Proposed Sandy Creek Koala Park

Dailan Pugh, North East Forest Alliance

Proposed Sandy Creek Koala Park

Dailan Pugh, North East Forest Alliance, August 2020.

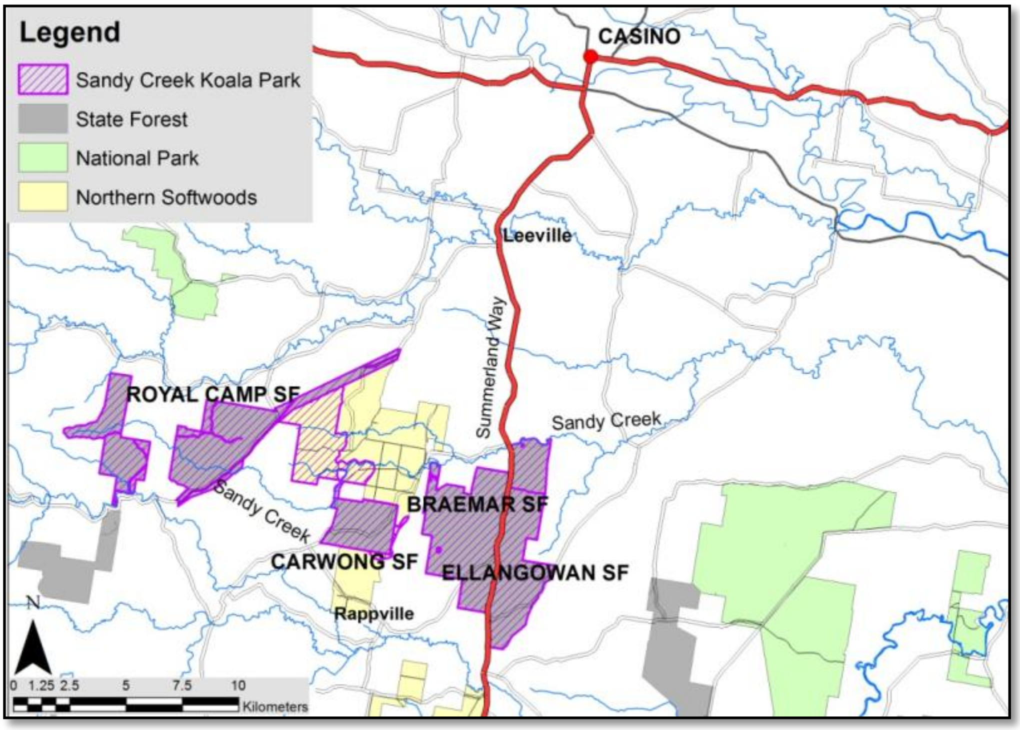
NEFA are proposing that 6,988ha of public land south-west of Casino in north-east NSW be created as the Sandy Creek Koala Park, comprised of Royal Camp, Braemar, Carwong and Ellangowan State Forests, and remnant native vegetation on land purchased for plantations. The Bandjalang clan are the recognised native title holders and so the future management of this reserve needs to be determined in consultation with them.

The genesis of this proposal was the finding of exceptional densities of Koalas at a number of localities and widespread Koala usage. The Koalas appeared to be increasing as the forests recovered from past logging, with good future prospects if the forest was allowed to age and provide increasing resources over time.

The Koalas suffered a mortal blow when the Busby's Flat fire swept through the proposal on the night of 8 October 2019, with the apparent loss of 78-89% of Koalas, which suggests the loss of 270-310 Koalas due to the fires and a surviving population that could be as low as 40-80 Koalas.

As most Koala feed trees survived the fires, Koala populations can recover over time and increase if survivors and their habitat are protected. Given the prognosis that Koalas are likely to become extinct in the wild by 2050 if we continue 'business as usual' , and the devastating impact of the 2019 fires on the Banyabba Koalas, protecting an area where Koala populations can recover is more important than ever.

This proposal is about stopping ongoing degradation and restoring what has been lost. Recovering Koalas, another 39 threatened species, inadequately reserved Richmond River lowland forests, forest carbon carrying capacity, and stream flows. It is about honouring the community's wishes and aspirations.



Location of proposed Sandy Creek Koala Park.

The proposal is predominately situated in the catchment of Sandy Creek, covering Spotted Gum-Grey Box-Red Gum forests on and adjacent to the Richmond River floodplain, around 22km south-west of Casino in north-east NSW.

In summary the ecological values protected by the proposed Sandy Creek Koala Park include:

- 5,260 ha (79% of proposal) of high to very high quality Koala habitat identified by the Government's Koala Habitat Suitability Model.
- 6,243 ha (91% of proposal) of inadequately reserved forest ecosystems that have not met their national (JANIS 1997) reserve targets.
- 916 ha of the Endangered Ecological Community Subtropical Coastal Floodplain Forest on the Richmond River floodplain
- habitat of 2 Critically Endangered, 2 Endangered, and 31 Vulnerable animals.
- 22 threatened fauna species that have not met reservation targets for viable populations.
- a stronghold for declining woodland/dry open forest bird species,
- habitat of 4 Endangered plants, and one Vulnerable plant

In summary the socio-economic benefits of protecting these forests are:

