Independent Forestry Panel

Public submission

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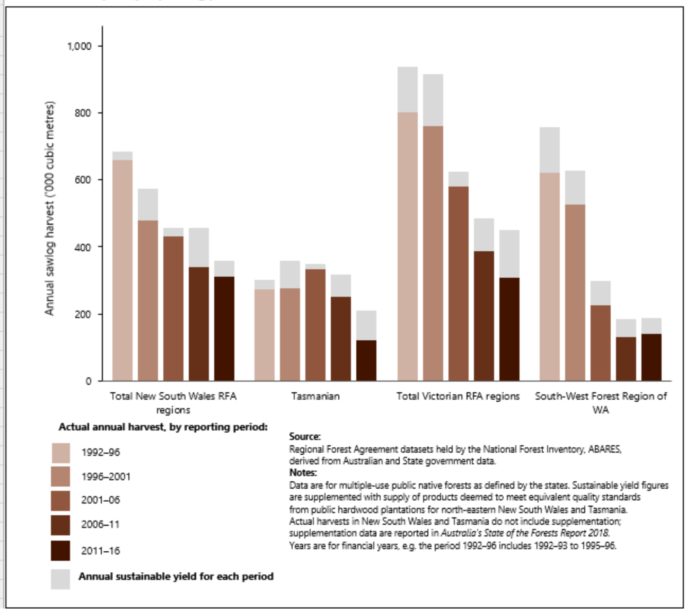
1. Sustainability of current and future forestry operations in NSW

Current industrial scale logging in native forests has been shown to be unsustainable, with reference to yield, economically and maintenance of biodiversity. With regard to yield, evidence is available in ABARES data[1] (figure below) and NSW Forestry Corporation's own estimates of yields. These estimates have been proven to be gross over-stated. Yields since 2010 from state forests have declined by 40% from 1.3 million tonnes down to 0.8 million tonnes in 2023. Yields are currently only 61% of those claimed, with the massive loss of resources in the 2019/20 fires yet to be factored in.

Figure 6 Average annual harvest and sustainable yield for multiple-use public forest in RFA regions, by state and five-yearly reporting periods



Native forest logging is also economically unsustainable because it can only continue to operate through major subsidies from government " it is therefore a highly significant (and increasing) burden on taxpayers (FrontierEconomics 2023). As an example, it was estimated that for the year 2019-2020, Forestry Corp of NSW received $249 million in subsidies and grants and still made a loss of $28m (FrontierEconomics 2023). These losses are not atypical for the native logging industry in NSW nor for the native forest logging industry in other States of Australia (reviewed by Lindenmayer 2024). The native forest logging or hardwood division of Forestry Corporation NSW has recorded losses for three successive years and was in July fined $360,000 for destroying hollow-bearing trees.

The native forest logging industry is not sustainable in relation to sustaining biodiversity in native forests. Native forest logging occurs in areas of high conservation value for threatened species (Ward et al. 2024). Indeed, recent analyses have shown that 43 species identified as being impacted by historical deforestation and degradation continue to be

[1] Substantial decreases in sustainable and actual yields from RFA regions were experienced across all states from 1992–96 to 2011–16 (Table A11, Figure 6).(RFA_ReservationResourceAvailability_v1.0.0.pdf) P.23.

impacted by logging (Ward et al. 2024). Logging not only significantly reduces critical habitat for species such as large old hollow-bearing trees, it also changes the composition of forests that make them unsuitable for leaf-feeding specialist animals like the Koala and Southern Greater Glider (Au et al. 2019).

A further threat to all measures of sustainability is the research showing that logged areas which then regenerate are more flammable. Logging thus contributes significantly to fire risks (Lindenmayer and Zylstra 2024). An analysis across the fire footprint of the Black Summer fires showed that logged forests always burn at higher severity than intact forests (Lindenmayer et al. 2022b). Moreover, logged forests burning under moderate fire weather conditions still burn at higher severity than intact forests burning under extreme fire weather conditions (Lindenmayer et al. 2022b). The additional fire burden created by logging forests can last for 40-70 years after cutover forests have been regenerated (Taylor et al. 2014, Wilson et al. 2022). Recurrent wildfires have major impacts on timber stocks (Bousfield et al. 2023), thereby disrupting industry supplies. This highlights the need to grow timber faster to increase the chances of producing a crop of merchantable trees before they are destroyed by wildfire (Cary et al. 2021, Bousfield et al. 2023). The best places to do this is in plantations (Lindenmayer et al. 2023b). In addition, new research has indicated that logged and regenerated native forests are 4 times more likely to burn than plantations " further underscoring the importance of plantations for future timber production (Bousfield et al., in re-review). Finally, the rapid increase in the frequency of high-severity wildfire in parts of south-eastern Australia (Lindenmayer et al. 2023a) clearly indicates that the probability of forests remaining unburnt for long enough to produce a viable crop of timber (before being burnt) are small (typically > 20% for an 80 year rotation) (see Cary et al. 2021). This was highlighted by the impacts of the Black Summer wildfire season, not only for NSW but also for north-eastern Victoria (Lindenmayer and Taylor 2020).

Sustainability of water supply is also affected adversely by logging. Native forest logging reduces the function and health of waterways, including streams and rivers

2. Environmental and cultural values of forests, including threatened species and Aboriginal cultural heritage values

1. Native forests have significant environmental values, values for threatened species (Ward et al.2024), and substantial cultural heritage values for First Nations peoples (Gott 2005). These values are usually degraded by logging operations. One of the straight-forward ways to maintain these values and not degrade them is by not logging native forests (Murray et al. 2024).

   Forests are vital refuges for many threatened species that rely on mature, intact forests. Recent research has shown for the endangered Yellow-bellied Glider (*Petaurus australis*), ……site occupancy increased with an increasing proportion of the landscape (within 400 m of the recorder) that had **<u>not</u>** been logged within the last 100 years or burnt by wildfire within the last 10 years. Habitat disturbance caused by logging and fire therefore limit the site occupancy of Yellow-bellied Gliders and likely impact its conservation status. It is therefore critical that appropriate management of timber resources protects large patches of old-growth forest providing food resources and hollows, and the connectivity between large forest patches."[2]

Another recent study[3] of long-term changes in arboreal marsupial detections post logging showed that almost all the Southern Greater Glider, the Yellow-bellied Glider, Krefft's Glider, and Leadbeater's Possum populations were strongly related to the abundance of hollow-bearing trees. The study showed there was an overall decline in populations of these four species associated with declines in hollow-bearing trees and temporal changes in stand age attributable to logging. The authors concluded that "...their findings underscore that forest management must properly address key drivers of decline. Management of montane ash forests must protect and promote the recruitment of large old hollow-bearing trees as a keystone resource for arboreal marsupials. Our results also highlight the substantial lag effects in forest condition resulting from past clearfelling and recurrent wildfires that has led to widespread forest degradation. Active, long-term forest restoration programs will be needed to address this problem."[3]

In summary, saving NSW's 269 nationally listed threatened forest species, including the endangered Koala and Greater Glider, requires that we stop logging their homes. Intact native forests, in addition to providing homes for a numerous threatened species, provides habitat connectivity, thus supporting biodiversity and ecosystem health.

3. Demand for timber products, particularly as relates to NSW housing, construction, mining, transport and retail

The vast majority of timber products (over 90%) used to construct houses in NSW, that is, sawn timber comes from plantations (ABARES 2021, Department of Agriculture Fisheries and Forestry 2023). That is, demands for timber can largely be met from plantations and have been increasingly so for many years. This highlights the fact that a transition to a plantation-only industry can meet timber requirements as has been the case in New Zealand (for more than 20 years) and has been the case in South Australia for many decades (Lindenmayer and Taylor 2022).

The native forest logging industry has long been overwhelmingly dominated by high volume, low value products (Lindenmayer and Taylor 2022) such as woodchips, paper pulp, and feedstock for packaging (Australia and National Forest Inventory Steering Committee 2018, ABARES 2021,Department of Agriculture Fisheries and Forestry 2023).

[2] Matthew Lefoe, Anthony R. Rendall, Freya McKinnon, Desley A. Whisson, Logging and wildfire limit the distribution of a vulnerable arboreal mammal,Forest Ecology and Management,Volume 503,2022,119773,ISSN 0378-1127,

[3] David B. Lindenmayer, Elle Bowd, Kara Youngentob, Maldwyn John Evans, Quantifying drivers of decline: A case study of long-term changes in arboreal marsupial detections, Biological Conservation,Volume 293,2024,110589,ISSN 0006-3207,

Thus there is no longer any need to log public native forests to build houses as plantations are supplying our high quality and composite timber products. The predominance of sawn timber from plantations, and of woodchips and paper pulp from native forests, is one of the key reasons why the former is profitable and has high levels of employment, whereas the latter is unprofitable and has dwindling levels of employment (Keith et al. 2016, see also Keith et al. 2017). This is as indicated by economic analyses conducted in the southern region of NSW (Frontier Economics and ANU 2021).

4. The future of softwood and hardwood plantations and the continuation of Private Native Forestry in helping meet timber supply needs

The future of the forest and timber industries in NSW is in plantations.
Hardwood and softwood plantations already provide 91% of Australia's log production. Investment in hardwood plantation on already cleared land would supply timber products into the future. Shifting to higher-value plantations can better meet timber needs.
The Federal Government acknowledges the benefits of growing our plantation estate[4]. These include increasing the supply of domestically grown timber products, sequestering carbon to help meet Australia's carbon emission reduction commitments and helping to offset reduced access to the native forest resource[4]. The Federal Government under the Australian Government's Support Planation Expansion program, which is providing $73.76 million in grant funding over four years from 2023–24 to 2026–27[4]. Importantly, the proportion of saw and veneer logs obtained from hardwood plantations needs to be increased, rather than being exported as low value woodchips.

The plantation industry is far more profitable, employs far more people, generates carbon pollution, and is significantly less fire-prone. Moreover, plantations produce wood crops faster and, as a result, are less likely to be lost to wildfire than long rotation native wood production forests (see analysis by Cary et al.2021). Plantations do need to be well managed, including for reducing fire risks. However, there are design principles, management strategies and new technologies which must be implemented to reduce the risks of plantation timber stock losses (Lindenmayer et al. 2022a, Lindenmayer et al.2023b).

Importantly new plantations must be planted on marginal cleared land and not involve the conversion of even limited areas of native forest to plantations. This practice is occurring in some parts of NSW and is an inappropriate form of land management (Lindenmayer and Hobbs 2004), negating the benefits of carbon capture and storage and biodiversity.

In addition, without competition from subsidised public forests there will be an increased incentive for selective logging of speciality purpose hardwoods from private forests.

[4] https://www.agriculture.gov.au/agriculture-land/forestry/australias-forests/plantation-farm-forestry

5. The role of State Forests in maximising the delivery of a range of environmental, economic and social outcomes and options for diverse management, including Aboriginal forest management models

The approximately 2 million hectares of native forests in NSW provide water for numerous town reservoirs, have the potential to contribute to increased tourism, provide ongoing employment and sequester and store carbon. This public owned resource as currently managed by the Forestry Corporation, is a loss making venture, relying on government subsidies and income generated from the profitable plantation sector plantations. In 2023 Forestry Corporation lost $15 million on their hardwood operations, that's a cost of $1,281 for each hectare logged. This is despite being paid $31 million for their community service obligations that year and obtaining tens of millions in regular equity injections. NSW taxpayers should not be paying to degrade their forests, increase fire risk, cause erosion and destroy threatened species and their habitat. Public forests are of greater economic benefit for water catchments, tourism and carbon storage than they are for logging to produce predominantly woodchips, firewood and other low value commodities. It is in the best interest of taxpayers to stop logging public native forests.

This range of environmental, economic and social outcomes will increase if logging is stopped. Forests cool the land, clean the air of pollutants and absorb carbon dioxide from the air which is stored in wood and soils – trees are a highly effective, proven carbon capture and storage devices.

Diverse forest management, particularly legitimate traditional indigenous management models, can enhance the cultural and social value of forests. Native forests have substantial cultural heritage values for First Nations peoples (Gott2005). Importantly these should not be co-opted by deceitful schemes like "Forest gardening" which appears to be industrial scale logging by another name. Forest Gardening apparently derived from the assertion that tall, wet forests were open and park-like at the time of British invasion (Gammage 2011, Pascoe and Gammage 2021). This assertion has been disproven by evidence obtained by detailed examination of historical, cultural and ecological records (Lindenmayer et al. 2024).

The native forest logging industry and lobby groups such as Forestry Australia have advocated that native forests should be subject to "Active Management" which includes thinning and other forms logging operations (Bennett et al. 2024, Keenan 2024). There is no empirical evidence to support claims that these operations will make forests more resilient to wildfires. There is evidence though that thinned forests burn at higher severity. This ahs been documented following wildfires in Victoria in 2009 (Taylor et al. 2020) and following the 2019-2020 Black Summer wildfires (Taylor et al. 2021), and by foresters (Buckley and Cornish 1991, Sebire and Fagg 1997, Fagg 2006).

