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Q1.	**First name**	Frances
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Q6.	**Postcode**	[redacted]
Q7.	**Country**	Australia
Q8.	**Stakeholder type**	Other

Q9. **Stakeholder type - Other**

We are an alliance of scientists and citizens and a mixture of many community groups concerned about the impact of native forest logging on biodiversity and climate

Q10. **Stakeholder type - Staff**

not answered

Q11.	**Organisation name**	Australian Forests and Climate Alliance
Q12.	**What is your preferred method of contact?**	Email
Q13.	**Would you like to receive further information and updates on IFOA and forestry matters?**	Yes
Q14.	**Can the EPA make your submission public?**	Yes
Q15.	**Have you previously engaged with the EPA on forestry issues?**	Yes

Q16. **What parts of the draft Coastal IFOA are most important to you? Why?**

The 'whole' of the draft Coastal IFOA is important to the Australian Forests and Climate Alliance (AFCA) as an example of government irresponsibility which could, in the not too distant future, come to be regarded also as an example of criminal negligence in government. In this case it will be the NSW EPA and Forests Corporation NSW which will have demonstrated negligence by agreeing to develop, and/or operate according to, a regulatory system that legitimises the continuation of a (now) dangerous activity, i.e. industrial native forest logging, (while claiming adherence to principles of ecological sustainable development, ESD). ESD is the rationale underpinning ecologically sustainable forest management, ESFM, which these agencies are charged with ensuring under Regional Forest Agreements. In future governments insisting that

departments act in a fraudulent and negligent manner might be held liable for their actions in office, but it is more likely that just the departmental heads and or Ministers who will be blamed/charged. Before exposing the importance of the danger of parts of the draft Coastal IFOA AFCA stresses the importance of acknowledging the danger of the entire premise on which the entire draft is founded, i.e. that industrial logging of native forests should continue. Global and Australian scientists have published dire warnings of the consequences of ongoing industrial logging of extant native forests. A sample of the 2017 warnings: World Scientists' Warning to Humanity: A Second Notice https://academic.oup.com/bioscience/article/doi/10.1093/biosci/bix125/4605229 Over 17,000 scientists have co-signed the article in Bioscience on 13 November 2017 calling for humanity to save itself by practicing a more environmentally sustainable alternative to business as usual. "Examples of diverse and effective steps humanity can take to transition to sustainability include the following (not in order of importance or urgency): (a) prioritizing the enactment of connected well-funded and well-managed reserves for a significant proportion of the world's terrestrial, marine, freshwater, and aerial habitats; (b) maintaining nature's ecosystem services by halting the conversion of forests, grasslands, and other native habitats; (c) restoring native plant communities at large scales, particularly forest landscapes; Australian native forests are in their worst state since European settlement despite the so-called sustainability of RFA logging which this draft Coastal IFOA seeks to extend. We can provide evidence for this with recent mapping, recently forwarded to His Royal Highness Prince Charles when warning him of the negligence of Australian forests agencies and governments. An overwhelming body of peer reviewed scientific studies have established that industrial native forest logging of Australian forests must end as soon as possible. Australian and international scientists have openly and transparently stated this and directed these statements both to the public and to Australian governments at all levels. For this reason AFCA considers that any government attempting to legitimise the continuance of dangerous industrial native forest logging (now threatening not only plant and animal but also human life, given established likely impact on climate change and extinction), is environmentally irresponsible and will come to be regarded as criminally negligent. In claiming that its new regulatory system adheres to 'sustainability' principles the NSW EPA will be defrauding the public. At some later date, as the crises of climate change and extinction unfold, governments will pay the price for what can only be considered gross negligence and/or corruption in exposing their citizens and the biological assets, of which they are the custodians, to such extreme danger. Here's an extract from a statement from Australian scientists in 2016 calling on ALL levels of Australian government to desist from further clearing/logging of native vegetation. SCIENTISTS' DECLARATION: ACCELERATING FOREST, WOODLAND AND GRASSLAND DESTRUCTION IN AUSTRALIA Australia's land clearing rate is once again among the highest in the world. Remaining forests and woodlands are critical for much of our wildlife, for the health and productivity of our lands and waters, and for the character of our nation. Of the eleven world regions highlighted as global deforestation fronts, eastern Australia is the only one in a developed country [3]. This problem threatens much of Australia's extraordinary biodiversity and, if not redressed, will blight the environmental legacy we leave future generations. Australia's wildlife at risk Already, Australia's environment has suffered substantial damage from clearing of forests, woodlands and grasslands, including serious declines in woodland birds and reptiles [4]. Vast numbers of animals are killed by forest and woodland destruction. For example, between 1998 and 2005 an estimated 100 million native birds, reptiles and mammals were killed because of destruction of their habitat in NSW [5]; in Queensland, the estimate was 100 million native animals dying each year between 1997 and 1999 [6]. As land clearing once again escalates, so too will these losses of wildlife. The loss of habitat is among the greatest of threats to Australia's unique threatened species, imperilling 60% of Australia's more than 1,700 threatened species [7]. Habitat protection is essential for preventing more species from becoming threatened in the future, adding to our burgeoning threatened species lists [8]. Habitat removal eliminates the plants and animals that lived in it; increases risks to wildlife from introduced predators; impacts surface and groundwater-dependent ecosystems, and fragments habitat so that individuals are unable to move through the landscape. It also reduces the ability of species to move in response to climate change [9]. The societal costs of forest and woodland destruction Forest and woodland destruction also causes long-term costs to farmers, governments and society. Removal of native vegetation: Hastens erosion and reduces fertility of Australia's ancient and fragile soils [10] Increases the risk of soils becoming saline [11] Exacerbates drought [12] Reduces numbers of native pollinators and many wildlife species (such as woodland birds and insectivorous bats) that control agricultural pests [13] Reduces shade for livestock from heat and wind. Continued and increasing removal of forests, woodlands and grasslands increases the cost of restoring landscapes and reduces the chance of success. For example, the Australian Government has committed to plant 20 million trees by 2020 [14]. Yet many more than 20 million trees are cleared every year in Queensland alone. Forest and woodland destruction increases the threat to some of Australia's most iconic environmental assets. Coral health on The Great Barrier Reef has declined

precipitously from the effects of high temperatures associated with climate change, poor water quality, and the flow-on impacts it triggers (such as crown-of-thorns outbreaks) [15]. Native vegetation removal from catchments that flow into the Great Barrier Reef liberates topsoil and contaminants, reducing water quality and threatening the health and resilience of the Great Barrier Reef [16]. Governments have already spent hundreds of millions of dollars on this problem, with estimates of the full cost of restoring water quality as high as AUD$10 billion [17]. Native vegetation is a major carbon sink. Forest and woodland destruction is the fastest-growing contributor to Australia's carbon emissions, as it transfers the carbon that was stored in the vegetation to the atmosphere. Hence, Australia's increasing forest and woodland destruction threatens its ability to meet its commitments under four major international treaties: the Convention on Biological Diversity, the World Heritage Convention, the Convention to Combat Desertification, and the Framework Convention on Climate Change. Urgently-needed solutions Develop and implement a strategy to end net loss of native vegetation, and restore over-cleared landscapes Recognise all biodiversity, not just threatened species, in policy and legislation for the management of native vegetation Establish clear, transparent and repeatable national reporting of clearing of native vegetation Use rigorous biodiversity assessment methods for assessing clearing requests, accounting for all potential impacts, including cumulative and indirect impacts Identify habitats that are of high conservation value for complete protection For unavoidable losses of native vegetation, require robust and transparent offsets that meet the highest standards and improve biodiversity outcomes Thirteen years ago, scientists from across the world expressed their grave concern about ongoing high rates of land forest and woodland destruction in the Australian State of Queensland18. For a while, the warning was heeded, and the Queensland state government acted to bring land clearing to historically low levels. The progress made then is now being undone. Forest and woodland destruction has resumed at increasingly high rates. This return of large-scale deforestation to Australia risks further irreversible environmental consequences of international significance. Today, scientists from across the world (including those listed), in conjunction with scientific societies and the delegates of the Society for Conservation Biology (Oceania) Conference, call upon Australian governments and parliaments, especially those of Queensland and New South Wales, to take action. We call for the prevention of a return to the damaging past of high rates of woodland and forest destruction, in order to protect the unique biodiversity and marine environments of which Australia is sole custodian. Signatories Scientific Societies The Society for Conservation Biology Oceania The Ecological Society of Australia The Royal Zoological Society of New South Wales The Australian Wildlife Management Society Scientists Name Affiliation Position Associate Professor Martine Maron The University of Queensland, Australia ARC Future Fellow and Associate Professor Professor Christopher Dickman The University of Sydney, Australia Professor in Ecology Professor Richard Kingsford Society for Conservation Biology (Oceania Section); Centre for Ecosystem Science, The University of New South Wales President; Director, Centre for Ecosystem Science Professor Hugh Possingham The University of Queensland, Australia ARC Laureate Fellow; Director, Centre for Biodiversity and Conservation Science Having provided a sample only of the evidence why industrial logging of native forests should not continue we progress to the importance of understanding how irresponsible and in fact criminal are the proposals of 'parts' of the draft Coastal IFOA. The 'parts' of the draft Coastal IFOA that are IMPORTANT to AFCA for their INABILITY to provide protection of the environment • Re-zoning of areas for planned increase in logging intensity; increase in the size of clear fell areas • Removal of (already inadequate) requirements to survey/check for threatened species and the removal of the requirement to provide prescribed protection zones and practices to ensure their survival, prior to logging • The reduction of the size of buffer zones in headwaters; the inadequacy of buffers against streams elsewhere • The removal of requirements for as many hollow bearing trees as possible to remain (former requirements already being inadequate and now being lessened); removal of the requirements for adequate recruitment trees needed to develop into hollow bearing trees for the future • The intention to de-protect informal reserves and areas formerly excluded from logging, e.g. old growth and rainforest, all of which should be protected across all of NSW • The lack of provision for koala habitat • The lack of provision for eucalypt nectar bearing food trees to be retained in sufficient quantity across forest landscapes

Q17. **What parts of the draft Coastal IFOA do you think have a positive outcome on the management of environmental values or the production of sustainable timber? Why?**

No part of the draft Coastal IFOA has a positive outcome on the management of environmental values or the production of sustainable timber. AFCA concurs with Australian and international scientists calling for an immediate halt to the industrial logging of native forests. There is a plethora of scientific evidence for this call. A fraction of this evidence is included in a link to an Appendix on our website which will be provided later in this submission. It is therefore our (AFCA's) opinion that there can be no positive outcome from the draft Coastal IFOA which is being 'Re-made' in an attempt to accommodate not only a continuance of industrial logging of NSW forests but an increase in the volume of wood to be removed from an already severely degraded public (and private) native forest estate. The Auditor General warned in NSW that parts of NSW native forests are being cut faster than they can grow back and this draft IFOA is made to accommodate an increase in wood cutting volume, not a diminishment. It is therefore severely flawed from the outset both in environmental terms and in ensuring sustainable wood supply. Forest management veterans warned in Background Briefing 2015 that the saw log industry in NSW has been and is further being 'murdered' but the NSW government, NSW EPA and Forests Corporation NSW has ignored this and crafts this draft Coastal IFOA as if these warnings and facts are not now public knowledge. http://www.abc.net.au/radionational/programs/backgroundbriefing/a-burning-question/6616386 The environmental values of the forests far outweigh the wood values (including in dollar terms) and this would be true even if burning native forest for energy generation becomes the norm as is approved by the agency devising this regulatory system; the forests are so degraded from industrialised government-subsidised logging that even the DPI consultants have highlighted problems of over-logging and the need for change. It is no time to be approving more native forest logging with even less environmental protection as the environmental and economic results of the last two decades of RFA logging have demonstrated. To develop a regulatory system without considering the negative impact of the activity which it seeks to regulate is absurd. As the climate gets hotter and drier with climate change, and as our population is growing, new management regimes are needed to take account of the importance of managing resilient, diverse forests for water supplies and growing the carbon store, for human health and recreation, and as the basis for far more important and valuable industries than a failing native forestry sector. This draft Coastal IFOA takes none of the above issues into consideration.