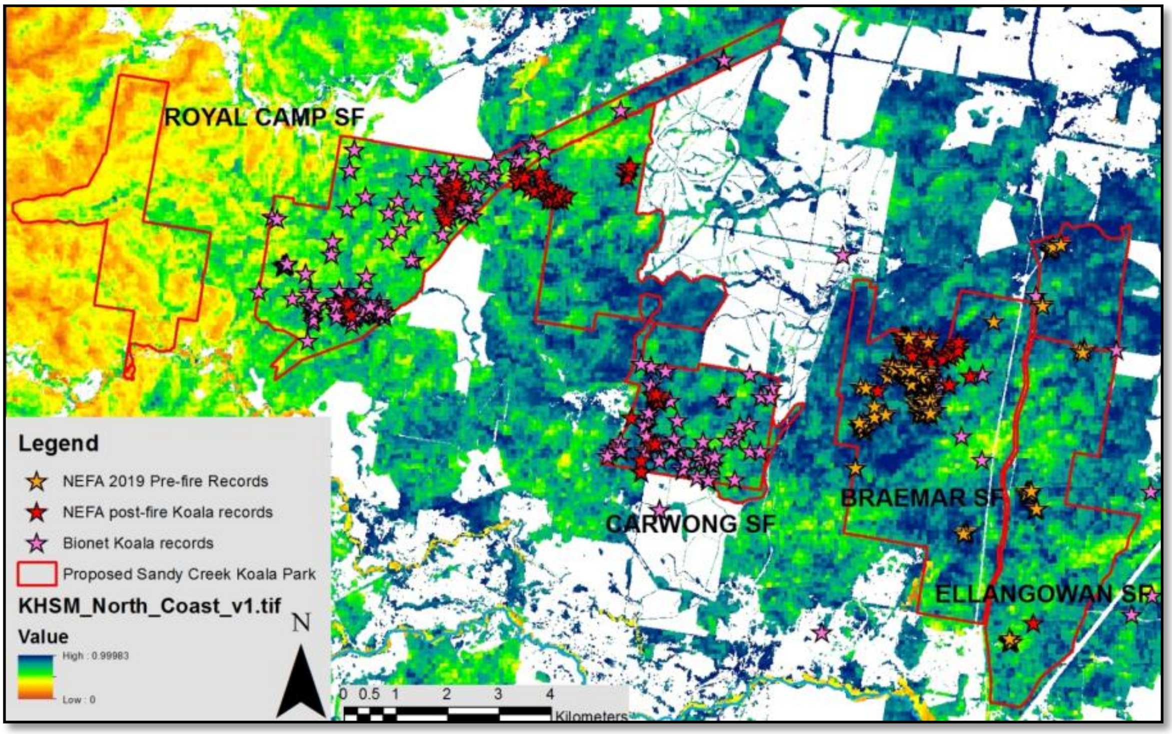
- satisfying the majority view of 65-70% of Australians who find logging of native forests unacceptable (compared to 10-17% who consider it acceptable), and the 71% of local residents who *support the creation of national parks to protect koalas from logging* (compared to 16% opposed).
- over the next century recovering 3.3million tonnes of atmospheric CO_2 released by logging, with an indicative current market value of over $56.8 million.
- increasing annual net CO_2 sequestration by an average of 44,200 tonnes of per annum, currently worth $687,000 per annum in Australian Carbon Credit Units.'
- for each 10,000 visitors per annum attracted generating $1.3 million in spending and 10.6 jobs in the region, as well as significantly reducing public health costs.
- over time restoring some 14,000 ML per annum of streamflows (worth $7 million per annum) lost by converting these forests to regrowth, with yields likely recovering at a rate of around 140 ML a year if the forests are protected.
- doubling the availability of nectar, which in a good year could equate to over 17.5 tonnes of honey worth over $100,000 at current wholesale prices.

When NSW Premier Gladys Berejiklian announced the NSW Government's Koala Strategy on 7th May 2018 their press release claimed *'The centrepiece of the NSW Koala Strategy is setting aside large swathes of land where koalas can thrive and new habitats can be created'*, with Environment Minister Gabrielle Upton stating:

> *It is absolutely vital that we protect land where koalas currently live - and secure land where new koala colonies may exist in the future.*

In the Sydney Morning Herald on 26 July 2020 Environment Minister Matt Kean claimed he wanted to see Koala populations doubled by 2050, stating *"Koalas are the most iconic example of our mismanagement of the environment and we've got to say 'enough is enough'."*

Enough is enough Premier Berejiklian, Koalas can bear no more.



All Koala records overlaid on DPIE model of likely Koala habitat (blue is highest quality habitat).

KOALA VALUES (Section 3.1.)

The Richmond River lowlands provide important Koala habitat, with the proposed Sandy Creek Koala Park demonstrated to support outstanding Koala densities. These forests are dominated by Spotted Gum and Coastal Grey Box, with significant numbers of Forest Red Gum, Slaty Red Gum and Small-fruited Grey Gum. These later 4 species are preferred Koala feed trees, and are what makes these forests of exceptional importance for Koalas.

Koalas within the proposed Sandy Creek Koala Park have been shown to preferentially choose larger trees for feeding, rarely using trees less than 20 cm diameter at breast height (dbh) and preferring trees >30cm dbh, with use increasing with tree size (Section 3.1.3.2). Before the fires it was expected that the high numbers of Koalas found in some areas was due to partial recovery from logging over 2 decades previously. It appeared that Koala numbers could more than double if the forest was left to mature. Conversely it was considered that re-logging would more than halve recovering populations.

Expectations changed on the night of 8 October 2019 when the Busby's Flat fire burnt out 93% of the proposal overnight - killing most of the Koalas. There was an apparent loss of 78-89% of Koalas, which suggests the loss of 270-310 Koalas due to the fires and a surviving population that could be as low as 40-80 Koalas. NEFA's observations indicate that around 14% of the Koalas were lost due to the ongoing drought after the fires and lack of comprehensive assistance to survivors. Despite our pleas the Government ignored their plight.

NEFA found that Koalas survived in areas that retained some canopy after the fires and is proceeding with this proposal on the basis that Koala populations have the ability to recover over time and expand back into the habitat they were eliminated from, though recovery will take decades. After then Koala populations will be able to grow along with their feed trees.

VEGETATION VALUES (Section 2).

The forests of the Richmond River lowlands have been extensively cleared and are very poorly represented in the reserve system. With 91% of this proposal comprised of forest ecosystems that have not satisfied the minimum reservation requirements of the national reserve criteria (JANIS 1997), it's protection will make a significant and necessary contribution to the national Comprehensive, Adequate and Representative Reserve System.

Remnants of the Endangered Ecological Community (EEC) Sub-tropical Coastal Floodplain Forest are scattered across the Richmond River floodplain, with 916 ha within this proposal.

These forests are home to 4 Endangered plants, and a stronghold for the Vulnerable Slaty Red Gum.

FAUNA VALUES (Section 3)

We are in an extinction crisis with populations of most native species crashing due to habitat loss and degradation. Climate heating, droughts, heatwaves and bushfires are now compounding threats. Within this proposal there are 2 Critically Endangered, 1 Endangered and 31 Vulnerable animals. With so much of their habitat cleared, degraded and burnt, the protection of these forests will help stabilise their depleted populations and facilitate their recovery over time.

These lowland forests are a stronghold for 18 threatened declining woodland/dry open forest bird species. The importance of these forests is increasing due to the severe climate change-induced droughts now impacting the western parts of their ranges.