6. Opportunities to realise carbon and biodiversity benefits and support carbon and biodiversity markets, and mitigate and adapt to climate change risks, including the greenhouse

gas emission impacts of different uses of forests and assessment of climate change risks to forests

Logging in native forests releases large amounts of carbon, contributing to climate change. Stopping logging allows forests to recover, helping them store more carbon and support climate goals. By stopping logging, forests can play a large role in mitigating climate risks and supporting opportunities in carbon markets. The March 2023 report by Jen Sanger, the Trees Project,[5] demonstrates that protecting New South Wales' native forests is a real climate solution[6]. David Lindenmayer and Brendan Mackey advise that stopping logging will save 15.3mt pa for 9 years and meet the 43% reduction in GHG by 2030 below 2005 levels Australian target[7]. Carbon savings from ending logging in Australia would automatically be counted in state and federal greenhouse gas accounts.

Carbon savings should not be monetised in carbon and biodiversity markets that allow damaging activities to be offset.

Forest governance expert Kate Dooley said ending native logging would do more to help Australia's climate goals than planting trees due to the time taken to replace old-growth forests' carbon-storage potential[8].

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[5] https://static1.squarespace.com/static/60b20f09dcfc4f2bd6b0c171/t/63ddcef58bf792078c351e0f/1675480953905/NSW+Carbon+Report.pdf

[6] *If native forests currently managed for logging were protected, we could prevent 76 million tonnes of carbon (CO2e) from entering the atmosphere by 2050.

[7] https://www.canberratimes.com.au/story/8740433/ending-native-forest-logging-key-to-emissions-reduction-expert

[8] https://www.aap.com.au/news/new-course-charted-for-nsws-troubled-forestry-industry/

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Communication

Forest Biodiversity Declines and Extinctions Linked with Forest Degradation: A Case Study from Australian Tall, Wet Forests

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Abstract: Tens of thousands of species are at risk of extinction globally. In many ecosystems, species declines are associated with deforestation. However, forest degradation also can profoundly affect biodiversity. I present a detailed case study of species declines associated with forest degradation in southeastern Australia's montane ash (*Eucalyptus* spp.) forests. The case study is based on ~40 years of long-term monitoring focused on declines (and potential extinction trajectories) of arboreal marsupials and birds, with a particular emphasis on key drivers, especially logging, wildfire, habitat loss, climate change, and interactions among these drivers. I discuss policy failures contributing to species declines, including ongoing logging of high-conservation-value forests, poor regulation of forest management, and inadequate design of reserves. I conclude with general lessons for better conservation and forest management efforts aimed at reducing forest degradation and loss of ecosystem integrity. I contend that ongoing logging in already highly degraded montane ash forests is inconsistent with the Australian government's commitment at the Glasgow COP26 meeting in 2021 on halting forest degradation. Similarly, the Australian Government has committed to preventing further extinctions in Australia, yet its current support for ongoing logging in montane ash forests through federal–state legislation will likely promote extinctions for some species. The inherent conflicts and contradictions between conservation and logging policies need to be addressed.

Keywords: arboreal marsupials; birds; clear-cutting; forest degradation; montane ash forests; species declines

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1. Introduction

Over 40,000 animal and plant species worldwide have been listed by the International Union for the Conservation of Nature (IUCN) as being threatened with extinction [1]. This comprises 28% of all species assessed, a very substantial increase from the 11,046 species reported as threatened in 2000 [1]. The average abundance of native species in most major terrestrial biomes has fallen by at least 20 percent, with human activities threatening more species with extinction now than ever before [2]. These sobering global patterns are reflected in the population trajectories of species in many nations around the world [3]. For example, at a continental level, Australia has lost almost 10% of its mammal fauna since European colonization [4] with three species of vertebrates (two mammals and one reptile) lost in the past decade alone [5]. Sometimes the direct cause of decline and/or extinction of a particular species is poorly known, which makes it difficult to identify and implement effective conservation measures. However, in other cases, long-term research and monitoring can uncover the key drivers of decline and extinction risk and in turn guide effective recovery actions [6,7].

In this paper, using insights from an array of observational studies and experiments [8] conducted over the past 40 years (see Table 1), I provide a detailed case study of species decline and erosion of ecosystem conditions in the tall, wet montane ash (*Eucalyptus* spp.) forests of the Central Highlands of Victoria. These forests support stands of the tallest flowering plants on earth, with old-growth trees reaching heights of ~90–100 m [9]

(Figure 1). Given the majority of the forest on which I focus is subject to logging followed by stand regeneration, this case study relates to the drivers of species decline and the erosion of ecosystem conditions linked to forest degradation rather than deforestation. For the purposes of this paper, the term degradation is drawn from general definitions of the concept provided by Thompson et al. [10]. These definitions relate to altered forest stand structure, forest composition, ecological dynamics, and ecosystem function relative to a benchmark condition, with such changes arising primarily from human activities such as logging [11,12]. Notably, Australia is a signatory to the Glasgow Leaders Declaration on Forest and Land Use [13], which aims to halt the degradation of natural forests. I focus on the declines (and potential extinction trajectories) of arboreal marsupials and birds, with a particular emphasis on key drivers of those declines, especially logging, wildfire, habitat loss, climate change, and interactions among these drivers. I then discuss some of the policy failures contributing to species declines, including ongoing logging of high-conservation-value forests, poor regulation of forest management, and inadequate design of forest reserves. I provide recommendations for action to limit biodiversity decline in montane ash forests. I conclude with some general lessons for better conservation and forest management efforts aimed at reducing forest degradation linked to species decline and loss of ecosystem integrity.

Table 1. Datasets collected or assembled and used in long-term studies in the montane ash forests of the Central Highlands of Victoria.

Dataset	Description	Example Citation/s
Long-term occurrence of arboreal marsupials	The abundance of different species of arboreal marsupials has been counted on 183 permanent long-term sites, each measuring 1 ha in size, since 1997. Data on the structure and composition of the vegetation, fire, and logging disturbance history at the site and in surrounding landscape have been used as covariates in statistical modelling of animal presence and abundance.	[14,15]
Long-term occurrence of forest birds	Detections of birds have been recorded since 2004 on 85 of the 183 long-term sites also surveyed for arboreal marsupials. Data on the structure and composition of the vegetation, fire, and logging disturbance history at the site and in surrounding landscape have been used in statistical models of animal presence and abundance.	[16,17]
Long-term abundance and condition of hollow-bearing trees on sites	Measurements of the conditions and abundance of all large, old, hollow-bearing trees (which provide den and nest sites for cavity-dependent animals) have been taken every two years on 183 long-term sites.	[18–20]
Long-term changes in vegetation structure on sites	Measurements of vegetation structure and plant species composition have been taken every 2–3 years at all 183 long-term field sites.	[21,22]
Fire severity in logged and unlogged areas	Fire severity in sample grids across the extent of the Central Highlands of Victoria was estimated using satellite data following a major conflagration in 2009.	[23,24]
Logging effects in areas of high conservation for wildlife	Across the Central Highlands of Victoria and elsewhere across Victoria, the amount of spatial overlap was calculated between areas of high conservation value for threatened species (as determined using species distribution models) and places logged or proposed for logging.	[25]
Post-fire "salvage" logging effects	The effects of post-fire logging on birds, soils, and plants have been documented on a subset of long-term sites in montane ash forests.	[26–28]
The importance of old-growth forest for biodiversity in montane ash forest	Analyses of relationships between arboreal marsupial and bird species occurrence and the ages of stands of forest on 183 long-term sites were completed.	[16,29]

Table 1. *Cont.*

Dataset	Description	Example Citation/s
Losses of old-growth forest in montane ash forests	Reductions in the spatial extent of old-growth forest were calculated from vegetation type, fire, and logging maps for sample grids across Victoria (including in the Central Highlands of Victoria).	[30]
Levels of stand regeneration	The prevalence of stand regeneration following wildfires was measured in relation to the ages of the stands at the long-term sites at the time they were burnt in wildfires in 2009.	[22,31,32]
Extent of forest fragmentation	For sample grids across the Central Highlands of Victoria, the level of disturbance from fire, logging, or both was calculated for montane ash forests. The distance from intact forest to a disturbance boundary created by logging (including roads) or wildfire also was calculated.	[33]
Microclimatic conditions	Daytime and nighttime temperatures were measured continuously for a year at 24 of the 183 long-term monitoring sites, with replicate sites in each of four different age classes (very young to very old) being measured.	[34]

Figure 1. Stand of old-growth mountain ash forest in the closed O'Shannassy Water Catchment in the Central Highlands of Victoria. The dominant overstory trees in this image are approximately 85 m tall. (Photo by Esther Beaton.)

2. Study Region and Disturbance Regimes

The Central Highlands region [35] is located approximately 100 km northeast of the city of Melbourne in the state of Victoria, southeastern Australia (Figure 2). The montane ash forests in this region are dominated by largely monotypic stands of one of three species of eucalypt trees—mountain ash (*Eucalyptus regnans*) (F. von Mueller), alpine ash (*Eucalyptus delegatensis*) (R.T. Baker), or shining gum (*Eucalyptus nitens*) (Deane and Maiden). The natural disturbance regime in these forests is comparatively rare, high-severity, stand-replacing wildfire, with the natural fire regime being a fire occurring once every ~75–150 years [36], which can occur over tens of thousands of hectares. However, major wildfires have become more frequent over the past century and have occurred in 1926, 1932, 1939, 1983, and 2009. For the purposes of various studies in montane ash forests, the fire severity is defined as the extent of loss or consumption of the vegetation and other biomass as a result of fire, and it can be determined from satellite data [23] or from on-the-ground surveys [37]. High-severity fires in montane ash forests are those conflagrations where there is a crown burn and much of the living vegetation is consumed [23].

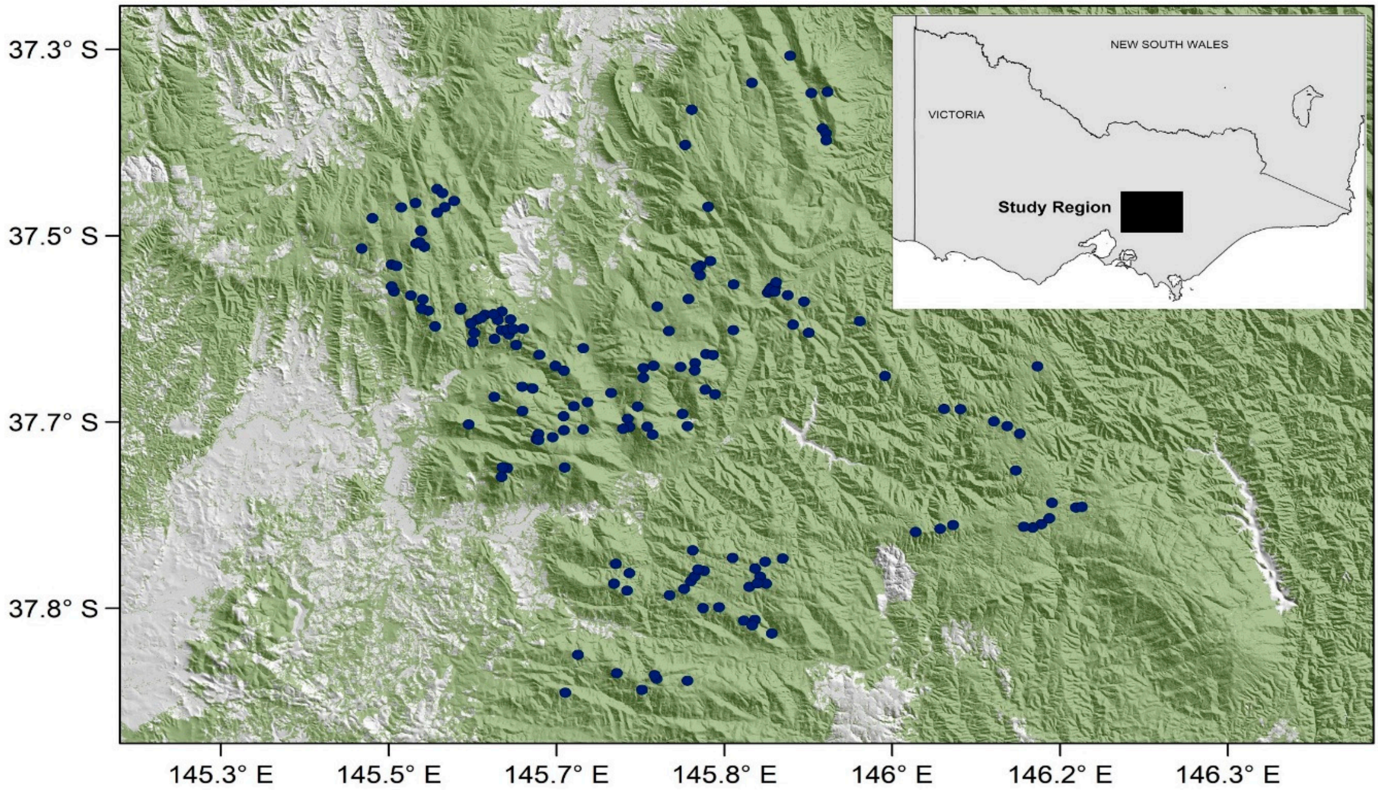

Figure 2. The location of the montane ash forests in the Central Highlands of Victoria, showing long-term field sites in the region where arboreal marsupials, birds, and vegetation structure and composition have been monitored since mid-1983 [38] (see Table 1 for further description of relevant datasets).