Q18. **What parts of the draft Coastal IFOA do you think have a negative outcome on the management of environmental values or the production of sustainable timber? Why?**

All parts of the draft Coastal IFOA are flawed and will have a negative outcome on the management of environmental values and the production of sustainable timber. 1) Proposals to countenance the concept of logging of informal reserves and/or special management zones for logging are the opposite of protection, either temporary or permanent. These will result in permanent destruction, not protection. Existing RFA commitments that protected old growth, rainforest, rare non-commercial forest types are potentially going to be sacrificed for the purpose of increasing wood supply volumes. In the 2014 consultations re the 'Re-make of the Coastal IFOAs' the EPA stated that the Premier had directed that there be no diminution of wood supply. This was an outrageous flouting of the RFA 'environmental sustainability' requirement because the Auditor General had already stated in his 2009 appraisal of wood supply volumes that 'North Coast forests are being cut faster than they can grow back'. If there is a lessening of the forest there is a lessening of the protection of the environment. Then, in 2015 the EPA promised no removals of protection would occur under the 'Remake of the IFOA'. It also promised retention of the Forest Management Zone (FMZ) layer, that this would not be changed. Now the likelihood of logging looms in Informal Reserves and/or Special Management Zones in order to accommodate an increase in wood supply volume. Here is an example of removal of protections, which will combine with other removals of protection to guarantee permanent destruction of the environment. Old Habitat Trees for Owls: There are plans to 're-map' that would permit 'landscape' areas formerly dedicated to the protection of particular species to be moved or modified to include and thereby substitute areas logged over the past 20 years. In the case of owls this will mean trees without hollows for them to shelter and breed in, in short to exist. There must be no change to 'owl landscape' protection mapping. Logging Old Growth and Rainforest: This is a most blatant (and we can only describe as insane) removal of a protective layer that will combine with other removals of protection to cause permanent destruction rather than protection. To revise criteria and methodology in order to re-map ecosystems 'out of existence' for the purpose of increasing wood supply volumes is so inconsistent with the original criteria and methodology applied in the Comprehensive Regional Assessment upon which the

RFAs were founded that this alone should be enough to render this draft Coastal IFOA illegal. Old growth and rainforest were protected as part of the CAR reserve system. The old growth eucalypts have the highest number of hollow-bearing trees essential as nests and dens essential for the range of hollow-dependent animals; the existing mature trees provide the nectar and seeds essential food resources for multiple species. They are utterly critical for maintenance of populations of forest dependent species throughout State Forests and vital as stepping stones between national parks. To propose removal of any bit of old growth or rainforest on the basis that it's needed to fulfil committed timber volumes is clear evidence that this draft Coastal IFOA is committed to the demands of the industry not the environment. In north-east NSW the new IFOA targets old growth forests via changing definitions and targets. Trial re-mapping results in 88% of mapped High Conservation Value old growth and 62% of mapped rainforest 'disappearing'. The significance of this is that (using the Natural Resource Commission's new criteria and methodology) of the 103,000 ha of protected old growth on State forests up to 58,600 ha or 57% could be logged. Of 81,567ha of protected rainforest up to 50,600 hectares or 62% could be logged. These forests are protected as Informal Reserves as part of NSW's Comprehensive Adequate and Representative reserve system, with old growth in the Upper North East included on the NSW Heritage Register. Old growth and rainforest contribute to a Comprehensive, Adequate and Representative reserve system so targets for their retention must be considered in relation to what they contribute to the entire reserve system. In the case of Old growth and rainforest every bit must be preserved. It is not scientifically meaningful to arbitrarily re-define targets for old growth for preservation as an isolated entity. It is an environmental absurdity that any old growth forest or rainforest could be logged under a regulatory system defining itself as 'sustainable'. Stream Buffers under the existing IFOA are already inadequate. All headwater streams should have a minimum buffer of at least 30m. To propose that buffers in headwater catchments be reduced to 5m is another indication of the way in which operational scale considerations are being applied so as to effect permanent destruction as opposed to protection. We have observed that there is a call to ensure that there are 10m riparian buffers on all streams in the intensive logging zone in catchments less than 20ha. We do not believe that there should be any 'intensive' logging zones at all but we would certainly agree that anywhere the maximum stream buffer should be implemented. Removal of requirements to retain recruitment trees and reduction of the incidence of retention of hollow-bearing trees: Given the acknowledged global shortage of older trees capable of providing habitat protection to threatened species this draft IFOA should be urgently implementing retention of all hollow bearing trees and recruitment of as many potential hollow bearing trees as possible. • No hollow bearing trees should be logged • At least 10 of the largest and healthiest trees per hectare should be retained in order to replace any hollow bearing trees that might senesce and/or to provide future hollow bearing (habitat) trees • Any tree greater than or equal to half a metre diameter should be retained and protected as a matter of urgency. Eucalypt feed trees: Nectar producing eucalypt feed trees must be retained. At least 10 hectares of nectar producing eucalypts should be protected within any forest compartment. These are critical for specific threatened species and might permit some future protection for species which will become threatened without retention of these feed trees. Any healthy mature/late mature eucalypts producing nectar must be retained. In potential habitat of Regent Honeyeaters and Swift Parrots there should be no logging to provide a chance for survival of these critically endangered species. Threatened Species: Another equally disgraceful and almost unbelievable corruption of the concept of protection is provision in this draft IFOA to remove protection for threatened species by removing the requirement to undertake pre-logging surveys and apply appropriate protections for all threatened species. Without this provision the draft IFOA is a sham that will be conveyed clearly to the public. The most inexpert person would be capable of understanding that to fail to survey for threatened species and to provide protection with mandatory logging exclusion zones is to make a mockery of any pretence of planning for species survival. The new draft IFOA must restore the provision for surveying for threatened species and ensure this is done by independent qualified experts who should make their own determination of the nature and extent of logging exclusion zones. Such experts must be independent of both the EPA and Forests Corporation NSW and their determinations should be made subject to peer review and subsequently binding on the government agencies' operations. As there has been so much damage to the environment under inadequately monitored threatened species protection provision to date it is now a matter of urgency that there be a full enquiry into the effectiveness of existing threatened species prescriptions for it is likely that these will need to be increased in order to effect recovery of species populations before further logging could take place. Explicit performance criteria and the means to achieve this need to be published so that independent expert advice can be obtained. Logging Intensity: It has been variously acknowledged over the last 10 years by the public, scientists, conservationists, EPA officers and the Auditor General that NSW forests have been massively over-logged during the current IFOA. Now the EPA plans to increase logging intensity. Harvest workers themselves have stated publically and allowed themselves to be recorded claiming that

harvest rotation times and methods have been degrading forests almost beyond recognition. Aerial footage and citizen scientist surveys have proven that a deliberate process of sterilisation of forests has been taking place in order to convert forest landscapes to pseudo Blackbutt plantations for the purpose of industry. This is all well documented and is well evidenced in the public domain. Let's take a look. Silvicultural practices under the current IFOA have been acknowledged by the EPAs own officers as illegal. The failure of AGS (clear felling) to achieve intended silviculture results was admitted in an RFA silvicultural review report. It mentioned weeds, bare ground and lack of appropriate regrowth. The failure of Single Tree Selection in its light and moderate forms is described as frequently not capable of achieving regeneration in accordance with Forests Corp harvest objectives. The Heavy Single Tree Selection method, whereby Forests Corp NSW removes in excess of 40% basal wood and often as much as 80 and up to almost 90%) is described by the EPA via Gary Whytcross, Director South and Forestry, EPA, as 'not consistent with the definition and intent of STS in the Integrated Forestry Operation Approvals (IFOAs) as well as FCNSW's own silvicultural guidelines.' To quote from the email in which this is admitted: Re: 'Intensive harvesting is outside the authorisation of the IFOAs The EPA has previously indicated its view that "regeneration harvesting", as practised by FCNSW, is not consistent with the definition and intent of STS in the Integrated Forestry Operation Approvals (IFOAs) as well as FCNSW's own silvicultural guidelines.' Yet the EPA plan more and worse in this new draft Coastal IFOA. Is this not corruption in some form? Forest management under the NSW RFA is not improving forest management but destroying the resource. In no way either could this be described as upholding any other ESFM principles given the shocking impact of removal of over 80% of basal wood from compartments across a region with the consequent baring of earth, loss of trees for lifeforms and regeneration induced bushfire traps that this form of harvesting is producing. It is unsustainable as these forest workers attest: https://www.youtube.com/watch?v=DDp60gf0Lmk An excerpt from an ABC Background Briefing Programme looking at what has happened in NSW forests under the current (less intensive) IFOA. Forest worker for 30 years (Pat Murphy) and another logging contactor explain the impacts of Forests Corporation logging practices instituted purely to adhere to an unsustainable timber supply agreement during the review period. Yet this intensive overcutting continued and is poised to increase with the re-zoning of over 140,000 ha across the state as 'intensive zone'. https://youtu.be/Npc2y3RA8kM www.abc.net.au/radionational/programs/backgroundbriefing/from-axes-to-ipads-logging-native-forests/6628110 Even the evidence of its own officers and staff is ignored by this draft IFOA. So despite evidence of what the EPA already know, i.e. that Forest Corporation NSW's self -determination that it could remove up to 80 and 90% of basal wood via a corrupt interpretation of compartment 'offsetting' has been illegal and that Forest Corporation NSW has not adhered to the current regulatory system, it now plans to change the regulatory system to accommodate an even more drastic phase of over-cutting, highly damaging increase in logging intensity for the purpose of industry. The proposed 140,000ha North Coast Intensive Zone is to be condemned. Clear-felling must not be allowed. It is an insult to forests that there is a proposal to clear fell at all in these so-called 'intensive zones' and to then increase logging intensity in the rest of the forests. That the EPA should consider sanctioning a minimal basal area to be retained is 10m2 ha in the "regrowth" zone and 12m2 ha in the non-regrowth zone is evidence that it is following the dictates of industry not environment. Even just to maintain the current overcutting rules the minimum basal area retention would have to be increased to at least 20 m2/ha across all forests. What should happen is for no native forest logging to occur so that these forests can have a hope of recovery and return to functioning ecosystems. If logging does not cease now it will result in even more of the native forest estate being converted into a sterilised factory for industry instead of functioning ecosystems. Only a complete moratorium on further logging will rectify this. Bell Miner Associated Dieback: That logging is a primary cause of Bell Miner Associated Dieback has been scientifically proven but the EPA fail to act on this and exclude logging from any area where this occurs. Koalas: The removal of the need to look for and protect high quality Koala habitat is blatantly destructive. It is the obligation of NSW to protect this nationally threatened species, the national icon! The identification and exclusion of logging from occupied core Koala habitat across all land tenures is of the highest priority if the ongoing decline is to be arrested and yet the draft IFOA removes the requirement to search out and protect high quality Koala habitat. In order to reverse the decline it is essential that protection be extended to previously occupied high quality habitat, habitat linkages between core habitat, and present and future climate refuges. Searches for all trees utilised by Koalas (with observations of Koalas, Koala scats and/or distinctive Koala scratch marks) must be undertaken before logging and all utilised trees protected.

Q19. **What are your views on the effectiveness of the combination of permanent environmental protections at the regional, landscape and operational scales (multi-scale protection)?**

Permanent environmental protection doesn't result from jargon. It occurs if there is actual protection at a bio-physical level. The draft Coastal IFOA is a miscellany of jargon that can potentially mislead the public or the consumer. Multi-scale protection is a made up term. It means nothing, particularly when the 'scales' referred to have no defined ecological significance, on their own. No matter how many 'scales' at which 'protection' is claimed there is either permanent protection or there isn't. A suite of meaningless descriptors does not protection make. Leaving habitat in place (not logging) and not removing it (not logging) is a more permanent protection than is making it non-existent by logging/removing it. That 'operational' scale is assumed by the question to be an aspect of 'multi-scale' protection is absurd. It has no relevance to the concept of 'protection'. The operations referred to do not afford protection, in fact the opposite. Attempting to marry a term relating to the expediency of industrial logging (operational requirements) with the concept of environmental protection is to give the game away, i.e. that this is a sham document for the purpose of greenwashing a damaging industry rather than protecting the environment. That permanent environmental protection might in any way be dependent on or qualified by operational requirements (scales) is indicative of the absurdity of this draft IFOA. Things that can be changed, i.e. operational regimes or better still, in this case, non- operational regimes (i.e. non logging) are what must take place if environmental protection is to occur. The bio-physical requirements of species cannot be accommodated to comply with an industrial operation. Operational scales are not an aspect of 'multi-scale protection' and the question should not pretend they are. Terms such as regional, landscape and operational scale only become meaningful or useful descriptors if employed by expert ecologists, graduates of courses dedicated to the study and appraisal of the best means by which permanent environmental protection can be achieved. They come into play when attempting to discern/decide the best possible means by which long term species/biodiversity protection can be afforded. Such graduate courses must be recognised by institutions suitably qualified to conduct them. EPA and Forests Corporation staff devising the draft Coastal IFOA is not suitably qualified ecological experts able to use these terms meaningfully. Furthermore they are not highly specialised ecologist seeking to develop the best possible means of long term species protection. The EPA and Forests Corporation staff is employees of a government public service which will not tolerate non-obedience to the political will. In this case they have been given a brief and the brief is to green-wash an activity known to harm species. If they do not perform in that brief they will not be employed. So they are not expert ecologists using this terminology in a scientific endeavour the goal of which is maximum species preservation. They are public servants hampered by a political brief. This document simply attempts to co-opt natural resource terminology to justify a plan for getting timber makes this entire regulatory 'Re-make' a sham. Unless utilised in reference to highly specific and well defined situations and applied to the biological needs of individual species, the terms landscape and regional scale are meaningless. Ecologists and indeed anyone with common sense and without a political agenda dictating their opinion would agree that: Unless underpinned by actual protection of sufficient and connected sites/area for all species comprising a given ecosystem at a frequency/level/amount/scale proven to provide adequate protection over time, claims of permanent regional and landscape protection are meaningless.

Q20. **In your opinion, would the draft Coastal IFOA be effective in managing environmental values and a sustainable timber industry? Why?**

No. It is a document that feigns adherence to scientific principles and in particular ecologically sustainable development principles, while ignoring scientific evidence that the very premises on which it is being drafted are flawed. We do not think this draft Coastal IFOA would provide protection either for environment or for the timber resource Were you to attempt to improve it you might consider undertaking the following: Re Environmental values: Re-examine the adequacy of the CAR reserve network of forest ecosystems that has been established (a key promise of the RFAs) and the location and ecological condition of any outstanding forest ecosystems, given the shocking damage to production areas for this impacts ecological outcomes of reserve networks. Establish the extent of bell-miner associated dieback (BMAD) on the public estate; budget and plan to accommodate rectification of this as it is a vast risk to the very existence of native forests in NSW. Examine the age-class distribution of the forest estate in Forest Management Zone 4 (timber harvesting) and the annual change in extent of age-classes under the current IFOA as age-class is an important predictor of the characteristics of a forest in regards its value to native fauna, volume of stored carbon, water provision and timber stocks. Correct implementation of ESFM should result in no change over time. Should you observe that there has been change over time the EPA might re-think continuing to log native forests. Annual trends in the extent of canopy loss/disturbance due to logging over the life of the RFAs need to be examined bearing in mind that correct implementation of ESFM should result in no change over time. If there have been changes the EPA needs to develop a regulatory regime that corrects rather than exacerbates canopy loss/disturbance. This might involve a ‘no logging’ regime in order to permit restoration. Examine the changes to the conservation status of forest species during the life of the RFAs and desist from logging where these are found to have been in decline. Industry sustainability values: another key aim of the RFAs and which should have resulted from the current IFOA and didn’t, as evidenced by the need for taxpayers to compensate multinational clients millions of dollars during its duration and loss to taxpayers of multimillions annually from the native forest logging sector. Why is the NSW EPA failing to not only question but condemn a planned increase in wood supply given this track record? Those developing this draft Coastal IFOA, supposedly the regulatory system for controlling unsustainable practices are not asking and demanding logical responses to the question that ‘goes begging’ before doing the government’s bidding in developing this disgraceful ‘greenwash’ document, the draft Coastal IFOA. Why is there such a determined governmental insistence that the draft Coastal IFOA accommodate increases in supply of high quality large sawlogs, high quality small sawlogs, pulp logs and other products when it has been proven the NSW public native forest estate cannot sustain present volumes? The public need to have answers to these questions in relation to the ‘sustainability’ of the native forest logging industry or they won't trust the new regulatory regime. They already no longer trust the native forest logging industry and this will confirm that opinion.

