-support frameworks. Many prescriptions for forest practices in temperate Australia have been developed to support wood production. In Victoria, for example, silvicultural practices were designed and refined according to management standards (e.g. DELWP 2021a) that were developed to meet the requirements of the *Code of Practice for Timber Production* (DEPI 2014). There are also silvicultural reference manuals by broad forest types (e.g. Flint and Fagg 2007) and native forest silviculture guidelines for a range of practices, including seed crop monitoring (Bassett 2011), browsing management (Poynter and Fagg 2005), eucalypt planting (Bassett et al. 2010) and thinning of box–ironbark (Fagg and Bates 2009) and red-gum forests (Fagg 2010). Although some of the information will be redundant due to the 2024 cessation of commercial timber harvesting in Victoria, the guidelines contain useful insights into practices that could be implemented for non-timber goals. For example, specifications for seed-related practices (monitoring, collection, extraction, testing, coating) are highly relevant for restoration of forests degraded by short-interval fires (e.g. Bassett et al. 2015), and ecological thinning (as specified in the box–ironbark and red-gum thinning guidelines) remains relevant as a potential practice for multiple values. Importantly, the silvicultural guidelines provide the rationale for implementing practices and a summary of evidence for prescriptions, including acknowledged uncertainties. As such, they provide a useful source and template for developing new guidelines and for capturing and communicating new evidence and learnings.

The appetite for diverse active management practices could outpace the availability of operational prescriptions for their implementation. As an example, there are many practices – beyond those identified in our review (Table 1) – that are described as relevant to goals for climate-change adaptation of forests (Table 4). Some of these practices are supported by evidence, but issues and uncertainties have been identified for others (Table 4). This reflects a general lack of rigorous evaluation of many adaptation-related practices (Hansen et al. 2023), including a 'relatively poor' knowledge base to support practice implementation in Australia's forests (Keenan 2017). While this could in part be due to a lack of opportunity to test new approaches and technologies, there might also be an element of playing catchup with new or multifaceted expectations for some practices. For example, ecological thinning has many potential purposes, including encouraging larger stems sooner for habitat and fire resistance, enhancing tree recovery from drought and other stressors, reducing fuel loads, and increasing forest water yields (Baker 2023). Nonetheless, ecological thinning

Table 4. Active management practices or strategies identified as relevant to climate-change adaptation of forests, broadly grouped under the 'resist' and 'direct' options of the RAD framework (Lynch et al. 2021)[a]

Option type	Category	Practice or strategy	Intended benefits[b]	Potential issues[c]	References
Resist	Protection	Protect old and/or large trees	A, S, B		Piovesan et al. (2022); Williams et al. (2023)
		Protect old-growth forests	A, B, S,		Ogden and Innes (2008)
		Maintain climate refugia	B, R		Millar et al. (2007); Ogden and Innes (2008); Peterson St-Laurent et al. (2021); Schuurman et al. (2021); Hylander et al. (2022); Thurman et al. (2022)
		Maintain ecosystem refugia	B, R		Hylander et al. (2022); Coop (2023)
		Maintain buffers around refugia	P, A		Hylander et al. (2022)
		Protect hydrological networks	B, E, RD		Hylander et al. (2022); Keenan (2017)
	Composition	Promote genetic/species/functional diversity	H, B, R		Peterson St-Laurent et al. (2021)
	Restoration	Reseed/replant to restore species	FP, B, S		Ogden and Innes (2008)
		Restore ecosystems	FP, H, B, R		Millar et al. (2007); Schuurman et al. (2021); Coop (2023)
	Ex situ	Seed banking	PS, B		Millar et al. (2007)
		Tree propagation in arboreta	PS, B		Ogden and Innes (2008); Piovesan et al. (2022)
		Nursery regimes for hardiness	RD		Keenan (2017)
	Disturbance management	Wildfire suppression or exclusion	P, A	B-	Millar et al. (2007); Schuurman et al. (2021); Coop (2023); Thom (2023)
		Prescribed burning for fuel hazard reduction	P, A	BUV	Jandl et al. (2019); Prichard et al. (2021); Collins et al. (2023); Thom (2023)
		Invasive species management	P, H, B, R		Millar et al. (2007); Ogden and Innes (2008); Peterson St-Laurent et al. (2021)
		Pathogen management	P, A, FP		Ogden and Innes (2008)
	Landscape configuration	Maintain structural heterogeneity	B, R		Cova et al. (2023)
		Maintain diverse forest states/conditions	H, RR		Millar et al. (2007); Ogden and Innes (2008); Zhu et al. (2023)
		Maintain connected landscapes	B, R		Millar et al. (2007); Ogden and Innes (2008); Peterson St-Laurent et al. (2021); Hylander et al. (2022)
Direct	Composition	Promote/introduce climate-adapted genotypes (planting, silviculture manipulations)	R, FP		Ogden and Innes (2008); Hylander et al. (2022)
		Promote genotypes/species with beneficial traits	FP, RD, RF		Hylander et al. (2022); Thom (2023)
		Plant/seed non-local provenances (climate-adjusted, threat-resistant)	FP, B, R		Harrison (2021); Thurman et al. (2022)
		Plant/seed novel plant species (climate-, fire-, drought-resistant)	FP, E	B-, H-	Millar et al. (2007); Millar and Stephenson (2015); Jandl et al. (2019); Peterson St-Laurent et al. (2021); Schuurman et al. (2021); Coop (2023)
		Relax seed zoning rules	B		Ogden and Innes (2008); Keenan (2017)
		Assisted migration of tree species	PS, FP	EG, H-	Millar et al. (2007); Ogden and Innes (2008); Clark et al. (2022); Kusbach et al. (2023); Royo et al. (2023)
	Structure	Thinning	V, E, RD, RF, RR	BUV, B-, EG	Horner et al. (2009); Millar and Stephenson (2015); Jandl et al. (2019); Keenan et al. (2021); Fulé et al. (2022); Moreau et al. (2022); Weston et al. (2022); André-Alphonse et al. (2023); Navarro-Cerrillo et al. (2023); Young et al. (2023); Vernon et al. (2023); Taylor et al. (2021a, 2021b)
		Planting/seeding densities	V		Jandl et al. (2019)
	Function	Fertilise to enhance tree growth	V, R, E		Ogden and Innes (2008)