Additionally the Endangered fish Purple Spotted Gudgeon has been recorded downstream from this proposal in Sandy Creek.

OLD TREE VALUES (Section 3.2.)

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, and they don't develop the large hollows needed by larger species until they are over 220 years old. Logging has severely depleted old trees.

Nectar is key resource for a variety of birds, arboreal mammals and flying foxes, with Spotted Gum a particular important winter food, particularly for seasonal migrants such as the Critically Endangered Regent Honeyeater and Swift Parrot. The larger eucalypts flower more frequently and prolifically, with trees over 40cm diameter flowering over twice as frequently and producing 4.4 to 12.3 times as many flowers as trees 25-39 cm diameter (Section 3.2.1.). Past logging has likely resulted in over a halving of nectar production. Protection of the proposed Sandy Creek Koala Park would over time more than double nectar production, which in a good year could represent over 17.5 tonnes of honey worth over $100,000. Though with 6 threatened species dependent upon nectar, and Flying Foxes starving to death, maintaining and increasing nectar is priceless.

Tree-hollows provide dens and nests that are essential homes to a multitude of species. The large hollows essential for large hollow-dependent animals, such as the threatened Powerful Owl, Masked Owl, Barking Owl, Greater Glider, Yellow-bellied Glider, and Glossy-black Cockatoo, are provided by trees over 200 years old. Within these forests large hollow-bearing trees have been reduced from 18.3 trees/ha down to 0.3 trees/ha, a 98.4% reduction in these vital resources (Section 3.2.2.). The loss of small hollows has been less severe (78%), though many of those left may be uninhabitable. The consequence is that populations of hollow-dependent species have been severely depleted, with many eliminated from extensive areas because of the lack of homes and others having to fight over the few hollows left. . 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. Given that many of these species are threatened with extinction, and the long time it takes to develop hollows, the restoration of hollow-bearing trees is priceless.

COMMUNITY PREFERENCE (Section 5.1.1.)

For 23 years the north coast community have demonstrated a clear and abiding preference for conservation over exploitation of public forests. A 2016 survey on behalf of the timber industry found 65-70% of Australians consider logging of native forests unacceptable (compared to 10-17% who consider it acceptable), and a 2018 ReachTEL survey found 71% of Lismore and Ballina residents *support the creation of national parks to protect koalas from logging* (compared to 16% opposed). There can thus be no doubt that creation of the proposed Sandy Creek Koala Park is in accord with the community's preferences and aspirations.

CARBON VALUE (Section 5.1.2.).

Due to our emissions of CO_2 the climate is heating at an accelerating rate. While we urgently need to reduce our emissions to limit global heating, we can only keep global temperature rises to below 2^oC if we increase removal of carbon from the atmosphere. Trees are essential elements of the earth's carbon cycle, taking in the CO_2 we omit, storing the carbon in their wood and soils, and giving us back oxygen. 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.

The total carbon carrying capacity of the forests of the proposed Sandy Creek Koala Park is estimated to be at least 1.6 million tonnes. Past logging has run down these carbon stores by 910,000 tonnes, releasing some 3.3 million tonnes of CO_2 into the atmosphere. This is therefore the carbon sequestration potential if the forests are allowed to regain their lost stores, which at current values ($17 tonne) is worth $56.8 million. While it will take a long time, the protection of these forests has the potential to make a significant contribution to ameliorating climate change.

Compared to continued logging, protection of the Sandy Creek Koala Park will result in the annual sequestration of an additional 40,200 tonnes of CO_2. At the current value of $17 a tonne for an Australian Carbon Credit Unit this is worth $686,600 per annum., over 30 years totalling 1.21 million tonnes of CO_2, worth $20.6 million dollars.

RECREATIONAL VALUE (Section 5.1.3.).

While tourism has taken a hit from COVID 19, it is one of the most rapidly expanding sectors of the north coast economy. In 2019 there were 35 million visits to the north coast generating $4,709 million in regional expenditure and 33,000 jobs. Natural areas are a major attraction for tourists and a major reason for visiting the region, with some 7.5 million visits to national parks in the NPWS North Coast region in 2019.

According to the National Visitor Survey, in 2018 each 10,000 visitors to the north coast spent $1.4 million and employed 10.6 people.

Depending on provision of infrastructure and the return of Koalas, the proposed Sandy Creek Koala Park is expected to attract tens of thousands of people a year who will boost the regional economy and jobs. This park will increase tourists using the Summerland Way and be a particular boost to the economy of Casino.

There is abundant evidence that recreating in natural areas significantly enhances most people's mental and physical health, which has flow-on effects on the nation's health costs. Relating this to the self-perceived Personal Wellbeing Index has resulted in an estimation of the annual health services value of Australia's national parks as ~$145 billion. Reserves that encourage increased recreation contribute to increasing this health benefit and reducing health costs.

WATER VALUE (Section 5.1.4.).

Increased transpiration of regrowth forests makes them heavy water users compared to oldgrowth forests. and thereby significantly reduces streamflows. By converting oldgrowth forest to regrowth, past logging has increased tree transpiration and reduced streamflows from the proposed Sandy Creek Koala Park by in the order of 14,000 Mega Litres (ML) per annum. This water volume is recoverable over time if these forests are allowed to mature, increasing streamflows and recharge of aquifers.

In 2020 the NSW Government set a minimum bid price of $500 per unit share for the Richmond Coastal Sands Groundwater Source, though the new Rocky Creek dam has a NPV of $15,000 per ML. The value of water will only increase over time as droughts become more frequent.

Based on the current minimum value of $500 per ML per annum, the potential value of the restored 14,000 ML of water yield is $7 million per annum. While it will take a century for yields to be fully restored, yields will increase at a rate of over 140 ML a year, with a compounding value of over $70,000 per annum.

TIMBER VALUE (Section 5.1.5.).

The history of logging north-east NSW's public forests has been one of public subsidisation of the depletion of large trees, and along with them declining nectar, tree-hollows, wildlife, sawlogs, and streamflows. The 2000 North East NSW Regional Forest Agreement was intended to herald an era of Ecologically Sustainable Forest Management, though yields of large high quality sawlogs have since declined by 41% and forests continue to be over-logged.