Q21. **General comments**

Even if AFCA thought that there was any scope for further native forest logging in Australia (which we don't) we do not think this draft Coastal IFOA would provide protection either for environment or for the timber resource. It is a scandalous cynical exercise and we reject it outright as we reject all aspects of the process of its development. We intend to make our thoughts on this known constantly as often as we can to as wide an audience as possible.

Q22. **Attach your supporting documents (Document 1)**

[redacted]

Q23. **Attach your supporting documents (Document 2)**

[redacted]

Q24. **Attach your supporting documents (Document 3)**

[redacted]

PLOS ONE

RESEARCH ARTICLE

Under What Circumstances Do Wood Products from Native Forests Benefit Climate Change Mitigation?

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Abstract

Climate change mitigation benefits from the land sector are not being fully realised because of uncertainty and controversy about the role of native forest management. The dominant policy view, as stated in the IPCC's Fifth Assessment Report, is that sustainable forest harvesting yielding wood products, generates the largest mitigation benefit. We demonstrate that changing native forest management from commercial harvesting to conservation can make an important contribution to mitigation. Conservation of native forests results in an immediate and substantial reduction in net emissions relative to a reference case of commercial harvesting. We calibrated models to simulate scenarios of native forest management for two Australian case studies: mixed-eucalypt in New South Wales and Mountain Ash in Victoria. Carbon stocks in the harvested forest included forest biomass, wood and paper products, waste in landfill, and bioenergy that substituted for fossil fuel energy. The conservation forest included forest biomass, and subtracted stocks for the foregone products that were substituted by non-wood products or plantation products. Total carbon stocks were lower in harvested forest than in conservation forest in both case studies over the 100-year simulation period. We tested a range of potential parameter values reported in the literature: none could increase the combined carbon stock in products, slash, landfill and substitution sufficiently to exceed the increase in carbon stock due to changing management of native forest to conservation. The key parameters determining carbon stock change under different forest management scenarios are those affecting accumulation of carbon in forest biomass, rather than parameters affecting transfers among wood products. This analysis helps prioritise mitigation activities to focus on maximising forest biomass. International forest-related policies, including negotiations under the UNFCCC, have failed to recognize fully the mitigation value of native forest conservation. Our analyses provide evidence for decision-making about the circumstances under which forest management provides mitigation benefits.

Introduction

Storage of carbon as biomass in the land sector is an important activity for climate change mitigation. Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere [1], and annually is around 10% of global anthropogenic emissions [2]. The global amount of emissions from deforestation and degradation continues to increase, but the proportional contribution to total emissions has decreased during the 20th century with increased fossil fuel use. The cross-over point of these sources of emissions is estimated to have occurred either early or late in the 20th century, depending on whether decomposition of wood products and changes in soil organic carbon due to land-use are accounted for [3]. In Australia, an estimated 44% of the carbon stock in temperate forests has been emitted due to deforestation [4].

Reducing these emissions and restoring the land carbon stock by identifying strategies for forest management that increase carbon storage is an important component of a comprehensive approach to climate change mitigation [5]. Carbon is stored in forest biomass, wood products and waste material in landfill. Furthermore, it is argued that mitigation benefits can be derived from using forest biomass as a feedstock for bioenergy, substituting for an equivalent amount of fossil fuel energy, and avoiding the associated carbon dioxide emissions. Similarly, it is claimed that use of wood products with lower embodied energy than other construction products can avoid emissions. Given that a range of forest management and carbon accounting strategies is possible with varying mitigation outcomes, a critical question is: how can we best manage forests and their harvested products to maximise carbon storage in the land sector and minimise net anthropogenic greenhouse gas emissions?

We focus this study on native forests, that is, self-regenerating ecosystems where ecological processes dominate. This is because their management for competing resources is controversial and scientific evidence is needed to evaluate options [5]. The options for carbon storage are often depicted as a dichotomy between commercial harvesting and conservation, although a range of management strategies exist for native forests. With commercial harvesting, native forests are logged at regular periods and the woody biomass is used as the raw materials for manufactured wood and paper products. Mitigation benefits potentially can arise from the carbon stored in the wood products, the forest regrowth that occurs in between harvests, and avoided fossil fuel emissions due to substitution by wood products and bioenergy. A strategy of conservation, whereby native forests are not harvested, allows carbon stocks to reflect ecosystem processes of growth, mortality, decomposition, and self-regeneration. A benefit of the native forest conservation strategy is that the forest carbon stock is at a maximum given the environmental conditions and disturbance regimes that characterise the landscape. Additionally, stability of these natural carbon stocks is conferred by the capacity for resilience and self-regeneration of natural ecosystem processes [6]. Under both strategies, fluctuations in the native forest carbon stock occur due to natural disturbances, especially wildfire, storms, pests and diseases [7].

Assessing the relative mitigation benefit of these two native forest management strategies depends on the amount of carbon transferred between natural and manufactured stocks and the longevity of these stocks. The key calculation is the impact a forest management strategy has on net land and fossil carbon stocks, which are then reflected in the atmospheric carbon dioxide concentration.

Different conclusions about mitigation benefits of forest management strategies have been reported in the literature over the last two decades [7–15] (Table A in S1 Appendix). The view stated in the IPCC's Fifth Assessment Report is that sustainable harvesting yielding wood products generates the largest mitigation benefit [16]. This opinion has been advocated by

politicians responsible for national forest policy [17], national forest policy statements [18], state agencies responsible for managing publicly-owned native forest land [19,20], and communicated to the public in media campaigns [21]. However, the published literature shows that the circumstances under which forest management provides mitigation benefits varies and is not universal. This uncertainty in, and controversy about, the role of native forests in climate change mitigation has led to inconsistencies in national and international policies about land management and climate policy.

Many of the differences in previous studies' conclusions are due to inconsistencies between them concerning: (i) the forest conditions in the reference case; (ii) the temporal scales over which the analyses are undertaken; (iii) the spatial scale of the analyses; and (iv) the substitution assumptions. The forest condition in the reference case (what would occur in the counterfactual if there was no change in management practice) determines the basis for comparison of carbon stocks against which potential gains and losses can be assessed. An initial loss of carbon occurs when a native forest, in an old-growth or primary condition, is harvested and replaced by a forest managed for products, or regrowth forest [8,22]. The difference in carbon stock can be assessed from the native forest as an average within its natural disturbance regime, compared with the managed forest as an average over the rotation period [23]. Temporal scales relevant for effective climate mitigation activities are within the next few decades [24]. A temporal imbalance between carbon emissions and uptake rates in the order of many decades may not provide a net mitigation benefit [25,26]. The assumptions underlying the mitigation benefits of product or energy substitution are often not made explicit and may not account for all factors. In our analyses, we have considered these issues, tested a range of parameter values, and explicitly defined the system conditions.

Our objective was to assess native forest management strategies to determine the circumstances that provide maximum benefits for climate change mitigation. We simulated the effect on carbon stocks of management strategies for two native forest systems from Australia: (i) mixed eucalypt forest in the South Coast Region of New South Wales (NSW); and (ii) Mountain Ash forest in the Central Highlands Region of Victoria. For both case studies, we compared the carbon stocks under two contrasting management scenarios: (i) harvested native forests, with options for accounting for the carbon storage in regrowth forest biomass, wood and paper products, landfill, and the carbon benefits of bioenergy substituted for fossil fuel energy, and (ii) conserved native forests, accounting for carbon storage in forest biomass, with options for accounting for substitution by non-native wood products. We tested a range of parameter values describing carbon stock dynamics that are general for other forest systems and identified key issues for analysing carbon stock changes that drive the outcomes of accounts.

The context of our research was to contribute to advancing the scientific understanding of carbon stock dynamics in forest system. This information is also relevant for the decision-making process about the relative benefits of native forest management strategies for climate change mitigation. The management of public native forests is determined by public policy through the political process. Decisions about forest management must account for environmental, social and economic factors. Simulations from scenarios of different forest management strategies are based on a range of input data and assumptions, which may be limited in some respects but represent the best currently available. These simulations demonstrate some of the consequences of different actions and so contribute information to the public, policy-makers and politicians.

Methods

Defining the carbon accounting framework

Our analyses required accounting for all carbon stocks in the native forest management system and post-harvest products: forest biomass carbon; harvested wood products; waste material; and potential substitution of wood products for other materials, and bioenergy for fossil fuel as a source of energy. All components of biomass were included in the carbon stock: living and dead, above-and below-ground biomass. Owing to data limitations, soil carbon stocks were excluded (Australia does not account for soil carbon in harvested native forests in its national greenhouse gas accounts for the same reason [27]). Changes in carbon stocks were described by transfers of biomass through forest harvesting, forest regrowth, wood products processing and use, rates of decomposition and combustion, energy conversion efficiencies, and disposal of waste (Fig 1). The proportions of each of these stocks vary depending on the forest type and species, silvicultural treatment and market for products. Carbon stocks were defined by their magnitude, longevity and stability [28].

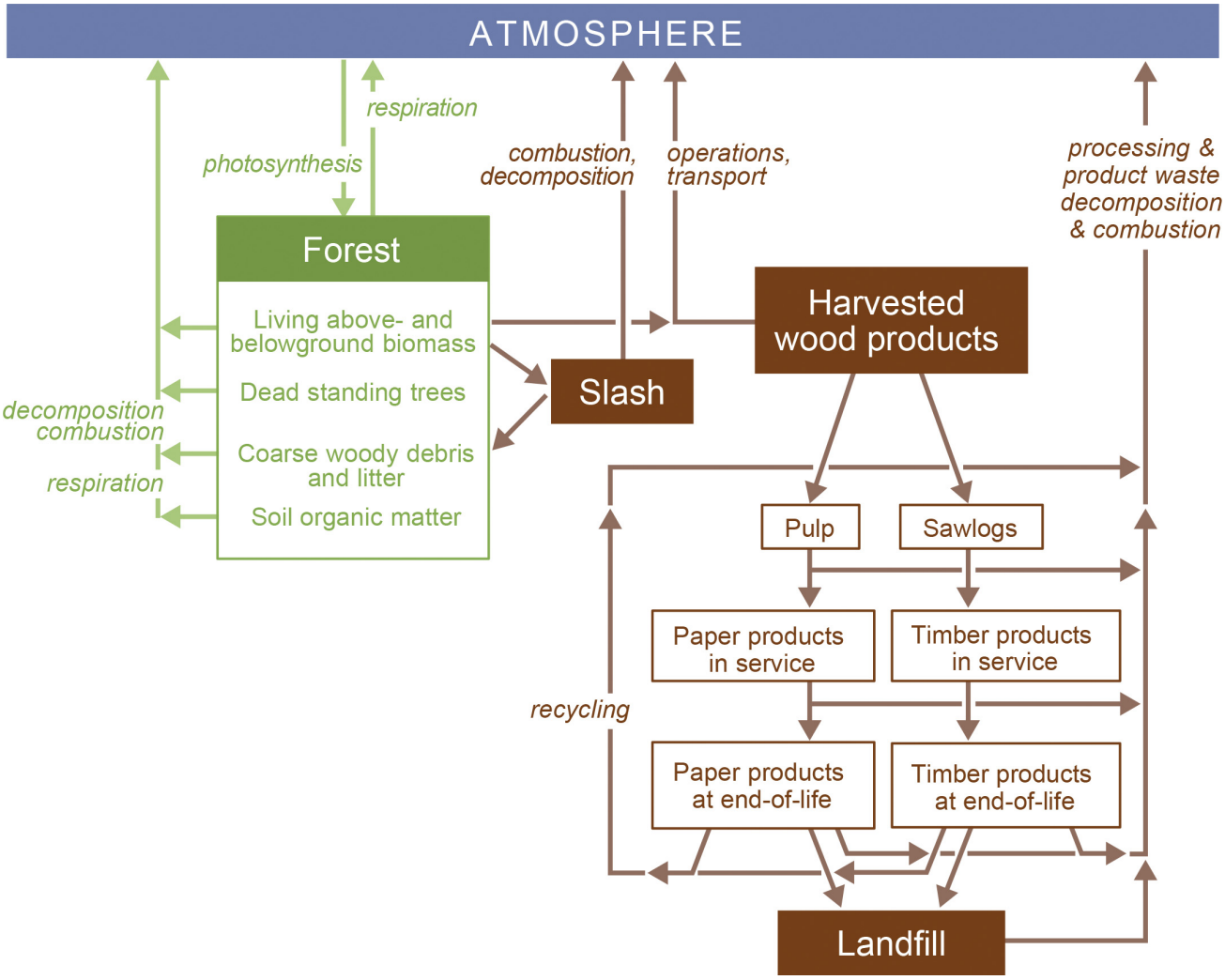

Fig 1. Carbon stocks and transfers in a forest and harvested wood products system. Boxes represent stocks of carbon, and arrows represent transfers between stocks with the process defined in italics.