[a]The practice list assumes currently forested landscapes (i.e. omits afforestation/reforestation of cleared land) and no commercial extraction of forest products (i.e. omits adaptations to harvesting regimes); [b]intended benefits as identified in the cited papers (i.e. not exhaustive of all intended benefits): A = protects, maintains or enhances natural assets (including keystone structures like large trees); B = protects, maintains or enhances forest biodiversity (including genetic diversity); E = protects, maintains or enhances ecosystem service provision; FP = protects, maintains or enhances persistence of forests and associated functions; H = protects, maintains or enhances general health (including general ecosystem function); *p* = protects against damaging agents (generally), and to reduce non-climatic stresses; PS = maintains or enhances retention of priority species; *R* = maintains or enhances general resilience; RD = maintains or enhances resilience to drought; RF = maintains or enhances resilience to fire; RR = reduces risks generally, including risk distribution or spreading; S = maintains or enhances forest structure; V = maintains or enhances forest vigour, including productivity; [c] potential issues, as identified in the cited papers (i.e. not exhaustive of all potential issues): B- = benefits can be opposite to those intended in some forest types; BUV = benefits uncertain or variable; EG = lack of operational evidence; H- = potential to cause negative effects on forest health.

remains underevaluated in most forest types of temperate Australia, including minimal field-based evaluation of how thinning mitigates tree drought stress in eucalypt-dominated forests. This limits the scope for defining ecological thinning prescriptions and ensuring that thinning to low retained basal area does not exacerbate tree water stress (i.e. maladaptation) by increasing within-stand atmospheric dryness (e.g. André-Alphonse et al. 2023). Equally, although a few studies have examined the utility of thinning to reduce fire risks (e.g. Volkova and Weston 2019; Taylor et al. 2021a, 2021b; Weston et al. 2022), results relating to eucalypt forests 'demonstrate mixed outcomes' (Keenan et al. 2021), suggesting there will be ongoing challenges with developing ecological thinning prescriptions for fire risk, let alone multiple values.

Interim working guidelines may be required for many active management practices to account for lags in available empirical evidence. These would require compilation and interpretation of diverse forms of knowledge, including personal understandings, literature reviews, meta-analyses, modelling and monitoring (Bernes et al. 2018; Hansen et al. 2023); they will also require clear statements of risks and uncertainties that in turn highlight areas of focus for new knowledge generation. Here, there is scope to prioritise and tailor evidence requirements by identifying levels of agreement and uncertainty. For example, evidence requirements for prac-

tices that have low uncertainty and non-contested outcomes might be less exacting and urgent than those that have high uncertainty and considerable disagreement about benefits (after Bosomworth et al. 2015). That is, just as active management implementation needs to be responsive to the pressing challenges posed by changing environmental and social conditions, so too does the generation of new evidence, requiring a 'reconceptualisation' of empirical approaches (Prober et al. 2019), including commitments to embed and capture learnings within multifaceted adaptive management cycles.

Building the evidence base for active management

A focus on learning through adaptive management provides opportunities to strategically design monitoring and research to improve the evidence base for active management. Adaptive management cycles for active management capture the outcomes of implementing single and contrasting practices (Williams and Brown 2018), including both technical and institutional learnings (Lynch et al. 2022). This is more than monitoring to confirm implementation or to check compliance with regulations – it is an ongoing commitment to the generation of new knowledge based on data captured during and after practice implementation that are analysed and tested against the collective understandings and assumptions established in the planning step (Schreiber et al. 2004), providing opportunities to revisit decisions, expectations, goals and practices (Williams and Brown 2018).

Well-designed targeted field experiments that embed research processes (e.g. critical analysis of data relative to research questions or hypotheses) remain the best option for providing new evidence and reducing uncertainties about active management practices (Hansen et al. 2023). This is particularly critical for new or contested practices, providing an avenue to test efficacy but also to reveal the unexpected in a contained way before widespread implementation (Prober et al. 2019). Potential for well-designed and targeted trials to ameliorate concerns about novel or contested practices is consistent with evidence from a recent study in Victoria that examined the views of interest groups and the public about different forest practices. Extensive implementation was not supported where practices were perceived to be potentially risky (reseeding with new species of plants) or 'ecologically damaging' (thinning); however, there was more consistent support from people of diverse backgrounds for small-scale trials that included research to improve evidence and reduce uncertainties (Ford et al. 2021).