Within the proposed Sandy Creek Koala Park logging has run-down tree biomass by 58% over the past century, which increases to 65% of biomass of trees above 30 cm dbh and to 83% of biomass for trees above 50 cm dbh. Continued logging is likely to reduce biomass by a further 39% over the next 20-30 years. The Forestry Corporation is seeking to develop a market selling trees for electricity generation to make ongoing logging viable as they run out of sawlogs. It is tree mining.

Historically the Forestry Corporation have operated at a loss, with only private sawmill owners making a profit from logging public forests. The public have further subsidised private sawmill owners by purchasing land for logging and plantations, grants to subsidise transport costs and upgrade sawmills, and compensation payments for failure to supply non-existent timber promised to sawmillers for free.

By including hardwood plantations, and excluding Community Service Obligations, EPA regulation and DPI Forestry research, in recent years the Forestry Corporation have returned a notional profit on its hardwood operations, for example in 2018/19 an average profit of $0.63 per hectare for hardwoods. There is no resource rent paid to taxpayers. By comparison softwood plantations return a profit of $301 per hectare. The sooner the Government transitions to plantations the better off taxpayers will be.

Proportionally the proposed Sandy Creek Koala Park represents timber industry employment of 5.4 persons in north-east NSW. To put the potential loss of jobs into perspective, ABARE identifies over the ten years from 2006 until 2016 the NSW timber industry shed 7,400 jobs through restructuring and mechanisation without any politicians or unions complaining.

The net economic benefits of logging public land accrue to private sawmill owners. Applying the industry's unverified claims of hardwood output processing values for north-east NSW proportionately, without deducting costs, indicates the claimed gross economic value of continuing logging of the proposed Sandy Creek Koala Park is in the order of $2 million per annum.

FOREST HEALTH VALUES (Section 4.)

It is of concern that before the fires, logging's promotion of lantana had enabled Bell Miners to proliferate in wetter gullies, initiating the Threatening Process of Bell Miner Associated Dieback, whereby Bell Miners exclude most other native species and promote sap-sucking psyillids which cause eucalypts to sicken and die (section 4.4.). The fires have killed most lantana, creating an opportunity to control this weed if urgent action is taken to stop its return.

It is evident that logging increases flammability of forests by promoting dense even sized regeneration and canopy continuity, decreasing separation of canopy from ground fuels, increasing transpiration of regrowth which dries the understorey, increasing understorey fuels with logging debris and promotion of dense growth of short lived species (section 4.5).

Exclusion of logging and removal of weeds will reverse dieback and reduce future fire threat over time as the forest recovers.

THE PROPOSED SANDY CREEK KOALA PARK

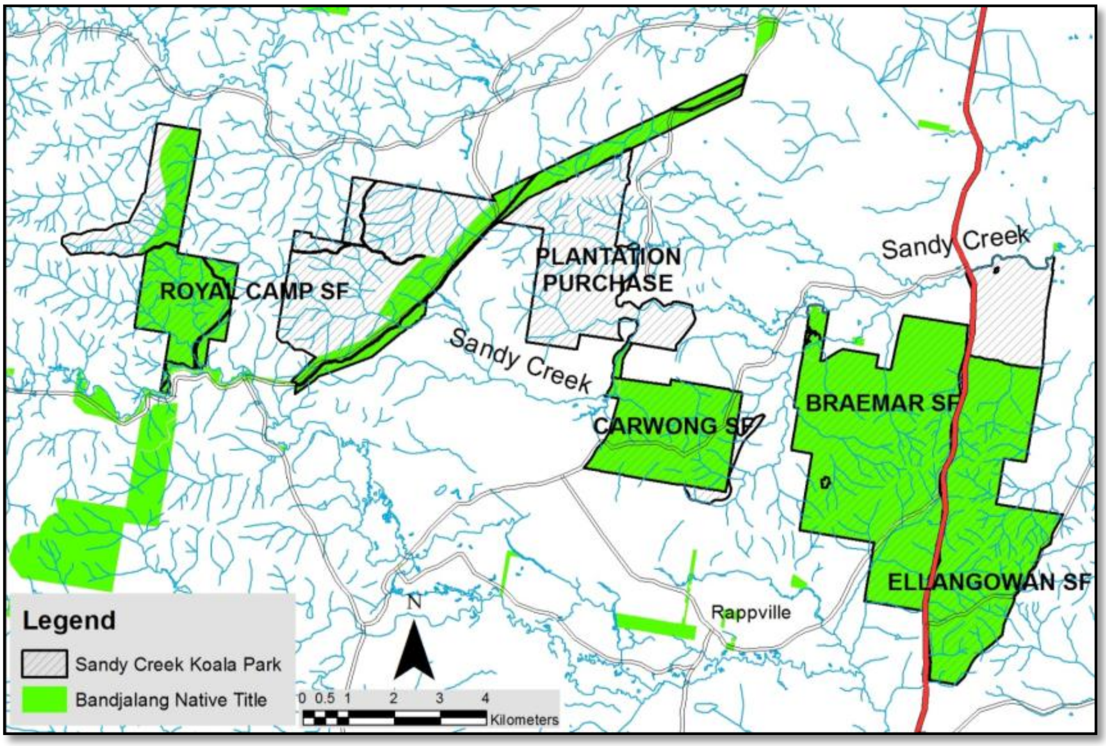
This proposal is about restoring values depleted by a century of logging: Koalas and other wildlife populations, carbon storage in biomass, nectar yields, tree-hollows, and water yields. As well as restoring these values, these forests will be of greater long-term economic benefit to the north coast as a contribution to the rapidly growing tourism industry rather than being used to prop up the rapidly declining and uncompetitive native forest logging industry.

On its own this proposal will not save Koalas or reverse climate heating, though it will make a significant contribution.

The creation of the proposed Sandy Creek Koala Park is clearly in the best interests of the north coast community, and the people of NSW.

A smaller area comprising Royal Camp and Carwong State Forests was first proposed as the Sandy Creek National Park by NEFA in 2014 following the finding of widespread Koala High Use Areas.

The 2019 finding by NEFA of even more extensive Koala High Use Areas in part of Braemar State Forest proposed for imminent logging, and widespread Koalas in the balance of this proposal, lead to this significantly expanded proposal.



Bandjalang Native Title consent determination areas.