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We selected two native forest management systems in Australia for our investigations that differed in forest ecosystem type, geographic location, forest management regimes, and the wood products derived from the timber harvesting. These forest types provide a significant proportion of harvested wood volumes in each state [29] and the forest management activities in these regions cover a range of logging intensities, which are comparable with forest management practices in other temperate forests.

We used a simulation model to describe the stocks of carbon, transfers between stocks and resulting changes in stocks for these forest systems. The main parameters in the model of the harvested forest system are listed in Table 1, together with the input data used to calibrate the models for the two case study regions. Data values were sourced from the most relevant and reliable published sources. Details of the derivation of data and range in values from different sources are described in S2 Appendix.

Case study 1: Mixed native eucalypt forest in the South Coast Region, NSW

The South Coast of NSW is a sub-region of Forestry Corporation of NSW's (FCNSW) commercial native forest estate. The sub-region is centred on Batemans Bay (35°42'26"S, 150° 10'38"E) and extends north to Nowra, south to Cobargo and west to Queanbeyan. A diversity of forest types occur with an associated range in productivities, in a complex mosaic pattern with species composition and forest structure related to environmental conditions, particularly

Table 1. Parameters describing carbon stocks and stock changes in the case study forest systems.

Parameter	South Coast NSW	ref	Mountain Ash Victoria	ref
Average carbon stock in total biomass across the forest region (tC ha^{-1})(Reference case)	116	[13]	485	[30]
Maximum carbon stock in aboveground living biomass at	130 (a)	[13]	775	[30]
a forest site (tC ha^{-1})	250 (b)	S2		
Biomass accumulation rate (tC ha^{-1})	AGB = 130 * (1 –exp(-0.022 * age))$^{0.52}$ (a)	S2	TB = 1200 * (1 –exp(-0.0045 * age))$^{0.7}$	[30]
	AGB = 250 * (1 –exp(-0.003 * age))$^{0.45}$ (b)	S2	AGB = 620 * (1 –exp(-0.0065 * age))$^{0.75}$	[31]
Mean annual increment (tC ha^{-1} yr^{-1})	1.64	*	6.45	*
MAI for species (m^3 ha^{-1} yr^{-1})	4.1	[32]	14	[32]
Increment converted from MAI (tC ha^{-1} yr^{-1})	1.44		5.9	
Proportion of aboveground biomass removed off-site as	0.35 (a)	[35]	0.4	[33]
wood products	0.22 (b)	[37]		
	0.61 (b)	[37]		
Biomass removed off-site (tC ha^{-1} yr^{-1})	0.36	*	1.58	*
Decomposition rate of slash and coarse woody debris	0.0486 yr^{-1}	[34]	0.0486 yr^{-1}	[34]
Proportion of wood products used for sawlogs	0.38	[13]	0.275	[33]
Production of sawlog products in-service (tC ha^{-1} yr^{-1})	0.058		0.158	*
Production of pulp products in-service (tC ha^{-1} yr^{-1})	0.28		0.79	*
Decomposable fraction of wood products in landfill: DOC_f	0.23	[35]	0.23	[35]
Decay rate in landfill: k	0.004 yr^{-1}	[36,29]	0.004 yr^{-1}	[36]

AGB aboveground living biomass, TB total living biomass,

* model output, S2 Appendix

(a) Parameter value used in the base case simulation,

(b) range in values used in the sensitivity analysis

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soil moisture and nutrient availability [37]. Forest types include Spotted Gum (*Corymbia maculata*), Coastal Moist Forest (*Eucalyptus saligna*, *E. pilularis*, *E. botryoides*, *Synacarpia glomulifera*), Silvertop Ash (*E. sieberi*), Coastal Dry forest (*C. gummifera*, *E. piperita*, *E. acmenoides*, *E. umbra*, *E. resinifera*, *E. paniculata*, *E. punctata*, *E. longifolia*, *E. globoidea*, *E. agglomerata*, *E. tereticornis*, *Angophora floribunda*, *E. moluccana*, *E. crebra*, *E. fibrosa*, *E. rudderi*), Brown Barrel (*E. fastigata*), Yellow Stringybark and Gum (*E. muellerana*, *E. melliodora*), and Tableland Gum (*E. dalrympleana*, *E. viminalis*) [38–40]. The South Coast sub-region produces approximately 20% of the wood volume from native forests in NSW [41].

The native forest management regimes applied in the region since the mid-1900s have covered a range of harvesting intensities: low intensity treatments such as single tree selective harvesting through to higher intensity group selection harvesting [42]. These treatments involve a proportion of the trees being felled either to supply wood products or to improve regeneration capacity of commercially desirable species. These forests are naturally multi-aged as the dominant trees species are not necessarily killed by even severe fire events. For our model, areas logged were defined in three ways: (i) the gross area of the total sub-region that is subject to harvesting; (ii) the net harvestable area which is the area of land where selective harvesting can occur based on the forestry regulations; and (iii) the logged area which is the actual area within which harvesting occurs (Table C in S2 Appendix). Simulations of carbon stock change were analysed for each of these areas to define the proportions of biomass remaining on-site and removed in harvested wood products.

The input data for our model are shown in Tables A, D and E in S2 Appendix. We have used data from FCNSW [9], and have compared these data with the range of data available from other sources. This comparison demonstrates the effect of differences in assumptions in carbon accounting on the outcome of net carbon stock change.

Case study 2: Mountain Ash native forest in the Central Highlands, Victoria

Our study region in the Central Highlands is between the towns of Marysville, Healesville, Warburton, Neerim South and Rawson in southern Victoria (37°20'–38°0'S and 145°30'–146°20'E) and includes parts of the VicForests Forest Management Areas of Central, Dandenong and Central Gippsland. Native forests in the region consist of several forest types, but we have confined our analysis to the Mountain Ash forest type (predominantly *Eucalyptus regnans*, with some *E. delegatensis* and *E. nitens*). This forest type currently occurs in State Forests where it is used for commercial wood production, and in conservation reserves and water catchments, some of which are protected. These forests have been harvested for over a century, initially by selective logging but increasingly intensified. Current harvesting practice is clearfelling and slash burning [43–45]. Clearfelling has also included salvage logging after wildfires [46]. The Ash forest type produces approximately 65% of the wood volume from native forests in Victoria [47]. These forests are subject to a disturbance regime of infrequent wildfires [48]. Within the boundary of a wildfire, usually less than half the trees are killed resulting in a mosaic of even-aged and multi-aged forests [49,50].

Potential Substitution

We included in our simulations estimates of the potential additional mitigation benefits from three forms of substitution. First, substituting biomass as a feedstock for bioenergy to displace fossil fuel-based energy generation. Second, the use of wood products that are assumed to displace more fossil fuel-intensive products. Third, substituting plantation-sourced wood products to displace native forest-sourced wood products, either from new or existing areas of

plantations. Plantations are considered as agricultural systems with crops of trees and where human management dominates. Although there can be a continuum of forest management systems, in Australia, native forest and plantation systems are distinct [18,27,51]. Substitution with plantation products provides a mitigation benefit when wood products are produced more efficiently with lower net carbon emissions.

The mitigation benefit of substituting wood products to directly displace fossil fuel energy or indirectly displace more energy-intensive products is defined by displacement factors with units of tC avoided emissions / tC in wood product. This unit represents the net amount of fossil fuel carbon not emitted as the result of 1 tC in biomass used for energy or stored in wood products [12,23]. The displacement factor includes reductions in emissions due to less embodied energy from acquisition of raw materials, transport and processing; avoiding emissions from the calcination process in cement production; and use of wood product residues for bioenergy in processing. Details of the calculation of displacement factors and the range of values for different products are given in Table H in S2 Appendix.

Simulations of carbon accounting under forest management scenarios

Reference scenario: We used the current state of native forest management in commercial state forests as the reference scenario for our simulations. Carbon stocks included the regrowth forest biomass, harvested wood products and waste deposited in landfill. Wood products included chips used for pulp and paper production, and sawlogs used for structural timber, floorboards, poles and landscaping. No wood is used for bioenergy.

We then ran simulations for the following two forest management scenarios.

Scenario (1): Management of native forests for maximum production of wood products and bioenergy. This scenario involved the same harvest intensity as the reference scenario but greater utilisation of products by displacing fossil fuel energy rather than accumulating stocks in harvest residues, landfill and pulp. Carbon stocks were accounted for in the forest regrowth between harvesting cycles, the carbon stock accumulated in manufactured wood products, and the avoided carbon emissions resulting from substituting fossil fuel sourced energy with bioenergy. Biomass for energy generation was derived from slash, wood product processing waste, wood products at-end-of-life instead of being deposited in landfill, and wood chips instead of using them for paper production.

Scenario (2): Management for native forest conservation. In this scenario, we simulated the carbon stocks that would accumulate if the current native forest was protected from harvesting and allowed to function under natural conditions.

To facilitate comparisons between scenarios, in scenario (2) we accounted for the carbon in wood products that were not produced from the native forest and were substituted with other products. We simulated three types of substitution. The first type of substitution used non-wood products that were mostly more fossil fuel intensive to produce. We used an average displacement factor of 2.1 tC tC^{-1} [23] for the gross wood products which were foregone by not harvesting the forest. This factor incorporated all greenhouse gas emissions from the non-wood products. These emissions due to substitution were subtracted from the carbon stock in the conservation native forest to give the net substitution carbon stock (Scenario (2a)). The second type of substitution used plantation wood products. The area of plantation forest required to produce an equivalent amount of wood products as derived from the current native forest was calculated. For the simulation, the same amount of wood products were produced, only they were produced from the plantation area, and the area of conservation native forest was reduced by an equivalent of the area required for the plantation (Scenario (2b)). The third type

of substitution used wood products from existing areas of plantations and maintained the entire area of native forest as conserved for carbon storage (Scenario (2c)).

For all scenarios, the area of land, harvest intensity and amount of wood products were kept consistent.

Sensitivity analysis

Several parameters contribute to uncertainty in the simulated carbon stock change under the different native forest management scenarios: (i) forest carbon accumulation rate and maximum carbon stock in undisturbed forests; (ii) proportion of biomass removed off-site as harvested wood products; (iii) wood products supply; (iv) longevity of wood products; (v) decay rate in landfill; (vi) differentiation of pools within wood and paper products and landfill with different decay rates; (vii) displacement factors for substitution of products; (viii) displacement factors for substitution of bioenergy; (ix) proportion of harvested biomass used for sawlogs and pulp; (x) proportion of slash combusted; and (xi) rotation length of harvesting. Lack of experimental data, both in general and for specific forest types, limit the capacity for simulation. For each of these eleven parameters, we tested a range of values from the literature to determine their effect on carbon stock changes in either the mixed native forest in NSW or the Mountain Ash forest in Victoria, depending on where uncertainty was greatest in these parameters.

Results

Mixed native eucalypt forest on the South Coast, NSW

The simulation of changes in carbon stocks under current native forest management (reference scenario) was calculated at the local scale for the logged area on a rotation of 70 years (Fig A (A) in S3 Appendix), for the net harvested area on a return time of 20 years (a new selection of trees is harvested from the coupe after 20 years) (Fig A (B) in S3 Appendix), and at the regional scale as an average across the landscape (Fig 2). In the simulation of the average carbon stock across the region over a 100 year time period, the area under the curve represents the cumulative carbon stock in the forest system over time (Fig 2). Identifying the carbon stocks in each type of harvested area in this way provided an understanding of the dynamics over time and the mosaic of areas aggregated at the landscape scale. The simulated carbon stock change from our model was compared with modelled outputs from FCNSW [13] and productivity data reported for the species (Table A in S3 Appendix).

Scenarios where the native forest was harvested for wood products (Reference and Scenario 1) yielded a lower total carbon stock over 20, 50 and 100 year simulation periods than the scenarios where the native forest was conserved and wood products were substituted (Scenarios 2a, 2b, 2c) (Table 2). Biomass accumulation rate in the regrowing forest was calculated using two equations with different coefficients depending on the assumed maximum biomass set by the asymptote of the equation (Equations (S2-1) and (S2-2) in S2 Appendix S2.1.2). Carbon stocks calculated using Equation (S2-2), which was derived from the average of site data and has a higher maximum biomass value, predicted higher stocks in the conservation forest scenarios (Scenarios 2a, 2b, 2c).