Long-term trials and monitoring programs will provide the strongest inferences about the success of active management practices relative to goals. Long-term evidence is particularly important in forest ecosystems where there can be decades-long lags between implementing a practice (e.g. translocating climate-adapted tree provenances or species) and detecting a negative outcome (e.g. 'cryptic maladaptation' in the form of tree death after unanticipated climate extremes; Benito-Garzón et al. 2013). Several long-term studies have been established in the native forests of eastern Australia, as recently summarised by Turner (2023). These have had mixed success, with key challenges being insufficient statistical power due to poor replication in the experimental design (Bennett and Adams 2004) and insufficient longevity to implement treatments and monitoring over meaningful timeframes, to curate and store data for future analyses, and/or to widely communicate key results (Turner 2023). Nonetheless, there remains considerable scope to document and learn from approaches and programs that have led to effective change (Lindenmayer et al. 2010). For example, there are several recent examples in the international literature of well-designed active management trials providing urgently needed data about adaptation plantings for climate change (Clark et al. 2022) and about restoration treatments to reduce forest vulnerabilities to damaging agents (Stephens et al. 2023). There might also be further opportunities to embed research-based monitoring in routine operations (e.g. evaluation and modelling of different fuel management techniques; Furlaud et al. 2023) and to opportunistically monitor 'natural experiments' leading to changed forest states, like the windthrow events that felled trees across extensive areas in central Victoria in 2021. In addition to improving empirical evidence, the collection and communication of long-term data can provide motivation for community support for ongoing or additional works (Lindenmayer et al. 2010), thereby enhancing social licence for more elements of active forest management (Ford et al. 2021).

Conclusion

Based on its representation in temperate-forest literature and in relation to associated concepts, we have established that active management is principally about human activity in forests and that it is a part of, rather than a type of, forest management. Active management involves the deliberate tending of an area of forest towards purposes or goals, which can be environmental, socioeconomic and/or cultural. It is not implemented in isolation but sits within broader frameworks or approaches that effectively represent and enact the overarching aspirations (philosophy, vision, paradigms) for forest management. This framing highlights some of the complexities of active management, namely the challenges associated with developing SMART goals for diverse potential purposes, choosing among multiple potential practices, and coordinating those practices in space and time, often in a context of high uncertainty (environmental, social, economic, and their combinations).

Our review clarifies the position of active management relative to associated concepts like adaptive management; namely, adaptive management can be both a paradigm for forest management and an operational framework, whereas active management is the equivalent of the implement step within an adaptive management or analagous framework. This highlights the potential for decision-support frameworks like adaptive management frameworks to structure the planning for active management and to capture evidence and collective learnings for subsequent decisions that are responsive to changing conditions. Given multiple sources of uncertainty, there is a pressing need to improve the knowledge base underpinning the implementation of active management within decision-support frameworks for Australia's temperate forests. This includes generation of diverse forms of knowledge suited to adaptive learning cycles (Driscoll et al. 2010), including evidence from existing case studies in and beyond Australia and from targeted trials of novel active management practices within adaptive management cycles that anticipate

challenging decisions, including those involving new forest trajectories and shifting societal values and expectations.

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Appendix. Review of active management usage in temperate-forest literature

Searches for the review were designed to provide an unbiased 'sample' of how active management is understood in temperate-forest literature. The two searches, to February 2024 inclusive, were as follows:

- Web of Science 'topic' search of title, abstract, author keywords and keywords plus: **(Forest* or tree*) AND temperate AND ("active management" or "active forest management")** – 50 papers
- Google Scholar search of entire paper: **"forest" OR "tree" AND "temperate" with exact phrases – "active management" OR "active forest management"**; filtered to include the 20 'most relevant' review articles after removing duplicates from the Web of Science search.

The 70 reviewed papers were:

(1) Allek A, Viany Prieto P, Korys KA, Rodrigues AF, Latawiec AE, Crouzeilles R. 2023. How does forest restoration affect the recovery of soil quality? A global meta-analysis for tropical and temperate regions. Restoration Ecology. 31(3):e13747.
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Reshaping forest management in Australia to provide nature-based solutions to global challenges

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ABSTRACT

It is time to move beyond the era of conflict and develop a new shared vision for the management of Australia's public forests. We need more holistic approaches that encompass all forest values across the landscape, rather than the current approach of dividing public forest management up across different government agencies. More collaborative approaches will be required to galvanise the resources, skills and knowledge that enables this shift in shared governance. Recent bushfires in Australia have heightened concerns that the management of public forest lands has largely failed to ensure the health of forest ecosystems, build resilience, and secure a promised balance between economic, social and environmental values. Investment in efforts to adapt forest management to address climate change has been limited; and empowering and increasing the role of Indigenous Australians in forest management could be significantly improved. Furthermore, the COVID-19 pandemic has highlighted the need to improve the resilience of regional communities to major shocks and stresses caused by factors that encompass market dynamics, supply-chain disruptions and natural disasters. Three key strategies are proposed to strengthen forest management in Australia: first, establishing new shared governance models that bring together government agencies with Indigenous Australians and actors from the private sector and civil society; second, extending active and adaptive management across forest landscapes that builds resilience in our forests, local communities and society; and third, integrating traditional knowledge with scientific evidence and innovative technologies to enhance forest management for improved resilience and other outcomes.

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Introduction

There is a need for new approaches to forest management in Australia. Forests play critical roles in conserving biodiversity, storing carbon and providing a wide range of environmental, social and economic benefits to society. However, internationally and in Australia, there are concerns about forest ecosystem health (MPIGA & NFISC 2018; WWF 2020). Land clearing, bushfires, invasive species, climate change and the interaction between these factors present ongoing and serious challenges to forest values (Jackson et al. 2017). Despite what is arguably an increasingly stringent regulatory environment and the ongoing expansion of the conservation reserve system, indicators of forest-dwelling and forest-dependent[1] threatened species and the condition and extent of some forest habitats continue to decline (MPIGA & NFISC 2018).

Amid these concerns, a body of opinion and media coverage often presents timber harvesting as a primary threat to forest ecosystems and suggests that ceasing timber harvesting will protect threatened species and habitats and reduce the risk of severe bushfires (Lindenmayer et al. 2020). Yet the situation is far more complex. Major threats to forest cover and forest ecosystems are a result of a historical legacy of extensive clearing of forests, as well as ongoing impacts of urban expansion, feral cats and other invasive species, changes to the frequency and intensity of fires, and climate change (Woinarski et al. 2015; Jackson et al. 2017; Wintle et al. 2019).