The Bandjalang clan first lodged a native title application in the 1996 and a bigger second application was lodged in 1998. The claim took 17 years to have their relationship with the land formally and legally recognised by the Federal Court. On 2/12/2013 Native Title was recognised over 2,750 square kilometres from Evans Head, north-west to Casino, inland to Busby Flat and south to Junction Hill near Grafton, with native title recognised over extensive areas of crown land and vested in the Bandjalang Aboriginal Corporation Prescribed Body Corporate.

NEFA considers that part of the outcome has to be giving the Bandjalang clan meaningful care and control of their native title lands, rather than just limited use rights. The form of this control will need to be negotiated between the NSW Government and the Bandjalang clan.

2 survivors of the 2019 fires in Braemar SF whose homes are scheduled for logging in February 2021

INDEX

1. PROPOSED SANDY CREEK KOALA PARK

It is proposed that the Sandy Creek National Park be created over 6,988 hectares of State Forests and Crown lands in the headwaters of Sandy Creek, in an area around 22km south and south-west of Casino.

Since NEFA stopped logging of Koala High Use Areas in Royal Camp State Forest in 2012 the evidence of the importance of first Royal Camp, then Carwong, and then Braemar State Forests for Koalas has accumulated and put beyond doubt the importance of these forests for Koalas. From our findings it is apparent that remnant forests with numbers of mature Small-fruited Grey Gums, Coastal Grey Box, Forest Red Gum and/or Slaty Red Gum, on and adjoining the Richmond River floodplain, provide habitat that is highly significant to maintenance of the regional Koala population, along with a variety of other threatened species and ecosystems.

Koalas within the proposed Sandy Creek Koala Park have been shown to preferentially choose larger trees for feeding, rarely using trees less than 20 cm diameter a breast height (dbh) and preferring trees >30cm dbh, with use increasing with tree size (Section 3.1.3.2). Before the fires it was expected that the high numbers of Koalas found in some areas was due to partial recovery from logging over 2 decades previously. While it is apparent that there were pockets of higher density, if the conservative estimate of one Koala per 20 ha is adopted this suggests there was a population of around 350 Koalas. It appeared that Koala numbers could more than double if the forest was left to mature. Conversely it was considered that relogging could more than halve recovering populations.

This all changed on the night of 8 October 2019 when the Busby's Flat fire burnt most of the proposal, eliminating Koalas from the most heavily burnt forests. After the fires drought persisted for two and a half months. NEFA's assessment of the impacts of the 2019 wildfire and drought on the proposed Sandy Creek Koala Park indicates the loss of 78-89% of Koalas and a surviving population of just 38-76 Koalas.

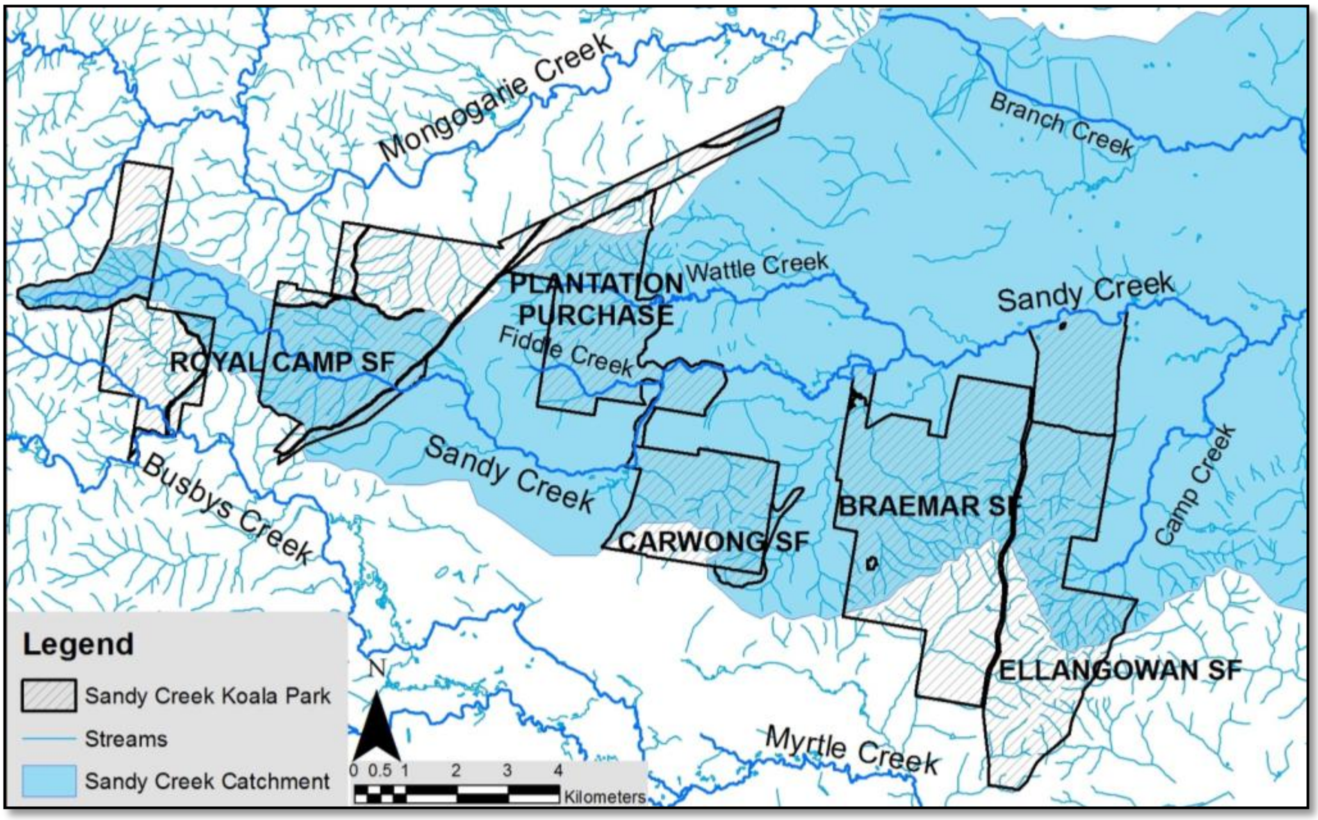
While Koalas have been decimated, NEFA have found pockets of surviving Koalas and that most feed trees have survived, meaning that Koalas can rebuild their populations over time and this can once again become a nationally significant Koala population. It may take decades, but if we stop cutting down their feed trees and instead allow them to grow, the prognosis is good. The proposed Sandy Creek Koala Park is still being pursued to enable this Koala population to recover and grow.