Mountain Ash native forest in the Central Highlands, Victoria

The simulation of changes in carbon stocks for the current native forest management of clearfelling (reference scenario) was calculated at the local scale for the logged area (Fig C in S3 Appendix), and at the regional scale as an average across the landscape (Fig 3)

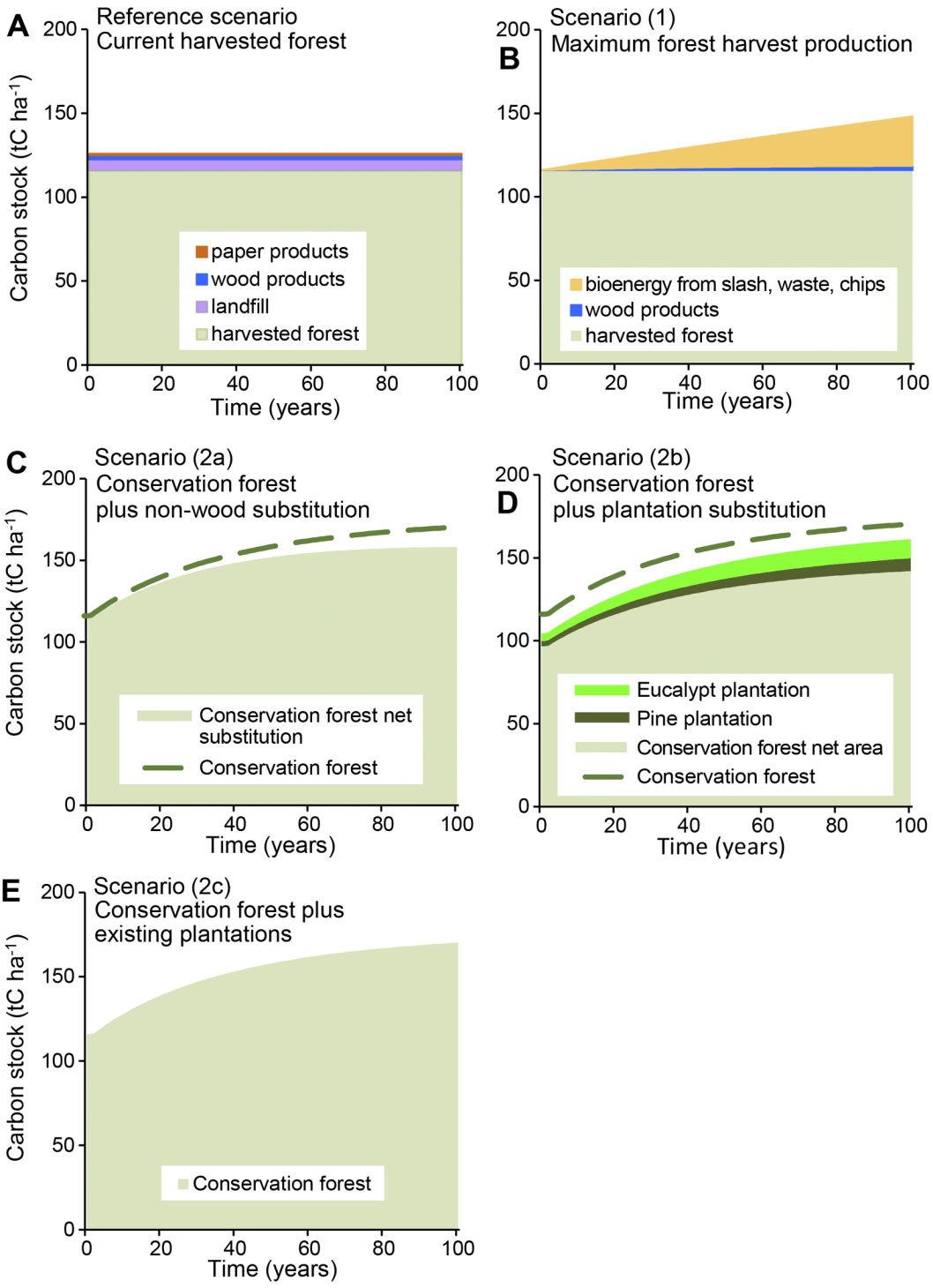

Fig 2. Regional average carbon stocks simulated over 100 years in South Coast mixed native eucalypt forest. Simulations were run for the reference case of current harvested forest (A), and four scenarios of forest management; scenario (1) maximum forest harvest production (B), scenario (2a) conservation forest plus non-wood substitution (C), scenario (2b) conservation forest plus plantation substitution (D), and scenario (2c) conservation forest plus existing plantations (E). All biomass pools in the harvested forest system were included, both on- and off-site. Carbon stock in harvested forest included above-and below-ground living and dead biomass. Carbon stocks shown for pine and eucalypt plantations included forest biomass living and dead, wood and paper products and landfill.

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Table 2. Total carbon stock (tC ha^{-1}) in the harvested or conserved forest scenarios in South Coast NSW forests, simulated over 20, 50 and 100 years and calculated using two equations for biomass accumulation rate (S2 Appendix S2.1.2).

Forest management scenario		20 yrs	50 yrs	100 yrs
Biomass accumulation rate Equation (S2-1):				
Reference	Current harvested forest	126	126	126
Scenario (1)	Maximum forest harvest production	123	134	151
Scenario (2a)	Conservation forest plus non-wood substitution	137	152	158
Scenario (2b)	Conservation forest plus plantation substitution	128	148	162
Scenario (2c)	Conservation forest plus existing plantation area	139	158	170
Biomass accumulation rate Equation (S2-2):				
Reference	Current harvested forest	126	126	126
Scenario (1)	Maximum forest production	123	134	151
Scenario (2a)	Conservation forest plus non-wood substitution	137	161	186
Scenario (2b)	Conservation forest plus plantation substitution	128	155	186
Scenario (2c)	Conservation forest plus existing plantation area	139	167	198

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Scenarios where the native forest was harvested for wood products (Reference and Scenario 1) yielded a lower total carbon stock over 20, 50 and 100 year simulations periods than the scenarios where the native forest was conserved and wood products were substituted (Scenarios 2a, 2b, 2c) (Fig 3 and Table 3). Biomass accumulation rate in the regrowing forest was calculated using two equations with different coefficients and assumed maximum biomass set by the asymptote of the equation (Equations (S2-3) and (S2-4) in S2 Appendix S2.2.2). Carbon stocks calculated using Equation (S2-3), which was derived from the average of site data and has a higher maximum biomass value, predicted higher stocks in the conservation forest scenarios (Scenarios 2a, 2b, 2c).

The effect of occurrence of a wildfire on the carbon stock dynamics over the 100 year simulation period was tested with a wildfire at year 56, which is half the estimated average return time for wildfires [52]. Emissions due to combustion were 10% of the biomass carbon stock and the carbon stock in the conservation forest after the fire consisted of regenerating vegetation, a small proportion of living trees, standing dead trees and coarse woody debris [50] (Fig E in S3 Appendix). Scenarios where the native forest was conserved, but burnt in a wildfire, and wood products were substituted still had the highest carbon stock, of living and dead biomass components, after the 100 year simulation period (Table 3).

Sensitivity analysis

Differences in simulated carbon stocks due to each of the ten parameters tested in the sensitivity analysis are shown as percentage change in Fig 4 and as absolute values in Tables B and C in S3 Appendix. The simulated carbon stocks were most sensitive to parameters that determine the amount of biomass in the forest. In both case studies this parameter was the rate of carbon accumulation (parameter i), which resulted in a difference of 9 tC ha^{-1} after 50 years in the South Coast forest, and 148 tC ha^{-1} after 50 years in the Mountain Ash forest. Additionally, in the Mountain Ash forest, the rotation length (parameter xi) resulted in a difference of 75 tC ha^{-1} after 50 years.

The stocks of carbon in wood products and landfill remained small compared with that in forest biomass, irrespective of the wood volume produced, the types and longevities of wood products, and transfer to landfill. Parameters describing longevity of pools, and the proportion

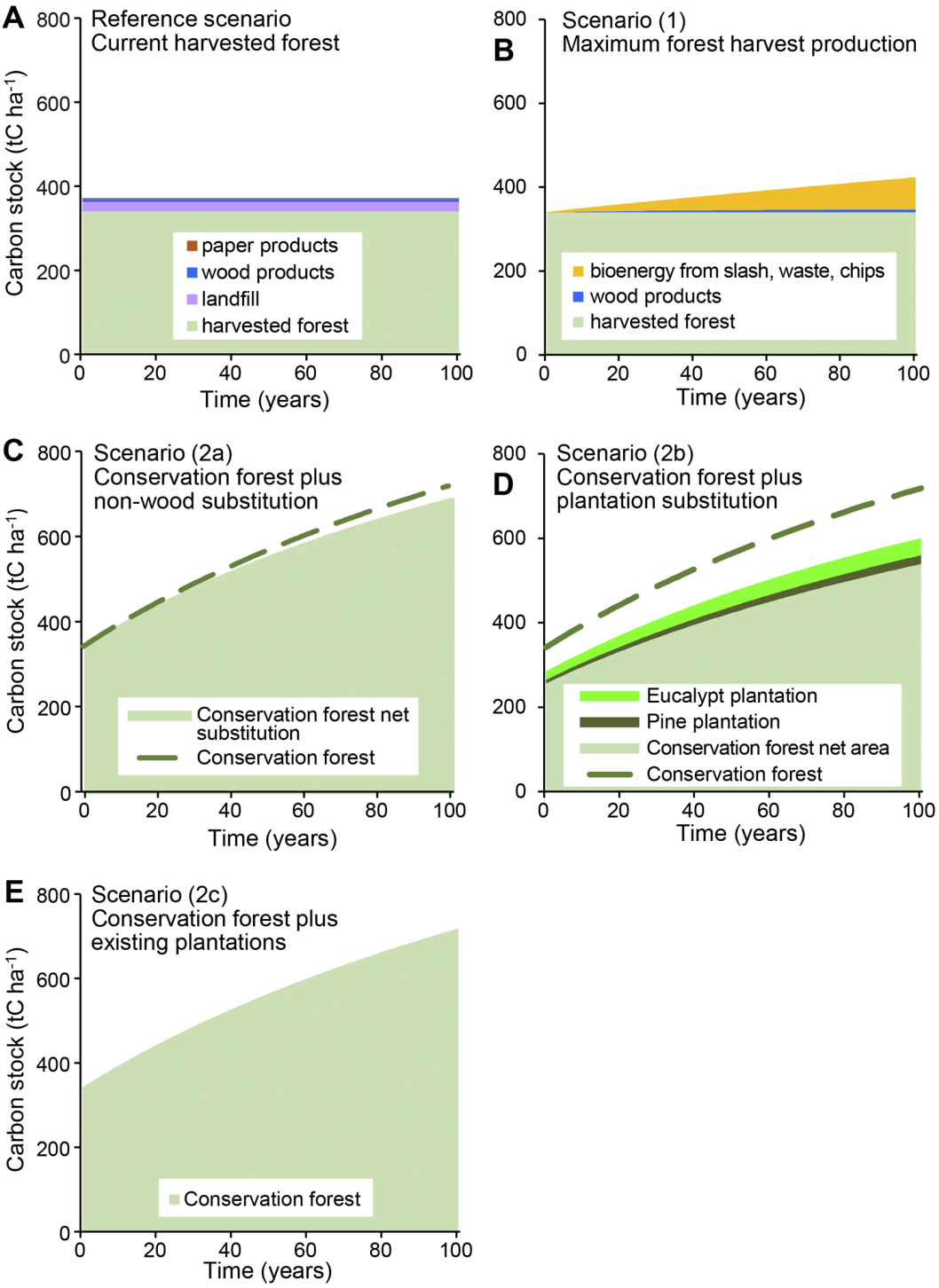

Fig 3. Regional average carbon stocks simulated over 100 years in Mountain Ash forest. Simulations were run for the reference case of current harvested forest (A), and four scenarios of forest management; scenario (1) maximum forest harvest production (B), scenario (2a) conservation forest plus non-wood substitution (C), scenario (2b) conservation forest plus plantation substitution (D), and scenario (2c) conservation forest plus existing plantations (E). All biomass pools in the harvested forest system were included, both on- and off-site. Carbon stock in harvested forest included above-and below-ground living and dead biomass. Carbon stocks shown for pine and eucalypt plantations included the forest biomass living and dead, wood and paper products and landfill. Forest carbon accumulation rate was calculated using Equation (S2-3) in S2 Appendix. See Fig D in S3 Appendix for calculation using Equation (S2-4) in S2 Appendix.

doi:10.1371/journal.pone.0139640.g003

Table 3. Total carbon stock (tC ha^{-1}) in the harvested or conserved forest system in Mountain Ash forests, simulated over 20, 50 and 100 years and calculated using two equations for biomass accumulation rate (S2 Appendix S2.2.2), and with a wildfire (Fig E in S3 Appendix).

Forest management scenario		20 yrs	50 yrs	100 yrs
Biomass accumulation rate Equation (S2-3):				
Reference	Current harvested forest	372	372	372
Scenario (1)	Maximum forest harvest production	359	385	424
Scenario (2a)	Conservation forest plus non-wood substitution	437	549	685
Scenario (2b)	Conservation forest plus plantation substitution	371	475	600
Scenario (2c)	Conservation forest plus existing plantation area	444	566	719
Biomass accumulation rate Equation (S2-4):				
Reference	Current harvested forest	283	283	283
Scenario (1)	Maximum forest harvest production	267	286	314
Scenario (2a)	Conservation forest plus non-wood substitution	325	406	499
Scenario (2b)	Conservation forest plus plantation substitution	264	336	418
Scenario (2c)	Conservation forest plus existing plantation area	330	418	523
Biomass accumulation rate Equation (S2-3), with wildfire:				
Reference	Current harvested forest	372	372	372
Scenario (1)	Maximum forest harvest production	359	385	424
Scenario (2a)	Conservation forest plus non-wood substitution	437	549	721
Scenario (2b)	Conservation forest plus plantation substitution	371	475	627
Scenario (2c)	Conservation forest plus existing plantation area	444	566	754

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of biomass in long-lived pools, had the greatest influence on these carbon stocks. However, differences in rates of transfer of carbon through harvested products did not result in major changes in the total carbon stock (Fig 4iv, 4v, 4vi and 4ix).

The sum of the differences in carbon stocks due to the parameter values that determine the stocks in products, slash, landfill and substitution (Tables B and C in S3 Appendix), was lower for all simulation time periods than the difference in carbon stock resulting from the scenario of changing native forest management to conservation, for both forest case studies (Tables 4 and 5).

None of the potential parameter values reported in the literature and tested in our analyses (Tables B and C in S3 Appendix) could increase the carbon stock in products, slash, landfill and substitution sufficiently to exceed the increase in carbon stock due to changing management of native forest to conservation.