The 1992 National Forest Policy Statement (Commonwealth of Australia 1992a) sets out a vision for the ecologically sustainable management of Australia's forests. The policy aims to deliver the full range of benefits that forests can provide now and in the future. Regional forest agreements (RFAs) provide the planning framework for implementing the goals of this policy statement in those regions in which natural forest wood production is important (Davey 2018). RFAs were developed to be 'long-term bilateral agreements that *strike a balance between the environmental, social, and economic uses of forests*' (emphasis added; DAWR 2019). However, it is apparent that this policy planning framework has not provided an effective or enduring mechanism for presenting and addressing trade-offs between values or for engaging the broader public in managing those trade-offs and providing assurance that different values are being properly considered.

Consequently, the priorities for managing public forests have swung over time between timber production and conservation, depending on political interests, rather than managing for all values and balancing environmental, social and economic goals. Jacobsen et al. (2020) reports an increase in the reserve system during the 20-year period of RFAs, with a corresponding decrease in areas available for harvesting wood products and sustainable yields of sawlogs on public land in these regions. Yet funding and resourcing for national parks have not evolved commensurate with the increases in area reserved, and economic activity from timber harvesting and the numbers of skilled forest workers have declined.

Forests have become political battlefields, and there appears to have been limited success in generating community

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[1]Forest-dwelling species are species that *may* use forest habitat for all or part of their lifecycles; forest-dependent species are species that *must* inhabit a forest habitat for all or part of their lifecycles (MPIGA & NFISC 2018).

agreement on the right approach to managing public forests. This situation is being exacerbated by the stresses imposed by large-scale bushfires and invasive species. Furthermore, there is limited evidence that changes in forest management are adequately addressing climate change or incorporating the interests, perspectives and traditional practices of Indigenous Australians and the changing views of society (Jackson 2019).

Improving the management of Australia's public land forests is constrained by community conflict, adverse media coverage, misinformed public debate, and stakeholder relations tarnished with acrimony.[2] As in other arenas of Australian public life, a focus on short-term political advantage has seen the promotion of simplistic solutions to complex problems. These solutions are not achieving conservation goals across the landscape, but they are generating considerable uncertainty for forest-based industries. There is little evidence that the situation will improve without a substantial change of approach (Kanowski 2017; Jackson 2019; Keenan 2019).

However, the 2019/20 Black Summer bushfires (Davey & Sarre 2020), closely followed by the COVID-19 pandemic, should provide the impetus to 'build back better' (OECD 2020); specifically, it should lead to changes in forest management to improve conservation measures, enhance forest resilience, and strengthen the capacity of regional communities and those in the wider economy to manage challenges in the future.

A holistic approach

New approaches are now needed to address these forest management challenges in Australia. We need more holistic approaches that encompass all forest values across the landscape, rather than the current approach of dividing up forest management across different government agencies and designated land management authorities.

We also need to ensure that forests are managed to enhance their resilience and enable them to recover from disturbance impacts and threats created by climate change and other factors. Forest resilience is vitally important for ecosystem health.

Increasing the resilience of forest ecosystems will help conserve biodiversity and sustain a broad range of ecological values. It will also support the development of sustainable livelihoods for regional communities. This view is underpinned by the paradigm that safeguarding human health, wealth and security is intrinsically linked to safeguarding environmental health (WWF 2020).

In this way, contemporary approaches to forest management will provide nature-based solutions to current challenges such as adapting to climate change and economic recovery from the COVID-19 pandemic. The International Union for Conservation of Nature (IUCN) describes nature-based solutions as:

> 'actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits' (IUCN 2020).

A more holistic and integrated approach to achieving the ecologically sustainable management of Australia's public land forests can provide a nature-based solution with the following outcomes (Figure 1):

- Resilient and healthy forests that enable communities to deal with climate change, bushfires, and other threats.
- Management of forest lands for all forest values, including the culture, knowledge, values and rights of Aboriginal and Torres Strait Islander peoples.
- Forest land management that supports a more circular, robust low-emissions economy to enable sustainable development and actively address climate change by using renewable resources, reducing waste, and recycling products through sustainable production systems with relatively low emissions-intensity profiles.

New forest management strategies

We suggest that desired outcomes for forests can be achieved by implementing three interlinked strategies (Figure 1), discussed in turn below:

(1) establishing and applying new shared governance models that bring together government agencies

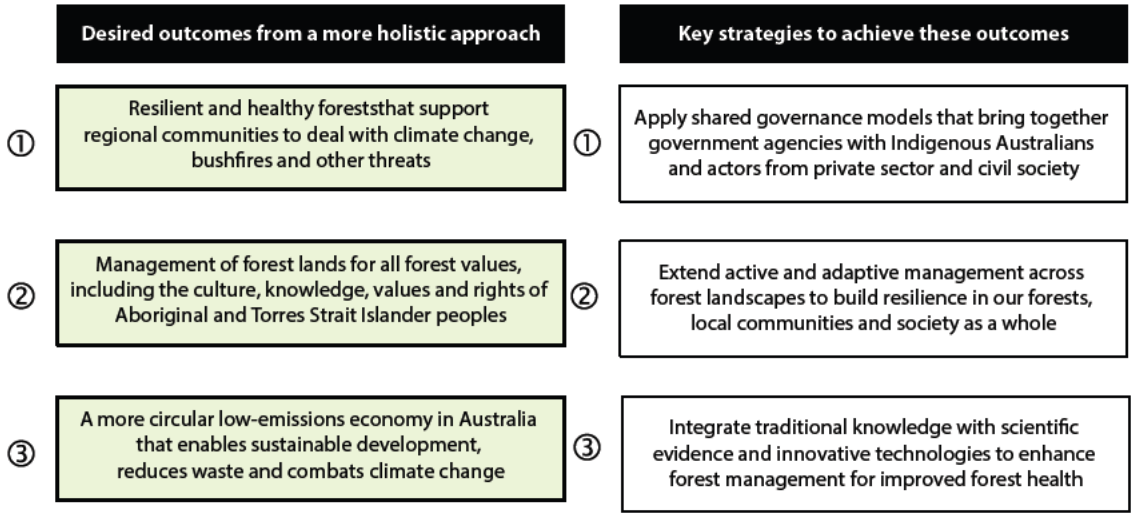

Figure 1. Key considerations for the development of a new shared vision for Australia's forests.

