Submission No 5

INQUIRY INTO LONG TERM SUSTAINABILITY AND FUTURE OF THE TIMBER AND FOREST PRODUCTS INDUSTRY

Organisation: North East Forest Alliance Inc

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Inquiry into the long term sustainability and future of the timber and forest products industry

Dailan Pugh, President, April 2021

SUMMARY

1. Climate Change (TOR b)

Climate heating, native vegetation and bushfires are intimately linked in that they all affect each other through the carbon and water cycles and other interactions. As the climate heats and rainfall becomes more erratic extreme fire weather is becoming more frequent and intense. Droughts and heatwaves dry foliage and kill plants, while desiccating potential fuels, increasing the flammability of vegetation. Burning forests promotes more flammable vegetation while releasing stored carbon to accelerate climate heating.

Compounding these interactions are land clearing and logging. Clearing forests releases carbon, increases regional temperatures and reduces rainfalls, thereby increasing fire risk, which is worsened by fragmentation and edge effects. Logging forests releases carbon, dries and heats the microclimate, changes fuel arrays and increases the loss of water through transpiration to make forests more vulnerable to burning.

The climate is heating at an accelerating rate, and along with it the threat of catastrophic wildfires. While we urgently need to reduce our emissions to limit global heating, we can only keep global temperature rises to below 2°C if we increase removal of carbon from the atmosphere using *natural climate solutions*.

A significant part of the solution to the climate crisis is to protect native forests from clearing and logging to allow them to regain their carbon carrying capacity. This is termed "proforestation" and is the only way of achieving the immediate results we need, as growing trees take up and store ever increasing volumes of carbon as they age. We can take immediate and meaningful action on climate heating just by stopping logging of public native forests and offering incentives to private landholders to protect theirs.

It is recommended that:

> 1a. To keep climate heating below the Paris target of 2°C, and limit the growing threat of catastrophic fires, it is essential that natural climate solutions are vigorously pursued, with urgent action taken to stop the clearing and logging of native forests (proforestation) so as to restore their carbon carrying capacity. With the collapse of forests already commenced, as evidenced by the 2019-2020 wildfires, there is no time to waste.
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> 1b. Plantations will be of little benefit to mitigate climate heating because their establishment usually releases soil carbon and so it takes 5-10 years before they become net carbon sinks, they are usually clearfelled on 10-30 year rotations for pulp therefore only providing temporary storage, and soil carbon losses may never be regained.
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> 1c. Mixed species regeneration and plantings are the most efficient and effective for capturing and storing atmospheric carbon, and local indigenous species provide the greatest biodiversity benefits. Though to maximise benefits they need to be established for the long-

term and appropriately protected. Rather than commercial plantations, the Government needs to encourage and support native forest regeneration as an urgent priority. The benefits of new regrowth for enhancing regional rainfalls, reducing temperatures and supporting biodiversity, needs to considered along with the effects on streamflows.

1.1. Logging has profound impacts on forest carbon storage by cutting and removing carbon stored in tree trunks, while converting carbon in leaves, branches, bark, tree bases and roots into detritus where it rots or burns. Young forests may be sources of CO_2, with forest's CO_2 sequestration increasing as they age. Logging has run down carbon stores by around 50% in affected forests and it can take over a century to regain the lost carbon. Protecting degraded forests allows them to become carbon sinks and recapture the lost carbon over time. This also had direct benefits for biodiversity.

1.2. The establishment of plantations involves significant soil disturbance and consequently the loss of soil organic carbon. It can take one or more decades for soils to recover the lost carbon. This means that it can take 5-10 years before biomass in plantations result in a net increase in carbon storage, even when established on cleared land.

1.3. Trees are increasing sickening and dying as the result of increasing droughts and heatwaves generated by global warming. This is not just a threat to forest ecosystems, it is also a threat to future timber supplies. This problem is aggravated by a variety of stressors on tree health, including logging, grazing and weed invasion. As evidenced by the increasing severity of droughts, heatwaves, and wildfires we are perilously close to a cascading series of feedbacks that cause the irreversible decline of forest ecosystems and the release of vast quantities of carbon stored in forest vegetation and soils into the atmosphere, making them into carbon sources rather than sinks. As shown by the 2019-20 fires we don't have any time to waste.

2. Sus Yields (TOR c,d)

The Forestry Corporation has a long history of over-estimating and over-allocating timber volumes from native forests, and nothing has changed. Since 2014 resource modelling has adopted radically different assumptions to more than double the identified long term modelled yields of high quality logs. At the time there were no tenure or exclusion area changes, so the doubling of volumes was purely based on changed modelling parameters.

This dramatic change was made secretively, and 4 years later the Government refused to release any relevant documents under a GI(PA) request on the grounds of cabinet confidentiality. That model is still relied on.

Most recently the 2019-20 wildfires burnt through half on north-east NSWs State forests, causing widespread tree deaths, with estimates that at least a third of the region's State Forests were significantly affected, with a loss of 10-50% of large sawlog sized trees over 30 cm diameter at breast height, and 50-100% of smaller trees. Despite this the Forestry Corporation are unbelievably claiming short-term losses of only 4% and long-term losses of just 1%.

What is most disturbing is that the Forestry Corporation is primarily relying on subjective opinion and extrapolation from a sample of just 0.85ha of south coast forests to estimate impacts on 424,200 ha of the very different north coast forests. For some unfathomable reason they refused to resample any of their 659 field plots within the heavily burnt forests to obtain real data on the fire impacts, though the way the data is presented gives the misleading impression that they did.

They are not proposing to undertake another assessment until 2024, after they have issued new Wood Supply Agreements to industry.

It is recommended that:

> 2a. The Forestry Corporation provide a detailed explanation of each of the changes that were made to parameters that allowed for the increase in the long term 20-100 year modelled yields of high quality logs from north east NSW from an average of 101,250 m^3/yr identified in 2010 up to 216,000 m^3/yr in 2014, with full justification as to why the changes were appropriate.
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> 2b. The Forestry Corporation be required to exclude all areas known to be significantly affected by drought or Bell Miner Associated Dieback from net area calculations, and project the likely changes in these forward for the next 100 years, in identifying current and future sustainable yields.
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> 2c. The Forestry Corporation be required, as a matter of urgency, to remeasure all their yield plots in fire affected forests to obtain a more reliable assessment of fire impacts on current and future yields.
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> 2d. That Forestry Corporation utilise force majeure clauses to immediately reduce timber commitments for the remaining term of existing Wood Supply Agreements in line with resource losses.
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> 2e. That no new Wood Supply Agreements be entered into, or extended, until after remeasuring of all fire affected yield plots is completed, the data analysed, and a report made public.

3. Ecological Sustainability (TOR g)

Prescriptions intended to mitigate the impacts of logging on threatened species and ecosystems are political constructs of unknown veracity that have never been subject to monitoring to assess their efficacy.

Basic ESFM principles such as the precautionary principle and adaptive management have never been applied. ESFM was legally unenforceable, enabling the Forestry Corporation to go on logging forests in ecological collapse due to Bell Miner Associated Dieback on the grounds that it hadn't been proved beyond doubt that logging is responsible (though it is blatantly obvious). Similarly the EPA and Forestry have consistently weakened and remove prescriptions for threatened species, never once strengthening them, since their inception in 1997, despite never monitoring their effectiveness. Adaptive management has become the refuge for rogues who say they will do something but never deliver.

Now the inherent inadequacies of the Coastal IFOA have been laid bare by the unprecedent drought and fires of 2019-20.

The 2019-20 bushfires have been of unprecedented scale and intensity, the burning of half the native vegetation and habitats has had massive impacts on north-east NSW's ecosystems, plants and animal populations. A variety of populations and species are likely to have been so significantly affected that they are at imminent risk of extinction. Others have been shoved further down that path. There needs to be urgent assessments of the most heavily impacted ecosystems and populations to assess their current status and the impacts of the fires upon them.

The burning of some 160,000 ha (35%) of rainforests should have been a wake-up call. This will result in significant loss and degradation of these priceless relicts from our Gondwanan past. Those burnt are now more vulnerable to further burning. The damage is so severe that with the increasing likelihood of repeat events this could be the start of ecosystem collapse. The burning of rainforest is akin to the bleaching of coral reefs, and is likely to follow a similar trajectory.

The wet-sclerophyll forests were already experiencing ecosystem collapse due to logging and lantana invasion, with the burning likely to aggravate this unless the return of lantana is prevented.

Recommendations:

> 3a. The Forestry Corporation has been logging under a set of protocols intended to mitigate environmental impacts since 1997. In all that time, with the exception of partial monitoring of 5 plants, they never attempted to monitor the effectiveness of those prescriptions in accordance with adaptive management, despite consistently weakening them. The new Coastal IFOA was a political compromise between the Forestry Corporation and the EPA aimed at minimising resource costs rather than reducing impacts on threatened species to a sustainable level. All logging prescriptions for threatened species need to be reviewed by independent experts, with the identification of needed enhancements to reduce impacts to a sustainable level, including specific performance measures and monitoring requirements.
>
> 3b. Ecological Sustainable Forestry is a meaningless platitude as it has never been enforced and no one heeds its basic principles such as the precautionary principle and adaptive management. Logging of forests affected by Bell Miner Associated Dieback has continued despite it being evident it is caused by lantana invasion following logging, on the grounds that this hadn't been proven beyond doubt, which is a perversion of the precautionary principle. This problem has been compounded by the EPA's failure to effectively audit logging operations.
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> 3.1a. The highest priority to mitigate impacts on native plants and animals is to protect the remaining unburnt and partially burnt refuges where species have survived the fires to allow them to increase populations and recolonise burnt habitat as it recovers, It is recommended that logging of all burnt forests, and all unburnt habitat with 10 km of firegrounds, be prohibited for a minimum of 10 years to avoid compounding impacts during this essential recovery period, and allow time for recovery of populations and recolonisation of burnt habitat.
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> 3.1b. Prescriptions for threatened flora and fauna were developed in a political process and were already inadequate before the fires, given the loss of individuals and degradation of habitat it is essential that there be an independent expert review of prescriptions by relevant experts
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> 3.1c. Logging makes forests more vulnerable to burning and increases their flammability. As extreme weather conditions are increasing in intensity and frequency, then to reduce the likelihood and impacts of future extreme fire events, logging of public native forests has to stop to reduce their increasing flammability, and to allow them to recover their natural resilience to future burning.
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> 3.1d. Some 160,000 ha (34.7%) of rainforest was burnt, with most of this suffering significant canopy damage. While some of this rainforest will die, most will regenerate though will be even more vulnerable to burning and elimination for decades to come. If we want to increase the chances of rainforests, and their inhabitants, surviving this unfolding environmental catastrophe, then we need to restore their natural resistance and resilience to burning by:
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> - ❑ Establish 50m buffers around all mapped rainforests within which logging and clearing is prohibited
> - ❑ Prohibiting roading through rainforests

- ❑ Stopping logging of developing rainforest
- ❑ Rehabilitating degraded stands and buffers, particularly those infested with lantana and those suffering from Bell Miner Associated Dieback

3.2. To redress the ongoing precipitous decline in native species reliant upon the resources provided by older trees it is essential that the removal of older trees be stopped and their recruitment actively encouraged. To improve ecological sustainability the requirements under the old IFOA to protect sound and healthy mature/late mature individuals of recruitment trees for hollow-bearing trees, significant winter nectar producing eucalypt species, sap-feed trees for Yellow-bellied Gliders and other key wildlife resources must be restored. The retention of all remaining mature trees over 60cm dbh as recommended by the 2011 National Recovery Plan for the Swift Parrot is strongly supported.

3.3. Now with the fires burning most known localities of the Hastings River Mouse there can be no excuse for continued complacency. Populations will have been decimated, and habitat degraded, making the current logging prescriptions redundant because habitat is likely not to be recognisable for some time and the low numbers of survivors will render trapping ineffective. All compartments with records or modelled habitat of Hastings River Mouse should be put under moratorium while surveys of known localities are undertaken to assess appropriate criteria and trapping effort to identify habitat, and to quantify whether it should now be considered critically endangered. For private properties all modelled habitat should be immediately placed under moratorium while an effective prescription is developed.

3.4a. Given the abundant evidence that logging is the primary cause of Bell Miner Associated Dieback, and that re-logging affected forests makes it worse, it is well past time that the logging of BMAD affected and susceptible forests is stopped and the process of restoration begun. If logging is to be allowed, it needs to be on a case by case basis, where lantana and Bell Miners are surveyed before the logging and monitored for five years afterwards. In keeping with the principle of adaptive management the results must be analysed, any needed corrective actions taken, and methods altered to minimise impacts before being trialled again.

3.4b. As the current aerial mapping is subjective and does not provide a reliable basis for identifying the current extent of BMAD or to be able to monitor changes over time, it is recommended that the worst BMAD affected areas be subject to objective and repeatable mapping using High Resolution Multi-spectral imagery and ALS Lidar to:

a) accurately identify the current extent of BMAD affected and susceptible forests
b) provide a baseline from which to assess changes over time
c) identify the variables affecting BMAD distribution
d) quantify the accuracy of current mapping and other remote sensing technologies
e) monitor the success of rehabilitation works.

3.4c. It is reprehensible that despite the public monies spent of rehabilitation works on both public and private lands over the past 20 years that only three studies have monitored the outcomes of treatments on BMAD affected forests in north east NSW, and that for the two studies undertaken on State forests the Forestry Corporation has been allowed to largely suppress and ignore the unfavourable results. In order to better understand the causes of BMAD and assess the effectiveness and costs of rehabilitation, the highest priority has to be to undertake independent and transparent lantana (and other problem plant) removal trials, using manual methods that minimise disturbance, with clear objectives, monitoring and reporting requirements.

3.4d. It is apparent that BMAD has reduced the volumes of timber available for logging from tens of thousands of hectares of public forests in north east NSW, and destroyed any prospect of such forests contributing to long-term timber volumes. It is also apparent that BMAD, and its impacts on forest productivity, are expanding. It is essential that this be accounted for in any future timber modelling before any further volumes are committed in Wood Supply Agreements

4. Managing public forests in the public interest (TOR e, f, i).

There needs to be a fundamental shift in the management and support for forestry. It needs to be recognised that logging of public forests is not in the community's best economic, social or environmental interests as far greater benefits can be generated by protecting forests and allowing them to mature: increasing carbon capture and storage, increasing water yields to streams and providing increased recreation benefits and tourism opportunities.

The current massive subsidies to the native forest industry through the Department of Primary Industries (including the Forestry Corporation) and grants to sawmill owners would be more efficiently and effectively directed to a transition program out of public native forests, boosting hardwood sawlog plantation supply and providing incentive payments to private native forest owners for maximising public benefits.

The significantly increased carbon sequestration from recovering forests would be of benefit to all Australians, including rural communities, both by contributing to NSW and Australia's obligations to reduce net carbon emissions and by helping mitigate some of the worst impacts of climate heating. The increased recreational and tourism opportunities will significantly boost regional tourism expenditure and jobs. The increased water yields to streams and aquifers will be a boon to downstream farmers and urban drinking water supplies.

Most significantly, by redirecting funding and subsidies from logging companies to landholders it will provide a direct economic benefit for the retention of native vegetation, and thus reward and encourage private landholders to manage native vegetation for the optimum public benefit.

Recommendations:

4a. The logging of public native forests has always been an economic burden on taxpayers due to the high subsidies paid, both through maintaining the loss making native forestry operations of the Forestry Corporation and through direct payments to sawmill owners and occasionally workers. The hidden costs are the rundown in timber volumes, water quality and quantity, and wildlife populations, as well as the increase in weeds and dieback. Given that plantations are far more efficient and profitable it is past time to complete our transition to them for future timber needs.

4b. Community attitude surveys over the past 24 years clearly show that the community prioritise wildlife, water and carbon storage values of forests above timber production. The University of Newcastle assessed the biodiversity value (Willingness To Pay) of creating the Great Koala National Park as around $530 million for the NSW population and $1.7 billion for all Australians. A 2016 survey for the timber industry of 12,000 people found that native forest logging was considered unacceptable by 65% of rural/regional residents across Australia, and acceptable by just 17% of rural residents. Logging of native forests has very low levels of social license and is clearly not in the public interest.

4c. Tourism is far more important to the north coast economy than logging, and is the fastest growing sector promising increasing economic and employment benefits. In 2019 over $867 million of tourist expenditure can be taken as associated with forested national parks. It is in the community's economic interest to convert more of our public native forests to national parks as this will provide more fulfilling recreational opportunities and attract tourists to the region, as well as encouraging them to stay longer. The potential regional benefits of converting State forests to National Parks has been demonstrated by the University of Newcastle's assessment that over 15 years the creation of the Great Koala National Park would result in 9,135 additional full time jobs, and increases in total output of $1.18 billion and value add of $531 million. The Government will maximise long term regional benefits by directing its resources into enhancing and diversifying forest recreational facilities, rather than upgrading private sawmills

4d. Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere, and annually is around 10% of global anthropogenic emissions. To address the growing threat of climate heating we need to both reduce emissions and increase sequestration of atmospheric carbon. Retaining forests and allowing degraded forests to regain their lost carbon are urgent actions we need to take to begin to redress climate heating on the scale required. Carbon credits offer a mechanism to reward landholders for protecting forests for carbon sequestration, though they need to include payments for standing carbon and annual sequestration when forests are protected. At the current ACCU carbon dioxide price of $17 a tonne, the value of carbon dioxide currently stored in a logged forest, combined with annual sequestration could equate to annual payments of $228-410/ha per annum to a landholder, all paid for with carbon credits. It is requested that the inquiry consider measures needed to facilitate a scheme that could realise such payments to land holders. Applying such values to the 500,000ha of logged and loggable State Forests in north-east NSW would equate to annual revenue of $114-205 million a year, just from stopping logging.

4e. All runoff from forests now has an economic value, though the value varies with downstream uses, with runoff feeding into urban water supplies being of the highest value. Stopping logging and allowing forests to mature will increase water yields over time as the forest's structure regrows, and thus stopping logging is of direct economic benefit to downstream water users. While the relative value of forest runoff will vary depending on its usage, it is apparent that in most instances it will be of higher economic benefit to maximise water yields by not logging forests. This value will escalate as climate change gathers momentum and dry periods become more frequent and severe.

4d. It would be of greatest public benefit if public monies currently used to subsidise the inefficient public native timber industry were redirected into regular payments for landholders who guarantee long-term protection (by zoning or covenant) and management of native forests to maximise carbon storage, water yields and biodiversity conservation, some elements of which could comprise:

a. Extending the Australian Government's Climate Solutions Fund (or creating a specific fund) to pay landholders who protect their forests for long-term carbon capture and storage. Rather than an auction process there needs to be standardized payments based on stored carbon, carbon sequestration and biodiversity value.
b. Extending eligibility for carbon credits to all forests, including those protected, rather than perversely just those that have first been approved for clearing or logging.
c. Paying landholders regularly for a portion of the current measured standing volume of carbon in living biomass.

d. Paying landholders regularly for additional carbon sequestration and storage in vegetation and soils.
e. Expanding NSW's Biodiversity Trust to make regular payments, in combination with carbon credits, to landowners for permanently protecting core koala habitat, and other areas of exceptional biodiversity value.

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1. Climate Change

(b) the impact of external influences on the timber and forest products industry, including but not limited to drought, water, fire, regulatory structures, habitat protection and local, state and federal policies regarding climate change and plantation establishment,

On the 26 February 2020 a number of Australia's leading scientists wrote an open letter to Australian parliaments calling for the immediate nationwide cessation of all native forest logging in response to the climate, fire, drought and biodiversity loss crises currently facing Australia

> *An open letter to the Parliament of Australia,*
>
> *Sadness at the losses from the fires sears our souls. Worse might lie in wait. We write to ask you to respond to the climate, fire, drought and biodiversity loss crises with an immediate nationwide cessation of all native forest logging.*
>
> *We need our forestry workers to be immediately redeployed to fire services support and national park management to help protect the forests and us from fire.*
>
> *Large, old-growth trees are important for carbon capture and storage and they keep on capturing carbon for their entire life. Logging increases fire hazard in the short term. Many native species rely on unlogged forests.*
>
> *Our timber needs can be met from existing plantations, with no need to log native forests. Native forest logging is heavily subsidised by our taxes, which can be better spent on fire mitigation.*
>
> *This is above politics –please show the leadership Australia desperately needs.*

Climate heating, native vegetation and bushfires are intimately linked in that they all affect each other through the carbon and water cycles and other interactions. As the climate heats and rainfall becomes more erratic extreme fire weather is becoming more frequent and intense. Droughts and heatwaves dry foliage and kill plants, while desiccating potential fuels, increasing the flammability of vegetation. Burning forests promotes more flammable vegetation while releasing stored carbon to accelerate climate heating.

Compounding these interactions are land clearing and logging. Clearing forests releases carbon, increases regional temperatures and reduces rainfalls, thereby increasing fire risk, which is worsened by fragmentation and edge effects. Logging forests releases carbon, dries and heats the microclimate, changes fuel arrays and increases the loss of water through transpiration to make forests more vulnerable to burning.

The climate is heating at an accelerating rate, and along with it the threat of catastrophic wildfires. While we urgently need to reduce our emissions to limit global heating, we can only keep global temperature rises to below 2^{o}C if we increase removal of carbon from the atmosphere using *natural climate solutions*. The only realistic means of rapidly achieving carbon sequestration of the magnitude required is to protect native forests to allow them to realise their carbon carrying capacity.

Globally, terrestrial ecosystems currently remove an amount of atmospheric carbon equal to one-third of what humans emit from burning fossil fuels, which is about 9.4 GtC/y (10^9 metric tonnes carbon per year). (Moomaw *et. al.* 2019). Forests cover about 30% of the Earth's terrestrial surface and store around 90% of terrestrial vegetation carbon (Besnard *et. al.* 2018).

Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere, and annually is around 10% of global anthropogenic emissions (Keith et. al. 2015). In Australia, an estimated 44% of the carbon stock in temperate forests has been released due to deforestation (Wardell-Johnson *et. al.* 2011), with stocks further reduced by around 50% in logged forests (Mackey *et. al.* 2008, Moomaw *et. al.* 2019).

The 2016 ratified Paris Climate Agreement declared a commitment to hold "the increase in the global average temperature to well below 2 °C above preindustrial levels" with a goal of limiting warming to 1.5°C. The Intergovernmental Panel on Climate Change (IPCC 2018), identifies that to achieve this the world needs to slow global emissions immediately and reach net zero carbon dioxide (CO_2) emissions by around 2050. Even then we need to remove copious quantities of carbon from the atmosphere. The IPCC (2018) identify:

> *All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence).*
>
> *...*
>
> *Model pathways that limit global warming to 1.5°C with no or limited overshoot project the conversion of 0.5–8 million km^2 of pasture and 0–5 million km^2 of non-pasture agricultural land for food and feed crops into 1–7 million km^2 for energy crops and a 1 million km^2 reduction to 10 million km^2 increase in forests by 2050 relative to 2010 (medium confidence). Land use transitions of similar magnitude can be observed in modelled 2°C pathways (medium confidence).*

Goldestein *et. al.* (2020) warn:

> *Given that emissions have not slowed since 2017, as of 2020, this carbon budget will be spent in approximately eight years at current emissions rates. Staying within this carbon budget will require a rapid phase-out of fossil fuels in all sectors as well as maintenance and enhancement of carbon stocks in natural ecosystems, all pursued urgently and in parallel.*

Limiting global warming below the 2°C threshold set by the Paris Climate Agreement is contingent upon both reducing emissions and removing greenhouse gases (GHGs) from the atmosphere. There has been considerable emphasis on failed mechanical schemes for increasing carbon capture and storage when for millions of years trees have effectively performed this function. There is growing recognition that we need to utilise natural climate solutions to have any chance of limiting global heating to below 2°C. These include protecting remnant vegetation from further degradation, encouraging regrowth of natural ecosystems, widespread planting of trees. and restoring soil carbon on agricultural lands.

It has long been recognised that we need natural climate solutions (NCS) to have any chance of limiting the worst effects of climate change (Sohngen and Sedjo 2004, Wardell-Johnson *et. al.* 2011, Keith *et. al.* 2015, Griscom *et. al.* 2017, Houghton and Nassikas 2018, Fargione *et. al.* 2018, Moomaw *et. al.* 2019, Goldestein *et. al.* 2020). As well as reducing atmospheric carbon, natural climate solutions have a multitude of environmental benefits including reducing flammability, enhancing rainfalls, reducing temperatures, enhancing streamflows (except for reforestation), protecting and enhancing natural habitats, restoring habitat linkages and improving soils.

Griscom *et. al.* (2017) calculate that natural climate solutions can provide 37% of cost-effective CO_2 mitigation needed through to 2030 for a >66% chance of holding warming to below 2°C, and 20% of cost-effective mitigation between now and 2050, further noting:

> *Thereafter, the proportion of total mitigation provided by NCS further declines as the proportion of necessary avoided fossil fuel emissions increases and as some NCS pathways*

> *saturate. Natural climate solutions are thus particularly important in the near term for our transition to a carbon neutral economy by the middle of this century.*

Griscom *et. al.* (2017) consider that "*Forest pathways offer over two thirds of cost-effective NCS mitigation needed to hold warming to below 2°C and about half of low-cost mitigation opportunities pathway*".

Fargione *et. al.* (2018) quantified the potential of natural climate solutions to increase carbon storage and avoid greenhouse gas emissions in the United States, finding "*a maximum potential of 1.2 (0.9 to 1.6) Pg CO_2e year^{-1}, the equivalent of 21% of current net annual emissions of the United States*", and concluding *"The conservation, restoration, and improved management of lands in the United States represent a necessary and urgent component of efforts to stabilize the climate".* Their solutions include reforestation of marginal farmland, extending logging cycles, increasing soil carbon, and avoiding emissions. They found that reforestation has the single largest maximum mitigation potential, followed by extending logging cycles on private lands, stopping forest and grassland clearing, improving farming practices and soil carbon, and restoring wetlands.

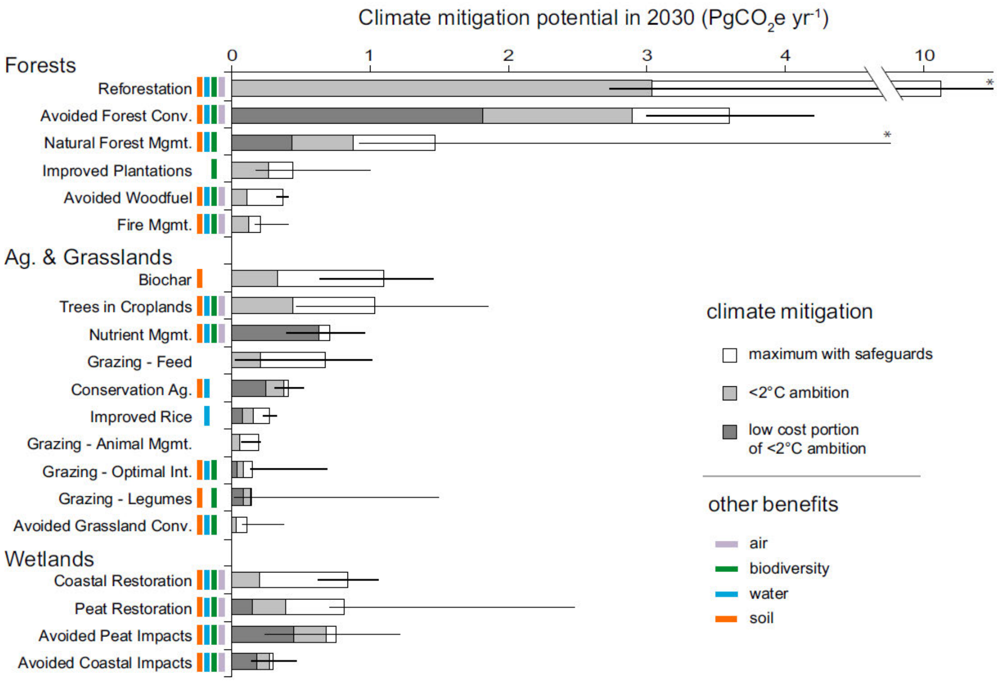


Fig. 1. from Griscom et. al. (2017): Climate mitigation potential of 20 natural pathways. We estimate maximum climate mitigation potential with safeguards for reference year 2030. Light gray portions of bars represent cost-effective mitigation levels assuming a global ambition to hold warming to <2 °C (<100 USD $MgCO_2e^{-1}$ y^{-1}). Dark gray portions of bars indicate low cost (<10 USD $MgCO_2e^{-1}$ y^{-1}) portions of <2 °C levels. Wider error bars indicate empirical estimates of 95% confidence intervals, while narrower error bars indicate estimates derived from expert elicitation. Ecosystem service benefits linked with each pathway are indicated by coloured bars for biodiversity, water (filtration and flood control), soil (enrichment), and air (filtration). Asterisks indicate truncated error bars.

The first step has to be to stop deforestation. Goldestein *et. al.* (2020) observe "*From 2000–2012, the aggregate of thousands of local decisions drove the loss of 2.3 million km² of forest cover worldwide. Human-driven loss was attributable primarily to agricultural expansion in tropical regions and to forestry in boreal and temperate regions*".

While reforestation has the highest potential carbon benefits if undertaken on a large scale, it requires an enormous amount of additional land, and will take some decades after establishment before the carbon sequestration benefits begin to manifest. As observed by Moomaw *et. al.* (2019)

"*newly planted forests require many decades to a century before they sequester carbon dioxide rapidly*". We cannot remove sufficient carbon by growing young trees during the critical next decade.

By contrast there are vast areas of forest in various states of degradation and regrowth that have the potential to rapidly increase their carbon sequestration and storage just by stopping cutting them down. Moomaw *et. al.* (2019) consider:

> *... growing existing forests intact to their ecological potential – termed proforestation – is a more effective, immediate and low-cost approach that could be mobilized across suitable forests of all types. Proforestation serves the greatest public good by maximizing co-benefits such as nature-based biological carbon sequestration and unparalleled ecosystem services such as biodiversity enhancement, water and air quality, flood and erosion control, public health benefits, low impact recreation and scenic beauty.*
>
> *Proforestation produces natural forests as maximal carbon sinks of diverse species (while supporting and accruing additional benefits of intact forests) and can reduce significantly and immediately the amount of forest carbon lost to non-essential management. Because existing trees are already growing, storing carbon, and sequestering more carbon more rapidly than newly planted and young trees (Harmon et al., 1990; Stephenson et al., 2014; Law et al., 2018; Leverett and Moomaw, 2019), proforestation is a near-term approach to sequestering additional atmospheric carbon: a significant increase in "negative emissions" is urgently needed to meet temperature limitation goals.*
>
> *Globally, existing forests only store approximately half of their potential due to past and present management (Erb et al, 2018), and many existing forests are capable of immediate and even more extensive growth for many decades (Lutz et al, 2018). During the timeframe while seedlings planted for afforestation and reforestation are growing (yet will never achieve the carbon density of an intact forest), proforestation is a safe, highly effective, immediate natural solution that does not rely on uncertain discounted future benefits inherent in other options.*
>
> *In sum, proforestation provides the most effective solution to dual global crises – climate change and biodiversity loss. It is the only practical, rapid, economical and effective means for atmospheric carbon dioxide removal among the multiple options that have been proposed because it removes more atmospheric carbon dioxide in the immediate future and continues to sequester it into the long-term future. Proforestation will increase biodiversity of species that are dependent on older and larger trees and intact forests and provide numerous additional and important ecosystem services (Lutz et al., 2018). Proforestation is a very low-cost option for increasing carbon sequestration that does not require additional land beyond what is already forested and provides new forest related jobs and opportunities along with a wide array of quantifiable ecosystem services, including human health.*

Moomaw et. al. (2019) "*conclude that protecting and stewarding intact diverse forests and practicing proforestation as a purposeful public policy on a large scale is a highly effective strategy for mitigating the dual crises in climate and biodiversity and ultimately serving the 'greatest good' in the United States and the rest of the world*".

Logging is the primary cause of carbon loss from forests, for example for the USA Moomaw et. al. (2019) consider "*Together, fires, drought, wind and pests account for ~12% of the carbon lost in the U.S.; forest conversion accounts for ~3% of carbon loss; and forest harvesting accounts for 85% of the carbon lost from forests each year*".

Houghton and Nassikas (2018) assessed the potential to take up the equivalent of 47% of global CO_2 emissions just by stopping clearing and degrading native vegetation, identifying "*the current* *gross carbon sink in forests recovering from harvests and abandoned agriculture to be -4.4 PgC/year, globally. The sink represents the potential for negative emissions if positive emissions from deforestation and wood harvest were eliminated*".

	Current average net emissions 2006–2015 (PgC/year)	Current average gross emissions 2006–2015 (PgC/year)	Net potential sink with a complete halt to deforestation and forest harvest 2016–2100 (PgC)
Temperate	−0.3	−1.1	−19
Tropics (Houghton & Nassikas, 2017) Simulation #2A	1.4	−0.5	−15
Tropics (with shifting cultivation) Simulation #2B	1.4	−3.3	−98
Global	1.1/1.1	−1.6/−4.4	−34/−117

Houghton and Nassikas (2018) conclude that:

> *... negative emissions are possible because ecosystems are below their natural carbon densities as a result of past land use. That is, potential negative emissions are directly coupled to past positive emissions. There is nothing magical about these negative emissions. They simply restore carbon lost previously. The corollaries of this conclusion are (i) that negative emissions will diminish as forests recover to their undisturbed state (negative emissions will only work for a few decades) and (ii) that much of that recovery will have occurred before 2100, according to these simulations.*

Sohngen and Sedjo (2004) cite one of their studies that "*showed that forests could account for approximately a third of total abatement over the next century*".

Trees are essential elements of the earth's carbon cycle, essential for mopping up excess atmospheric carbon and putting it out of harm's way. Trees continue to take up CO_2 and store exponentially increasing volumes of carbon in their wood and soils as they age. The older trees and forests are the more carbon they store making them vital components of the solution to rapidly escalating climate heating.

Because of their extent fires can release significant volumes of carbon, largely as CO_2, though this is primarily carbon sequestered in dead biomass and a portion of it may end up as char sequestered in alluvial deposits or soils if fires are not too frequent. Some trees may be killed, though the dead standing trees may slowly release their carbon over decades.

Logging is by far the biggest threat to terrestrial carbon stores. Cutting down and bulldozing trees releases their stored carbon, with at best a small fraction stored in timber products with a life of a few decades. Within our logged forests the volumes of carbon stored have been halved and continue to decline as retained old trees die out, logging intensifies and return times become more frequent.

A significant part of the solution to the climate crisis is to protect native forests from clearing and logging to allow them to regain their carbon carrying capacity. This will provide immediate results as growing trees take up and store ever increasing volumes of carbon as they age. We can take immediate and meaningful action on climate heating just by stopping logging of public native forests and offering incentives to private landholders to protect theirs.

Native forests play a crucial role in the storage of carbon and the sequestration of carbon dioxide from the atmosphere. Old growth forests are the most significant carbon storehouses, with most carbon stored in the oldest and biggest trees (Roxburgh *et.al.* 2006, Mackey *et. al.* 2008, Sillett *et.al* 2010, Dean *et. al.* 2012, Stephenson *et. al* 2014, Keith *et. al.* 2014b). Forests also remove carbon dioxide from the atmosphere and sequester it in live woody tissues and slowly decomposing organic matter in litter and soil. (Zhou *et. al.* 2006, Luyssaert *et. al.* 2008)

Forests accumulate carbon when their photosynthesis driven gross primary production (GPP), is greater than their carbon loss through ecosystem (plant and microbial) respiration (ER), giving them a positive net ecosystem production (NEP). These have diurnal variations, with photosynthesis dominant during the day and respiration at night.

With the urgent need to sequester carbon from the atmosphere we should be managing our forests as carbon sinks. As Mackey *et. al.* (2008) conclude;

> *The remaining intact natural forests constitute a significant standing stock of carbon that should be protected from carbon-emitting land-use activities. There is substantial potential for carbon sequestration in forest areas that have been logged commercially, if allowed to regrow undisturbed by further intensive human landuse activities*

It is recommended that:

1a. To keep climate heating below the Paris target of 2°C, and limit the growing threat of catastrophic fires, it is essential that natural climate solutions are vigorously pursued, with urgent action taken to stop the clearing and logging of native forests (proforestation) so as to restore their carbon carrying capacity. With the collapse of forests already commenced, as evidenced by the 2019-2020 wildfires, there is no time to waste.

1b. Plantations will be of little benefit to mitigate climate heating because their establishment usually releases soil carbon and so it takes 5-10 years before they become net carbon sinks, they are usually clearfelled on 10-30 year rotations for pulp therefore only providing temporary storage, and soil carbon losses may never be regained.

1c. Mixed species regeneration and plantings are the most efficient and effective for capturing and storing atmospheric carbon, and local indigenous species provide the greatest biodiversity benefits. Though to maximise benefits they need to be established for the long-term and appropriately protected. Rather than commercial plantations, the Government needs to encourage and support native forest regeneration as an urgent priority. The benefits of new regrowth for enhancing regional rainfalls, reducing temperatures and supporting biodiversity, needs to considered along with the effects on streamflows.

1.1. The Influence of Logging

Logging has profound impacts on forest carbon storage by cutting and removing carbon stored in tree trunks, while converting carbon in leaves, branches, bark, tree bases and roots into detritus where it rots or burns. Logging has a far more significant impact on forest carbon stores than burning, generally logging has run down carbon stores by around 50% in affected forests (Noormets *et. al.* 2015).

For many decades the prevalent myth was that forests over 100 years old stop accumulating carbon, based on the premise that as forests age the decrease in the volume of photosynthetic leaves relative to respiring sapwood results in a decline in net ecosystem production (NEP). This myth has been demonstrated to be wrong by numerous studies that have proven that forests continue to sequester carbon as they age (Harmon *et. al.* 1990, Carey *et. al.* 2001, Chen *et. al.* 2004, Falk *et. al.* 2004, Roxburgh *et.al.* 2006, Mackey *et. al.* 2008, Luyssaert *et. al.* 2008, Dean *et. al.* 2012, Keith *et. al.* 2014b, Curtis and Gough 2018), though the rate of sequestration may decline in some of the oldest forests (Carey *et. al.* 2001, Luyssaert *et. al.* 2008, Curtis and Gough 2018). During droughts forests can become carbon sources rather than sinks (Chen *et. al.* 2004, Falk *et. al.* 2004).

In fact regrowth forests (less than 15-30 years old) may be carbon sources due to lower leaf areas resulting in reduced sequestration and higher respiration from the residual carbon in soils and woody debris (Chen *et. al.* 2004, Luyssaert *et. al.* 2008).

It is also evident that structurally complex forests are more effective at sequestering carbon than simplistic monocultures, for example Gough *et. al.* (2019) found that "*Forests that were more structurally complex, had higher vegetation-area indices, or were more diverse absorbed more light and used light more efficiently to power biomass production, but these relationships were most strongly tied to structural complexity*".

There can be no doubt that it is the big old trees that store and sequester the most carbon. For example Roxburgh *et.al.* (2006) found:

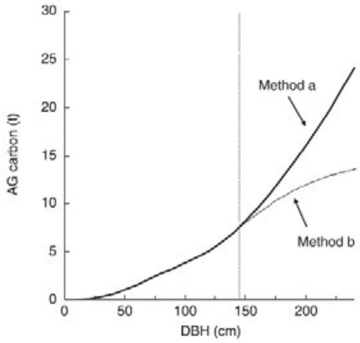
> *In mature forests, large diameter trees greater than 100 cm d.b.h. comprised 18% of all trees greater than 20 cm d.b.h. and contained 54% of the total above-ground carbon in living vegetation. ... The influence of large trees on carbon stock therefore increases with their increasing size and abundance.*

Similarly Moomaw *et. al.* (2019) identify

> *Each year a single tree that is 100 cm in diameter adds the equivalent biomass of an entire 10-20 cm diameter tree, further underscoring the role of large trees (Stephenson et al., 2014). Intact forests also may sequester half or more of their carbon as organic soil carbon or in standing and fallen trees that eventually decay and add to soil carbon (Keith et al., 2009). Some forests continue to sequester additional soil organic carbon (Zhou et al, 2006) and older forests bind soil organic matter more tightly than younger ones (Lacroix et al., 2016).*

Keith *et. al.* (2014b) found large trees >100 cm diameter contributed 76% of the biomass in old growth sites, but only 43% of tree numbers, with remnant old trees also making significant contributions in predominately regrowth stands.

Above-ground biomass/carbon relationship to tree diameter at breast height. From Roxburgh *et.al.* (2006). Method A assumes minimal internal tree decomposition. Method B allows for internal decay.



Sillett *et.al* (2010) found that traditional ground-based measurements are inadequate to quantify whole tree wood production of tall tree species, finding that *"larger trees produce more wood annually than smaller trees",* and that *"annual aboveground wood production increased with size and age up to and including the largest and oldest trees"* they measured.

Similarly Stephenson *et. al* (2014) concluded:

> *Here we present a global analysis of 403 tropical and temperate tree species, showing that for most species mass growth rate increases continuously with tree size. Thus, large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree.*

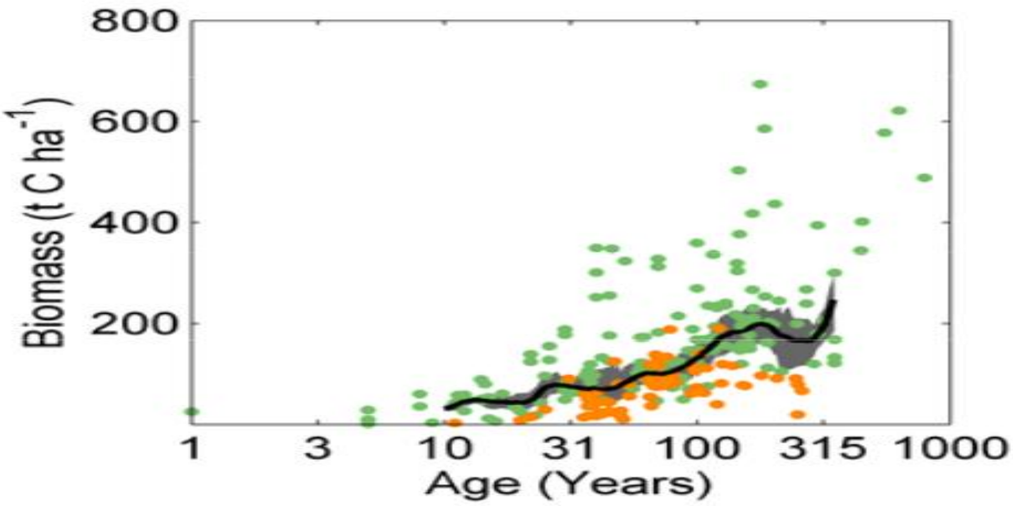


Figure S3 from Luyssaert *et. al.* (2008) showing Biomass accumulation as a function of stand age, shown as the relationship between aboveground biomass and the logarithm of stand age. The thick black line shows the weighted mean within a moving window of 15 observations. The grey area around this line shows the 95% confidence interval of the median. Each data point represents a forest stand (green is temperate, and orange is boreal), many of which have different growing conditions and species composition.

It is blatantly obvious that by removing the largest trees that logging dramatically reduces the carbon stored in forests (Roxburgh *et.al.* 2006, Mackey *et. al.* 2008, Wardell-Johnson *et. al.* 2011, Dean *et. al.* 2012, Keith *et. al.* 2014b, Keith *et. al.* 2015). The accumulation of carbon with age is not limited to individual trees, but is also evident that oldgrowth forests can go on sequestering carbon indefinitely. It is only in oldgrowth forests that the maximum volume of carbon is stored, and forests reach their carbon carrying capacity.

In America Harmon *et. al.* (1990) found that during simulated harvesting carbon storage is reduced by 49-62% and does not approach old growth storage capacity for at least 200 years (even when storage in wooden buildings is accounted for).

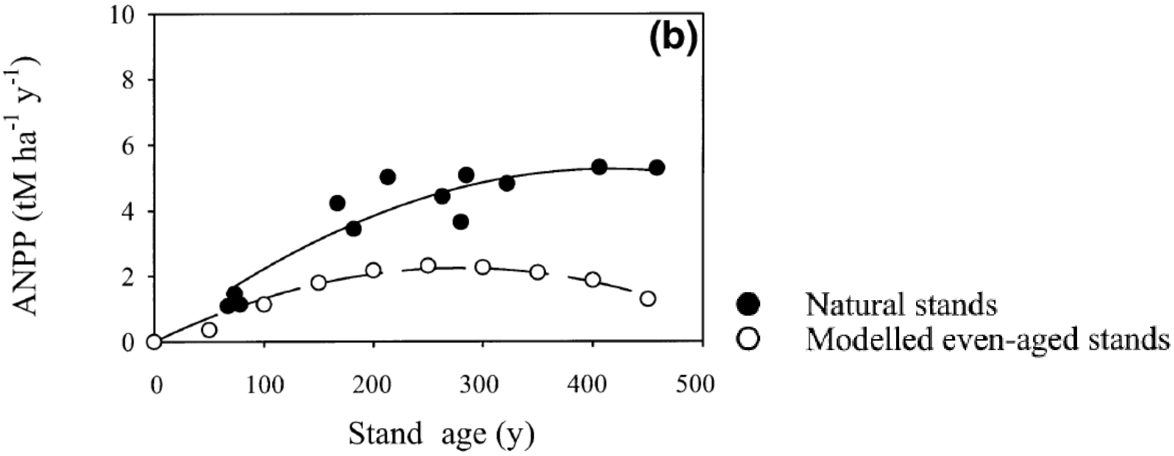


Fig 2(b) from Carey *et. al.* (2001), annual net primary productivity for natural subalpine forest stands of different ages in the northern Rocky mountains and simulated whitebark pine stands.

Luyssaert *et. al.* (2008) found "*Consistent with earlier studies, biomass continues to increase for centuries irrespective of whether forests are boreal or temperate*".

Carey *et. al.* (2001) assessed 67 to 458 year old subalpine forests in the northern Rocky Mountains and found that net ecosystem production, assessed as aboveground net primary productivity (ANPP), increased over time, well above single species models indicated:

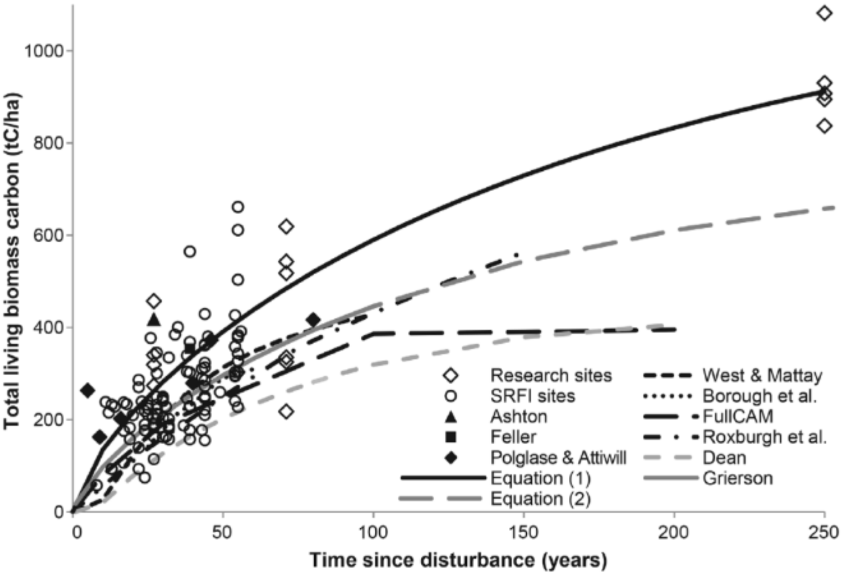
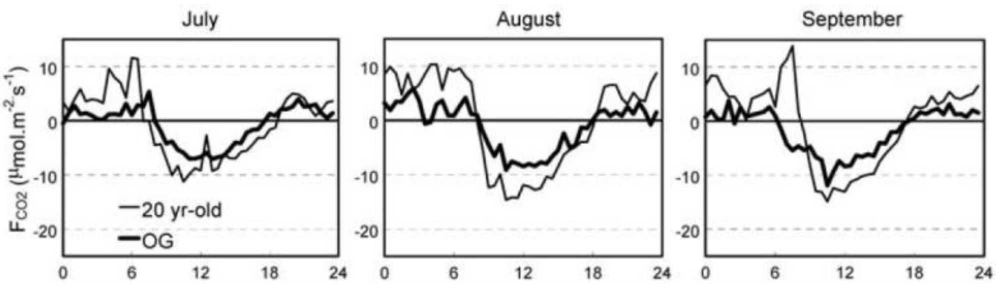


Fig. 7 from Keith et. al. (2014b): "Carbon accumulation in living biomass (above- and belowground) over time in E. regnans forest based on site data and equations from the literature and current study". Details are provided in the paper, though the trends over time are clear.

Chen *et. al.* (2004) assessed 20, 40 and 450 year old Douglas-fir dominated forests in Washington, USA, finding that all three age classes were net carbon sinks during the dry warm summers, except in one year when the oldgrowth was affected by drought and became a carbon source.



Figures 2 and 3 from Chen *et. al.* (2004) showing average diurnal fluxes of carbon dioxide (CO2) in a 20- and a 450-year-old Douglas-fir forest in southern Washington, USA. Negative values indicate uptake (that is, sink); positive values indicate loss (that is, source). Note the significantly increased respiration of 20 yr old forest.

Chen *et. al.* (2004) conclude:

> *... our results strongly suggest that the old-growth forest may be a stronger carbon sink than previously believed. However, given its shift between a carbon source and sink in these two summers, the potential for long-term net carbon accumulation in the old-growth stand is uncertain. The 2 years of data for the summer season examined imply that these forests are sensitive to interannual weather conditions and thus will be sensitive to any directional climate change.*
>
> *The conversion of long-lived forests into young stands may change the system from a sink to a source of carbon for several decades because the lower leaf area in regenerating forests*

> *limits photosynthesis while the residual carbon in soils and woody debris contributes to respiration, whereas old-growth forests may continue to function as a net carbon sink, in addition to their many other important ecosystem functions (for example, critical habitat, aesthetic values, watershed protection). Stands younger than 20 years old are expected to be carbon sources because of low photosynthetic potential and substantial respiratory losses ...*

For oldgrowth forests, Luyssaert *et. al.* (2008) undertook a search of literature and databases for forest carbon-flux estimates, finding:

> *Old-growth forests remove carbon dioxide from the atmosphere at rates that vary with climate and nitrogen deposition. The sequestered carbon dioxide is stored in live woody tissues and slowly decomposing organic matter in litter and soil. Old-growth forests therefore serve as a global carbon dioxide sink ... forests between 15 and 800 years of age, net ecosystem productivity (the net carbon balance of the forest including soils) is usually positive. ... Old-growth forests accumulate carbon for centuries and contain large quantities of it. We expect, however, that much of this carbon, even soil carbon, will move back to the atmosphere if these forests are disturbed.*

Luyssaert *et. al.* (2008) consider

> *We speculate that when high above-ground biomass is reached, individual trees are lost because of lightning, insects, fungal attacks of the heartwood by wood-decomposers, or trees becoming unstable in strong wind because the roots can no longer anchor them. If oldgrowth forests reach high above-ground biomass and lose individuals owing to competition or small-scale disturbances, there is generally new recruitment or an abundant second canopy layer waiting in the shade of the upper canopy to take over and maintain productivity.*
>
> *Although tree mortality is a relatively rapid event (instantaneous to several years long), decomposition of tree stems can take decades. Therefore, the CO_2 release from the decomposition of dead wood adds to the atmospheric carbon pool over decades, whereas natural regeneration or in-growth occurs on a much shorter timescale. Thus, old-growth forest stands with tree losses do not necessarily become carbon sources, as has been observed in even-aged plantations (that is, where trees are all of the same age).*

Luyssaert *et. al.* (2008) emphasise:

> *In fact, young forests rather than old-growth forests are very often conspicuous sources of CO_2 (Fig. 1a) because the creation of new forests (whether naturally or by humans) frequently follows disturbance to soil and the previous vegetation, resulting in a decomposition rate of coarse woody debris, litter and soil organic matter (measured as heterotrophic respiration) that exceeds the NPP of the regrowth.*

Curtis and Gough (2018) similarly found that a long held theoretical assumption of carbon neutrality in old-growth forests was not supported by their assessment of global data for northern deciduous forests, noting:

> *All stands older than 2 yr were net carbon sinks, including 12 forests > 100 yr old, and we found little evidence of declining carbon storage during mid-succession (100–200 yr) and more gradual declines than expected in late succession (> 200 yr, Fig. 3). On average, NEP was lower in very old forests, but the decline from peak annual carbon storage was gradual, falling to half the maximum value at 315 yr, well within late succession.*

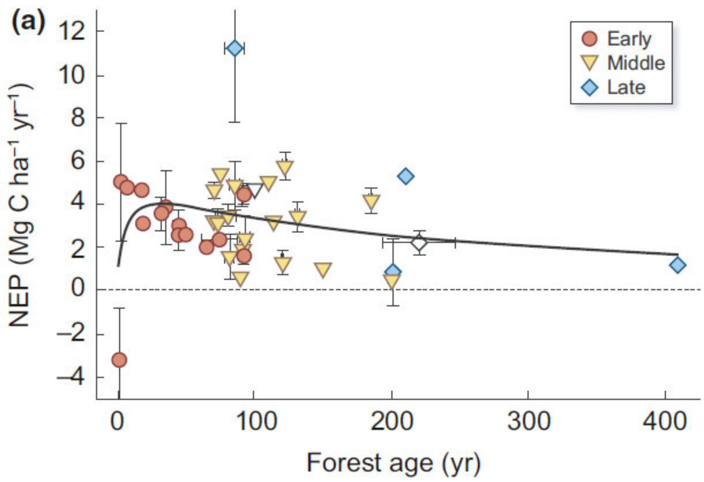


Fig 3(a) from Curtis and Gough (2018), showing no evidence for a steep decline in Net Ecosystem Productivity during mid-succession

Curtis and Gough (2018) concluded "*new observations, ecological theory and our emerging biological understanding of temperate forest ecosystems point to sustained* [Net Ecosystem Productivity] *in aging temperate deciduous forests*", and thus carbon uptake. They consider:

> *... the conservation of these aging forests into late stages of ecosystem development is likely to result in nominal reductions in the land carbon sink, whilst maintaining an immense store of terrestrial carbon, and restoring the many ecosystem services afforded by the resurgence of biologically and physically complex forest ecosystems in eastern North America.*

From their consideration of global data, Besnard *et. al.* 2018 concluded that "*forest age was a dominant factor of NEP spatio-temporal variability in both space and time at the global scale as compared to abiotic factors, such as nutrient availability, soil characteristics and climate. These findings emphasize the importance of forest age in quantifying spatio-temporal variation in NEP using empirical approaches".*

In regards to logging Mackey *et. al.* (2008) note:

> *The carbon stock of forests subject to commercial logging, and of monoculture plantations in particular, will always be significantly less on average (~40 to 60 per cent depending on the intensity of land use and forest type) than the carbon stock of natural, undisturbed forests.*
> *...*
> *The majority of biomass carbon in natural forests resides in the woody biomass of large old trees. Commercial logging changes the age structure of forests so that the average age of trees is much younger. The result is a significant (more than 40 per cent) reduction in the long-term average standing stock of biomass carbon compared with an unlogged forest. ..*

In Australian forests Roxburgh *et.al.* (2006) found that following logging:

> *Model simulations predicted the recovery of an average site to take 53 years to reach 75% carrying capacity, and 152 years to reach 90% carrying capacity.*

Keith *et. al.* (2015) demonstrate that changing native forest management from commercial harvesting to conservation "*results in an immediate and substantial reduction in net emissions relative to a reference case of commercial harvesting*":

> *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.*

There is abundant evidence that numerous animal species prefer larger trees for increased resources, such as browse and nectar, and that many are dependent upon the hollows provided by the oldest trees. Hatanaka *et. al.* (2011) sought to measure the direct relationship between carbon and birds in Victorian forests aged from less than 5 years old to mature stands more than 100 years old, finding

> *Mature forest stands had the highest number of bird species, abundance and biomass, and the most distinctive bird assemblages compared with regrowth forest sites ... On average, there were 72% more species per stand in mature stands than in older regrowth (41–60 years). There also were 72% more individuals and a huge increase in bird biomass (176%).*

Hatanaka *et. al.* (2011) recommend:

> *There is a need to complement carbon crediting with biodiversity credits to avoid perverse investment outcomes ... If our results are widely applicable, then the preservation of old-growth forests is about a two-fold greater (bird) biodiversity benefit compared with even the oldest regrowth stands, notwithstanding comparable aboveground carbon storage levels. ...*
>
> *Mature vegetation simultaneously maximizes both avian biodiversity and above-ground carbon storage. These results bolster arguments for allocating highest priorities to the preservation of old-growth forest stands rather than alternative investments (e.g. reafforestation for carbon sequestration)*

When a tree is logged most of it is left behind in the forest to rot or burn. Of the logs removed, some 40-60% may end up as offcuts or sawdust in the production of sawntimber, or the whole logs may be chipped, with only the sawntimber component being used for longer-term products which may store the carbon for a few years or decades. It is apparent that most of the accumulated carbon stored in any tree logged is quickly released, and the relatively small volumes stored in products and landfill do not offset the lost carbon (Wardell-Johnson *et. al.* 2011, Dean *et. al.* 2012, Keith *et. al.* 2014b, Keith *et. al.* 2015).