The primary form of human disturbance in montane ash forests is high-intensity clear-cutting operations conducted on a 40–80 year rotation [39] (Figure 3). Cutblocks are typically 15–40 ha in size, with up to three contiguous adjacent logged areas able to be cut, summing to a maximum of 120 ha of harvested area [40]. Approximately 50% of the montane ash forest in the Central Highlands of Victoria has been clear-cut in the past 50 years [33]. In the event of wildfire, burnt stands of montane ash forest are typically subject to post-fire ("salvage") logging [28]. Importantly, the forests in the Central Highlands of Victoria are owned largely by the Government of Victoria, with the majority of the forest estate (~80%) available for logging. Following logging, cutblocks are then subject to assisted regeneration practices (primarily through aerial seeding of overstory trees) [32].

Figure 3. Clear-cut area in the montane ash forest of the Central Highlands of Victoria. (Photo by Chris Taylor.) This image shows an area that was formerly dominated by alpine ash forest.

2.1. Long-Term Biodiversity Monitoring in Montane Ash Forests

Montane ash forests have been the target of intensive animal and plant monitoring since July 1983 [41] (see Table 1). Much of this work is focused around monitoring on more than 180 long-term field sites where surveys of arboreal marsupials, birds, vegetation structure, and plant species composition are completed regularly (typically annually) [15,16,22]. These monitoring sites span forests in wood production forests and protected areas, enabling the analyses of the tenure differences in animal species occurrence, vegetation structure, and plant species composition.

Surveys of arboreal marsupials have focused on a suite of species including the critically endangered Leadbeater's possum (*Gymnobelideus leadbeateri*) (McCoy), the endangered southern greater glider (*Petauroides volans*) (McGregor), the yellow-bellied glider (*Petaurus australis*) (Shaw), Krefft's glider (*Petaurus notatus*) (Cremona), the mountain brushtail possum (*Trichosurus cunninghami*) (Lindenmayer), the common ringtail possum (*Pseudocheirus peregrinus*) (Boddaert), and the feathertail glider (*Acrobates pygmaeus*) (Shaw). The majority of these species are cavity dependent, and their occurrence in montane ash forests is strongly associated with the abundance of large, old, hollow-bearing trees [15].

Surveys of birds on the long-term monitoring sites show that the bird assemblage in montane ash forests is comparatively species rich, comprising ~70 species from a wide range of guilds and functional groups [42]. The assemblage includes a number of species of conservation concern such as the crested shrike-tit (*Falcunculus frontatus*) (Latham), the flame robin (*Petroica phoenicea*) (Gould), and the gang-gang cockatoo (*Callocephalon fimbriatum*) (Lesson). Most species are strongly associated with old-growth stands [16], with the flame robin being the only early successional specialist in montane ash forests [43]. Notably, all of these bird species occur outside of montane ash forests and beyond the Central Highlands region.

Detailed vegetation surveys at the long-term sites in the montane ash forests include measurements of the condition of large, old, hollow-bearing trees (which are key nest sites for cavity-dependent fauna), the prevalence of understory trees (e.g., stocking rate and projective foliage cover) such as *Acacia* spp. trees, and elements of cool temperate rainforest such as *Nothofagus cunninghamii* (Hook.) [44], in addition to the abundance of an array of shrubs and other plants (e.g., tree ferns) [31]. There is a suite of rare and threatened plant species in montane ash forests, including shiny nematolepis (*Nematolepis wilsonii*) (Walsh & Albr.), tree geebung (*Persoonia arborea*) (F. von Mueller), and tall astelia (*Astelia australiana*) (Willis) [45].

2.2. Additional Supporting Datasets

A range of spatiotemporal datasets (see Table 1) have been assembled, such as those on the timing and extent of wildfires and logging, as well as datasets on environmental attributes such as slope, aspect, rainfall, and temperature. These data have been used primarily as covariates in statistical analyses of biodiversity responses. The logging and fire information are publicly available datasets extracted from satellite imagery, some of which have been ground-truthed with on-the-ground inventory surveys [33].

3. General Methodology

The general approach to the long-term studies in montane ash forests has been to use statistical modelling to relate a particular set of potential explanatory variables to response variables typically collected in detailed field surveys such as the presence/absence of a given species of arboreal marsupial, site occupancy by particular species of birds, or the occurrence or foliage cover of a particular plant species. The data on the explanatory variables were gathered in field surveys or extracted from government databases (e.g., slope, aspect, time since the last fire, and time since the last logging event).

All statistical analyses of the factors influencing key response variables were conducted under the supervision of, or in close collaboration with, a highly experienced professional statistical scientist. The results of the analyses have been written up in more than 150 peer-reviewed scientific articles, and they form the empirical basis for the summary presentation in this paper on species and ecosystem decline.

4. Evidence of Species and Ecosystem Decline

Time series data from long-term field sites (see Table 1) provide compelling evidence for the declines of a number of key species in montane ash forests [15]. For example, the levels of site occupancy of Leadbeater's possum declined by ~50% between 1997 and 2020 [15]. The site occupancy of the southern greater glider has declined by ~80% over the same period [15]. The yellow-bellied glider has become too rare to conduct analyses of the species' temporal trajectory.

There is evidence from the time series data that while some bird species are exhibiting recovery following the most recent major wildfires in 2009 [17], a number of species are undergoing a marked decline in site occupancy. Example species include the crested shrike-tit and the red-browed treecreeper (*Climacteris erythrops*). The early successional specialist, the flame robin, has become extremely abundant on sites burnt in the 2009 fires and continues to exhibit high levels of site occupancy in the 12+ years post-fire [17].

Beyond the marked declines in a number of mammal and bird species, a formal analysis using the IUCN Red Listed Ecosystem process revealed that the mountain ash ecosystem per se is at high risk of collapse [46] and has been classified as critically endangered [47]. The risk of ecosystem collapse is linked with regeneration failure associated with young eucalypt trees being burnt and killed by successive wildfires occurring in stands too young to be sexually mature [48–50]. Ecosystem collapse would manifest as the eucalypt-dominated forest being replaced by *Acacia* spp. woodland [32].

5. Drivers of Decline

Repeated analyses of our long-term datasets show there are a number of important drivers of species, habitat, and ecosystem decline, several of which act at multiple spatial scales (from the individual tree level to stand and landscape levels). These drivers are wildfire, logging, habitat fragmentation resulting from logging, loss of old-growth resulting from fire and past logging, loss of hollow-bearing trees through natural attrition and logging and wildfire, and climate change. I briefly outline the effects of these drivers of decline below. These drivers do not act in isolation but interact to further reinforce the loss of biodiversity, habitat degradation, and erosion of ecosystem integrity [51]. I have therefore also provided some commentary on the interactions among the drivers of species decline.

5.1. Fire

Fire is a natural ecological process in montane ash forests [48]. Indeed, mountain ash and alpine ash stands rely on periodic wildfires for natural regeneration [49,52]. However, repeated large-scale wildfires can have marked negative effects both on key elements of biodiversity and on ecosystem integrity. The effects of fire as a driver of species decline can manifest at several spatial scales. For example, at a stand level, fire can have direct impacts through killing animals on a burned site [53] or indirect impacts through reducing the abundance of habitat attributes such as large, old, hollow-bearing trees [54]. At a landscape scale, species such as Leadbeater's possum, the southern greater glider, and the yellow-bellied glider are significantly less likely to occur where there has been widespread fire relative to areas where fire has been less extensive [15,37,55]. Importantly, there are high levels of spatial dependence in wildfire in montane ash forests; that is, areas next to highly flammable young forests are at risk of burning in the same fire event (Figure 4). This can affect, for example, remnant patches of old-growth forest that are adjacent to young forest (see Figure 4). Finally, at a whole-of-ecosystem level, repeated, high-severity fires with short inter-fire intervals may result in widespread regeneration failure and thereby trigger the collapse of the entire mountain ash ecosystem [50] and the alpine ash ecosystem [49]. Ecosystem collapse would have major implications for those species strongly associated with such environments (e.g., Leadbeater's possum) [56].

Figure 4. Burnt stand of old-growth mountain ash forest adjacent to burnt area of flammable young regrowth mountain ash forest. (Photo by David Lindenmayer.)

5.2. Logging

Logging can act as a driver of species decline at several spatial scales. At a site level, areas with a history of logging are characterized by fewer hollow-bearing trees [18], and this in turn leads to such places being unsuitable habitat for a range of cavity-dependent species [29]. Notably, areas of high conservation value for threatened biodiversity in montane ash forests are also those places often scheduled for logging under the Victorian Government's Timber Release Plan [25]. Past logging operations dating back over 120 years have removed extensive areas of old-growth montane ash forest, and this has had negative impacts on a range of old-growth-associated taxa such as the southern greater glider [29] and the yellow-bellied glider [55,57]. At a landscape scale, the levels of site occupancy in species such as Leadbeater's possum and the yellow-bellied glider are significantly lower with increasing amounts of logging in the landscape [15,55]. Similarly, increasing amounts of logging at a landscape scale results in increased rates of collapse of large, old, hollow-bearing trees, including in remaining areas of adjacent uncut forest [20].

5.3. Forest Fragmentation

Montane ash forests are highly fragmentated as a result of past logging and wildfires (see Figure 5). For example, the distance from a randomly selected point to a disturbance boundary (e.g., a road or logged cutblock) is just 71 m in wood production forests (versus > 1700 m in protected forests) [33]. Fragmentation has a number of important ramifications for biodiversity conservation and ecosystem conditions in montane ash forests. First, fragmentation is detrimental to area-sensitive taxa such as the yellow-bellied glider, which requires extensive areas of intact old-growth forest [57]. Second, fragmentation creates edge effects such as increased wind speeds that elevate the rates of collapse of large old trees [20] (which are in turn key elements of habitat for cavity-dependent species). Third, fragmented forests dominated by extensive areas of young, highly flammable forest are at risk of supporting high-severity fires that burn across large areas of the landscape [50], killing animals, damaging habitats, and reducing the extent of old-growth forest.

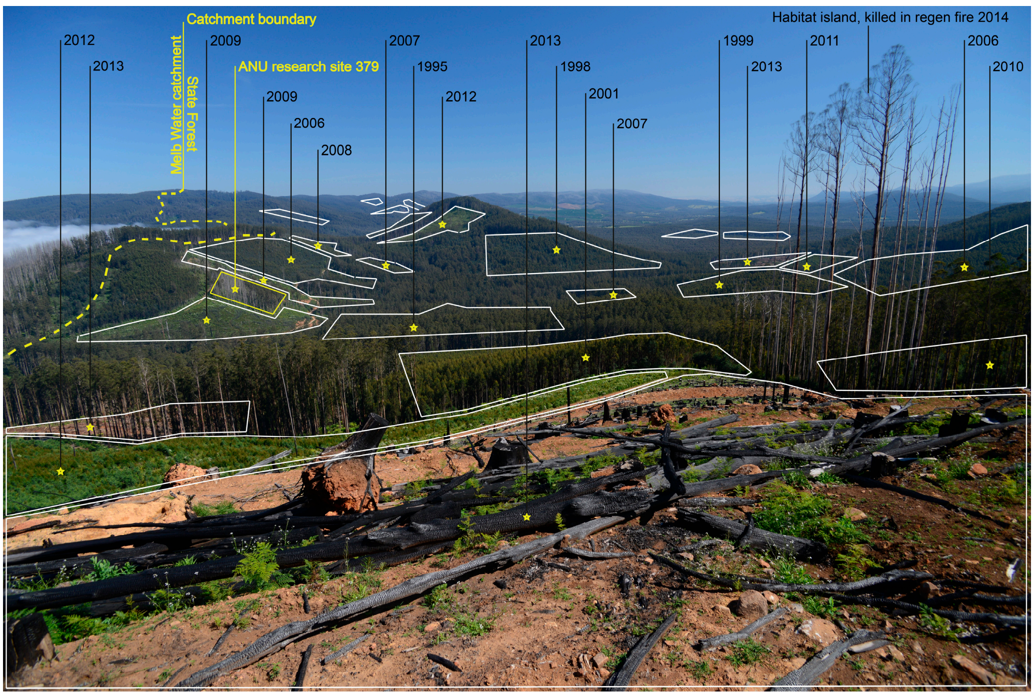

Figure 5. The location of cutblocks (shown in white polygons and labelled by the year of cutting) highlighting the extent of fragmentation in a montane ash forest landscape in the Central Highlands of Victoria. One of the long-term sites (site #379) is shown by a yellow-bounded polygon in the central left of the image. (Photo by David Blair.)

5.4. Loss of Hollow-Bearing Trees and Old-Growth Forest

Large, old, hollow-bearing trees are critical habitat attributes for a wide range of cavity-dependent fauna, and their abundance is a significant explanatory variable in habitat suitability models for almost all species of arboreal marsupials in montane ash forests [15,58]. The abundance of these trees is declining rapidly, with ~50% of long-term sites that supported such trees in 1997 no longer having any hollow-bearing trees almost 25 years later [15]. Populations of hollow-bearing trees are forecast to decline in abundance by 90% by 2065 and before existing mature trees (that are currently ~80 years old) will reach an age where they first begin to develop cavities [56]. Many existing large, old, hollow-bearing trees were killed or scarred in major wildfires in 1939 but are now deteriorating rapidly in condition [19]. The marked decline in large, old, hollow-bearing trees in montane ash forests has been a result of recurrent wildfire, logging, and post-fire (salvage) logging over the past century [56].