[2]See this relevant example of reporting on community conflict over forest management in Australia: https://www.theguardian.com/environment/2018/mar/20/regional-forest-agreement-renewals-spark-fresh-forest-wars.

with Indigenous Australians and actors from the private sector and civil society
(2) extending active and adaptive management across forest landscapes that builds resilience in our forests, local communities, and society as a whole
(3) integrating traditional knowledge with scientific evidence and innovative technologies to enhance forest management for improved forest health and resilience.

Establishing new shared governance for integrated, collaborative management

First, there is a need to manage forest lands as an integrated whole. Thackway et al. (2005) proposed an integrated framework for managing forest and non-forest lands by applying ecosystem-based approaches to bioregional land management and planning.

Forest governance is complex, in large part because forests can provide many different values, and this has often generated conflict between those with different views (Keenan 2019). In Australia, forest governance models are predominantly tenure-based and, in broad terms, there is limited integration across institutions, landscapes and tenures (Kanowski 2017).

These observations have given rise to previous calls for new approaches to policy development and implementation that 'recognize and accommodate the plurality of interests in forests', enhance coordination and integration between institutions and across landscapes, and empower and enable the diverse communities of interest in forests (Kanowski 2017).

International research on new governance models for natural resource management reflects an increasing preference for more collaborative approaches that bring together government and non-government actors from the private sector and civil society, including First Nations and Indigenous Peoples. New governance models need to have the capacity to deal with complexity and uncertainty; manage interdependencies among actors; foster connectedness between diverse interests at different scales and across jurisdictions; and galvanise resources, skills and knowledge more effectively than current conventional government practice (Lockwood et al. 2010).

An extensive study of natural resource management authorities in Australia led to the identification of eight principles that can be used as guidance for the establishment of good-practice, multilevel governance: legitimacy; transparency; accountability; inclusiveness; fairness; integration; capability; and adaptability (Lockwood et al. 2010). These principles are also relevant for addressing the complex environmental policy challenges presented by forest management. Although similar principles were applied in the assessment of ecological sustainable forest management in developing RFAs in the 1990s (Davey 2018), there has been no continued monitoring of these principles to ensure the realisation of good-practice, multilevel governance across public forest landscapes.

There is no 'one size fits all' arrangement. To address current and emerging challenges facing Australia's forests, we need new and innovative governance models and partnerships that:

- respect the culture, knowledge, practices, values, views and rights of Aboriginal and Torres Strait Islander peoples and the overall interests of society
- genuinely engage stakeholders in forest-related decisions that affect them, with clear recognition that the health of our society is closely tied to the health of our forests
- monitor governance arrangements to ensure the integrated and collaborative management of all forest values across the public forest estate
- enable the Australian community to develop an improved understanding of the functioning and benefits of forests and the need to actively manage forests
- ensure that the benefits of forest management primarily flow to regional communities, thereby providing the resources needed for local management, jobs, enterprises and social benefits
- promote collaborative decision-making processes that are transparent, fair and effective.

Canada, Finland, Germany and Sweden all have leading examples of shared-governance models that show how forest management functions can be integrated across government (Moore & Tjornbo 2012; Borrass et al. 2017; Eriksson et al. 2018; Rantala et al. 2020). In Canada, landmark agreements have been reached between provincial governments, First Nations, industry and non-government organisations (Price et al. 2009). In the Nordic countries, there are durable models in which single forest management agencies have responsibility for managing forests for conservation and sustainable use.

Australian states and territories should develop integrated land management agencies that include a clear focus on native title settlement processes, collaborative management, and increased accountability for all forest values.

Extending active and adaptive management across forest landscapes to increase forest resilience

Second, there is a need for active and adaptive management across forest landscapes to strengthen their resilience to climate change, bushfires and other threats.

In the wake of last summer's bushfires across Australia (Davey & Sarre 2020), there were calls for public natural forests to be left untouched to recover (Lindenmayer et al. 2020). Certainly, extensive areas of burnt forest now need to be protected and carefully managed to enable natural recovery processes to take effect. However, the paradox of this situation is that one of the primary causes of the destructive impacts of those and previous bushfires has been a 'lack' of active and adaptive land management over past decades (Morgan et al. 2020)—specifically, a lack of fuel reduction and limited development of forest mosaics and strategic fire breaks to slow or halt the spread of fires. Humanity has altered forest landscapes to such an extent that they now require active management to ensure ecosystem health and build resilience to bushfires and climate change.

International wildfire experts note that mitigating bushfire disasters will require greater use of prescribed burning in suitable forest types to reduce bushfire risks and impacts (Moreira et al. 2020; Morgan et al. 2020), while recognising it is not a panacea for major bushfires and can have limited impact on slowing major bushfires under extreme conditions

(Hislop et al. 2020). Similarly, leading forest policy researchers have observed the need for a national bushfire policy and that active land management such as prescribed burning and forest thinning must be at the core of any such policy.