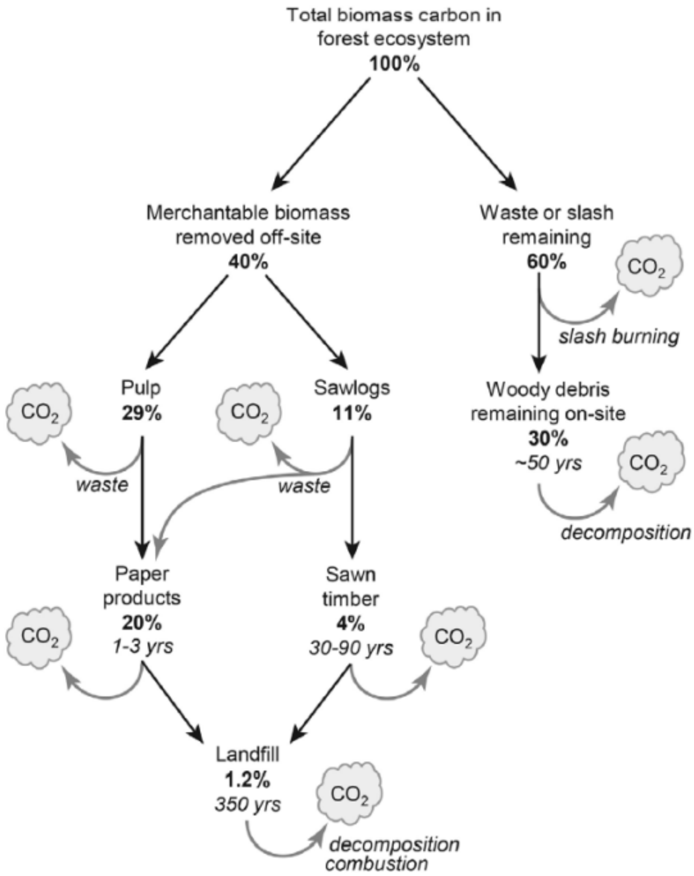


Fig. 8 from Keith *et. al.* (2014b). Transfer of biomass carbon during harvesting and processing of wood products. Numbers in bold represent the proportion of the total biomass carbon in the forest that remains in each component. Numbers in italics are the average lifetime of the carbon pool.

Logging has profound impacts on forest carbon storage by cutting and removing carbon stored in tree trunks, while converting carbon in leaves, branches, bark, tree bases and roots into detritus where it rots or burns. Young forests may be sources of CO_2, with forest's CO_2 sequestration increasing as they age. Logging has run down carbon stores by around 50% in affected forests and it can take over a century to regain the lost carbon. Protecting degraded forests allows them to become carbon sinks and recapture the lost carbon over time. This also had direct benefits for biodiversity.

1.2. Plantations do not Provide Immediate Carbon Benefits.

The establishment of plantations involves significant soil disturbance and consequently the loss of soil organic carbon. It can take one or more decades for soils to recover the lost carbon. This means that it can take 5-10 years before biomass in plantations result in a net increase in carbon storage, even when established on cleared land.

From their review of plantations in eastern Australia, Turner *et. al.* (2005) found that plantations may reduce soil carbon for the whole rotation (up to 30 years), with overall biomass growth often not off-setting establishment losses for 5-10 years

> *... after establishment, there are reduced inputs of carbon into the soil from prior vegetation or rapidly growing weeds, together with accelerated decomposition of soil organic matter as a result of disturbance, and this leads to a net loss of soil organic carbon. In some systems this loss of soil organic carbon is not balanced by carbon biomass sequestration until 5–10 years after establishment and on some sites, a reduction in soil organic carbon may remain until the end of the rotation. ... There was a general pattern of reduced carbon in surface soil immediately after plantation establishment and with time this extended deeper into the soil profile. The actual quantities varied greatly depending on the soil type. The decline was primarily a result of losses of labile carbon and was greater when the previous land use had essentially been native vegetation or highly improved pastures as opposed to regrowth woodland, or native pasture, or degraded land. In the absence of further disturbance, soil organic carbon can accumulate to pre-establishment levels but many short rotation plantations are terminated prior to this being attained.*

From their review of Australian studies Polgase *et. al.* (2000) found

> *For soil in the <10 cm or < 30 cm layers, there were significant effects of stand age on C change. Soil C generally decreased during the first 10 years (particularly the first five years) of afforestation followed by a slower rate of recovery and accumulation.*

For north-east NSW Polgase *et. al.* (2000) found

> There is a decline in C in the surface 10 or 50 cm for about 15 years after plantation establishment and then a general levelling out. The initial decline in soil C was 10%-12% yr_{-1} during the first two years after afforestation. Twenty-five years after afforestation, change in soil C was only –1.13 to –1.18 % yr^{-1}.

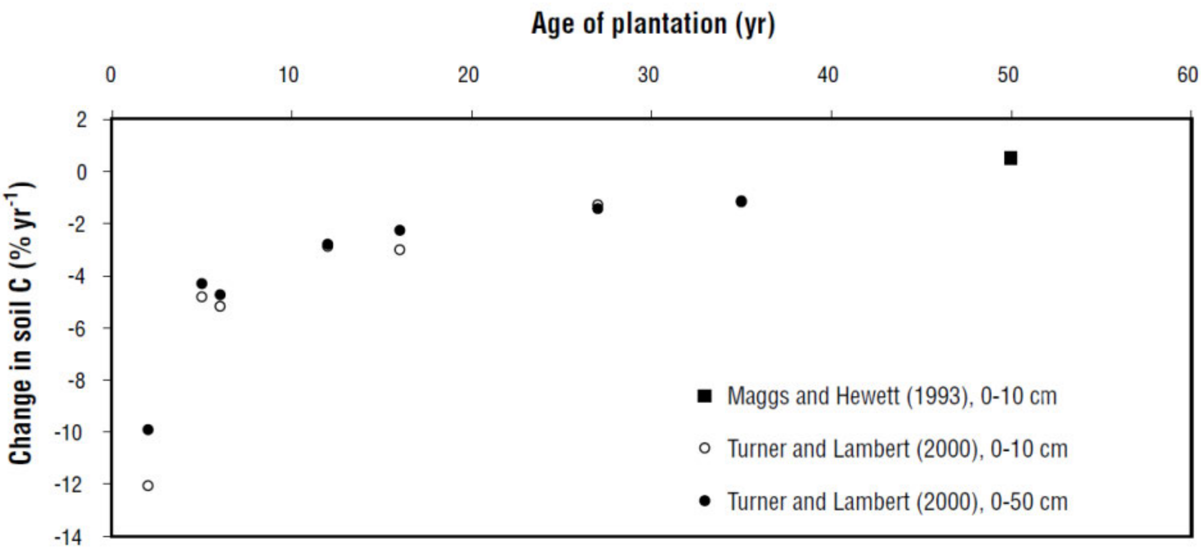


Figure 12.2. from Polgase *et. al.* (2000) Change in soil C in 0-10 cm or 0-50 cm layer under 2- to 50-year-old forest on ex-pasture land in the subtropical climatic regions of Queensland and the north coast of New South Wales.

Polgase *et. al.* (2000) consider that the "*losses in soil C*" by Turner and Lambert (2000) "*were by far the largest recorded in any of the studies reviewed*" and thus should be "*treated with caution*", summarising them as:

> *The paper by Turner and Lambert (2000) used a chronosequence approach to estimate change in soil C following afforestation. The calculated decrease (0-50 cm) during the first two years was about 3,900 g m^{-2} (1,900 g m^{-2} yr^{-1}) for P. radiata plantations and 8,400 g m^{-2} (4,200 g m^{-2} yr^{-1}) for the E. grandis chronosequence. Turner and Lambert (2000) further state that it may take 10-20 years before losses from soil C are offset by accumulation in biomass.*

From their comparison of 26 year old eucalypt reforestation with agricultural sites in Western Australia, Harper *et. al.* (2012) found that soil organic carbon up to 0.3 m depth ranged between 33 and 55 Mg ha^{-1}, "*with no statistically significant differences between tree species and adjacent farmland*".

1.2. The establishment of plantations involves significant soil disturbance and consequently the loss of soil organic carbon. It can take one or more decades for soils to recover the lost carbon. This means that it can take 5-10 years before biomass in plantations result in a net increase in carbon storage, even when established on cleared land.

1.3. The Struggling Forests

There is no time to waste in turning this around as forests are already succumbing to climate change and reducing their ability to take up the carbon we emit. The increasing frequency of wildfires is accelerating the degradation of forests, as evidenced by the burning of 35% of north-east NSW's rainforests in the 2019-20 fires. If forests are turned from carbon sinks into carbon sources we have no chance of averting the unfolding climate catastrophe. We must act now while forests still have the ability to assist the transition.

The consequences of increasing temperatures and more erratic rainfall due to climate change are more frequent droughts and extreme temperatures. Steffen et.al. (2015) identify that by 2070 Sydney's average number of hot days (>35°) will increase from 3.4 to somewhere between 4.5-12 days per annum. As identified by Fensham *et. al* (2009)

> *A doubling in the frequency of severe droughts has been predicted under future climate scenarios. The physiological effect of drought on trees may well be enhanced by rising temperatures, ... Enhanced drought conditions will intensify tree-death which is likely to be a symptom of global climate change.*

Allen *et. al.* (2008) note *"studies compiled here suggest that at least some of the world's forested ecosystems already may be responding to climate change and raise concern that forests may become increasingly vulnerable to higher background tree mortality rates and die-off in response to future warming and drought",*

Episodes of widespread tree mortality in response to drought and/or heat stress have been observed across the globe in the past few decades. As noted by Anderegg et. al. (2016):

> *... the principal cause of drought induced tree death has been found to be the failure of a plant's vascular water transport system through embolism caused by air bubbles during high xylem tensions caused by low soil moisture and/or high atmospheric evaporative demand during drought, though there are numerous other contributing influences*

Griscom *et. al.* (2017) warn "*Unchecked climate change could reverse terrestrial carbon sinks by midcentury and erode the long-term climate benefits of NCS. Thus, climate change puts terrestrial carbon stocks (2.3 exagrams) at risk*", noting:

> *Delaying implementation of the 20 natural pathways presented here would increase the costs to society for both mitigation and adaptation, while degrading the capacity of natural systems to mitigate climate change and provide other ecosystem services. Regreening the planet through conservation, restoration, and improved land management is a necessary step for our transition to a carbon neutral global economy and a stable climate.*

Bastin *et. al.* (2019)'s assessment is that forests are coming under increasing stress due to climate heating, with tropical forests most at risk of being lost by 2050:

> *our model highlights the high probability of consistent declines of tropical rainforests with high tree cover. Because the average tree cover in the expanding boreal region (30 to 40%) is lower than that in declining tropical regions (90 to 100%), our global evaluation suggests that the potential global canopy cover will decrease under future climate scenarios ... leads to a global loss of 223 Mha of potential canopy cover by 2050,*

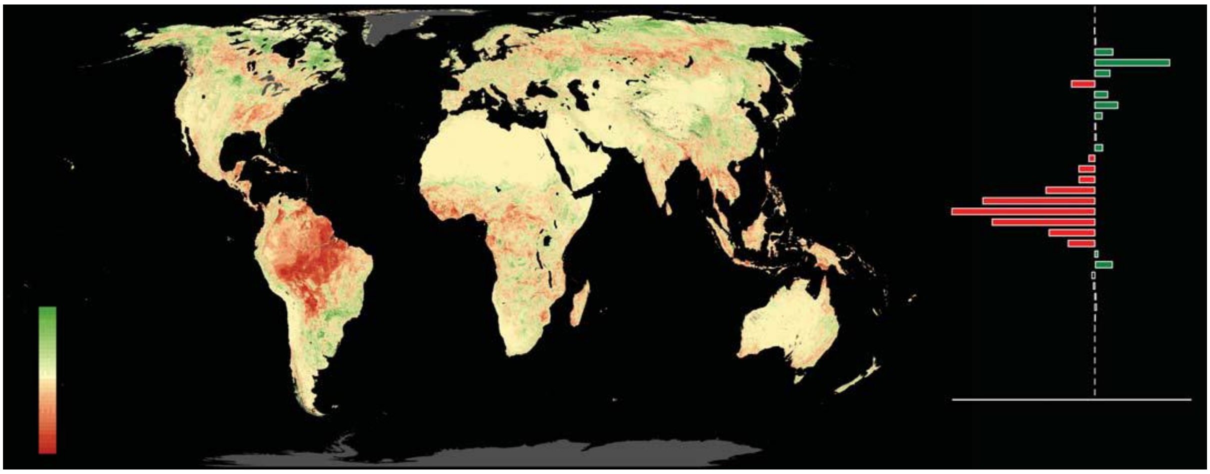


Fig. 3 from Bastin et. al. (2019): Risk assessment of future changes in potential tree cover. (A) Illustration of expected losses in potential tree cover by 2050, under the "business as usual" climate change scenario (RCP 8.5), ... (B) Quantitative numbers of potential gain and loss are illustrated by bins of 5° along a latitudinal gradient.

Tree dieback has been recognised in the New England area since the mid 1800's (Lynch *et. al.* 2018), though it achieved widespread notoriety during the 1970s and 1980s. This dieback has been attributed to a multitude of factors including clearing, fungi, grazing, native animals (e.g. koalas, possums, territorial birds), climatic changes, land degradation, parasitic plants, and repeated defoliation by insects.

Ross and Brack (2015) assessed 'Monaro dieback' as affecting 2,000 km^2, with almost all Ribbon Gum (*E. viminalis)* within that area either dead or severely affected. The problem dated back to 2005. Ribbon Gum is the dominant species in the region, and the only one badly affected, yet they considered that at the then rate "*it seems inevitable that E. viminalis will disappear entirely from the Monaro region*".

Lynch et. al. (2018) identify that in the ACT region there has been severe dieback of Blakely's Red gum (*Eucalyptus blakelyi*) dating back to 2004, with an additional 7 eucalypt species affected in recent years.

Australia's forests and woodlands are strongly influenced by large climatic variability and recurring droughts. Extreme droughts can cause widespread tree death in agricultural lands, woodlands and forests (Fensham and Fairfax 2007, Fensham *et. al* 2009, Mitchell *et.al.* 2014, Ross and Brack 2015). Mitchell *et.al.* (2014) identify that a wide range of studies have implicated temperature increases as amplifying moisture deficit, heat stress, and the impacts of biotic agents on tree species.

Within trees hydraulic failure (desiccation of water conducting tissues within the plant) and carbon starvation (depletion of available carbohydrates and failure to maintain defences against biotic agents) have been singled out as causes of tree death (Mitchell *et.al.* 2013, 2014). Mitchell *et.al.* (2014) found that periods of heat stress during droughts were likely to have been pivotal in initiating tree death. Species have been found to have differing susceptibilities (Calvert 2001, Fensham and Fairfax 2007, Mitchell *et.al.* 2013, Ross and Brack 2015, Lynch *et. al.* 2018). Fensham *et. al* (2009) also found trees at higher densities more vulnerable. In some cases, a drought event may simply be the coup-de-grace for a weakened stand of trees.

Mitchell *et.al.* (2014) consider their findings suggests that "*regardless of regional climatic differences, tree populations among many species in Australian ecosystems tolerate at least 98% of the climatic conditions they experience and become vulnerable to drought stress events beyond this common climatic threshold"*, noting "*the likelihood of drought events crossing these thresholds and inducing mortality will increase significantly under future climate scenarios for many forest and woodland ecosystems globally"*.

Interactions of drought effects with biotic agents and their feedbacks can also significantly change the demographic patterns of tree mortality (Anderegg et. al. 2016). Droughts can increase attacks by a variety of insects. Keith et. al. (2012) found the "*combined impact of drought stress and insect damage resulted in markedly reduced growth (45–80%) and higher mortality of trees (5–60%)*", concluding "*Drought conditions result in (1) weather conditions that break the synchronisation of insects with parasites and predators resulting in insect outbreaks, (2) moisture stress that predisposes trees to attack by insects, and (3) moisture stress that restricts leaf regeneration after damage*". Marsh and Adams (1995) found that chronic insect infestations and periodic insect outbreaks may be supported by high concentrations of nitrogenous solutes in sap and foliage, especially epicormic foliage, which in turn may be a response to drought.

Lambert (2015) observe:

> *Epicormic leaves of eucalypts following sessions of defoliation have been observed to contain high levels of nitrogen, particularly nitrogenous solutes such as proline, compared to mature leaves (Marsh and Adams 1995). Foliage nitrogen levels are also high during periods*

> *of drought when nitrogen soil availability increases. Xylem sap taken from dying trees contained a higher level of nitrogen than that taken from healthy trees (Marsh and Adams 1995). The increased uptake of nitrogen has been related to increases in herbivory, eventually leading to tree decline (Landsberg et al. 1990, Granger et al. 1994).*

Mitchell *et.al.* (2014) warn:

> *Changes in the frequency of extreme drought under the scenario presented here and elsewhere ... may also reduce vegetation resilience through time if a complete recovery of plant vasculature, carbohydrate status and defensive mechanisms is not realized in the intervening years between drought events. A small number of predicted droughts fell outside the margins of the observed record and are perhaps indicative of "mega-drought" conditions, characterized by higher intensities and longer durations than have ever been observed in the historic record ... If realized, these climate events may generate unprecedented, extensive die-off that could induce long-term shifts in vegetation structure and function.*

An American study found forests are shifting to communities that can cope with greater average water stress as well as more variability in water stress, primarily through the death of less hardy tree species (Trugman et. al. 2020)

1.3. Trees are increasing sickening and dying as the result of increasing droughts and heatwaves generated by global warming. This is not just a threat to forest ecosystems, it is also a threat to future timber supplies. This problem is aggravated by a variety of stressors on tree health, including logging, grazing and weed invasion. As evidenced by the increasing severity of droughts, heatwaves, and wildfires we are perilously close to a cascading series of feedbacks that cause the irreversible decline of forest ecosystems and the release of vast quantities of carbon stored in forest vegetation and soils into the atmosphere, making them into carbon sources rather than sinks. As shown by the 2019-20 fires we don't have any time to waste.

2. Sus Yields

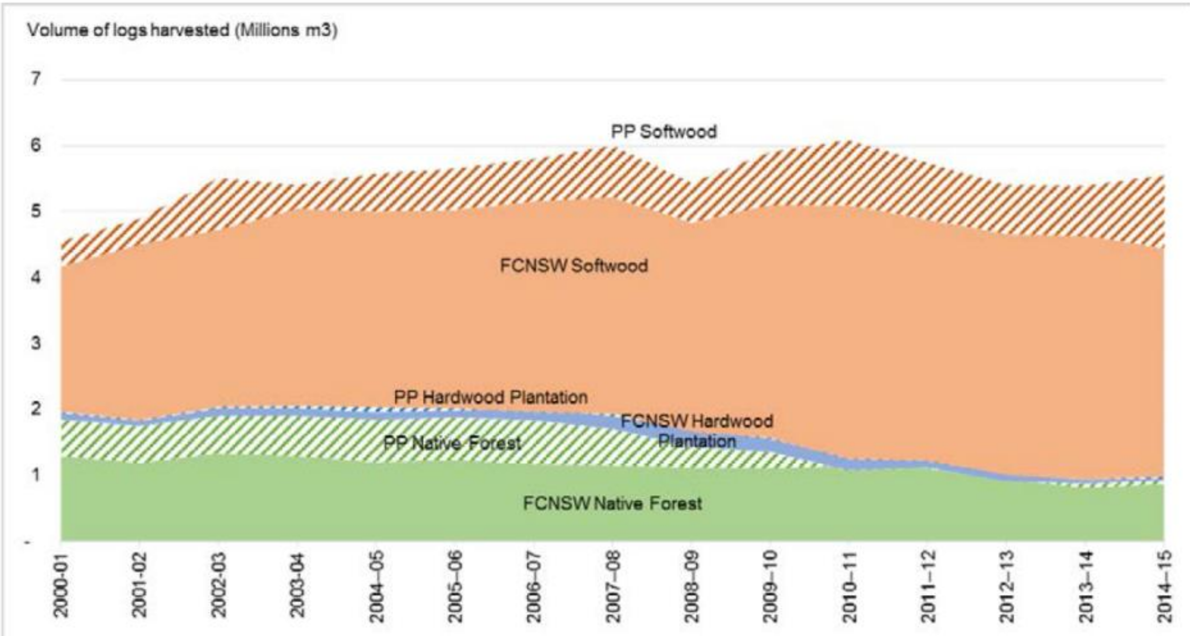
(c) projections for softwood and hardwood supply and demand over the next 30 years, & (d) transparency and data reporting of timber supply,

There is a common pattern to the privatisation of public resources which is evident with the over-allocation of water, fisheries and timber from public land. The resources are allocated to industry for free based on historical allocations at levels that are clearly unsustainable, requiring massive expenditure of public monies to buy back allocations for resources that never existed, while still allowing unsustainable exploitation. After years of payouts and poor implementation all these sectors are still in a mess.

While the Regional Forest Agreements of the late 1990s and early 2000s poured hundreds of millions of dollars into timber industry restructuring, plantation establishment and upgrading of private sawmills, the industry has continued to decline due to gross over-cutting of native forests and industry restructuring for efficiency.

The 2018 State of Forests report (ABARE 2018) identifies that in NSW *'average annual harvest for multiple-use public native forests*' dropped from 507,000 cubic metres per year over 2002-06, down to 387,000 cubic metres per year over 2012-16, a decline of 24%. For private forests, over the same period the decline was even greater, from 587,000 cubic metres down to 93,000 cubic metres, a decline of 84%. This gives an overall yield decline of 56% over a decade due to continued gross over-cutting.

Figure 2.1 Total logs harvested in NSW



From IPART (2017) PP refers to Private Forestry, it is noted ' The decline to almost no private property volume does not fully reflect the current situation, which may arise due to a lack of reporting through to ABARES.'

While resources from native forests have declined, yields from plantations have increased. Nationally 26.0 million cubic metres (86% of the total log harvest) was derived from commercial plantations in 2015–16:

- 9.8 million cubic metres of plantation hardwood logs (only 2% by volume was sawlogs and 98% by volume was pulplogs)
- 16.2 million cubic metres of plantation softwood logs (60% by volume sawlogs, and 39% by volume pulplogs).

Australia's current hardwood sawlog yields from native forests can be satisfied simply by increasing yields of sawlogs from hardwood plantations to 23%.

ABARE 2018 identify that in NSW, employment in the forestry sector (including the plantation sector) declined over the ten years 2006-16 from 23,792 to 16,396 (31%), primarily due to *'consolidation of processing into larger facilities with higher labour efficiencies, and restructuring of the sector'*. It is intriguing that the industry does not consider the loss of 7,396 jobs due to over-logging and restructure as a problem, though any losses due to conservation are portrayed as a disaster.

Allocations of timber from public native forests in Wood Supply Agreements in north east NSW has always been plagued by over estimation and allocation of resources. Resource shortfalls have been used as excuses to cut environmental constraints, while requiring payouts of over $13 million of public monies to buy back, or compensate for, commitments of phantom timber.

In the North East NSW Regional Forest Agreement regions, Wood Supply Agreements (WSAs) were issued (for free) in 1998 for 269,000 m^3/yr (cubic metres per annum) of Large High Quality (LHQ) Logs from north-east NSW public forests and hardwood plantations, to log at 124% of the then estimated sustainable yield for the next 20 years. At that time NEFA presented detailed evidence to the Government that resources had been over-estimated.

The 2000 North East Regional Forest Agreement with the Commonwealth Government entrenched this unsustainable logging, with grants for purchasing private land for logging, purchasing timber from private land and establishing plantations to make this more sustainable beyond 2020. It soon became apparent that the estimated resources weren't there as by 2002 it was evident that the actual yields were 87 per cent of that predicted, which was followed by a series yield revisions, compensatory payments for inability to supply commitments, substitutions of small sawlogs for large, WSA buybacks and progressive windbacks of environmental constraints.

In June 2001 State Forests of NSW forgave a $1 million debt of Ford Timbers in return for a WSA of 15,000 m^3/yr of Large HQLs. The Public Accounts Committee questioned the appropriateness of this given that Ford Timbers was never required to pay an up-front fee for the original allocation.

In September 2004 State Forests released their report “A Review of Wood Resources on the North Coast of New South Wales” which gave modelled yields of LHQ sawlogs over 20 years of 205,000 m^3/yr, with yields modelled to drop to around 64,000 m^3/yr after 2023. The caveat was “*the modelled outcome is generally 10-15% above the likely outcome”.*

New Wood Supply Agreements were issued in 2003 (for free), reputedly for 224,244 m^3/yr of LHQ sawlogs (though various figures are used) until 2023, then in 2005 the Forestry Corporation added the equivalent of some 32,000 m^3/yr of LHQ sawlogs in new WSA commitments for girders. veneer, piles and poles. Not unsurprisingly these new commitments were again found to be unattainable, with Boral taking Forests NSW to court for failure to honour WSAs for every year from 2004 until 2010, resulting in a Government payout to Boral of $550,000 for the first 3 years, and undisclosed amounts thereafter.

Since 2014 resource modelling has adopted radically different assumptions to increase the long term 20-100 year modelled yields of high quality logs from an average of 101,250 m^3/yr identified in 2010 up to 216,000 m^3/yr in 2014. This predates the Boral buyback and there is no explanation as to how this doubling of the volumes of High Quality Logs over 100 years was achieved. It appears to be partially attributed to the application in modelling of the unlawful intensive logging regime "regeneration Single Tree Selection", that the Government legitimised in the new logging rules, though this doesn't account for the magnitude of the increase.

GI(PA) requests years later in 2018 to obtain documents explaining the change in modelling parameters behind this dramatic change in modelled estimates were refused on the grounds of cabinet confidentiality. So there remains no public justification for how timber volumes were miraculously doubled.

This over-commitment was ultimately resolved by the Government paying Boral $8.55 million in 2014 to buy back some 50,000 m^3/yr of Boral's WSA for high quality sawlogs. As a result of the Boral buyback the Forestry Corporation reduced the 2014 Wood Supply Agreement commitments for LHQ sawlogs to 127,137 m^3/yr, with an additional 31,351 m^3/yr of LHQ sawlogs as girders. veneer, piles and poles.

The NRC (Todd Maher 12 Jun 2018) maintain that the modelled yield of High Quality Logs over a hundred year period is an average of 237,000 m^3/yr, with an average of 132,000 m^3/yr LHQ sawlogs and 105,000 m^3/yr small high quality (SHQ) sawlogs per annum. Over the next 20 years the mix was assessed as being an average 166,000 m^3/yr LHQ and 71,000 m^3/yr SHQ logs per annum.

The Forestry Corporation data provided under GIPA on yields and WSAs shows that from 2014/19 (the 5 years since the Boral buyback and reduction of WSA commitments) there has been a total overcut of 64,729m^3 of Large HQL, 31,524 m^3 of Small HQL, 8,298 m^3 of girders, 3,302 m^3 of piles and 917m^3 of poles, with an undercut of 11,571 m^3 of veneer. Conversion to Large HQL shows this represents an overcut of 67,591 m^3 of LHQ logs and 29,608 m^3 of SHQ logs.

The total over-cut of 97,119 m^3 high quality logs is timber that was bought back by the NSW Government from Boral, which at a cost of $19 m^3 has already cost taxpayers $1,847,000. Now it is being sold back to the sawmillers at the Forestry Corporation's profit, and significant environmental cost. This sacrificing of long-term sustainability for short-term profits is part of Forestry Corporation's need to return a profit.

The 2014 remodelled volumes have underpinned all subsequent yield assessments, the latest of which is the Forestry Corporation report '2019–20 Wildfires, NSW Coastal Hardwood Forests Sustainable Yield Review' , which undertakes a preliminary desktop review of the likely impacts of the Black Summer wildfires on timber resources.

The Forestry Corporation estimate is that there has been a significant loss of trees across at least a third of the north coast's State Forests (north from Gosford), with a loss of 10-50% of large sawlog sized trees over 30 cm diameter at breast height, and 50-100% of smaller trees.

Overall, across the north coast State Forests, the Forestry Corporation estimate there has been a loss of around 10% of sawlogs and 25% of smaller trees. North from Coffs Harbour these losses increase to 15% of sawlogs and 35% of smaller trees.

It is bewildering how the Forestry Corporation can conclude from this data that there will only be a 4% reduction in high quality sawlogs from the north coast over the next decade and only a 1% reduction over the next century. And it is shocking that it appears the NSW Government intends to rely upon this simplistic review, which builds on the unbelievable doubling of yield estimates in 2014, to sign new Wood Supply Agreements to replace the current 20 year agreements due to expire in 2023.

It beggars belief that the Forestry Corporation did not remeasure any of their 659 field plots within the heavily burnt forests to obtain real data on the fire impacts so that they can more accurately quantify impacts and future yields, and is instead basing their assessment of fire impacts on 424,200 ha of north coast forests on a sample of 0.85ha of Eden forests! Over a year after the fires, with foresters wandering around burnt forests all the time, it is simply untenable to claim they couldn't remeasure plots for safety reasons.

It is not apparent that the worsening impacts on tree growth and mortality from droughts and Bell Miner Associated Dieback have been taken into account in adjusting yield projections, including the previous decision to exclude 11,000 ha of BMAD affected forests from yield calculations. The spatial data available on drought and BMAD affected forests has not been removed from net area calculations.

As identified in section 4.3 of this submission:

> ***It is apparent that BMAD has reduced the volumes of timber available for logging from tens of thousands of hectares of public forests in north east NSW, and destroyed any prospect of such forests contributing to long-term timber volumes. It is also apparent that BMAD, and its impacts on forest productivity, are expanding. It is essential that this be accounted for in any future timber modelling before any further volumes are committed in Wood Supply Agreements.***

Around 77% of timber commitments in current NSW WSAs expire in 2023, with the balance expiring in 2028 (IPART 2017).

The last 2 times the NSW Government gave sawmill owners guarantees for specific timber volumes in 1998 and 2003 they were found to be gross over-estimates and it cost NSW taxpayers over $12 million to buy back non-existent timber we gave to sawmillers for free. Once again the NSW Government is poised to issue new Wood Supply Agreements based on what appear to be grossly inflated and unreliable resource assessments.

It is recommended that:

> **2a. The Forestry Corporation provide a detailed explanation of each of the changes that were made to parameters that allowed for the increase in the long term 20-100 year modelled yields of high quality logs from north east NSW from an average of 101,250 m^3/yr identified in 2010 up to 216,000 m^3/yr in 2014, with full justification as to why the changes were appropriate.**
>
> **2b. The Forestry Corporation be required to exclude all areas known to be significantly affected by drought or Bell Miner Associated Dieback from net area calculations, and project the likely changes in these forward for the next 100 years, in identifying current and future sustainable yields.**
>
> **2c. The Forestry Corporation be required, as a matter of urgency, to remeasure all their yield plots in fire affected forests to obtain a more reliable assessment of fire impacts on current and future yields.**
>
> **2d. That Forestry Corporation utilise force majeure clauses to immediately reduce timber commitments for the remaining term of existing Wood Supply Agreements in line with resource losses.**
>
> **2e. That no new Wood Supply Agreements be entered into, or extended, until after remeasuring of all fire affected yield plots is completed, the data analysed, and a report made public.**

2.1. The 2003/4 WSA Commitments

Forests NSW's (2005) ESFM Plan identifies that in 2003 a new 'Wood Supply Agreement Strategy' was adopted for 223,077 m^3/yr of Large HQL for 20 years until 2023, with 215,422 m^3/yr guaranteed and 7,655 m^3/yr subject to a variety of caveats. While annual volumes were decreased by 15%, the 5 year extension increased overall volumes of large high quality sawlogs committed by up to 17%. In addition the WSA Strategy included 88,859 m^3/yr of Small HQL for 20 years until 2023 with 57,759 m^3/yr guaranteed and 31,100 m^3/yr subject to a variety of caveats.

Forests NSW's (2005) ESFM Plan provides the details of Wood Supply Agreements for north east NSW.

Table 9. 2004 Wood Supply Agreement Strategy. From Forests NSW ESFM Plan (2005)

Product	WSA Volume	WSA Type
High-quality large Products	215,422	A
	7,655	B
High-quality small Products	57,759	A
	31,100	B
Low Quality Sawlogs	14,897	A&B
	190,000	C
Total Volume	516,833	

Forests NSW (2005) explain:

> The Type A agreements are for a fixed volume for a twenty-year period.
>
> *The Type B agreements provide 75% of the volume fixed for the first 10 years, with future volumes subject to resource assessment review in years 10 and 15 of the agreement. The remaining 25% is a share of production capped at 25% of the total agreement, also subject to review in years 10 and 15.*
>
> *The Type C agreements are based on a share of production and if there is insufficient production in any year, the available volume will be distributed equitably amongst customers as a share of the total production in that year. The figure under WSA for Type C is a target volume rather than a fixed commitment.*

The Government removed the need for a yield review in 2006 and the clause from the WSAs that allowed yields to be adjusted in line with revised resource assessments.

The Forests NSW (2005) ESFM Plan states:

> *The supply of HQL sawlogs will be the most difficult issue over the next twenty years ... FRAMES modelling shows that a large proportion of the HQL commitment over the next 20 years will be sourced from areas that are difficult and expensive to access.*

The claimed WSA 'Strategy' was uncreditable. it beggars belief that the intent was to issue WSAs for up to 223,077 m^3/yr of Large HQL for 20 years when the resource modelling had only identified had only identified an average of 205,000 m^3/yr as being available for the first 20 years, and this had been identified as likely to be over-estimated by 10-15%.

It is unclear how the WSA 'Strategy' was implemented, as subsequent documents put the WSA commitments as a lot less. The 2009 RFA review (NSW&CoA 2009) identifies the annual commitments for the financial years 2004-2007 as 209,500 m^3/yr for 'High-quality large sawlogs (incl. veneer and girders)' and 63,772 m^3/yr for high quality small sawlogs. These commitments are reflected by the Auditor General (2009) who also identifies an additional 28,850 m^3/yr of poles and piles, commenting "*Around a third of poles and piles supplied meet the specifications of a high quality large sawlog*".

	Large HQL m^3/yr	Small HQL m^3/yr
2003 Modelled Volume	205,000	71,000
2003 Modelled Volume minus 15%[1]	174,250	60,350
FC 2005 ESFM Plan WSAs	223,077	88,859
RFA Review (2009)	209,500	63,772
Auditor General (2009) WSA [2]	219,117	73,389

Comparison of 2003 yield assessment with various claims of WSA commitments.

1: Adjusted to account for the caveat that "*modelled outcome is generally 10-15% above the likely outcome".*

2: Adjusted to account for Auditor General's statement that around a third of poles and piles are high quality large sawlogs, and the Forestry Corporation's advice that a third of pole allocations should be deducted for comparison to FRAMES, with the remaining third assumed to be small HQL.

However the data are looked at it is apparent that the WSAs issued in 2003 and 2004 were for significantly higher volumes than were modelled to be available for the next 20 years. Given the major reductions that were expected to occur after 2023 it is extraordinary that such excessive commitments were made.

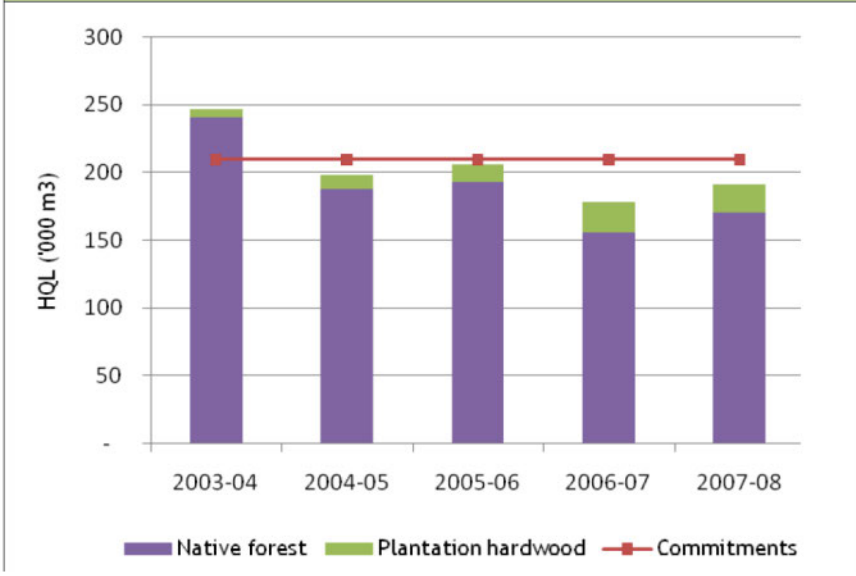
In order to boost resources in 2004 the Environment Protection Licence was amended to exclude most operations from its ambit, with the specific intent of opening up buffers on "unmapped" drainage lines for logging, contravening the principles of ESFM, but giving the Forestry Corporation access to significant additional resources.

It was clear that the new WSA were grossly unsustainable and it soon became apparent that Forests NSW could not honour the commitments. In 2006 Forests NSW had to pay Boral $550,000 in compensation for 34,000m^3 of high quality large sawlog they were unable to supply during 2004-2006. In 2010 Boral Timber commenced legal proceedings against Forests NSW for failure to supply commitments every year since 2006, though the outcome is confidential.

For large high quality sawlogs in 2006 Forests NSW purchased 2,000 m^3/yr of a WSA for $500,000. In 2007 Forests NSW purchased a WSA for 10,194 m^3/yr for $2,277,000.

Since the WSA's were originally issued in 1998 the then commitments for 269,000 m^3/yr of large high quality sawlogs, piles and veneer logs (Large HQL) per annum from north east NSW have almost halved down to 142,757 m^3/yr in 2018. Since the 2003/4 new WSA commitments of large HQL have been reduced from 209,500 m^3/yr of Large HQL by 32%.Though actual yields have been well below commitments in most years.

Exhibit 20: Harvesting results for North Coast large high quality logs



Auditor General (2009) found that the commitments for high quality large sawlogs were not being met.

For north-east NSW Appendix K of the RFA review (EPA 2017) states:

> *Figure 7 shows that the total HQL and HQS harvested in the North East RFA region was below the RFA commitment level each year of the 2004 to 2014 period.*
>
> *While the North East RFA provides for an annual harvest of 269,000 m3, the North East region WSA commits FCNSW to provide considerably lower volumes. This variance is due to improvements to FRAMES and sustainable yield calculations that were made after the North East RFA was signed.*

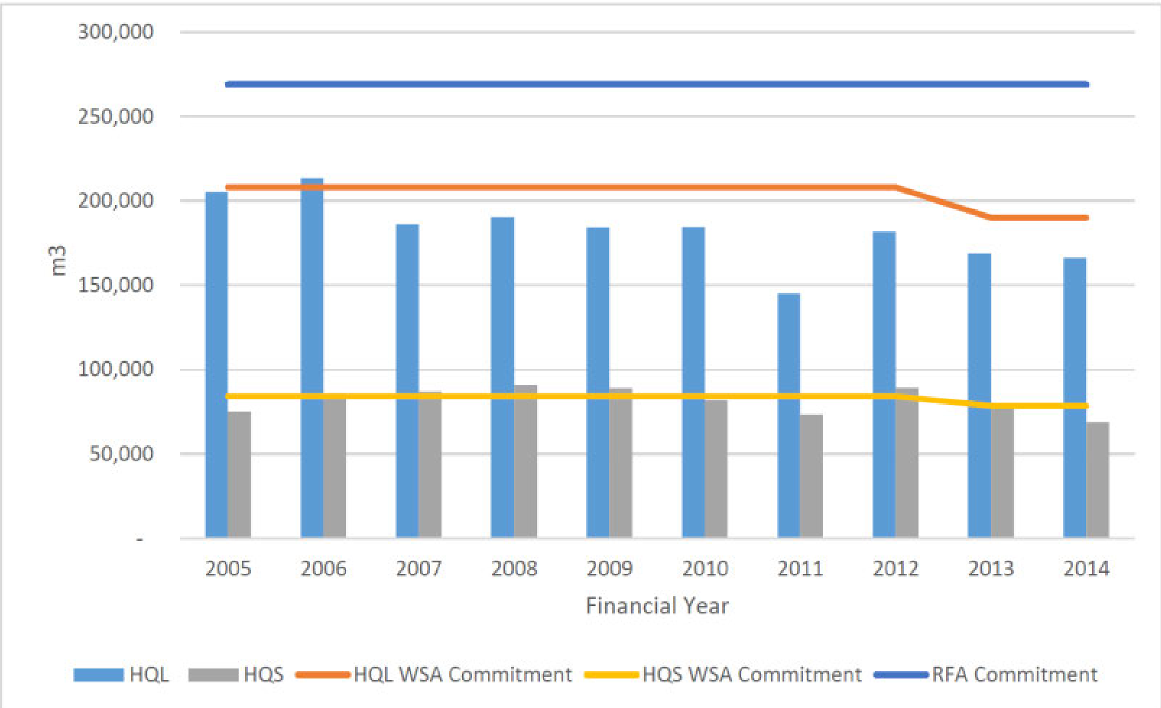


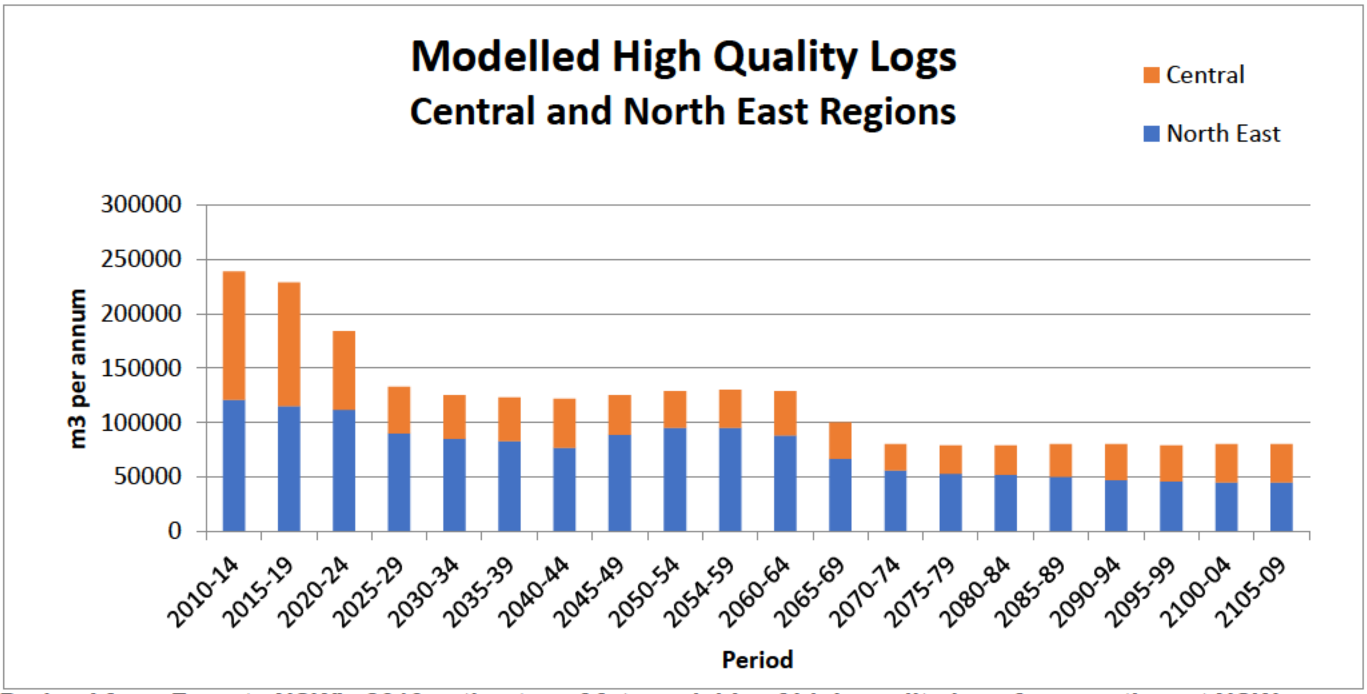
Figure 7 from EPA (2017): High quality large and high quality small timber production from North East RFA region combined from July 2004 to June 2014. Note that the RFA commitment was only for Large HQL, a discrepancy not mentioned by the EPA.

In 2009 the Auditor General concluded:

> *We also found that Forests NSW should have sufficient timber to meet its wood supply commitments which are fixed for periods up to 2023 using both native and plantation hardwood. ...*
>
> *...*
>
> *To meet wood supply commitments, the native forest managed by Forests NSW on the north coast is being cut faster than it is growing back. This is especially the case for the blackbutt species. This does not mean that the forest will not regrow but there will be a reduction in yield in the future.*

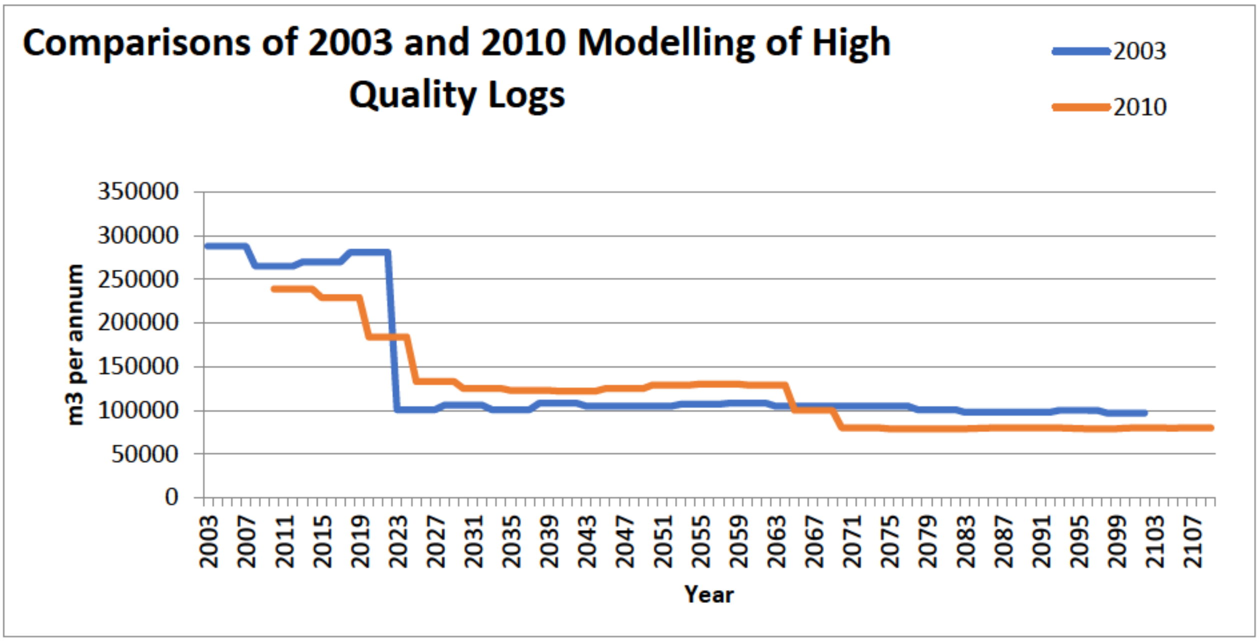
The Auditor General's (2009) 'Recommendation 4' required that Forests NSW publicly report the results of yield estimates for high quality sawlogs, high quality sawlogs, low quality logs and pulpwood for each region. In response to the Auditor General's request for updated yield assessment, Forests NSW (2010) 'Forests NSW Yield Estimates for Native Forest Regions' undertook revised modelling. This shows *"estimated annual yields by broad product category in cubic metres (m^3) over the next 100 years*". Unfortunately Forests NSW once again failed to provide any detail.

For this assessment the data for the "North East" and "Central" regions were combined to identify the 2010 estimated long-term yields of large and small high quality logs from north east NSW. This shows that yields of HQL would begin to drop after 2020 down to some 127,000 m^3/yr, before declining further after 2064 down to around 80,000 m^3/yr. This long-term trend of declining yields was consistent with all yield projections up to that time. These show the significance of the yield decline expected to occur in the near future at that time.



Derived from Forests NSW's 2010 estimates of future yields of high quality logs from north east NSW.

This assessment is consistent with the 2003 modelling, taking into account the over-logging that had since occurred.



Comparison between FRAMES yield models for HQL from 2003 and 2010. Note: The 2003 modelling has the caveat "*the modelled outcome is generally 10-15% above the likely outcome due to factors that cannot be incorporated for practical reasons or cannot be adequately represented mathematically*" (Section 3) - these figures have not been adjusted to account for this.

The modelling shows a dismal future for hardwood supply from north east NSW, which was always an intended outcome of the intentional overcutting for 20 years. Despite the buybacks and yield reductions, and intentional over-cutting, by 2012 sawmillers were openly expressing concerns about future timber yields, proposing that national parks needed to be opened up for logging to meet expected shortfalls after the expiry date of the WSAs in 2023, or sooner.

In his evidence to inquiry into the management of public land in New South Wales Grafton sawmiller, Bruno Notaras, (2012) complained:

> *I have stopped investing because we are not sure whether we are going to have wood. All indications are that by 2019 it will be pretty tough. I am not sure whether forestry can estimate really how much is out there, because what I have seen is that where we used to work in a 28-year rotation, we are now going back into the same areas in six to 10 years and it is surprising the amount of wood that you are getting out of those areas.*

The General Purpose Standing Committee No. 5 (2013) inquiry into the management of public land in New South Wales reported:

> ***6.46*** *Serious concerns over the sustainability of current logging practices have been raised by inquiry participants from the timber industry with particular concerns over future resources. Greensill Bros Pty Ltd expressed that the view that 'under the current regulations restricting access, the small area of forests is being overcut'. Newells Creek Sawmilling Company similarly said that 'we are overcutting the bush because we are limited to a small area for sustainable forestry while vast areas have been locked up for timber production and placed under the management of National Parks'. Mr Notaras highlighted the long term implications for the industry, contending that 'they will not have high quality large logs in the future'.*
>
> ***13.44*** *On the North Coast, wood supply agreements that were originally signed in 1998 were reviewed in 2003 following further reservation of native hardwood forests. Mr Douglas Head described the situation on the North Coast as being unsustainable post 2023, when the current agreements are due to expire. He commented that 'At the moment, we are in an*

> *unsustainable pattern … in the longer term' and contended that 'we will not be able to do in 2024 what we are doing now, and nor should we'.*

Rather than regulating their use of available sawlogs on a sustainable basis the industry wanted to be given more land to log. In 2012 the Chair of the General Purpose Standing Committee No. 5 asked the Executive Director of the NSW Forest Products Association, how much area of land *"would need to be returned and made available for harvesting in order to meet the contractual obligations and the forecast timber delivery in those RFAs?"*, to which Mr. Ainley (2012) responded "*At a guess, I would suggest that we would need a little more than one million hectares to be returned. However, it depends on which hectares, where they are and how the regulations may affect them*".

The Forestry Corporation (Annual Report 2014-15) also acknowledges it *"… may have onerous contracts in relation to wood supply agreements for native forest timber",* for which the present value of the contract is negative.

Even after the Boral buyback these same concerns of overcutting and the unreliability of the Forestry Corporation's over-estimations persist today as shown by the NSW Department of Primary Industries (2017) Primary Processors Survey Report (see Section 5.1). There is further to go, the GHD (2017) NSW Department of Primary Industries report recommending *"that a buyback in the order of 15,000 m^3 is targeted".*

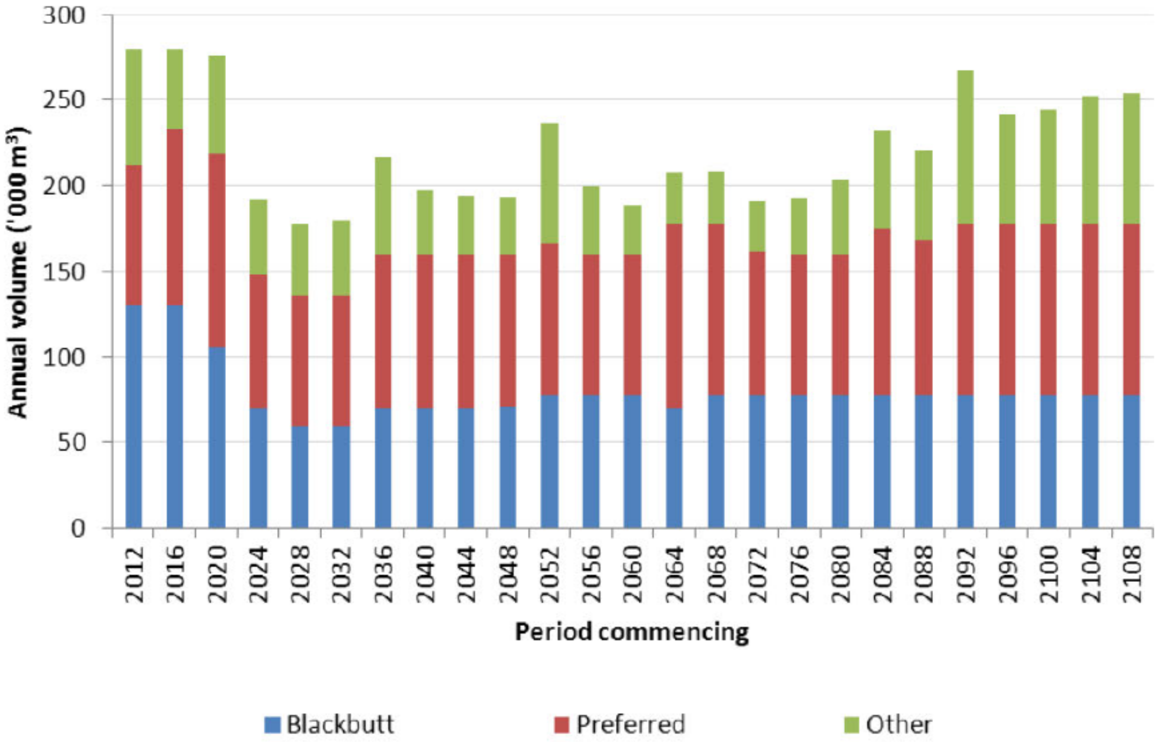
2.2. The 2012/14 Yield Review

In May 2012 the NSW Government established a Project 2023 Steering Committee to investigate the issues associated with timber supply on the north coast including sustainability of supply to the end of the term of current wood supply agreements in 2023 and over the long term. This identified major resource shortfalls at the end of the current WSA.

The Steering Committee engaged URS Australia Pty Ltd to conduct a review of timber resources on the north coast though refused to release the URS reports. Instead the NSW Government (2014) would only report on what the Government concluded. The NSW Government (2014) Project 2023 - North Coast Resources Review states:

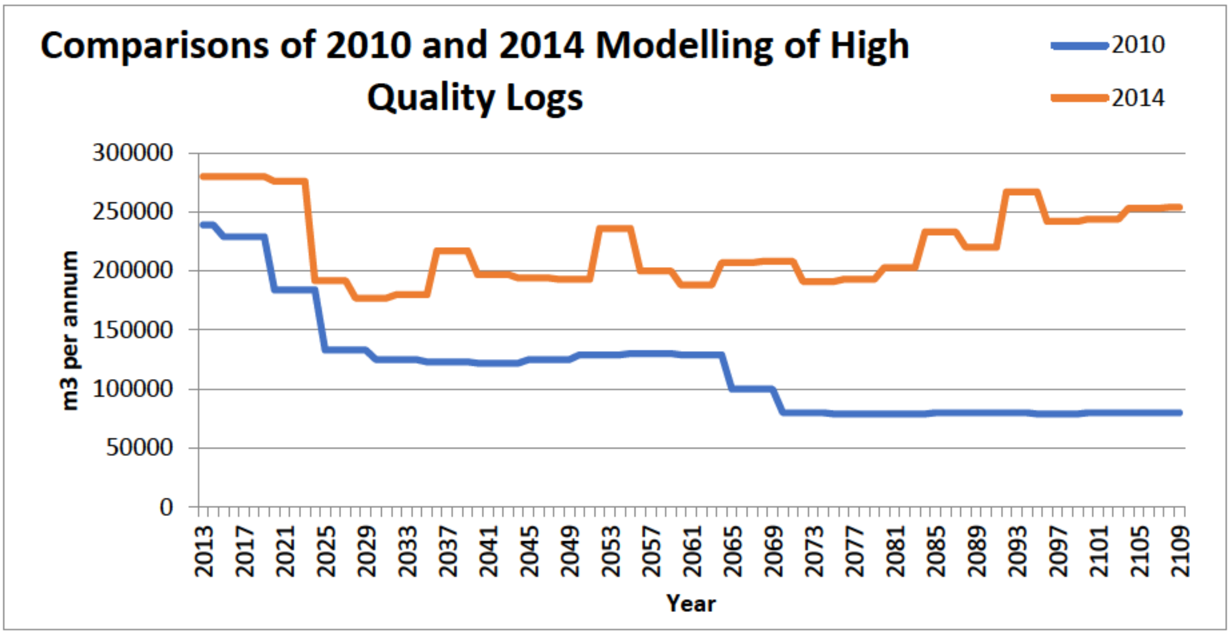
> *The key conclusion was that under the current scenario high quality (HQ) sawlog volumes can be maintained in the short term but not into the medium term ...*
>
> *Updated modelling of the status quo indicates the volume of total HQ logs could be maintained at the level of existing Wood Supply Agreement (WSA) supply commitments, of around 275,000 m3 per year until 2023. Beyond 2023, HQ sawlog volumes are predicted to decline markedly.*
>
> *...The reduction in supply from native forests occurs primarily in the Blackbutt forest types. ... the current harvest levels for HQ Blackbutt cannot be maintained at a stable yield and ... this is forecast to result in a significant decline in the availability beyond 2023.*

Figure 1. HQ log supply by species



Modelling of high quality logs undertaken as part of Project 2023 - North Coast Resources Review.