Old-growth forest (where large, old, hollow-bearing trees are most abundant [59]) is an important habitat for some species such as the yellow-bellied glider and the southern greater glider [29,55]. In addition, the vast majority of birds in montane ash forests are strongly associated with old- growth forest [16]. Like hollow-bearing trees, there has been a marked decline in the amount of remaining old-growth forest relative to historical levels [30]. Only 1886 ha or ~1.2% of the ~171,000 ha of the mountain ash ecosystem in the Central Highlands is old-growth forest; it was formerly 30–60% more extensive than it is currently [60]. Old-growth alpine ash forest is even rarer; just 0.47% remains in the Central Highlands region. The major drivers of the decline of old-growth montane ash forest are the same as for large old trees—past extensive logging, wildfire, and post-fire salvage logging [30].

5.5. Climate Change

Climate change is having a range of direct and indirect impacts on biodiversity in montane ash forests. Bioclimatic modelling suggests that the environmental niche for species such as Leadbeater’s possum (and the montane ash forests on which the species relies) will shrink significantly as a result of climate change [61–63]. Climate change is also likely to have marked effects on other species such as the southern greater glider, which is known to be heat sensitive [64]. The southern greater glider is a foliage-feeding specialist [65], and high overnight temperatures in this ecosystem will likely impair the foraging ability of the species [66]. Notably, recent studies have shown that the southern greater glider is increasingly absent from lower-elevation sites in montane ash forests, with the occurrence of the species in these forest types now largely confined to areas 600–900 m above sea level [29].

Importantly, for some species such as the southern greater glider, there will be limited opportunity for uphill migration to higher elevations with increasing temperatures associated with climate change. This is because of elevation-related transitions from mountain ash to alpine ash forests, as the latter occur at higher and colder locations than the former [67]. However, stands of alpine ash appear to unsuitable habitat for the southern greater glider [29], possibly because they do not provide appropriate foraging leaf resources for the species.

Climate change is having a range of other effects in montane ash forests. Elevated temperatures appear to have contributed to the increased rates of mortality in (formerly) living large, old, hollow-bearing trees [54]. Climate change also may affect the regeneration niche of montane ash eucalypt tree species [68], potentially leading to ecosystem collapse [32]. The increased prevalence of high-severity wildfires is also strongly associated with climate change in southeastern Australia [69,70], including in montane ash forests. The impacts of fires on biodiversity in montane ash forests are outlined above.

6. Interactions among Drivers of Declines

The key drivers of decline outlined above can interact to further exacerbate species decline. For example, logging has been shown to elevate the risk of high-severity wildfire [23,24], with high-severity fire in turn having negative impacts on a wide range of species (e.g., [37,55]). When forests are burnt, they are subject to post-fire ("salvage") logging (Figure 6), with major negative impacts on arboreal marsupials [71] and birds [28], plants [22,26], and soils [27]. There is also a likely interaction between fire dynamics and the loss of old-growth forest in montane ash forests [72], with the predominance of young, highly flammable forest having a major impact on spatial contagion in wildfires [50].

Figure 6. Post-fire ("salvage") logging operation following wildfires in 2009. (Photo by David Lindenmayer.)

Other interactions between drivers of decline were touched on in the preceding section, including the accelerated losses of hollow-bearing trees associated both with logging at a site level [18] and with increasing amounts of logging at a landscape scale [20]. Similarly, the effects of climate change on some elements of the biota are likely to be exacerbated by logging, as young regenerating stands experience significantly higher temperatures and greater fluctuations in temperatures than older forests [34]. An example is the heat-sensitive southern greater glider [66].

7. Ineffectiveness of Conservation Strategies

Management interventions such as the establishment of reserves have been shown to be important for conserving biodiversity in many parts of the world [73–75]. However, levels of reservation are inadequate in montane ash forests [76,77]. This is despite (1) clear evidence of marked declines in a range of species in montane ash forests, including iconic taxa such as Leadbeater's possum, which is on a global extinction trajectory, and the southern greater glider, which is at risk of regional extinction (as has occurred elsewhere in its distribution [78]), and (2) compelling insights into the drivers of species decline.

A range of factors have contributed to the inadequate conservation outcomes to date in montane ash forests. First, analyses of the existing reserve system show that it does not support viable populations of many threatened forest-dependent species [25,76,77]. Indeed, in the case of the montane ash forests, independent assessments indicate that the entire ecosystem needs to be protected from logging to conserve species such as Leadbeater's possum [79,80]. Conversely, ongoing logging remains a major threat to biodiversity and ecosystem integrity. Logging is taking place in areas of high conservation value for threatened biodiversity [25]. Notably, legal counsel for the Victorian government's logging company VicForests admitted in court that his client must log threatened species habitat to remain economically viable [81] or at least make smaller financial losses than it already does. Moreover, areas targeted for logging are not adequately surveyed by VicForests staff prior to them being cut, resulting in losses of threatened species and their habitats [82].

Second (and related to the first problem outlined above), logging operations are poorly regulated in montane ash forests [83]. Logging exclusion zones are routinely cut illegally, as are forests on steep slopes that are supposed to be exempt from logging [84]. The state government regulatory body, the Office of the Conservation Regulator, has been found to be ineffective in regulating the logging operations conducted by VicForests, lacking the resources, data, and monitoring capability to effectively do so [83].

Third, no provision is being made to adequately protect the existing areas of currently advanced regrowth forest to eventually be recruited to become the "next old growth" [85]. This is despite the amount of old-growth forest being at historically low levels [60]. Moreover, changes in the definition of old-growth forest have made it far harder for areas to be classified as old growth and therefore more difficult to protect them [30]. Old-growth mountain ash forest was formerly defined as stands of dominant overstory eucalypt trees exceeding 120 years old [86]. This is the age when large *Eucalyptus* trees first begin to develop cavities [87], becoming critical nesting and denning resources for an array of cavity-dependent species in these ecosystems [88]. However, the Government of Victoria redefined old-growth mountain ash forest as stands of overstory eucalypt trees exceeding 250 years [89], although the ecological basis for this change is flawed, not only for cavity-dependent animals but also because more than 75% of old-growth forest cover has been lost in Victoria in the past 25 years [30].

Fourth, some new activities, such as the creation of expansive fire breaks that result in the establishment of "laneways" of cut areas throughout the forest, are accelerating the rate of loss of hollow-bearing trees.

Finally, ineffective legislation at state and Australian government levels means that logging operations take precedence over threatened species protection, even when such operations have been found to routinely breach codes of forest practice [81]. Moreover, even when logging operations have been found to be illegal (e.g., because they have occurred on steep slopes or in harvesting exclusion areas) [84], rather than change practices, ineffective laws have been altered to make previously illegal logging legal [90].

8. What Is Needed to Prevent Extinctions?

The montane ash forests of the Central Highlands of Victoria are, arguably, among the best studied forest ecosystems globally [38,41]. The long-term work in these ecosystems is a rare example of a set of environments where declines have been well documented and the drivers of decline are well understood. Given such information, What is needed to prevent declines and even possible extinctions of biodiversity in these ecosystems? In Table 2 and then also further below, I outline some of the key approaches to tackle threats in montane ash forests and limit the risks of species declines and extinctions.

An obvious first step to improve conservation outcomes in montane ash forests, as well as limit species declines and potential future extinctions, must be to reduce the number of stressors in these ecosystems. Multiple interacting stressors can place species at elevated risk of decline and extinction. Indeed, the number of threats to which a species is exposed is a key factor driving the decline in populations of vertebrates globally [91]. I argue that the removal of native forest logging as a major stressor in montane ash forests should occur as quickly as possible. This could (and should) be done within the next 1–2 years—there is precedent for this in other Australian states [92] and internationally (e.g., in New Zealand) [93]. Sources of plantation timber to substitute for pulpwood and woodchips derived from montane ash forests are readily available (and are actually superior feedstock for activities such as paper manufacturing) [93]. Part of the rapid transition could be supported financially by having a price on carbon, whereby the emissions prevented by not logging forests [94] would attract investment from other industries seeking to offset their greenhouse gas emissions.

A second task to better conserve montane ash forests and their associated biota will be to commence active restoration programs. These programs would aim to expand the old-growth estate to be as extensive as possible given not only its potential role in limiting the spread and spatial contagion in fire [72] but also its value for biodiversity conservation [30,60]. Part of such efforts to expand the size of the old-growth estate would include investing in new technologies to better protect montane ash forests from wildfires. Such technologies include drones and sensor arrays to quickly detect ignitions when they occur and then dispense pilotless aerial vehicles with payloads of water or retardant to suppress fires as quickly as possible when it is easiest to extinguish them [95]. In addition, there are extensive areas of montane ash forest that have poor levels of natural regeneration (Taylor et al., unpublished data), and hence, the restoration of tree cover is urgently needed in these places.

A third task must be to maintain long-term monitoring programs to continue to quantify changes in species occurrence and ecosystem conditions (and links between them), as well as document how they respond to interventions such as the cessation of logging and increased forest protection.

Table 2. Threats, threat effects, and ways to mitigate them in the montane ash forests of the Central Highlands of Victoria (see text for further details).

Threat	Threat Effects	Mitigation of Threat	Citation/s
Wildfire	Directly kills animals Alters habitat suitability (e.g., promotes the rate of loss of hollow-bearing trees) Removes old-growth forest Alters stand-level microclimate	Preclude fire wherever possible Use new technology to facilitate rapid detection and rapid suppression of wildfires Exclude logging that promotes severe fire	[23,77,95]
Logging	Directly kills animals Alters habitat suitability (e.g., loss of hollow-bearing trees) Sets back the rate of recruitment of suitable new habitat (e.g., old-growth forest) Increases rates of collapse of hollow-bearing trees Alters stand-level microclimate	Cease logging native forests Expand protected areas to better conserve threatened species	[18,53,54,56,60,76,77]
Fragmentation	Elevates windthrow of large old trees Compromises habitat suitability for cavity-dependent species Alters fire dynamics at stand and landscape levels May influence patterns of genetic variability within key populations	Cease logging native forests	[20,50,72,96,97]

Table 2. *Cont.*

Threat	Threat Effects	Mitigation of Threat	Citation/s
Loss of hollow-bearing trees	Impairs habitat suitability for cavity-dependent fauna	Protect all existing hollow-bearing trees, even individual large old trees Ensure provision of sufficient recruit trees to replace existing old trees when they are lost Cease logging native forests Expand protected areas	[15,25,88]
Loss of old growth	Alters fire dynamics Reduces the extent of suitable habitat for old-growth-associated species	Cease logging native forests Bolster protection of areas in landscapes where old-growth forest is most likely to develop. Take stronger legal action to enhance old-growth protection. Redefine old-growth forest	[30,60,98]
Climate change	Reduces the spatial extent of species distributions Elevates mortality of large old trees Increases stressors on heat-sensitive species Increases the risk of wildfires	Cease logging native forests Reduce greenhouse gas emissions	[54,61,62,66,69]

Delays in Cessation of Native Forest Logging in Montane Ash Forests

The Government of Victoria has indicated that in 2030 it plans to cease native forest logging not only in the Central Highlands of Victoria but also statewide [99]. While I welcome this decision, it nevertheless allows a further seven years of additional logging to take place, which is highly problematic given that 65% of all logging in Victoria is concentrated in the Central Highlands region. Failure to make a rapid transition out of logging in montane ash forests will continue to erode populations of key species, degrade their habitat, exacerbate the losses of large old trees, set back the recruitment of new cohorts of eventual old-growth forest, increase the fire proneness of the landscape (risking ecosystem collapse), and make the task of recovery and restoration more difficult. Indeed, prolonged and steep declines that have been documented in this study are likely to be indicative of extinction trajectories, at regional or even global scales. Continued declines such as those associated with ongoing logging risk creating the need for "crisis management" approaches to biodiversity conservation in montane ash forests. Crisis management can include expensive, high-risk strategies that often fail, such as captive breeding and reintroduction programs. Notably, such programs for the critically endangered Leadbeater's possum have already failed repeatedly but are continuing even though the species' habitat is being logged at the same time (D. Harley, personal communication). I believe that it makes little sense to embark on expensive reintroduction and translocation programs if the major drivers of decline (such as logging) are still in place.

9. General Lessons

This case study from the montane ash forests of the Central Highlands of Victoria has focused on circumstances where biodiversity loss and the erosion of ecosystem conditions are outcomes of the impacts of forest degradation—similar to the forest degradation problems in many natural forests globally [10–12]. There is now a global agreement to address forest degradation, and Australia is a signatory to that initiative [13]. On this basis, I argue there are some lessons from this case study that may have broader implications for biodiversity conservation and forest management in other jurisdictions.