Rather than leaving nature to take its course, there is a need for the more active and adaptive management of forests to maintain or enhance ecological functionality and improve forest resilience to shocks such as landscape-scale severe bushfires and the impact of climate change. The need for adaptive forest management as a prerequisite for sustainable forestry in the face of climate change is recognised by European ecologists (Bolte et al. 2010)—an integral part of an overall strategy of 'avoiding the unmanageable and managing the unavoidable' (Bolte et al. 2010, p. 116) and, specifically, of avoiding climate change becoming a global catastrophe.

In the United States of America, extensive fires have ravaged forests and rangelands across the western states over the past two decades (Williams et al. 2019). In the face of catastrophic fires in 2020, occurring less than two years after the devastating bushfires of 2017 and 2018 that burnt over 1.4 million ha, California's Deputy Director of Resource Management stated:

> 'We're kind of past the point of "Do No Harm". We're going to have to have forest management. It's challenging but not unsolvable . . . We have the leading scientists and there is an emerging consensus on best practices. It's now a matter of learning by doing it, and just getting dirty' (Helvarg 2020).

Indigenous Australians are also calling for more active and adaptive management to care for country and keep it healthy. In Victoria, the Federation of Traditional Owners has stated that we need a more holistic and landscape view of planning and management:

> 'We view the natural world within an interconnected ecological, cultural and livelihood system. Land and waters managed for landscape and community health require active management to be able to restore, maintain and enhance its biodiversity and to improve its ability to effectively recover from shocks and stresses. We take a holistic and landscape view for planning and management, using fire as an integral management tool for maintaining a productive landscape' (DELWP 2017, p. 7).

Active management means a preparedness to conduct interventions that will conserve and restore biological diversity, ecological functions and evolutionary processes at multiple spatial and temporal scales. It incorporates better management of fires, with effective use of prescribed burning, through methods that include traditional Aboriginal land management and cultural burning (Binskin et al. 2020; Morgan et al. 2020; Owens & O'Kane 2020). It may also include silvicultural interventions to restore or enhance structural diversity and increase resilience to bushfires and other shocks while maintaining biodiversity at the landscape level (Messier et al. 2014; Gonsalves et al. 2018).

To be clear, active management is not a call for commercial timber harvesting in national parks and conservation reserves. It is a call to recognise forests as complex systems and to actively manage forests for their health, to maintain their full range of values and to build resilience (Woinarski et al. 2011). Active management includes reducing the threats to forests, preparing forests for future threats, maintaining the capacity of forests to recover after disturbances, and restoring forests that have been degraded.

Adaptive management acknowledges the complexity of natural ecosystems and the uncertainty associated with a broad range of biological, political, social and climatic challenges facing forests. In North America, there is a substantial body of research based on managing forests as 'complex adaptive systems', which provides a scientific foundation that not only acknowledges and accommodates uncertainty but also helps both production- and conservation-oriented forest managers as well as policymakers to better understand how ecosystems respond to change and how management can influence these responses (Messier et al. 2014).

Adaptive management is promoted worldwide as an ongoing process of regularly setting and reviewing management objectives based on credible evidence, consulting with stakeholders, implementing forest management and conservation actions to achieve the planned objectives, and monitoring and evaluating the effectiveness of forest management as well as changes in forest health. Adaptive management requires robust modelling based on multiple lines of evidence that clearly shows the likely outcomes of forest management action or inaction. The effectiveness of forest management should also be regularly evaluated against the outcomes forecast by models. Such an approach can provide stronger assurance to a broad range of stakeholders that Australia's forests can be managed responsibly and sustainably.

Current and emerging technologies, including multi-satellite coverage and drones that provide increasingly clever and cost-effective ways to closely monitor forest health and key biodiversity metrics, will enable more timely adjustments to management strategies and actions.

Australia should develop systems, processes and models to support a new approach to managing public forests that incorporates active *and* adaptive management across forested landscapes.

Integrating traditional knowledge with scientific evidence and innovative technologies

Third, there is a need for comprehensive, reliable and timely data and information on the status and trend of a broad range of forest indicators, including ecological integrity, ecosystem services and the benefits and costs for society.

While improvements in the completeness and availability of data on key indicators used in forest management have been made in recent decades (MPIGA & NFISC 2018; Read & Howell 2019), substantial data gaps remain (MPIGA & NFISC 2018). In some cases, data and information do not cover a sufficiently long period to allow the assessment of trends in forest indicators. Critically, information on the impacts of climate change on forest management is inadequate (see Keenan 2017), and publicly available data and reports do not readily allow the determination of management effectiveness both within and outside the national reserve system in terms of biodiversity goals.

Further work and funding are also required to expand and bring together research, scientific assessment and traditional knowledge to identify and prioritise active and adaptive management opportunities. As pointed out by Kile et al. (2014), Ferguson (2015) and Kanowski (2017), Australia's research capacity to support adaptive forest management has declined significantly with each decade since the 1980s. Turner and Lambert (2016) reported forest research

expenditure in Australia in 2013 at around AUD 48 million, which represented a reduction of about 60% from forestry research expenditure in the mid-1980s.

Although Australia's knowledge generation and analysis relevant to forests is relatively substantial and sophisticated, Kanowski (2017) noted that some of the key challenges are more at the interface between knowledge and governance, and in the integration across sectors, than in the limitations of knowledge itself. Notwithstanding this, knowledge remains contested in various arenas of Australian forest governance, and these contested areas can impede or confound policy decisions and management actions. Having access to credible evidence is not only important for adaptive forest management but also essential for society to make informed decisions about the future of Australia's forests. The ongoing conflict over how forests should be managed is often fuelled by misinformation and opinions. This has led to forest management and use decisions that fail to achieve ecological integrity and meet human wellbeing needs.