While the assumptions used to underpin the new modelling are not revealed, the outcomes reveal a major change from previous yield modelling which all display far more significant drops in supply after the end of the current WSAs and declining yields thereafter. This is demonstrated by a comparison between the 2010 modelling and the 2014 remodelling.



Note the very dramatic increases in volumes expected by the 2014 modelling compared to Forests NSW's 2010 modelling. The differences are so large compared to all Forestry Corporation's previous modelling that it is hard to give the 2014 claims any credibility.

The review of modelled yields in 2010 showed that yields of HQL would begin to drop after 2020 down to some 127,000 m^3/yr, before declining further after 2064 down to around 80,000 m^3/yr. In comparison the 2014 review identifies that yields are not predicted to drop until after 2023 to around 198,400 m^3/yr of HQL, before again increasing after 2083 to around 252,000 m^3/yr.

The revised modelling increases the long term 20-100 year modelled yields of HQL from an average of 101,250 m^3/yr identified in 2010 up to 216,000 m^3/yr. Over the overlapping 97 year period of 2013 to 2109 the 2010 modelling generates a total volume of 11.3 million m^3 of HQL compared to the 2014 modelling generating a volume of 21.3 million m^3 of HQL, almost double the 2010 total volumes. The differences are astoundingly large, with volumes significantly increased in the short and medium term, and yields more than tripled in the last 20 years. The differences are so large compared to all Forestry Corporation's previous modelling that it is hard to give them any credibility.

Based on their highly questionable modelling the Steering Committee determined:

> *... that the option of buyback of 50,000 m3 per year of HQ logs including 40,000 m3 per year of Blackbutt is the most effective way of bringing harvest levels to an even flow, sustainable yield. ... The Government accepted this recommendation of the Steering Committee.*

On 10 December 2018 NEFA submitted a GI(PA) request for, in part:

1) *In relation to Project 2023 - North Coast Resources Review:*
    i) *Copies of the Stage 1 October 2012 and Stage 2 February 2013. URS Australia Pty Ltd reviews of timber resources in north-east NSW.*
    ii) *All correspondence (excluding drafts not sent), records of meetings or file note records of phone calls between the Forestry Corporation and URS Australia Pty Ltd relating to the reviews*
    iii) *Records of meetings, correspondence and recommendations of the Project 2023 Steering Committee*

There were 13 documents identified as relevant to this request, but access to all of them was refused by the Forestry Corporation on the 21 February 2019 on the basis of cabinet confidentiality:

Doc No.	Description of record	Format of Record Provided	Public interest(s) against disclosure	Document Released Yes / No / Partial
1	North Coast Resources Review - Stage 1 - Draft report_1 Oct 12	Digital	Schedule 1, Clause 2	No
2	North Coast Resources Review - Stage 2 Final Report	Digital	Schedule 1, Clause 2	No
3	Draft minutes 15 June 2012	Digital	Schedule 1, Clause 2	No
4	Letter to Premier 2 July 2012	Digital	Schedule 1, Clause 2	No
5	Final draft minutes 3 Sept 12	Digital	Schedule 1, Clause 2	No
6	Draft 2023 minutes 9 October all comments (2Nov12)	Digital	Schedule 1, Clause 2	No
7	Forests NSW – 2023 Steering Committee Workshop FINAL – part of 9 October meeting minutes	Digital	Schedule 1, Clause 2	No
8	Draft minutes previous meeting 6 December	Digital	Schedule 1, Clause 2	No
9	IFOA Review Report 13 December 2012	Digital	Schedule 1, Clause 2	No
10	Draft Minutes meeting 23 Jan 13 revised April	Digital	Schedule 1, Clause 2	No
11	Draft Minutes meeting 21 March 13 sent May13	Digital	Schedule 1, Clause 2	No
12	Signed letter to Minister Parker, Hodgkinson and Premier – Project 2023	Digital	Schedule 1, Clause 2	No
13	SC2023 Report Final – attached to letters to Ministers	Digital	Schedule 1, Clause 2	No

Public Interest against Disclosure

Forestry Corporation has received objections in relation to the release of documents 1-13 on the basis that they are cabinet information. Pursuant to Schedule 1, clause 2 of the GIPA Act, it is to be conclusively presumed that there is an overriding public interest against disclosure of cabinet information.

Balancing competing submissions about public interest

Section 13 of the GIPA Act requires me to balance competing submissions about public interest, unless there is an overriding public interest against disclosure. Determining whether there is an overriding public interest against disclosure requires the correct categorisation of the various documents in the attached schedule.

The documents listed were prepared for the 2023 Steering Committee. The documents were created by a Steering Committee established to inform Cabinet decision making and reference Cabinet decisions within them.

I consider that document 1-13 in the attached schedule are therefore properly classified as cabinet information as defined in clause 2(1) of the GIPA Act on the basis that they include:

- documents prepared for the dominant purpose of being submitted to Cabinet for Cabinet's consideration (2)(1)(b)
- documents prepared for the purpose of being submitted to Cabinet for Cabinet's approval for the document to be used for the dominant purpose for which it was prepared (2)(1)(c)
- documents that reveal or tend to reveal Cabinet's deliberations or decisions (2)(1)(d)
- documents that would reveal or tend to reveal the position that a particular Minister has taken, is taking, or has been recommended to take, on the matter in Cabinet.

I am therefore not required to apply the public interest test to document 1-13 as there is a conclusive presumption against release.

2.3. Boral's Deal

In 2003 Boral's new WSA was for 165,000 m^3/yr of Large HQL (up to 24,350 m^3/yr of which may be substituted with small sawlogs at a ratio of 1 to 1.25), of which at least 60% must be Blackbutt and 25% over 50cm centre diameter. No other sawmillers obtained such specific and preferential commitments to species volumes and log quality.

In 2005 Boral bought out Fennings Timbers who operated a flooring plant at Gloucester and a sawmill in Walcha. The Walcha mill had older equipment and technology and was identified as requiring some capital expenditure to upgrade operations to Boral standards. The Walcha WSA gave them an additional 18,000 m^3/yr of Large HQL, raising their stake to 87% of large sawlog allocations, and 5,723 m^3/yr of Small HQL.

As a result of legal action in 2006 Forests NSW had to pay Boral $550,000 in compensation for 34,000m^3 of Large HQLs they were unable to supply during 2004-2006. In 2010 Boral Timber commenced legal proceedings against Forests NSW for failure to supply commitments every year since 2006, though the outcome is confidential.

In July 2008 Boral announced it would shutdown the Walcha site with 20 job losses, blaming a weak housing market and increasing costs. In August there was a community demonstration outside the mill with the ABC (14/08/2008) reporting "*A spokesman for the CFMEU at the site, Bluey Menon says the Government must revoke its log supply agreement with the company and not allow Boral to transfer local logs to other mills*". NEFA could not understand why the CFMEU were so intent of giving tradeable WSAs to private sawmill owners during the RFA negotiations without any requirements for either local or value-adding processing.

In 2012 the Forestry Corporation obtained Fenning's WSA from Boral for 23,723 m^3/yr. Boral apparently wanted to dispose of it because of the poor quality of Tableland eucalypts, and presumably the industry downturn at the time. In keeping with the misinformation surrounding these WSA it is hard to fathom exactly what occurred. The Forestry Corporation (Rahmat Khaiami, 18 March 2015) claim that "*Boral paid compensation to terminate the Walcha WSA*" while the EPA (2017) RFA Review claims that "*a customer sold its Walcha–Styx River allocation in the LNE sub-region to the State of NSW, thereby reducing the WSA volume by 23,723 m^3*". So who paid whom is open to question, and the amount paid is unknown. Allocations of HQL were appropriately reduced.

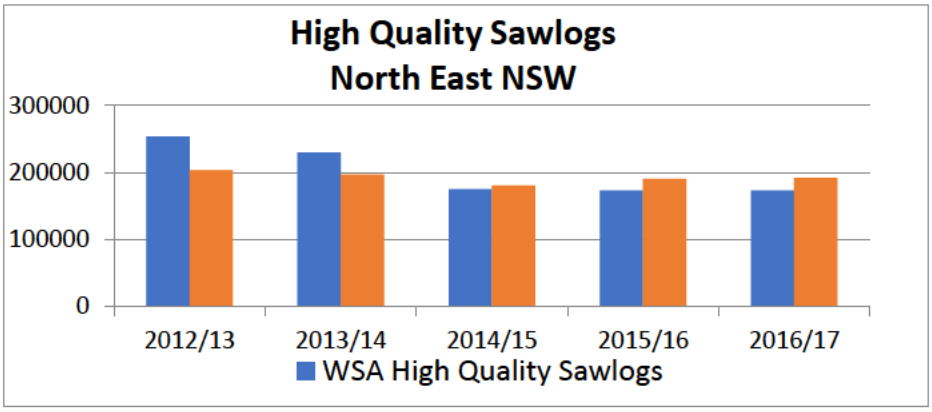
Boral's 2012 Annual Report identifies that their hardwood division was not performing very well at the time: "*Hardwood and Softwood volumes declined 14-15% and Woodchip volumes were 26% lower due to weaker exports*". Boral's 2013 Annual Report similarly identifies a significant downturn in their timber market, though makes no mention of their retiring the Walcha WSA:

> *"The Timber business reported a 19% revenue decline and an $11 m reduction in earnings on the prior year, as a result of a number of factors, including:*
>
> - *significantly lower demand for decorative hardwood products at the premium end of the new housing and alterations and additions markets;*
> - *increased import and domestic competition in softwood and hardwood; and*
> - *a substantial decline in revenue from the woodchip export business as the high Australian dollar reduced price competitiveness*

Boral's 2013 Annual Report notes "*In Timber, Boral has been working cooperatively with the Forestry Corporation of NSW to better align short-term log supply with lower demand. Negotiations are continuing to find a sustainable solution that better aligns cyclical demand with available log supply through the term of Boral's Wood Supply Agreements*".

In 2014 the NSW Minister for Primary Industries, Katrina Hodgkinson, announced the decision to pay Boral $8.55 million to buy back 50,000 m^3/yr of HQL allocations for the next nine years, reducing their WSA for Large HQL down to some 125,000 m^3/yr. Some 40,000 is to be blackbutt, leaving Boral with a minimum of 58,000 m^3/yr of blackbutt sawlogs. The Minister for Primary Industries, Katrina Hodgkinson (24 June 2014),claimed:

> *"This buyback will allow the continued maturing of North Coast forests and has been agreed in negotiations between the Forestry Corporation of NSW and its largest hardwood customer on the North Coast, Boral," Ms Hodgkinson said.*
>
> *"Our North Coast forests are certified sustainable, but projections show that without this buyback we would have needed to dramatically reduce the volume of timber supplied to industry after 2023 to ensure the forests continue to be healthy and productive."*
>
> *...*
>
> *"This buyback from the biggest player in our native forest timber industry, Boral, secures the long-term viability of the industry as a whole by bringing the supply of timber from the region's forests back to a sustainable level.*



The Boral buyback had limited affect on the actual cut of large and small high quality sawlogs, as logging transitioned from a significant under-cut to a significant over cut. If the actual commitments are 12,194 m^3 per annum less because of the 2006-7 buybacks the undercut is reduced, though the overcut is significantly increased.

Boral's WSA was extended from December 2023 to December 2028, giving them an additional 5 years allocation. This means that the Government paid $8.55 million to buy back a total of 450,000 m^3 of sawlogs (9 years), while giving the company an additional 580,000 m^3 of sawlogs for free. Boral also had their preferential allocation of Blackbutt and log qualities extended for a further 5 years.

According to Forestry Corporation data after 2013/14 allocations of large high quality sawlogs were reduced by 43,693 m^3/yr and of small high quality sawlogs by 11,395 m^3/yr. This gives a total reduction of 55,088 m^3/yr. This discrepancy is yet to be resolved.

Boral's 2014 Annual Report identifies "*Reduced demand in Timber (Hardwood) due to imports, and low levels of alterations and additions, and highend detached housing activity*", "*Underlying Hardwood volumes remained flat year-on-year, with only structural products achieving a price rise. The hardwood market remains challenging due to increased imports, domestic competitive pressures and subdued demand in the high-end alterations segment.*", and "*Renegotiated hardwood timber supply from Forestry Corporation of NSW to better align with demand*".

There has been significant concern within the industry regarding the favourable conditions of Boral's WSA.

The ABC (1 June 2017) reported that "*A mediator has been appointed to avoid a bitter legal dispute over alleged unfair contracts in the regional timber industry*", reporting Andrew Hurford as saying "*contracts between its competitor, Boral, and the NSW Government-owned Forestry Corporation gave Boral an unfair advantage over other timber processors*". The intent appears to have been to obtain generous conditions and 5 year extensions in other WSAs.

The NSW Department of Primary Industries (2017) 'Review of Coastal Hardwood Wood Supply Agreements, Final Report' identifies that there was widespread concern within the timber industry over the preferential treatment of Boral and the secretive nature of the favourable deals done with Boral, for example:

> *Major issues were raised from stakeholders in relation to the transparency, equity, fairness and efficiency of the allocation of hardwood timber resources on the North Coast. These concerns related predominantly to the differences between the Boral contract and other WSA holders for High Quality sawlog allocations and the impact this is having on supply areas and species mix.*

> *Prior to the release of the details of the 2003 Boral contract through State freedom of information processes in 2012, stakeholders claimed to be unaware of the difference in species provisions between the Boral contract and other High Quality sawlog customers ...*
>
> *A number of customers provided evidence of the subsequent and necessary changes to their indicative species mix, which is having resultant impacts on their business viability. These impacts typically included:*
>
> - *A decrease in supply of the preferred species, including Blackbutt and Spotted Gum, required to meet contractual obligations to Boral*
> - *An increase in the less desirable species, particular the New England tableland species following the closure of the Walcha sawmill*
> - *Increasing delivery charges as supply is required to be met from harvesting of forests further away from their respective businesses, and*
> - *Lumpy monthly deliveries in terms of both total volume and species mix.*
>
> *... It is noted that there were customers on the North Coast who indicated that they may not remain viable for the remaining term of their agreements under current supply arrangements.*
>
> *... Further, many questioned the appropriateness of Boral's contract management role for the new haulage consortium suggesting that it gives them a potential supply advantage over other customers. It was highlighted that this perception was causing further angst and mistrust amongst the industry when considered in the context of the already differing WSA provisions between Boral and other North Coast High Quality sawlog customers.*
>
> *... There is a strong feeling of inequity amongst the industry in relation to Boral's species specific provisions and that the original granting of these provisions lacked both accountability and transparency.*

The NSW Department of Primary Industries (2017) concluded:

> *We found that there are particular issues around equity and efficiency of allocation of high quality sawlogs on the North Coast ...*
>
> *It is generally accepted commercial practice that businesses may enter into different supply and sales arrangements with different customers, however, this is generally the case when it can be determined that there is a commercial advantage from doing so. During the course of this review, GHD has not been advised of a clearly documented rationale for the allocation of species specific conditions to any one customer in 2003, nor did the original allocation of Type A WSAs rely on a market-based approach to determine best value options against a predetermined set of criteria.*

It is obvious that the resource allocations in the current WSAs were not made in an open, transparent, equitable or fair process. No one can understand why Boral was given such a favourable deal in 2003, and NEFA can't understand why increased resources were given away to sawmillers for free at clearly unobtainable and unsustainable volumes, with these extended for 3 years past the expiry of the RFA. There are many things that appear improper about the allocation of public resources to private sawmillers in 2003/4 that should be investigated. The 2014 buyback from Boral prolonged the existing issues of favourable treatment.

2.4. 2021 Yield Review

The Forestry Corporation report '2019–20 Wildfires, NSW Coastal Hardwood Forests Sustainable Yield Review' undertakes a preliminary desktop review of the likely impacts of the Black Summer wildfires on timber resources. They identify that within the North Coast RFA region, 49 per cent of the native forest area available for harvesting (referred to as net harvestable area or NHA) was impacted by fire.

The Forestry Corporation created their own map of fire severity across all the native State forests in the coastal regions of NSW, called RAFIT. They claim:

> *Forestry Corporation staff carried out months of field assessments and inspections of fire grounds in order to begin planning processes for timber supply, restore safe forest access and carry out general land management and planning activities. This involved taking georeferenced photos and unmanned aerial vehicle (UAV) imagery in the various RAFIT severity classes as mapped (Figure 5 and Figure 6). These images were compiled in a database and used to validate the mapping product. A series of workshops was held to elicit the base rule set for each region based on the cumulative understanding of Forestry Corporation staff to calibrate observations of damage levels in the different severity classes of RAFIT.*

This sounds like an extremely ad-hoc and subjective process with high potential error. What is most perplexing is that the Forestry Corporation did not remeasure any of their 659 field plots within the heavily burnt forests to obtain real data on impacts so that they can more accurately quantify impacts and future yields, stating:

> *inventory plots have not been re-measured in forests impacted by fire due to the significant safety risks during the period since the fires. As a result, new inventory data from fire-damaged stands is not available.*

The Forestry Corporation report on the locations of the inventory plots they rely upon for their yield assessments on the north coast, identifying that 89% of them fall within the 49% of burnt forests, with 36% within hotter fires. This has greatly compromised their yield projections, which makes it even stranger that they didn't remeasure them:

> *There are 1821 active plots used for native forest modelling on the North Coast. Table 17 summarises the count of plots by locality and burn class. Overall, 19 per cent of the active plots in the region were impacted by a hot fire (RAFIT Class 4), and 17 per cent by crown fire (RAFIT Class 5).*

The presentation of these plots, and those in other regions, provides a misleading impression that they were actually considered. It is extraordinary that they did not attempt to remeasure any of the plots during their "*months of field assessments and inspections of fire grounds".* Why not? This would have given them objective data and enabled a more accurate assessment rather than "*broad assessments of tree damage and mortality in different size classes*".

The only plots they appear to rely on are a token 17x0.05-hectare plots from a 2016 Class 5 fire in the Eden Region. A 0.85ha a sample of one burn class in the southern forests cannot be considered to have any credibility for the Eden region, let alone the whole of NSW. The pretence that a miniscule sample of south coast forests can be considered representative of the 424,200 ha of the very different north coast forests assessed is a pathetic joke. This doesn't have a shred of scientific credibility, they should be ashamed of themselves.

By way of comparison, for NEFA's proposed 7,000 ha Sandy Creek Koala Park myself and one or two volunteers measured all trees >10cm diameter on 87x0.05 ha plots to assess current carbon stocks (doing 12-14 plots a day) – and we were concerned that we did not have enough replicates to assess the full range of forest classes. We did this after the fires, and there were no safety issues. Unfortunately it was too soon after the fires to assess recovery, as this was only just occurring towards the end of our sampling. So how can a professional organisation only assess a fifth of what we did (likely devoting less that 2x2 person days to sampling), and then claim their 0.85ha sample as adequate to extrapolate across 2 million hectares of State Forest?

The Forestry Corporation estimate is that there has been a significant loss of trees across at least a third of the north coast's State Forests (north from Gosford), with an overall loss of 10-50% of large sawlog sized trees over 30 cm diameter at breast height, and 50-100% of smaller trees.

North Coast native forest base net area by RAFIT class (hectares)

Supply zone	1&2: No fire or cool burn	3: Moderate burn	4: Hot burn	5: Crown fire	Total	RAFIT 4 Percentage	RAFIT 5 Percentage
SZ 1: Far North Coast	25,700	15,200	24,200	14,800	79,900	30%	19%
SZ 2: Coffs-Grafton	33,200	25,200	25,000	28,100	111,500	22%	25%
SZ 3: Mid North Coast	45,800	19,300	10,100	9,100	84,300	12%	11%
SZ 4: Taree	41,500	13,900	7,300	5,200	67,900	11%	8%
SZ 5: Hunter	26,700	7,700	3,100	400	37,900	8%	1%
SZ 6: Walcha-Styx	14,600	10,900	12,700	4,500	42,700	30%	11%
Total North Coast	187,500	92,200	82,400	62,100	424,200	19%	15%
Percentage of area	44%	22%	19%	15%	100%		

For north-east NSW the Forestry Corporation identified 22% of the net harvest area being affected by a RAFIT Class 3 "moderate burn", which indicates some canopy loss and likely some tree loss, yet make no attempt to account for the likely significant loss of resources in this category. For the south coast they do accept that Alpine Ash may have been significantly affected, including future growth and timber quality, though for the north coast, without any justification, this category has been dismissed as "no impact". This is an unjustified and untenable assumption.

The Forestry Corporation identified 19% of the net harvest area being affected by a RAFIT Class 4 hot burn, with 50% of trees of trees less than 30 centimetres in diameter immediately killed by fire, and 10% of trees greater than 30 centimetres in diameter also killed.

The Forestry Corporation identified 15% of the net harvest area being affected by a RAFIT Class 5 crown burn / scorched, with all trees less than 30 centimetres in diameter assumed to have been killed, and 50% of trees greater than 30 centimetres assumed to have been killed. All surviving trees are assumed to have no growth for one modelling period (four years) after fire.

The Forestry Corporation does recognise that recently logged stands were more severely impacted in the most severely burnt forests, stating:

> *Plots falling into tracts where harvesting was undertaken between 2015 and 2019 are assumed to have 90 per cent of trees present immediately killed by fire. This applies to four per cent of the region.*

Similarly the Forestry Corporation assume that the "*North Coast native forest current intensive harvest tracts",* totalling 12,000 hectares of forest converted to even aged regrowth/plantings, subjected to burning was killed. These results confirm the findings elsewhere that logging of forests and their conversion to regrowth makes them more vulnerable to fires.

Overall, across the north coast State Forests, the Forestry Corporation estimate there has been a loss of around 10% of sawlogs and 25% of smaller trees. North from Coffs Harbour these losses increase to 15% of sawlogs and 35% of smaller trees.

These quantifications of impacts of the 2019-20 fires on resources are very simplistic, and unjustified, assumptions to use as a basis for quantifying impacts on resources. In reality tree losses could be significantly greater.

It also appears the Forestry Corporation have excluded the growing impacts of droughts on forests and resources in their review, stating:

> *It should be noted however, that in some localities it was difficult to fully exclude the changing drought influence on the dNBR value. The rapid drought-based deterioration of dNBR values on some sites has resulted in their classification as RAFIT 2: low severity reflecting drought stresses rather than fire influence.*

Accounting for resource losses due to increasing droughts should be a fundamental requirement in our rapidly warming world, with widespread death of trees from droughts becoming more commonplace it will have a significant impact on yields into the future.

Similarly there has been no attempt to account for Bell Miner Associated Dieback. Its not even clear whether they left out the 11,000 hectares of forest in the Forestry Corporation's Urbenville Management Area that the Natural Resources Commission (2016 p54) *'Advice on Coastal Integrated Forestry Operations Approval remake*' identifies as being excluded because of BMAD and EECs:

> *A substantial portion of Urbenville Management Area in Supply Zone 1 is excluded from harvesting through this analysis. Five of the state forests in this area were considered impractical to manage for commercial purposes given reductions in net harvest area and areas affected by Bell Miner Associated Dieback.*

The outcome of the Forestry Corporation's shoddy remodelling of sustainable timber yields has no credibility. It is bewildering how the Forestry Corporation can conclude from this data that there will only be a 4% reduction in high quality sawlogs from the north coast over the next decade, claiming:

> *The total yield of high-quality timber products has not been significantly impacted by the fire, with the main reductions in the first four periods ranging from four to six per cent. Although full yield recovery is achieved after 65 years, the fires have caused a small (one per cent) drop in the overall supply of high-quality logs on the North Coast.*

And their pretence, apparent in the graph below, that for the period 2036 to 2051 the loss of all trees <30cm diameter in 15% of the forest, and half of these in 19% of the forest (and unknown numbers in other burnt forests), will have no discernible influence on yields of high quality logs beggars belief.

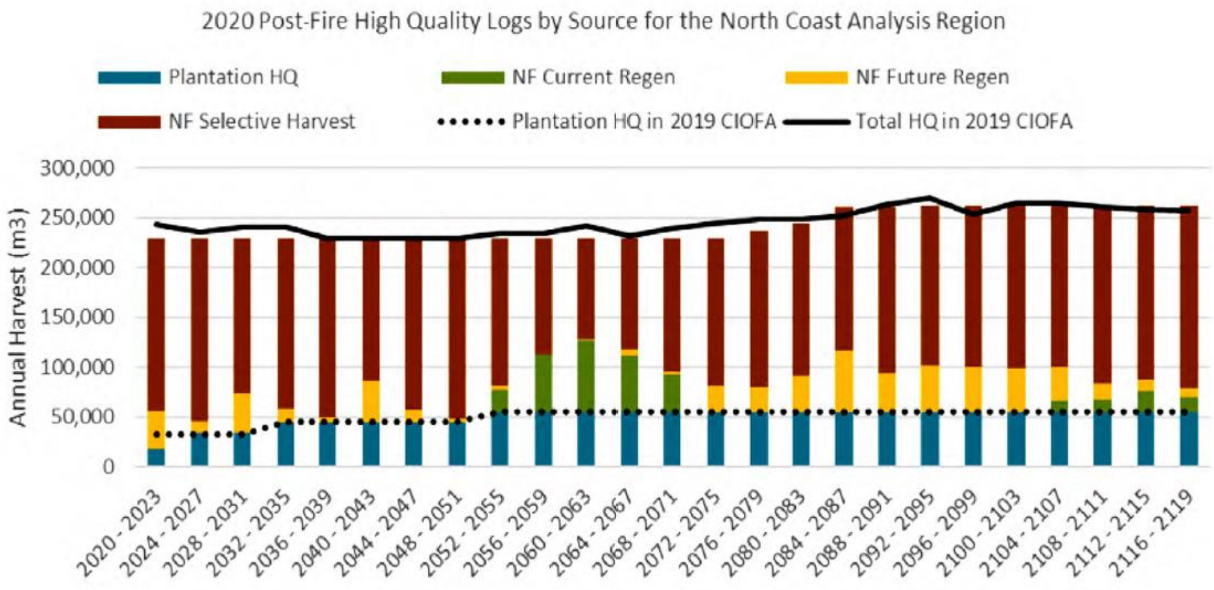


Figure 43: Post fire high-quality (HQ) log wood flows for the North Coast Region by source.

It appears the NSW Government intends to rely upon this simplistic review to sign new Wood Supply Agreements to replace the current 20 year agreements due to expire in 2023, as it is noted "The next review of Sustained Yield modelling for the NSW RFA regions is due in 2024".

The last 2 times the NSW Government gave sawmill owners guarantees for specific timber volumes in 1998 and 2003 they were found to be gross over-estimates and it cost NSW taxpayers over $12 million to buy back non-existent timber we gave to sawmillers for free.

At the very least the Government owes taxpayers a full and proper assessment of the bushfire impacts before they consider repeating past mistakes.

3 Ecological Sustainability

(g) the environmental impact and sustainability of native forest logging, including following the 2019/20 bushfire season,

NEFA (2018) has previously made a detailed submission on the failure of forestry operations in north-east NSW to comply with recovery plans and conservation advices for a variety of federally listed species: Submission to Australia's faunal extinction crisis. Compliance of Forestry Operations in North East New South Wales with Commonwealth Requirements for Threatened Species and Ecosystems (submission 405 to Australia's faunal extinction crisis). That submission provides reviews of the treatment of a range of species listed under the EPBC Act and is thus relied upon in this submission as to why current management of those species is not ecologically sustainable.

NEFA's submission partially considers NSW regulatory compliance with two multi-species Recovery Plans, and Recovery Plans and/or Conservation Advices for one Threatened Ecological Community, 17 threatened animals and 11 threatened plants, while, for some species, considering examples from NEFA Audits relating to the implementation of IFOA prescriptions in practice. Only the Hastings River Mouse as examples herein, with the discussion on the Hastings River Mouse is specifically considered in an updated account herein, which includes taking the 2019/20 wildfires into account.

NEFA demonstrated that before the fires federally listed threatened species and ecosystems were not being provided with the protection intended and often legally required. The Private Native Forestry Code generally provides no real species-specific protection for threatened species as there is no pre-logging survey, while the new Coastal IFOA reduces or removes most current species-specific protection for threatened species while significantly increasing logging intensity. In summary NEFA found:

1. Many Federally threatened species are not covered by Recovery Plans, have Recovery Plans that have expired or are not required to have Recovery Plans.
2. It is apparent that many Recovery Plans, particularly multi-species plans, fail to consider logging impacts or provide sufficient guidance on how to address forestry impacts and guide the recovery of threatened species.
3. While Recovery Plans are required by the NE RFA to be accounted for in logging operations, in practice Recovery Plans and Conservation Advices are generally ignored when planning and undertaking forestry operations.
4. One of the key requirements of numerous Recovery Plans and Conservation Advices (as well as being an ESFM principle) is to monitor the effectiveness of logging/management prescriptions and adjust them accordingly (adaptive management), yet it appears that in the past 20 years only 5 plant species have been subject to token monitoring and despite significant damage to those species there has yet been no change to prescriptions. For most prescriptions there are no performance measures and Government's apparently don't care if they are effective.
5. In practice Threatened species management prescriptions are often breached and yet there is little meaningful enforcement or consequences, and rarely any rehabilitation or compensatory habitat requirements.
6. On private lands there are numerous prescriptions for threatened species, though as there are few records of threatened species on private lands and no requirements to survey for them, they are rarely provided any protection in practice. Without surveys to trigger species-specific prescriptions they are tokenistic.
7. The Commonwealth Government uses the existence of an RFA as an excuse for ignoring the impacts of forestry on threatened species, irrespective of whether Recovery Plans and prescriptions are complied with or whether prescriptions are weakened or removed.

8. The NSW Government uses the existence of an RFA as an excuse for ignoring Federal Recovery Plans, Conservation Advices and new listings.
9. The new Coastal IFOA removes and reduces protection for most Federally listed threatened species.
10. The new Coastal IFOA proposes significantly increasing logging intensity, removing the need to retain most mature trees (nectar feed trees and recruitment habitat trees), reduces riparian buffers, and proposed the logging of oldgrowth and rainforest in Informal Reserves ,and yet none of the retained prescriptions for threatened species have been increased to take this into account.

There have been a multitude of cuts to environmental protections since the inception of the RFA, justified on the need to increase resources to help meet timber commitments. In 2003, in order to increase the harvestable area, "buffers on buffers" were removed by allowing trees to be dropped into, and machines to enter, exclusion areas.

Following the over-allocation of modelled available yields in 2003, in 2004 the Environment Protection Licence was amended to exclude most forest operations from its ambit, with the specific intent to allow the Forestry Corporation to log the 10m buffers required by the licence on "unmapped" streams in order to increase resources. There was no consideration of environmental impacts.

There were numerous amendments to the Threatened Species Licence from 2003 until 2011 that removed or reduced protection for threatened species and exclusion areas.

Since 2000 there have also been a number of species added to Federal Threatened species lists (such as the Greater Glider), and a number of new Recovery Plans prepared, yet there have been no changes to the Threatened Species Licence to reflect these changes.

From 2006 the Forestry Corporation began applying an unlawful version of the silvicultural prescription of Single Tree Selection (STS) involving up to 90% basal area removal, compared to STS's limit of 40% basal area removal (and retention of all trees under 20cm diameter at breast height (dbh)). In 2016 the EPA (pers. comm.) on behalf of the Environment Minister stated this intensity *"is not consistent with the definition and intent of STS (Single Tree Selection) in the Integrated Forestry Operations Approval (IFOA).* This dramatically increased logging intensity has increase timber yields while greatly increasing environmental impacts, particularly on fauna. This unlawful logging was then adopted as the standard logging intensity for the new logging rules and yield assessments in the Coastal IFOA.

Throughout the deliberations of the EPA and the Forestry Corporation on the new Coastal IFOA the emphasis has always been on removing or minimising environmental protections to ensure no reduction in timber yields. There were numerous reductions in environmental constraints that were agreed between the agencies in negotiating the Coastal IFOA, such as:

- increasing logging intensity across public forests (mostly doubling tree removal), and create a 140,000ha North Coast Intensive Zone to allow Eden-style alternate coupe clearfelling,
- halving the measly 10m wide stream buffers in our vital headwaters while also allowing logging of riparian habitat protected for the past 20 years,
- removing the requirements to protect the next largest trees as recruitment trees to replace the hollow-bearing trees as they die out,
- removing the requirement to protect a sample (i.e. variously 3-5 per hectare) of mature high nectar-producing trees so essential to provide the abundant nectar needed by a plethora of species.
- removing of the need to survey for most threatened species, the removal of most species specific prescriptions and the opening up of most exclusions for threatened species established over the past 20 years.

- removing of requirements to thoroughly search for Koalas ahead of logging and protect Koala High Use Areas, while zoning 43% of the highest quality habitat for extensive clearfelling.
- allowing logging dieback to run rampant through our forests.

There were a variety of issues that the agencies were not able to agree on (NRC 2016), for which the Natural Resources Commission (NRC) mostly sided with the Forestry Corporation against the EPA on the basis of resource shortfalls, including:

- reductions in the minimum area of landscape exclusions within logging areas
- reductions in the minimum numbers and size of trees to be retained for Koalas
- increases in the minimum sizes of "giant trees" to be retained
- increases in the size of patches allowed for clearfelling
- reductions in minimum basal area retention under "selective" logging

In summary the changes made by the Coastal IFOA to species-specific prescriptions for north-east NSW are:

- Of the 20 Federally Threatened animal species with species-specific protection requirements (excluding nests/roosts), the proposal is to retain current prescriptions for 4 species, reduce protections for 3 species, and remove protections for 13 species.
- Of the 171 Federally threatened plants or populations that currently require species-specific protection (exclusion buffers, management plans) the proposal is to remove protections for 120 species, reduce protection for 14, retain protections for 17, marginally increase protection for 10, and 7 are uncertain.

The new Coastal IFOA only mentions recovery plans in one place, where it requires "*incorporate actions specified in approved recovery plans, action statements and Saving our Species plans published by the Office of Environment and Heritage or equivalent*" when the Forestry Corporation are preparing "***species management plans*". The only Federally threatened species identified as requiring Species Management Plans in north-east NSW are the Eastern Bristle Bird and the plants *Euphrasia arguta*, Native Jute (*Corchorus cunninghamii*), and Milky Silkpod (*Parsonsia dorrigoensis*).

It is evident that any pretence of Ecologically Sustainable Forest Management has been abandoned with the new Coastal IFOA. There have been major reductions in protections for Federally listed threatened species without any attempt to assess the consequences. Now those inadequacies have been laid bare by the unprecedent drought and fires of 2019-20.

The 2019-20 bushfires have been of unprecedented scale and intensity, the burning of half the native vegetation and habitats has had massive impacts on north-east NSW's ecosystems, plants and animal populations. A variety of populations and species are likely to have been so significantly affected that they are at imminent risk of extinction. Others have been shoved further down that path. There needs to be urgent assessments of the most heavily impacted ecosystems and populations to assess their current status and the impacts of the fires upon them.

The burning of some 160,000 ha (35%) of rainforests should have been a wake-up call. This will result in significant loss and degradation of these priceless relicts from our Gondwanan past. Those burnt are now more vulnerable to further burning. The damage is so severe that with the increasing likelihood of repeat events this could be the start of ecosystem collapse. The burning of rainforest is akin to the bleaching of coral reefs, and is likely to follow a similar trajectory.

The wet-sclerophyll forests were already experiencing ecosystem collapse due to logging and lantana invasion, with the burning likely to aggravate this unless the return of lantana is prevented.

There can be no doubt that a multitude of wildlife died in the 2019-20 fires, from the invertebrate world of the leaf litter to up to Koalas in the tree tops. The fires were of unprecedented proportions, in north-east NSW burning out half the forests, including a contiguous 1.9 million hectares from Tenterfield on the tablelands to Iluka on the coast and from near Bonalbo in the upper Clarence River down to near Gloucester on the Manning River. Within the burnt grounds it was so dry that fires burnt through riparian vegetation and rainforests, the usual refuges for many species.

The fires last year were superimposed on an existing fire regime, with many areas burnt just a year or two ago burnt again, and occurred during an extreme drought when the forest was exceptionally dry and stressed. The drought continued after the fires, compounding impacts and hindering recovery.

The recovery of survivors will vary with species, though the impacts on many populations were so severe that they are unlikely to recover, and many will lag the recovery of their habitat. It is the lost tree hollows that will take centuries to recover. Urgent action is need to stop ongoing loss of key resources, particularly large old trees, and to facilitate the recovery of the worst affected species.

The fires also had a significant impact on timber resources, though this has only been subject to a cursory assessment (see Section 2).

Given the abject failure of NSW's legislative processes to demonstrate that they provide meaningful or adequate protection for Commonwealth listed Threatened species, the frequency with which management intent does not comply with Recovery Plans and Conservation Advices, the demonstrated failure to often implement prescriptions, and NSW's intent to significantly increase logging intensity and reduce protection for Threatened species, and then the major impact of the bushfires upon threatened speciesa there needs to be a significant re-write of the Threatened species provisions of the IFOA and PNF Code to ensure that they implement the identified recovery actions and provide the protection required for nationally

Maintaining viable populations of fauna is a key requirement of ESFM, though it is evident that there needs to be a significant expansion of reserves in north-east NSW to achieve this. For establishing the Comprehensive Adequate and Representative Reserve System in accordance with the objective of the national forest reserve criteria (JANIS 1997*) "to maintain viable populations of native forest species throughout their natural ranges",* reservation targets were established for indicative viable populations of all priority fauna in north-east NSW on a meta-population basis (Flint *et. al.* 2004). A review of target achievement in 2004 (Flint *et. al.* 2004) found that only 31% of the targets for 710 fauna populations had been achieved, with 72 (52%) of the 139 species with targets set failing to meet target for any of their populations, noting:

> *The most poorly represented habitats are coastal dry sclerophyll, tablelands dry sclerophyll and coastal nonforest complex with mean target achievement of 40%, 42% and 43% respectively (Table 5). Of these, the coastal dry sclerophyll is the most poorly reserved on public land with significant improvements possible through additional reservation of public tenures.*

This is demonstrated by the poor outcomes for forest owls:

Table 9. Population target achievement for the four threatened forest owls.

Species	Population	Habitat Target area (ha)	Targeted No of Breeding Units (no)	No of Breeding Units Reserved (no)	Mean Target Met (%)
Barking Owl	1	402492	805	91	11%
	2	402492	805	143	18%
Total		804984	1610	234	14%
Masked Owl	1	734847	735	160	22%
	2	734847	735	172	23%
Total		1469694	1470	332	22%
Powerful Owl	1	377964	378	168	44%
	2	377964	378	298	79%
Total		755928	756	466	61%

Extract from Flint et.al. 2004.

Flint *et. al.* (2004) comment:

> *The Barking Owls and Masked Owls T. noveahollandiae inhabit the more dry, open forests that have been subject to extensive clearing in the coastal lowlands and on the tablelands. These dry coastal forests in particular are the most poorly reserved broad habitat type in the region (Table 5). The reservation outcome for these two large home range species is very poor, with habitat for only 234 pairs of breeding Barking Owls formally protected. Major additions to the reserve system are required to promote the survival of these two species.*

Clause 46 of the North East RFA states "*New South Wales confirms its commitment to the achievement of ESFM on Public and Private Land consistent with the principles of Ecologically Sustainable Forest Management at Attachment 14, and to the ongoing review and subsequent implementation of its legislation, policy, plans, Codes and Regional Prescriptions to ensure ESFM objectives can be achieved in a more efficient regulatory environment*".

The RFA Review claims that "*the NSW Government confirmed its commitment to the achievement*[35] *of ESFM consistent with the following five principles*":

> **Principle 1**: Maintain or increase the full suite of forest values for present and future generations across the NSW native forest estate
> **Principle 2**: Ensure public participation, access to information, accountability and transparency in the delivery of ESFM
> **Principle 3**: Ensure legislation, policies, institutional framework, codes, standards and practices related to forest management require and provide incentives for ecologically sustainable management of the native forest estate
> **Principle 4**: Apply precautionary principles for prevention of environmental degradation
> **Principle 5**: Apply best available knowledge and adaptive management processes.

In many ways these requirements are not being honoured.

ESFM was actioned in the Integrated Forestry Operations Approval (IFOA) clause 2.7.1 which required that in carrying our forestry operations *"SFNSW must give effect to the principles of ecologically sustainable forest management".* Though nobody was responsible for enforcing what are termed the non-licence terms of the IFOA. The EPA would not accept responsibility for enforcing this, and whenever we had a complaint directly relating to breaches of the ESFM principles we were told to take it up with the responsible Ministers. When we did they would do nothing about our complaints, as evidenced by their refusal to take any action to stop the Forestry Corporation undertaking intensive logging in contravention of the IFOA specified limits on logging intensity (which is also a breach of ESFM). There was no oversight or enforcement of the ESFM principles.

The most obvious failing of ESFM is the Government's refusal to stop logging Bell Miner Associated Dieback (BMAD) affected and susceptible forests (see section 3.3). The actions of logging opening up the canopy and disturbing the understorey, allows the ingress and proliferation of lantana (a Key Threatening Process), which often results in Bell Miner dominance, exclusion of most other native birds, and consequently dieback (another Key Threatening Process). Initiating and promoting BMAD is in direct contravention of the RFA's ESFM principles:

> *Principle 1: Maintain or increase the full suite of forest values for present and future generations across the NSW native forest estate*
> *Principle 4 Apply precautionary principles for prevention of environmental degradation*
> *Principle 5 Apply best available knowledge and adaptive management processes*

By no stretch of anyone's imagination can the initiation and spread of BMAD be considered to comply with ESFM requirements to:

- *Maintain ecological processes within forests (such as the formation of soil, energy flows and the carbon, nutrient and water cycles, fauna and flora communities and their interactions).*
- *Maintain or increase the ability of forest ecosystems to produce biomass whether utilised by society or as part of nutrient and energy cycles.*
- *Ensure the deleterious effects of activities/disturbances which threaten forests, forest health or forest values are minimised.*
- *Maintain ecological processes within forests (such as the formation of soil, energy flows and the carbon, nutrient and water cycles, fauna and flora communities and their interactions).*
- *Maintain or increase the ability of forest ecosystems to produce biomass whether utilised by society or as part of nutrient and energy cycles.*

Both the Forestry Corporation and the EPA use claims of uncertainty as their reason for doing nothing about the BMAD problem despite the fact that the weight of research clearly indicates logging is the principal initiator of both lantana invasion and BMAD, and that the limited monitoring clearly shows that re-logging affected stands compounds the problem. Doing nothing about the most probable (and NEFA maintains certain) cause is in direct contravention of the precautionary princple:*'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation'.*

While the Government pretends to have turned over a new leaf with the new Coastal IFOA, they are still allowing logging of BMAD affected and susceptible forests to continue, while they do yet another review of potential causes. This is "*fiddling while Rome burns*" and a direct contravention of the basic precepts of ESFM, in particular the precautionary principle.

From well before the RFA, and repeatedly since, NEFA have been asking for Government agencies to monitor the effectiveness of prescriptions intended to reduce environmental harm. This has been a requirement of numerous recovery plans, including the Northern Rivers Regional Biodiversity Management Plan (a national multi-species Recovery Plan), which has an action

> *7.1.5. Develop appropriate criteria and indicators to review the effectiveness of threatened species protection measures currently employed in public and private native forestry activities. Strengthen threatened species protection measures where they are shown to be inadequate.*

The principle of monitoring a prescription and then using the results of that monitoring to improve the prescription is called adaptive management and is a basic tenet of ESFM. For example ESFM Principle 5 requires that "*ESFM would utilise the concept of adaptive management and continuous* *improvement based on best science and expert advice and targeted research on critical gaps in knowledge, monitoring or evaluation*".

Adaptive Management is a key requirement of ESFM, most Recovery Plans and Conservation Advices, and Forestry management plans yet it is not applied in practice.

It appears that in north-east NSW the impact of forestry has only been assessed for 5 plants and despite significant impacts no modification of prescriptions has yet been made. It is not believed that any other flora or fauna prescriptions have been subject to monitoring to assess their effectiveness, though this does not stop the Forestry Corporation claiming otherwise. In relation to biodiversity Forests NSW (2005) ESFM Plan notes:

> *Forests NSW will use adaptive management principles and actions within State forests to complement the management of the CAR reserve system.*
>
> *…*
>
> *During operations, site specific conditions are continually assessed, results recorded, the appropriateness of operational conditions reviewed and plans amended where necessary.*

We have come across no evidence of this, quite to the contrary we are concerned that Forestry Corporation does not learn from their mistakes. We are most concerned that neither the EPA nor Forestry Corporation have bothered to assess the effectiveness of most prescriptions over the past 20 years and improved them accordingly. Rather than applying adaptive management as a routine practice we find that Forestry Corporation use it as an occasional excuse to log somewhere they shouldn't.

There has been no strengthening of any of the Licence prescriptions included in the current licences since they were first issued 20 years ago, though there have been numerous instances of weakening and removal of prescriptions, not one of which has been based on monitoring of the effectiveness of either the old or new prescription.

The Private Native Forestry (PNF) Code has a range of record-based prescriptions for nationally listed threatened species, though there are few existing records on private lands and no survey requirements. This means that threatened species and ecosystems are usually provided with no protection what-so-ever in private forestry. If you don't look you don't find, if you don't find you don't protect. Excusing logging operations on private lands from any obligations for threatened species or ecosystems under the EPBC Act, with virtually nothing done to mitigate impacts on them, is the single biggest rort of the NE RFA.

Application of prescriptions in the real world is where the process can often fail. In practice poor implementation is a common occurrence in NSW. NEFA considers that this is testimony to regulatory failure in NSW. Even the small sample of convictions Justice Pepper (*Director-General, Department of Environment, Climate Change and Water v Forestry Commission of New South Wales [2011] NSWLEC 102*) reviewed led her to conclude:

> *However, in my view, the number of convictions suggests either a pattern of continuing disobedience in respect of environmental laws generally or, at the very least, a cavalier attitude to compliance with such laws.*
>
> *... Given the number of offences the Forestry Commission has been convicted of and in light of the additional enforcement notices issued against it, I find that the Forestry Commission's conduct does manifest a reckless attitude towards compliance with its environmental obligations ...*

The cases reviewed by Justice Pepper were just the few that the EPA has prosecuted the Forestry Corporation for and some of those for which Penalty Notices had been issued. There are a plethora of quite serious offences that the EPA have only taken token, if any, regulatory action for. Justice Pepper's conclusions were only based on a small sample of the Forestry Corporation's offences.

All the years of regulation have failed to arrest the criminal behaviour of the Forestry Corporation, failed to implement the principles of ESFM and failed to provide the protection our threatened species so desperately require. It is evident is that the EPA's token 'proactive' audits and failure to apply meaningful deterrents has allowed the Forestry Corporation's *reckless attitude towards compliance with its environmental obligations* to flourish.

An example is provided by NEFA’s 2015 audit of Cherry Tree State Forest. In spite of making Endangered Ecological Communities (EECs) a compliance priority the EPA refused to take any regulatory action what-so-ever in response to the roading and logging the Endangered Ecological Community Lowland Rainforest in Cherry Tree State Forest in response to NEFA's audit (Pugh 2015) . The rainforest had been mapped for decades and it had been identified and mapped as the State EEC Lowland Rainforest in a joint mapping project by both the EPA and the Forestry Corporation in 2016. NEFA's review of that mapping identified 33 incursions into mapped Lowland Rainforest affecting 4.5 ha. Despite their own mapping the EPA (Jackie Miles, 1-12-17) said they would do nothing because they could not determine beyond reasonable doubt that it was an EEC.

Similarly the EPA refused to even consider or mention 90ha of the State EEC Grey Box-Grey Gum Wet Sclerophyll Forest the Forestry Corporation logged within the Cherry Tree compartments. This too had been mapped jointly by both the EPA and the Forestry Corporation as an EEC in 2016, though the EPA refused to even consider it on the grounds that they had a Memorandum of Understanding with the Forestry Corporation not to use their mapping of it as a 'backward looking compliance tool', this is despite NEFA identifying numerous breaches within it before the EPA mapped it.

Though the most outrageous abrogation of their duty was the EPA (Michael Hood,1 December 2017) stating that they would take no regulatory action at all for 122 breaches of habitat tree protections they identified in Cherry Tree State Forest likely "*as a result of harvesting operations*", because they were not able "*to prove beyond reasonable doubt that each individual instance of damage or debris was as a result of those undertaking the harvesting operation*" "*nor could it obtain evidence that would rebut a defence that the damage was caused by some other means*". It is blatantly obvious in most cases that the damage is caused by side-swiping of trunks, machinery damage to roots or trees being felled onto retained trees. This was a new low for the EPA.

3a. The Forestry Corporation has been logging under a set of protocols intended to mitigate environmental impacts since 1997. In all that time, with the exception of partial monitoring of 5 plants, they never attempted to monitor the effectiveness of those prescriptions in accordance with adaptive management, despite consistently weakening them. The new Coastal IFOA was a political compromise between the Forestry Corporation and the EPA aimed at minimising resource costs rather than reducing impacts on threatened species to a sustainable level. All logging prescriptions for threatened species need to be reviewed by independent experts, with the identification of needed enhancements to reduce impacts to a sustainable level, including specific performance measures and monitoring requirements.

3b. Ecological Sustainable Forestry is a meaningless platitude as it has never been enforced and no one heeds its basic principles such as the precautionary principle and adaptive management. Logging of forests affected by Bell Miner Associated Dieback has continued despite it being evident it is caused by lantana invasion following logging, on the grounds that this hadn’t been proven beyond doubt, which is a perversion of the precautionary principle. This problem has been compounded by the EPA’s failure to effectively audit logging operations.

3.1: Bushfire impacts

Due to climate heating bushfires are becoming more frequent and intense. As evidenced in 2019-20, droughts and heatwaves are drying forests out and making them more flammable. In 2019, New South Wales had its warmest January to August period on record for overall mean temperature (1.85 °C above average), By 9 September, more than 50 fires were active in NSW, with five fires burning out of control and 3 watch and act alerts in place for blazes at Drake near Tenterfield, Ebor near Armidale and Shark Creek in the Clarence Valley.

From August 2019 until January 2020 the wildfires devastated 2.4 million hectares of north-east New South Wales (north from the Hunter River to the Queensland border, and from the coast west to include the New England Tablelands), encompassing 29% of the region and around half the remnant native vegetation. For this review primary reliance was placed on DPIE's GEEBANG v2 burn mapping

These fires were unusually extensive and intensive because of record low rainfalls and extreme temperatures. In summary comparison of GEEBAM v2 fire mapping with other data for north-east NSW shows the fires burnt:

- 1,324,772ha of Public Lands (54.2% of burn) and 1,118,659ha of Private Lands
- 868,714 ha (59%) of National Parks, with 517,802 ha suffering significant (full or partial) canopy loss. This includes 180,295 ha (58.3%) of the NSW section of the Gondwana Rainforests of Australia World Heritage area, including some 26,283 ha (24.4%) of World Heritage listed rainforest.
- 456,058 ha (54.4%) of State Forests, with 259,293 ha suffering significant canopy loss. This includes 16,000 hectares (43%) of Pine Plantations, most of which burnt intensively, rendering them useless for future production.
- Some 160,000 ha (34.7%) of rainforest, with 124,494 ha (78% of burnt rf) suffering significant canopy loss
- 851,847 ha (66%) of mapped oldgrowth forest, with 420,257 ha suffering significant canopy loss
- 322,191 (29.4%) of Koala Habitat Suitability Model (north-east NSW) classes 4&5, with 196,663 ha suffering significant canopy loss. (Note this is limited to the north-east NSW bioregion)

North-east NSW (north from the Hunter River) provides core habitat for half of the 113 animal species that the experts commissioned by the Commonwealth Department of Agriculture, Water and the Environment identified as needing urgent help to survive in the wake of devastating bushfires.

The 57 species occurring in north-east NSW identified as being at highest risk of extinction are comprised of 10 birds, 13 mammals, 9 reptiles, 11 frogs, 12 spiny crayfish and 2 freshwater fish species. These include the Rufous Scrub-bird, Regent Honeyeater, Hastings River Mouse, Long Sunskink, Manning River Helmeted Turtle, Broad-headed Snake, Pugh's frog, Mountain frog, Sphagnum frog, Peppered Tree Frog, New England treefrog, Tyler's toadlet, Small Crayfish, Smooth Crayfish, Ellen Clark's Crayfish, Hairy Cataract Crayfish, Oxleyan Pygmy Perch, and Clarence River Cod.

The crayfish in particular are not recognised as threatened species in NSW and thus not provided with any specific protection. Given their stream habitats they are directly affected by logging due to its affects on riparian habitat, water quality and streamflows, there needs to complete protection of upstream catchments so as not to compound burning impacts. This applies to listed frogs, turtles and fish as well.

The Commonwealth identifies the highest priority actions for all species as protecting unburnt habitat patches and carrying out rapid ground assessments of remnant populations.

In their simplistic assessment the NSW Government also identified Pugh's frog, Hastings River Mouse, Brush-tailed rock-wallaby, Parma wallaby, Yellow-bellied glider, New England Tree Frog, and Davie's Tree Frog as having more than half their known localities burnt.

Many north coast species have had most of their known localities burnt, with Pugh's Frog losing 89% and Hastings River Mouse 82%. Rainforests have been burnt, with some unlikely to recover, numerous hollow-bearing trees have been burnt out and cut down, eucalypt flowering has been set back for years, many understorey feed trees (i.e. forest oaks for Glossy Black Cockatoos) have been killed, streams have been polluted. Due to the extent of the fires, these are significant impacts on the populations and survival of numerous threatened species.

Recommended changes in logging prescriptions to mitigate fire impacts:

3.1a. The highest priority to mitigate impacts on native plants and animals is to protect the remaining unburnt and partially burnt refuges where species have survived the fires to allow them to increase populations and recolonise burnt habitat as it recovers, It is recommended that logging of all burnt forests, and all unburnt habitat with 10 km of firegrounds, be prohibited for a minimum of 10 years to avoid compounding impacts during this essential recovery period, and allow time for recovery of populations and recolonisation of burnt habitat.

3.1b. Prescriptions for threatened flora and fauna were developed in a political process and were already inadequate before the fires, given the loss of individuals and degradation of habitat it is essential that there be an independent expert review of prescriptions by relevant experts

3.1c. Logging makes forests more vulnerable to burning and increases their flammability. As extreme weather conditions are increasing in intensity and frequency, then to reduce the likelihood and impacts of future extreme fire events, logging of public native forests has to stop to reduce their increasing flammability, and to allow them to recover their natural resilience to future burning.

3.1d. Some 160,000 ha (34.7%) of rainforest was burnt, with most of this suffering significant canopy damage. While some of this rainforest will die, most will regenerate though will be even more vulnerable to burning and elimination for decades to come. If we want to increase the chances of rainforests, and their inhabitants, surviving this unfolding environmental catastrophe, then we need to restore their natural resistance and resilience to burning by:

- **Establish 50m buffers around all mapped rainforests within which logging and clearing is prohibited**
- **Prohibiting roading through rainforests**
- **Stopping logging of developing rainforest**
- **Rehabilitating degraded stands and buffers, particularly those infested with lantana and those suffering from Bell Miner Associated Dieback**

3.1.1. Logging Effects on Burning

Logging makes forests more vulnerable to wildfires and increases their flammability by drying them, increasing fuel loads, promoting more flammable species, and changing forest structure. This includes increasing the risks of canopy fires by reducing canopy height, increasing tree density and increasing fuel connectivity from the ground into the canopy.

Lindenmayer *et. al.* (2009) note:

> *Logging can alter key attributes of forests by changing microclimates, stand structure and species composition, fuel characteristics, the prevalence of ignition points, and patterns of landscape cover. These changes may make some kinds of forests more prone to increased probability of ignition and increased fire severity*

Conversion of natural multi-aged forests to predominately regrowth increases their vulnerability to burning by:

- increasing transpiration and loss of available soil moisture (Vertessy *et. al.* 1998)
- reducing canopy density, changing the microclimate and causing drying of understorey vegetation and the forest floor (Lindenmayer *et. al.* 2009)
- changing forest structure by creating a more horizontally and vertically continuous fuel layer - increasing shrub cover, increasing stocking densities, reducing inter crown spacing, reducing canopy base-height (Gill and Zylstra 2005, Lindenmayer *et. al.* 2009, Cohn *et. al.* 2011, Taylor *et. al.* 2014, Zylstra 2018, Cawson *et. al* 2018)
- natural self-thinning of post-fire regrowth creating large amounts of fine fuels from suppressed plants in the early stages of regrowth (Taylor *et. al.* 2014, Zylstra 2018),
- changing the understorey vegetation composition by opening the canopy and increasing disturbance adapted species (Gill and Zylstra 2005, Lindenmayer *et. al.* 2009, Zylstra 2018, Cawson *et. al* 2018)
- spreading lantana and increasing understorey flammability (Fensham 1994, Gill and Zylstra 2005, Murray *et. al.* 2013)
- logging slash fuelling fires (Lindenmayer *et. al.* 2009)

Forest canopies create their own microclimate by moderating temperature extremes and enhancing humidity. Davis *et. al.* (2019) found "*microclimate buffering was most strongly related to canopy cover*", while Kovács *et. al.* (2017) found "*The midstory and the shrub layer play key roles in maintaining the special microclimate of forests with continuous canopy-cover*".