It is proposed that 6,972ha of public land be created as the Sandy Creek Koala Park, comprised of Royal Camp, Braemar, Carwong and Ellangowan State Forests, native vegetation within the Northern Softwoods Region, and linking Crown land. The Northern Softwoods land in this vicinity is not identified as a legal State Forest, though it was purchased for the establishment of pine plantations on the cleared portions, leaving the significant area of native forest linking Royal Camp and Carwong State Forests available for reservation. In addition, 14ha of Crown lands forming an essential link between Carwong State Forest and the native vegetation on the Northern Softwoods Region land is recommended for inclusion, or protection in some form.

Tenure of proposed Sandy Creek Koala Park

State Forest	Area (ha)
ROYAL CAMP[1]	2,239
BRAEMAR	2,024
CARWONG	611
ELLANGOWAN	1,173
NORTHERN SOFTWOODS	927
CROWN	14
	6,988

1: includes road reserves in Royal Camp SF

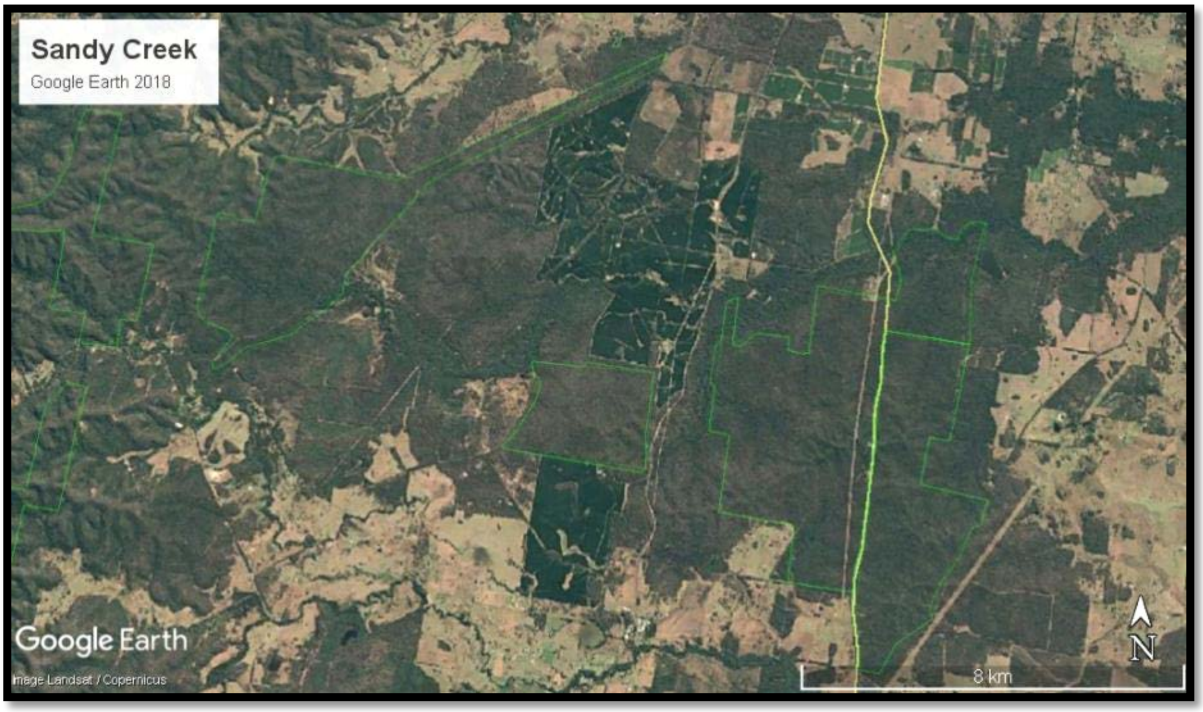


Proposed Sandy Creek Koala Park

The burning of the pine plantations provides an opportunity to undertake environmental plantings to enhance links between Carwong State Forest with Braemar State Forest and native forests on the plantation lands linking through to Royal Camp State Forest, thus significantly increasing the viability of the proposal.

There are 2,400 ha of predominately vegetated private properties adjoining and linking these State Forests that should be considered as high priority to enhance connectivity and consolidation of the proposed reserve. These should be considered as priorities for voluntary purchase or conservation agreements should this proposed reserve be created. In 2016, the NSW Government announced an initiative to assist in the long to protection of priority koala habitat. It has allocated $20 million over 5 years to purchase and conserve land (in the National Parks reserve system) which protects priority koala habitat (OEH 2017). These purchases are to be made in line with NPWS acquisition criteria with a focus on koala habitat and occupancy.

There are 14 forest ecosystems within the proposed Sandy Creek Koala Park. In accordance with the national forest reserve criteria (JANIS 1997), for the RFA most of these ecosystems were given a target for inclusion of at least 15% of their estimated pre-European (1750) extent to be included in formal reserves, except for Lowlands Grey Box which was assessed as Vulnerable and also given a target of 60% of its remaining extent. Eight of the forest ecosystems remain below target, with 5 not even achieving half their targets, giving 6,243 ha (91%) of the proposal comprised of inadequately reserved ecosystems. Of the 26 known or expected threatened animal species within this proposal for which reserve targets for minimum viable populations were set in the RFA, only 4 (15%) have met targets, and 17 (65%) have achieved less than half their minimum reservation targets. Reservation of these forests will make a significant contribution to the national Comprehensive, Adequate and Representative Reserve System.



The proposed Sandy Creek Koala Park occurs in the national South East Queensland Bioregion, which is part of one of the world's 35 biodiversity hotspots because of its exceptional species endemism (at least 1,500 endemic plant species, i.e., 0.5% of all known species) and habitat loss (70% or more of an area's primary vegetation cleared) (Williams *et.al.* 2011).

Over millions of years Australian forests have evolved in isolation from the rest of the world, giving rise to a unique assemblage of species with complex inter-dependencies we still don't understand. Australia's State of the Forests Report 2018 (ABARES 2018) identifies that nationally there were 2,486 native forest-dwelling vertebrate fauna species and 16,836 species of vascular flora. Of these, 307 vertebrate fauna species and1,074 vascular flora species are listed as nationally threatened under the EPBC Act, representing 12.3% of forest vertebrate fauna species and 6.4% of forest vascular flora species. Then there is a greater multitude of invertebrates, fungi, algae and other organisms, most of which we know little about.