Forest policy and forest management decisions must be based on scientific evidence and traditional knowledge. Regular monitoring and transparent reporting on the status of and trends in forests and the effectiveness of forest management actions are key to informing and updating our understanding over time. These data should underpin adaptations in policy and management.

In light of this, there is a need to review the indicators used to report on forests and forest-dependent industries, including a review of gaps such as climate and an assessment of the relevance and effectiveness of current forest-related indicators. There is also a need to improve public reporting for all forests using approaches that can be understood easily by decision-makers and the community. These datasets need to be properly curated and publicly available.

Furthermore, a more collaborative approach to research and improved efforts to build scientific consensus about forest-related issues is important for achieving active and adaptive forest management outcomes. Citizen science offers great potential to improve datasets, particularly using technology that enables geo-location, species identification and instantaneous reporting.

This will require more people in the bush—more Indigenous and local rangers working with local communities to actively manage forests according to local needs and local knowledge of the landscape. This, in turn, will require a quantum shift in resources for forest management and new modes of finance involving public- and private-sector partners. The savannah burning programs across northern Australia are examples of how private-sector and government carbon finance is providing resources to put people back on country to restore ecosystems and the physical and mental health and cultures of Indigenous communities (Barber & Jackson 2017; Russell-Smith et al. 2017; Russell-Smith et al. 2018).

Australia should implement strategies to bring together scientific evidence and traditional knowledge to better understand the status, trends and effectiveness of forest management and policy decisions.

Creating a circular, low-emissions economy

The strategies outlined above have the potential to substantially improve the management of Australia's forests and thereby increase forest resilience to shocks and stresses, such as those generated by bushfires and invasive species and those anticipated with climate change. These strategies will also strengthen Australia's capacity to shift from a linear to a more circular economy.

In a traditional linear economy, resources are taken to make into products that are used and then disposed of (Lambert 2018). The circular economy is an alternative construct in which the goal is to keep resources in use for as long as possible (Commonwealth of Australia 2018), extract the maximum value from them while in use, then recover and regenerate products and materials for further production and consumption (Lambert 2018). In a circular economy, resources are obtained sustainably and recycled as much as possible, including through advanced and emerging technologies based on renewable resources.

Australia is the sixth most forested country in the world (after the Russian Federation, Brazil, Canada, the United States and China) with 3 3% of the world's forests (FAO & UNEP 2020). As stewards of such a significant portion of the world's forests, Australia has not only the opportunity but a global responsibility to manage its forests in accordance with internationally recognised principles of ecologically sustainable development. Australia's *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992b) defines ecologically sustainable development as: using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

These principles should be applied to forest management and the sustainable use of forest resources in Australia as part of the development of a more circular, low-emissions economy. There are several reasons for optimising the utilisation of our own forest resources, both natural and planted, in these contexts. These include the emissions associated with international trade (e.g. OECD 2021) and the limitations of relying on legality and sustainability systems in other countries (e.g. Garcia 2017).

Although globalisation and international trade are key drivers of global prosperity, climate change and the COVID-19 pandemic have highlighted the dependencies and risks associated with a highly connected world and the need for sustainable production systems in Australia and more resilience in the economy.

The federal and state governments in Australia have embraced the principles of a circular economy (Commonwealth of Australia 2018; NSW Government 2019; DELWP 2020; DWER 2020), which ultimately is intended to change patterns of natural resource use to achieve sustainable growth. This includes avoiding waste and pollution, keeping existing products and materials in use, regenerating natural systems, and better managing material flows to benefit human health, the environment and the economy.

Wood has been described as the ultimate renewable[3] material, and the federal government has recognised that trees are a sustainable, renewable resource for future generations when carefully managed (DAWE 2019). Wood also provides

[3]The Ultimate Renewable™ is an industry campaign to promote the sustainability and environmental advantages of Australian forestry and wood products. Further information is available at: https://www.theultimaterenewable.com.au/.

a sophisticated alternative to other building materials that generate more greenhouse gas emissions in their production. In this way, the use of renewable forest fibre and wood products, sourced from Australian plantations and sustainably managed natural forests, is clearly aligned with established policy principles and would contribute directly to building and strengthening a circular economy in Australia.

Australia can draw on the lessons being learned in Europe and Canada, which have established national strategies focused on the development of bioeconomies; these incorporate the principle of a circular economy but extend it to encompass the sustainable use of renewable biological resources.

In Europe, there is a policy goal for a more innovative and low-emissions economy, reconciling the demands for sustainable agriculture and fisheries, food security, and the sustainable use of renewable biological resources for industrial purposes while ensuring biodiversity and environmental protection. To achieve this, the European Commission first established a bioeconomy strategy in 2012 (European Commission 2012; Winkel 2017). This strategy encompassed support for research and development across agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries to promote innovation for sustainable growth in Europe. It was updated in 2019 (European Commission 2019).

Similarly, Canada's National Bioeconomy Strategy (Bioindustrial Innovation Canada 2019) notes that the country's competitive advantages for a bioeconomy include its access to biomass, global leadership in forestry and agriculture, sustainable resource management and skilled workforce. The strategy features the need to establish a biomass supply and good stewardship of agricultural and forestry lands.

Given these international examples, there is an opportunity for Australia to establish itself as a global leader by shifting from a linear to a circular economy. Such a shift would support the further development of advanced technologies and a highly skilled workforce equipped to compete in global markets.