Logging changes the structure of forests and thus increases ground temperatures and reduces humidity (Brosofske *et. al.* 1997, Chen *et. al.* 1999, Dan Moore *et. al.* 2005,), as identified by Chen *et. al.* (1999) "*Patches that have been recently disturbed by human-induced or natural processes tend to have higher daytime shortwave radiation, temperature, and wind speed than undisturbed patches; in addition, these variables show greater spatial and temporal variability*".

From their review of the effects of logging on riparian areas in America, primarily in catchments less than 100 ha in area or streams less than 2 to 3 m wide, Dan Moore *et. al.* (2005) concluded:

> *Forest harvesting can increase solar radiation in the riparian zone as well as wind speed and exposure to air advected from clearings, typically causing increases in summertime air, soil, and stream temperatures and decreases in relative humidity.*

They identify "*the magnitude of harvesting related changes in riparian microclimate will depend on the width of riparian buffers and how far edge effects extend into the buffer*", citing a variety of studies which show "*that much of the change in microclimate takes place within about one tree* *height (15 to 60 m) of the edge. Solar radiation, wind speed, and soil temperature adjust to interior forest conditions more rapidly than do air temperature and relative humidity*".

Stand age has a significant effect on hydrological processes in forests, with regrowth significantly increasing transpiration and rainfall interception by canopy trees, which in turn creates a drier microclimate and increases drying of soil and litter. This in turn influences litter decomposition and the build up of surface fuels.

Vertessy *et. al.* (1998) have attempted to quantify the different components of rainfall lost by evapo-transpiration, identifying them as: interception by the forest canopy and then evaporated back into the atmosphere; evaporation from leaf litter and soil surfaces; transpiration by overstorey vegetation; and transpiration by understorey vegetation. All of these have been measured as declining with increasing forest maturity, with the exception of understorey transpiration which becomes more important as transpiration from the emergent eucalypts declines.

Rainfall interception is the fraction of gross rainfall caught by the forest canopy and evaporated back to the atmosphere. This is water lost to the understorey and groundwaters, as noted by Vertessy *et. al.* (1998):

> *rainfall interception rate rises to a peak of 25% at age 30 years, then declines slowly to about 15% by age 235 years. If we assume a mean annual rainfall of 1800mm for the mountain ash forest, stands aged 30 years intercept 190 mm more rainfall than old growth forest aged 240 years.*

Evaporation is also greater from soils and litter in regrowth forests.

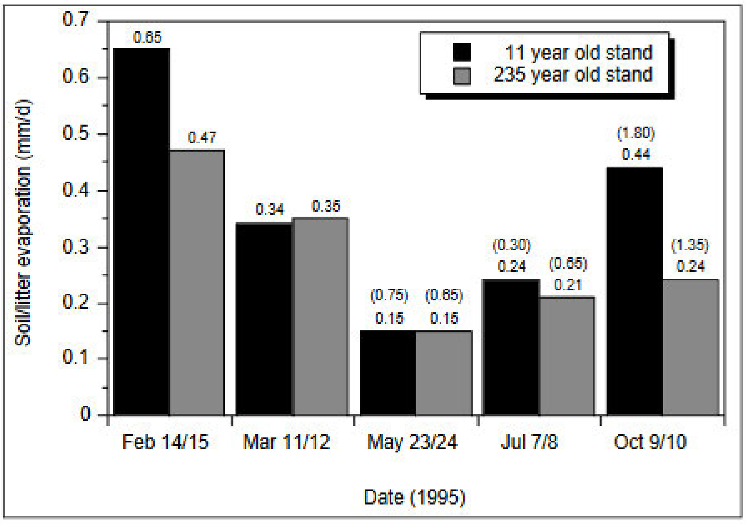
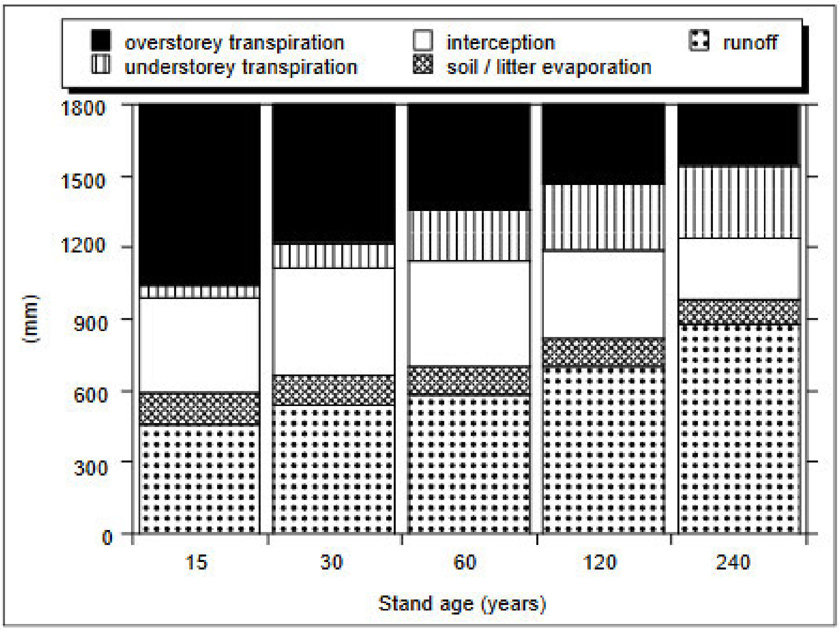


Figure 22 from Vertessy *et. al.* (1998): Comparison of soil/litter evaporation estimates beneath 11 and 235 year old mountain ash forest stands.

Reduction of oldgrowth forests to regrowth thus clearly dries out the forest and thereby increases the flammability of leaf litter.



Water balance for Mountain Ash forest stands of various ages, assuming annual rainfall of 1800 mm (Figure 24 from Vertessy et. al. 1998)

The reduced water yields particularly affect riparian areas and the availability of free water.

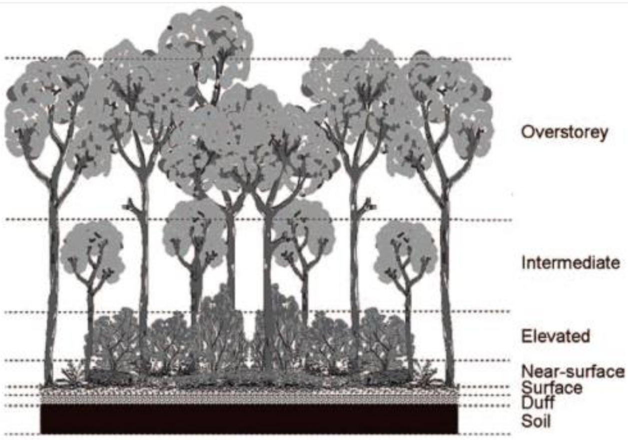


Figure 3.6 from Sullivan *et. al.* (2012) showing categories of forest fuel strata.

Flammability of surface fuels in forests is influenced by their nature and structure, though moisture content of living and dead fuels is the most fundamental constraint on biomass flammability. Forests which have denser canopies result in microclimates characterized by higher humidity, lower wind velocities, cooler temperatures, reduced evaporation and hence reduced fire risk compared to more open-canopied forests. From their comparisons of temperate rainforests and eucalypt forests, Clarke *et. al.* (2014) found "*there was no evidence of higher flammability of litter fuels or leaves from frequently burnt eucalypt forests compared with infrequently burnt rainforests*", concluding "*the manifest pyrogenicity of eucalypt forests is not due to natural selection for more flammable foliage, but better explained by differences in crown openness and associated microclimatic differences*".

Lindenmayer *et. al* (2009) observe "*logging in some moist forests in southeastern Australia has shifted the vegetation composition toward one more characteristic of drier forests that tend to be more fire prone*".

Forests can be separated into strata, with the surface fuels being primarily responsible for most of the fuel consumed and energy released by a fire, though it is the tall shrubs and regenerating trees of the elevated fuel layer that "*has a major influence on flame dimensions, particularly flame height*" and the development of crown fires (Sullivan *et. al.* 2012).

As forests age the gap between canopy and understorey plants and fuels develops, reducing stand flammability and the risk of canopy fires (Cohn *et. al.* 2011, Taylor *et. al.* 2014, Zylstra 2018). As identified by Zylstra (2018) eucalypt forests have evolved the ability to create mature environments that suppress the spread of fire. It is logical that as logging removes mature trees and promotes regrowth that it increases connectivity with ground fuels and therefore the risk of crown fires, though there is strong opposition to any suggestion that such fundamental changes in forest structure can influence crown fires (i.e. Attiwill *et. al.* 2014).

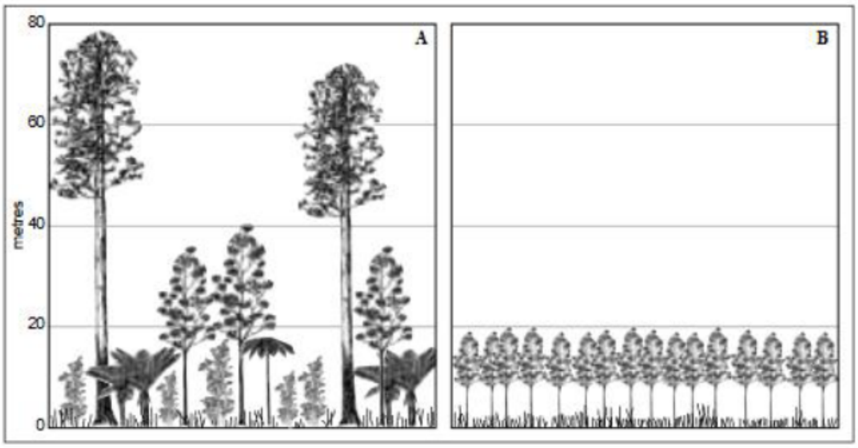


Figure 9 from Vertessy *et. al. 1998*: Comparison of forest structure in (A) old growth and (B) regrowth mountain ash stands. It beggars belief the anybody could deny that the reduced canopy height and increased canopy continuity in a drier regrowth forest is likely to result in increased crown fires.

From their studies of the 2009 Victorian fires Price and Bradstock (2012) concluded "*Probability of crown fires was higher in recently logged areas than in areas logged decades before*"

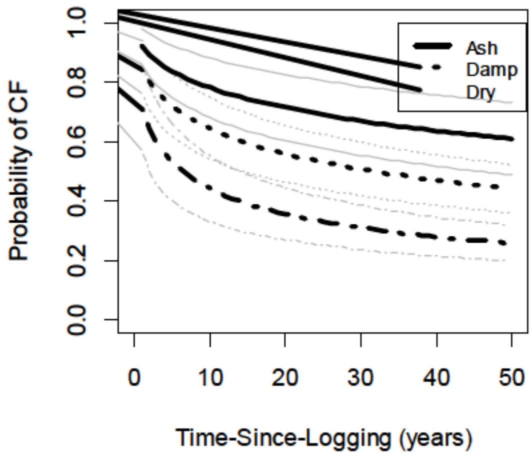
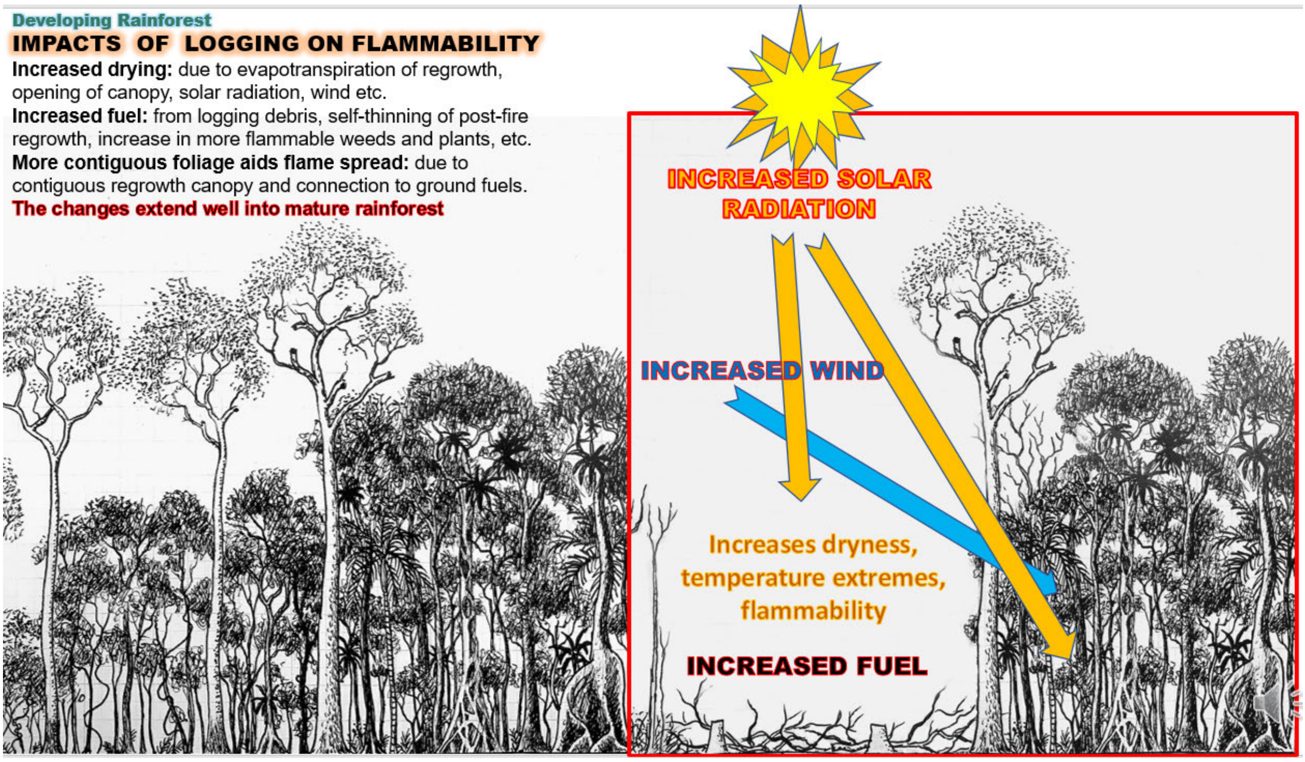
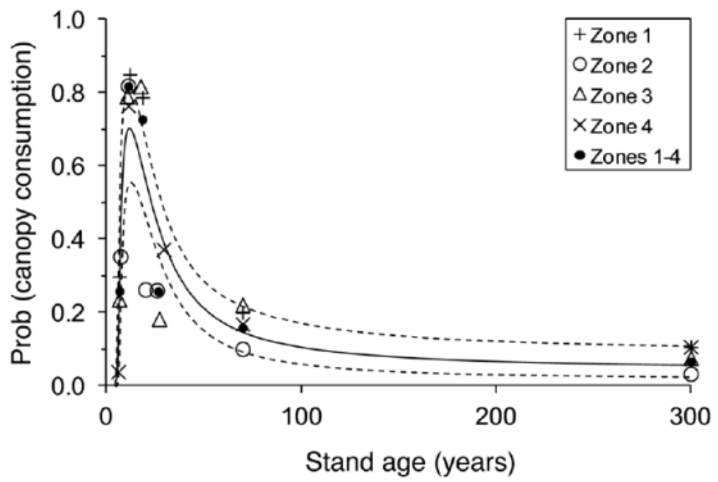


Figure 1 from Price & Bradstock (2012): Model predictions for crown fire (CF) against time-since-logging and forest type using the best model. In all cases, the models are for fire weather Moderate, slope = 0, topographic position = 50%, time-since-fire = 25 years, and aspect = East. Confidence limits for predictions for each forest type are shown.



Taylor *et. al.* (2014) assessed the impact of Victoria's 2009 wildfires on Mountain Ash forests, finding "*the probability of canopy consumption increased rapidly with age up to approximately 15 years ... In stands older than 15 years, the probability of canopy consumption decreased with age, such that it rarely occurred in stands aged around 300 years".* They note:

> *... a strong relationship between the age of a Mountain Ash forest and the severity of damage that the forest sustained from the fires under extreme weather conditions. Stands of Mountain Ash trees between the ages of 7 to 36 years mostly sustained canopy consumption and scorching, which are impacts resulting from high-severity fire. High-severity fire leading to canopy consumption almost never occurred in young stands (<7 years) and also was infrequent in older (>40 years) stands of Mountain Ash.*



Probability of canopy consumption versus stand age (Fig 7 from Taylor *et. al.* 2014)

From his study of 58 years of fires in the Australian Alps Zylstra (2018) found that "*forests were most likely to experience crown fire during their period of regeneration*", noting:

> *The strongest response was observed in tall, wet forests dominated by Ash-type eucalypts, where, despite a short period of low flammability following fire, post-disturbance stands have been more than eight times as likely to burn than have mature stands. The weakest feedbacks occurred in open forest, although post-disturbance forests were still 1.5 times as likely to burn as mature forests.*

After logging the large quantities of tree crowns, crushed plants and reject logs make the forest more vulnerable to burning, as noted by Lindenmayer *et. al.* (2009):

> *Large quantities of logging slash created by harvesting operations can sustain fires for longer than fuels in unlogged forest and also harbor fires when conditions are not suitable to facilitate flaming combustion or the spread of fire*

For Jarrah forests, Burrows *et. al.* (1995) identify that the severity of wildfires and damage to retained trees has increased since pre-European times which "*can be attributed largely to logging debris which ignites during summer wildfires*".

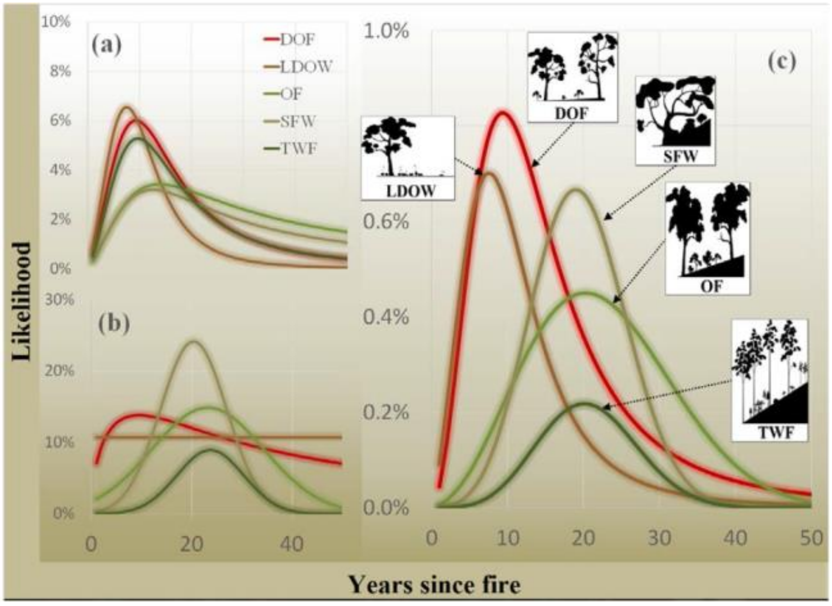


Figure 5 from Zylstra (2018). Flammability trends for each formation, where the *x*-axis gives years since the last fire, and the *y*-axis gives likelihood for (a) fire burning a point (L_f), (b) crown fire occurring if that point is burning (L_{cb}); and (c) crown fire occurring at any point (L_c). Labels refer to dry, open forest (DOF), low, dry open woodland (LDOW), open forest (OF), subalpine forest and woodland (SFW), tall, wet forest (TWF).

In the longer term weed invasion can also make the forest more vulnerable to burning. Lantana (*L. camara)* is the most widespread and successful weed throughout north-east NSW, benefitting from logging and other activities that open the forest canopy enough for it to thrive. Lantana now dominates the understorey in tens of thousands of hectares of northeast NSW"s forests. Fire and cattle grazing are significant contributors to the successful invasion of lantana (Gentle and Duggin 1997), and it in turn can increase the flammability of vegetation (Fensham *et. al*. 1994, Gill and Zylstra 2005, Berry *et. al* 2011, Murray *et. al.* 2013, Bowman *et. al.* 2014). Of the 79 species from dry sclerophyll forests tested by Murray *et. al.* (2013), lantana had the third shortest mean time to ignition for fresh leaves.

From their study of the Forty Mile Scrub National Park, Fensham *et. al*. (1994) found "*the proliferation of lantana results in the build up of heavy fuel loads across the boundary of dry rainforest and savanna woodland. Recent fires have killed the canopy trees in a large area of dry rainforest within the Park*". From their study of dry rainforests, Berry *et. al* (2011) concluded that *L camara* was less ignitable than native dry rainforest species, though:

> *Fuel bed depths, leaf litter depths, percentage cover by fuels and amount of medium size class fuels were higher in dry rainforest invaded by* L.camara *than in noninvaded forests. This suggests that the mechanism by which* L.camara *alters the fire regime in dry rainforest is by shifting the distribution of available fuels closer to the ground and providing a more continuous fuel layer in the understory*

The increasing dominance of forest understoreys by lantana in north-east NSW due to logging significantly increases forest's flammability and the wildfire threat.

3.2. Maturity Matters

It is the bigger and older trees that provide the high level of resources required by the majority of specialised threatened vertebrate species. It may take trees one or two decades before they begin to flower and set seed, which they produce in increasing abundance as they mature. Numerous species of invertebrates, many birds, and a variety of mammals feed on these flowers and seeds. As they mature their trunks, branches and leaves also exude a variety of sweet substances used by many species. Numerous invertebrates harbour within the rough and shedding bark of eucalypts where they are eagerly sought out for food by many vertebrate species. Yellow-bellied and Squirrel Gliders chew channels through their bark to tap trees for sap. As the trunks and branches thicken the trees provide more stable nesting and roosting sites, while enabling Koalas to hug them on hot days to keep cool.

The older a tree gets the more browse, nectar, seeds and other resources they provide for wildlife. Once eucalypts are over 120-180 years old they begin to provide the small hollows needed by a variety of native wildlife for denning, nesting and shelter. Though it is not until they are over 220 years old that they provide the larger hollows required by species such as owls, cockatoos and gliders. They may live for 300-500 years, sometimes longer.

A major problem for many threatened vertebrate forest fauna species is the ongoing and cumulative decline in larger trees. Regrettably old trees have been dramatically reduced in State forests as they are progressively converted into younger stands. The removal of protection for most mature trees in the new Coastal Integrated Forestry Operations Approval (CIFOA) is a significant blow to the numerous animals that rely upon them for critical resources, whether it is a Koala relying on them for browse, birds searching decorticating bark for invertebrates, gliders tapping them for sap, or one of the many who depend on their abundant nectar.

The depleted numbers of mature nectar feed trees and hollow-bearing trees are limiting wildlife populations in public forests, including in most coastal parks established over logged degraded forests. Restoring hollow-bearing trees across public forests is a key necessity to improve ecological sustainability. Enabling trees to age will stop the ongoing attrition of live mature trees and allow them to develop hollows over time, though it will take over a century before a reasonable complement of hollow-bearing trees, and wildlife populations, are restored.

Loyn (1985) identified those vertebrate species most vulnerable to logging to be those using old trees for feeding, such as honeyeaters and mistletoebirds which feed on mistletoe nectar or fruit, some insectivorous birds which forage amongst decorticated eucalypt bark or among canopy foliage, and some arboreal marsupials which feed on sap and invertebrates from large eucalypt trunks and branches or on canopy foliage in mature eucalypts.

Even when they die large trees can remain standing for decades, and when they fall the large logs can persist for more decades. They can go on providing dens, nest sites and food long after they die.

3.2. To redress the ongoing precipitous decline in native species reliant upon the resources provided by older trees it is essential that the removal of older trees be stopped and their recruitment actively encouraged. To improve ecological sustainability the requirements under the old IFOA to protect sound and healthy mature/late mature individuals of recruitment trees for hollow-bearing trees, significant winter nectar producing eucalypt species, sap-feed trees for Yellow-bellied Gliders and other key wildlife resources must be restored. The retention of all remaining mature trees over 60cm dbh as recommended by the 2011 National Recovery Plan for the Swift Parrot is strongly supported.

3.2.1. Nectar Availability

Nectar is a key food that many vertebrate species depend on. Eucalypt species can produce copious nectar though most flower unreliably, often at intervals of several years, so nectarivorous species need to be able to track nectar across the landscape or switch to other foods when nectar is in short supply. Law and Chidel (2007) found "*in exceptional years, 1000 ha of spotted gum forest flowering from April-August could yield five tonnes of honey"*.

The flowering of trees and abundance of nectar is directly affected by rainfall over the previous 6 months (Hawkins 2017), reducing in droughts and following bushfires (Law *et. al.* 2000, Law and Chidel 2009, Moore *et. al.* 2016). The erratic production of nectar is likely to become more so in the future as climate heating gathers momentum, as stated by Butt *et. al.* (2015) "*as a consequence of the increasing incidence of droughts and heat waves, the net quantity of nectar at flower, stand and landscape scales may be reduced, and its temporal variability increased*".

The conversion of multi-aged forests to regrowth greatly compounds resource shortfalls for this proposal's increasingly threatened species.

Older trees produce significantly more flowers and nectar than young trees and thus are of particular importance to fauna relying on these food sources, such as the threatened Regent Honeyeater, Swift Parrot, Black-chinned Honeyeater, Little Lorikeet, Grey-headed Flying Fox, Squirrel Glider and Yellow-bellied Glider.

For Mountain Ash trees Ashton (1975) found "*The mature forest produced 2.15-15.5 times as many flowers as the pole stage trees, and 1.5-10 times as many as the spar stage forest".* From her study of the flowering phenology displayed by seven Eucalyptus species in a Box-Ironbark forest, Wilson (2003) found *"trees in size - classes >40 cm flowered more frequently, for a greater duration, more intensely and had greater indices of floral resource abundance than trees < 40 cm DBH"*.

For Spotted Gum forest in southern NSW Law and Chidel (2007, 2008, 2009) found large trees (>40cm dbh) carried 3,600 flowers compared to 816 flowers on medium trees and 283 flowers on small trees (<25cm dbh), noting "*mature forest produced almost 10 times as much sugar per ha as recently logged forest, with regrowth being intermediate*" And for Grey Ironbark *Eucalyptus paniculata* forests large trees carried 12,555 flowers compared to ,1024 flowers on medium trees and 686 flowers on small trees, noting "*old regrowth forest (232 g sugar per night per 0.2 ha) produced just over 7 times the sugar of recently logged forest (32 g), while regrowth forest was intermediate (91 g)*."

As well as producing more flowers larger trees also tend to flower more often (Law *et. al.* 2000, Law and Chidel 2007), for example Law *et. al.* (2000) found that large Spotted Gum *Corymbia variegata* flowered every 2.3 years whereas medium sized trees flowered every 5.9 years.

The abundance of flowers provided by trees directly affects their suitability for foraging by numerous animals. Mature and older trees have been significantly diminished across these forests, and along with them the abundance and reliability of nectar essential to maintain resident and seasonal populations of nectar feeders.

To obtain an indicative estimation of the loss of nectar due to logging, the averages of the number of flowers per Spotted Gum and Grey Ironbark in the 3 size classes identified by Law and Chidel (2007) were applied to the plot data for the proposed Sandy Creek Koala Park to identify the indicative reduction in nectar likely to have been caused by logging to date.

It was found that the number of trees per hectare, and thus the numbers of flowers per hectare, have increased in the 15-39.9 cm dbh size classes, though halved in the more prolific flowering trees >40 cm dbh. This gives an indicative overall decline of 43% in the number of flowers, and thus nectar, per hectare. Though the reduction would be higher than this, likely over 50%, due to the more abundant flowering in the heavily depleted larger size classes (i.e. particularly 50-80cm dbh), and less frequent flowering of smaller trees.

Size Class	Trees/ha		Flowers/tree[1]	Flowers/ha		
	Logged	Unlogged		Logged	Unlogged	Change
15-24.9	98.4	95	484.5	47,675	46,028	+1,647
25-39.9	71.6	43.3	920	65,872	39,836	+26,036
40+	45.9	95	8,077.5	370,757	767,363	-396,606
			TOTALS	**484,304**	**853,226**	**-368,922**

Indicative changes in abundance of flowers, and thus nectar, per hectare likely to have resulted from past logging of proposed Sandy Creek Koala Park
1. Flowers per tree is the average of the numbers given for Spotted Gum and **Grey Ironbark by Law and Chidel (2007).**

Extrapolating from the example cited by Law and Chidel (2007) where "*in exceptional years, 1000 ha of spotted gum forest flowering from April-August could yield five tonnes of honey*", if applied to the 7,000 ha proposed Sandy Creek Koala Park the likely >50% reduction in nectar would equate to >17.5 tonnes of honey. The current wholesale price of honey is around $6.20 a kilo, so this loss of flowers could be worth at least $108,500 in a single good year. That is also a lot of food for a lot of animals.

Researchers at Australia's Threatened Species Recovery Hub (Geyle *et. al.* 2018) recently identified that the Regent Honeyeater and Swift Parrot have a 57% chance of extinction and a 31% chance of extinction respectively within the next 20 years, ranking them the 7th and 13th most threatened birds in Australia.

The Regent Honeyeater is listed as Critically Endangered under the EPBC Act. The 2016 National Recovery Plan for the Regent Honeyeater identifies "*It is important to identify and retain trees that produce relatively high levels of nectar. In some areas where there has been a history of removal of large trees, regent honeyeaters often select the largest available trees of the 'key' species"*. John Gould (cited by Crates 2018) stated *"Although it is very generally distributed, it's presence appears to be dependent upon the state of the Eucalypti, upon whose blossoms the bird mainly depends for subsistence; and it is, consequently, only to be found in any particular locality during the season when those trees are in full bloom. It generally resorts to the loftiest and most fully-flowered trees".*

The Recovery Plan identifies key feed tree species for the Regent Honeyeater as including Swamp Mahogany *Eucalyptus robusta,* and Spotted Gum *Corymbia macula,* noting "*Mature, large individual trees tend to be more important as they are more productive, particularly on highly fertile sites and in riparian areas (Webster & Menkhorst 1992; Oliver 2000). Trees in such areas tend to grow larger (Soderquist & MacNally 2000) and produce more flowers (Wilson & Bennett 1999)*".

The Swift Parrot *Lathamus discolor* is listed as 'Endangered' under the EPBC Act. The 2011 National Recovery Plan for the Swift Parrot identifies the loss of mature trees and the abundance of nectar they provide as a major threat, noting:

> *Based on current knowledge of the ecology and distribution of the Swift Parrot the persistence of this species is mainly threatened by loss and alteration of habitat from forestry activities including firewood harvesting, clearing for residential, agricultural and industrial developments, attrition of old growth trees in the agricultural landscape, suppression of forest regeneration, and frequent fire. The species is also threatened by the effects of climate change, food and nest source competition, flight collision hazards, psittacine beak and feather disease, and illegal capture and trade.*
>
> *Forestry activities, including firewood harvesting result in the loss and alteration of nesting and foraging habitat throughout the Swift Parrot's range ... The harvesting of mature box-ironbark woodlands of central Victoria and coastal forests of New South Wales for forestry reduces the suitability of these habitats for this species by removing mature trees which are preferred by Swift Parrots for foraging and that provide more reliable, as well as greater quantity and quality of food resources than younger trees (Wilson and Bennett 1999; Kennedy and Overs 2001; Kennedy and Tzaros 2005)*

The Recovery Plan identifies "*Swift Parrots have been found to preferentially forage in large, mature trees (Kennedy 2000; Kennedy and Overs 2001; Kennedy and Tzaros 2005) that provide more reliable foraging resources than younger trees".* Brereton *et. al*. (2004) found:

> *Swift Parrots showed a clear preference for larger Blue-gum trees: Blue-gum trees in which Swift Parrots foraged were ~40% larger than surrounding (non-forage) trees, while the size-class distribution of forage trees was significantly skewed towards larger tree-size compared with surrounding non-forage trees. The mean flowering intensity of forage trees was also significantly greater than the mean flowering intensity of non-forage trees. Both flowering frequency and flowering intensity increased with tree size, although there was a trend for both flowering frequency and intensity to decline in the largest tree size-classes.*

Coastal forests have been identified as significant winter food resources for Swift Parrots, with Forest Red Gum accounting for 49% of all coastal foraging observations (Saunders and Heinsohn 2008). It is important to recognise that the north coast forests with an abundance of these winter flowering species are of increased importance for nectarvores during droughts, when drier western forests are too drought stressed to produce much nectar. For Swift Parrots Saunders and Heinsohn (2008) found:

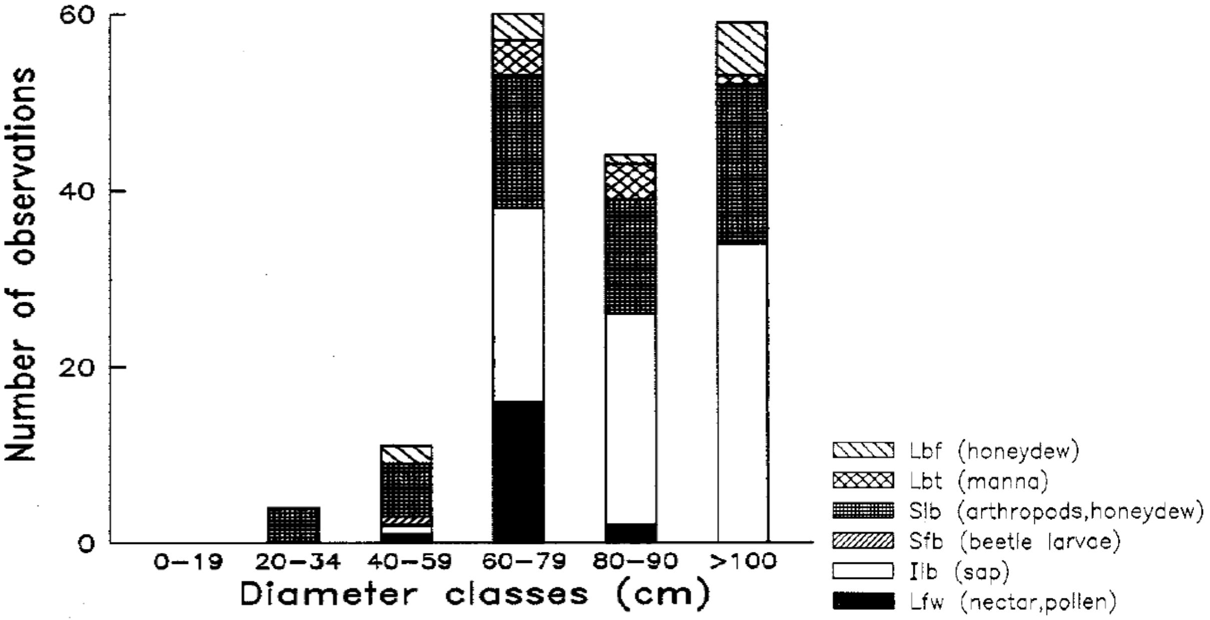
> *The greatest variability in use of habitat in this study occurred on the central and northern coasts of NSW. Although these coastal regions often supported small numbers of Swift Parrots, this changed dramatically during drought conditions in 2002 (Bureau of Meteorology 2002; Bureau of Meteorology 2006). The numbers of Swift Parrots foraging in these coastal regions increased substantially during this year, with a large proportion of the population apparently using these areas as drought refuges. Our study draws attention to the importance of these refuge areas for the long-term viability of the Swift Parrot population, as for other fauna dependent on highly variable environments*

Yellow-bellied Glider and Squirrel Glider are two marsupials that have a high reliance upon older trees for the abundance of nectar and other resources they provide.

Eyre and Smith (1997) found that Yellow-bellied Gliders preferred forests containing gum-barked and winter flowering species, and that within these forests they were "*more abundant in the more productive forests with relatively high densities of ironbark and gum-barked species > 50 cm diameter*". Wormington *et. al.* (2002) found that "*the density of hollow-bearing trees >50 cm dbh,* *tree height and increased length of time since the last logging contributed to the presence of yellow-bellied gliders*".

Kavanagh (1987) found that Yellow-bellied Gliders primarily selected trees of certain species and secondarily trees of larger size for foraging, with 92% of trees used for foraging over 60 cm dbh and 58% over 80 cm dbh. Kavanagh (1987) found that larger trees provide a variety of resources:

> *Tree size. The size of trees used by foraging animals was influenced by the type of substrate being exploited (Fig. 5). Gliders were observed licking flowers mainly in medium to large trees, and licking honeydew from the branches of some very large trees. Large trees (> 80 cm DBH) were important as a source of sap: the diameters of important sap-site trees in the study area ranged from 56 to 164 cm in E. viminalis (mean ~SD1,10 t 31.3 cm, n = lo), and from 74 to 143 cm in E. fastigata (105 k21.2 cm, n = 14). Decorticating bark provided a foraging substrate which gliders utilised from trees of a wide range of size, and was the only substrate to be exploited from small (<40 cm DBH) trees.*



Diameter classes of trees in which the different foraging behaviours of yellow-bellied gliders were observed (from Kavanagh 1987).

Kavanagh (1987) concluded:

> *The gliders in my study area selected the trees with the greatest number of flowers in which to forage for nectar; these would have been the older trees, because mature trees (c.200 years old) produce 2.2-15.5 times as many flowers as pole stage trees (c.25 years old). The importance of manna, lerp and honeydew as food for forest vertebrates has only recently been appreciated ... The gliders obtained them from large trees.*
>
> *...*
>
> *These results suggest that mature forests which provide sufficient diversity of the favoured eucalypt species will be the habitats with the highest concentration of yellow-bellied gliders.*

Mackowski (1988) found that the trees tapped for sap by Yellow-bellied Gliders in northern NSW had a mean diameter (dbh) of 65.6 cm and *"a minimum dbhob of about 30 cm"*. Similarly in south-east Queensland Eyre and Goldingay (2005) found "*Of the tree species used for sap feeding by gliders, trees >40 cm in diameter at breast height (DBH) were used more than would be expected on the basis of their abundance in the forest*". They also found *" An increase in the basal area of cut stumps and dead trees in the forest stand was related to an increase in the number of sap trees observed that more trees were tapped for sap",* considering:

> *This is thought to be due to reduced availability of other foraging resources. ...In southern Queensland, this basal area threshold is equivalent to 9 trees ha^{-1} in the 61–80-cm DBH class, or 17 trees ha^{-1} in the 41–60-cm DBH class, which in general (based on regional-scale data) approximates 25–35% removal of the original tree basal area, or 20–30% removal of the overstorey canopy. This could lead to a decrease in potential foraging substrates, such as decorticating bark (for arthropod searching) and flower cover (for nectar and pollen feeding), necessitating a heavier reliance upon sap trees in glider diet to maintain energy requirements".*

Hawkins (2017) consider "*The one consistent feature of the annual nectar cycle was a period of scarcity in late winter and spring (August-September); this has also been identified as a time of scarcity in northern New South Wales by Law et al. (2000)*". Law *et al* (2000) comment:

> *shortages commonly occur from late winter to spring. Species that flower reliably in this period include Eucalyptus robusta, Eucalyptus tereticornis and Eucalyptus siderophloia in late winter and E. siderophloia and E. acmenoides in spring.*

From their study of Squirrel Gliders in Bungawalbin Nature Reserve, Sharpe and Goldingay (1998) observed Squirrel Gliders feeding on nectar and pollen in 59% of all observations, noting *"[Banksia] integrifolia accounted for over 50% of these observations*", and "*Squirrel gliders appeared to use all flowering E. siderophloia available to them at this time. Eucalyptus seeana was also used heavily when in flower*". From radio-tracking Sharpe and Goldingay (2007) concluded "*the spatial organisation of home ranges of squirrel gliders at Bungawalbin was strongly influenced by the distribution of key winter- and spring-flowering trees*". Sharpe (2004) concluded "*The over-harvesting of E. siderophloia in timber production forests would have the potential to adversely affect nectarivorous species, such as the squirrel glider and the yellow-bellied glider, both of which are listed as threatened in NSW*".

At their study site in south-east Queensland Dobson *et.al.* (2005) found that Squirrel Gliders fed 48% of the time on nectar and pollen derived from 10 tree species, with *E. tereticornis* accounting for 55% of all records. From their studies of this population Sharpe and Goldingay (2010) concluded "*Variation in nectar availability appears to have a substantial influence on the dynamics of squirrel glider populations*".

Nectar and pollen were particularly important for Squirrel Gliders during winter and early spring (Sharpe and Goldingay 1998), with their populations varying with the number of flowering trees, and susceptible to crashing when key nectar trees fail to flower. Sharpe (2004) observed that "*Gliders rapidly lost weight between July and September 2000, which coincided with extremely dry conditions and a lack of flowering in Eucalyptus siderophloia, an important nectar source*". This was followed by a loss of almost 80% Gliders between September and November 2000, likely due to the "*sudden onset of hot conditions in the late winter of 2000*".

From their study of Squirrel Gliders in Victoria, Holland *et. al.* (2007) concluded:

> *The high density of large trees is a critical element of habitat quality. Not only were large trees preferentially selected for foraging, they also provide gliders with hollows for nesting (van der Ree 2000). Retention of large trees should therefore be a priority, and lack of regeneration is of serious concern, with trees not being replaced as they senesce.*

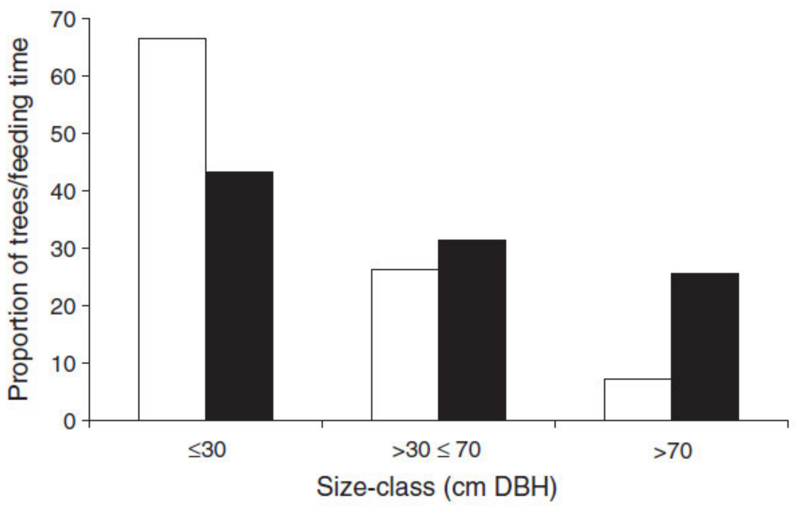


Fig. 3. from Holland *et. al.* (2007):The proportion of total *Eucalyptus microcarpa* trees in each size category (clear bars), and the proportion of total feeding time of squirrel gliders within trees in each size category (shaded bars) near Euroa, Victoria.

These results show that Squirrel Gliders are vulnerable to logging that reduces tree sizes and thus the quantity and regularity of nectar, and that nectar shortages also make them particularly vulnerable to unseasonal heat waves due to climate heating.

Flying foxes are another key nectar feeding species, Ebby (1999) considers:

> *... more reliable resources are produced in lowland coastal woodlands in northern New South Wales and in southern Queensland dominated by E. tereticornis, E. robusta, M . quinquenervia and Banksia integrifolia (Clemson 1985; Pressey and Griffith 1992). In approximately 30% of years the only significant winter foraging resources available in New South Wales occur in coastal woodlands at low elevations and large numbers of flying-foxes congregate in these areas, as illustrated by this study. Grey-headed Flying foxes are known to migrate from camps many hundreds of kilometres away to utilize these winter resources (Ehy 1991).*
>
> *Grey-headed Flying-foxes are additionally impacted by incremental reductions in food availability throughout their range as a result of forest clearing and degradation, forestry practices, eucalypt dieback, drought, fire and the vulnerability of nectar flow to fluctuations in temperature and rainfall".*

For the Grey Headed Flying Fox, Ebby and Law (2008) consider:

> *Winter presents the greatest food resource bottleneck for the species. In winter, productive areas are concentrated in coastal floodplains, coastal dunes and inland slopes in SEQ and northern NSW. The majority of winter habitats are heavily cleared, poorly conserved and recognised as endangered vegetation communities.*

The fact that in 2019 masses of flying foxes starved to death is testimony to this problem of declining nectar resources.

The previous Threatened Species Licence under the IFOA had a variety of requirements for the retention of mature trees as recruitment habitat trees to replace hollow-bearing trees, as 3-5 eucalypt nectar feed trees per hectare, and as feed trees around records of a variety of threatened fauna (such as 15 mature smooth-barked feed trees within 200m of Yellow-bellied Glider records).

With the rewrite of the new Coastal IFOA logging rules the initial intent of the EPA was to remove all requirements to protect mature trees, though, presumably after intervention by the Commonwealth, the required retention of 5 mature to late-mature nectar feed trees per hectare in compartments within 2km of existing records (less than 20 years old) of Swift Parrot and Regent Honeyeater was reinstated. However the requirement to survey for these species was removed.

There are vaguely expressed intentions to include mature trees in Wildlife Habitat and Tree Retention clumps, though nothing is quantified or enforceable.

Law and Chidel (2007) found that while in good years eucalypts can produce a surplus of nectar, in poor years the limited nectar was rapidly consumed, leading them to observe "*Depletion of nectar in poor flowering years justifies management prescriptions that retain mature trees of locally important flowering species (currently six per ha) in the areas zoned for logging. The fact that total sugar content tends to be higher in lower slope areas (e.g. riparian zones) is also important in ameliorating logging impacts*". It speaks volumes for the integrity of NSW's IFOA remake that the Forestry Corporation ignored their own research recommendations.

3.2.2. Hollow-bearing trees

Once eucalypts are over 120-180 years old they begin to provide the small hollows needed by a plethora of native wildlife for denning, nesting and shelter. Though it is not until they are over 220 years old that they provide the larger hollows required by species such as owls, cockatoos and gliders. They may live for 300-500 years, sometimes longer.

Seventy species (28%) of vertebrates use hollows in north-east NSW (Gibbons & Lindenmayer 2002). The loss of the hollows provided by large old trees has been identified as a primary threat to a variety of priority species in north east NSW (Environment Australia 1999, Appendix 1); 4 mammals (non-flying), 20 bats, 3 birds, 2 frogs, 3 reptiles and 4 snakes.

Gibbons and Lindenmayer (2002) documented that relatively undisturbed temperate and sub-tropical eucalypt forests contain 13–27 hollow-bearing trees per hectare. Only some hollows have appropriate entrance sizes and depths for fauna, with only 43-57% of hollows found to be used by fauna, and 49-57% of hollow-bearing trees used (Gibbons and Lindenmayer 2002).

Animals do not select hollows at random; factors such as entrance size and shape, depth, degree of insulation and location greatly affect the frequency and seasonality of hollow use. Many species use multiple hollows which they move between. For example, the Brush-tailed Phascogale has been found to use 27-38 different hollows (Gibbons & Lindenmayer 2002), Craig (1985) found that a family group of 3 Yellow-bellied Gliders "*used at least eight den trees within their home area*", and Brigham *et. al.* (1998) found that Australian Owlet-nightjars move approximately 300m between roost sites every 9 days on average, with individuals using 2-6 different cavities over 1-4 months, noting "*our results suggest that birds may be loyal to a group of 2-6 trees in a relatively confined area*".

Based on a number of assumptions, various estimates of the numbers of hollow-bearing trees occupied by vertebrate fauna have been made, with Gibbons & Lindenmayer (2002) assuming that *"hollow-bearing trees in forests are likely to be occupied at a rate of around 6-15 per hectare".*

For our plot assessments of the proposed Sandy Creek Koala Park NEFA measured plots in both unlogged and logged Spotted Gum forests south of Casino in order to be able to assess structural changes resultant from past logging. The original forests contained a minimum of 18.3 trees/ha with the large hollows suitable as dens and roosts of large hollow-dependent animals such as the threatened Powerful Owl, Masked Owl, Barking Owl, Greater Glider, Yellow-bellied Glider, and Glossy-black Cockatoo. Due to past logging there are now only an average of 0.3 trees/ha with large hollows left, a 98.4% reduction in these vital resources, meaning that populations of such species have been significantly affected, with strong competition for remaining hollows. The loss of small hollows has been less severe (78%), though many of those left may be uninhabitable. Of the 17 threatened hollow-dependent species using these forests, 15 had reserve targets set in 1998 and only 2 of these met targets and can therefore be considered to be adequately protected in national parks.

There are numerous species occurring in this proposal that depend upon the large hollows provided by old eucalypts for nesting or denning, such as the Vulnerable Powerful Owl, Masked Owl, Barking Owl, Greater Glider, Yellow-bellied Glider, and Glossy-black Cockatoo. Others that require smaller hollows include the Vulnerable Brush-tailed Phascogale, Squirrel Glider, Hoary Wattled Bat, Yellow-bellied Sheathtail-bat, Greater Broad-nosed Bat, Turquoise Parrot, Dusky Woodswallow, Brown Tree-creeper and Little Lorikeet. There is an urgent need to restore hollow-bearing trees to recover these species.

The NSW Scientific Committee (2007) has identified Loss of Hollow-bearing Trees as a Key Threatening Process. The maintenance of large old hollow-bearing trees in perpetuity is the single most important requirement for the survival of the numerous animal species that rely on their hollows for denning, nesting or roosting**.** To maintain continuity of supply of these resources by such long lived organisms it is essential to ensure that there are enough small hollow-bearing trees to replace the large hollow-bearing trees when they die, and enough strong and health mature trees to develop into the hollow-bearing trees of the future.

As noted by Gibbons and Lindenmayer (2002):

> *Hollow-bearing eucalypts are extremely long-lived 'organisms'. Eucalypts typically have a life span of 300-500 years, and dead trees may provide hollows for a further 100 years. The age at which they 'reproduce' hollows (typically 150-250 years) represents one of the slowest 'reproductive cycles' for any organism. Failure to replace hollow-bearing trees as they are lost will result in prolonged temporal gaps in the resource that will not only reduce the area of suitable habitat for hollow-using fauna, but could also fragment populations of species unable to occupy areas lacking hollows. The dispersal of hollow using species also will be impaired".*

Lindenmayer *et. al.* (2014) recognise that:

> *... drivers of large old tree loss can create a "temporary extinction," that is, a prolonged period between the loss of existing large old trees and the recruitment of new ones (Gibbons et al. 2010b). The length of a temporary extinction may vary (e.g., 50 to 300+ years) ... Temporary extinction has the potential to drive species strongly dependent on large old trees to permanent local or even global extinction. In other cases, existing large old trees may be doomed to eventual extinction because the animals that dispersed their seeds have disappeared".*

Logging significantly increases tree mortality. After logging the retained trees are more vulnerable to windthrow and post-logging burning (Saunders 1979, Recher, Rohan-Jones and Smith 1980, Mackowski 1987, Smith and Lindenmayer 1988, Milledge, Palmer and Nelson 1991, Smith 1991a, Gibbons and Lindenmayer 2002). Gibbons and Lindenmayer (2002) note *"studies consistently show that the number of hollow-bearing trees that occurs on logged sites is negatively associated with the number of harvesting events*", and *"logging may result in a pulse of mortality among retained trees after each cutting event"*.

From a study of the effects of logging and fire on hollow-bearing trees on the Dorrigo, Guy Fawkes and Chaelundi plateau, McLean *et. al.* (2015) concluded:

> *Logging intensity was negatively correlated with tree diameter at breast height (DBH), and the density of both hollow-bearing trees and hollows. Losses of hollow-bearing trees and hollows occurred through an interaction between logging intensity and fire frequency,*

> *resulting in an absence of recruitment of hollow trees. However in unlogged forest, fire was positively correlated to the density of hollows. Under a regime of frequent fire, in areas that have had some degree of logging activity, a net loss of hollows may occur. We recommend additional hollow recruitment trees be retained on logged sites in the future if no net losses of hollows are to occur in the future, or for wider unlogged buffers to be established adjacent to the cutting area.*

To maintain habitat trees in perpetuity there is a necessity to account for natural and logging/burning induced tree-deaths when prescribing retention rates for both hollow-bearing trees and recruitments sufficient to maintain the prescribed number of habitat trees over long time frames (Recher, Rohan-Jones and Smith 1980, Mackowski 1984, 1987, Recher 1991, Scotts 1991, Traill 1991). In natural forest there is a self thinning process that results in significant mortality as trees mature (Mackowski 1987, Smith 1999). Though there is also a high likelihood of mortality due to other factors. As noted by Mackowski (1987 p124) *"the frequent occurrence of fire in this site height blackbutt forest precludes a 100% chance of survival - a proportion will be damaged, or weakened, or burnt down by each fire. These trees are also subject to the risk of lightning and windstorm damage."*

The 2019 fires took a significant toll on remaining hollow-bearing trees, as well as larger Coastal Grey Box, with many observed to have collapsed.

To account for mortality over time there is a necessity to retain progressively increased numbers of trees in smaller age classes.

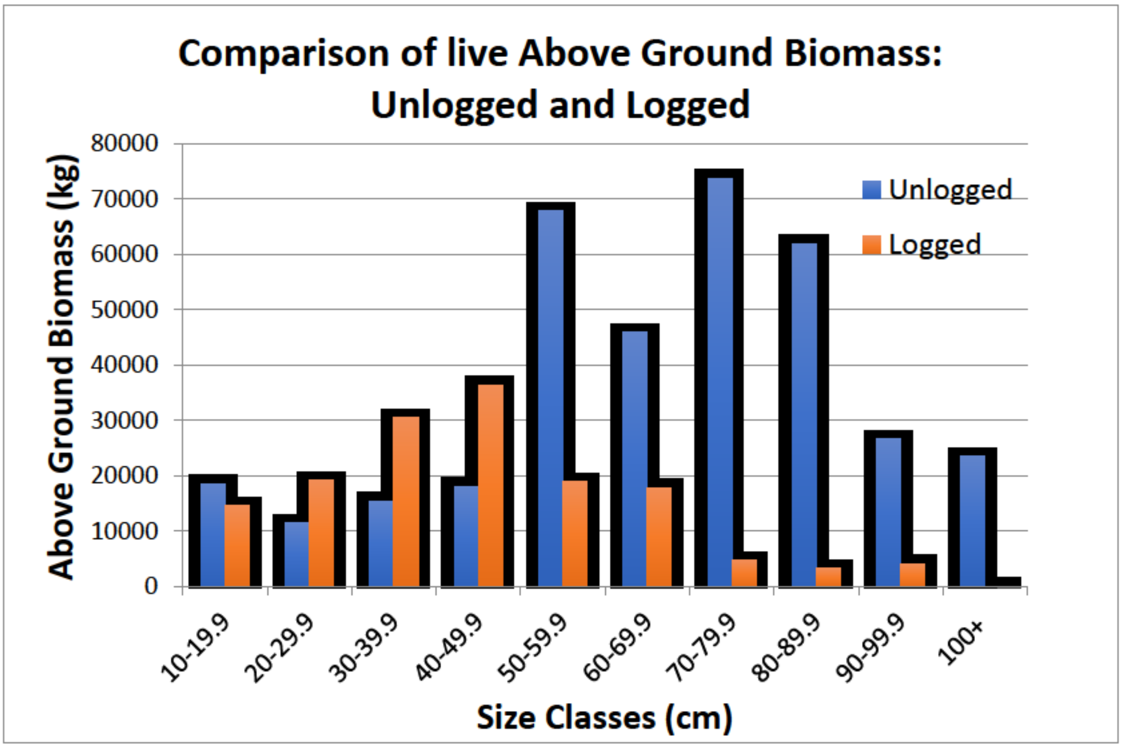
COASTAL BLACKBUTT RETENTION RATES REQUIRED TO MAINTAIN 10 HABITAT TREES PER TWO HECTARES IN PERPETUITY. The assumption is made that there will be 50% mortality of recruitment trees every 80 years. Adapted from Mackowski 1987.

Diameter (dbhob) cm.	Age yrs	Time-span in size class yrs	Mackowski's requirements for 3 Habitat Trees per Hectare over 100cm	Requirements to retain 10 Hollow-bearing Trees per Two Hectares
20-60	16-68	52	11.5	38.3
60-100	68-144	76	4	13.3
100-140[A]	144-224	80	2	6.6
140-180[B]	224-304	80	1	3.3

A - stage at which hollows suitable for small wildlife form.
B - stage at which hollows suitable for large wildlife form.

Most of the loggable State Forests have been subject to repeated logging events and thus there are few large hollow-bearing trees left. The low numbers are a significant constraint on the viability and populations of many species. Restoring populations of hollow-dependent species in these forests depends upon retaining sufficient mature trees to be able to develop the necessary hollows to replace, maintain and restore hollow-bearing trees over time.

For example, the assessment undertaken by NEFA for their proposed Sandy Creek Koala Park found there are currently only 9.7 trees per hectare in the 60+ cm dbh size class, and only 2.4 per hectare in the 70+ cm dbh size class. There are thus few trees to replace the remnant large-hollow bearing trees as they die, let alone restore these vital resources to a sustainable level. Meaning that unless all large trees are retained there will be a continuing attrition of large-hollow bearing trees into the future.



Comparison of Above Ground Biomass of logged and unlogged plots in the proposed Sandy Creek Koala Park showing the dramatic reduction in the biomass of larger trees due to logging.

Lindenmayer *et. al.* (2014) warn "*Existing policies are failing. New polices and management actions are required to conserve existing large old trees, provide for their recruitment, and maintain an age structure for tree populations that ensures a perpetual supply of large old trees thereby sustaining the critical functional properties that such trees provide. Without urgent action this iconic growth stage and the biota and ecological functions associated with it are in danger of being seriously depleted or even lost in many ecosystems*".