Discussion

Relative mitigation benefit of native forest management strategies

We have demonstrated that changing native forest management from commercial harvesting to conservation can make an important contribution to climate change mitigation. Throughout the 100 year simulation period, the net carbon stocks were higher in the conservation scenarios (Scenario 2) than in the harvest scenarios (Reference case and Scenario 1), with the difference representing the net abatement from conservation. An important attribute of the abatement from avoided native forest harvesting is its upfront profile: stopping harvesting results in an immediate and substantial reduction in net emissions relative to the reference case where commercial harvesting continues. Because the economic returns from native forest harvesting are typically low or negative, and the abatement occurs upfront, the cost of mitigation from

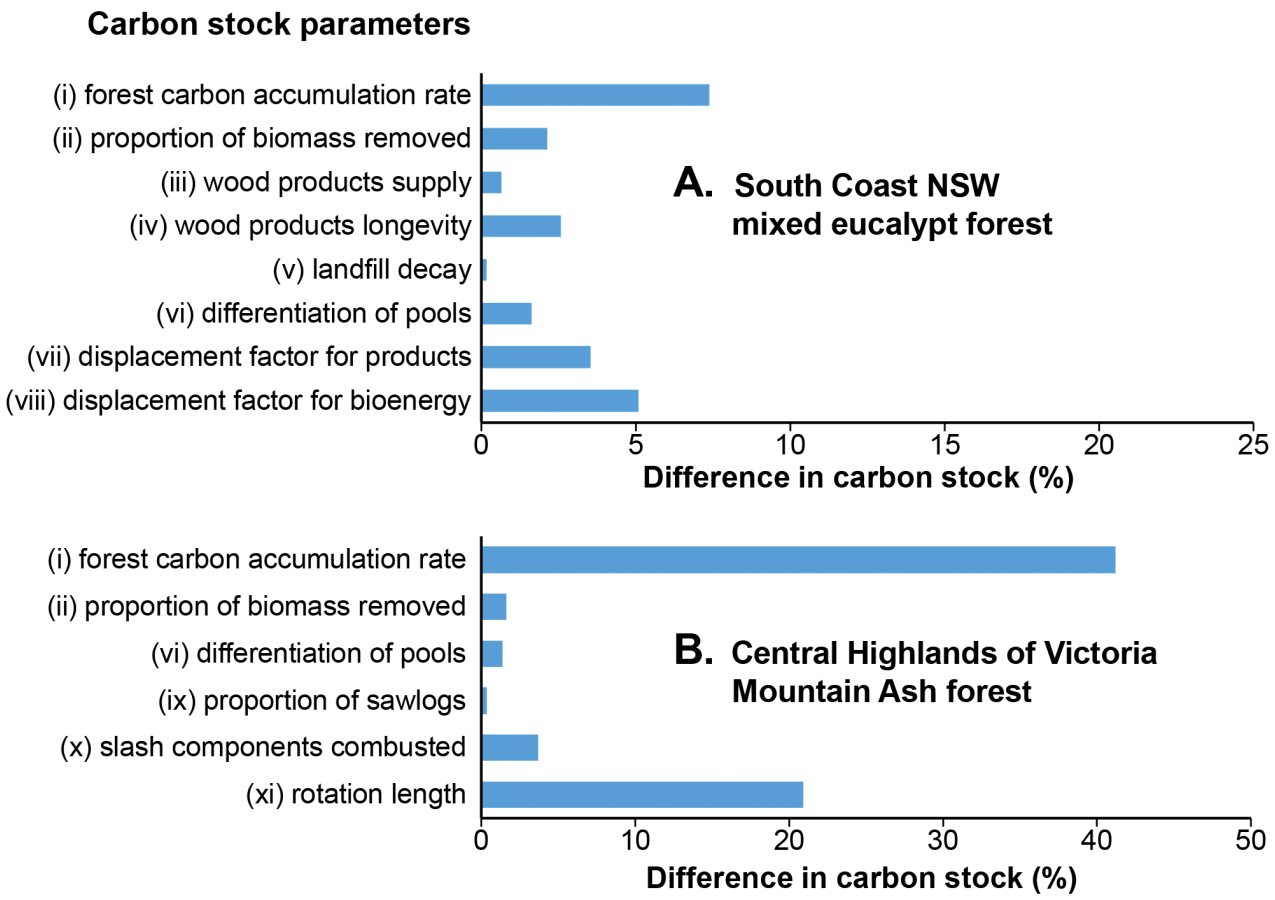

Fig 4. Differences in simulated carbon stocks (tC ha^{-1}) as percentages of the total system carbon stock. Differences were calculated from use of minimum or maximum values of parameters listed in Tables B and C in S3 Appendix in a simulation for 50 years in (A) mixed native eucalypt forest on the South Coast of NSW, and (B) Mountain Ash forest in the Central Highlands of Victoria.

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avoided harvesting is often less than other forms of land sector abatement, such as reforestation, where the climate benefits are incremental over long timeframes [53]. Mitigation benefits from forest management can be achieved by increasing the area and effectiveness of the protected area network and providing incentives for off-reserve conservation to maximise carbon stocks and biodiversity, and hence the resilience of ecosystems [4].

Table 4. Change in carbon stocks (tC ha^{-1}) over the 20, 50 and 100 year simulation periods for scenarios of conservation forest with product substitution (Table H in S2 Appendix) compared with harvested forest plus products and landfill in NSW South coast forest. The difference in carbon stock due to scenarios is compared with the sum of the differences due to parameter values.

	Conservation forest			Harvested forest
	20 yrs	50 yrs	100 yrs	constant over time
Forest biomass	139	158	170	116
Products	-2.4	-6.0	-12.1	3.3
Landfill				6.5
Total	136.6	152.0	157.9	125.8
Difference due to scenarios (conservation—harvested)	10.8	26.2	32.1	
Difference due to sensitivity of parameter values	6.4	13.0	25.8	

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Table 5. Change in carbon stocks (tC ha^{-1}) over the 20, 50 and 100 year simulation periods for scenarios of conservation forest with product substitution (Table H in S2 Appendix) compared with harvested forest plus products and landfill in Mountain Ash forest. The difference in carbon stock due to scenarios is compared with the sum of the differences due to parameter values.

	Conservation forest			Harvested forest
	20 yrs	50 yrs	100 yrs	constant over time
Forest biomass	444	566	719	340
Products	-7.0	-16.9	-33.5	9.2
Landfill				22.5
Total	437	549	685	372
Difference due to scenarios (conservation—harvested)	65	177	313	
Difference due to sensitivity of parameter values	10.6	21.7	35.0	

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The climate change mitigation benefits derived from native forest conservation are mainly attributable to the fact that the largest carbon stocks and highest longevities of stocks occur in forest biomass (Tables 3 and 4). In the harvesting scenarios, only a small proportion of harvested wood products is transferred to pools with high longevities (Figs B and E in S2 Appendix).

While our results were based on two case study forest systems, the analyses tested a range of published parameter values. Hence, our conclusions are likely to be relevant to many other forest types. The results from our case studies are also in agreement with previous studies. Based on modelled simulations of different forest systems, Schlamadinger and Marland [54] concluded that conservation of forests and allowing regrowth provided the greatest carbon benefit for up to 100 years, even under different reference cases, growth rates and conversion efficiencies. After 100 years, the net carbon benefit was similar in many of the scenarios whether trees were used for harvest, energy and wood products, or whether they were conserved for their carbon stocks. Schlamadinger and Marland [55] also found there was a long-standing debt of net carbon emissions associated with a forest management system of harvested wood products and bioenergy due to the initial harvest of native forest with a large standing stock of biomass.

Additionally, the rules and procedures adopted by governments and international organisations for the accounting of greenhouse gas emissions, that is the policy institutions, influence the assessment of relative benefit of mitigation activities. Despite testing a range of institutional assumptions, the conclusion remained that greater mitigation benefit was gained by conserving forests in southern NSW than their sustainable harvest [56].

Our sensitivity analyses showed that parameters affecting carbon accumulation in forest biomass had a greater influence on total carbon stocks than those affecting transfers among wood products. This result has also been noted by Schlamadinger and Marland [9]. None of the parameters we tested that influence management of a harvested forest system could increase the carbon stocks to levels greater than the stocks in a conservation forest over simulations up to 100 years.

Native forests are most valuable for mitigation when conserved because their biomass carbon stocks continue accumulating under natural ecosystem processes of regeneration and growth [55,57]. Evidence for the higher carbon stocks in native forests than regrowth forests has been recognised in national policies [24]. Even in the early stages of negotiation of the Kyoto Protocol, Schulze et al. [58] proposed that the greatest net carbon benefit would be achieved by avoiding emissions from deforestation and forest degradation, and protecting existing native forests. To date, however, international forest-related policies, including negotiations under the U.N. Framework Convention on Climate Change, have failed to recognize fully the mitigation value of native forest conservation [59].

Use of harvested wood products from plantations, as commercial crops of trees, and regrowth forests [60] does provide storage of carbon and in theory can be substituted for more fossil fuel energy-intensive products. Wood products are a source of renewable construction materials that produce less greenhouse gas emissions per unit mass than most non-wood substitutes where fossil fuels are used in the production process or as the primary energy source, such as steel. Plantations combine storage of carbon in forest biomass with supply of products. Net carbon stock change assessed from a reference state of current land management as existing plantations or establishing plantations on previously cleared land, with plantations managed for production of wood and paper products, provides the optimal integration of storage of carbon combined with supply of products; noting that this does not account for the initial loss of carbon when the land was first cleared. The efficiency of plantation production is demonstrated by the total carbon dioxide emissions for logs from softwood plantations being 50–75% less than for hardwood logs from native regrowth forests in Australia [61]. Emissions per cubic metre of log harvested from Australian native hardwood forests were estimated to be among the highest in the world [61]. Carbon storage can be maximised in plantations by increasing the proportion of merchantable biomass, efficiency of processing, and longevity and recycling of products.

Key issues influencing carbon accounting

During our analysis of changes in carbon stocks in harvested native forest systems, we identified key issues that influence the outcomes of carbon accounting. Incorporating these issues collectively in a conceptual accounting framework is beneficial for evaluating relative mitigation benefits of native forest management strategies. Mitigation benefits of forest management strategies should be assessed in terms of the long-term standing stock of carbon in the forest landscape and any changes over time in the net exchange of carbon with the atmosphere. Carbon stocks in biomass represent temporary storage that depends on the longevity and stability of the pools. These stocks will affect the concentration of carbon dioxide in the atmosphere only if there is a net change in the total biomass stock.

There is a lack of consistency in the treatment of some issues related to accounting of mitigation benefits. To improve understanding of the accounting system, clarity is required around the following six issues.

Reference case

The reference case must be defined to provide the basis for comparison with alternative scenarios of forest management systems [54]. We analysed carbon stocks using the current regime of native forest management for commercial production as the reference scenario and compared this with two alternative scenarios of conservation native forests and harvested forests for maximum production of wood products and bioenergy. Defining explicitly the reference as the current condition of the forest is important for the comparison. For example, the biomass carbon stocks of a native forest subject to natural disturbance regimes but not logging will, by definition, be at their maximum or carrying capacity. By comparison, the biomass carbon stock in a regrowth forest subject to logging will be lower than the carrying capacity. At the landscape scale, stocks in regrowth forests may have a trend over time due to management activities, or may be at a steady state of growth and harvest removals.

Evaluating the impacts of native forest management activities must include quantification of carbon stocks in the natural ecosystem or primary forest [59] to determine the potential for sequestration by the regrowing forest to restore the carbon loss due to harvesting. Differences in estimation of sequestration potential have occurred because of assumptions about carbon

accumulation rates in older forests. One view is that saturation of carbon stock occurs at forest maturity [13,62,63], whereas other estimates have shown continued accumulation of carbon in old-growth forests centuries old [58,64,65].

Longevity of stocks

Carbon is transferred through plants, soil, products and waste materials. However, the average magnitude of these biomass pools and their longevity are the key parameters determining the contribution to mitigating atmospheric carbon dioxide concentration. Our sensitivity analyses demonstrated that changing the proportions of biomass utilised in different forms—slash, sawlog or pulp products, and landfill—had a relatively small influence on total carbon stocks (Fig 4). The longevities of these biomass pools were similar for various combinations of products. Combinations of sawlog ($k = 0.0198\ yr^{-1}$) and paper ($k = 0.346\ yr^{-1}$) products and processing waste ($k = 1\ yr^{-1}$) had similar longevities to that of slash ($k = 0.0486\ yr^{-1}$), and hence created little change in the total carbon stock (Tables D and E in S2 Appendix). Increasing the proportion of sawlog products and their input to landfill ($k = 0.004\ yr^{-1}$) did increase the carbon stock, but less than half of the biomass allocated to sawlogs was transferred to timber products because of the high proportion of processing waste (Figs B and E in S2 Appendix).

In contrast, the increased forest biomass from conserving native forest and allowing continued growth, increased the magnitude and longevity of the total carbon stock (Figs 2 and 3). This has also been shown in other forest types [7]. The carbon stocks of native forests are typically affected by natural disturbance events, such as fire, but these result in relatively small fluctuations due to emissions, with the carbon stock regained within a decade through regeneration, as shown in Fig E in S3 Appendix. Hence, the biomass carbon stocks in conserved native forests on a landscape basis can be considered as a stable stock with the value fluctuating in response to natural disturbances around a long term mean. Additionally, evidence from the 2009 wildfire in the Mountain Ash forest showed that protected old-growth forests were less likely to burn at high severity [66–68]. Even when the fluctuations in carbon stocks due to wildfires are included in long-term analyses of carbon dynamics, the conclusion remains that total carbon stocks are highest in conserved forests [7].