First, quantifying declines and associated risks of extinction has been possible only through long-term monitoring. I argue that monitoring and assessment needs to be completed at multiple levels of biological organization—individual keystone structures, individual species, assemblages, habitat suitability, landscape patterns and heterogeneity, and overall ecosystem conditions. Such monitoring needs to document relationships among species, habitat suitability, and ecosystem decline, as well as the impacts of stressors (and their interaction). Monitoring programs are underpinned by an understanding that persistent and prolonged declines of species or attributes of habitat suitability (e.g., the abundance of large old trees) are a major warning sign that stronger and more effective management actions are needed [100]. Part of the focus on stressors should include an assessment of the implications of disruptions to key ecological processes such as, in the case of montane ash forests, changes in fire dynamics, reduced levels of hollow tree recruitment, and impaired regeneration success.

Second, the effectiveness of management interventions to mitigate the effects of stressors needs to be monitored and at different spatial scales (as done in this case study for old growth at individual tree, stand, and landscape levels). Of course, gathering high-quality data from monitoring programs (and the improved understanding that comes with it) of species population trajectories and ecological processes will amount to little if policy and management practices do not respond to this information [100]. Reactions to such information need to be timely to avoid the dire situation that species and ecosystems require crisis management strategies such as captive breeding programs.

A third key lesson from this case study is that simple conservation targets, even relatively ambitious ones such as 30% reservation levels, may be inadequate for species, habitats, and ecosystems that are highly threatened. This is an interesting point as the Australian Government has committed to conserving 30% of all of the nation's ecosystems by 2030. However, in the case of the montane ash forests, the very high risks of ecosystem collapse and the marked declines in the populations of many species indicate that targets such as 30% reservation will be insufficient. Indeed, all current data indicate that all of the mountain ash and alpine ash forest estate needs to be protected from logging [79,80].

Finally, there is a critical need to determine whether management actions at a landscape and ecosystem level for a given ecosystem are consistent with national and international commitments and agreements. For example, ongoing logging in the already highly degraded montane ash forests (that will only further degrade this ecosystem) is inconsistent with the Australian Government's commitment at the Glasgow COP26 meeting in 2021 on halting forest degradation [13]. Similarly, the Australian Government has committed to preventing further extinctions in Australia [101], yet their current support for ongoing logging in montane ash forests through federal–state legislation such as the Regional Forest Agreements [81] will likely lock in regional (and potentially global) extinctions for some species. The inherent conflicts and contradictions between conservation policies and policies that promote logging need to be urgently addressed.

10. Conclusions

The results from an extensive body of scientific research and monitoring conducted in the montane ash forests of the Central Highlands of Victoria over the past ~40 years show that some species are declining, and some are on a regional or even global extinction trajectory. There is also strong evidence of declines in the amount of suitable habitat for wildlife and evidence of the widespread erosion of ecosystem conditions in montane ash forests. Fire, logging, habitat loss, and climate change are the primary drivers of these declines and are major contributors to forest degradation. Current conservation policies are ineffective and have ignored, in part, much of the body of scientific evidence gathered in these forests. Indeed, policies to continue logging clash with those to protect biodiversity and are at odds with national and international commitments to protect biodiversity and prevent forest degradation. Removing logging immediately is critical to tackle the widespread ecological problems in montane ash forests if extinctions are to be avoided. Targeted restoration programs through the protection of high-conservation-value areas, revegetation on sites with failed natural regeneration, and efforts to limit extensive high-severity wildfire will be critical to recover montane ash forests and their associated biodiversity. Timely intervention is essential to prevent the situation becoming so dire that expensive, high-risk, crisis management strategies such as captive breeding and translocation programs will be required.

11. Recommendations for Policy-Makers and Forest Managers

The 40 years of work in montane ash forests have some important implications for policy-makers and forest managers. A small subset of these are briefly outlined below.

1. Cease all logging operations in montane ash forests as soon as possible.
2. Bolster legal and management protection of natural assets such as old-growth forest, large old trees, and forest habitats where key species of conservation concern have been recorded, including locations where detections of critically endangered and endangered species have been made.
3. Strengthen fire protection measures in montane ash forests, including through the use of new technologies to quickly detect and rapidly suppress ignitions.
4. Develop and implement restoration programs, including in places where natural regeneration has failed. This includes advance preparation for restoration in the event of further wildfires and where burnt young forest may not regenerate naturally and artificial stand regeneration measures (such as through additional seeding) might be required.

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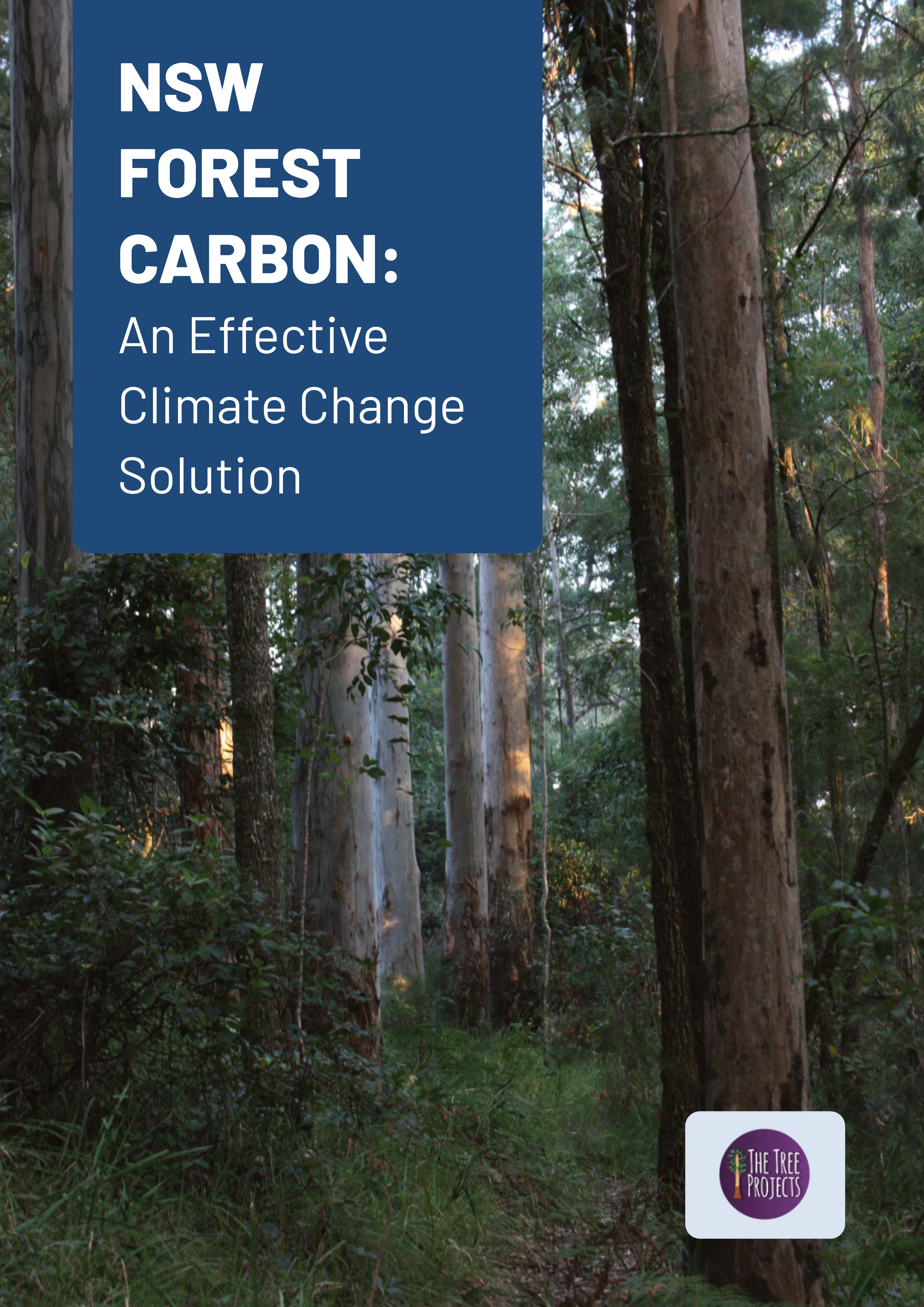
NSW FOREST CARBON:

An Effective Climate Change Solution



THE TREE PROJECTS

NSW FOREST CARBON:

An Effective Climate Change Solution

WE NEED TO ACT NOW ON CLIMATE CHANGE

Protecting native forests is a low-cost, effective and immediate way to take real action on climate change. Protecting native forests reduces emissions and allows forests to draw down considerable amounts of carbon from the atmosphere.

HIGH LEVELS OF EMISSIONS

Native forest logging in New South Wales emits around 3.6 million tonnes of carbon each year.

EQUIVALENT TO 840,000 CARS

Emissions from native forest logging are equivalent to the annual emissions of 840,000 cars.

76 MILLION TONNES OF CARBON BY 2050

can be prevented from entering the atmosphere if forests are protected rather than logged.

$2.7 BILLION

BENEFIT IN CLIMATE MITIGATION

Protecting native forests could provide $2.7 billion worth of climate benefit to the community.

Authored by Dr Jennifer Sanger, The Tree Projects. Contact: thetreeprojects@gmail.com. Cover photo: Learnscope Creative Commons

This document has been adapted from the reports: J. Sanger (2022) Tasmania's Forest Carbon and J. Sanger (2022) Victoria's Forest Carbon, The Tree Projects.

The Tree Projects recognise that the forests of New South Wales exist on the unceded land of several different Sovereign Aboriginal Nations. We acknowledge the Traditional Owners and their long and ongoing custodianship of Country and pay our respects to Elders past and present.

REPORT SUMMARY

We need to take immediate action on climate change. Protecting New South Wales' forests is a low-cost and effective way to reduce emissions. By ending native forest logging immediately, forests can continue to grow and draw down a significant amount of carbon dioxide from the atmosphere and store it long-term. Protecting New South Wales' native forests is real action on climate change.

The logging of native forests in New South Wales releases vast amounts of carbon dioxide into the atmosphere. Due to the way that emissions are reported, the emissions from native forest logging are not separated from the carbon dioxide absorbed by our forests. Only a net figure is reported. This net figure makes it impossible to tell how many greenhouse gas emissions are coming from native forest logging.

Research conducted for this report found that greenhouse gas emissions from native forest logging in New South Wales is approximately 3.6 million tonnes of carbon (CO_2e) per year. This shows that native forest logging in New South Wales is a significant source of emissions. It has the same annual emissions as 840,000 medium sized cars or is close to four and a half times the annual emissions of New South Wales' domestic aviation.

This figure is based on 'short-term' and 'long-term' emissions. Around 64% of a forest's carbon is released within a few years of logging. Most of the wood removed from New South Wales' forests goes into single-use products such as paper, which have a short lifespan. As much as 40% of the forest's biomass is incinerated, which immediately emits carbon dioxide, methane and nitrous oxides in to the atmosphere.

Long-lasting wood products such as sawn timber only represent about 4-8% of the forest's carbon. Around 30% of the forest's biomass, mainly consisting of woody debris and stumps, gets left behind on-site after burning. This can take up to 50 years to break down and emit the stored carbon.

Currently in New South Wales, forests containing 2.2 million tonnes of carbon (CO_2e) are logged each year. However, annual emissions are estimated to be higher due to the lag effects of waste breaking down on-site from decades-old logging when the rate of harvest was twice as high.

When forests are logged, two-thirds of the carbon is released within two years. Some of these carbon dioxide emissions will be recovered as some native forests regrow after logging. However, it takes many decades to centuries for forests to capture lost carbon. We cannot wait decades to centuries. We need to reduce emissions now to prevent catastrophic climate change.

Protecting New South Wales' native forests is a real climate solution. If native forests currently managed for logging were protected, we could prevent 76 million tonnes of carbon (CO_2e) from entering the atmosphere by 2050. This could provide close to $2.7 billion in benefit to help mitigate climate change.

Our smartest choice would be to protect New South Wales' native forests - this will prevent significant emissions and allow forests to continue to draw carbon down from the atmosphere.

FORESTS ARE IMPORTANT FOR THE CLIMATE

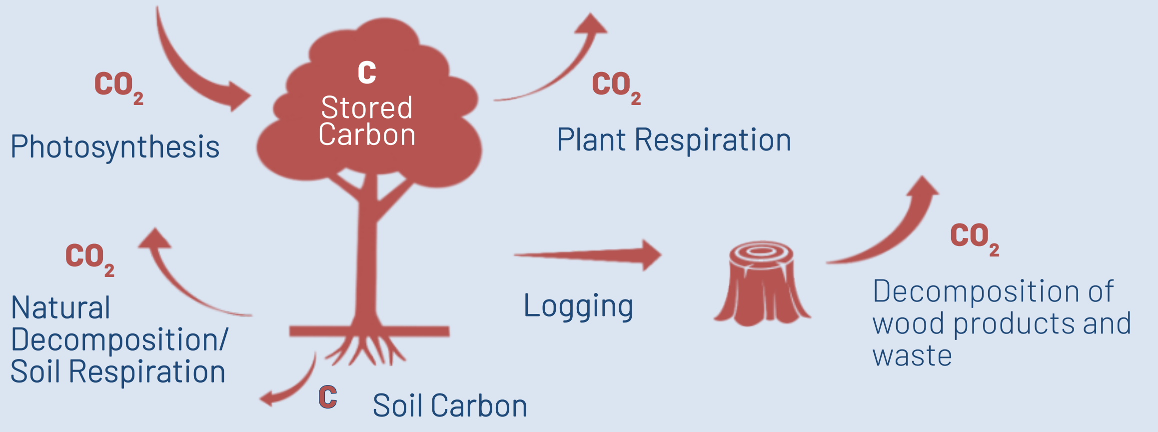
Forests capture carbon from the atmosphere and store it long-term. This carbon is released back into the atmosphere when a forest is logged.