Lindenmayer *et. al.* (2014) consider "*A critical step in large old tree management is to stop felling them where they persist and begin restoring populations where they have been depleted*".

Hollow-bearing trees, and with them hollow-dependent species, have already been decimated within State forests. The problems such fauna are facing is expected to exponentially worsen as the few remaining large old hollow-bearing trees die-out without replacement trees being available. The full ramifications of irreversible changes already set in place will take a century or more to become fully manifest as the few retained hollow-bearing trees die with even fewer replacements available. A "temporary extinction," due to a prolonged period between the loss of existing large old trees and the recruitment of new ones is inevitable under current management. The few patches from which logging is excluded will do little to ameliorate this.

For example, Milledge (2019) undertook surveys for Barking Owls at 56 sites in the Bungawalbin Creek catchment and at 33 sites in the Upper Coldstream River catchment, finding that they display high site fidelity, though appeared to have significantly diminished on State Forests:

> *The Barking Owl population in the Bungawalbin Creek catchment appears to have remained stable over the past three decades whereas that in the Upper Coldstream River catchment has apparently declined. In Pine Creek State Forest in the latter catchment, four of five previously occupied territories appear to have been lost, possibly due to intensive forestry and associated management practices.*
>
> *The apparent decline in habitat quality in State Forests in the study area was also evident to a lesser extent in Bungawalbin, Doubleduke and Gibberagee State Forests where areas with*

> *historical records no longer appeared to be supporting Barking Owls during the current survey ...*

Squirrel Gliders only require small hollows for denning, though these still require relatively large trees to form. Beyer *et. al.* (2008) found at Bungawalbin that 9 (50%) of 18 den trees used by squirrel gliders were dead trees and 9 were live trees, with diameters of 53.2 ± 6.8 cm for dead trees, and 72.4 ± 7.9 cm for live trees. They identified den trees as a declining resource, observing a den tree collapse rate of 3% per year, with the dead trees considered particularly vulnerable to burning.

Given the slow ageing of eucalypts, and their ultimate mortality, there is a need to retain the remaining hollow-bearing trees, along with the largest and healthiest mature trees to be available for replacements as hollow-bearing trees die.

The aim should be to retain all large trees to increase the availability of hollows over time. This is a long-term process. The old logging rules required the retention of the remnant hollow-bearing trees and for each a healthy mature recruitment tree, as well as requiring retention of a variety of mature trees for nectar. The new Coastal Integrated Forestry Operations Approval (CIFOA) will significantly increase impacts by removing protection for mature recruitment trees and nectar feed trees, as well as allowing for increased logging intensities.

The previous Threatened Species Licence under the IFOA had a variety of requirements for retention of a minimum of 5-8 hollow-bearing trees per hectare, or however many were left. For each hollow-bearing tree they also required retention of a large healthy mature tree as its recruitment (R trees).


With the change to the new logging rules in Braemar SF, which remove the need to retain mature recruitment (R) trees, the Forestry Corporation has been cancelling protection for those identified under the old rules. In this case 26 Koala scats were found under this Grey Gum.

The new CIFOA requires the retention of 8 hollow-bearing trees per hectare. NEFA's plots in the proposed [Sandy Creek Koala Park]() show a current density of 8.3 potential hollow-bearing trees per hectare within this proposal, though observations in areas marked-up for logging in Braemar SF showed that many of these are not being identified as hollow-bearing trees by the Forestry Corporation. Though the bigger problem is that most of the trees identified by NEFA only had potential small hollows unsuitable for many species. It will take many decades for these smaller trees to develop large hollows, provided they are not cut down in the interim.

The key question is whether existing National Parks alone are sufficient to maintain viable populations of such species into the future. The answer is clearly no. For example the Barking Owl only achieved a mean of 14%, and the Squirrel Glider a mean of 17%, of the reservation targets set for viable populations (Flint *et. al*. 2004). The existing reserve system is grossly inadequate to maintain hollow-bearing dependent species into the future.

3.3. Hastings River Mouse Case Study

The Hastings River Mouse *Pseudomys oralis* is listed as 'Endangered' under the EPBC Act. The Hastings River Mouse *Pseudomys oralis* is restricted to upland open forests and woodlands with grass, heath or sedge understorey in north-east New South Wales and south-east Queensland, it is patchily distributed with seven known genetically discrete populations.

There is no '*Conservation Advice'* or *'Listing Advice"* though there is a Recovery Plan developed by NSW in 2005 and adopted by the Commonwealth in 2008 Recovery Plan for the Hastings River Mouse *(Pseudomys oralis)*.

The protracted process of adopting the plan is testimony to NSW's antagonism to Recovery Planning. The Hastings River Mouse (HRM) Recovery Team had its inaugural meeting on the 23rd and 24th July 1992. This was the first recovery team for a threatened fauna species formed in NSW. The Recovery Team implemented a 3 year research program with the aim of finalising a Recovery Plan within 4 years, i.e. by 1996. While the research was completed, the NPWS frustrated the preparation of the plan. After years of procrastination the preliminary draft Recovery Plan was prepared on 19th May 1997 and discussed at the HRMRT meeting of 23rd May. The next meeting of the HRMRT was not until 22nd December 1997, with the draft Recovery Plan not provided until just before that meeting. The final version of the Plan was to be agreed by the 13th February 1998. The HRMRT did not meet again. The Recovery Plan for the Hastings River Mouse was not adopted until April 2005, thirteen years after it was started and 8 years after the draft plan was prepared.

Habitat alteration and fragmentation of Hastings River Mouse habitat is predominantly a result of frequent fire, forestry activities, clearing activities, grazing and weed infestation (DECCW 2005). The Recovery Plan states:

> *Timber harvesting impacts adversely on the Hastings River Mouse by reducing shelter provided by hollow logs and old-growth stems with butt cavities. Harvesting activities also open up the understorey and create roads and tracks potentially leading to increased predation pressure. The Hastings River Mouse has been found in logged areas (Meek et al 2003), however, the largest and most stable populations located to date occur in unlogged old-growth forest (Townley 2000a).*

The Recovery Plan identifies some actions as:

> *6.2 Research*
>
> *Specific Objective: Increase understanding of the ecology and management of the Hastings River Mouse, particularly in relation to disturbance and threatening processes.*
>
> *Action 2.3: Give priority to research projects that focus on the impact of disturbance, threatening processes and the development of mitigation measures.*

> *Justification: Although significant research has been conducted on the Hastings River Mouse, aspects of the species' ecology and causes of rarity remain unclear. Additional knowledge of the species' ecology and response to disturbance and threatening processes will assist in refining and directing recovery actions.*
>
> *6.5 Management*
>
> *Specific Objective: To implement effective management of Hastings River Mouse populations.*
>
> *Action 5.1: Develop Hastings River Mouse population management programs based on the best available knowledge and the Interim Management Guidelines provided in Appendix 3.*
>
> > *Justification: To ensure that populations of the Hastings River Mouse are actively managed using the most recent and available knowledge.*
> >
> > *Specific Objective: To ensure that Hastings River Mouse populations and habitats are identified and managed to minimise impact from developments and activities.*
>
> *Action 5.2: Develop and provide Environmental Impact Assessment (EIA) guidelines to councils and development control authorities to assist in the assessment of potential impacts from activities on Hastings River Mouse populations or habitat.*
>
> > *Justification: To adequately assess the likelihood of presence of Hastings River Mouse populations or habitat in an area, specific survey and assessment techniques are required. Guidelines should have modelled habitat maps attached. Interim guidelines are provided in Appendices 3 and 4.*
> >
> > *Performance Criterion: Guidelines are developed within the life of the plan.*
>
> *Action 5.3: Develop guidelines for the management of Hastings River Mouse populations and habitat and provide to public authorities, land management agencies and private landholders associated with the management of the Hastings River Mouse.*
>
> > *Justification: Provision of guidelines will assist in the management of Hastings River Mouse populations being incorporated into existing planning and management processes. Interim guidelines are provided in Appendix 3.*
> >
> > *Performance Criterion: Guidelines are developed and provided to relevant land managers, public authorities and land holders within three years of the commencement of the plan.*

The 2005 Recovery Plan includes "*Appendix 2. Interim Hastings River Mouse Trapping and Population Survey Guidelines*" identifying "*The minimum specifications for trapping are as follows*":

> *a) The minimum trap effort at a locality must be 100 size A Elliott traps over four nights (400 trap nights) for areas up to 50 hectares of moderate or high quality habitat or both. An additional 400 trap nights (100 traps for four nights) per 50 hectares above the original 50 hectares.*

The 2005 Recovery Plan includes as "Appendix 3. Interim Hastings River Mouse Management Guidelines":

> *Timber Harvesting*
>
> *<u>Surveys:</u> Pre-logging habitat and population surveys (Appendixes 1 & 2) should be carried out by the relevant agencies in areas not covered by the Integrated Forestry Operations Approvals for the Upper North East and Lower North East Regions.*
>
> *<u>Timber Harvesting</u>: Timber harvesting and associated activities should be excluded from areas of medium to high quality Hastings River Mouse habitat.*

> *Within a 200 m buffer around medium to high quality Hastings River Mouse habitat and mapped Hastings River Mouse corridors the following should apply:*
> - *if the area is unlogged or has not been logged since 1950 it will remain unlogged;*
> - *in other areas a minimum of six mature trees with basal hollows, or trees likely to develop basal hollows, per hectare will be retained; all burning will be excluded; and no fire wood collection should occur within 200 m of a known Hastings River Mouse population.*

At Carrai and Werrikimbe, Tasker and Dickman (2004) undertook surveys to assess differences between small mammals at sites that had been grazed and burnt compared to sites with no evident recent burning or grazing, finding 3 Hastings River Mice at 2 grazed sites out of 6,705 trap-nights. This was too small a sample to analyse statistically, though Tasker and Dickman (2004) commented:

> *The only two of our grazed/burnt sites at which this species was found had by far the highest number of logs and mid-storey shrubs ("Rolf" site), and the densest cover of ferns ("Fitzroy" site) of any of the grazed/burnt sites.*
>
> *Thus, although the moderately frequent burning associated with many cattle-grazed areas produces an ideal food supply, too-frequent burning or more intense grazing (as in other grazed forests), may remove the essential shelter component for this species. The fire ecology of P. oralis is a topic that warrants further study and manipulative experimentation.*

The Forestry Corporation are strong advocates for the self-justifying (i.e., Pyke and Read 2003) argument that because Hastings River Mouse occurs in localities where logging or burning has occurred that such disturbances are benign or even necessary, as exemplified by Meek's (2003) statement "*where there has been a continuous history of burning, grazing and/or logging, P. oralis survives and breeds successfully*". (i.e. Meek *et. al.* 2003, Meek 2003, Law *et. al.* 2016).

As identified by Pyke and Read (2002) not all fire is equivalent as there are numerous variables associated with fires, they consider:

> *The management of fire in and around P. oralis populations is likely to be particularly difficult to resolve because it may be an inappropriate fire regime (i.e., fire frequency, intensity and seasonal timing) rather than the presence or absence of fire that has adverse impacts on the species. As already noted, the presence of fire has been found to be associated with positive, negative or neutral impacts on P. oralis. The challenge will therefore be to determine fire regimes that are beneficial to the species.*

A Law *et. al* (2016) study firstly involved resampling Hastings River Mouse logging exclusions, identifying a decline in the total number trapped since the pre-logging surveys, leading them to conclude the results support their hypothesis that Hastings River Mouse declines *"when disturbance is excluded or too frequent*". Though their results are also open to the interpretation that the exclusion areas are inadequate to mitigate logging impacts, an interpretation is that supported by the apparent increasing numbers with time since logging.

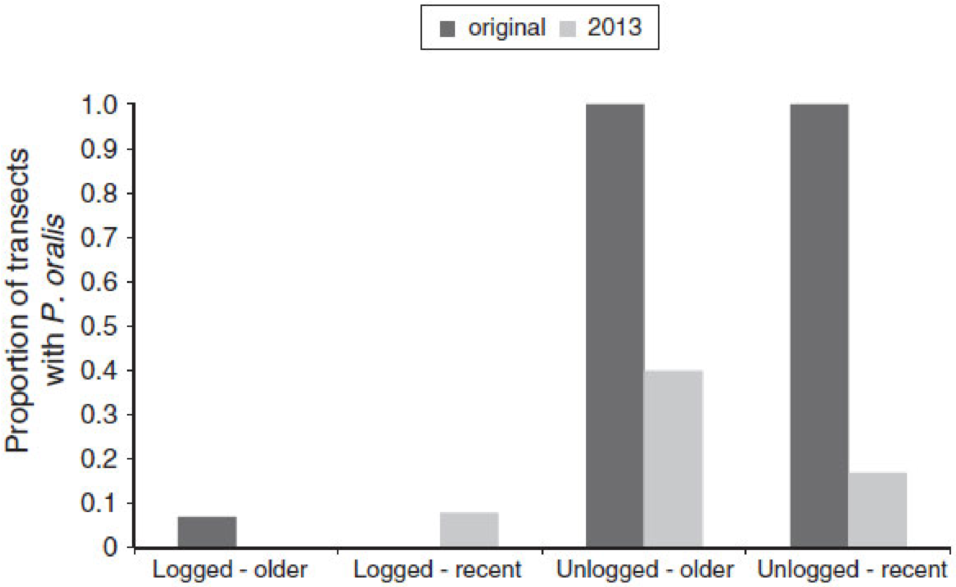


Fig. 1. from Law et. al (2016). Proportion of transects at which Hastings River mouse, *Pseudomys oralis*, was caught in original pre-harvest and repeat surveys (2013). Older (7–15 years) and recent (2–6 years) refer to the time periods since the original surveys were undertaken. Unlogged refers to areas where the species was recorded originally and logging was excluded. Logged refers to areas where the species was originally absent but was subsequently logged.

Law *et. al* (2016)'s interpretation is somewhat simplistic as there is apparently no consideration of other factors that could have contributed to the decline, such as logging around the exclusions or subsequent burning events or grazing. While Law *et. al* (2016) do not account for burning or grazing they recognise them as a significant unaccounted issue:

> *One of the key findings from our study was that our repeat survey in 2013 recorded few P. oralis individuals compared with the initial surveys, which were conducted either 2–6 years or 7–15 years previously. Many sites did not appear to offer suitable habitat for P. oralis, either because the original habitat model was not reliable (B. Law, T. Brassil, L. Gonsalves, pers. obs.) or because subsequent management rendered sites unsuitable. For example, extensive grazing and frequent burning have favoured simple and patchy ground cover dominated by blady grass, Imperata cylindrica, at some sites, such as in Chaelundi State Forest. This would partly explain the continuing low occurrence of P. oralis in 2013 at sites where the species was previously absent. Many of these sites were originally marginal for the species and remained so when we surveyed them. There are likely to be many factors at play leading to the lower numbers of P. oralis trapped in 2013, including some sites that were originally suitable subsequently being rendered unsuitable. For example, at one site (Marengo State Forest), seven P. oralis individuals were trapped originally on two transects in November 2010; however, the site was then burnt three times in 2 years by either arson or grazing leasees (J. Willoughby, pers. comm.) and no individuals were trapped in November 2013, when a patchy ground cover had recovered and floristic diversity was slightly above average. At another site, six P. oralis individuals were caught on one transect in 2009, whereas heavy grazing was evident at this site in 2013, resulting in closely cropped grass cover and a lack of P. oralis captures. These observations suggest that frequent disturbance that simplifies ground cover (Catling 1991) is detrimental for P. oralis. Dense ground cover and abundant shelter sites (e.g. logs, rocks) are recognised as key components of the habitat of P. oralis (Townley 2000; Meek 2002; Meek et al. 2006), which is also consistent with the results of our PCA.*

Without accounting for all significant factors any conclusions from such data are spurious.

Law *et. al* (2016) undertook a second set of surveys "*targeting high-quality P. oralis habitat as determined by expert field inspection*" in areas that were no longer classified as high quality habitat under changes to the IFOA made in 2011 and thus "*logging was permitted under the IFOA*". It is perplexing as to why the EPA changed the rules, at Forestry's insistence, in 2011 to exclude such high quality modelled habitat. Though it is not surprising. Sites were stratified by time since logging: immediate (<1 year since logging, *n* = 1), recent (2–6 years since logging, *n* = 4), intermediate (7–15 years since logging, *n* = 3) and exclusion of logging (35–45 years since logging, *n* = 3).

Law et. al (2016) found that Hastings River Mouse is positively "*associated with a greater cover of heath, lomandra and logs and, to a lesser extent, floristic diversity*" and negatively associated with Bush Rats. They do note that "*rat numbers were high on some transects after logging*", though summarily dismiss it as an inconvenient fact.

Most relevantly they found a total of just 27 Hastings River Mice on the sites with "*a four-fold greater number in intermediate-logging sites than in logging-exclusion sites (Dunnett's test, P < 0.05), whereas recently logged sites were in between (Dunnett's test, P > 0.05). In addition, the single site (two transects) surveyed less than a year after logging recorded no P. oralis".* In summary Law *et. al* (2016) state "*We found that recovery after logging was rapid, peaking ~15 years post-logging, but then declining beyond 35–45 years post-logging*".

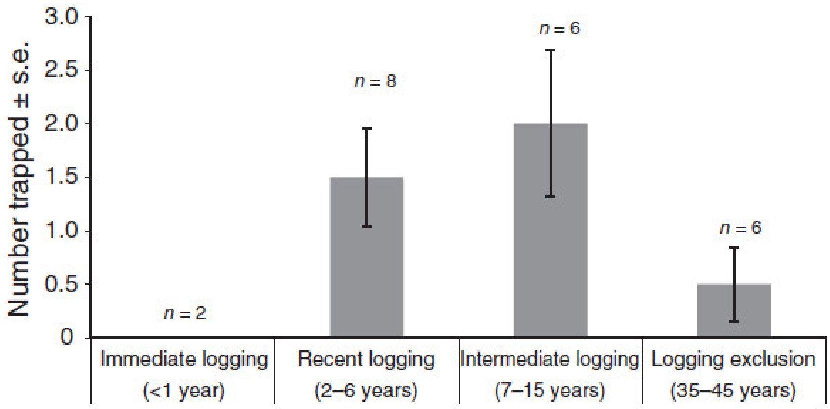


Fig. 3 from Law *et. al* (2016). Mean number of Hastings River mouse, *Pseudomys oralis*, trapped per transect at different times since logging.

As there are no baseline pre-logging data, and so many potential variables that could have affected these results it is hard to fathom how Law *et. al* (2016) could conclude that their findings just relate to time since logging. Yet again the influence of fire is recognised, but not accounted for. Law *et. al* (2016) observe "*Three sites had bare ground generated by recent fire and these were characterised by an absence of P. oralis and other small mammals*", and "*Binns (1995) observed in the Dorrigo forests that unlogged areas were, on average, less recently burnt than were logged sites and this could have contributed to the decline of P. oralis we documented in our surveys where logging was excluded*".

Law *et. al* (2016) hypothesise:

> *Initially, P. oralis is likely to be absent or rare in the 1–2-year period of recovery from the mechanical damage to ground cover from logging (and post-logging burn). Thereafter, a dense ground cover flourishes, whereas the canopy remains open. Then, depending on the site and fire frequency, the site remains suitable for P. oralis or the shrub and eucalypt regrowth layer develops in a more dominant state than it was preharvest and the quality of the ground cover diminishes. If the site progresses along this latter path, then R. fuscipes dominates in shrub, fern, and eucalypt regrowth habitat that has only sparse grassy understorey.*

While Law *et. al* (2016) use their hypothesis to justify frequent logging disturbance (based upon questionable premises), their conclusions can equally be interpreted to argue that the loss of oldgrowth forest, and the ongoing decline in larger trees, with the promotion of dense tree regrowth that shades the understorey, will have significant impacts on the feed species and groundcover attributes required by Hastings River Mouse. It is likely that their habitat is being degraded with each logging event.

The Hastings River Mouse was one of those targeted for reservation in the CRA process, with population targets established for 8 discrete populations. These targets were adopted to represent the number of breeding females required to be included in reserves to achieve the long term survival of the species. As with most endangered species the CRA process abjectly failed to deliver on the reservation requirements for this species, with only 8% of the mean of the habitat targeted for reservation included in the reserve system in north-east NSW, with 6 populations achieving less than 10% of their reservation targets (see Table).

HASTINGS RIVER MOUSE RESERVE STATUS IN NORTH EAST NSW AS AT 2004 (From Flint *et. al.* 2004)

	Population Targeted for Reservation (no females)	Estimated Total Population Reserved	Percentage of Reserve Target Achieved
Hastings River Mouse - pop.1	4238	3	1%
Hastings River Mouse - pop.2	4251	116	3%
Hastings River Mouse - pop.3	4251	322	8%
Hastings River Mouse - pop.4	4251	47	1%
Hastings River Mouse - pop.5	4238	523	12%
Hastings River Mouse - pop.6	4238	1231	29%
Hastings River Mouse - pop.7	4251	287	7%
Hastings River Mouse - pop.8	4251	334	8%
TOTAL	33969	2863	8%

The Hastings River Mouse has already been identified as having a high likelihood of becoming extinct within the next 50 years. The extremely low level of reservation achieved has guaranteed that this will be the case unless strong and effective management is applied off-reserve. The RFA requires that IFOA prescriptions take into account the extent of reserved habitat (1A 9, 1(B)13).

3.3.1. Threatened Species Licence

For public lands the 1988 Threatened Species Licence gave forests NSW the choice of establishing *"An exclusion zone, or exclusion zones, ... to protect all modelled habitat within the compartment*" or undertaking specified habitat assessments to identify habitat of moderate or high suitability within which targeted trapping surveys are required (TSL 8.8.9).. The Threatened Species Licence (TSL 6.13) required that exclusion zones of 200 metres must be established around records of Hastings River Mouse, extending to 800m in Hastings River Mouse habitat assessed as of moderate or high suitability. So the requirement is to only protect part of the medium and high quality habitat if they happen to catch a Hasting River Mouse, with no application of a 200m buffer to that habitat..

This is effectively a major reduction on what the Recovery Plan identifies as a Management Guideline in Appendix 3 for logging, though the Recovery Plan recognises this prescription, stating:

> *In NSW, an Integrated Forestry Operations Approval (IFOA) granted under part 4 of the NSW Forestry and National Park Estate Act 1998 (FNPE Act) regulates the carrying out of certain forestry operations, including logging, in the public forests of a region. The terms of the Threatened Species Licence of the IFOA outline the minimum protection measures*

> *required to limit the impact of forestry activities on threatened species and their habitats and forms the basis for DECC regulation of those activities. The Threatened Species Licence for the Upper North East and Lower North East Regions include measures for the protection of the Hastings River Mouse.*
>
> *Specific prescriptions for the Hastings River Mouse state that where there is a record of the species in a compartment or within 800 m outside the boundary of the compartment the following must apply:*
>
> > *a) Within 800 m of a record of the Hastings River Mouse, 'specified forestry activities' as defined in the IFOA, are prohibited from all areas assessed as moderate or high suitability Hastings River Mouse habitat.*
> >
> > *b) An exclusion zone of at least 200 m radius must be implemented around all records of the Hastings River Mouse.*
>
> *The prescriptions dictate how targeted surveys for the Hastings River Mouse and habitat suitability assessments must be conducted. Hastings River Mouse microhabitat models (Smith & Quin 1997) used to determine the level of habitat suitability are included in the prescriptions (See Appendix 1).*
>
> *There are potential threats from logging to Hastings River Mouse sites on private property. Issues relating to timber harvesting include road construction, use of heavy machinery, timber removal and burning to stimulate regeneration and limit wildfires (Smith et al. 1994).*
>
> *Many of the identified threats to the Hastings River Mouse are intrinsically linked and the magnitude of the effect of one threat is often related to the presence or absence of other threatening processes*

The Threatened Species Licence was amended in 2007 and in 2010 so as to allow logging operations within 31 compartments in 6 State Forests to be undertaken within areas that would otherwise be required to be protected (TSL 6.13B). These included Mount Mitchell State Forest Compartments 16, 17 and 18. This over-rides TSL 6.13 by establishing mapped HRM exclusion zone and HRM operational zones, with snigging and roading allowed in the operational zones.

These changes were in contravention of the Recovery Plan Action 5.1: Develop Hastings River Mouse population management programs based on the best available knowledge and the Interim Management Guidelines provided in Appendix 3. It is a safe bet that this major wind-back in protection for the Hastings River Mouse was never subject to monitoring to assess impacts on Hastings River Mouse and the effectiveness of the new measures.

What is most alarming is that this reduced protection appears to have been approved because of the high numbers of Hastings River Mice in these areas. For example, there were 16 records of Hastings River Mouse made in compartment 16 of Mount Mitchell SF, indicating a much larger population inhabiting the area and one likely to be of national significance. Such areas should be designated critical habitat and fully protected (particularly given the poor reservation status of this species) rather than being allowed to be logged with reduced protection.

The 2010 Review of NSW Forest Agreements and Integrated Forestry Operations Approvals: Upper North East, Lower North East, Eden and Southern regions stated:

> *Current Hasting River Mouse survey requirements and exclusion zones do not reflect current knowledge of Hasting River Mouse occurrence. Habitat suitability surveys are used to identify areas where trapping is required but are limited to areas within modelled habitat. The model is deficient because many records of the species fall outside of modelled habitat.*

> *To counter this deficiency, habitat suitability surveys within compartments containing 'known habitat' as well as those containing modelled habitat is appropriate; however, there is a need for Forests NSW to document the process of 'rapid assessment' of habitat suitability.*
>
> *Forests NSW proposes that the Hastings River Mouse is now more widespread and numerous than when existing conditions were developed, and that the home range of the species is now known to be relatively small. As such, Forests NSW considers that exclusion zones of up to 800 m diameter are not appropriate.*

One of the recommended changes was:

> *Forests NSW is to apply an exclusion zone covering 12 ha (equivalent to a circle of approximately 200 m radius) where there is a record of Hastings River Mouse of suitable habitat.*

It is astounding that the EPA (2010) justify the reduced prescriptions on the grounds that the Hastings River Mouse is "*now more widespread and numerous".* While more localities of mice had been identified because of the requirements for pre-logging surveys, it is pertinent that from its re-discovery in 1969 up until the EPA's claim of numerous mice, it had been recorded from less than 700 localities. This is by no measure a large number of records over 40 years. Even with all the Forestry surveys over the past decade there are only 311 locality records for this short lived species on State Forests.

In contravention of the Recovery Plan requirement the prescription for the Hastings River Mouse was changed on the 7 November 2011. There does not appear to have been any attempt to critically review Forests NSW's claims, or to assess the likely consequences of the changes on Hastings River Mouse. The retention of habitat around Hastings River Mouse records was dramatically reduced from an exclusion area encompassing all habitat of moderate or high suitability within 800m (a potential maximum of 200ha) and all land within 200m, down to a 12ha exclusion area encompassing as much habitat as practical around a record:

> *6.13 Hastings River Mouse Pseudomys oralis*
>
> *Where there is a record of a Hastings River Mouse in the compartment or within 200 metres outside the boundary of the compartment, the following must apply:*
>
> *a) A 12 ha exclusion zone that takes in as much Suitable Habitat for Hastings River Mouse as practical, must be established around the record. The exclusion zone need not be symmetrical and should, where possible, link to other areas excluded from harvesting activities.*

This had the effect of opening-up large areas of Hastings River Mouse Habitat protected for well over a decade for logging.

Instead of undertaking surveys the Forestry Corporation have the option under condition 7(x) of "An exclusion zone, or exclusion zones, must be implement to protect all modelled habitat within the compartment".

The 7 November 2011 change also significantly reduced the likelihood of locating Hastings River Mouse by, for example, halving the Recovery Plan's (Appendix 2) trapping effort of a minimum of 400 trap nights per 50ha down to 200 trap nights per 50ha:

> *8.8.9 B Targeted surveys*
> *Surveys to determine the presence of Hastings River Mouse must be conducted as follows:*
> *a) The minimum specifications for trapping are as follows:*
>
> > *i. The trap effort is to be at a rate of 1 size A Elliott trap over four nights for each hectare identified as having Suitable Habitat for Hastings River Mouse (either as the*

result of habitat suitability surveys under 8.8.9A or otherwise such as during compartment traverse or incidentally recorded).
i. The minimum number of traps will be 50 for up to 50 hectares, with 25 additional traps for each 25 hectares increment above 50 hectares, as follows:

- *10-50 hectares 50 traps*
- *50-75 hectares 75 traps*
- *75-100 hectares 100 traps*
- *> 100 hectares add additional 25 traps for each 25 ha increment*

This change makes it less likely that the Hastings River Mouse will be located where it occurs. For example Meek et. al. (2003) report the results of pre-logging surveys for Hastings River Mouse at 7 sites where it was recorded (there is no information on how many apparently suitable sites it was not recorded at) identifying "*Trap success for P. oralis at Marengo was 1.7% (excluding recaptures), 0.1% at Chaelundi, 0.3% at Hyland, 0.7% for Styx River, 0.8% for Glen Elgin, 0.4% for Enfield and 0.2% for Gibraltar Range*". At 3 sites only single Hastings River Mouse were recorded, being 1 per 800 trap nights at Chaelundi, 1 per 400 trap nights at Hyland and 1 per 250 trap nights at Enfield (given the minimum effort was meant to be 400 trap nights it is not known why the Enfield trap nights were so low).

Given this confirmation of the low likelihood of detecting Hastings River Mouse, even when it is present, it is perplexing as to why the EPA effectively removed protection from many localities by reducing required trap-nights and thus the probability of detecting any Hastings River Mice that are present.

This major reduction in habitat protection is contrary to the National Recovery Plan for this species, most significantly Appendix 2. minimum specifications for trapping and Appendix 3 Timber Harvesting Guidelines. Such ad-hoc and unjustified changes are contrary to the objective to implement effective management of Hastings River Mouse populations in accordance with actions 5.1. and 5.2:

There is evidence that Hastings River Mice declined in exclusion areas following logging, even with significantly larger exclusions than now applied (Law *et. al* 2016, see above discussion). Foresters complain that the models being relied upon for prescriptions are unreliable, with modelled habitat deleted from a 2011 revision found to have significant occupancy (Law *et. al* 2016). Trapping effort to locate any mice present was halved despite evidence that this would mean Hastings River Mice would no longer be detected at some sites (Meek *et. al.* 2003, see below).

The outcome is that many areas of occupied Hastings River Mouse Habitat is being logged without any prescriptions being applied what-so-ever (Law *et. al* 2016, see above discussion), while prescriptions applied are apparently inadequate.

The TSL prescription is often ignored, for example, in three separate forests Sparks (2010) identified a total of 83 hectares of modelled habitat of the Hastings River Mouse that was logged without the required habitat or trapping surveys having been undertaken to justify not excluding the areas from logging. Because the required surveys were not done it is not known what effect this had on Hastings River Mouse. In a typically grossly inadequate response, the EPA (then DECCW) issued warning letters for two of these three breaches.

3.3.2. Private Native Forestry

The Private Native Forestry Code of Practice for Northern NSW requires:

> *Where there is a Hastings River mouse record within the area of forest operations or within 200 metres of the area of forest operations, the following must apply:*

> *(a) An exclusion zone with a 200-metre radius (about 12.5 hectares) must be identified, centred on the location of the record, within which the following additional prescriptions must be implemented:*
>
> > *(i) No forest operations or removal of understorey plants or groundcover are permitted.*
> > *(ii) No post-harvest burning is permitted.*
> > *(iii) Disturbance to any seepage areas within or adjacent to the exclusion zone, as well as to ground logs, rocks and litter, must be minimised.*

The Recovery Plan (DECCW 2005) identifies that "*Eight percent of known Hastings River Mouse sites are located on private land. There is a high probability that additional populations are located on private land*". There are likely to be significant populations on freehold land as 21% of high quality habitat is modelled on freehold land.

The prescription applied to forestry operations on freehold land are a sham. Contrary to the Recovery Plan, the Private Native Forestry Code of Practice for Northern NSW ignores modelled habitat for this species and requires that a 200m exclusion area must be established around any known records. Because there are no requirements for surveys to locate this species (even in modelled habitat), and it is unlikely they will have been previously recorded on most private property sites where it occurs, this prescription will have absolutely no effect on most logging operations undertaken within occupied Hastings River Mouse habitat on private land.

3.3.3. Coastal IFOA

For Hastings River Mouse the new Coastal IFOA requires:

> *Where there is a record of a Hastings River Mouse in the operational area, or within 200 metres outside the boundary of the operational area:*
>
> > *(a) an exclusion zone that is 12 hectares or greater must be retained around each record, which must:*
> >
> > > *i. be dominated by Hastings River Mouse micro-habitat;*
> > > *ii. have a low edge to area ratio; and*
> > > *iii. link to other ESAs.*

The current requirement to encompass "as much Suitable Habitat for Hastings River Mouse as practical" has effectively been reduced to " dominated by Hastings River Mouse micro-habitat" which is a lesser requirement.

The new IFOA Protocol 20: Pre-operational surveys (8) (f) Hastings River Mouse trapping surveys proposes "*25 traps for each 25 hectares of Hastings River Mouse micro-habitat in the base net area, with a minimum effort of 50 traps*", with traps "*placed for a minimum of four nights*". This is equivalent to the current prescription.

The Recovery Plan for the Endangered Hastings River Mouse was adopted in 2005 by NSW thirteen years after it was started and 8 years after the draft plan was prepared. It was adopted in 2008 by the Commonweaith. It includes specific survey and habitat requirements which were initially incorporated into the Threatened Species Licence in a reduced form. In contravention of the Recovery Plan the Threatened Species Licence was amended in 2007 and in 2010 so as allow logging operations within 31 compartments in 6 State Forests to be undertaken within areas that would otherwise be required to be protected. The prescription for the Hastings River Mouse was changed in November 2011 to significantly reduce exclusion areas and survey requirements to reduce the likelihood of detecting its presence. Habitat retention requirements have been further reduced in the Coastal IFOA. There is evidence that the reduced surveys have significantly reduced the likelihood of detecting Hastings River Mouse, though there has never been any attempt to assess the effectiveness of the reduced prescription. The new prescriptions are clearly not consistent with the Recovery Plan.

The Endangered Hastings River Mouse is one of those species worst affected by the 2019 fires in Australia. While there is a debate about long-term impacts, it is a species that is known and agreed to be significantly affected in the short-term by burning and logging.

On the 20 January the NSW Government identified that 82% of the known localities of Hastings River Mouse had been burnt, the third worst affected species in NSW. With its identified susceptibility to burning and over 80% of the 1,000 locations it has ever been recorded at in NSW burnt in the 2019-20 fires it is vulnerable to having been eliminated from a large part of its range. On 11 February 2020 the Commonwealth identified the Hastings River Mouse as one of 113 animal species nationally assessed by an expert panel as the highest priorities for urgent management intervention, noting:

> *Two priority actions should be carried out for all high priority species: 1) Rapid on-ground surveys to establish extent of population loss and provide a baseline for ongoing monitoring. 2) Protecting unburnt areas within or adjacent to recently burnt ground that provide refuge, as well as unburnt areas that are not adjacent to burnt areas, especially from extensive, intense fire.*

The Commonwealth has included Hastings River Mouse *Pseudomys oralis* as one of 17 mammals of high priority for urgent management intervention , because it is one of 6 mammals with a high Risk value and one of 11 mammals with high trait scores for Fire-and Post-fire mortality. Hastings River Mouse is given one of the highest RISK due to imperilment and fire overlap of 6, and one of the highest Score for Fire and Post-fire mortality of 17.

The Commonwealth (2020) identify as required actions:

Protecting unburnt areas within or adjacent to recently burnt ground that provide refuges.

- *Essential for all priority taxa.*

Rapid on-ground assessment for species and communities of concern (survey to establish extent of pop loss, and establish baseline for ongoing monitoring).

- *Essential for all priority taxa.*

Feral predator and herbivore control to reduce the pressure on native species where appropriate.

- *Control of introduced predators for species that are highly susceptible to predation, especially after fire (loss of cover). Actions could include provision of artificial shelters, or predation exclusion (by fencing) as well as, or instead of, reducing predator numbers. Examples include:*
    - *All 14 ground-dwelling priority mammals (although potentially less critical for some species).*
- *Control of introduced herbivores, by exclusion or by reducing numbers. Examples include:*
    - *All ground-dwelling mammals (herbivores need food; all species need cover).*

In accordance with the Recovery Plan prescription, an 800m radius area was mapped around all NSW records of Hastings River Mouse to assess recent impacts. This was intersected with Forestry Corporation logging history from July 2000 to March 2019 for State Forests to identify the magnitude of logging impacts since the RFA (note that logging records are incomplete). To assess the magnitude of the impacts of the recent fires, the 800m buffers were intersected with GEEBAM v2 mapping of recent fires to identify the extent of disturbances in the vicinity of records.

There are 17,836 ha of State Forests within 800m of records of Hastings River Mice. Over the past 20 years more than 6,777 ha (38%) of this has been logged. Last year up to 15,955 ha (89%) was burned. This represents significant disturbance in the vicinity of records.

Canopy burning (GEEBAM v2p2) within 800m of records of Hastings River Mouse in NSW for (a) all tenures, (b) State forests, and (c) Styx River State Forest.

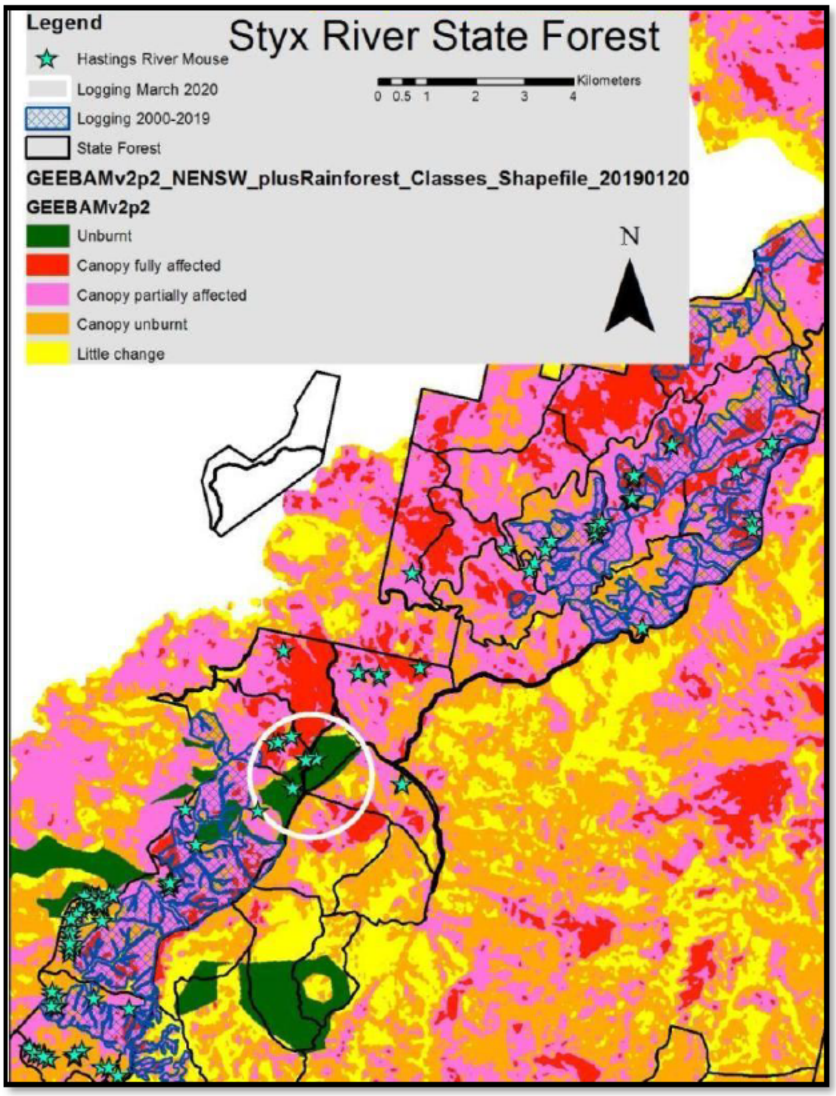
	Canopy fully affected (ha)		Canopy partially affected		Canopy unburnt		Little change		Unburnt		TOTAL
	ha	%	ha	%	ha	%	ha	%	ha	%	ha
All records	4,801	13.1	13,097	35.8	8,340	22.8	3,006	8.2	7,383	20.2	36,727
State Forest	2,729	15.3	8,010	44.9	4,365	24.5	851	4.8	1878	10.5	17,933
Styx River SF	677	16.3	2,230	53.6	936	22.5	105	2.5	210	5.1	4258

The Forestry Corporation have concentrated their logging activities in Styx River State Forest in recent years with 19 compartments totalling 6,211 ha (36%) logged since 2011. Some 32% of the potential habitat of the Hastings River Mouse has been logged in the past decade. Fire burnt into Styx River State Forest in mid November and by late December 2019 78-89% of the forest had burnt, of the 198 locations identified for Hastings River Mouse only 5 (2.5%) escaped burning, with some 95% of potential habitat burnt. In addition some 32% of potential habitat has been logged in the past decade.

Logging started in Compartments 540, 541, 542 and 552 in August 2017 and continued until around 6 March 2020. The logging rules only require surveys of limited samples of the area and then for small 12ha exclusions around one or more records. There are no requirements to identify the full extent of occupancy and protect all mice. The Harvesting Plan map identifies 9 exclusion areas, each around 12 ha in size, around 26 locations of Hastings River Mouse. Strangely the Harvesting Plan itself does not acknowledge the presence of Hastings River Mouse or discuss its requirements.

Of the 9 Hastings River Mouse exclusion areas only the two in the unburnt patch escaped burning, with the other 7 fully burnt, comprised of 16% canopy fully affected, 47% canopy partially affected and 37% canopy unburnt according to GEEBAM v2. Contrary to the Commonwealth's advice the NSW Government continued to log the only unburnt patch of occupied Hastings River Mouse habitat known in Styx River State Forest where 5 Hastings River Mice had been found. It is astounding that the Environment Protection Authority allowed this to continue from mid-November 2019 until after conservationists went public in the beginning of March 2020.

Because the recent fires occurred during a record drought and heatwave the intensity of the fire has severely impacted the canopy in many places, with the ground layer of vegetation, leaf litter and woody debris, which is the habitat for the Hastings River Mouse, consumed or compromised throughout. Resprouting of plants from underground rhizomes is occurring in burnt areas but is dominated by soft bracken *Pteridium esculentum* and *Lomandra* spp. While this may provide some cover for surviving small mammals it is not the preferred habitat of HRM and will likely favour competing species such as the Bush Rat *Rattus fuscipes*. The uniform nature of the ground fire has not produced cooler patch areas which would allow for a range of ground plants to establish and provide the diverse range of food source which HRM require.



Map showing Hastings River Mouse records, canopy loss from 2019 fire, and logging 2011-March 2019 (note later logging records not available), with the unburnt patch logged in late February 2020 indicated. There are 4,158 ha of Styx River State Forest within 800m of records of Hastings River Mice. Over the past 10 years more than 1,322 ha (32%) of this has been logged. In 2019 up to 3,948 ha (95%) was burned. The combination of logging and burning impacts represents a very significant level of disturbance in a short period of time for a disturbance sensitive species.

The unburnt patch encompassing the two Hastings River Mouse exclusions is 160 ha, of which the HRM exclusions total around 29ha. There are some additional stream exclusions though most of the balance of the unburnt patch was being logged at the time of the assessment, adjacent and right up to the exclusion zones. This included areas outside the exclusions that were likely HRM habitat.

Logging in unburnt areas adjacent to Hastings River Mouse Exclusion Zones that was potential HRM habitat.

While Law *et. al* (2016) conjecture about the long-term impacts of logging and appropriate burning regimes, it is apparent from their results that the short-term impacts of both logging and fire on the habitat and populations of Hastings River Mouse are significant. Therefore the already diminished populations of Hastings River Mouse will have been significantly diminished by the vast majority of their habitat being burnt. To now log their unburnt refuges, or the burnt refuges where mice have survived, is criminal and has to stop.

3.3. Now with the fires burning most known localities of the Hastings River Mouse there can be no excuse for continued complacency. Populations will have been decimated, and habitat degraded, making the current logging prescriptions redundant because habitat is likely not to be recognisable for some time and the low numbers of survivors will render trapping ineffective. All compartments with records or modelled habitat of Hastings River Mouse should be put under moratorium while surveys of known localities are undertaken to assess appropriate criteria and trapping effort to identify habitat, and to quantify whether it should now be considered critically endangered. For private properties all modelled habitat should be immediately placed under moratorium while an effective prescription is developed.

3.4: Bell Miner Associated Dieback

Forests affected by Bell Miner Associated Dieback (BMAD) are characterized by low dense understories of weeds (mostly lantana) or vines, overtopped by scattered dead or dying eucalypts, with a cacophony of Bell Miner calls.

Bell Miners are the Bell Birds that were eulogized in Henry Kendall's 1869 poem. Henry Kendall was appointed inspector of state forests in 1881. Little did he realise that the "Bell-birds" he extolled would one day cause the degradation and death of the forests he loved at the hands of the agency he served. Now the "*notes of the bell-birds ... running and ringing"* are no longer confined to the "*spring and to rive*r" and are expanding throughout the landscape at an alarming rate. To many their calls no longer have connotations of *"the beauty and strength of the deep mountain valleys"* but rather of lantana understories and dying trees.

By the early 1940s (Campbell and Moore 1943) BMAD was recognised as killing thousands of hectares of forest. It is not a new problem, just a neglected one that appears to be rapidly expanding.

The seriousness of BMAD is acknowledged in the NSW & CoA (2009) 5 year review of the RFA:

> *The resultant cycle of tree stress commonly causes the eventual death of forest stands, and serious ecosystem decline. In NSW the potential impact of BMAD-induced native vegetation dieback represents a serious threat to sclerophyll forest communities, particularly wet sclerophyll forests, from Queensland to the Victorian border. The forests most susceptible to dieback are those dominated by Dunn's white gum (Eucalyptus dunnii), Sydney blue gum (E. saligna), flooded gum (E. grandis) and grey ironbark (E. siderophloia). There is also evidence that some normally nonsusceptible dry sclerophyll types may be affected when dieback is extreme. Current estimates place the potential at-risk areas at a minimum of approximately two and a half million hectares across both public and private land tenures in NSW.*
>
> *BMAD is emerging as a pressing forest management issue in both the UNE and LNE regions. The potential impacts include:*
>
> - *degradation of sclerophyll forest ecosystems across the UNE and LNE*
> - *reduction in diversity and abundance of threatened flora and fauna species including Dunn's white gum and rufous bettong*
> - *increased weed invasion and associated displacement of native forest species.*
>
> *Dieback-affected areas are located in the catchments of the major rivers of the North Coast of NSW including the Tweed, Richmond, Clarence, Macleay and Hastings. Maintenance of water quality in these river systems is critically dependent on maintenance of healthy forest cover over the catchment uplands. Bell miner associated dieback has the potential to degrade these forests, and consequently impact negatively on rivers and catchment communities through increased sediment and nutrient loads, and increased frequency and intensity of flooding.*

Serious stuff, but not enough for the Government to stop compounding the problem by logging affected and susceptible stands.

Since 1992 NEFA have raised the problem of BMAD in numerous forums, committees, submissions, audit reports and complaints to both State and Federal Environment Ministers. We have accompanied the Forestry Corporation CEO Nick Roberts, the EPA's CEO Barry Buffier, and the then Minister for the Environment Mark Speakman, and a variety of others, on site inspections of BMAD to demonstrate the problem. We have made numerous submissions to inquiries, identified the problem in forest audits, and publicised the problem.

The core of the problem with having it addressed is the refusal for the Forestry Corporation or the Environment Protection Authority to admit any connection with logging – despite the abundant evidence to the contrary.

The basic process for initiating Bell Miner Associated Dieback (BMAD) is:

- Logging removes canopy and creates soil disturbance
- lantana invades and takes over understorey
- Bell Miners thrive in altered habitat and aggressively exclude most other species
- Bell Miners 'farm' sap sucking psyllids that feed on eucalypt leaves,
- populations of psyllids explode, sucking the life out of eucalypts
- eucalypts sicken and die, often over decades
- BMAD

NEFA has no doubt that it is clear that logging initiates lantana invasion and BMAD, and that relogging affected stands aggravates BMAD.

The NSW Scientific Committee's (2008) final determination for listing 'Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners' as a Key Threatening Process notes that

> *Broad-scale canopy dieback associated with psyllids and Bell Miners usually occurs in disturbed landscapes, and involves interactions between habitat fragmentation, logging, nutrient enrichment, altered fire regimes and weed-invasion (Wardell-Johnson et al. 2006). ... Over-abundant psyllid populations and Bell Miner colonies tend to be initiated in sites with high soil moisture and suitable tree species where tree canopy cover has been reduced by 35 – 65 % and which contain a dense understorey, often of Lantana camara.*

Lantana itself is a weed of national significance and a key threatening process. The NSW Scientific Committee has also listed the 'Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens. lat*)' as a Key Threatening Process, noting *"There is a strong correlation between Lantana establishment and disturbance ..., with critical factors being disturbance-mediated increases in light and available soil nutrients".*

Stone *et. al.* (1995) undertook a review for State Forests, finding that *"The vast majority of plots (97%) had been exposed to some degree of logging and were on their second or third rotations ... A possible long-term explanation of why the dieback problem may be increasing, is that the proportion of moist sclerophyll forest being exposed to selective logging is increasing throughout the State."*

Based on her research for the Forestry Corporation and review of the literature, Stone (1999) put forward a conceptual model for BMAD identifying logging as the initial cause:

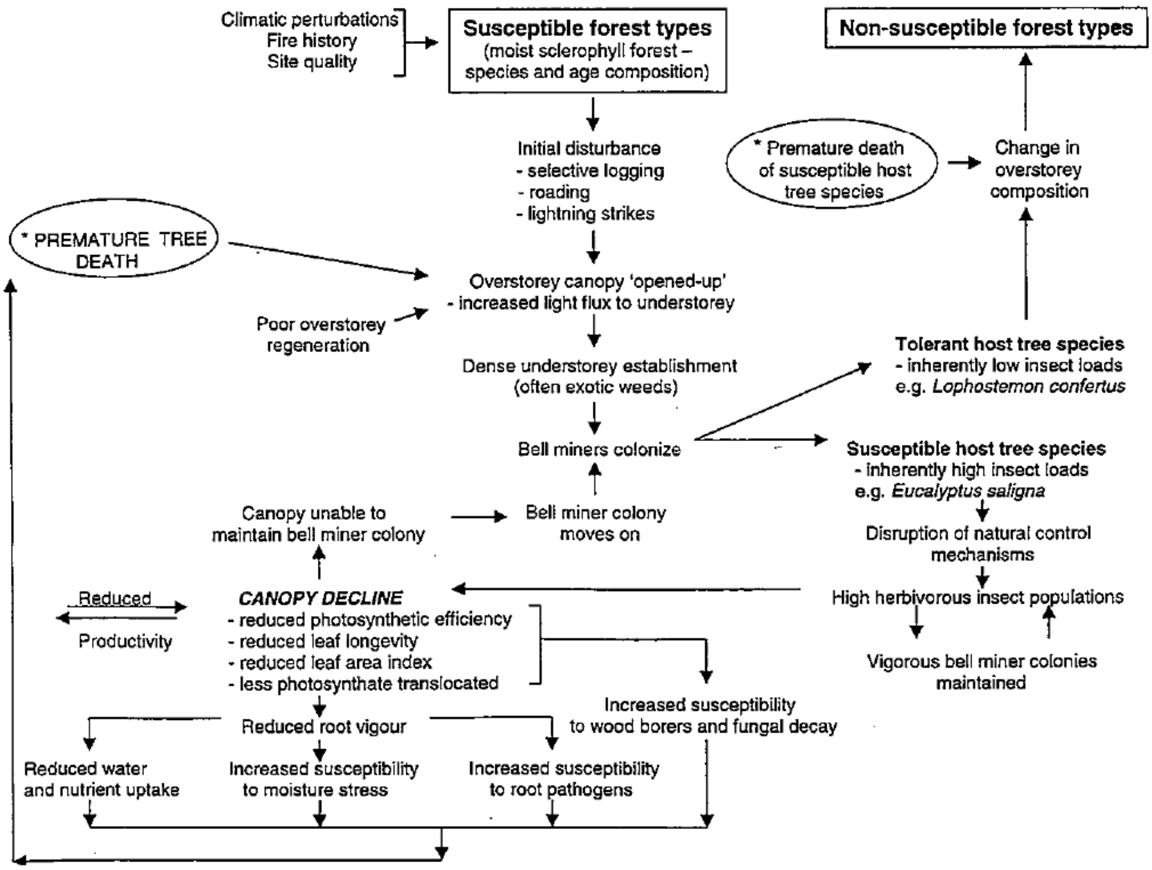


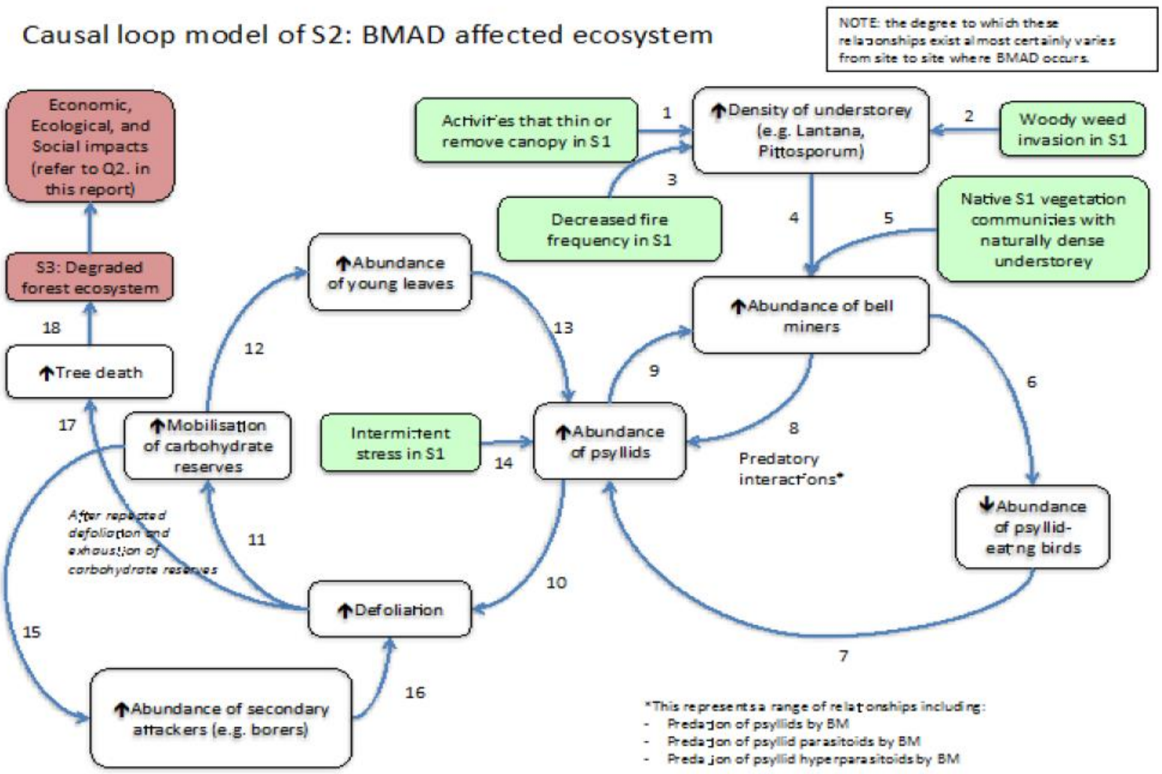
Figure 1. A conceptual model illustrating possible relationships and several feedback loops between processes which may contribute to canopy dieback associated with bell miners in moist eucalypt forests.

Kavanagh and Stanton (2003) in their assessment of logged and unlogged coupes over 22 years near Eden, considered that the increase in Bell Miners in moist forest types at the heads of two gullies in logged coupes *"provides support for the hypothesis (Stone 1999) that logging disturbance can be a contributing factor in creating the habitat conditions required by the Bell Miner"*.

Florence (2005) also emphasised the "struggle" between eucalypt and rainforest as a fundamental factor in BMAD, basically concluding, as has been apparent for many decades, that such forests are not suitable for the management they are being subject to:

> *Where destabilised by post-settlement fire and logging, changes in ecosystem processes may have exposed the limits of the eucalypts' capacity to cope with soils with consistently high levels of available nutrients.*

NSW DPI recently completed another literature review of the causes of BMAD (Silver and Carnegie 2017). Almost 20 years after Stone (1999) they derived yet another conceptual model, which yet again identifies "*activities that thin or remove canopy*" as the primary cause of BMAD.