Timeframes of accounting

The timing matters for activities to reduce emissions and contribute to climate change mitigation. The next decade is the critical time to implement mitigation activities if we are to limit global warming to less than 2°C above the pre-industrial global mean temperature; the internationally agreed target [24]. The benefit of reducing emissions depends on both the magnitude and timing of the occurrence of mitigation activities. A major benefit of changing native forest management activities to conservation as a form of mitigation is that implementation can be relatively rapid: there is an instant benefit from the avoided emissions that would otherwise have occurred; plus additional, albeit more slowly gained, benefits through sequestration from native forest restoration and reforestation [69].

The assumption of carbon neutrality of bioenergy, based on the equivalence of carbon fluxes in emissions and regeneration of the forest, is time-dependent. The time taken to replenish the initial biomass carbon stocks that were depleted by logging must be accounted for when evaluating mitigation benefit of forest management strategies. The time to repay this carbon debt will depend on the initial carbon stock and the rate of accumulation into woody biomass pools [25].

Our comparison of scenarios of carbon stock change in the NSW South Coast and Victorian Mountain Ash forests showed that over a 100 year simulation period, the highest stocks would

be achieved from conserving native forests. Over longer time periods, and depending on the displacement factor, substitution of bioenergy may have a greater rate of increase in carbon stocks. However, given the urgency of the climate change problem [24], implementing forest management actions that increase emissions within, and only provide a benefit after, 100 years are not useful mitigation activities. Additionally, projections over many decades have a declining reliability, and displacement factors are likely to decrease over time.

Storage in landfill

The carbon storage capacity of landfill depends on the rates of decay of waste material, which is one of the most difficult parameters to estimate. We used the default value from Australia's National Carbon Accounting System (NCAS) [35], which was derived from measurements of decayed material in landfills that were only up to 46 years old, or just over one half-life for wood [36]. However, the IPCC [70] recommends that data on rates of decay should be collected over time period equivalent to 3 to 5 half-lives to achieve an acceptable accuracy of the results. The difficulty in estimating this parameter and consequent wide range in values contributes to uncertainty in carbon accounts (Table E in S2 Appendix).

The scenario of maximising carbon storage in harvested forest systems relies on the long-term storage of waste material in landfill. Only a proportion of wood and paper products are transferred to landfill (0.44 to 0.95 depending on product type [35]), and of this amount, proportions of 0.23 for wood and 0.49 for paper products decompose (Table E in S2 Appendix). The proportion of the initial forest carbon stock that remains in long-term storage in landfill is less than 3% (Figs B and E in S2 Appendix).

Additionally, other issues with landfills may make long-term storage not a sustainable option. Landfills occupy large areas of land, often near urban areas, so that disposal of waste in ever-increasing areas of landfills has become non-viable [71]. Many regional and national policies aim to minimise waste disposal [72]. In Australia, the proportion of wood waste transferred to landfill is decreasing and the proportion utilized for combustion is increasing [18]. Both carbon dioxide and methane are produced during decomposition, and about a third of the methane generated is captured or oxidised before release [35]. Additionally, the stability of carbon stocks in landfill is uncertain. The very low rates of decomposition reported are based on anaerobic conditions, but these conditions cannot be assured in the future. Decomposition would increase if the site became aerobic. However, there is an increasing trend for methane capture and combustion. The potential for changed conditions for decomposition in the future creates a great risk for greenhouse gas emissions [8]. Use of wood product waste for bioenergy instead of input to landfills would provide a helpful substitution for fossil fuel energy sources [73].

Substitution of products and energy

Wood products are a renewable source of construction material and energy. Hence, their utilisation potentially can provide mitigation benefits if they substitute for more emissions-intensive products. However, increasing sequestration in the land sector requires use of wood products and/or bioenergy that are additional to the current forest harvesting regime [74–76]. This means an increase in productivity, by increasing the area of forest harvested, the intensity of harvesting, or the efficiency of product utilisation. The capacity for additional production in terms of forest area available and wood yield would need to be demonstrated, and competition with other land uses evaluated. A simulation of potential carbon sequestration in wood products and landfill should start at the current level of production, not zero, and predict the potential for additional production and carbon storage. Foregone fossil fuel-based products and energy sources must be demonstrated.

We used constant displacement factors for wood products and bioenergy in our simulation based on current rates. However, it is likely that these factors will decrease over time as limits exist to the amount of substitution of wood products due to the effects of market and policy factors. Additionally, abatement opportunities are being sought in all sectors of the economy to meet mitigation obligations, which are likely to increase use of other renewable energy sources and increase energy efficiency, thereby driving down displacement factors over time.

Biomass is a renewable form of energy but it is not carbon neutral. An opportunity cost is incurred from the loss of the initial carbon stock and potential for carbon sequestration when a forest is used for harvested products [75,76]. Additionally, loss of carbon occurs through processing waste, and energy is required for processing and transport. Biomass has a higher rate of carbon emissions per unit energy produced than oil or natural gas, and biomass is usually burned with a lower efficiency than fossil fuels [77–80]. In fact, quantification of the global warming potential of carbon dioxide emissions from combustion showed that bioenergy derived from slow-growing forests was higher than that from fossil fuels over the whole period for at least a 100-year time frame [81]. Additionally, provision of wood for bioenergy from existing harvested forest systems means increasing the intensity of harvesting or utilising the slash. Removing additional residue material, particularly foliage, bark and small branches, increases nutrient removals and likely impacts soil organic matter, so that the sustainability of the practice would need to be carefully monitored [78,82].

The value of substituting wood products is only valid if the alternative products are more fossil fuel intensive to produce. Both the use of fossil fuel in the production process, such as coal in the case of steel, and as the energy source in their manufacture, must be considered. If non-fossil fuel sources are used as raw materials and energy for manufacturing then there would be no mitigation benefit from using wood products. Wood products have lower embodied energy than many other products but their substitution provides only a temporary store of carbon [77].

Boundaries of the system

In our analysis, we have confined the boundaries of the system to the physical transfer of carbon and ensured comprehensiveness in accounting for the stocks. However, analysis of the broader system required for land use decision-making should include socio-economic, institutional and land use management factors that influence the transfers of carbon stocks.

In the current study, as in many other studies (for example [9,12,13]), direct substitution of products and energy for fossil fuel emissions was assumed. This means that the cessation of native forest harvesting necessarily results in substitution by non-native forest wood products and energy sources. However, consideration should be given to the supply and demand for products, potential sources of alternative products, markets and regulatory factors to assess feasibility of the substitution.

Substitution by bioenergy must directly displace fossil fuel emissions to be of benefit for mitigation [26]. Direct substitution may not occur where demand for energy exceeds current supply in developing countries because sources of bioenergy are likely to increase energy consumption, not reduce fossil fuel emissions [55]. Where there are national policies that guarantee a specified amount of renewable energy (for example, a 'renewable portfolio standard'), increases in bioenergy are likely to replace other forms of renewable energy such as solar and wind, and so not reduce emissions [56]. Global empirical analysis of the use of bioenergy has shown displacement of fossil fuel sources is much less than unity [83]. Additionally, practicalities of the market must be considered, such as transport distance from product source to energy generator.

The land resources required to produce wood products and the opportunity costs of alternative land uses, such as production of food and fibre and human settlements, need to be considered within regional land use management decisions [77]. Very large land areas would be required to make a significant contribution to climate change mitigation through bioenergy substitution, and this would compete with other land uses and put pressure on existing forests. An assessment of the land resources required globally to produce biomass for biofuel substitution of transport fuels concluded that areas of land were not available on the scale required [11]. Finally, we note that photovoltaic cells are more efficient than the photosynthetic processes in plants at converting sunlight to forms of energy that can be used (about 1% compared to 6–21% [82,83]). Not only does bioenergy therefore require large areas of land, it also needs fertile and well-watered land; the same land needed for growing food.

Conclusions

The mitigation benefit of carbon stock changes due to forest management is determined by the net effect on the atmospheric carbon dioxide concentration over time [77]. Based on this assessment, we found that the greatest mitigation benefit from native forest management, over the critical decades within the next 50 years, is achieved by protecting existing native forests. None of the potential parameter values, which create uncertainty in quantifying transfers of carbon stocks, could increase the stock in products, slash, landfill and substitution sufficiently to exceed the carbon stock in the conservation native forest. While data to define some carbon stocks and stock changes are limited, we attempted to apply the greatest range of potential parameter values available from current data sources and the literature, in order to test the results and identify the consequences of different assumptions.

Wood products are valuable stores of carbon compared with the sources of emissions from other construction materials; but most wood products can be sourced from plantations. Currently, 84% of log volume is harvested from plantations in Australia [29]. Substitution of fossil fuel energy is best achieved by using non-carbon renewable energy sources like solar, wind, tidal and geothermal power, which also require less land area. Wood has many benefits as a construction material; but it does not have a climate change mitigation benefit compared with conservation of native forests.

Supporting Information

S1 Appendix. References about mitigation benefits of forest management in the literature.
(PDF)

S2 Appendix. Input data for calculation of forest carbon stock.
(PDF)

S3 Appendix. Results.
(PDF)

S4 Appendix. References for Supporting Information.
(PDF)

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Author Contributions

Conceived and designed the experiments: HK. Analyzed the data: HK AM. Wrote the paper: HK DL AM BM.

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Why Native Forest Logging Must End

A brief glimpse of industrialised logging in Australia now

Australia's Native Forests

Can store more carbon per hectare and for a longer period of time than equatorial rainforests famous for this function.

Due to policy failure resulting from the perpetuation of industry rhetoric that native forest logging is done sustainably, Australia is now:

- **one of 11 hotspots of global deforestation**
- **a significant contributor to emissions from *forest degradation*, which in the last decade, has doubled globally. This statistic does not even include emissions from *deforestation* arising from the clearing of native vegetation.**
- **the world leader in mammal extinction**
- **a major leader in other extinctions**
- **at the epicentre of what is now the first human induced global extinction event occurring at an exponentially accelerating rate**

Native forests are logged under RFAs - Regional Forest Agreements.

Myth propounded by the federal and state governments is that RFAs guarantee sustainable native forestry. The reality is routine destruction

Industry lobbyist, Forest and Wood Products Australia – FWPA – claims Australian native forestry is 'World's Best Practice Sustainable Logging'

This claim is repeated across various PR media by state forestry agencies and FWPA. Although now functioning as quasi privatised corporations, state forestry agencies are funded by taxpayers. As industry partners with FWPA, they use taxpayer money for community education to promote FWPA's 5 year Corporate Plan which aims to:

- ***claw back the industry's eroding social licence to keep logging native forests***
- ***secure access to the last of the public forest resource for their private profit***

RFAs provide legal exemption to state forestry agencies from federal environment law. In 2017, the first of these disastrous 20 year 'agreements' expires in 2017 in Tasmania. RFAs in other states expire soon after. Scientists and ecologists want RFAs abolished. But the logging industry has pressured government to promise to roll them over for at least another 20 years. To ensure industry gets its way FWPA's relentless marketing machine is on full throttle. Their rhetoric of *a new era in logging* conceals major deals with political parties. Both Labor and the Coalition have already promised to renew RFAs but the Coalition has also promised to automatically 'roll them over' as the industry now demands - so that as soon as RFAs expire in the next 2 decades they will be renewed.

The public is being set up to accept ongoing extensions of logging contracts that sign away Australia's public native forests

Renewing RFAs under this government would give international and some Australian corporation's ongoing access to clear fell and burn our forests. Habitat critical to our most endangered wildlife will disappear - along with species literally clinging to life within it.

Victorian Faunal Emblem

the Fairy or Leadbeaters Possum

About 1,000 left in an area about 80 X 70 km will be logged if Victorian RFA renewed, the timber and woodchips sold as 'sustainably produced'.

Western Australian Faunal Emblem
the Numbat

only 1,000 left in the wild but their forest can be clear-felled
'World Best Practice Sustainable Logging'

Greenwashing: A common process by which companies trick the public into believing products or practices are sustainable is through a sustainability certification scheme. A green organisation is targeted, often one in financial trouble. The company/industry claims it wants to be environmentally responsible and asks the green group for help to promote a sustainability brand. As people lack the means to verify the sustainability claims, they need to rely on a green group's endorsement. The naïve or cash strapped green group provides its logo and co-operation in a public relations campaign to promote the 'certified' brand. Greenwashing is concealing resource exploitation by national governments and corporations that operate worldwide.

PLANET ARK

Partner to Forest Wood Products Australia's campaign to promote wood use as a climate change solution, Planet Ark endorses logging Australian native forests although if left standing, some can store more carbon per hectare than equatorial rainforests, and are critical for the survival of wildlife on the edge of extinction.

Planet Ark endorses industry and governments' claim that RFA logging is sustainable.

Planet Ark says 'wood should be sustainably sourced…by which we mean certified'. Though certification schemes vary and The Australian Forestry Standard certifies the status quo,

Planet Ark believes:

'choice of forest certification scheme is a decision for forest owners/managers'

Why the native forest logging myth?

No longer do bullock teams romantically weave between tall trees carefully retained till fully mature, for felling by a brave forester's axe, or a chainsaw, every bit being used.

Local economies no longer rely on small timber mills to provide regions with the hardwood once necessary for people's sheds, houses, bridges and railways.

Somehow along the way state forest agencies have been 'corporatised'. Our forests are no longer managed for the public but for powerful corporate clients, guaranteed wood supplies for chipping, pulp and paper, largely exported. State forest agencies contract the machinery that crushes forest understories as forest stands are stripped to make the operation economic for machinery/transport consortiums and corporate clients.