Trees absorb carbon dioxide from the atmosphere and store it long term. If the forest is left undisturbed it will continue to store carbon indefinitely. The world's remaining forests contain 861 billion tonnes of carbon (carbon dioxide equivalent: CO_2e) – that's equivalent to nearly a century's worth of the world's annual fossil fuel emissions at current rates.[1]

When forests are logged or cleared, most of the stored carbon is released into the atmosphere. Around 12% of global greenhouse emissions are caused by deforestation and logging. This makes deforestation the third largest contributor to emissions after the energy and agricultural sectors.[2] Protecting native forests is a simple way to prevent emissions.

Native forests are especially good at absorbing carbon dioxide from the atmosphere. By allowing forests to remain intact and allowing degraded forests to regrow, a significant amount of carbon can be drawn down from the atmosphere and stored long-term. If forest protection and restoration happened at a global scale, it would contribute one-third of the total climate change mitigation that we need by 2030.[2]

CARBON CYCLE OF NATIVE FORESTS



FORESTS STORE CARBON

Forests store carbon in living trees, dead wood, leaf litter and in the soil.

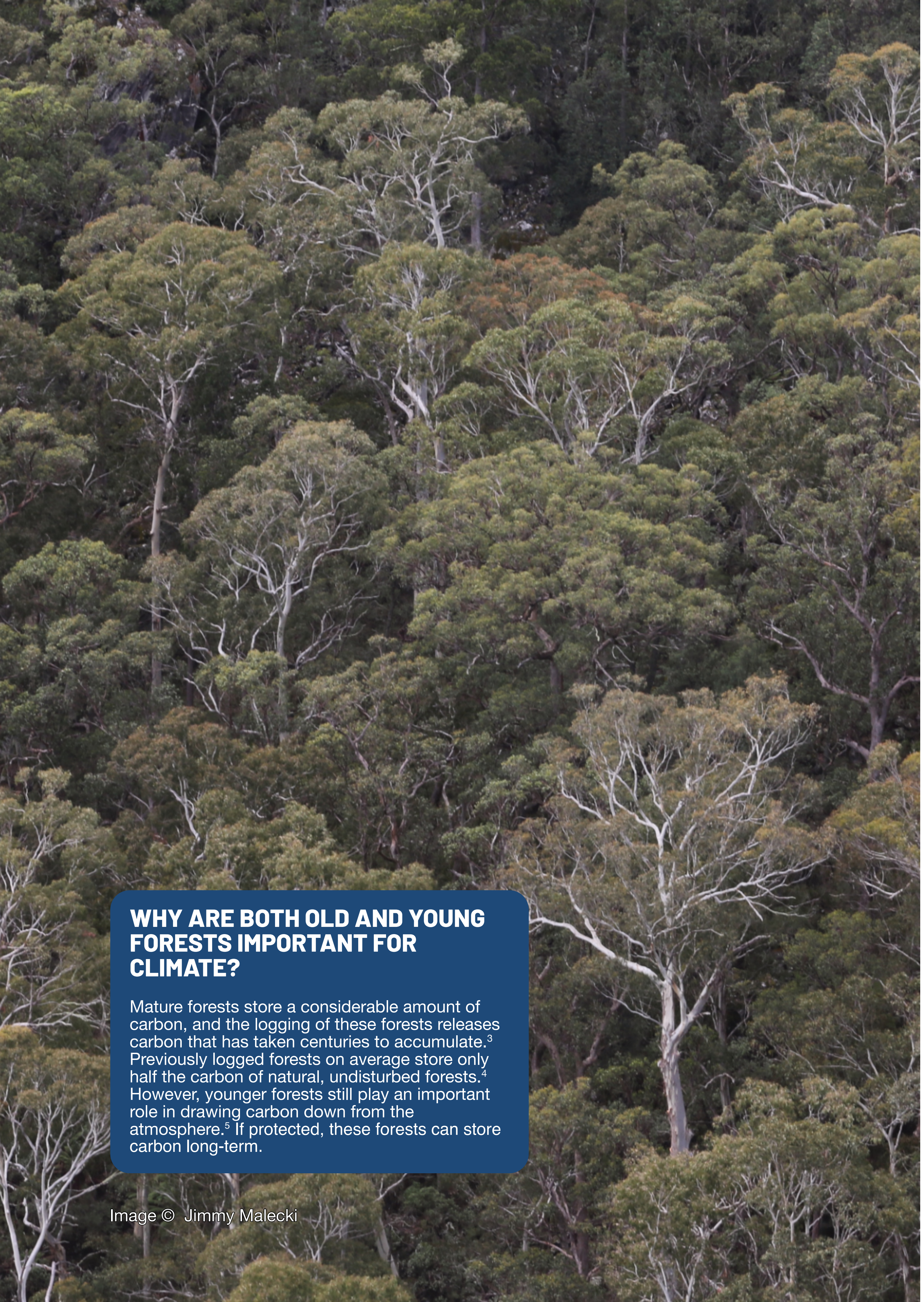
FORESTS ABSORB CARBON

Forests draw down carbon dioxide from the atmosphere.

FORESTS ARE A SOURCE OF CARBON

Logging forests releases stored carbon back into the atmosphere.

Image © Dailan Pugh



WHY ARE BOTH OLD AND YOUNG FORESTS IMPORTANT FOR CLIMATE?

Mature forests store a considerable amount of carbon, and the logging of these forests releases carbon that has taken centuries to accumulate.[3] Previously logged forests on average store only half the carbon of natural, undisturbed forests.[4] However, younger forests still play an important role in drawing carbon down from the atmosphere.[5] If protected, these forests can store carbon long-term.

Image © Jimmy Malecki

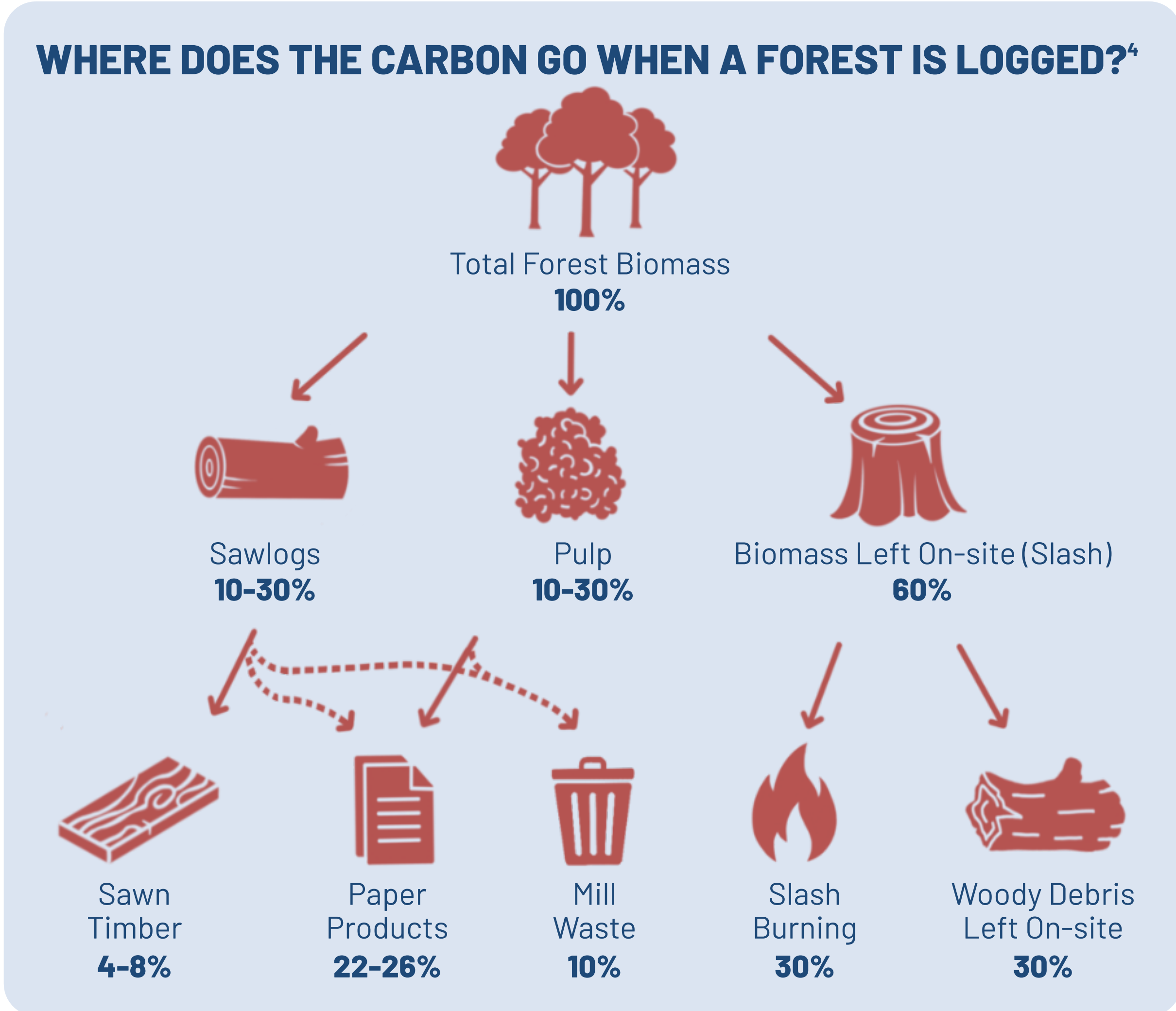
WHAT HAPPENS TO THE CARBON WHEN FORESTS ARE LOGGED?

When a forest is logged in New South Wales only 4-8% of the carbon gets stored in long-term timber products.

Many people incorrectly assume that when a native forest is logged, most of the carbon gets stored in timber products. This is not the case.

A forest is made up of biomass which includes all the trunks, branches, leaves and roots. This is where the carbon is stored. When a forest is logged, 60% of the above-ground biomass gets left on-site.[4] This waste is either burned or left to rot, releasing carbon into the atmosphere.

Only 4-8% of the forest's biomass gets turned into sawn timber which is used for building houses and furniture (4% from forests from southern NSW and 8% in northern NSW). The rest goes into short-lived products such as paper and cardboard.



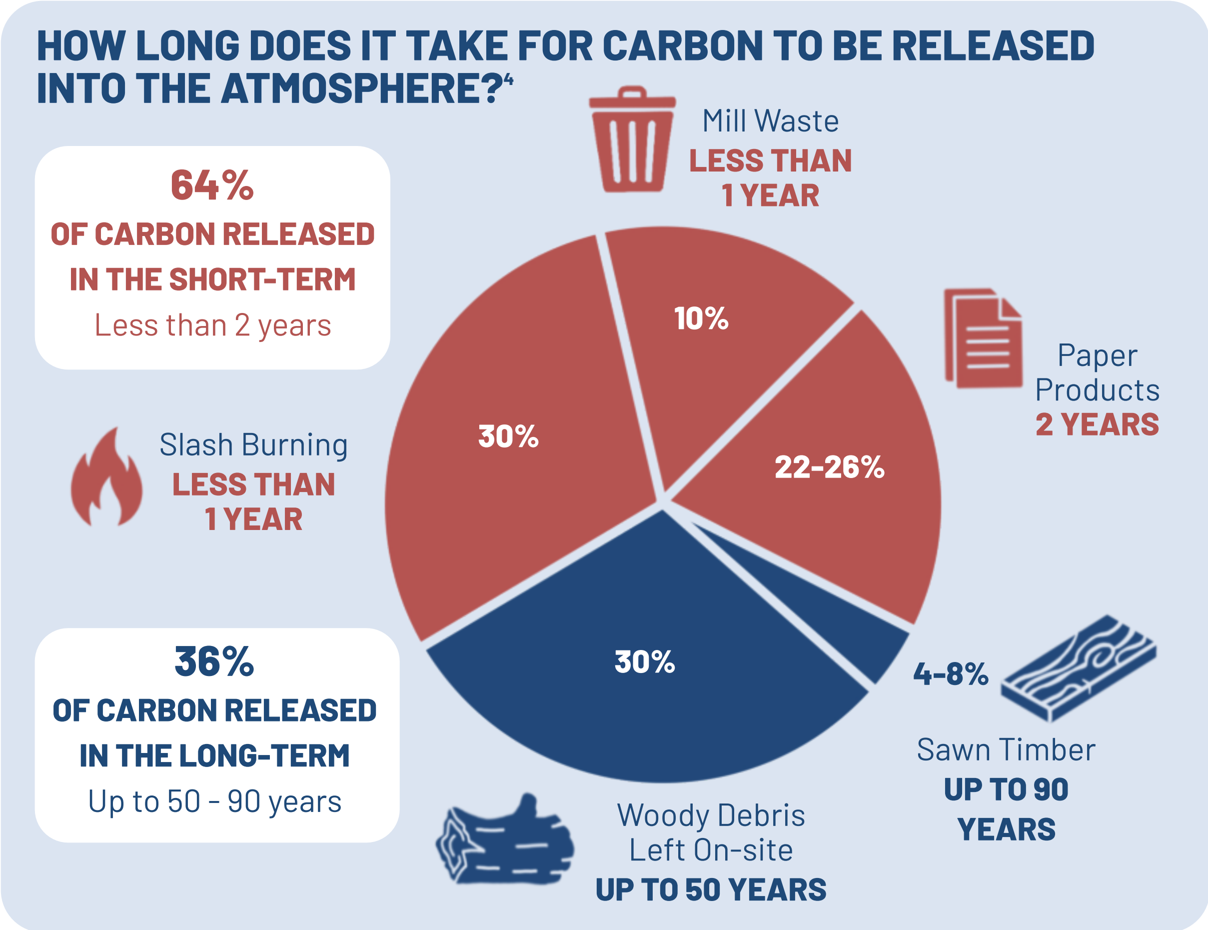
The reality of native forest logging in New South Wales is that most of the forest ends up as woodchips and waste. Native forests mainly get turned into temporary, disposable products like paper and cardboard.