Over the past two centuries we have fundamentally altered forests by clearing, logging, livestock grazing, feral predators, weeds and changed fire regimes, decimating wildlife populations and disrupting the ecosystems processes that sustain them.

There are 39 species recorded in or near the proposed Sandy Creek Koala Park that are listed as threatened under NSW's *Biodiversity Conservation Act 2016*; 4 Endangered plants, 1 Vulnerable plant, 2 Critically Endangered animals, 2 Endangered animals, and 30 Vulnerable animals. The Endangered Ecological Community Subtropical Coastal Floodplain Forest is widespread on the Richmond River floodplain. Five of these animals and one plant are also listed as threatened under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, along with the additional nationally Vulnerable Greater Glider.

Trees are the longest lived organisms that characterise forests, providing increasing resources as they age, taking decades to begin flowering and centuries to develop the hollows that so many of our unique species rely upon. Trees over 40 cm dbh produce around 9 times as many flowers, and flower more frequently, than trees 25-40 cm dbh. Logging has halved the number of trees over 40 cm dbh, reduced the number of trees with small hollows by over 75% and reduced the number of trees with large hollows by over 98%. Those species most affected by the loss of old trees include the six threatened nectarivorous species and the 17 threatened hollow-dependent species. There will be strong competition for remaining hollows, with some homeless species unable to survive.

The Endangered fish Purple Spotted Gudgeon has been recorded downstream on Sandy Creek and will be affected by activities within the proposal, particularly reduced streamflows due to the increased transpiration of regrowth.

We have long utilised forests as sources of wood, though they provide much more to our wellbeing. They take in the carbon dioxide we emit, store the carbon in their wood and soils, and give us back oxygen. This process is driven by evapotranspiration where moisture from the soil and leaves, along with heat, are transported into the atmosphere, before water droplets condense around organic aerosols released by the trees, with trapped heat released and the water falling as rain elsewhere. Their vast subterranean networks of roots and fungi bind soils, store water, and prevent erosion. They slowly release stored water to streams, regulating streamflows and reducing flooding.

The climate is heating at an accelerating rate, and along with it the increasing threat of droughts, heatwaves and 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.

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 to 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^{o}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.

Griscom *et. al.* (2017) calculate that natural climate solutions (NCS) 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.*

Forests in various states of degradation and regrowth 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.*
>
> *...*
>
> *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.*

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.*

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.

NEFA's plots show that within the proposed Sandy Creek Koala Park past logging has reduced the forest's live biomass, and the carbon it stores, by 59%. If logging is stopped and the forests are allowed to regrow, over the next century they have the capacity to re-sequester the 3.3 million tonnes of CO_2 released to the atmosphere by past logging. At the current market value of $17 a tonne, the indicative value is over $57.3 million. While protecting these forests on their own will not solve climate heating, they are part of the solution.

Compared to continued logging, protection of the Sandy Creek Koala Park will result in the annual sequestration of an additional of 41,600 tonnes of CO_2. At the current value of $17 a tonne for an Australian Carbon Credit Unit this is worth $707,000 per annum., over 30 years totalling 1.25 million tonnes of CO_2, worth $21.2 million dollars.

By converting oldgrowth forest to regrowth, past logging has increased tree transpiration and reduced streamflows from the proposed Sandy Creek Koala Park by in the order of 14,000 ML per annum. This water volume is recoverable over time if these forests are allowed to mature, increasing streamflows and recharging aquifers. Once recovered this lost water can be put to other uses with a potential value of $7 million per annum. While it will take time for full yields to be restored, yields will increase relatively rapidly over the next few decades, likely compounding at a rate of around 140 ML per annum.

Tourism is one of the most rapidly expanding sectors of the north coast economy. Because of its location adjacent to the Summerland Way, and the drawcard of Koalas, with appropriate infrastructure the proposed Sandy Creek Koala Park has the capability to attract tens of thousands of visitors per annum. Each 10,000 visitors has the potential to spend $1.4 million in the regional economy and employ 10.6 people.

Using the forests to generate carbon credits, water yields and attract tourists will generate greater aggregate net economic benefits to the community than continued logging. The avoidance of carbon emissions by retaining trees, and their ongoing carbon sequestration, will contribute to mitigating both our climate and extinction emergencies and thus provide a far higher benefit to the people of NSW than logging them. The community have made it clear time and time again that their preference is to protect both public forests and Koalas, so creation of the proposed Sandy Creek Koala Park is clearly in the public interest.

2 survivors of the 2019 fires in Braemar SF whose homes are scheduled for logging in February 2021

2. VEGETATION VALUES

There are14 forest ecosystems mapped within the proposed Sandy Creek Koala Park, with half these under 100 hectares in extent. The majority of the forests are dominated by Large-leaved Spotted Gum (*Corymbia henryi)* and Coastal Grey Box (*Eucalyptus moluccana*), in various combinations with a variety of other eucalypts, with Forest Red Gum (*E. tereticornis)* dominating the Endangered Ecological Community Subtropical Coastal Floodplain Forest on the Richmond River floodplain.

These forests are home to 4 Endangered plants, and a stronghold for the Vulnerable Slaty Red Gum.

The forests of the Richmond River lowlands have been extensively cleared and are very poorly represented in the reserve system. With 91% of this proposal comprised of forest ecosystems that have not satisfied the minimum reservation requirements of the national reserve criteria (JANIS 1997), it's protection will make a significant and necessary contribution to the national Comprehensive Adequate and Representative Reserve System.

The remnant forests on the Richmond River floodplain were identified as the Endangered Ecological Community (EEC) *Subtropical Coastal Floodplain Forest* in December 2004, with 916 ha mapped within this proposal. Though the Forestry Corporation went on illegally logging it, with 11.5% of its extent on State Forests since logged, including 70 ha in this proposal.