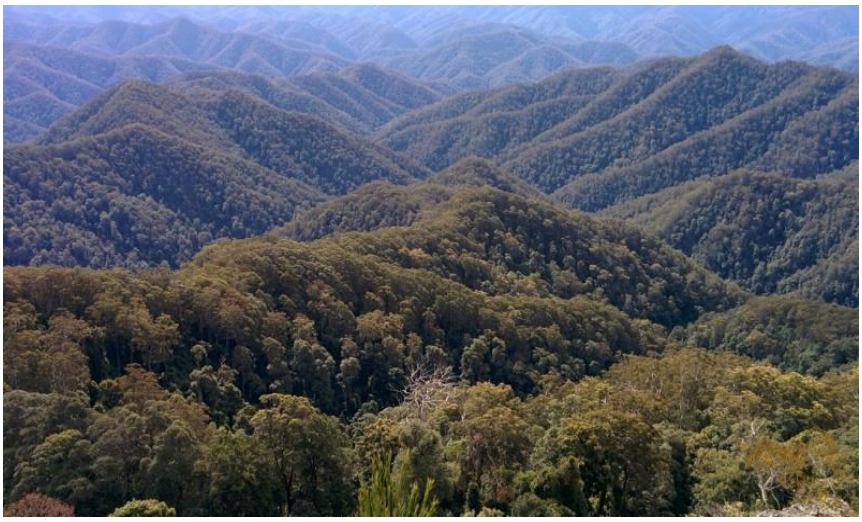
Australia continues its brutal historic clearing but no longer for immediate survival, and now with machines designed to take more, faster.

Australian native forests are now part of a global supply chain of wood chip and forest biomass for processing into thumb sized wood pellets for combustion with coal in power stations.

With the advent of the international wood biomass trade, Earth's original forests are being swiftly and surely obliterated.

In Australia senior state forest executives work closely with logging industry's lobby groups. Some move in and out of management roles with state forest agencies and on and off industry boards. Backed by large corporations, this coterie of industry professionals organises the 'promises' and policy platforms from government regarding access to and sale of Australia's forests.

Thus timber supply agreements with multinationals that include massive government (read *taxpayer*) compensation to logging companies should there be shortfall of *supply*. Add to these unethical operations the fact that native forests are – as a matter of routine - logged at a loss of tens of millions a year to taxpayers.



The impact of native forest logging on

- **landscape amenity (beauty)**
- **wildlife and crucial habitat**
- **water resources**
- **soil stability**
- **climate moderation**
- **and the world's greatest land based carbon sinks**

cannot be overstated.

Scientists, citizens and conservation groups are working desperately to reveal the impact of industrial logging and the loss of our forests. They resign from government work and advisory roles as they are politically gagged. Many finance film, forest tours and camps, public presentations and social media to get the facts to the public. People donate to hire planes or drones to show the logging hidden behind the highways.

Mid North Coast: Intense logging of native forest and deliberate removal of 'un-wanted' species alongside clear fell of plantations to make it hard to distinguish which is which when it regrows. One valley 40 truckloads a day to 'engineer' forests for BORAL

New South Wales

Where Forests *Corporation* NSW mercilessly 'hammers' the habitat of the national icon so that not just Koalas but many more wildlife creatures, once common, enter the extinction conveyor belt of the industry's *production forests*

2017 Forests Corporation and Environment Protection Agency relax the rules

- ✓ **to keep timber supply up to multinational**
- ✓ **to re-zone 100,000 hectares *intensive area* to legalise total clear of native forests including koala habitat – *state sanctioned slaughter***

New South Wales

Intensive logging of coast and hinterland in less than 10 year rotations, deliberate removal of species not wanted by industry. So gone are the food trees of Koalas, Glossy Black Cockatoos and much else. As Forests Corporation NSW *sterilises native forests* that once included wildlife it re-brands them *'Production Forests'*.

It's 80 years before hollows begin to develop in trees to become the only shelter/ protection for forest dependent marsupials, owls and some insect groups. Tree hollows are critical for reproduction, to bear and nurture young. Industrial logging cycles now less than 10 years is creating a uniformly immature forest landscape almost devoid of the hollows on which our creatures depend. Across the continent this loss of hollows is leading to inevitable mass extinction

'Destroy non commercial' so thousands of Tallowood - Koalas preferred food tree are pushed over, roots exposed in the sun to die. Likewise Glossy Black Cockatoo prime food tree Allocasuarina torulosa is systematically obliterated by the tens of thousands

South Coast Wombats are buried alive in their burrows. Yellow Bellied Glider below, killed by logging, once common they are becoming rare.

Millions of creatures die in logging operations even before the starvation and exposure suffered when the vegetation is gone, with no hollows in which to shelter, no leaves, flowers, nectar or insects to eat. The insects too require the forest ecosystem in order to exist.

Across NSW clear felling, burning and crushing of forests as Forests Corporation removes unwanted species to promote Blackbutt dominance. To supply BORAL 100,000 hectares has now been re-zoned 'intensive' for total clear fell, in this sterilization process engineering the new *production forest*

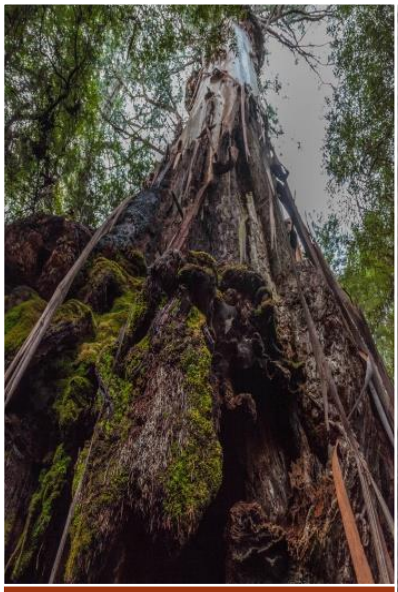
Tasmania

Obliteration of Ancient Forests

and Their Inhabitants

Tasmanian Regional Forest Agreement expires 2017

Coalition promise *perpetual* renewal



Vast tracts of unique forests are logged in Tasmania including rich carbon stores, habitat for rare, threatened, endangered and critically endangered species. Forests are clearfelled and burnt. Forests like the rainforests in the Tarkine, critically endangered Swift Parrot habitat, and tall eucalyptus forests are being lost or are on the logging schedule. Reserves have been opened to logging and legislation was changed so areas previously scheduled for reservation will be available for logging.

Tas state govt admits logging is unsustainable and subsidised.

In 2017 $0.5 million for propaganda and another 4 million to come. TFES subsidy of $148 million to log exports estimated, despite $67 million loss 2015-6.

As at 2012

- $100 million federal subsidy for 6 years
- outright operating loss averaging $100 million per annum for previous 4 years
- unfunded superannuation liability well over $100 million

Rare species like giant freshwater crayfish and spotted tail quoll and endangered Masked Owl and Tasmanian Devil all at risk of annihilation in Tarkine scheduled for logging in February kept at bay only by citizens working with environment groups

Forest coupe in the Arve, near Tahune Airwalk, cable logged, clearfelled, then burned using a napalm like incendiary to encourage the growth of a Eucalypt monoculture. It was old growth 'mixed wet forest', Eucalyptus regnans and rainforest species, habitat of endangered devils, quolls, forest owls and a myriad of other wild lifeforms.

www.crikey.com.au/2012/08/21/tasmanias-forestry-sector-akin-to-work-for-the-dole

Victoria

Brown Mountain Old Growth 2009 …. logged then burnt

and across the state the machines move on

Victoria

Enchanting forests that store vast amounts of carbon are home to exquisite creatures. But an entire Mountain Ash ecosystem faces ecological collapse.

Giant old growth Mountain Ash forests from Mt Yalmy, capable of immense long term CO2 storage then right: Matlock Plateau a once-was Mt Ash forest that is critical for Greater Glider, Leadbeaters Possum, the forest owls and so many others. After decades of clear fell only 1% remains of original Mt Ash forest ecosystems, bringing them to the brink of ecological collapse.

East Gippsland Old Growth being converted to single stand species and called regeneration

$5 million for one native forest logging job, the full cost to taxpayers to subsidise the machinery, equipment and infrastructure such as roads.

$5 million for one native forest logging job
Paying for once common wildlife species to join the swift path to extinction

Western Australia

No matter how endangered

No matter how ancient

In WA it can be obliterated

Western Australia

WA Forest Products Commission (FPC) cost taxpayers $34 million over the last 4 years. Native forest logging provides only 300 logging industry jobs. Quokkas and other forest wildlife draw tourists internationally but are killed or die as a result of logging and burning.

The FPC is exempt from federal laws to protect species and WA's *Biodiversity Conservation Act 2016* will not protect native plants and animals from the harmful impacts of logging. Marri trees, a keystone forest species and critical habitat for cockatoos, are dying across their range, killed by the marri canker.

70% of possums die within 2 weeks of habitat being logged. Here is the rare Western Ringtail, recently included on the critically endangered list yet it could be extinct within 20 years. Clear felling of karri continues with scant regard for the need to retain old hollowed habitat trees or protect steep slopes or stream reserves

Chuditch or Western Quoll are killed during logging or starve later or can't reproduce because they are left without dens, as hollow logs and stumps are removed or burnt. Jarrah forests are being stripped for low grade logs with pressure to increase the volume by up to three times the current amount.

Trees carbon dated to 600 years old clear felled, for paper

Changing NSW logging rules from inadequate to 'NO Restrictions'

Report of discussions with EPA, Forests Corporation NSW, industry reps compiled by observer at the first of the Community Consultation Workshops re Remake Costal IFOA (held Wauchope RSL).

Kathy Jones, then Regional Manager for Forests Corporation stated in the focus group meeting that

"That everything is exhausted on the coastal flat country so we have to go to the catchments"

Community Consultation meeting March 21st, 2014

Present at one of 4 'workshop tables' Kathy Jones Manager Wauchope Forestry District
A forestry worker, a BORAL worker possibly with the name Watts, a member of Hoffman's logging and haulage. EPA Reps included Gary Whytcross and Steve Hartley, then Crown Forestry and Policy Regulatory Officer.

The point was made by a community member that many people who use the forests were noticing that the forests roads are badly maintained and that there is much more wood taken from the forests. He asked how they would cater for people who want to go in the forest.

Forests Corp NSW said they have no budget and that the only ones with any maintenance are those that are done up in order to extract logs. Re fire maintenance or any other purpose for road maintenance they do not do it.

When community member reminded the meeting forests used to be selectively logged and asked if there would still be timber there today had they been selectively logged the government and industry reps said that the reason there wasn't enough timber was that National Parkss had been created.

FCNSW and the EPA agreed that the process of extraction can be improved and made more economically effective. The loggers said they have problems with being limited by creek crossing and slope steepness protections.

The EPA rep said "you the loggers are the ones with the experience and know how to log so we are giving you scope to exercise that experience." The EPA rep asked the logging contractors "How do you feel about being the ones who make the decision on where and how to log, how steep it is, where you should go to get the wood? Because we are 'trying to fast track it' so that you won't get held up and it can be more profitable to you? How do you feel about being the one who decides is too steep or not, whether or not there is a creek or tributary?"

The logging contractor said I feel under confident if I have to take responsibility for a breach.

The EPA rep countered this by saying 'No if you go in and log a steep area and then there is a large amount of rain and the creek is polluted then we will be able to say that it is not your fault (your/the contractor)."

EPA rep suggested that it is ok to clear fell a steep slope because when there is a heavy downpour of rain the soil is not lost but the soil all clumps up and then stops any more soil running away.

Regarding preparing sites for logging in terms of filter strips and so on, the EPA said that where there is an area that has a creek flowing and if you are able to ascertain that you won't damage it by driving through it then you can. The contractor was assured that now they can drive through drainage lines without any consequences legally as regards soil erosion.

Later when this table presented its findings its scribe was able to say that the contour humps damage the axles of the trucks and that there was a recommendation that requirement for these might be removed.

The logging contractors were all saying they do not have enough resource. When community rep asked whether this was because they have taken too much too soon and asked Kathy Jones about how the volume has changed Kathy Jones Senior Stewardship Officer Forestry Central Region said that they are not taking as much (except for 2011) which she admitted was a big volume logging year. All however admitted that they 'don't have the market'.

When asked why they don't go back to the old method of taking 15% only? The forestry answer was that the native forests have been flogged so extensively that what's left in them is rubbish so that they will have to get rid of it and re-plant them. The Forests Corp NSW worker used the word 'flogged'. He was referring to all the forests not just the plantations.

The community rep asked if they will plant original species there. Kathy Jones said they will regenerate the forests to be Blackbutt because that is what the coastal forests are. The community rep suggested there are other species. Kathy Jones Foresty Worker admitted that there will also be some Bluegum planted.

Re the status of regeneration in regrowth forests and coppicing off the stump: they shrugged this off as an issue.

Regarding a lack of wood: They all said that this will change and that they have it sorted and that the reserve areas will be national parks.

Re training: Discussion about GPS. There will be no mark up and EPA reps said that the habitat trees etc will be on the loggers' GPS. The logging contractor said that the problem is that the contractors cannot use the GPS despite the fact that they have one day training. The logging contractors said they needed more than one day's training. That even if they don't attend the course they are still marked as passing the course because the 'training' company says that the friends can pass the information on.

8.3 Steep slope harvesting trial

The current EPL does not provide for steep slope logging because it limits timber extraction to slopes less than 30 degrees for forestry operations and assumes the use of ground-based extraction methods.

To overcome the inherent limitations associated with ground-based extraction methods on steep slopes, other forestry jurisdictions both in Australia and overseas have adopted alternative methods, including cable extraction. These alternative systems that do not require a network of tracks to extract the timber reduce the potential for soil erosion and water pollution.

FCNSW will conduct a small scale trial to determine which techniques can be used to augment ground-based methods on steep country in coastal NSW. The trial will evaluate the benefits, costs, operational constraints and controls that might be necessary to meet the objectives of

access to timber on steep slopes while meeting the IFOA objectives of protecting the aquatic environment and mitigating harm to threatened species.

Further information on the trial is available on the IFOA remake website at http://www.epa.nsw.gov.au/forestagreements/coastIFOAs.htm