For Australia to transition to a more circular, low-emissions economy based on the increased use of renewable energy and sustainable forest products, key initiatives would likely need to include:

- ensuring that Australia's forest biodiversity is adequately conserved through complementary management within and outside the reserve system
- increasing investment in plantations as a renewable source of forest fibre and timber products
- supporting innovation and development for renewable and sustainably managed products from natural forests and plantations that have a lower emissions intensity compared to other products and can be recycled for long-term use and carbon storage
- enhancing the utilisation of forest residues associated with sustainable forest management activities
- supporting innovation and development for the manufacturing of engineered wood products to meet society's consumption requirements efficiently with available forest resources (doing more with less), notably through an increased reliance on plantation resources using, for example, engineered wood products such as cross-laminated timber.

The way forward

Australia's forest lands are at risk of losing their natural resilience to recover from shocks and disturbances. More active, adaptive and integrated forest management, incorporating the principles of Indigenous Australians and led by them, is fundamental to addressing this issue; but first we need to redress the legacy of past approaches that have hampered forest management policies, systems and structures and created an environment where stakeholder conflict and ineffective management decisions predominate. We need to envisage and adopt new ways of doing to promote forest resilience and support resilient and sustainable communities.

We encourage the federal and state governments of Australia to lead a collaborative initiative to convene with a broad range of stakeholders to discuss and develop a new shared vision for the management of natural forest lands, based on the strategies outline above. We consider the federal and state governments to be the most appropriate initiators of this process, recognising that the management of public forests is a major source of contention and that governments are responsible for establishing the governance arrangements, policy settings and regulatory frameworks for forests.

We suggest a multiphased approach that takes into account national-, state- and regional-level responsibilities for key functions, including land management, environmental protection and economic development. In the first phase, the federal and state governments could convene a meeting through a national-cabinet-style process, as seen in response to the COVID-19 pandemic. The intergovernmental meeting should engage and explore key issues relating to:

- the importance of maintaining resilient and healthy forests across all land tenures to address the challenges of climate change, while also developing a more circular, low-emissions economy in Australia
- concurrently, the importance of recognising the role of Traditional Owners in caring for country and the management of land, including forests, and the need to increase their involvement in decision-making
- observations on other national and intergovernmental policy commitments, such as in Europe and Canada, to establish a forest-based bioeconomy encompassing economic activities relating to *all* forest ecosystem services through plans and strategies designed to 'tackle sustainability-related conflicts and maximise sustainability-related synergies' (Winkel 2017)
- the overarching principles that should be applied consistently across all states in respect to forest management and community expectations of forest management and uses
- the utility of the platform provided by the RFAs in Australia to develop more socially inclusive governance arrangements for forest management at the subnational level
- the respective roles of federal and state governments in convening forums with a broad base of stakeholders to discuss socially inclusive governance arrangements for forest management at the subnational level
- collective views on whether the focus of these forums should be specifically on sustainable forest management across public land tenures or a broader, multisectoral consideration of the development of a more circular, low-emissions economy, if not a bioeconomy, in Australia.

In the second phase, it is suggested that state governments convene state-based meetings or forums with key stakeholders and representative organisations to discuss the development of a new shared vision for the management of public forest lands (which may inform private natural forestry in due course). Initial meetings of these state-based forums should be directed to scoping the process for engagement and an ongoing dialogue among stakeholders, in contrast to seeking agreement directly on a new vision or solution.

Through the scoping phase for further work in Australia, particular attention should be given to bringing together Traditional Owners and Indigenous Australians with key actors from the private sector and civil society and drawing on a broad base of inputs to a workable process for ongoing dialogue based on the principles of active and adaptive forest management across public land.

In designing these forums, state governments could refer to or engage with The Forests Dialogue (TFD), an international initiative that provides leaders in the forest sector with an ongoing, multistakeholder dialogue (MSD) platform and process focused on developing mutual trust, a shared understanding and collaborative solutions to challenges in achieving sustainable forest management and forest conservation around the world.

Regionally specific references may include international case studies, such as the development of the Great Bear Rainforest Land Use Agreement in British Columbia, Canada, in which stakeholder groups and First Nations took leadership roles and worked together to propose solutions to governments (Moore & Tjornbo 2012); in this case, the model centred on ecosystem-based management (Price et al. 2009). Another relevant example from North America is the *Healthy Forests, Healthy Communities* paradigm promoted in the United States, which in states like Oregon has focused on the need for active management to address the 'forest health crisis'. For example, this might mean management to restore forests susceptible to historically atypical large-scale fire and insect and disease infestations; and acknowledging the critical importance of local community capacity to support forest restoration and stewardship, which in turn provides communities with economic and cultural benefits (Kelly & Bliss 2009).

We believe it is important that, from the outset, these forums recognise the broad range of roles that forests can play in addressing the challenges of climate change and the multiple demands of pluralistic societies. These forums should also recognise the momentum building in other countries for the more active and adaptive management of forests and the opportunity to 'build back better' through the post-COVID-19 recovery across a range of sectors, including forestry and forest use. This recognition may assist in bringing a diverse range of stakeholders together with a shared understanding of the complex interdependencies between society and the natural environment and the need for a holistic approach to ecologically sustainable development in Australia.

Following broad agreement on the process or processes for ongoing dialogue, stakeholders at the state and regional levels could then continue to meet and support the development of a new shared vision for forests within the respective state or region. These forums could be further informed by the TFD experience worldwide or be based on existing platforms for MSD in Australia, such as Catchment Management Authority programs or state government-led regional development initiatives.

Through ongoing dialogue, we envisage that the multistakeholder forums would focus on the needs of individual regions and communities and strive to agree on new governance arrangements that are socially inclusive and respectful of all forest values. These forms of engagement may then effectively empower land management agencies to implement actions aligned with that vision, and these agencies could assume responsibility for providing monitoring reports over time.

In this way, through collective action across multiple states and regions, the realisation of a new shared vision for the management of Australia's forests would represent a nature-based solution contributing directly to post-COVID recovery and mitigating the threats of climate change and bushfire.

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