Summary extracts from literature review of Silver and Carnegie (2017):

- *Activities that reduce the density of overstorey canopy, or produce gaps in the overstorey, result in increased light availability and reduced competition for space and other resources resulting in an increase in density of understorey plants, such as lantana*
- *Numerous studies have shown that woody weed invasion, especially lantana, leads to an increase in density of the understorey, often to the detriment of native understorey and mid-storey tree species. Canopy thinning or gaps provide ideal conditions for lantana (primarily increased light), which tends to subsequently dominate the site (Duggin and Gentle,1998; Gentle and Duggin,1997). Lantana can take better advantage of increased resources (nutrients) following disturbance, thus accumulating more biomass and further suppressing native shrub species (Gentle and Duggin, 1998).*

- *A dense understorey, either of exotics (e.g. lantana) or natives, is said to be the preferred habitat of Bell miners for nesting as it is assumed such habitat "facilitates cooperative defence of their territory from predators and competitors (Stone et al., 2008).*
- *Numerous studies have shown that Bell miners apply interspecific aggression via mobbing behaviour to exclude other avian species from their colony territory.*
- *A high proportion of the avian species that are excluded from Bell miner sites, such as spotted pardalotes, white-naped honeyeaters and crimson rosellas, predate on psyllids*
- *Several studies have reported an observed increase in psyllid numbers in areas supporting high numbers of Bell miners*
- *Numerous studies have shown the link between high numbers of psyllids and Bell miner abundance, with Bell miners observed at sites with high numbers of psyllids*
- *Numerous studies have shown a clear link between psyllid attack and defoliation*
- *When biotic or abiotic agents defoliate trees, they utilise carbohydrates — via ongoing photosynthesis or from storage organs — to replace foliage. If trees are repeatedly severely defoliated, such that photosynthesis is hindered (or ceases) due to lack of photosynthetic tissues (leaves), then carbohydrate stores can be depleted during crown replacement and ultimately result in dieback and death*
- *Numerous studies have measured the mobilisation of stored carbohydrates to replace foliage following defoliation events*
- *the favourableness of E. blakelyi leaves as a source of food was the principal influence affecting Glycaspis spp. abundance; young leaves (4–8 weeks old) were more favourable than mature leaves,*
- *Plant stress results in increased concentrations of nitrogen in the phloem, which benefits sap-sucking insects (Huberty and Denno, 2004). Conversely, the resultant reduction in turgor from drought stress may impede psyllid feeding due to reduced turgor. Intermittent water stress, therefore, appears to benefit sap-suckers as opposed to continuous water stress.*
- *Severe and repeated defoliation by insects, resulting in reduced carbohydrate reserves, has been shown to result in an increase in attack by secondary pests and diseases.*
- *Secondary pests and diseases attack trees weakened by repeated defoliation and starved of carbohydrate reserves.*
- *Several studies have shown that repeated, severe defoliation by insects (or artificial crown removal) can exhaust carbohydrate reserves due to ongoing crown regeneration — and lack of carbohydrate replacement via photosynthesis due to lack of photosynthetic organs — leading to tree mortality*

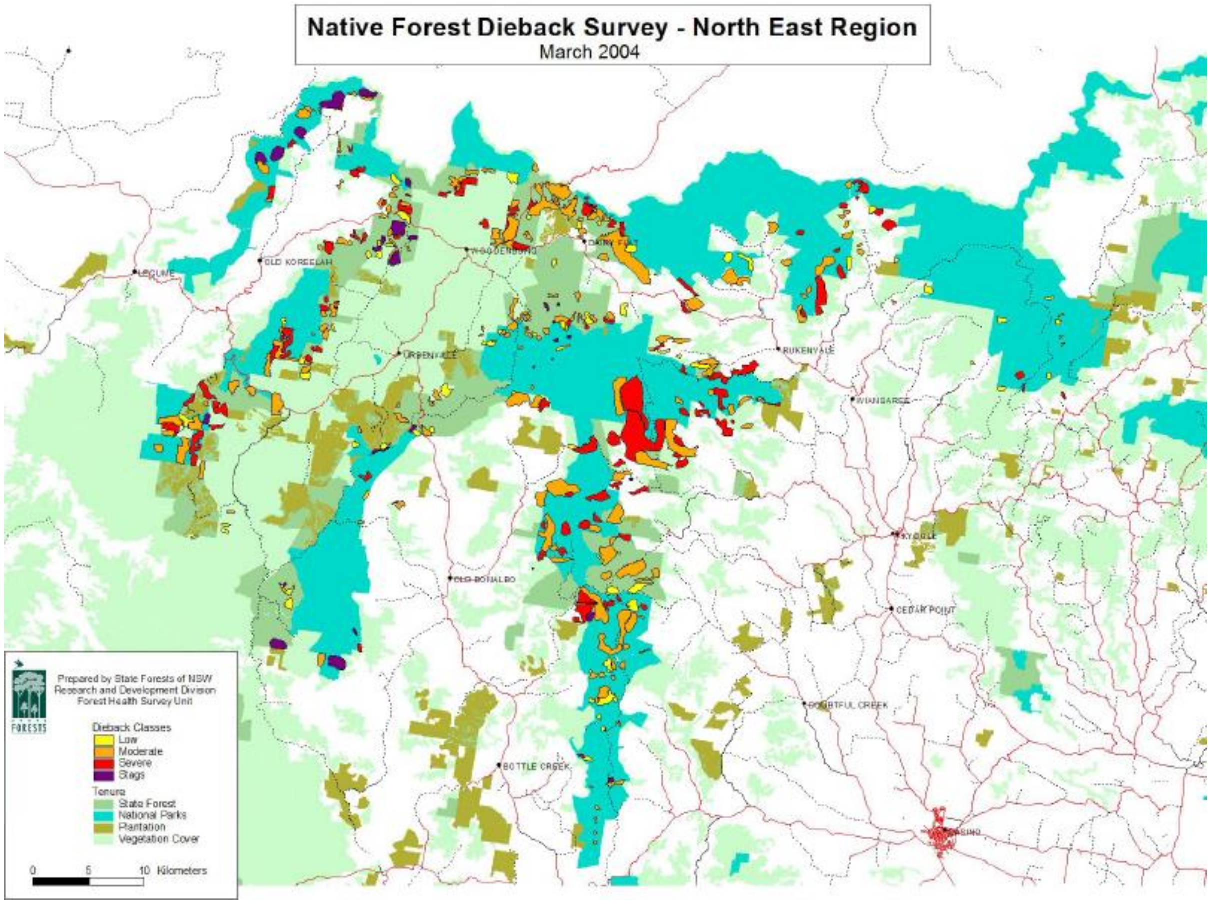
NEFA have been trying for years to get the Environmental Protection Authority to take action on this issue and to stop the Forestry Corporation from targeting BMAD affected and susceptible stands for logging, and to rehabilitate areas after logging. BMAD has been specifically identified in NEFA reports and audits of logging Yabbra (2009), Royal Camp (2012), Koreelah (2013), Richmond Range (2014), Donaldson (2014), Cherry Tree (2015) and Sugarloaf (2016) State Forests. The agencies refusal to apply the precautionary principle was established early on. In 2010 the Department of Environment Climate Change and Water (DECCW - the forerunner of the EPA forest unit) responding (Simon Smith, DECCW, 19/5/2010):

> *DECCW notes your concerns regarding Bell Miner Associated Dieback (BMAD) and the principles of ecologically sustainable forest management. It is noted however that the NSW Scientific Committee's determination in relation to broad-scale canopy dieback associated*

> *with psyllids and Bell Miners "involves interactions between habitat fragmentation, logging, nutrient enrichment, altered fire regimes and weed-invasion". The Scientific Committee's determination also notes that "at present, no single cause explains this form of dieback. And it appears that 'Forest eucalypt associated with over-abundant psyllids and Bell Miners' cannot be arrested by controlling a single factor". An Inter-agency BMAD working group is working to improve knowledge on the interrelation of land management activities and the prevalence of BMAD.*
>
> ...
>
> *As noted above, the NSW Scientific Committee's determination notes that there is inadequate information available to determine if Bell Miner populations and Bell Miner associated Dieback has been favoured by these logging and burning operations.*

This is not how the precautionary principle is intended to be applied.

Silver and Carnegie (2017) include a series of profiles of incomplete and anecdotal "trials", including over areas with no apparent BMAD. The only two with any relevance to forestry were conducted by the Forestry Corporation in Donaldson State Forest in 2005 and Mount Lindesay State Forest in 2007, using $120,000 of Environmental Trust monies with a requirement that they be monitored for 15 years. Despite an inter-agency committee overseeing the project, the consultants claimed to not be aware of the outcomes of these trials until provided with a 2015 Forestry Corporation powerpoint by me, and even then they did not report on the dramatic results (see below). The fix has been in on this issue for years.



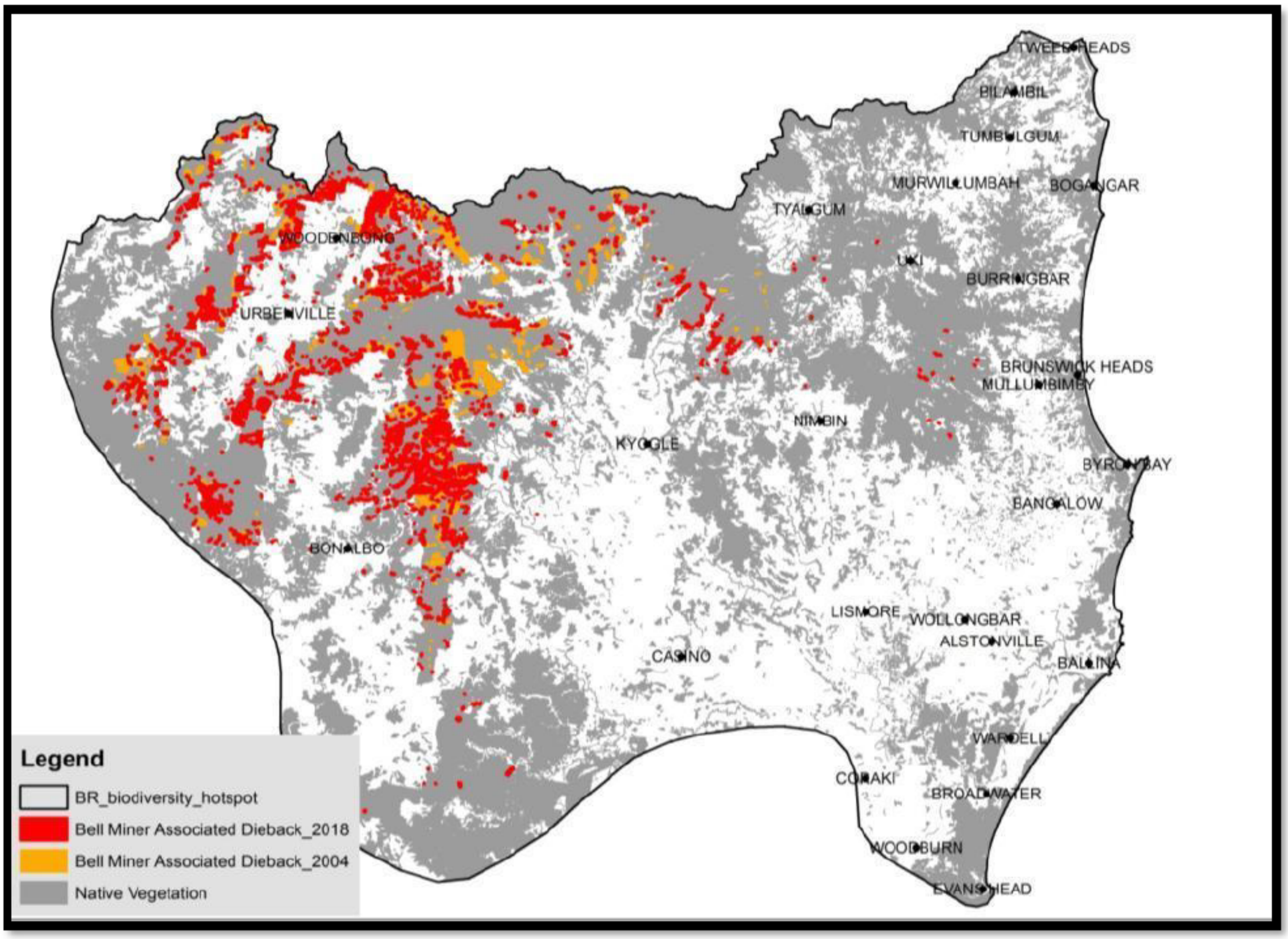
State Forests' (Carnegie 2004) 2004 mapping of BMAD in the western Border Ranges.

In 2004 State Forests (Carnegie 2004) used a helicopter to sketch-map almost 20,000 hectares of the approximately 100,000 hectares of apparently susceptible forest types in the Urbenville

Management Area as being affected by dieback attributed to BMAD. The mapping identified the following areas of severity classes: Low 2,205ha Moderate 9,776ha, Severe 6,511ha, and Stags1,382ha. The 2004 assessment was conservative as many areas known to be affected were missed, even when on the flight path (Jurskis and Walmsley 2012, Pugh 2014).

The process was repeated by Silver and Carnegie 2017, who mapped 44,777ha of BMAD over some 1,250,000 hectares of forest north from Taree, comprised of 17,005ha on State Forest, 12,822ha on National Park, 1,540 on Crown Land, 12,885ha on private property and 525ha on plantations.

For the same area covered by Carnegie (2004), the 2017 mapping identified some 22,000ha of BMAD which would seem to be a good match, except that there is only an overlap of some 5,000ha (13%) between the two mappings which is an extraordinary mismatch, though as both mapping projects were undertaken by the same lead mapper the differences cannot be attributed solely to observer bias. Differences could be partially explained by annual fluctuations in perceived canopy health with weather conditions, though as 74% of the areas identified as severely affected in 2004 (i.e. *"consisted of many dead trees, severe thinning of crowns, low stocking rate of susceptible species and greatly increased mesophyllic ground story vegetation including weeds such as lantana"*) were mapped as having no dieback in 2018, it is hard to fathom how they could now have no visual evidence of dieback.



Forestry's mapping of BMAD in the Border Ranges region. The map shows the area mapped in 2018 (red) with the additional areas mapped in 2004 (orange). It is considered that both need to be adopted to obtain a realistic assessment of BMAD distribution, though even then the mapping misses a number of areas known to be affected and does not recognise those areas in the early stages of BMAD.

Given that BMAD affected forests are not recovering, and that many areas have been observed to have deteriorated (pers. obs.) it is considered that the only way to reconcile the divergent mapping is to combine it to identify overall extent. This gives a total area of 37,100 ha, which is 40% more than mapped by Silver and Carnegie 2017. This is considered to be conservative as it appears that the mapping is missing some areas and not picking up many areas with the early symptoms of dieback (dense lantana understories and large populations of psyllids), where trees are sickening but as yet without major canopy damage.

So it is conservatively estimated that there is well over 100,000 ha of BMAD in north east NSW.

Recently the Natural Resources Commission identified a variety of issues with dieback of various forms, though in keeping with previous obfuscation they make no mention of logging or the role that it plays in BMAD. Matusick and Fontaine (2021) do mention:

> *For Bell-miner dieback, and other dieback events suspected to involve miner species, trials and research experiments are required to test the hypothesis outlined by Stone (1999) and Stone et al. (2008) regarding the role of lantana and canopy disturbance in creating and maintaining forest structural conditions that are favoured by miners. If the hypothesis is confirmed to be accurate, forest treatment protocols can be developed in order to restore forest patches that currently favour Bellminers or prevent the creation of more forest in this structural condition. Some combination of active silvicultural- and weed-management will likely be required in order to correct for the current ecological dysfunction.*

Under "Land-use and management" in their summary Matusick and Fontaine (2021) only highlight fire regimes as warranting investigation. Though the category of "*Leaf-feeding Insects"* does include *"Through experimentation, testing the hypothesis developed by Stone (1999) regarding the role of lantana in ecosystem dysfunction in northeastern NSW*". This advice is then translated by Natural Resources Commission into advice on recommended research priorities for the Environmental Trust, logging is of course ignored in the 20 research categories, with only "animal and plant control" coming close to dealing with the lantana issue.

It is clear that the NSW Government intends to go on ignoring the causes of BMAD so that they can go on logging affected and susceptible stands. They are intentionally ignoring the elephant in the room yet again. This demonstrates that their new commitment to monitoring for the RFA is another sham.

3.4a. Given the abundant evidence that logging is the primary cause of Bell Miner Associated Dieback, and that re-logging affected forests makes it worse, it is well past time that the logging of BMAD affected and susceptible forests is stopped and the process of restoration begun. If logging is to be allowed, it needs to be on a case by case basis, where lantana and Bell Miners are surveyed before the logging and monitored for five years afterwards. In keeping with the principle of adaptive management the results must be analysed, any needed corrective actions taken, and methods altered to minimise impacts before being trialled again.

3.4b. As the current aerial mapping is subjective and does not provide a reliable basis for identifying the current extent of BMAD or to be able to monitor changes over time, it is recommended that the worst BMAD affected areas be subject to objective and repeatable mapping using High Resolution Multi-spectral imagery and ALS Lidar to:

- **f) accurately identify the current extent of BMAD affected and susceptible forests**
- **g) provide a baseline from which to assess changes over time**
- **h) identify the variables affecting BMAD distribution**
- **i) quantify the accuracy of current mapping and other remote sensing technologies**

j) monitor the success of rehabilitation works.

3.4c. It is reprehensible that despite the public monies spent of rehabilitation works on both public and private lands over the past 20 years that only three studies have monitored the outcomes of treatments on BMAD affected forests in north east NSW, and that for the two studies undertaken on State forests the Forestry Corporation has been allowed to largely suppress and ignore the unfavourable results. In order to better understand the causes of BMAD and assess the effectiveness and costs of rehabilitation, the highest priority has to be to undertake independent and transparent lantana (and other problem plant) removal trials, using manual methods that minimise disturbance, with clear objectives, monitoring and reporting requirements.

3.4d. It is apparent that BMAD has reduced the volumes of timber available for logging from tens of thousands of hectares of public forests in north east NSW, and destroyed any prospect of such forests contributing to long-term timber volumes. It is also apparent that BMAD, and its impacts on forest productivity, are expanding. It is essential that this be accounted for in any future timber modelling before any further volumes are committed in Wood Supply Agreements

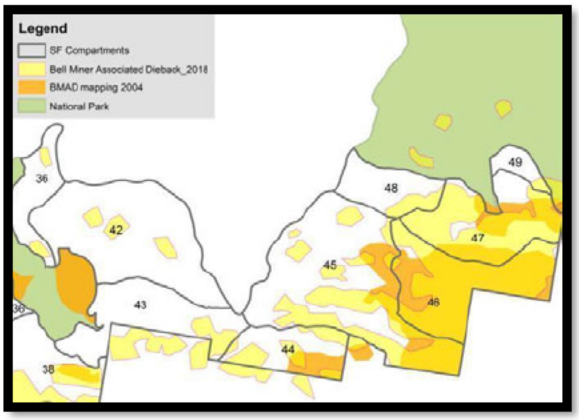
3.4.1. Donaldson Case Study

The Forestry Corporation prepared a Harvest & Rehabilitation Operational Management Plan for Compartments 44-49 of Donaldson State Forest on 17 October 2003. The forest was last logged in 1976-82 and had "*not been grazed or burnt for approximately 10 years*" (Shipman 2006).

In 2005 the BMAD Working Group determined to help fund trials of lantana control on Donaldson State Forest as one of three trials of using understorey control to redress BMAD (Pugh 2014). The trial was intended to:

- *Remove 25 hectares of dense shrub understorey in moist sclerophyll forest using dozer with follow-up spraying of herbicide.*
- *Remove 20 hectares of dense shrub understorey in grassy forest using dozer with follow-up regular low intensity fire.*
- *Remove 34 hectares of light to medium density shrub understorey in grassy forest using regular low intensity fire.*

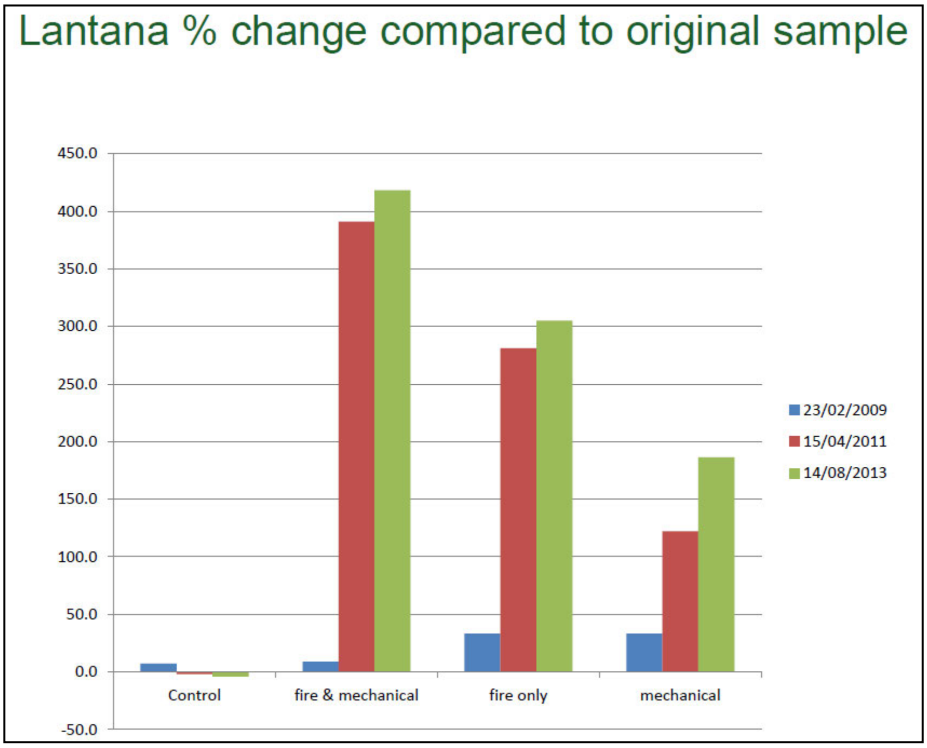
The trial was meant to go for 15 years from November 2005 till 2020, with annual reports for first 3 yrs, then every 2 years thereafter. Costs were given as $35,203 in kind and $67,336 from the Environmental Trust via the BMAD working group.

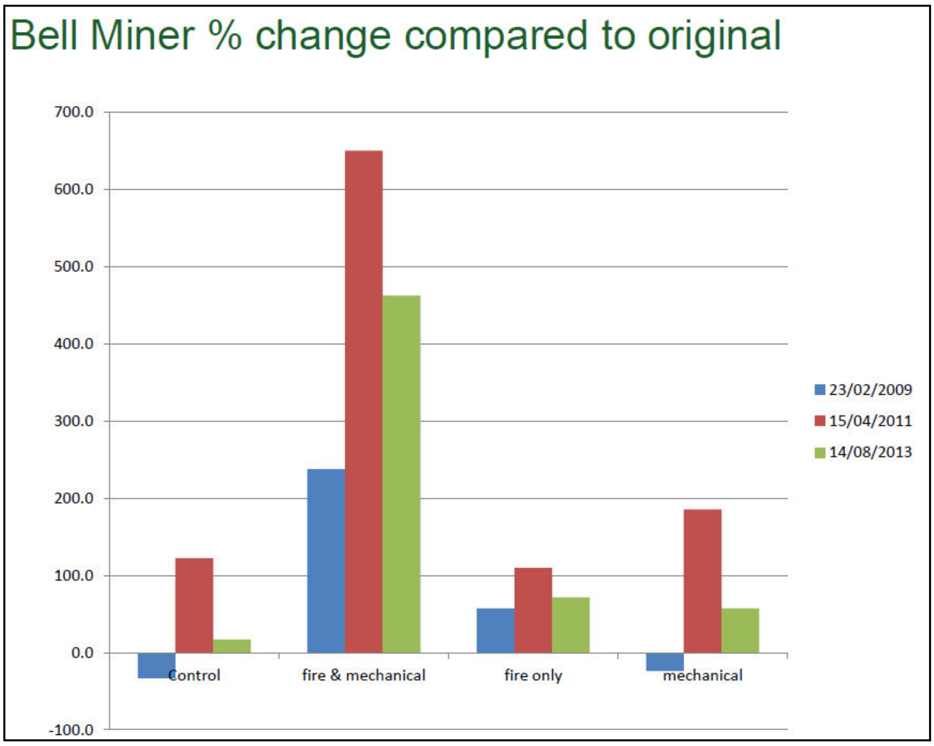


2004 and 2018 mapping of BMAD, Donaldson State Forest.

Shipman (2006) undertook intensive sampling of part of this area in compartment 46. Unfortunately the write up of results is poor, selective (i.e. native species other than eucalypts were classed as "weeds") and confusing. Shipman (2006) reports that *"the prolific weed growth became a problem after fire*", and that "*There was patchy and generally poor regeneration of native forest eucalypts over the three treatments*".

The Donaldson Trials clearly show dramatic increases over 8 years, with, for example, the combination of fire and mechanical treatments resulting in 420% increases in lantana, and 460% increases in Bell Miners after 8 years(FCNSW 2015).





The Forestry Corporation (2015) results for Donaldson State Forest.

The Forestry Corporation (2015) summarising:

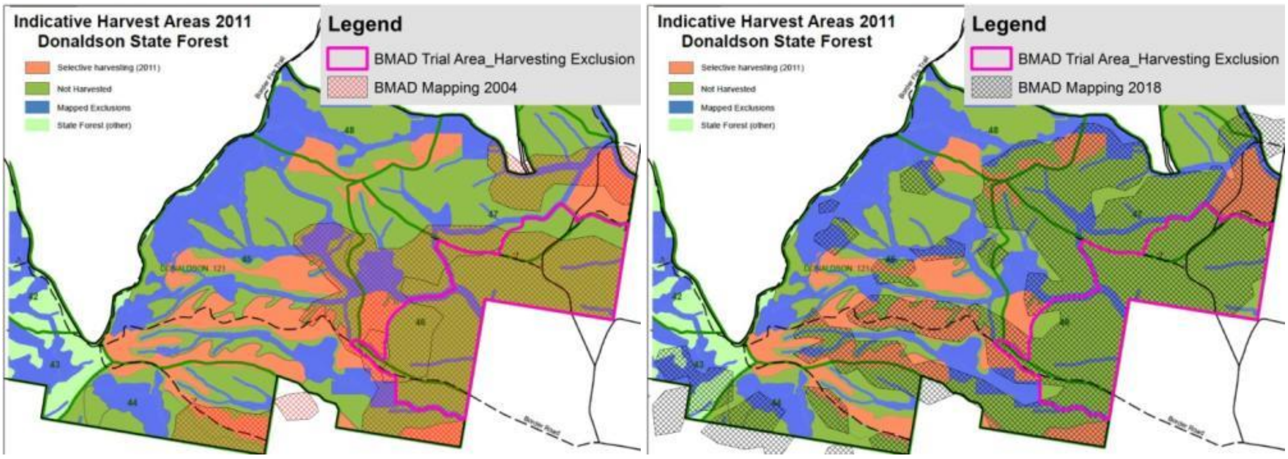
- *Compromised experimental design reduces confidence in trial results*
- *Increase in Lantana especially in combined fire & mechanical treatment*
- *Bell Miner increase, but issues with data collection, inconsistent recording methods*
- *No regeneration or canopy health data*
- *Both treatments and control sites remain seriously unhealthy stand*

In 2011 the Forestry Corporation ignored the outcomes from their Donaldson trial, returning to Donaldson 44, 45, 46, 47, 48 and 49 in 2009. Logging commenced on 23 September 2009 and was suspended on 27 October 2009 presumably when the Forestry Corporation recognised that they were logging in contravention of the requirements of the 2003 Harvest & Rehabilitation Operational Management Plan. A new Harvesting Plan was prepared in 2010, identifying:

> Dieback is evident in various levels across parts of the harvest area. In affected areas the site is understocked and trees have thin crowns. There are numerous dead stags scattered across the harvest area. In affected areas understorey is predominately lantana under more open canopy and there is little healthy regrowth or potential for regrowth in the current state.

There was no mapping of BMAD. The trial area was to be excluded from logging, though elsewhere the intent was to "*Remove unhealthy merchantable trees*", with any treatment to be decided by the forester in charge:

> **Treatment**
>
> Treatment is to be developed on a site specific basis as operations progress by the Harvesting Team Leader and may involve a combination of harvesting, seed tree retention, mechanical disturbance, planting, weed control, and reintroduction of a low intensity fire regime. Treatments to be applied as required to obtain satisfactory regeneration event..



Comparison of BMAD mapping for 2004 (LEFT) and 2018 (RIGHT) overlaid on 2011 logging area (orange). While both mappings are of questionable veracity they indicate that the treatment of the trial area had no appreciable positive benefit on BMAD extent (and may have had a negative effect) and that the 2011 logging may have expanded the BMAD problem to higher elevations.

As the Forestry Corporation were undertaking preparatory roadworks to commence logging in compartments 36 and 42 of Donaldson State Forest in May 2014 the North East Forest Alliance undertook a brief inspection of compartments 36 and 42 (Initial Assessment, Donaldson State Forest), finding a number of stream breaches and relatively small patches of BMAD, recommending:

1. *Given the rampant Bell Miner Associated Dieback at lower elevations in compartments 43, 44, 45, 46, 47, 48 and 49, the abject failure of rehabilitation trials in compartments 44-49, the*

yet limited occurrences in compartments 36 and 42, and the high susceptibility of these forests to lantana invasion and BMAD that no logging should take place until:

a. The extent and severity of BMAD in compartments 36 and 42 is fully and accurately mapped;
b. The area of susceptible forest types is clearly delineated;
c. An explicit management and rehabilitation strategy is identified for affected and susceptible areas; and
d. Sufficient resources are available to immediately undertake and monitor required rehabilitation works.

NEFA followed this up with the report "For Whom the Bell Miners Toll" (Pugh 2014) on BMAD, which included a review of the BMAD trials in Donaldson and Mount Lindesay State Forests, emphasising the failure of the Forestry Corporation to undertake the required monitoring and reporting. Forcing the Forestry Corporation (2015) to belatedly compile their monitoring results into a brief report.

Part of the Donaldson trial area in compartments 45 and 46 was visited in May 2014, with the track forming the boundary of the Shipman (2006) area walked and visually assessed. NEFA (Pugh 2014) found:

Dense lantana growth meant that the area could not be readily assessed away from the track. The visual evidence is that, in this area at least, the trials utterly failed to control lantana, Bell Miners or BMAD. Lantana dominates the understorey, many trees are dead, most remaining eucalypts show evidence of BMAD (mostly severe), regeneration of eucalypts is patchy, wattles or lantana dominate large areas with few eucalypts. The Forest Red Gum stands at lower elevations seem to have been particularly severely affected with numerous dead and dying trees and little eucalypt regeneration.




ABOVE Photos of the BMAD trial area taken in May 2014.

ABOVE Photos of the 2011 logging adjacent to the BMAD trial area taken in May 2014.

In response to a complaint about the proposed logging from Jimmy Malecki the EPA (Steve Hartley 1 August 2014) responded:

> Although the EPA is taking action on BMAD, it should be noted that there is no clear consensus between experts on the causes or viable treatments for this threat. BMAD involves complex interactions between a number of biological factors and occurs across state forests, national parks and private lands.
>
> The EPA has raised the issue of BMAD with the Office of Environment and Heritage, the National Parks and Wildlife Service and the Forestry Corporation of NSW and will continue to work with these agencies where appropriate to develop cross tenure approaches to improve knowledge on this issue.
>
> The EPA will continue to monitor the situation in Donaldson State Forest and has included the area in our forward native forestry audit program. However, as noted above, there is no mechanism in the existing forestry approvals to prevent or restrict harvesting in BMAD affected or potential areas.

The outcome was that the Forestry Corporation's logging schedules identified logging as current in compartments 36 and 42, later adding compartments 44-49, of Donaldson State Forest for years, though thankfully logging has not yet resumed.

3.4.2. Mount Lindesay Case Study

NEFA inspected compartment 276 and 279 of Mt Lindesay SF in 1997 when on the North East State Forest Harvesting Advisory Board (NESFHAB) in response to the Forestry Corporation's proposal to log the area. At that time the whole compartment was dominated by Bell Miners, particularly at lower elevations where BMAD was evident. Bell Miners had apparently been in the vicinity for a long time as the nearby "Bellbird Rest Area" was shown on the 1985 Second Edition of the Forestry Corporation's Forest Project Map.

BMAD in the vicinity of the now removed Bell Bird Rest Area, Compartment 276, May 2014

This area highlighted the issue of BMAD for the NESFHAB, leading to the preparation of "Discussion Paper: Psyllid/Bell Miner dieback area management" (Sharpe 1997) that proposed undertaking large scale rehabilitation of severely affected areas, and as part of the Harvesting Plan process mapping areas affected (by class), identifying proposed management (including excluding logging from areas *"if it is decided that harvesting will further exacerbate the problem and that rehabilitation works are either impractical or unlikely to succeed"*) and details of specific remedial works. Unfortunately the Forestry Corporation blocked progress on this until the NESFHAB was disbanded and then abandoned it.

An outcome of the NESFHAB was a project to use Digital Multi-Spectral Video (DMSV) to quantify the extent and degree of canopy dieback in a 10,000 ha study area centred on Mount Lindesay, with the aim to be able to later use map comparisons *"to determine the stability of bellminer colonies, rate of spread of the dieback, make predictions on future spatial patterns and directions of the dieback across the landscape and confirm the stand risk criteria"*. In the end 5,000ha of State Forests was mapped using DMSV (all of Mt. Lindesay SF and compartments 34, 38, 55-58 of Donaldson SF), with 1:25,000 aerial photographs of all compartments and infra-red aerial photos of 8 compartments. It appears this $100,000 project was subsequently abandoned.

The Forestry Corporation established logging trials in BMAD in compartments 276 and 279 of Mt Lindesay State Forest in 2007 with over $50,000 of Environmental Trust monies contributed through the BMAD Working Group as one of four trials of using understorey control to redress BMAD (Pugh 2014). It must have been apparent by then that the Donaldson trials failed. The forest had been variably logged, with the logging trials situated in a variety of forest types and a mixture of growth stages (disturbed oldgrowth, disturbed mature and young) mostly heavily logged from 1974-84, and the "control" mostly re-logged in 1996. The trials involved logging in combination with variable applications of mechanical disturbances, weed spraying, and burning, with some follow up weeding and planting. Objectives of the project were:

1. Lantana cover reduced to less than 15%
2. Increased health of retained trees
3. Decrease in abundance of bell miners (An indication of reduced habitat or food)
4. Maintenance of grassy understoreys
5. Restoration of severely degraded stands with natural regeneration, supplementary seeding and enrichment planting of native over-storey species
6. Integration of harvesting and rehabilitation

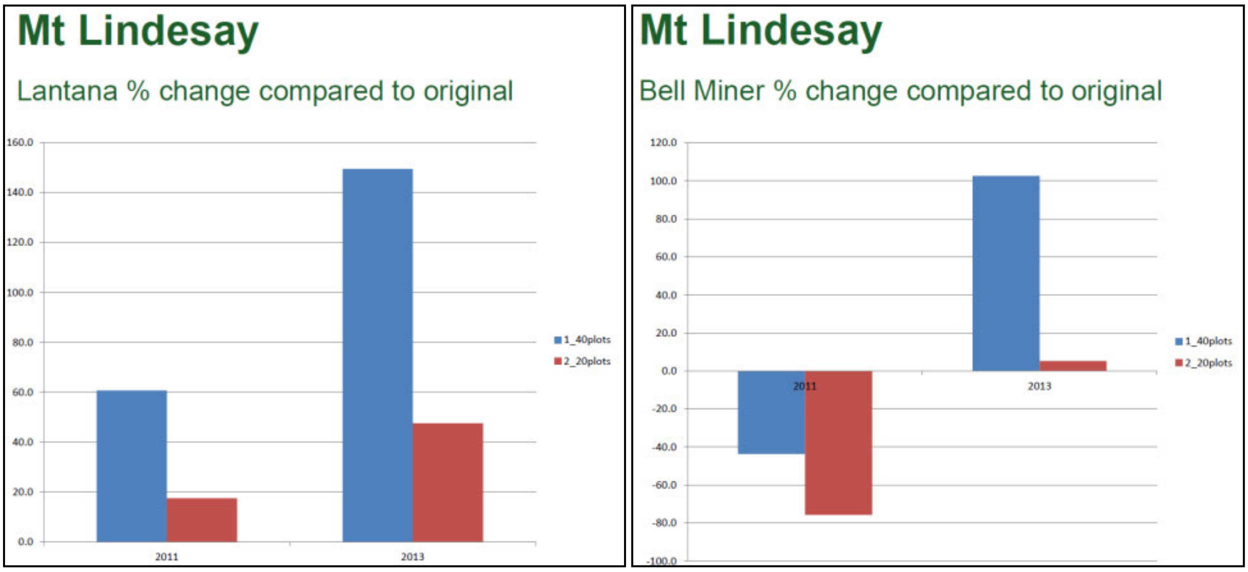
Forty plots were established in treated and 20 in control areas (logged in 1996 and suffering from dieback) with stratification based on broad forest types. Harvesting was conducted over the period May to September 2007. The results were apparently confounded by good rainfall leading to an improvement in tree health, a decline in lantana and a decline in Bell Miners on all plots, including the control. The reported results were only for the first two years. St.Clair (2009) reports on the outcomes, which can be summarised as:

- within 2 years Bell Miner numbers had recovered to pre-treatment levels relative to controls;
- Bell Miner numbers were related to lantana density;
- reductions in lantana cover was significant only in moderate and high intensity fire treatments, though lantana was showing significant recovery in the second year;
- the treatments did not improve the health of the retained trees relative to controls;
- Brush Box regeneration was two orders of magnitude greater than the eucalypts;
- regeneration of eucalypts was inadequate at most sites; and
- planting of eucalypt seedlings is vital to maintain a natural species composition in mixed stands.

The number of variables involved (such as 6 different forest types, numerous different canopy species, different understorey types, different disturbance histories and intensities, 4 disturbance types, lantana control, replanting etc) confounds meaningful interpretation of the results, particularly as there is "*No recording of what has occurred where*" (Forestry Corporation 2015). Undaunted St.Clair (2009) uses his short-term results and some convoluted logic to support his pre-determined position that the *“removal of bell miners and poisoning or burning of lantana per se will not improve tree health. The phenomenon of linked lantana, psyllid and bell miner invasions is a consequence of poor tree health caused by deteriorating root function under changing soil conditions in the absence of fire as proposed by Jurskis (2005)”*. Based on this flawed assumption he goes on to make a variety of far reaching recommendations.

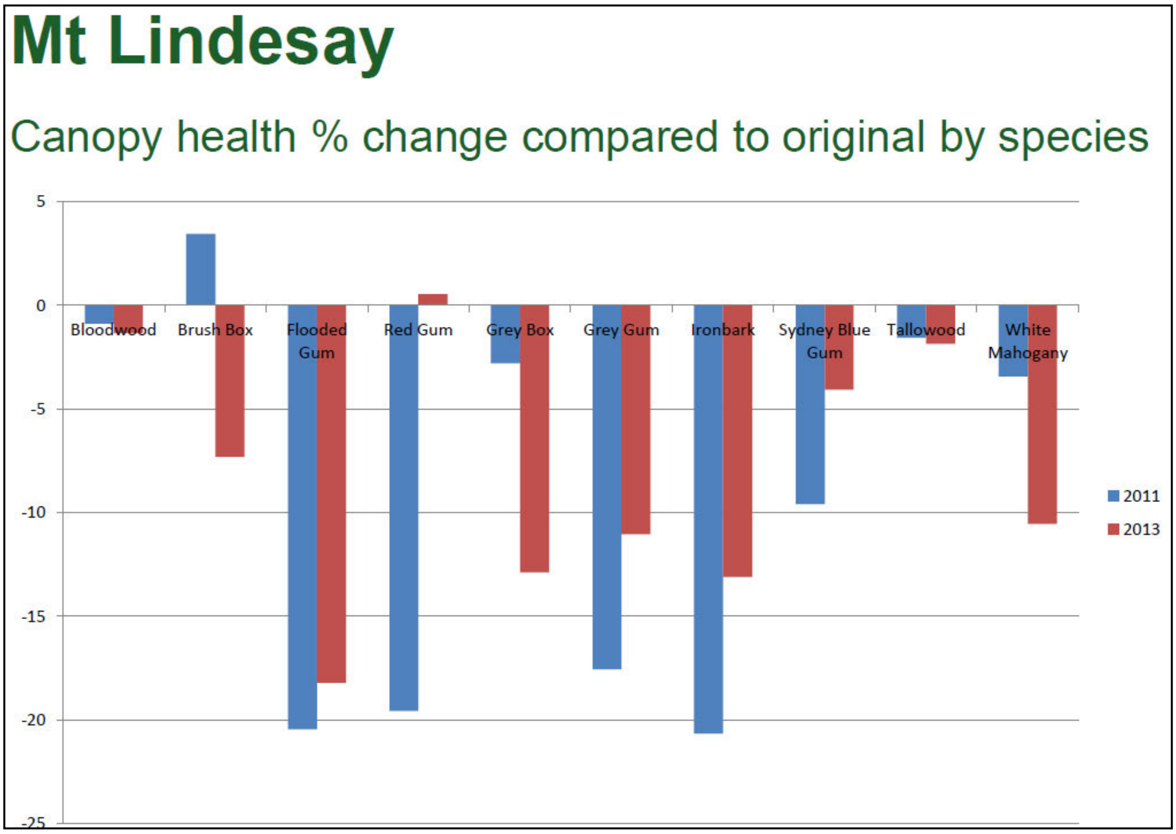
St.Clair (2009) does note “*Whilst the cost of the project was significant, the opportunity cost of doing nothing is greater. The cost of rehabilitation was less than the likely loss of production if the forest continued to decline and die*”. St.Clair’s (2009) estimated rehabilitation costs per hectare over 40 years ranged from $200-2,500, though given the poor prognosis for much of his sites this may just reflect initial costs.

For Mt. Lindesay over 6 years the Forestry Corporation found significant increases with a variety of treatments, including logging and burning: lantana 145%, Bell Miners 104%,



Forestry Corporation (2015) results for 2011 and 2013 reported for Mt. Lindesay State Forest. For these graphics blue represents the 40 trial plots and brown the 20 control plots.

The Forestry Corporation (2015) also report 10-20% declines in canopy health of Flooded Gum, Grey Box, Grey Gum, Ironbark and White Mahogany over the 6 years, which they consider "good".

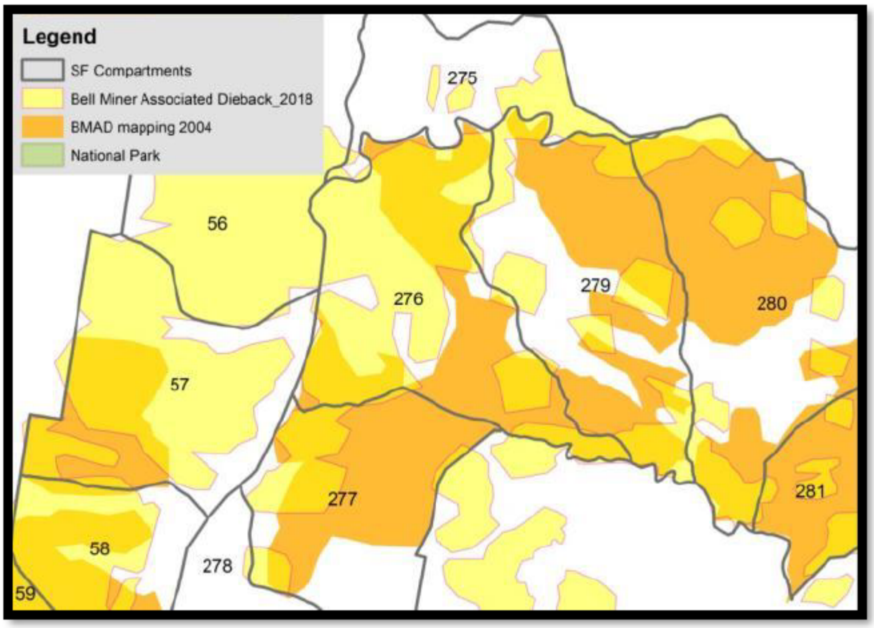


From Forestry Corporation (2015) showing significant declines in the health of most species following the trials.

Strangely the Forestry Corporation (2015) concluded these results showed:

- *Variable change in Lantana*
- *Variable change in Bell Miner abundance*
- *Variable change in canopy health by species, some recovery may be evident*

- *Canopy health generally ok.*
- *Regeneration good in parts (particularly where planted) but no data has been collected on this yet*



2004 and 2018 mapping of BMAD, Mt Lindesay State Forest.

NEFA (Pugh 2014) inspected the area and found:

> *For this review Hildebrand Road on the boundary between the compartment 276 and 279 was traversed in May 2014. BMAD was found to be widespread. The abundance of Bell Miners and lantana appeared to have markedly increased, and the structure of the forest deteriorated, since our 1997 assessment. There are numerous dead, dying and other BMAD affected trees, large areas have no or little overstorey, lantana dominates most of the understorey with large areas of wattles and patchy regeneration of eucalypts. As with Donaldson it is apparent that the full ramifications will become apparent over the next 15-25 years once the wattles begin to senesce and the regrowth reaches pole stage and begins to show the effects of BMAD. It is evident that the objectives of the trial were not achieved and that the trials were once again an abject failure.*

BMAD in Yabbra State Forest, 4 years after logging, with rehabilitation refused.

Photo of BMAD in Mount Lindesay taken in 2004.

The Forestry Corporation, with the connivance of the EPA, have been routinely flouting the principles and intent of Ecological Sustainable Forest Management by logging forests affected by, or susceptible to Bell Miner Associated Dieback

It is very disheartening to visit dying forests year after year as the Forestry Corporation target them for liquidation logging, removing all merchantable trees, and leaving seas of lantana with scattered dead and dying trees in their wake. In general they refuse to undertake rehabilitation, at best planting some token seedlings that they don't maintain. The problems of facilitating the spread of lantana and dieback is ignored.

The wanton devastation of vast areas of forests and their wildlife has been underway for decades and is rapidly worsening, yet both those responsible for the environmental atrocities and those responsible for stopping them couldn't care less.

The latest subjective aerial mapping (undertaken from 2015-17) (Silver and Carnegie 2017, and subsequent updates) is claimed to have covered some 1,250,000 hectares of forest north from Taree, with 44,777ha of BMAD mapped. Comprised of 17,005ha on State Forest, 12,822ha on National Park, 1,540 on Crown Land, 12,885ha on private property and 525ha on plantations.

One problem is that comparison with 2004 mapping of the western Border Ranges undertaken by the same mapper using similar methods identified very different results, with only a 13% overlap between the two mappings (see Border Ranges Case Study). This and other evidence suggests that the 2017 mapping has grossly under estimated BMAD extent, by some 40% if the 2004 mapping has any credibility.

There has also been no recent BMAD mapping south from Taree. yet past mapping has identified significant areas of BMAD in that region, it would be reasonable to assume that a third of BMAD occurs south of Taree. Given these considerations it is reasonable to assume that there are over 100,000 ha of BMAD affected forests in north-east NSW.

Since 1992 NEFA have raised the problem of BMAD in numerous forums, committees, submissions, audit reports and complaints to both State and Federal Environment Ministers. We have accompanied the Forestry Corporation CEO Nick Roberts, the EPA's CEO Barry Buffier, and the then Minister for the Environment Mark Speakman, and a variety of others, on site inspections of BMAD to demonstrate the problem. We have made numerous submissions to inquiries, identified the problem in forest audits, and publicised the problem. Many others have pursued other paths to having the problem recognised. And they all end in the same place, deliberate obfuscation and denial by NSW Government agencies.

4. Managing public forests in the public interest.

(e) opportunities for the timber and forest products industry and timber dependent communities and whether additional protections, legislation or regulation are required in New South Wales to better support the forestry products industry and timber-dependent communities, including opportunities for value adding,

(f) the role of the government in addressing key economic, environmental and social challenges to the industry, including funding and support to encourage improvements in forestry practices, training, innovation and automation, workplace health and safety, industry and employee support, land use management and forestry projects,

(i) best practices in other Australian and international jurisdictions in relation to the sustainability of the timber and forest products industry, including social sustainability, community and Indigenous engagement and multiple uses of the forest estate and

Public lands are owned by the community. Taxpayers have long subsidised the logging of public lands for private profit. We provide the land on which public forestry is undertaken. and over the decades have expended a fortune in purchasing additional lands for logging and plantation establishment. There have been a multitude of taxpayer monies spent as grants for planting timber crops, subsidising log haulage and upgrading sawmills. The most obvious taxpayer subsidy has been in covering the substantial losses of the Forestry Corporation, in all its manifestations, for decades. Then there are the Government costs associated with the Environment Protection Authority's (and its predecessors) regulation, DPIE Forestry research, inquiries, and forest assessments (such as the Comprehensive Regional Assessment).

The biggest failure of forestry is the lack of any return to the community for the use of public land. The community have paid private sawmillers to run-down biomass, water yields, nectar, tree hollows and wildlife populations, while spreading weeds, dieback and fire risks, and degrading soils and streams. There is no resource rent being paid to the community, so we are being duded in many ways, as noted by URS (2008):

> *Extracting resource rent from the use of the state's forest resources – resource rent is the additional profit above "normal" business profits that can be gained by providing access to a natural resource. Because resource rent is in excess of normal business profits, there is a rational for governments to collect some of this rent on behalf of the owners of the resource – the community.*

There needs to be a fundamental shift in the management and support for forestry. It needs to be recognised that logging of public forests is not in the community's best economic, social or environmental interests as far greater benefits can be generated by protecting forests and allowing them to mature: increasing carbon capture and storage, increasing water yields to streams and providing increased recreation benefits and tourism opportunities.

The current massive subsidies to the native forest industry through the Department of Primary Industries (including the Forestry Corporation) and grants to sawmill owners would be more efficiently and effectively directed to a transition program out of public native forests, boosting hardwood sawlog plantation supply and providing incentive payments to private native forest owners for maximising public benefits.

The significantly increased carbon sequestration from recovering forests would be of benefit to all Australians, including rural communities, both by contributing to NSW and Australia's obligations to reduce net carbon emissions and by helping mitigate some of the worst impacts of climate heating. The increased recreational and tourism opportunities will significantly boost regional tourism expenditure and jobs. The increased water yields to streams and aquifers will be a boon to downstream farmers and urban drinking water supplies.

Most significantly, by redirecting funding and subsidies from logging companies to landholders it will provide a direct economic benefit for the retention of native vegetation, and thus reward and encourage private landholders to manage native vegetation for the optimum public benefit.

Recommendations

4.1. The logging of public native forests has always been an economic burden on taxpayers due to the high subsidies paid, both through maintaining the loss making native forestry operations of the Forestry Corporation and through direct payments to sawmill owners and occasionally workers. The hidden costs are the rundown in timber volumes, water quality and quantity, and wildlife populations, as well as the increase in weeds and dieback. Given that plantations are far more efficient and profitable it is past time to complete our transition to them for future timber needs.

4.2. Community attitude surveys over the past 24 years clearly show that the community prioritise wildlife, water and carbon storage values of forests above timber production. The University of Newcastle assessed the biodiversity value (Willingness To Pay) of creating the Great Koala National Park as around $530 million for the NSW population and $1.7 billion for all Australians. A 2016 survey for the timber industry of 12,000 people found that native forest logging was considered unacceptable by 65% of rural/regional residents across Australia, and acceptable by just 17% of rural residents. Logging of native forests has very low levels of social license and is clearly not in the public interest.

4.3. Tourism is far more important to the north coast economy than logging, and is the fastest growing sector promising increasing economic and employment benefits. In 2019 over $867 million of tourist expenditure can be taken as associated with forested national parks. It is in the community's economic interest to convert more of our public native forests to national parks as this will provide more fulfilling recreational opportunities and attract tourists to the region, as well as encouraging them to stay longer. The potential regional benefits of converting State forests to National Parks has been demonstrated by the University of Newcastle's assessment that over 15 years the creation of the Great Koala National Park would result in 9,135 additional full time jobs, and increases in total output of $1.18 billion and value add of $531 million. The Government will maximise long term regional benefits by directing its resources into enhancing and diversifying forest recreational facilities, rather than upgrading private sawmills

4.4. Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere, and annually is around 10% of global anthropogenic emissions. To address the growing threat of climate heating we need to both reduce emissions and increase sequestration of atmospheric carbon. Retaining forests and allowing degraded forests to regain their lost carbon are

urgent actions we need to take to begin to redress climate heating on the scale required. Carbon credits offer a mechanism to reward landholders for protecting forests for carbon sequestration, though they need to include payments for standing carbon and annual sequestration when forests are protected. At the current ACCU carbon dioxide price of $17 a tonne, the value of carbon dioxide currently stored in a logged forest, combined with annual sequestration could equate to annual payments of $228-410/ha per annum to a landholder, all paid for with carbon credits. It is requested that the inquiry consider measures needed to facilitate a scheme that could realise such payments to land holders. Applying such values to the 500,000ha of logged and loggable State Forests in north-east NSW would equate to annual revenue of $114-205 million a year, just from stopping logging.

4.5. All runoff from forests now has an economic value, though the value varies with downstream uses, with runoff feeding into urban water supplies being of the highest value. Stopping logging and allowing forests to mature will increase water yields over time as the forest's structure regrows, and thus stopping logging is of direct economic benefit to downstream water users. While the relative value of forest runoff will vary depending on its usage, it is apparent that in most instances it will be of higher economic benefit to maximise water yields by not logging forests. This value will escalate as climate change gathers momentum and dry periods become more frequent and severe.

4.6. It would be of greatest public benefit if public monies currently used to subsidise the inefficient public native timber industry were redirected into regular payments for landholders who guarantee long-term protection (by zoning or covenant) and management of native forests to maximise carbon storage, water yields and biodiversity conservation, some elements of which could comprise:

- **f. Extending the Australian Government's Climate Solutions Fund (or creating a specific fund) to pay landholders who protect their forests for long-term carbon capture and storage. Rather than an auction process there needs to be standardized payments based on stored carbon, carbon sequestration and biodiversity value.**
- **g. Extending eligibility for carbon credits to all forests, including those protected, rather than perversely just those that have first been approved for clearing or logging.**
- **h. Paying landholders regularly for a portion of the current measured standing volume of carbon in living biomass.**
- **i. Paying landholders regularly for additional carbon sequestration and storage in vegetation and soils.**
- **j. Expanding NSW's Biodiversity Trust to make regular payments, in combination with carbon credits, to landowners for permanently protecting core koala habitat, and other areas of exceptional biodiversity value.**

4.1. The Economic Cost of Logging Public Forests

The Forestry Corporation have historically operated at a loss on native forests. Pugh (1992) reviewed the then Forestry Commission 1981/2 to 1990/1 Annual Reports for the adjacent Management Areas of Murwillumbah, Urbenville, Casino West and Grafton, finding that over the ten years the losses totalled over $1 million (in 1991 dollars), without accounting for head office costs, noting that:

> *most of the Management Areas began to improve financially around 1987/88. This was due to the passage of the Forestry Amendment Act which gave an additional subsidy to the Forestry Commission by relieving them of the interest payable on <u>their accumulated debt of some $110 million</u>! They were supposed to pay a dividend to Treasury in return, though failed to do so in 1987/88 or 1988/89 (PAC 1990 p27)*

The NSW Auditor-General (2009) wondered how Forests NSW will perform in the future, given that:

> *... Native forest operations operated at a loss of $14.4m for 2007-08. We are unable to conclude if this is the result of inefficient operations, or because prices do not reflect the true cost of meeting wood supply commitments or a mixture of both.*

In response to questions on notice from the General Purpose Standing Committee No.1 Budget Estimates 2009-10, the Forestry Minister Steve Whan identified that Forests NSW's native forest operations ran at a loss of $8.1 million in 2009/10, stating:

> *Given, as reported by the Auditor General in 2009. that the current cash flow of Forests NSW Native Forests Operations Branch is negative, any NPV calculation now will result in a valuation of zero.*

The Forestry Corporation's losses in 2012/13 were $15 million and in 2013/14 $11.8 million. From 2014/15 until 2018/19 the Forestry Corporation have had a marginal "*positive result*" on 'hardwood' operations, totalling $13.2 million over the 5 years. For example the 2018/19 Annual Report gives "*normalised earnings*" (*Excludes significant items such as revaluation impact, impairments and impact on superannuation funds, before taxes*) for the 2019 financial year as $1.1 million. This is an averaged return of $0.63 per hectare (over 1749,471ha).

There is a deliberate confusing of plantations with native forests in NSW. Profits from hardwood plantations are included with profits from native forests which masks the actual losses from native forest logging. Plantations are used to subsidise native forest logging.

The Forestry Corporation's small positive result for 2018/19 is dependent on receiving $17.5 million as Government grants for Community Service Obligations (provision of recreation facilities, education and advisory services, government liaison and regulatory services, community fire protection and research). It is intriguing that the claimed expenditure on CSOs has increased from $11.1 million in 2006/7 (URS 2008) to $18.1 million in 2018/19, a $7 million (39%) increase in 12 years. This is certainly a good way to change a loss into a profit.

Then there are the costs of regulation by the EPA and forestry research by DPI Forestry. The later is effectively an offshoot of the Forestry Corporation, being moved to DPI to cut costs, and their research reflects their forestry bias.

There are also numerous other public subsidies to the timber industry. For example as an outcome of the NSW Regional Forest Agreements the NSW and Federal Governments spent $131.5 million from 1995 to 2007 on the New South Wales Forest Industry Structural Adjustment Package (NSW FISAP) programs to assist 192 businesses and 683 displaced forest workers. Industry Development Assistance totalled $77.2 million, Worker Assistance $29.5 million and Business Exit Assistance $24.8 million.

There have been numerous State and Federal grants to the Forestry Corporation to purchase land over the decades. For example FISAP included $7.5 million to purchase forested or substantially forested private properties in north-east NSW for logging. The Forestry Corporation 2018/19 Annual Report identifies that "*around 350 hectares of new land was purchased as part of a four-year, $24 million equity injection from the NSW Government to acquire new land for establishing timber plantations*."