NOT ALL CARBON IS RELEASED IMMEDIATELY

Two-thirds of the forest's carbon is released within a few years, while the remainder can take up to 50 years to be emitted.

When a native forest is logged, two-thirds of the carbon is released within two years.[4] This is because most wood removed from the forest is woodchipped and turned into short-lived products like paper and cardboard. The burning of waste left on-site and mill waste also releases greenhouse gases immediately.

Sawn timber has the longest lifespan of up to 90 years, however this only makes up 4-8% of the forest's carbon.[6] Most of the long-term stored carbon of a forest is in the woody debris which is left on site as waste after logging – this can take up to 50 years to break down.

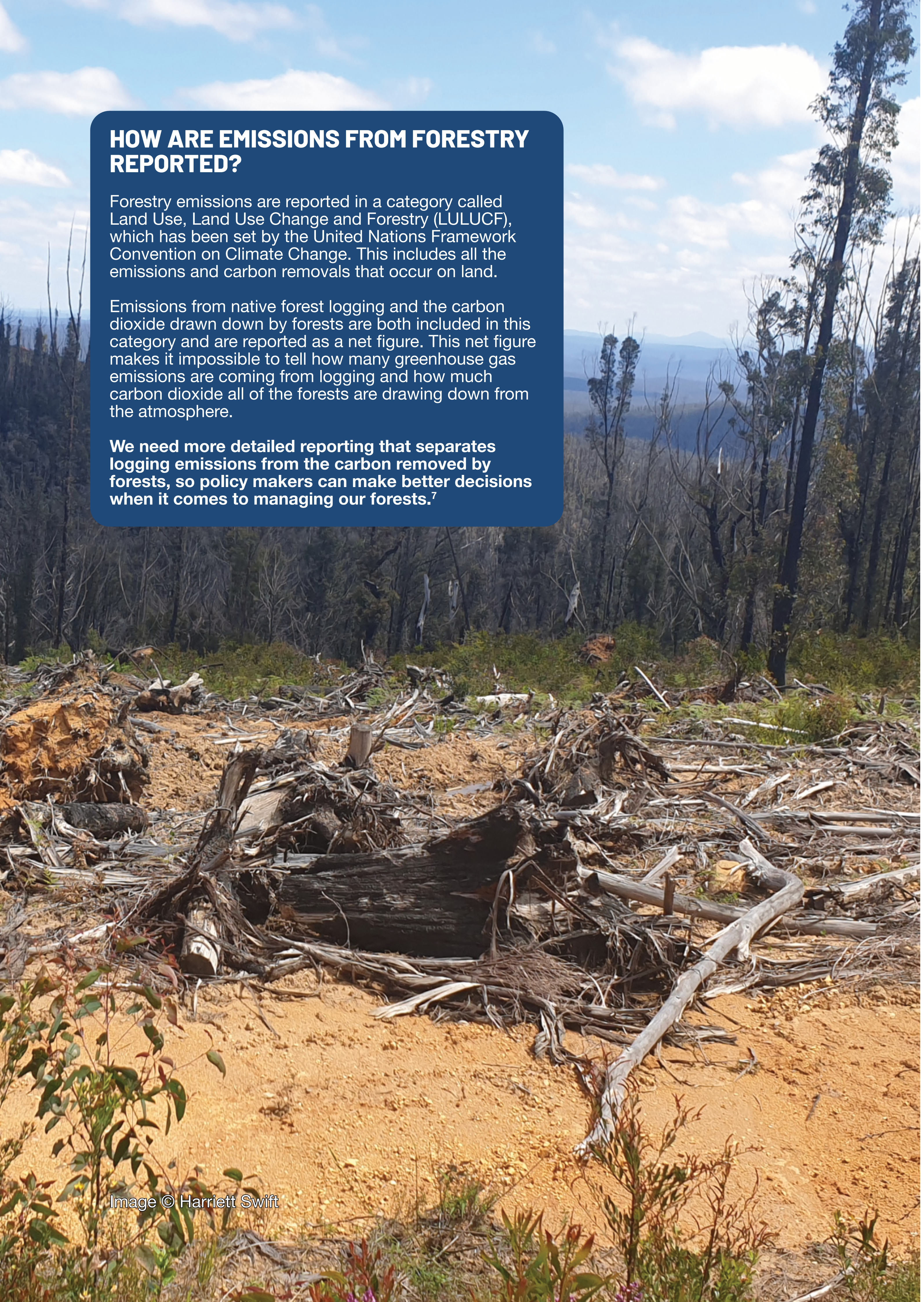


WHY DO THESE DIFFERENT TIMESCALES MATTER?

Around 64% of emissions from forestry are considered short-term, that is, they are released within two years. The remaining 36% is considered long-term and are mainly from rotting wood left on-site that can take decades to decompose.

If we were to stop native forest logging today, we would be able to stop the short-term emissions immediately. This would reduce emissions by two-thirds. However, we would still be experiencing long term emissions caused by previous decades of logging.


Image © Jimmy Malecki



HOW ARE EMISSIONS FROM FORESTRY REPORTED?

Forestry emissions are reported in a category called Land Use, Land Use Change and Forestry (LULUCF), which has been set by the United Nations Framework Convention on Climate Change. This includes all the emissions and carbon removals that occur on land.

Emissions from native forest logging and the carbon dioxide drawn down by forests are both included in this category and are reported as a net figure. This net figure makes it impossible to tell how many greenhouse gas emissions are coming from logging and how much carbon dioxide all of the forests are drawing down from the atmosphere.

We need more detailed reporting that separates logging emissions from the carbon removed by forests, so policy makers can make better decisions when it comes to managing our forests.[7]

Image © Harriett Swift

NATIVE FOREST LOGGING IN NSW RELEASES A HIGH AMOUNT OF EMISSIONS

Native forest logging in New South Wales emits approximately 3.6 million tonnes of carbon (CO_2e) each year.

Research conducted for this report estimates that the logging of New South Wales' native forests emits 3.6 million tonnes of carbon (CO_2e) per year (averaged over five years).*

The amount of logging has varied significantly over the last five years. Due to fires and floods in 2020 and 2021, the amount of forest that was logged was significantly lower than previous years.

This has meant that emissions over recent years have varied dramatically. For instance, emissions in 2018 were 4.2 million tonnes of carbon (CO_2e), while they were only 2.8 million tonnes of carbon (CO_2e) in 2021. The total amount of logging in state forests has risen by 175% from 2021 to 2022, and could potentially rise further in the future.[8]

Each year, forests containing 2.2 million tonnes of carbon (CO_2e) are logged in New South Wales.* Two-thirds of this carbon will be emitted within two years. However, New South Wales is still experiencing long-term emissions from decaying waste from the past few decades when the rate of logging was twice as high. This increases the estimates of current emissions. Furthermore, additional greenhouse gas emissions are caused from the burning of waste, which produces methane and nitrous oxide emissions.[9]

The 3.6 million tonnes of carbon (CO_2e) emitted by native forest logging in New South Wales is equivalent to the emissions of 840,000 medium sized cars, or is four and a half time the emissions of the New South Wales domestic aviation sector.

Ending native forest logging would significantly reduce New South Wales' greenhouse gas emissions.

THE 3 MILLION TONNES OF CARBON EMITTED BY FORESTRY IS EQUIVALENT TO:

- The annual emissions of 840,000 cars
- Four and a half times the New South Wales domestic aviation industry
- The annual emissions of 265,000 Australian homes
- 390,000 return flights to London

WHAT ABOUT SOIL CARBON?

Soil carbon is carbon that is stored underground as organic matter. It can make up to 27% of the overall carbon in a forest.[10] Logging forests gradually releases a substantial proportion of the soil carbon.

When a forest is logged, soil carbon can take longer to be released into the atmosphere than the above ground carbon. More research is needed on this topic, and due to lack of data we have not added this to our calculations. However, it still makes up a significant part of the emissions of native forest logging.

*See appendix for methodology on how these figures were calculated

NATIVE FOREST LOGGING IS NOT CARBON NEUTRAL

Forests are regrown after logging, however it can take centuries to re-capture the emitted carbon.

After native forests are logged, the sites are often burned by high intensity fires, eucalypt seedlings germinate and a forest slowly starts to re-grow. However, it would take centuries for the original amount of stored carbon to be absorbed by the re-growing forest.

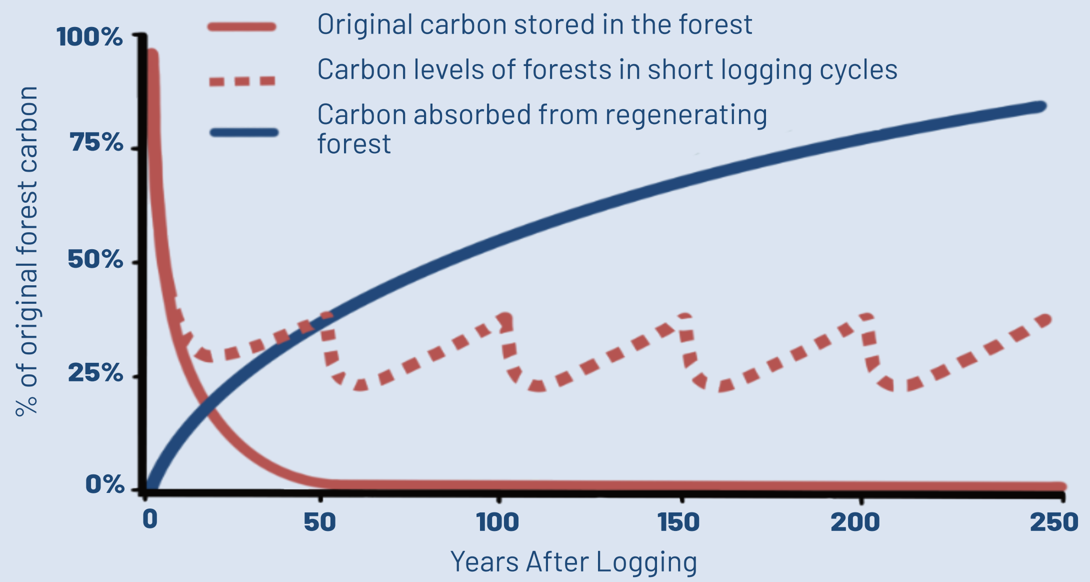
What matters most are the short-term emissions from native forest logging. Around 64% of the forest's carbon is released within a few years. At current logging rates, this is around 1.8 million tonnes of carbon (CO_2e) per year. Over these few years, when the short-term emissions have been released, the regrowing forests have not been able to draw down much carbon. This creates a huge carbon deficit.[11]

Furthermore, once logged, forests are often put into logging cycles of 40-80 years and the original amount of carbon is never recovered. These forests will only ever store a fraction of their potential carbon if they are continually logged.[4]

Native forest logging is not carbon neutral. The best use for our native forests is to protect them and to allow young forests to keep growing. This will allow significant amounts of carbon to be drawn down from the atmosphere which can be stored long term if forests are protected.

We cannot wait centuries for regrowing forests to re-capture carbon lost during logging. We need to stop emissions now. We can prevent significant emissions by protecting our native forests.

HOW DOES LOGGING AFFECT THE AMOUNT OF CARBON STORED IN A FOREST OVER TIME?[6]



Once a forest is logged, it can take decades to centuries for the carbon to be re-captured. We cannot wait that long - we need short-term solutions to the climate crisis.

FORESTS: THE BEST CARBON CAPTURE TECHNOLOGY

The impacts of climate change are increasing, and the world is searching for ways to draw carbon dioxide down from the atmosphere. While carbon capture technologies exist, they use huge amounts of energy and there is no secure way to store the carbon. Trees are currently the most efficient and cheapest form of carbon capture.

Forests are the best solution to the problem: they draw significant quantities of carbon from the atmosphere and store it long-term.

Protecting our forests is a cost-effective and practical solution to absorbing the large amount of carbon that we need to mitigate climate change.

CARBON POTENTIAL OF NSW FORESTS

New South Wales' forests store lots of carbon. If protected, they can make a real impact on climate change.

New South Wales has a vast forest estate. If protected, these forests could help fight climate change by storing significant amounts of carbon that would otherwise be released if they were logged.

Over the long-term, we could prevent around 76 million tonnes of carbon (CO_2e) from entering the atmosphere by 2050 if we protected New South Wales native forests instead of logging them. What's more, if protected, native forests have the potential of drawing down significant amounts of carbon from the atmosphere and storing it long term.