Most recently to aid recovery after the 2019/20 fires the NSW Government announced NSW Government's $140 million Bushfire Industry Recovery Package to help forestry, horticulture, agriculture and aquaculture industries impacted by the recent bushfires, including up to $20 million for haulage of burnt timber and $40 million to help privately-owned wood processing facilities recover and rebuild. And on 21 May 2020 the NSW Government announced a $46 million "*stimulus funding*" for "*the largest replanting program in the state's history*".

As an example of the public subsidy to sawmillers:

> *As at October 2001, Boral has spent more than $10 million in capital as part of the FISAP program and a further $5.5 million is currently being invested in a key project to upgrade Boral's green mill at Koolkhan on the NSW north coast. The remaining $29.5 million of Boral's planned investment will be made at Boral's north coast timber mills including those at Murwillumbah, Koolkhan, Kyogle, Maxwells Creek and Herons Creek.*
>
> *The overall program involves total expenditure of $45 million by Boral Timber, with the NSW and Federal Governments providing $22.5 million.*
>
> *Timber companies also received government funding under various Commonwealth Regional Development programs, including the dairy industry restructuring scheme.*

As Boral received public money with one hand they took with the other. Soon after new Wood Supply Agreements (WSAs) were given to sawmillers for free in 2003, in a series of court cases Boral took Forests NSW to court for failure to honour WSAs for every year from 2004 until 2010, resulting in a Government payout to Boral of $550,000 for the first 3 years, and undisclosed amounts thereafter. This was ultimately resolved by the Government paying Boral $8.55 million in 2014 to buy back some 50,000 m^3/yr of Boral's WSA for HQ sawlogs, as well as extending their WSA for a further 5 years (effectively giving them more timber than they bought back).

The price customers pay for logs includes a 'stumpage charge' to encompass the cost of forest management and growing, and a 'delivery charge' to encompass the actual harvesting and transport costs for delivering the logs to the mill. The delivery charge incorporates the costs of the harvesting contractor, the trucking of logs to the mill gate, along with a FCNSW harvesting administration charge.

In 2016-17 Forestry Corporation customers paid an average of $128.66 per cubic metre for logs obtained from native forests, comprised of a stumpage charge of $56.26 and a delivery charge of $72.40. The delivery charge is comprised of harvesting costs of $44.54, haulage costs of $29.81, and is meant to include administrative costs of $3.60 (IPART 2017). It is interesting that in 1995 State Forests (1995b) identified "*the costs of management directly associated with harvesting, selling and marketing in the Casino management area*" as $5.25 per cubic metre, so, even without accounting for CPI there has reputedly been a major reduction in administration costs since then.

	Stumpage charges	Delivery charges	Harvesting costs	Haulage costs	ABS CPI
Average price per m^3 in 2016-2017	$56.26	$72.40	$44.54	$29.81	
Average price/cost increase over 2002-2003 to 2016-2017	4.3%	3.8%	5.1%	3.7%	2.5%[a]

Table 2.6 from IPART (2017): FCNSW's per unit costs and revenue. Stumpage charges are the estimated cost of forest management and growing. Harvesting and haulage costs are paid by FCNSW to contractors doing harvesting and haulage. Delivery charges are paid by sawmills to FCNSW for the harvesting and haulage services.

Stumpage costs vary with products, though specific details of these were not obtained except graphically.

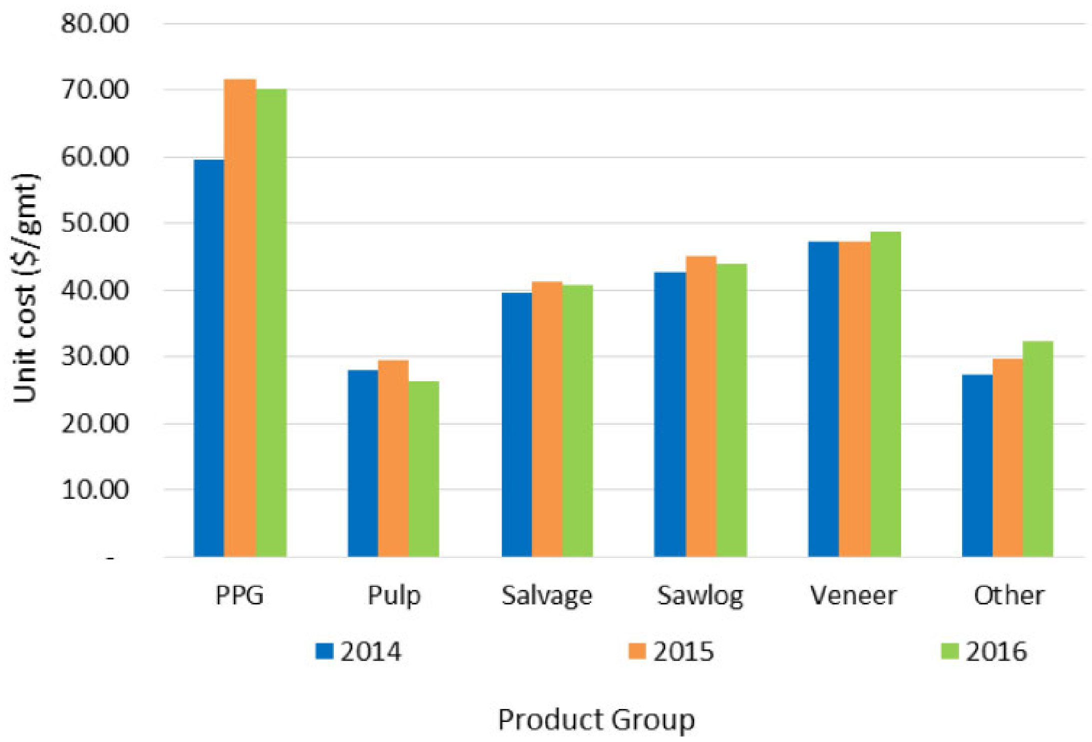


Figure 3-2: from Indufor (IPART 2017) Average Cost by Product 2014 - 2016

Regarding administrative costs, IPART (2017) found the Forestry Corporation's "*current delivery charges recover only about 1% (or 5 cents per m^3) of these costs*", noting:

> *Administration costs are now being indirectly recovered by FCNSW through the stumpage royalty, not through delivery charges.*
>
> *This analysis suggests that FCNSW's average administration charge per m^3 of native timber supplied has fallen from about $3 in the period 2003 to 2010 to –$2 in 2017.*

IPART (2017) identify harvesting and haulage costs are increasing:

> *FCNSW's harvesting and haulage costs, as well as stumpage prices, have generally increased at a faster pace than CPI inflation. In particular, harvesting costs have increased at around 5% per year, on average, over 2002-2003 to 2016-2017. .. average haulage distances have risen for major sawmill customers over the last 15 years.*

Based on the Forestry Corporation's 2018/19 Annual Report they only return a notional average profit of $0.63 per hectare for hardwoods (including hardwood plantations, and excluding Community Service Obligations, EPA regulation and DPI Forestry research). There is no direct public benefit from logging of public native forests. By comparison in 2018/19 the Forestry Corporation's Softwood Plantations Division managed 242,738 hectares of pine plantations in NSW and returned 'normalised earnings' of $73 million, which is $301 per hectare. The sooner the Government transitions to plantations the better off taxpayers will be.

Further, should the NSW government fully consider the poor performance of the Forestry Corporation as an entity that is deemed to be dedicated to making the most of the "common wealth" shared by the NSW residents, the result would no doubt be either the closing down or total re-structuring of the Forestry Corporation. It is clear that this entity has consistently failed to meet the minimal economical returns required to successfully operate a business; its activities continue to rapidly depreciate the intrinsic value of its native forests portfolio (which is a common property of the residents of NSW); it has been consistently subsidized by the NSW Government, while other areas that require funding have been neglected.

On behalf of the Australian Forest Products Association, Ernst and Young (2019) prepared the report '*The economic impact of the cancellation of NSW North Coast Wood Supply Agreements due to the creation of the Great Koala National Park*'. It is based on the assumption that the creation of the GKNP will result in the cancellation of all Wood Supply Agreements in the north-east NSW RFA area (termed NCFA), loss of 415,000m^3 of harvested hardwood timber per annum, and the closure of most sawmills, including the whole of Boral's operations. So their scenario is the shutting down all logging of public native forests in north-east NSW.

The current timber industry in north-east NSW is claimed to employ 1,048 people in production and 3,687 in processing, totalling 0.71% of total employment (Ernst and Young 2019). Ernst and Young (2019) claim that their "*worse case scenario*" of cancelling all WSAs and Boral closing their timber business will result in the loss of 566 direct jobs in north-east NSW (which is only 12% of industry employment, and 0.08% of regional employment), which is claimed to flow on to 826 indirect jobs. Ernst and Young (2019) advise that rather than converting their employment data to 'full-time equivalent', their employment figures *include casual, part-time and fulltime jobs*.

The University of Newcastle (2021) notes:

> *The NPA further cites 2015 Parliamentary Budget Office (PBO) costings for establishing the proposed GKNP of $119.5 million over two years, including:*
> - *The cost of redundancy payments ($50.8 million)*
> - *Business exit assistance which incorporates timber buy-backs, worker retraining and reliant business assistance ($64.1 million)*
> - *Mill clean-up costs ($4.6 million).*
>
> *The NPA notes that the PBO's costings (similar to the EY report) also assumed that all state native forest logging would be impacted, that all WSAs in the north east NSW would need to be cancelled and therefore that state native forest logging would end.*

To put the potential loss of jobs into perspective, State of the Forests 2018 (MPIG 2018) identifies that from 2006 until 2016 timber industry employment in NSW declined from 23,792 persons to 16,396 persons, an average annual decline of 740 persons per year, noting:

> *The key drivers for the reduction in total employment in the forest sector were consolidation of processing into larger facilities with higher labour efficiencies, and restructuring of the sector*

The DPI (2018) 'North Coast NSW Private Native Forest Primary Processors Survey Report' estimated 'the private property primary processing sector on the north coast of NSW directly employs 516 people, with the production flow-on and consumption flow-on likely to create a further 344 jobs regionally.

Table 19 Ratios for hardwood processing calculated from data in 'The Economic Impact of the NSW Timber Industry 1995 Margules Groome Poyry' for the north coast of NSW[30]

Hardwood processing of private native forest logs	Direct	Production flow-on	Consumption flow-on	Total
Employment calculated ratios	1	0.1130	0.5039	1.6170
Employment numbers	516	58	260	835

DPI (2018) 'North Coast NSW Private Native Forest Primary Processors Survey Report'

In relation to multipliers, Driml (2010) observe:

> *Total effects are direct plus flow-on effects. It is important to take care in interpreting the larger total effect figures. They should not be used to directly compare industries, due to double counting issues. For instance, in the café example above, the sales from agriculture to tourism will also be recorded as output from agriculture. Direct effects should be used when making comparisons among industries or across regions.*

As identified by the University of Newcastle (2021) the economic and social benefits of protecting forests far outweigh the economic costs. With carbon credits, increased recreation, increased water yields and other benefits it clearly in the community's best economic interest to stop logging public forests. This is also in accord with community preferences.

The logging of public native forests has always been an economic burden on taxpayers due to the high subsidies paid, both through maintaining the loss making native forestry operations of the Forestry Corporation and through direct payments to sawmill owners and occasionally workers. The hidden costs are the rundown in timber volumes, water quality and quantity, and wildlife populations, as well as the increase in weeds and dieback. Given that plantations are far more efficient and profitable it is past time to complete our transition to them for future timber needs.

4.2. Social Value

A valid consideration of the most appropriate uses of public forests must account for community preferences. These are part of the commons in which we all own a share. The aim has to be to manage public forests to maximise benefits to the community. Economic benefits accruing to individuals are often used to decide uses of public lands, though private gain does not reflect what is in the best interests of the community.

Economists often use "non-use values" as a means of incorporating community values into economic valuations, these are often characterised as ecological function value, option value, existence value and bequest value. The need to incorporate these into economic assessments is well established in the literature. Community attitude surveys are a clear indicator of community preferences and the magnitude of "non-use values". Bennett's (1998) rule of thumb for forest protection benefits is that non-use values are worth three times the value of recreational use.

The presence of existence value is a powerful social reason for conservation and is a value felt by all Australians. All Australians own an equal share in the public forests and they are all entitled to an equal say in their future. Theoretically each Australian who feels a personal consumption loss if the proposal goes ahead should be compensated.

To identify the environmental benefits of creating the Great Koala National Park the University of Newcastle (2021) undertook a Willingness To Pay (WTP) assessment, noting:

> *Biodiversity provides a so-called 'non-use' value to society. This is a value which comes from knowing an environmental feature will continue to exist in future, irrespective of any expectation of actual use. This value is generally estimated on the basis of stated preference methods which assess individuals' WTP to protect and maintain particular habitats or species which they may never themselves see*

A 'meta-analysis' of 159 Willingness To Pay valuations from 62 publications was undertaken, where non-use values were measured in terms of WTP for biodiversity improvements or WTP to avoid biodiversity loss, identifying:

- *The central average estimate across all studies reviewed in detail is that households would be prepared to make an annual payment of $161 (or a one-off payment of $203) to preserve biodiversity*
- *Households were found to have a WTP of $148 per annum to recover or improve biodiversity or of $186 per annum to prevent biodiversity loss*
- *The average WTP for biodiversity in Oceania (which includes Australia) is $207 per annum*
- *The average WTP for biodiversity in a forest habitat is $276 per annum (more than for other types of habitat)*
- *The annual WTP for biodiversity also varied with the indicator of interest, for instance $200 for habitat quality, $76 for species abundance, and $158 for species richness.*

The University of Newcastle (2021) assessment shows that the environmental benefits of creating the Great Koala National Park equate to added biodiversity value of:

•Around $530 million for the NSW population
•Around $1.7 billion for all Australians.

A major requirement of any social assessment, and a key component of determining the social values of public lands, is the determination of public preferences. The Community Attitude surveys undertaken for the CRAs (McGregor *et. al.* 1997, a,b) show that the regional communities place far more emphasis upon "forest protection values" than "opportunity costs" and establish that "non-use" values are extremely important to the broad regional community. McGregor *et. al.* (1997) concluded *"Forests have a very strong symbolic environmental value that people want to preserve even if this is seen to cause local social and economic difficulties."*

On behalf of the National Parks Association, in the lead up to the 2018 State Election ReachTEL conducted a survey of 700 residents across the New South Wales state electorate of Lismore and 729 across Ballina during the night of 6th December 2017.

In response to the question '*Would you support the creation of national parks to protect koalas from logging and land clearing?*', in Lismore 68.3% responded 'Yes', 16.8% 'No', and 14.8% ' Unsure/Don't know', in Ballina 74.2% responded 'Yes', 15.1% 'No', and 13.0% ' Unsure/Don't know'.

Of those with an opinion, 82% supported creating Koala parks to protect Koalas from logging and clearing.

In response to the question about relative values of native forests: '*There are two million hectares of publicly owned state forests in NSW. What do you think is the best use of these forests?*'

	Lismore (%)	Ballina (%)
The protection of forest wildlife, nature and trees	47.9	48.6
The protection of water supplies	23.4	23.4
Safely storing carbon in trees	10.9	7.9

Recreation activities	8.5	8.6
Logging for timber and woodchips	7.3	9.2
Logging and burning for biomass power	2.1	2.2

These results are consistent across both electorates and show that the community clearly prioritorise wildlife, water and carbon storage values of forests above timber production, and roughly put recreation values on a par with timber values.

It is clear that the logging of native forests has no social licence, as even the industry has found. The unpublished Forestry and Wood Products report "Community perceptions of Australia's forest, wood and paper industries: implications for social license to operate" (Schirmer *et. al.* 2018) surveyed 12,000 people from throughout Australia in 2016 and found.

- Native forest logging was considered unacceptable by 65% of rural/regional and 70% of urban residents across Australia, and acceptable by 17% of rural and 10% of urban residents. Eleven per cent of rural/regional and 9% of urban residents found this neither acceptable or unacceptable, and 8% and 11% respectively were unsure whether it was acceptable.
- 45% felt the forest industry had negative impacts on attractiveness of the local landscape and only 22% that it had positive impacts; agriculture and tourism were viewed as having more positive impacts, and mining somewhat more negative impacts
- 53% felt the industry impacted negatively on local traffic (and 16% positively); similar proportions reported negative impacts on traffic from tourism and mining activities, and 30% from agriculture
- 58% felt the industry had negative impacts on local road quality while 16% felt it had positive impacts; mining was also viewed as having negative impacts, while agriculture and tourism were viewed as having slightly more positive impacts.

The report concludes:

> *Views were very strong about unacceptability of native forest harvesting, with most of those who indicated it was unacceptable choosing the response of 'very unacceptable' rather than moderately or slightly unacceptable.*
> *The activity of harvesting timber from native forests has very low levels of social license in Australia, both in regions where this activity occurs and in those where it doesn't. Even amongst the groups who have the highest levels of acceptance of this activity (farmers), and in the regions with highest acceptance (mostly those in which there is higher economic dependence on native forest logging), more people find this activity unacceptable than acceptable.*
> *...*
> *The activity of harvesting timber from native forests has very low levels of social license in Australia, both in regions where this activity occurs and in those where it doesn't. Even amongst the groups who have the highest levels of acceptance of this activity (farmers), and in the regions with highest acceptance (mostly those in which there is higher economic dependence on native forest logging), more people find this activity unacceptable than acceptable. The similarity of views about logging of native forest with views about mining activities suggests that it is viewed as an activity that is non-renewable or unsustainable, rather than as having some of the positive environmental attributes of actions such as establishing solar or wind farms. The strength of views of many people about native forest harvesting suggests potential that this activity is considered incompatible with values held by many people.*
> *...*

> *Native forest harvesting has very low social license, with very few people being at the 'acceptance' level. Many of those who do not find this activity acceptable are likely to be at the blocking or withheld level of social license, rather than the tolerance level, based on the strength of their negative response when asked about acceptability. Even amongst the groups and in the regions with the highest acceptance of this activity, less than 30% find it acceptable and the majority find it unacceptable. Planting trees on good agricultural land for wood and paper production, however, has higher levels of social license: 43% find timber plantations acceptable, and of the 29% who find it unacceptable most do not find it highly unacceptable (instead reporting slight or moderate unacceptability), indicating many are at the 'tolerance' level rather than withholding or blocking social license.*

This perception exists because it is a rapacious industry overseen by blind bureaucracies who just perpetuate and compound concerns by lack of meaningful constraints and poor regulation. The NSW Government agencies refuse to recognise and accept deeply and long held community concerns and preferences, instead labelling them as "*negative views", "misguided hyperbole" and "fake news", as* demonstrated by the NSW Department of Primary Industries (2018):

> *The suggestion of government 'promotion of private native forestry' is a call to counter the negative views, 'fake news' and around sustainable native forestry, and promote the industry and timber products as a sustainable, ecologically beneficial and a carbon neutral material the public should use above all others.*

Social licence is something that needs to be earned, it can't be manufactured by a public relations campaign and blatant propaganda while the root causes are ignored, and often exasperated by further weakening of rules and regulations.

Community attitude surveys over the past 24 years clearly show that the community prioritise wildlife, water and carbon storage values of forests above timber production. The University of Newcastle assessed the biodiversity value (Willingness To Pay) of creating the Great Koala National Park as around $530 million for the NSW population and $1.7 billion for all Australians. A 2016 survey for the timber industry of 12,000 people found that native forest logging was considered unacceptable by 65% of rural/regional residents across Australia, and acceptable by just 17% of rural residents. Logging of native forests has very low levels of social license and is clearly not in the public interest.

4.3. Recreational Benefit

Visitation to, and management of protected areas, provide economic stimulation to regional economies from the associated expenditures that occur within the region. Visitors may buy food, refreshments, fuel, vehicle repairs, accommodation, and/or crafts in local towns, or stay in resorts or on farms, or take tours, all of which can add up to significant local expenditure and employment. Tourism is the most rapidly expanding sector of the regional economy. The rapidly escalating economic value of national parks for recreation does outweigh any short-term economic return from logging, mining and/or grazing.

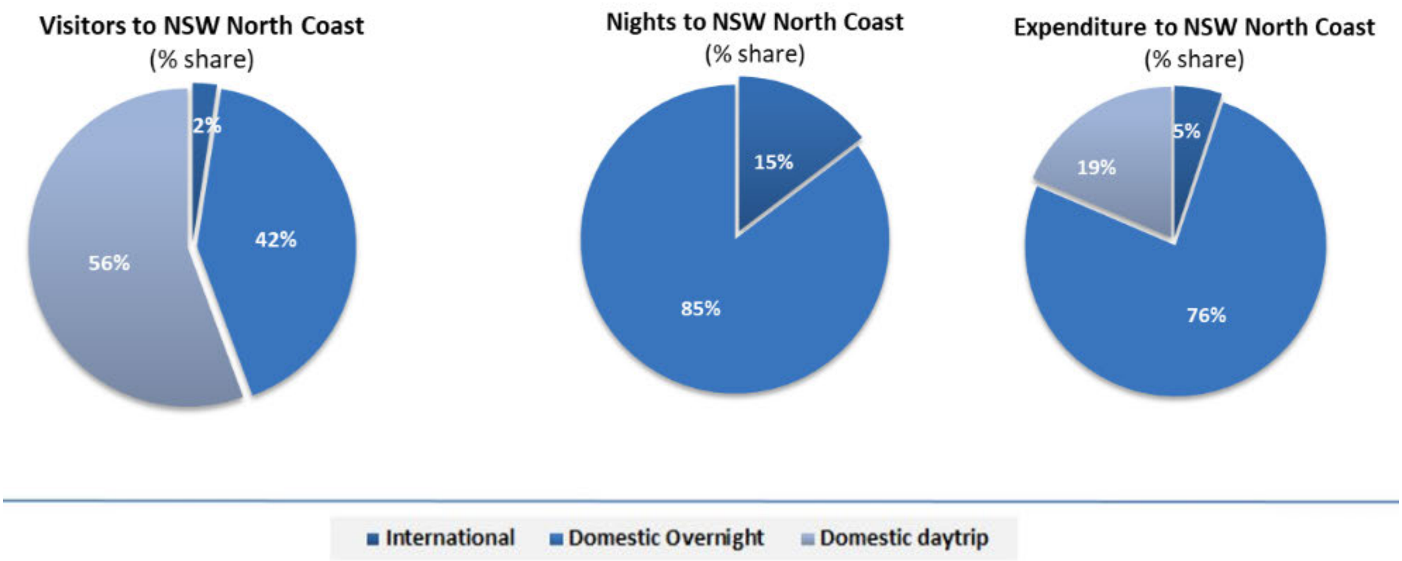
The 2019 National Visitor Survey shows in 2018–19, tourism directly contributed $18.5 billion to the NSW economy, with a flow-on effect of 84 cents for every dollar spent, generating an extra $19.6 billion to the New South Wales economy. Direct employment was 191,800 people, with a flow-on of 104,400 people. The 2019 National Visitor Survey shows that in NSW 4.4 million international tourists spent $565 million.

In the 2019 calendar year the North Coast of NSW had the third highest visitation of all Australian regions, following Sydney and Melbourne. The NSW North Coast visitor profile identifies NSW North

Coast received 43.8% of international visitors, 23.5% of domestic overnight visitors and 18.1% of domestic daytrip visitors to Regional NSW.

North Coast	Visitors (millions)	Visitor Nights (millions)	Average Nights	Spending (millions)	Spend per night	Spend per visitor
domestic overnight visitors	6.4	24.3	3.8	$3,900	$163	
domestic day trip visitors	8.5			$962		$113
International visitors	0.375	4.2	11.1	$265	$63	

NSW North Coast visitor profile, Year ending December 2019



NSW North Coast visitor profile: Visitors, Nights and Expenditure of International and Domestic visitors to the North Coast for year end December 2019.

The NSW North Coast visitor profile, identifies that from the year ending December 2014 until December 2019:

- domestic visitors, nights and expenditure were up 36.5%, up 34.5% and up 53.7%, respectively.
- domestic day trip visitors and expenditure were up 39.3% and up 61.1%, respectively.
- international visitors, nights and expenditure were up 39.7%, up 41.6% and up 58.9%, respectively.

There have been many attempts over the years to identify the economic benefit of national parks and reserves to regional economies. Driml (2010) considers:

> *There are two alternative approaches to measuring the value of tourism to national parks and interpreting its economic significance. One, consumer surplus, is a measure of economic welfare and is grounded in microeconomic theory. The other is a measure of contribution of spending by tourists to the economy and fits into frameworks used in national accounting.*

The economic stimulus provided to regional economies by National Parks and reserves arises from two sources:

- expenditure in the region by visitors to the protected areas; and.

- expenditure in the region that is associated with the management of reserves.

Regarding direct use values Driml (2010) comments:

> *One approach to valuing natural environment areas, such as national parks, has been to focus on placing a dollar value on direct uses such as tourism. This is generally easier than employing some of the more challenging and less accepted methodologies to value indirect use and other values. Thus estimating direct use values can provide a partial economic value of natural environment areas.*

The expenditure of visitors to national parks can be readily assessed through visitor surveys, the challenges are identifying the proportion of that expenditure that can be attributed to national parks, and the flow-on effects of that expenditure through local, regional and State economies.

From their NSW telephone surveys Roy Morgan (2019) identify that in 2018 45.6% of NPWS park visitors indicated that their *only reason* for their trip was to visit the NPWS park, 25.2% gave the visit as the *main reason* for their trip (75% of reason) and 16.4% give the visit as one of the main reasons (50% of reason).

Based on the National Visitor Survey (TRA pers.comm.) statistics, for the north coast in 2019 there were 34,795,000 visits (visitor nights plus domestic days) generating $4,709 million in regional expenditure, with the average spend per 1,000 visits being $135,335.

North Coast NSW	Visitors ('000)	Visitor Nights ('000)	Regional Expenditure ($M)	Average Expenditure per Trip $	Average Expenditure per Night $
2018					
International	349	3,480	223	639	64
Domestic overnight	5,582	20,583	3,479	623	169
Domestic day	7,329		816	111	
	13,260	24,063	4,517	341	154
2019					
International	364	4,099	272	747	66
Domestic overnight	5,884	23,263	3,623	616	156
Domestic day	7,433		814	109	
	13,681	27,362	4,709	344	142

National Visitor Survey (TRA pers.comm.) visitation for north coast NSW

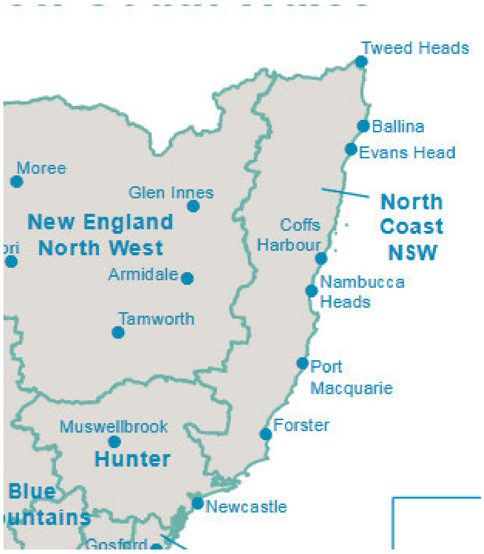
Note: Travellers who stay for one or more nights in a location while travelling (domestic overnight visitors and international visitors) or spend at least four hours on a round trip more than 50km away from home (domestic day visitors).

The National Visitor Survey (TRA pers.comm.) also collect data on tourism spending associated with 'bushwalking and rainforest walks', which is likely to reflect a subset of national park visitation. These data are averaged over four year periods. For the north coast these data indicate that 204,000 (around 60%) of international visitors engaged in these activities, spending an average of $62 per night and $595 per trip. An average of 902,000 domestic overnight visitors (around 20%) took walks, spending an average of $161 per night and $773 per trip. For domestic day visitors an average of 414,000 (around 6%) took walks, spending an average of $115 per trip. Taken together these represent 6,714,000 visits (overnights plus day trips) per annum, 19.3% of total visitation to the north coast, generating $867 million in regional expenditure, with a spend of $129,133 per 1,000 visitors.

North Coast NSW 4yr average 2016-19	Visitors ('000)	Visitor Nights ('000)	Regional Expenditure ($M)	Average Expenditure per Trip $	Average Expenditure per Night $
International	204	1,960	121	595	62
Domestic overnight	902	4,340	698	773	161
Domestic day	414		48	115	
	1520	6,300	867	1483	223

National Visitor Survey (TRA pers.comm.) Bushwalking/rainforest walks for north coast NSW

NPWS branches



Tourism Regions Australia

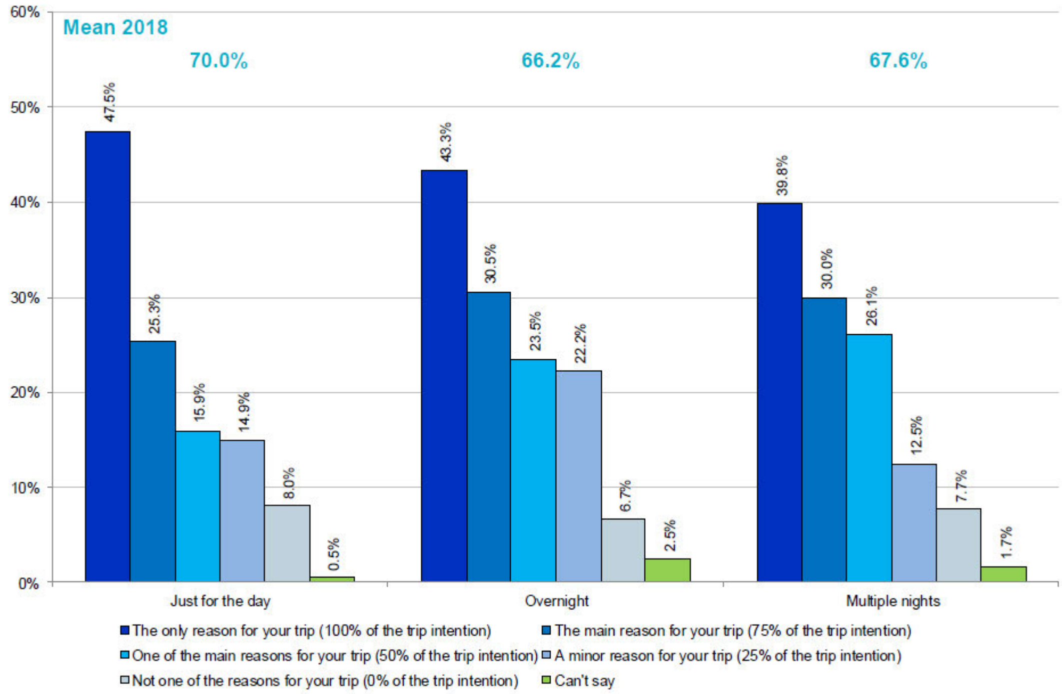
Destination NSW

Based on Roy Morgan (2019) the smaller NPWS North Coast region visitation is likely to have reached park visitation rates of 7.8 million in 2019. This shows that overall park visitation was far higher than identified in the National Visitor Survey category 'bushwalking and rainforest walks', which is expected given that the Roy Morgan (2019) data includes people making shorter day trips and people visiting parks for other reasons (i.e. picnicking and water-based activities).

Comparison of Roy Morgan (2019)'s 2018 visitation for the NPWS north coast branch with the National Visitor Survey's larger north-coast tourism region indicates that well over 21% of north coast visitors go to national parks.

The averaged annual North Coast regional tourist expenditure of $867 million for 2019 can be taken as a minimum conservative estimate of expenditure associated with forested national parks.

Chart 57: Role of NPWS Park Visit in Trip Decision by Duration of Visit



Source: NPWS Parks Visitor Surveys 2018
Base: n=1,741

National parks are a main attractor of tourists to the region. From their NSW telephone surveys Roy Morgan (2019) identify that in 2018 45.6% of NPWS park visitors indicated that their *only reason* for their trip was to visit the NPWS park, 25.2% gave the visit as the *main reason* for their trip (75% of reason) and 16.4% give the visit as one of the main reasons (50% of reason).

The act of converting a State Forest to a National Park can increase its recreational use, and therefore its economic contribution to the economy, because national parks are an international concept and this recognition attracts both domestic and international tourists. As noted by Buultjens and Luckie (2004):

> *National park visitation is a prominent part of both domestic and inbound travel within Australia. In a 1998 survey of international visitors to Australia it was found that 47 per cent of visitors aged 15 and over reported that they had visited at least one national park during their trip (BTR 1998). Visitation to national parks was even higher (57 per cent) among those international visitors travelling for holiday or pleasure purposes. For domestic travellers, visiting national parks is also popular. The National Visitor Survey revealed that a visit to a national park featured in 13 per cent of domestic overnight trips in 1999 (BTR 1999). This figure is significant when considering that domestic tourism in Australia represents a much larger market compared to inbound tourism.*

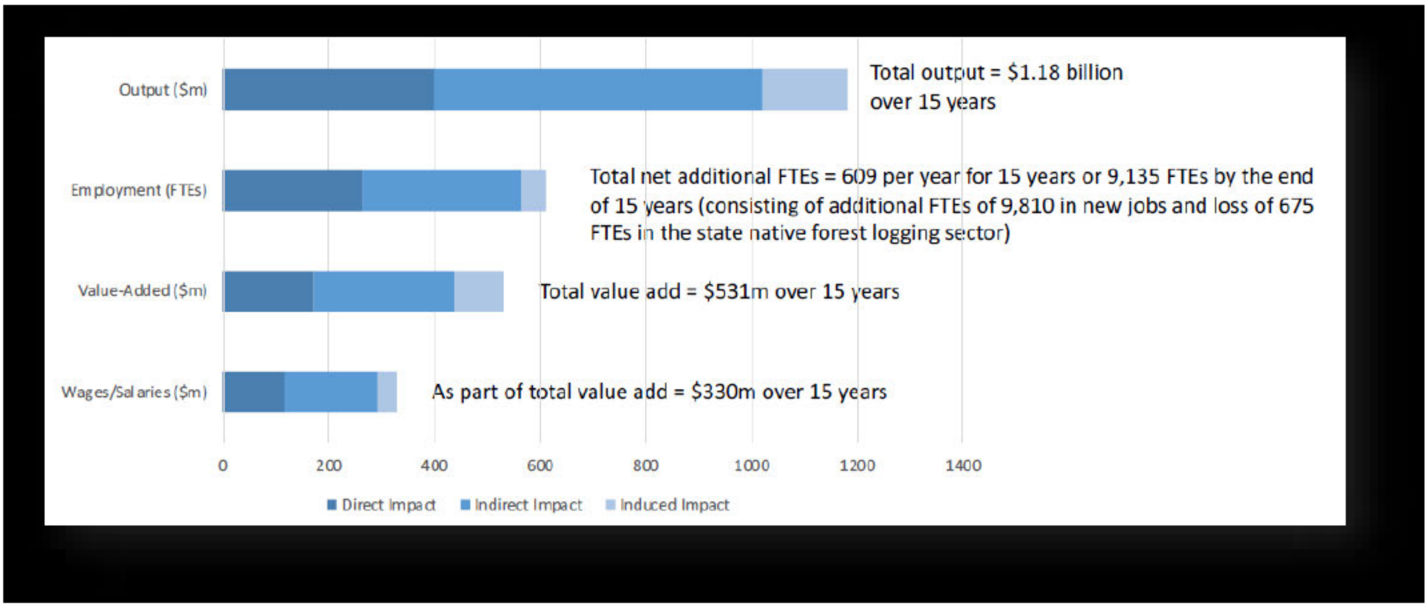
Visitation to, and management of protected areas, provide economic stimulation to regional economies from the associated expenditures that occur within the region. Visitors may buy food, refreshments, fuel, vehicle repairs, accommodation, and/or crafts in local towns, or stay in resorts or on farms, or take tours, all of which can add up to significant local expenditure and employment. Tourism is the most rapidly expanding sector of the regional economy. The rapidly escalating economic value of national parks for recreation does outweigh any short-term economic return from logging, mining and/or grazing.

The University of Newcastle (2021) undertook an economic impact analysis (EIA) and environmental benefit assessment (EBA) of the potential regional and broader impacts of the proposed Great Koala National Park (GKNP) which is located in five local government areas (LGAs): Bellingen Shire Council, Clarence Valley Council, Coffs Harbour City Council, Kempsey Shire Council and Nambucca Shire Council. This assessment provides an indication of some of the costs and benefits of ending logging of State Forests, they note:

> *There are five broad economic impacts resulting from the proposed GKNP:*
>
> *1. An increase in capital investment in the region (from government funds)*
>
> *2. An increase in operating expenditure*
>
> *3. An increase in the number of visitors staying longer in the region and an increase in the number of international visitors and higher per visitor spending across all market segments due to a national and international marketing and branding campaign*
>
> *4. A transition from state forest native logging activity in the region*
>
> *5. The provision of an industry transition assistance package by the NSW Government.*

Their assessment shows that the potential tourism benefits of creating the proposed GKNP far outweigh the economic costs associated with phasing out the logging of public native forests within the proposal. Identifying the net impact of creating the park as:

> *•Increase in total output of $1.18 billion over 15 years*
>
> *•Additional FTEs of 9,810 in new jobs by the end of 15 years and loss of 675 FTEs in the state native forest logging sector over 10 years i.e. net additional 9,135 FTEs*
>
> *•Additional total value-added of $531million over 15 years. Of this, $330million is paid in wages and salaries in net present value terms to workers living in the region.*



Tourism is far more important to the north coast economy than logging, and is the fastest growing sector promising increasing economic and employment benefits. In 2019 over $867

million of tourist expenditure can be taken as associated with forested national parks. It is in the community's economic interest to convert more of our public native forests to national parks as this will provide more fulfilling recreational opportunities and attract tourists to the region, as well as encouraging them to stay longer. The potential regional benefits of converting State forests to National Parks has been demonstrated by the University of Newcastle's assessment that over 15 years the creation of the Great Koala National Park would result in 9,135 additional full time jobs, and increases in total output of $1.18 billion and value add of $531 million. The Government will maximise long term regional benefits by directing its resources into enhancing and diversifying forest recreational facilities, rather than upgrading private sawmills

4.4. The carbon sequestration value of stopping logging.

Vast areas of remnant native forests have had their carbon storage in trees, logs, litter and soils dramatically reduced by logging and ringbarking, with their carbon released into the atmosphere to add to the growing problem of global heating. The degraded carbon stores in logged forests now represent an opportunity to remove significant volumes of carbon from the atmosphere and store it back in the recovering forest. Significant emissions can also be avoided by ceasing logging and the continuing running down of forest carbon stores.

Using the forests to generate carbon credits will generate greater aggregate net benefits to the community than logging. The avoidance of emissions by retaining trees, and their ongoing carbon sequestration, provides a higher benefit to the people of NSW than logging them. Protecting forests is an essential part of the solution to climate change and generates the greatest economic benefit to the people of NSW.

Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere, and annually is around 10% of global anthropogenic emissions (Keith et. al. 2015). In Australia, an estimated 44% of the carbon stock in temperate forests has been released due to deforestation (Wardell-Johnson *et. al.* 2011), with stocks further reduced by around 50% in logged forests (Mackey *et. al.* 2008, Moomaw *et. al.* 2019).

The Intergovernmental Panel on Climate Change (IPCC 2018), identifies that to limit global heating to 1.5^{o}C or even 2^{o}C the world needs to slow global emissions immediately and reach net zero carbon dioxide (CO_2) emissions by around 2050. Even then we need to remove copious quantities of carbon from the atmosphere. The IPCC (2018) identify:

> *All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence).*
> ...
> *Model pathways that limit global warming to 1.5°C with no or limited overshoot project the conversion of 0.5–8 million km^2 of pasture and 0–5 million km^2 of non-pasture agricultural land for food and feed crops into 1–7 million km^2 for energy crops and a 1 million km^2 reduction to 10 million km^2 increase in forests by 2050 relative to 2010 (medium confidence). Land use transitions of similar magnitude can be observed in modelled 2°C pathways (medium confidence).*

Goldestein *et. al.* (2020) warn:

> *Given that emissions have not slowed since 2017, as of 2020, this carbon budget will be spent in approximately eight years at current emissions rates. Staying within this carbon budget will require a rapid phase-out of fossil fuels in all sectors as well as maintenance and enhancement of carbon stocks in natural ecosystems, all pursued urgently and in parallel.*

With the urgent need to sequester carbon from the atmosphere we should be managing our forests as carbon sinks. As Mackey *et. al.* (2008) conclude;

> *The remaining intact natural forests constitute a significant standing stock of carbon that should be protected from carbon-emitting land-use activities. There is substantial potential for carbon sequestration in forest areas that have been logged commercially, if allowed to regrow undisturbed by further intensive human landuse activities*

Vast areas of remnant native forests have had their carbon storage in trees, logs, litter and soils dramatically reduced by logging and ringbarking, with their carbon released into the atmosphere to add to the growing problem of global heating. The degraded carbon stores in logged forests now represent an opportunity to remove significant volumes of carbon from the atmosphere and store it back in the recovering forest. Significant emissions can also be avoided by ceasing logging and the continuing running down of forest carbon stores.

Allowing forests to recover and regain their lost carbon is termed proforestation. It is a significant and essential part of the measures needed to limit global warming to 1.5 ^{o} or 2^{o} C. There are vast areas of forest in various states of degradation and regrowth that have the potential to rapidly increase their carbon sequestration and storage just by stopping cutting them down. Moomaw *et. al.* (2019) note:

In sum, proforestation provides the most effective solution to dual global crises – climate change and biodiversity loss. It is the only practical, rapid, economical and effective means for atmospheric carbon dioxide removal among the multiple options that have been proposed because it removes more atmospheric carbon dioxide in the immediate future and continues to sequester it into the long-term future. Proforestation will increase biodiversity of species that are dependent on older and larger trees and intact forests and provide numerous additional and important ecosystem services (Lutz et al., 2018). Proforestation is a very low-cost option for increasing carbon sequestration that does not require additional land beyond what is already forested and provides new forest related jobs and opportunities along with a wide array of quantifiable ecosystem services, including human health.

The big advantage of proforestation is that there is no waiting, the forests are already growing and absorbing more carbon as they age, we just need to let them do their thing and we can start the process of reducing atmospheric carbon. But we need to start now. As identified by Keith *et. al.* (2014b):

> *Avoiding emissions from forest degradation and allowing logged forests to regrow naturally are important activities for climate change mitigation. The former prevents further increases, and the latter helps reduce atmospheric concentrations of carbon dioxide. This kind of rapid response over the next few decades is important to allow time for technological advances in renewable energy sources that will hopefully eliminate the need for fossil fuel use (Houghton 2012).*

Houghton and Nassikas (2018) assessed the potential to take up the equivalent of 47% of global CO_2 emissions just by stopping clearing and degrading native vegetation, identifying "*the current gross carbon sink in forests recovering from harvests and abandoned agriculture to be -4.4 PgC/year, globally. The sink represents the potential for negative emissions if positive emissions from deforestation and wood harvest were eliminated*".

Houghton and Nassikas (2018) conclude that:

> *... negative emissions are possible because ecosystems are below their natural carbon densities as a result of past land use. That is, potential negative emissions are directly coupled to past positive emissions. There is nothing magical about these negative emissions. They simply restore carbon lost previously. The corollaries of this conclusion are (i) that negative emissions will diminish as forests recover to their undisturbed state (negative emissions will only work for a few decades) and (ii) that much of that recovery will have occurred before 2100, according to these simulations.*

Sohngen and Sedjo (2004) consider:

> *If incentives are provided to increase the stock of carbon, land owners may shift their management regimes from providing timber outputs to providing carbon sequestration. Some of the adjustments can occur relatively quickly, for example, by holding trees longer than the economically optimal rotation age, or stopping deforestation. Other adjustments, however, may occur over longer time periods, such as replanting agricultural land to trees.*

One means of payment for carbon sequestration is based on the 'rental concept' where "*carbon temporarily stored can be paid while it is stored, with no payments accruing when it is no longer stored*" (Sohngen and Sedjo 2004). Though Sohngen and Sedjo (2004) propose a variation where a price for a ton of abatement is paid in the year in which it occurs and a tax is paid in the year in which the emission occurs, considering "*The price of a ton of carbon sequestered or the tax on carbon emitted in any given year is the marginal cost of energy abatement*".

From their economic assessment in the United States Lubowski *et. al.* (2006) considered various levels of subsidy/tax payments, finding "*When a $100 per acre subsidy/tax is introduced, forest area almost doubles during the simulation period, from 405 to 754 million acres*", and concluding:

> *... if emission reductions in the United States on the scale proposed under the Kyoto Protocol were to be achieved entirely through domestic actions (forest-based sequestration and/or energy-based abatement activities) and with the type of policy incentive considered in this paper, our analysis implies that 33% to 44% of the reductions could be met cost-effectively through forest-based sequestration.*

It is relevant that Lubowski *et. al.* (2006) found "*lower marginal costs of carbon sequestration when timber harvesting is prohibited on lands enrolled in the carbon sequestration program. Marginal costs fall because the additional present value costs of enrolling lands on which harvesting is prohibited are more than outweighed by the additional present value carbon sequestered*", and because the restrictions on harvesting increase timber prices creating incentives for other landholders to retain their forests.

Luyssaert *et. al.* (2008) identify that one of the failings of the Kyoto Protocol is that only anthropogenic effects on ecosystems are considered, resulting in the perversion that "*15% of the global forest surface, which is currently not being considered for offsetting increasing atmospheric CO_2 concentrations, is responsible for at least 10% of the global NEP*". Considering that

> *The present paper shows that old-growth forests are usually carbon sinks. Because old-growth forests steadily accumulate carbon for centuries, they contain vast quantities of it. They will lose much of this carbon to the atmosphere if they are disturbed, so carbon-accounting rules for forests should give credit for leaving old-growth forest intact.*

Moomaw *et. al.* (2019) consider "*Private forest land owners might be compensated to practice proforestation, for sequestering carbon and providing associated co-benefits by letting their forests continue to grow*".

4.4.1. North East NSW's Carbon Sequestration Benefits

Roxburgh *et.al.* (2006) and Mackey *et. al.* (2008) advocate an approach to assessing the carbon stocks of native forests based on the Carbon Carrying Capacity of oldgrowth forest. Mackey *et. al.* (2008) consider that for reliable carbon accounts two kinds of baseline are needed;

> *1) the current stock of carbon stored in forests; and*
>
> *2) the natural carbon carrying capacity of a forest (the amount of carbon that can be stored in a forest in the absence of human land-use activity). The difference between the two is called the carbon sequestration potential—*
>
> > *the maximum amount of carbon that can be stored if a forest is allowed to grow given prevailing climatic conditions and natural disturbance regimes*

Oldgrowth forests thus provide the baseline of how much carbon remnant forests used to contain before the European invasion and the past 230 years of accelerating degradation. The difference between original carbon volumes and current volumes, is the volume that degraded remnant forests are capable of recovering from the atmosphere if allowed to grow old in peace. Mackey *et. al.* (2008) consider:

> *Once estimates of the carbon carrying capacity for a landscape have been derived, it is possible to calculate a forest's future carbon sequestration potential. This is the difference between a landscape's current carbon stock (under current land management) and the carbon carrying capacity (the maximum carbon stock when undisturbed by humans).*

Average Carbon Carrying Capacity of the Eucalypt Forests of South-eastern Australia. (from Mackey *et. al.* 2008)

Carbon component	Soil	Living biomass	Total biomass	Total carbon
Total carbon stock for the region (Mt C)	4,060	4,191	5,220	9,280
Carbon stock ha^{-1} (t C ha^{-1})	280 (161)	289 (226)	360 (277)	640 (383)

Carbon stock per hectare is represented as a mean and standard deviation (in parentheses), which represents the variation in modelled estimates across the region. The study region covers an area of 14.5 million ha.

Proforestation has the potential to take-up and store a significant proportion of NSW's annual carbon emissions. The Commonwealth of Australia (2019) give NSW emissions for 2016/17 as 131.5 million tonnes $CO_{2\text{-}e}$ (carbon dioxide equivalent) with stationary energy (which generates heat and electricity) the largest contributing sector. NSW's emissions represent 25% of Australia's total emissions.

To obtain an indication of the carbon sequestration potential of proforestation of north-east NSW's forests the methodology of Mackey *et. al.* (2008) was applied. This makes it clear that allowing north-east NSW's forests to recover from past logging can make a significant contribution to redressing NSW's CO_2 emissions.

The North-east NSW RFA regions, north from the Hunter River, total 8.5 million ha, of which 1,472,000 hectares is national parks and nature reserves and 838,000 hectares is State Forests. Some 278,000 ha of State Forests is classed as FMZ 1, 2 and 3A and taken to be informal reserves. native forests in various stages of degradation, with 127,000 hectares of plantations. Around half the national parks and the informal reserves were protected either as an outcome of the Regional Forest Agreement process in 1998 or the Forest Icon decision in 2003, so significant parts had previously been logged.

Oldgrowth forests best approximates those forests that have not been significantly affected by logging or other disturbances such as intense wildfire, though many of these areas survived as oldgrowth because they are steep and low productivity forests (i.e. with relatively low carbon volumes). The last assessment of oldgrowth forests was for the Regional Forest Agreements, so can only be considered current as at around 1997. This identifies 1.3 million hectares of old growth forest in that part of the North East RFA region north from the Hunter River. There has been no assessment of how much of the 462,000 ha of rainforest identified in the RFA is oldgrowth,

North East NSW (CRA Regions - north from Hunter River) broad forest structure as mapped at 1998 according to current tenure, note that growth-stage mapping was primarily limited to eucalypt and Brush Box dominated forests and excluded rainforest, melaleuca forests and non-forest communities.

GROWSTAGE	National Park (ha)	State Forest Informal Reserve (ha)	State Forest General Logging (ha)	Other tenures (ha)	**TOTALS (ha)**
Rainforest	263,504	81,491	2,862	114,227	462,084
Candidate Old Growth	720,120	120,347	49,674	419,075	1,309,216
Other Forests	348,306	61,298	452,516	1,508,017	2,370,136
TOTALS	1,331,930	263,136	505,052	2,041,318	4,141,436

Based on the CRA data from 20 years ago, around 2.3 million ha (64%) of remnant eucalypt forests had then been logged (or otherwise degraded) and had significantly reduced carbon storage below original carrying capacity. Since then it can be expected that most of the oldgrowth forest in the general logging area on State Forests has been logged, along with significant areas of oldgrowth forest on private lands, though it also needs to be considered that a large proportion of oldgrowth remaining at that time had survived because it was low-productivity forest on poor soils and steep slopes.

Based on environmental and cultural heritage data generated by the NSW Office of Environment & Heritage for the *Biodiversity Conservation Act 2016* and the *Local land Services Act 2013,* DPI (2018) identify old growth forest as a regulatory constraint covering 139,542ha of private land in the north-east NSW RFA area, which is considerably less than mapped in 1998. It is assumed that some of this difference is because of changes in thresholds for mapping and protecting old growth forests on private lands, and because of logging since 1998.

DPI (2018) identify the total area native forests in private ownership in the whole of the North East RFA regions (which is a larger area than the figures cited above) as 2.8 million ha of native forests, with the union of all regulatory exclusion categories (including oldgrowth) covering 734,992 ha, or 25.6%, of the total area of private native forest on the NSW north coast. Application of this constraint to the above growth stage data for "other" lands suggests that over 1,500, 000 ha of degraded private forests are available for logging have carbon sequestration potential.

Commonwealth of Australia (2019) give NSW emissions in 2016/17 as 131.5 million tonnes $CO_{2\text{-}e}$ (carbon dioxide equivalent) with stationary energy (which generates heat and electricity) the largest contributing sector. NSW's emissions represent 25% of Australia's total emissions.

Proforestation has the potential to take-up and store a significant proportion of NSW's annual carbon emissions. Previously logged and otherwise disturbed forests incorporated into north-east NSW's existing formal and informal reserves decades ago are likely currently taking up the equivalent of 3.6% of NSW's annual CO_2 emissions. If logging of north-east NSW's State Forests were stopped tomorrow they would immediately begin sequestering in the order of 6.5% of NSW annual emissions, and by stopping logging there would be additional benefits in avoided emissions. Given these are public lands and most Wood Supply Agreements expire in 2023, with Boral's expiring in 2028, the rapid phase-out of logging of public lands is readily achievable. Though given the urgency of the climate emergency the phase-out needs to start immediately.

Area of degraded eucalypt and Brush Box Forest with carbon sequestration potential in north east NSW, note this is only indicative though shows the magnitude of benefits that will accrue over time from protecting forests.

	Areas of degraded forests ha	Total Carbon Carrying Capacity[1] (t C)	Current Carbon Stock[2] (t C)	Carbon Sequestration Potential (t C)	Carbon Dioxide Sequestration Potential[3] ($t\ CO_2$)	Annual Sequestration potential[4] ($t\ CO_2$)	% of NSW Annual Emissions[5]
Protected, National parks and informal reserves	409,600	262144000	191365120	70778880	2597584906	4727605	3.6
Loggable State Forests	502,200	321408000	192844800	128563200	471826944	8587250	6.5
Loggable Private Lands	1,500,000	960000000	576000000	384000000	1409280000	25648896	19.5
TOTALS	2,411,800	1543552000	926131200	617420800	2265934336	41240005	29.6

1. An average of 640 t per ha is taken as the potential Carbon Carrying Capacity
2. Assumed that Carbon Carrying Capacity in degraded forests has been reduced by 40% (Mackey *et. al.* 2008), except in reserve areas which were protected at various times, particularly over the period 1982 until 2003, with the majority being protected in 1998, to account for the time since protection it was assumed for this exercise that they had already regained a third of their lost carrying capacity resulting in a current deficit of 27% of capacity.
3. Application of conversion factor of 3.67 for tonnes of carbon to tonnes of carbon dioxide equivalent
4. Conversion factor of 0.0182 $t\ CO_2\ yr^{-1}$ (for 100 years) to identify annual avoided emissions (Mackey *et. al.* 2008)
5. Based on NSW emissions in 2016/17 of 131.5 million tonnes CO_2-e (carbon dioxide equivalent) (Commonwealth of Australia 2019).

The biggest gains in sequestration, up to some19.5% of NSW's annual emissions, would come from assisting private landholders in north-east NSW to protect their forests. It is recommended that to encourage landholders to manage their forests for carbon sequestration and storage, whether in soils or vegetation, those storing above average volumes of carbon should receive annual payments proportional to the volume stored at that time and the ecosystem benefits (i.e. threatened species habitat) it provides. This will recompense landholders for providing a public benefit and be an incentive for increasing storage.

For NEFA's proposed Sandy Creek Koala Park (south of Casino in the Richmond Valley) we assessed current biomass and carbon stocks by measuring 75 plots in logged forests on 10 transects, and the proforestation carbon carrying potential from 12 plots on two transects in similar unlogged forests'. For these medium site quality Spotted Gum forests we identified that past logging had reduced live biomass (above and below ground) from 454 tonnes/ha down to 190 tonnes/ha, a reduction of 265 tonnes/ha. This represents 132 tonnes of carbon per hectare and is the volumes recoverable over time if the forest was left to mature.

	Aboveground biomass		Belowground biomass		Total biomass	
	Biomass (t/ha)	Carbon (tC/ha)	Biomass (t/ha)	Carbon (tC/ha)	Biomass (t/ha)	Carbon (tC/ha)
Unlogged	363	182	91	45	454	227
Logged	152	76	38	19	190	95
Reduction	211	106	53	26	265	132

Estimates of biomass and carbon volumes per hectare within the logged forests of the proposed Sandy Creek Koala Park, compared to an unlogged control site in Banyabba State Forest. Note that this excludes dead standing trees and logs, so is an under-estimation.

NEFA also applied annual growth rates derived from south-east Queensland to NEFA's plot data to identify indicative carbon sequestration volumes per hectare if the forests were allowed to grow for

30 years. This gave a carbon sequestration rate of 1.75 tonnes per hectare per annum over 30 years, totalling 52.6 tonnes of carbon per hectare by 2050.

	Aboveground biomass		**Belowground biomass**		**Total biomass**	
	Biomass (t/ha)	Carbon (tC/ha)	Biomass (t/ha)	Carbon (tC/ha)	Biomass (t/ha)	Carbon (tC/ha)
Current	151.6	75.8	37.9	19.0	189.5	94.8
Increase by 2050	84.3	42.2	21.1	10.5	105.4	52.6
Average annual increase	2.81	1.41	0.70	0.35	3.51	1.75

Estimates of Carbon sequestration potential from application of growth rates derived from Ngugi *et. al.* (2015) to plot data for the proposed Sandy Creek Koala Park (dead standing trees and logs omitted)

This provides an indication of the carbon sequestration potential of medium site quality Spotted Gum forest that has been subject to repeated logging operations in the past, if protected from further logging. Sequestering 1.75 tC/ha a year is equivalent to 6.42 tonnes of CO_2/ha per annum, or 193 tonnes of CO_2/ha by 2050. The total recoverable over 100 years is 484 tonnes of CO2/ha.

The starting point of the degraded forest is 95 tC/ha of living biomass, which is equivalent to 349 tonnes of CO_2/ha. If a landholder agrees to permanently protect this (in an environmental zone or by covenant), or if it is already protected, it should also be recognized as part of a protected carbon bank and a proportion of its carbon value paid to the landholder on a regular basis.

It needs to be recognised that Spotted Gum forests grow slowly compared to many other forest types, so these figures represent the lower bounds of those achievable. This estimate for Spotted Gum of 6.42 tonnes of CO_2/ha per annum is significantly less than the 17.1 tonnes of CO_2/ha per annum derived from Mackey *et. al.* (2008). There could be a variety of reasons for these differences, particularly the relatively small size and volumes of trees left in these forests and lower growth rates, such that it is considered that the sequestration volumes identified by Mackey *et. al.* (2008) could be obtained in more productive forest types. Thus for illustrative purposes a range of potential carbon sequestration of 6.4 – 17.1 tonnes of CO_2/ha per annum is assumed for logged over forests in north-east NSW.

Atmospheric carbon does have a high cost and thus value. Given that Governments have decided to use market mechanisms to regulate the carbon cycle it is essential that values represent the true costs if perverse consequences are to be avoided.

Though as noted by Keith *et. al.* (2017b):

> *There is no exchange value for carbon sequestration in native forests because forest protection is not an approved abatement activity under the Australian Government regulations (Clean Energy Regulator 2016). However, carbon is sequestered by forests and this benefits the public and state and national emissions reduction targets. Hence, the value of carbon sequestration could be exchanged if market access was permitted under the Emissions Reduction Fund (DotEE 2017). Based on SNA approaches to valuation when market prices are not observable, the SEEA (SEEA 2014b, p113) uses a market price equivalent. This is usually based on the market price of similar goods or services. In the case of carbon sequestration, the price of carbon abatement is set by government auction irrespective of the activity or methodology for abatement (Clean Energy Regulator 2015).*

In Australia the Gilliard Government introduced the Clean Energy Futures Plan which briefly established a carbon price up to $24.15 per tonne before being abolished by the Abbot Government in 2014.

In 2014 the Government invested $2.55 billion in the Emissions Reduction Fund with the aim *'of reducing emissions at lowest cost and purchasing genuine and additional emissions reductions*'. A number of activities are eligible under the scheme and participants can earn Australian carbon credit units (ACCUs) for emissions reductions. One ACCU is earned for each tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project for 100 years. The baseline is the estimation of abatement that would occur in the absence of a project. So the key measure under the current system is additionality.

Australian carbon credit units (ACCUs) have been issued for a range of projects, including "*reducing emissions on the land by protecting native forest that would otherwise have been cleared*", with the example cited being a payment of $9,554,383 for protection of 7,000ha of semi-arid scrub which was estimated to sequester 60,000 tonnes of carbon annually.:

> *Peter was scheduled to clear 7,000 hectares of forest on marginal land on his property. Peter committed to keeping these forests standing for 100 years as an Emissions Reduction Fund project. In exchange he receives carbon credits which he can sell back to the Government*

Payment of carbon credits for avoided deforestation is not far removed from payment to avoid logging, which is a partial and staged form of land clearing. Though this example also demonstrates the absurdity of a system that only recognises the value of carbon stored in native vegetation if approval is first obtained to clear it.

On 25 February 2019 the Australian Government established a Climate Solutions Fund to provide an additional $2 billion to continue purchasing low-cost abatement.

Reputex Energy (March 26th, 2020) identify:

> *International carbon prices have tumbled amid fears that a COVID-19 induced economic downturn will curb industry demand for carbon allowances, causing a heavy sell-off by investors. In Europe, EUA prices fell over 11 per cent last week, referred to as Black Monday, reaching a low of €15.24/t (A$28), down from €29.94/t (A$54) in mid-July 2019.*
>
> *Locally, the Australian Carbon Credit Unit (ACCU) spot price has continued to trade between $16.50-17/t since late-February, at low volumes, down from a four-year high of $17.50 in December-19.*

The Clean Energy Regulator's Quarterly Carbon Market Report for the first quarter of 2020 identifies 'The tenth Emissions Reduction Fund auction secured 1.7 million tonnes of carbon abatement from 12 contracts and 11 projects at an average price of $16.14 per tonne, for a total commitment of $27.6 million'. In relation to this auction Reputex Energy (April 3rd, 2020) state:

> *The Clean Energy Regulator remains unwilling to contract at higher prices, not accepting a number of higher priced bids at Auction 10.*
>
> As noted in our earlier update*, the unwillingness of the Regulator to contract at higher prices has effectively collapsed the ERF market, with the low price ceiling failing to unlock higher cost abatement projects, while eroding market sentiment as bidders sit on the sidelines or wait for more favourable prices in the secondary market or via direct offtake agreements.*
>
> *At these contracting volumes, the ERF is unlikely to make a large contribution to Australia's national emissions reduction abatement task, with a re-working of the scheme needed to better incentive industry participation.*

It is considered that carbon prices, particularly in Australia, grossly undervalue the true cost of carbon, and what the likely future value of carbon will be. A recent study by Boston Consulting Group 'The Staggering Value of Forests—and How to Save Them' considered

The estimated total value of the world's forests is as much as \$150 trillion—nearly double the value of global stock markets. The ability of forests to regulate the climate through carbon storage is by far the largest component of that total value, accounting for as much as 90%.

We quantified the first component by determining the amount of carbon currently stored in tree biomass. On the basis of that figure, we calculated the CO_2 emissions that existing forests have prevented from being released into the atmosphere. Those prevented emissions, roughly 1,000 Gt of CO_2 in total, are priced at \$27 to \$135 per Gt CO2 to arrive at the climate-regulatory value from carbon capture and storage. The lower figure represents the current 50-day moving average of the carbon price in the EU, while the higher figure is the price necessary to keep global warming below 1.5°C by 2030 according to the Intergovernmental Panel on Climate Change (IPCC).

Keith *et. al.* (2017b) similarly note:

The price of carbon sequestration in the market does not equate to the social cost of carbon, that is, the marginal damage costs caused by carbon dioxide emissions if they were not avoided. An average value of the social cost of carbon was estimated to be \$58 tC^{-1} (\$212 tCO_2^{-1}) based on a literature survey (Tol 2005). This social cost represents the trade-off between avoided impacts of climate change and the costs of emission reduction.

For Victorian Central Highlands forests Keith *et. al.* (2017a) applied the then ACCU carbon price to calculate:

The carbon sequestration potential of ceasing native forest timber harvesting and allowing continued forest growth was estimated to be 3 tC ha^{-1} yr^{-1} (averaged between 1990 and 2015), which is equivalent to AUD\$134 ha^{-1} yr^{-1}. Over the area of forest that had been logged, this potential increase in carbon stock was 0.344 MtC yr^{-1}, equivalent AUD\$15.5 million yr^{-1} (Table 1).

While \$17 a tonne can be considered the current market cost of carbon dioxide in Australia's shambolic carbon market, there can be no doubt that as climate chaos gains momentum, and the Federal Government can no longer deny the urgency of the problem, that the carbon value will rapidly escalate to reflect the true cost of emissions and the cost of removing atmospheric carbon.

If the minimal value of \$17 a tonne is applied to the range of potential carbon sequestration of 6.4 – 17.1 tonnes of CO_2/ha per annum for logged over forests in north-east NSW (as identified above) the annual CO_2 sequestration would be worth \$109-\$291 per ha per annum. Using the live carbon pool of 95 tC/ha identified above by NEFA as a baseline, this is equivalent to 349 tonnes of CO_2/ha, and would therefore have a current carbon value of \$5,933 per hectare, or \$119 per annum if spread over 50 years.

It is proposed that if the existing carbon bank is protected from clearing or logging in perpetuity (such as through E2 zoning or covenant) then regular payments could be made to the landowner for a portion of its current carbon value, and for its carbon increment. In the example above this would equate to annual payments of \$228-410/ha per annum to a landholder, all paid for with carbon credits. This creates a realistic incentive for protecting forests.

Applying such values to the 500,000ha of logged and loggable State Forests in north-east NSW would equate to annual revenue of \$114-205 million a year, just from stopping logging.

As carbon increases to a more realistic value so too would the payments to landholders. All forests should be available for such payments irrespective of currently allowable uses (ie logging or clearing constraints).

Loss of carbon from deforestation and degradation has contributed 35% of the accumulated anthropogenic carbon dioxide concentration in the atmosphere, and annually is around 10% of global anthropogenic emissions. To address the growing threat of climate heating we need to both reduce emissions and increase sequestration of atmospheric carbon. Retaining forests and allowing degraded forests to regain their lost carbon are urgent actions we need to take to begin to redress climate heating on the scale required. Carbon credits offer a mechanism to reward landholders for protecting forests for carbon sequestration, though they need to include payments for standing carbon and annual sequestration when forests are protected. At the current ACCU carbon dioxide price of $17 a tonne, the value of carbon dioxide current stored in a logged forest, combined with annual sequestration could equate to annual payments of $228-410/ha per annum to a landholder, all paid for with carbon credits. It is requested that the inquiry consider measures needed to facilitate a scheme that could realise such payments to land holders. Applying such values to the 500,000ha of logged and loggable State Forests in north-east NSW would equate to annual revenue of $114-205 million a year, just from stopping logging.

4.4.2. Other Australian Assessments of Carbon Benefits of Protecting Forests

There have been a variety of Australian studies undertaken on the costs and benefits of managing forests for carbon sequestration that consistently find that the greatest net benefit comes from stopping logging.

For their assessment of existing and potential carbon stocks in south-east Australia, including north-east NSW, Mackey *et. al.* (2008) found;

> *Our analyses showed that the stock of carbon for intact natural forests in south-eastern Australia was about 640 t C ha^{-1} of total carbon (biomass plus soil, with a standard deviation of 383), with 360 t C ha^{-1} of biomass carbon (living plus dead biomass, with a standard deviation of 277).*
>
> *...*
>
> *The highest biomass carbon stocks (more than 1500 t C ha^{-1}) are in the mountain ash (Eucalyptus regnans) forest in the Central Highlands of Victoria*
>
> *...*
>
> *Using our figures, the total stock of carbon that can be stored in the 14.5 million ha of eucalypt forest in our study region is 9.3 Gt, if it is undisturbed by intensive human land-use activity and allowed to reach its natural carbon carrying capacity ... Note that while our model estimates the average total carbon stock of natural eucalypt forests at 640 t C ha^{-1}, real site values range up to 2500 t C ha^{-1}. This range reflects the natural variability found across landscapes in the environmental conditions and disturbance regimes that affect forest growth.*

Average Carbon Carrying Capacity of the Eucalypt Forests of South-eastern Australia. (from Mackey *et. al.* 2008)

Carbon component	Soil	Living biomass	Total biomass	Total carbon
Total carbon stock for the region (Mt C)	4060	4191	5220	9280
Carbon stock ha^{-1} (t C ha^{-1})	280 (161)	289 (226)	360 (277)	640 (383)

Carbon stock per hectare is represented as a mean and standard deviation (in parentheses), which represents the variation in modelled estimates across the region. The study region covers an area of 14.5 million ha.

Oldgrowth forests thus provide the baseline of how much carbon remnant forests used to contain before the European invasion and the past 230 years of accelerating degradation. The difference between original carbon volumes and current volumes, is the volume that degraded remnant forests are capable of recovering from the atmosphere if allowed to grow old in peace. Mackey *et. al.* (2008) consider:

> *Once estimates of the carbon carrying capacity for a landscape have been derived, it is possible to calculate a forest's future carbon sequestration potential. This is the difference between a landscape's current carbon stock (under current land management) and the carbon carrying capacity (the maximum carbon stock when undisturbed by humans).*

From their assessment Mackey *et. al.* (2008) concluded:

> *The carbon carrying capacity of the 14.5 million ha of eucalypt forest in our study area is about 9 Gt C (equivalent to 33 Gt CO_2). About 44 per cent of the area has not been logged and can be considered at carbon carrying capacity, which represents about 4 Gt C (equivalent to 14.5 Gt CO_2). About 56 per cent of the area has been logged, which means these forests are substantially below their carbon carrying capacity of 5 Gt C. If it is assumed that logged forest is, on average, 40 per cent below carbon carrying capacity (Roxburgh et al. 2006), the current carbon stock is 3 Gt C (equivalent to 11 Gt CO_2). The total current carbon stock of the 14.5 million ha is 7 Gt C (equivalent to 25.5 Gt CO_2). If logging in native eucalypt forests was halted, the carbon stored in the intact forests would be protected and the degraded forests would be able to regrow their carbon stocks to their natural carbon carrying capacity. Based on the assumptions above, the carbon sequestration potential of the logged forest area is 2 Gt C (equivalent to 7.5 Gt CO_2).*

The other key attribute is the rate at which carbon is sequestered by vegetation, which governs how quickly the carbon can be removed from the atmosphere. Mackey *et. al.* (2008) note:

> *Gross primary productivity (GPP) is the annual rate of carbon uptake by photosynthesis. Net primary productivity (NPP) is the annual rate of carbon accumulation in plant tissues after deducting the loss of carbon dioxide by autotrophic (plant) respiration (Ra). This carbon is used for production of new biomass components—leaves, branches, stems, fine roots and coarse roots—which increments the carbon stock in living plants. Mortality and the turnover time of carbon in these components vary from weeks (for fine roots), months or years (for leaves, bark and twigs) to centuries (for woody stem tissues). Mortality produces the dead biomass components that provide the input of carbon to the litter layer and soil through decomposition. ...*
>
> *The proportion of carbon uptake used for biomass production is represented by the ratio of NPP:GPP.*
>
> *...*
>
> *Our analyses (Table 1) showed that the stock of carbon for intact natural forests in our study area is about 640 t C ha_{-1} and the average NPP of natural forests is 12 t C ha^{-1} yr^{-1} (with a standard deviation of 1.8). In terms of global biomes, Australian forests are classified as temperate forests. The IPCC default values for temperate forests are a carbon stock of 217 t C ha^{-1} and an NPP of 7 t C ha^{-1} yr^{-1}.*

For their assessment of south-east Australia, Mackey *et. al.* (2008) adopted the conversion that every 1 t CO_2 stored (for 55 year) is equivalent to 0.0182 t CO_2 yr^{-1} (for 100 years) of avoided emissions, finding that:

> *Our analysis shows that in the 14.5 million ha of eucalypt forests in south-eastern Australia, the effect of retaining the current carbon stock (equivalent to 25.5 Gt CO_2 (carbon dioxide)) is equivalent to avoided emissions of 460 Mt CO_2 yr^{--1} for the next 100 years. Allowing logged forests to realize their sequestration potential to store 7.5 Gt CO_2 is equivalent to avoiding emissions of 136 Mt CO_2 yr^{--1} for the next 100 years. This is equal to 24 per cent of the 2005*

Australian net greenhouse gas emissions across all sectors; which were 559 Mt CO_2 in that year.

In Tasmanian wet-eucalypt forests Dean *et. al.* 2012 found:

Over the last two decades, the majority of forest C destined for short- or long-term emission (LTE, i.e. over several centuries and multiple harvests) was from clearfelling the higher-biomass wet-eucalypt forests on public land. ... The first cycle of conversion of primary-forests contributed 43(±5)% to the LTE, and the LTE constituted ~50% of the primary-forest C stock. Whether the first logging of even-aged primary-forests was prior to or after maturity, the LTEs were equivalent, although short-term emissions (STEs) were ~2× higher from old-growth.

Tables 3a and b from Dean *et. al.* 2012:

Table 3a
Comparison of [long-term average] C stocks and changes for Site-1 (even-aged *E. regnans*, mixed-forest) with an ensuing sequence of 80-yr harvesting cycles.

	Primary-forest C (long-term average) (Mg ha^{-1})	Harvesting cycle (long-term average) (Mg ha^{-1})	Δ (Mg ha^{-1})	Δ (%)
Total-C	1246	595	−651	−52%
Biomass	549	150	−399	−72%
SOC	627	326	−301	−48%
Necromass (forest debris)	67	45	−22	−33%
Wood-products	0	70	70	–

Half-lives: SOC 550 years, sawlog 40 years, pulpwood 2 years (including mill residues).

Table 3b
Comparison of [long-term average] C stocks and changes for Site-2 (uneven-aged, wet-sclerophyll) with an ensuing sequence of 15-yr plantation harvesting cycles.

	Primary-forest (long-term average) (Mg ha^{-1})	Harvesting cycle (long-term average) (Mg ha^{-1})	Δ (Mg ha^{-1})	Δ (%)
Total-C	127	37	−90	−71%
Biomass	121	17	−104	−86%
Necromass (forest debris)	2.4	2.2	−0.2	−9%
Wood-products	0	18	18	–

Total does not include SOC. Half-lives: pulpwood 1.73 years, fibreboard 9.55 years, mill residue 0.2 years.

Perkins and Macintosh (2013) undertook an economic analysis to compare the net financial benefits from harvesting NSW's Southern Forest Region's (SFR's) native forests with those produced by conserving the forests and generating carbon credits, finding that *"using the forests to generate carbon credits will generate greater aggregate net benefits than harvesting"*. They note:

The analysis in this paper suggests that, in the absence of a rebound in relevant wood product prices (especially the export woodchip price), continued harvesting in the SFR is likely to generate substantial aggregate net losses over the next 20 years. In the core harvest scenario (H1), the combined net financial benefits generated by the Forestry Corporation of NSW and the SFR's private hardwood processors over the period 2014-2033 were estimated at between -$40 million and -$77 million. These losses would be borne by the Forestry Corporation of NSW and SEFE; the sawmills are projected to produce a small positive net financial benefit over the projection period. This is mainly because the Forestry Corporation of NSW and SEFE's operations subsidise SFR hardwood sawmilling.

Stopping harvesting and using the native forests of the SFR to generate carbon credits offers a viable alternative to commercial forestry. In the core no-harvest scenario (CC1, method 1), it was estimated that the New South Wales government could earn 33.8 million ACCUs over the period 2014-2033 (an average of 1.7 million per year). The net financial benefits that could be generated through the sale of these credits (accounting for transaction and management costs) were estimated at $222 million. The Australian government would also receive the benefit of 12.8 million residual FM credits from the cessation of harvesting in the SFR over the period 2014-2033. However, if the New South Wales government receives ACCUs, the financial benefits to the Australian government are likely to be relatively small as lost company tax revenues associated with ceasing harvesting would largely cancel out the financial benefits received from the residual FM credits.

Overall, the analysis supports two general conclusions:

- *under current and likely future market conditions, the harvesting and processing of native logs in the SFR is likely to generate substantial losses; and*
- *the aggregate net financial benefits are likely to be significantly higher if commercial harvesting is stopped and the native forests of the SFR are used to generate carbon credits.*

Macintosh *et. al.* (2015) conducted life-cycle assessments of Green House Gasses (GHG) in the NSW Southern Forestry Region (SFR), a commercial public native forest estate covering almost 430,000 ha, comparing ongoing logging and woodchipping (sustainable use) with stopping logging (conservation), finding:

The results of the basic scenarios suggest conservation will produce significantly better GHG outcomes than sustainable use over the projection period, with cumulative abatement of 57-75Mt of CO2-equivalent emissions (MtCO2e; Fig. 1). The greater emissions from the sustainable use scenario are attributable to the high proportion of biomass left on the forest floor after harvesting and the low percentage of roundwood assigned to long-lived wood products.

...

With the scope of inquiry confined to impacts on national net emissions, conservation of the SFR generated 79-85MtCO2e of cumulative abatement over the projection period relative to the sustainable use reference case, 10-21MtCO2e above the equivalent results from the basic scenarios (Fig. 3).

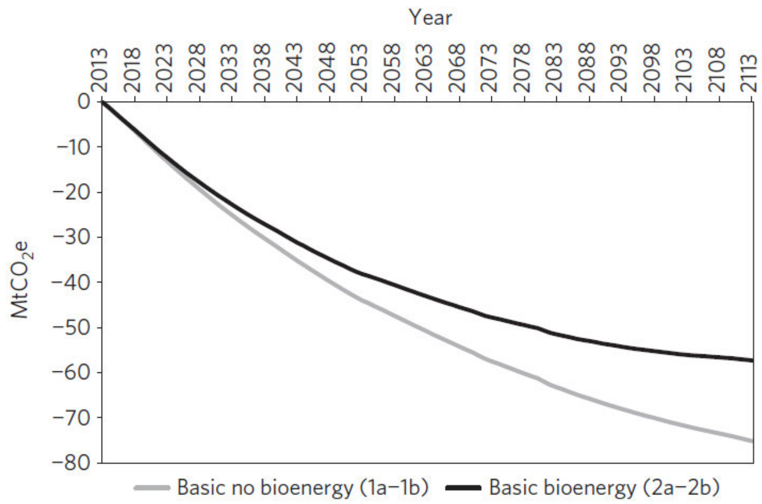


Fig 1 from Macintosh *et. al.* (2015). Basic scenarios—difference between the sustainable use reference case and the conservation scenario as cumulative net GHG emissions. Net emissions were calculated as the net flux difference (emissions less removals) between the sustainable use reference case and the conservation scenario. Negative net emissions occur when net emissions in the conservation scenario are less than those in the sustainable use reference case (abatement).

Macintosh *et. al.* (2015) considered a variety of timber substitution scenarios, assuming if harvesting ceased in the SFR, most of the substitutes for the foregone sawnwood products are likely to be imported or derived from domestic plantations, with Japan likely obtaining equivalent woodchips from eucalypt plantations in Vietnam. They found that if sawnwood timber substitution comes from Australian or New Zealand plantations then there was still a net benefit from a conservation outcome, though if substitution comes from Indonesian rainforests the sustainable use scenario had a net carbon benefit.

Keith *et. al.* (2014b) assessed the effects of logging on Mountain Ash forests in Victoria, demonstrating:

... that the total biomass carbon stock in logged forest was 55% of the stock in old growth forest. Total biomass included above- and below ground, living and dead. ... Reduction in carbon stock in logged forest was due to 66% of the initial biomass being made into products with short lifetimes (,3 years), and to the lower average age of logged forest (,50 years compared with .100 years in old growth forest). Only 4% of the initial carbon stock in the native forest was converted to sawn timber products with lifetimes of 30–90 years.

...

Only the sawn timber products and dead and downed woody debris remaining on-site had mean residence times in the order of decades

...

We estimated that continued logging under current plans represented a loss of 5.56 Tg C over 5 years in the area logged (824 km^2), compared with a potential gain of 5.18–6.05 TgC over 5 years by allowing continued growth across the montane ash forest region (2326 km^2)

...

As a logging system averaged spatially across the landscape with areas at different times since logging, the average carbon stock was 37% of the initial stock. The maximum carbon stock at age 50 years was 44% of the initial stock. After a single logging event, accumulation of carbon took 250 years to regain the initial stock.

Table 2 from Keith *et. al.* (2014b): Current carbon stock in living and dead biomass components for different age classes of montane ash forest (mean ± SE; n = 6).

	Biomass carbon stock (tC/ha)			
Forest age	Living trees	Standing dead trees	Woody debris† + litter	Total
1983 regrowth	293 ± 43	34 ± 8	78 ± 15	405 ± 33
1939 regrowth	426 ± 64	89 ± 31	88 ± 25	603 ± 74
Old growth	930 ± 41	41 ± 25	65 ± 9	1039 ± 44

† Woody debris refers to dead and downed woody debris.

Table 4. from Keith *et. al.* (2014b): Projected biomass carbon stocks in the montane ash forest study area (2326 km^2) estimated from the current carbon stock (CCS) in 2010; predictions for +20 years (2030), +50 years (2060), +100 years (2110) and +150 years (2160); and the carbon carrying capacity (CCC).

	Total biomass carbon stock (Mt C)‡					
Carbon accumulation method†	CCS	2030	2060	2110	2160	CCC
Eq. 1	113	133	162	196	221	204
Eq. 2	113	130	152	177	194	204

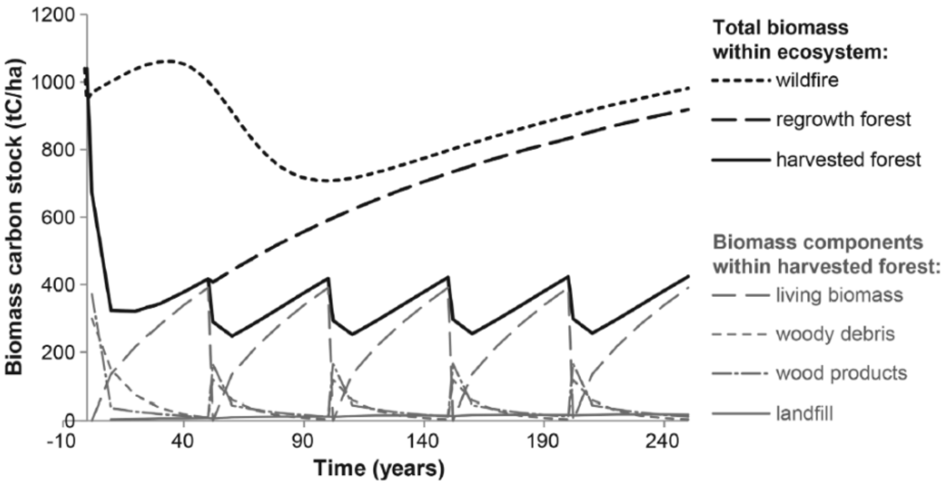


Fig. 10. from Keith *et. al.* (2014b): Changes in total biomass carbon stock of the ecosystem over time under three scenarios (shown as black lines) from an initial stock of a native forest: (1) wildfire that

occurred at time 0 years and then the forest regenerated and dead biomass decomposed over time, (2) regrowth forest after logging once and regeneration, and (3) harvested forest under a regime of repeated logging rotations consisting of clearcutting and slash burning on a 50 year cycle

Keith *et. al.* (2014b) consider that older forests can have even greater carbon stocks:

> *Maximum carbon stock of living biomass occurs in old growth forests, such as our research sites dominated by approximately 250-year-old trees. However, old growth forests of* E.regnans *and other eucalypts can have maximum ages up to 400–500 years (Gilbert 1959, Ogden 1978, Wellington and Noble 1985, Banks 1993, Looby 2007, Wood et al. 2010), and so the maximum stock could be higher than our site values (Stephenson et al. 2014). Defining this asymptote is hampered by limited data for old forests.*

For south-east NSW and East Gippsland, Keith *et. al.* (2015) assessed "*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.*" They "*demonstrated that changing native forest management from commercial harvesting to conservation can make an important contribution to climate change mitigation*", finding "*stopping harvesting results in an immediate and substantial reduction in net emissions*", and "*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*".

	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	

Table 4 from Keith *et. al.* (2015). Change in carbon stocks (tC ha^{-1}) over the 20, 50 and 100 year simulation periods for scenarios of conservation forest with product substitution 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	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	

Table 5 from Keith *et. al.* (2015). Change in carbon stocks (tC ha^{-1}) over the 20, 50 and 100 year simulation periods for scenarios of conservation forest with product substitution 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.

Keith *et. al.* (2015) also considered the effects of a wildfire, recognising that they affect the carbon stocks of native forests, but "*result in relatively small fluctuations due to emissions, with the carbon stock regained within a decade through regeneration*", noting "*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*".

4.5. Valuing Forest's Water Yields

Forests are key components of the earth's water cycle. Forests do not just respond to rainfall, they actively generate their own. They recycle water from the soil back into the atmosphere by transpiration, create the updrafts that facilitate condensation as the warm air rises and cools, create pressure gradients that draw moist air in from afar, and, just to be sure, release the atmospheric particles which are the nuclei around which raindrops form.

Forests have been described as 'biotic pumps' driving regional rainfall because their high rates of transpiration return large volumes of moisture to the atmosphere and suck in moisture laden air from afar.

While most of our rain originates from evaporation of the oceans, it is estimated that 40% of the rain that falls on land comes from evaporation from the land and, most importantly, from transpiration by vegetation. Recycled water vapour becomes increasingly important for inland rainfall.

Having created and attracted the water vapour, the plants then make it rain. Plants emit volatile organic compounds (VOCs), such as plant scents and the blue haze characteristic of eucalypt forests. They play an important role in communication between plants, and messages from plants to animals, and also between plants and moisture-laden air. They oxidise in the air to form the cloud condensation nuclei around which waterdrops form.

The transpiration of vegetation also results in evaporative cooling whereby the surface heat is transferred to the atmosphere in water vapour. The resultant clouds also help shade and cool the surface.

Forests store water in their tissues, in the soil amongst their roots and in the protected microclimate beneath their canopies, releasing it over time to the atmosphere by evapotranspiration and to streams through the groundwater system. Forests are a vital component of our hydrological cycle and due to their roles in attracting and recycling rainfall, reducing temperatures and regulating runoff they provide immense economic benefits to human societies. Their importance will become increasingly significant as climate change results in more erratic rainfalls and intense dry periods.

Of the rain that falls upon a forested catchment some is evaporated directly from leaf and ground surfaces and part may be redirected by surface flows directly into streams. Except in intense rainfall events, the majority can be expected to infiltrate the soil where it is used for transpiration by plants, with the excess contributing to groundwater seepage into streams or possibly seeping deep down to aquifers. In a natural forest situation most of the streamflow response to rainfall is provided by the groundwater system.

The eWater CRC notes:

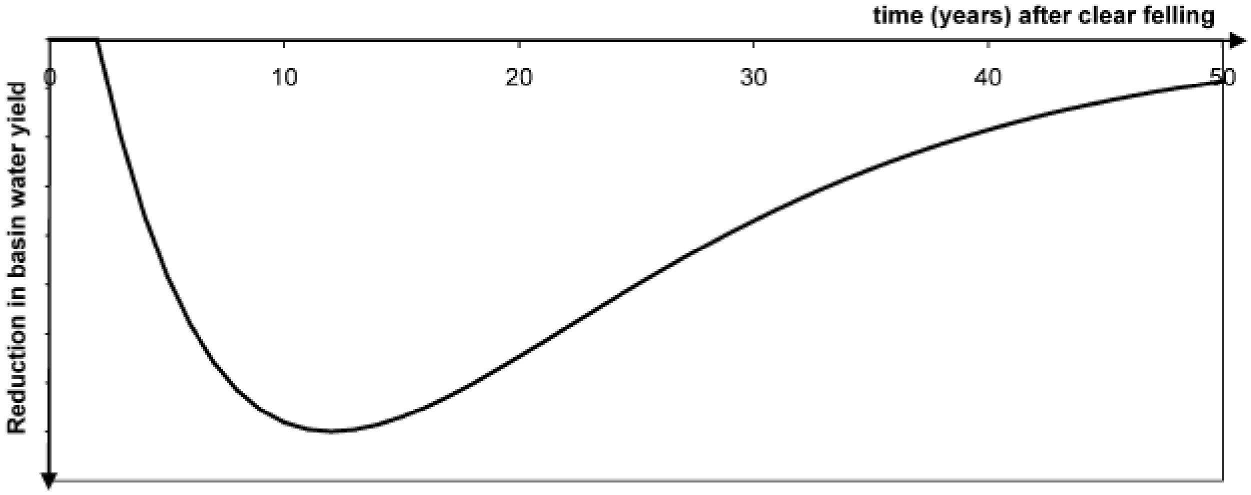
> *All plants evaporate water through their leaves. This water is extracted from the soil root zone, and the rate of evaporation depends on the weather, the available soil moisture, and the total area of leaves in the vegetation (trees and understorey). There are differences between various forest types, but basically different forests have evolved to make optimum use of the available rainfall to ensure their survival. Streamflow in drier periods is the "left-over rainfall" that passes beyond the root zone and exudes into the stream from boggy areas and the water table next to the stream. In storms, water runoff also occurs where the rainfall is intense enough to exceed the capacity of the soil to absorb it, or where the soil is already saturated. This runoff results in rapid increases in streamflow, or floods during major storms.*
>
> *For example, during an average year at a south eastern Australian catchment where the annual rainfall is 1000 mm, the forest canopy may intercept and evaporate 150 mm of the*

> *rainfall before it reaches the ground. The forest may consume a further 750 mm by plant transpiration, leaving only 100 mm to appear as streamflow (this is equivalent to a water yield of 1 megalitre per hectare). Of this 100 mm, 80 mm may occur as short-term runoff during storms, while the remaining 20 mm occurs as sustained dry-weather flow or "baseflow".*

Dargavel *et. al* (1995) note:

> *Streamflow is the residue of rainfall after allowing for evaporation from vegetation, changes in soil storage from year to year and deep drainage to aquifers. Forest management operations can interfere with these processes by:*
>
> - *changing the type of vegetative cover on a catchment. Experimental results show that these changes can affect evapotranspiration and therefore streamflow;*
> - *changing the soil properties. The ability of the soil to both absorb and store moisture infiltration can affect the proportion of rainfall delivered. Forest operations which compact the soil can reduce both infiltration and storage capacities.*

The most significant relationship between water yields and vegetation is that related to forest age. The basic relationship between water yields and eucalypt forest age was established by studies of regrowth Mountain Ash forests following wildfires in Victoria. Kuczera (1985, cited in Vertessy *et. al*. 1998) developed an idealised curve describing the relationship between mean annual streamflow and forest age for mountain ash forest. This shows that after burning and regeneration the mean annual runoff reduces rapidly by more than 50% after which runoff slowly increases along with forest age, taking some 150 years to fully recover.



Kuczera (1985) Curve, reduction and recovery of water yields following loss of overstorey.

Tree water use has been found to be primarily related to sapwood extent, with the thickness of sapwood, and the basal area of sapwood declining as forests age, even though overall basal area increases (Dunn and Connor 1994, Roberts *et al.* 2001, Macfarlane and Silberstein 2009, Buckley *et.al.* 2012, Benyon *et. al.* 2017).

Dunn and Connor (1994) made diurnal measurements of sap velocity in 50-, 90-, 150- and 230-year-old mountain ash (*Eucalyptus regnans* F. Muell.) forests in the North Maroondah catchment finding "*The measurements have shown a significant decrease in overstorey water use with age. At the extreme, measured daily water use of the mature forest is 56% smaller than that of the regrowth forest.",* concluding:

> *There was a significant decline with age in the overstory sapwood conducting area of these forests. In order of increasing age, the values were 6.7, 6.1, 4.2 and 4.0 m^{-2} ha^{-1}, respectively. ... Annual water use decreased with forest age from 679 mm for the 50-year-old*

> *stand to 296 mm for the 230-year-old stand. ... The annual water use of the intermediate-aged stands was 610 and 365 mm for the 90- and 150-year-old stands, respectively.*

Roberts *et al.* (2001) studied water use of different aged stands of *Eucalyptus sieberi* (Silvertop Ash) within Yambulla State Forest, with an average annual rainfall of 900 mm per year, finding:

> *Stand sapwood area declined with age from 11 m^2 ha^{-1} in the 14 year old forest, to 6.5 m^2 ha^{-1} in the 45 year old forest, to 3.1 m^2 ha^{-1} in the 160 year old forest. LAI was 3.6, 4.0, and 3.4 for the 14, 45, and 160 year old plots, respectively. Because of the difference in sapwood area, plot transpiration declined with age from 2.2 mm per day in 14 year old forest, 1.4 mm per day in 45 year old forest, to 0.8 mm per day in 160 year old forest.*

Macfarlane and Silberstein (2009) assessed the water use related characteristics of regrowth and old-growth forest in the high (1200 mm $year^{-1}$) rainfall zone of jarrah forest in Western Australia, finding (SAI sapwood area index):

> *The old-growth stands had more basal area but less canopy cover, less leaf area and thinner sapwood. ...SAI of the regrowth forest at Dwellingup (7.0 m^2 ha^{-1}) was nearly double that of the old growth 3.7 m^2 ha^{-1}),..*
>
> *... At the old-growth site, daily transpiration rose from 0.4 mm day^{-1} in winter to 0.8 mm day^{-1} in spring-summer. In contrast, at the regrowth site transpiration increased from 0.8 mm day^{-1} in winter to 1.7 mm day^{-1} in spring-summer. Annual water use by the overstorey trees was estimated to be ~200 mm $year^{-1}$ for the oldgrowth stand and ~420 mm $year^{-1}$ at the regrowth stand, which is 17% and 35% of annual rainfall, respectively.*

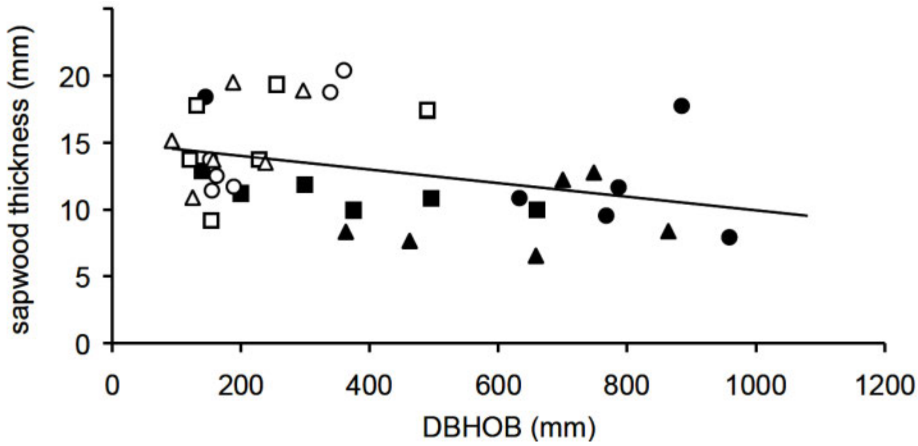


Figure 5 from Macfarlane and Silberstein (2009) sapwood thickness versus tree diameter (measured at breast height over bark, DBHOB) at the old-growth (closed symbols) and regrowth (open symbols) study sites.

For 'actual evapotranspiration' (E_a) Benyon *et. al.* (2017) identify:

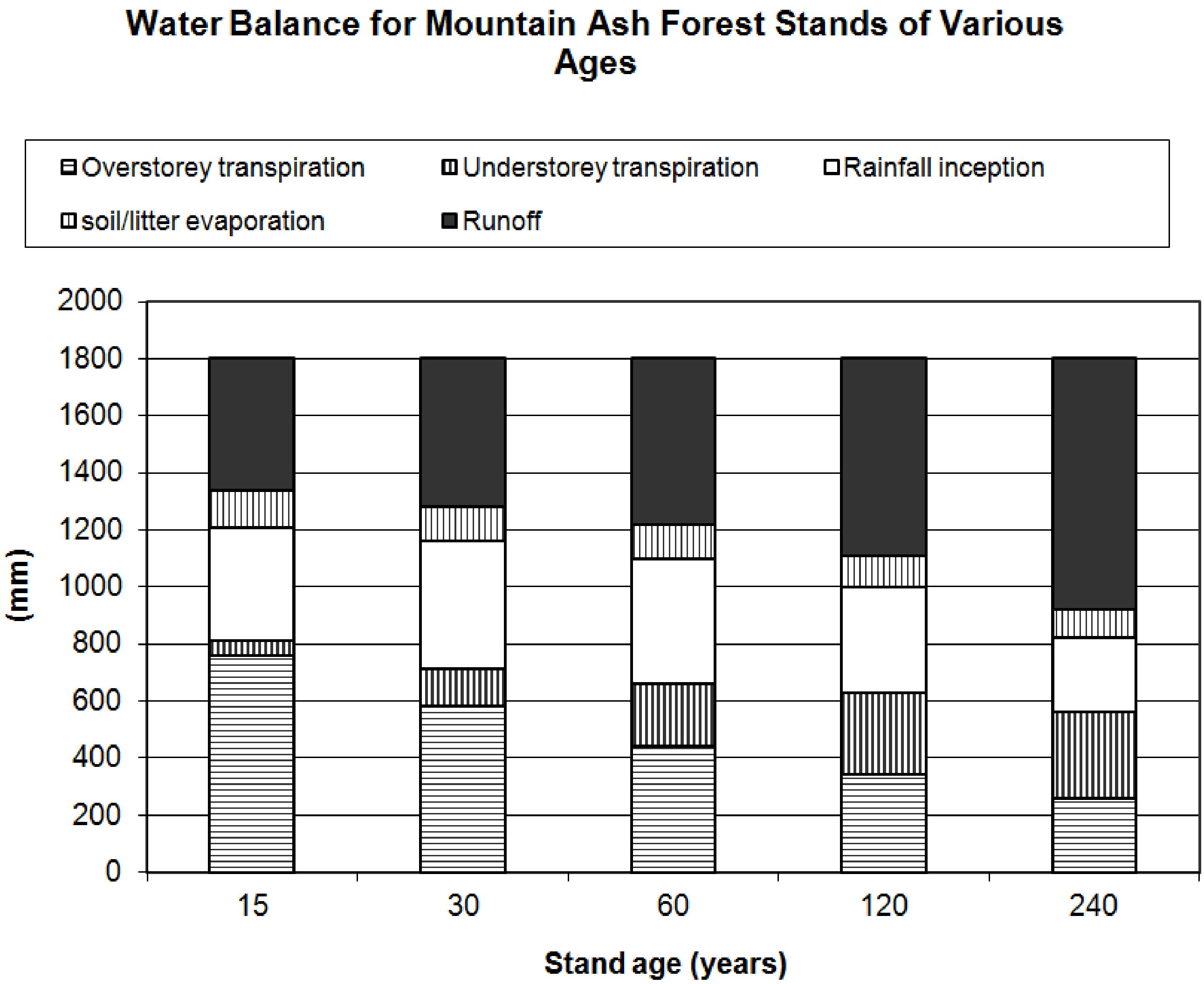
> *... in even-aged eucalypt forests in south-eastern Australia, catchment mean overstorey sapwood area index (SAI), estimated from a relationship between stand mean sapwood thickness and tree density (trees ha^{-1}), applied to repeated measurements of tree density and mean tree diameter over several decades, was strongly correlated with catchment mean annual E_a, estimated as annual precipitation minus annual streamflow (Benyon et al., 2015).*

From their study of Mountain Ash forests, Benyon *et. al.* (2017) concluded (E_a actual evapotranspiration, SAI sapwood area index):

> *In non-water-limited eucalypt forests, overstorey sapwood area index is strongly correlated with annual overstorey transpiration and total evapotranspiration. Interception loss from the overstorey is also positively correlated with overstorey SAI. ... Variation in SAI explained almost 90% of the between-plot variation in annual E_a across three separate studies in non-*

> *water-limited eucalypt forests. Our results support the use of measured spatial and temporal variations in SAI for mapping mean annual E_a (Jaskierniak et al., 2015b) and for modelling longterm streamflows in ungauged catchments (Jaskierniak et al.,2016).*

Vertessy *et. al.* (1998) have attempted to quantify the different components of rainfall lost by evapo-transpiration, identifying them as: interception by the forest canopy and then evaporated back into the atmosphere; evaporation from leaf litter and soil surfaces; transpiration by overstorey vegetation; and transpiration by understorey vegetation. All of these have been measured as declining with increasing forest maturity, with the exception of understorey transpiration which becomes more important as transpiration from the emergent eucalypts declines.



Water balance for Mountain Ash forest stands of various ages, assuming annual rainfall of 1800 mm (from Vertessy et. al. 1998)

The generalised pattern following heavy and extensive logging of an oldgrowth forest is for there to be an initial increase in runoff from disturbed areas peaking after 1 or 2 years and persisting for a few years. Water yields then begin to decline below that of the oldgrowth as the regrowth uses more water. Water yields are likely to reach a minimum after 2 or 3 decades before slowly increasing towards pre-logging levels in line with forest maturity.

For Mountain Ash forest in Victoria, a mean annual rainfall of 1,800 mm/yr has been found to generate a mean annual runoff from oldgrowth Mountain Ash forest of about 1,200 mm/yr (Kuzcera 1987, Vertessy *et. al.* 1998). After burning and regeneration the mean annual runoff reduces rapidly by more than 50% to 580 mm/yr by age 27 years, after which runoff slowly increases along with forest age, taking some 150 years to fully recover (Kuzcera 1987). Following clearfelling of a forest there may or may not be an initial increase in water yields for a relatively limited period. Thereafter water yields usually decline relatively rapidly in relation to growth indices of the regrowth, after some decades maximum transpiration of the regrowth is reached and water yields begin to recover with increasing forest maturity.

In the Barrington Tops area Cornish (1993) found that *"water yield decline exceeded 250 mm in the sixth year after logging in the catchment with the highest stocking of regeneration and the highest regrowth basal area".* This represents a major reduction given that the mean runoff pre-logging was only 362 mm (38-678 mm) and that only 61% of its catchment was logged.

Cornish and Vertessy (2001) report that the yields kept declining:

> *Water yields in a regrowth eucalypt forest were found to increase initially and then to decline below pre-treatment levels during the 16-year period which followed the logging of a moist old-growth eucalypt forest in Eastern Australia. ... Yield reductions of up to a maximum 600 mm per year in logged and regenerated areas were in accord with water yield reductions observed in Mountain Ash (Eucalyptus regnans F.J. Muell.) regeneration in Victoria. This study therefore represents the first confirmation of these Maroondah Mountain Ash results in another forest type that has also undergone eucalypt-to-eucalypt succession. Baseflow analysis indicated that baseflow and stormflow both increased after logging, with stormflow increases dominant in catchments with shallower soils. The lower runoff observed when the regenerating forest was aged 13–16 years was principally a consequence of lower baseflow.*

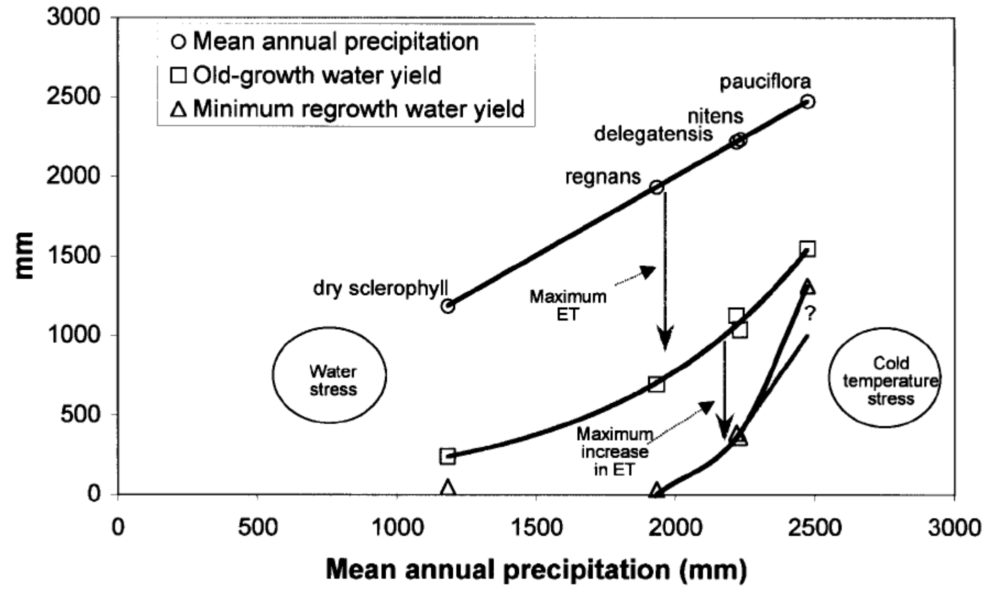
Cornish and Vertessy (2001) elaborate:

> *This analysis indicates that (in common with the results of many previous studies, e.g. Bosch and Hewlett, 1982) canopy removal increased water yield substantially. Mean increases here were frequently significant while the regrowth trees were less than 3 years old. As the trees increased in age water use increased, but mean water use was not significantly different from the pre-treatment forest between ages 3 and 12. Water yields then declined further between ages 13 and 16 years, resulting in mean reductions being statistically significant in all but one catchment.*

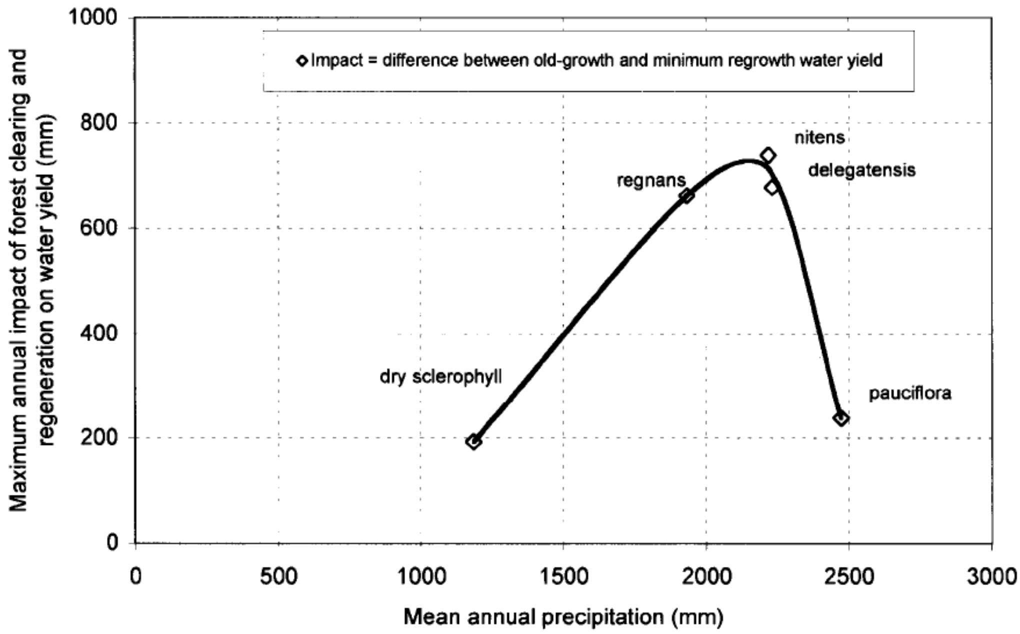
Vertessy (1999) notes that "*the maximum decrease in annual streamflow is over 60 mm per 10% of forest area treated, which is similar to the maximum reductions noted for Victorian mountain ash forests*".

The process of increasing water use by regrowth is relatively well understood and has been found to apply across forests, though localised impacts are complicated by varying vegetation types and conditions within a catchment, the depth of soils, rainfall and a multitude of environmental variables, and the compounding effects of events over time.

For example Peel *et. al.* (2000) undertook modelling in the Maroondah and Thomson catchments to identify the variations in water yield depressions according to forest types and rainfall.



Summary of simulated impacts of forest clearing and regeneration on water yield, showing the relationship between species, precipitation, and water yields. From Peel *et. al.* (2000)



Relationship between species, precipitation and maximum impact of regeneration on water yields. From Peel *et. al.* (2000)

The effects of yield reductions are most pronounced in dry periods as the vegetation utilises proportionately more of the rainfall. As identified by Peel *et. al.* (2000) for dry sclerophyll forests, it is likely that there are prolonged periods where the regrowth is utilising most of the rainfall, leaving little for runoff into streams.

It is during dry periods, which are becoming more frequent and extreme with climate heating, that runoff is of the most value. Forests, particularly oldgrowth, are increasingly important during such periods due to their ability to hold and slowly release water. NSW Office of Water (2010) caution:

> *Many of the coastal unregulated rivers within NSW have extreme competition for water during dry periods. In-stream values can be stressed during these low flow periods, wildlife becomes concentrated in particular locations and water quality can deteriorate through eutrophication.*

After leaving the forests there are a variety of calls upon the water released into streams and aquifers from irrigation, industry and fisheries. The Water Management Act 2000 requires water sharing plans to:

- *Allocate water between all water users and the environment*
- *Improve river health*
- *Provide security for water users*
- *Meet the needs of regional communities*
- *Enable water trading.*

Water Sharing Plans in NSW allow the trade of allocation water. As a tradeable commodity water has an economic value, though this is highly variable depending on availability and competition for available supplies. Wilks Water identify prices as high as $6000 to $6,400 per ML from 15 November 2019 to 8 May 2020 in Victoria's Murray-Goulburn, though these drop to $600-900 per ML in other areas. In 2020 the NSW Government made available 51,269 ML of Groundwater across 11 Water Sharing plans with minimum bid prices as low as $500/ML.

The value of water in a catchment is far higher if used for potable drinking water. For example Rous County Council is currently going through a process of examining options to supplement the regional water supply. Hydrosphere Consulting 2020 identify the cost of the cheapest option, building a second dam on Rocky Creek, for augmenting regional water supplies as having a NPV of $15,000 (2020 $, 40 years @ 5%) per ML secure yield

All runoff from forests now has an economic value, though the value varies with downstream uses, with runoff feeding into urban water supplies being of the highest value. Stopping logging and allowing forests to mature will increase water yields over time as the forest's structure regrows, and thus stopping logging is of direct economic benefit to downstream water users. While the relative value of forest runoff will vary depending on its usage, it is apparent that in most instances it will be of higher economic benefit to maximise water yields by not logging forests. This value will escalate as climate change gathers momentum and dry periods become more frequent and severe.

4.6. Providing Incentives to Private Landholders

We are in climate and extinction crisises that are being worsened by the degradation of habitat, release of carbon dioxide and loss of carbon sequestration potential caused by land clearing and logging.

It is clear that the majority of rural residents value koalas and the bush, and are opposed to clearing and logging it, though contrary to community preferences the NSW Government is reducing constraints on land clearing and logging, increasing allowable logging intensities, and reducing protections for Koalas. The NSW Government is pandering to vested interests, loggers and developers, to over-ride community preferences and rights. If we want to reverse the extinction trajectory of Koalas then we need to increase legal protection for their habitat, and reward landholders for protecting it by adapting adapting current carbon credits and biodiversity trust funding, and help them manage it.

To improve regulation of PNF in NSW, Prest (2003) makes a number of recommendations, including:

> *offering financial incentives and other inducements for biodiversity conservation and for positive land-management actions to private landholders, in order to overcome existing countervailing incentives to destroy biodiversity.*

To stop rampant landclearing in eastern Australia, WWF (Pacheco *et. al.* 2021) recommend:

● *Enhance funding to support farmers and graziers to regenerate forests, with incentives for those who demonstrate improved forest condition.*

● *Develop policies and structures to support a transition from native forest logging to plantations and independently certified forest management.*

Further noting:

The Australian, Queensland and NSW governments have a range of markets to support carbon offsets and land restoration, particularly to financially reward graziers and farmers who allow natural forest regeneration. Additional financing and long-term funding security is required to expand and improve these schemes, secured with covenants on land titles or carbon farming contracts to provide permanent protection. These would assist conservation of Australia's globally significant forest carbon stocks, enabling them to be actively managed as a carbon sink to deliver increased carbon abatement and sequestration to support a safe climate.

Proforestation (allowing existing forests to grow old) has the potential to take-up and store a significant proportion of NSW's annual carbon emissions, with north-east NSW's forests alone capable of sequestering over 30% of NSW's annual carbon emissions. Forests thus provide the only realistic means of reducing atmospheric carbon, while at the same time addressing our species extinction crisis.

The Australian Government's Climate Solutions Fund currently grossly underprices 'Australian carbon credit units' (ACCUs) at $17. NEFA's assessment is that a logged medium site quality Spotted Gum forest (comprising core Koala habitat) has a carbon pool of 95 tC/ha of living biomass (equivalent to 349 tonnes of CO_2/ha if it was clearfelled) and the ability to sequester and store 6.42 tonnes of CO_2 per annum. Applying the ACCU value to these makes the current living biomass worth $5,933 per hectare and the annual increment worth $109 per ha per annum. With more productive ecoystems (ie Blue Gum-Tallowwood stands) and more realistic carbon prices these values rapidly escalate.

The NSW Government's strategy for private lands is to focus on using the $350 million biodiversity trust to pay regional landowners for protecting koala habitat as an alternative to regulation, though this is being done in ignorance of where core Koala habitat is. In December the Government announced $11.8 million for 1,094 hectares of land in the Southern Highlands to be protected koala habitat in perpetuity. There is no information provided on how much constitutes "core Koala habitat", though the price per hectare is $10,786. If this were averaged over 100 years the cost is $108 per annum, which is less than the carbon value.

NRC (2018) identify: *As of March 2019, BCT has invested $55.72 million and secured new conservation agreements totalling 19,091 hectares for conservation since the start of the reform. Investment by region was:*

1. *Central West ($17.5 million/3,984 hectares)*
2. *Murray-Riverina ($13.14 million/5,138 hectares)*
3. *South-East ($12.87 million/3,783 hectares)*
4. *Northern Inland ($5.91 million/4,700 hectares)*
5. *North Coast ($6.3 million/684 hectares).*

While there is no indication of the level of protection provided, the price per hectare for the north coast is $9,211.

What is needed is for the Australian Government to extend it's Climate Solutions Fund (or use another mechanism) to pay landholders for storing and sequestering carbon in forests on land protected in perpetuity, and for this to be complemented by funding from NSW's Biodiversity Trust for lands of exceptional biodiversity value. There are advantages to providing regular payments to the landowners at the time, rather than one-off windfalls payments to a single landowner.

It would be of greatest public benefit if public monies currently used to subsidise the inefficient public native timber industry were redirected into regular payments for landholders who guarantee long-term protection (by zoning or covenant) and management of native forests to maximise carbon storage, water yields and biodiversity conservation, some elements of which could comprise:

- **k. Extending the Australian Government's Climate Solutions Fund (or creating a specific fund) to pay landholders who protect their forests for long-term carbon capture and storage. Rather than an auction process there needs to be standardized payments based on stored carbon, carbon sequestration and biodiversity value.**
- **l. Extending eligibility for carbon credits to all forests, including those protected, rather than perversely just those that have first been approved for clearing or logging.**
- **m. Paying landholders regularly for a portion of the current measured standing volume of carbon in living biomass.**
- **n. Paying landholders regularly for additional carbon sequestration and storage in vegetation and soils.**
- **o. Expanding NSW's Biodiversity Trust to make regular payments, in combination with carbon credits, to landowners for permanently protecting core koala habitat, and other areas of exceptional biodiversity value.**

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