Protecting New South Wales' forests is a low-cost, effective and immediate way to reduce emissions and draw carbon down from the atmosphere.

IF NSW FORESTS WERE PROTECTED, 76 MILLION TONNES OF CARBON COULD BE PREVENTED FROM ENTERING THE ATMOSPHERE BY 2050. WHAT'S THAT EQUIVALENT TO?

- Taking every single car off the road in Australia for an entire year
- Converting 240,000 Australian homes to solar
- Shutting down Australia's dirtiest power plant, eight years early
- Shutting down an average Hunter Valley mine four and a half years early

PROTECTING FORESTS HELPS AUSTRALIA MEET ITS NET ZERO TARGET

If native forests were protected in New South Wales, our forests could provide carbon sequestration services equivalent to $2.7 billion from now until 2050 (assuming a carbon price of $35 a tonne).

The Emissions Reduction Fund received criticism in early 2022 when it was revealed that the scheme had failed to reduce greenhouse gas emissions. This is because 80% of the carbon credits approved under the scheme do not represent real or new cuts in greenhouse gas emissions.[12]

If native forests were protected in New South Wales, we would see real cuts to emissions and a considerable amount of carbon could be drawn down from the atmosphere and stored long-term. This would be a significant step in helping Australia meet its emissions reduction commitments. In comparison to the Emissions Reduction Fund, protecting New South Wales' forests is a cost-effective alternative which would mean real cuts to emissions.

$2.7 BILLON

Protecting New South Wales' native forests could provide carbon mitigation services that are worth $2.7 billion to the community.

PLANTATIONS CAN MEET OUR TIMBER NEEDS

Plantations are a more climate friendly choice than native forest logging.

Plantations are a logical solution to native forest logging. Not only do plantations produce 14 times more usable wood per hectare than native forests,[13] they also produce less emissions when logged. The harvesting of plantations produces 60% less carbon dioxide emissions than the logging of native forests.[14] This is due to the large amount of waste biomass that is discarded on-site when a native forest is logged.

Close to 90% of Australia's wood now comes from plantations and with the proper investment plantations could meet all of Australia's wood needs.[15] It is therefore possible to quickly transition out of native forest logging.

PLANTATIONS ARE A CLIMATE FRIENDLY ALTERNATIVE TO NATIVE FOREST LOGGING:

60% less

The harvesting of plantations produces 60% less CO_2 emissions than native forest logging

14x more

Plantations produce 14 times more wood products per hectare than native forests.

NATIVE FOREST TIMBER IS NOT A CLIMATE-FRIENDLY SOLUTION FOR CONSTRUCTION

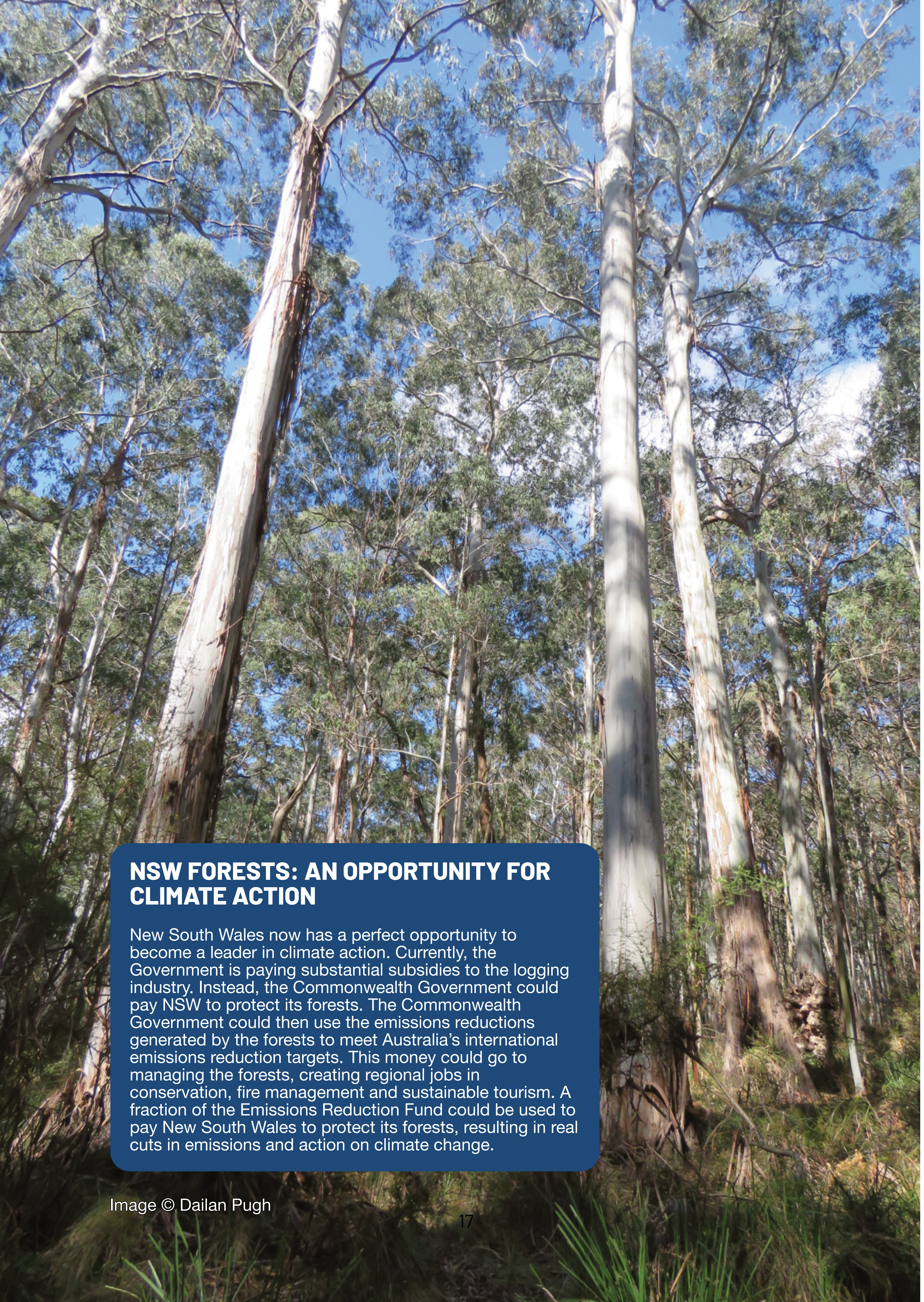
The majority of wood from native forests goes into woodchips, with very little going into sawn timber used for housing.[4] Native forest logging is not essential for the construction industry. Proper investment into plantations can provide climate friendly wood products.

The construction industry has a huge climate impact, responsible for 36% of Australia's annual emissions.[16] The production of concrete and steel requires huge amounts of energy. However, the alternative of using wood products from native forests is not a climate-friendly solution.

Research from Australia has shown mid-rise buildings made from concrete generate just 9% more greenhouse gas emissions than buildings made from plantation softwood.[17] Considering that emissions from native forest logging are close to three times that of softwood plantations, using timber from native forests is not a good climate-friendly solution.

PLANTATIONS COULD PROVIDE ENOUGH HARDWOOD TIMBER

Around 85% of eucalypt plantations are used for paper and cardboard and are harvested on short 10 to 20-year rotations. If these plantations were grown for 25 years or longer and managed appropriately, they could produce sawn timber suitable for building. Allowing eucalypt plantations to grow longer would not only allow them to absorb more carbon, but would yield a more valuable product that would store carbon long-term.[18]



NSW FORESTS: AN OPPORTUNITY FOR CLIMATE ACTION

New South Wales now has a perfect opportunity to become a leader in climate action. Currently, the Government is paying substantial subsidies to the logging industry. Instead, the Commonwealth Government could pay NSW to protect its forests. The Commonwealth Government could then use the emissions reductions generated by the forests to meet Australia's international emissions reduction targets. This money could go to managing the forests, creating regional jobs in conservation, fire management and sustainable tourism. A fraction of the Emissions Reduction Fund could be used to pay New South Wales to protect its forests, resulting in real cuts in emissions and action on climate change.

Image © Dailan Pugh

PROTECTING NATIVE FORESTS IS CLIMATE ACTION

We cannot wait for decades or centuries for forests to regrow after logging to reabsorb lost carbon. We need to make immediate cuts to emissions now.

Climate change is upon us and we must do everything that we can to reduce our emissions. In New South Wales, native forest logging is a high-emitting industry, with emissions of 3.6 million tonnes of carbon (CO_2e) per year. Ending native forest logging immediately would prevent short-term emissions of 1.8 million tonnes of carbon (CO_2e) per year. It will also prevent long-term emissions in decades to come.

If we end native forest logging now, we could prevent 78 tonnes of carbon (CO_2e) from entering the atmosphere between now and 2050. This is worth $2.7 billion in carbon sequestration services to the community. What's more, by protecting our forests, we can allow regrowing forests to draw significant amount of carbon down from the atmosphere and store it long-term.

The reality of native forest logging in New South Wales is that most of the forest ends up as woodchips and waste. A better use of our forests is to protect and value them for the climate mitigation services they provide. Protecting native forests is also important for many other reasons, including biodiversity and our own well-being. Forests also hold spiritual significance and are fundamental to the living culture of First Nations peoples.

We have an easy opportunity to make a difference to New South Wales' emissions. Let's not miss out on our chance to make a real contribution to addressing the most pressing issue of this century. By ending native forest logging immediately, New South Wales can make a significant contribution to taking strong action on climate change.

BY PROTECTING NATIVE FORESTS, WE CAN:

Immediately stop
1.8 MILLION TONNES OF CO_2
Emissions each year

Prevent
76 MILLION TONNES OF CO_2
By 2050

$2.7 BILLON
Provide
$2.7B IN CARBON MITIGATION
By 2050

We need to take immediate action on climate change. Not only do we need to reduce emissions but we need to draw down carbon from the atmosphere. Protecting forests is a low-cost, effective and immediate way to achieve both emissions reduction and to absorb carbon from the atmosphere.

ENDING NATIVE FOREST LOGGING IS REAL ACTION ON CLIMATE CHANGE.

APPENDIX:

Methodology For Calculating Annual Emissions From Native Forest Logging

Calculations for emissions from native forest logging in New South Wales: 3,603,876 tonnes of CO_2e per year (averaged over the last 5 years; 2019-2022)

Estimated emissions from native forest logging over the last five years: 2018: 4.27Mt CO_2e; 2019: 4.19Mt CO_2e; 2020: 3.38Mt CO_2e; 2021: 2.80Mt CO_2e and 2022: 3.37Mt CO_2e.

Emissions from native forest logging in New South Wales were estimated using reported wood volume removed from native forests. This method was selected as wood volume is used by the Australian Department of Industry, Science, Energy and Resources in the compilation of the National Inventory Report 2019.[22] The methods used to calculate emissions from native forests are aligned with the 2006 Guidelines for National Greenhouse Inventories and subsequent amendments.

The volume of native forest timber logged each year in New South Wales from 1970 to 2022 was recorded from Forestry Corporation of NSW reports,[8] ABARES,[19] State of the Forest Reports[20] and the Forest and Timber Inquiry Report 1991[21]. The volume of all logs (saw log, peeler log, pulp etc.) was recorded then converted to dry weight using 620-710kg/m^3 density.[22,23]

For each year from 1970 to 2022, the amount of carbon in the total above ground ecosystem biomass was calculated by halving the total tonnes of dry weight of timber products to represent the amount of carbon. Since the amount of wood removed from the forest represents on average 40% of the total above ground ecosystem biomass,[4] the value was multiplied by 2.5 to account for the remaining 60% biomass left on-site after logging.

When a forest is logged, not all the carbon from the forest is emitted straight away. Different wood products and types of waste have different lifespans which impact how quickly carbon is emitted. Annual emissions for 2018-2022 were calculated by adding short-term emissions and long-term emissions.

Short-term emissions were 64% of the total forest carbon of logged forests over the two previous years. This includes additional emissions from methane and nitrous oxides when 40% of biomass (slash and mill waste) which is burned. A value of 2,560kg CO_2e per tonne of dry weight biomass was assumed to account for additional biomass.[9,24]

Long-term emissions include unburnt biomass left on-site (30%) and sawn timber (4-8% depending if timber is from northern or southern NSW). Emissions from these sources were calculated by assuming that the biomass left on-site has a linear decomposition rate which was calculated over the last 50 years. The 4-8% of carbon from sawn-timber was estimated to have a lifespan of 90 years. Long-term storage in landfill is considered to be less than 3% and therefore has not been included in this analysis[4].

Soil carbon has not been considered, and often contributes a significant part of a forest's carbon. It has not been considered in this report as there is insufficient data to accurately account for soil carbon. Therefore the value of 3.7 million tonnes CO_2e is considered an underestimate.

These calculations are for the emissions from native forest logging of the above ground biomass, and do not account for the carbon that may be absorbed as the forest regrows. This carbon can take decades or centuries to be recovered.

The annual emissions from native forest logging given in this report are an estimate. Some assumptions have been made given the lack of data, or data not being available. For instance, additional emissions from biomass burning have been estimated from overseas studies and wood-fire heating.

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