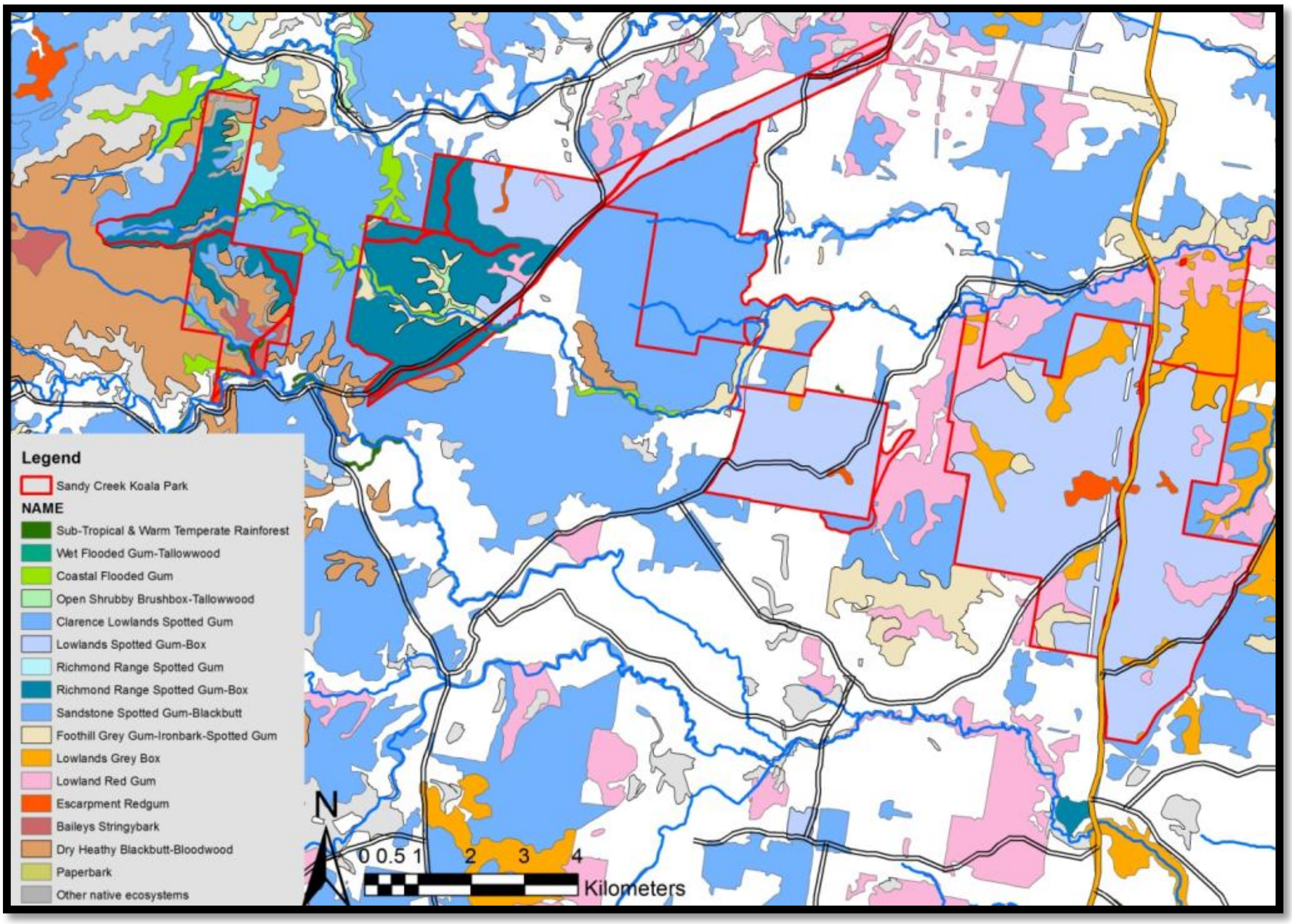
The nationally Vulnerable Slaty Red Gum (*Eucalyptus glaucina)* is the only species in this area for which the impacts of logging were partially assessed over the 20 years since the RFA. The results were significant, with 30% of trees up to 60 cm dbh damaged by logging (5 logged) and a population decline 3 years after logging.

2.1. Ecosystems

There are 14 forest ecosystems, as defined in the 2000 North East NSW Regional Forest Agreement (RFA), comprising 6,761 ha of the State Forests (including the Northern Softwoods Region) proposed as the Sandy Creek Koala Park.

In accordance with the national forest reserve criteria (JANIS 1997), for the RFA most of these ecosystems were given a target for at least 15% of their estimated pre-European (1750) extent to be included in formal reserves, except for Lowlands Grey Box which was assessed as Vulnerable and also given a target of 60% of its remaining extent. Rainforest was given a target of 100% of remaining extent.

According to the 2018 RFA "variation", for the Upper North East NSW region as at 2017, of the 149 forest ecosystems for which there were targets, 51 (34%) have not achieved the target of 15% of their pre-European extent in formal and informal reserves. Eight of the forest ecosystems within the proposed Sandy Creek Koala Park remain below target, with 4 not even achieving half their targets, giving 6,243 ha (91%) of the proposal comprised of inadequately reserved ecosystems. The conversion of these forests to National Parks will make a significant contribution to the national CAR reserve system.



2005 vegetation map produced for the Northern Rivers Catchment Management Authority (NRCMA) based on data from the Comprehensive Regional Assessment (CRA). Note that the discrimination of ecosystem types is greater for State Forests, i.e. Richmond Range Spotted Gum-Box and Lowlands Spotted Gum-Box are classed with Clarence Lowlands Spotted Gum on private lands (including the plantation purchase lands).

The Endangered Ecological Community (EEC) *Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion* was gazetted as an Endangered Ecological Community on the 17 December 2004. It covers parts of the floodplains of the Clarence and Richmond Rivers, and was only mapped for State Forests by the EPA in June 2016.

NEFA has previously complained about logging of this EEC in Compartments 145 and 146 of Doubleduke State Forest (Pugh 2010a, 2010b). In response to our complaints in October 2011 the Chief Executive Officer of the Office of Environment and Heritage commenced legal proceedings against the Forestry Corporation of NSW for logging 120 mature trees in 7.5 ha of the EEC in contravention of section 118A(2) of the *National Parks and Wildlife Act 1974*. In July 2012 the EPA withdrew from its prosecution of Forests NSW, claiming this was because *"Forests NSW evidence raised questions about the interpretability of the soil related component of the NSW Scientific Committee's determination".*

RFA ECOSYSTEMS	Area (ha)	RFA Target	CAR Reserved*
Sub-Tropical & Warm Temperate Rainforest	12.8	100%	NA
Wet Flooded Gum-Tallowwood	5.3	15%	7%
Coastal Flooded Gum	38	15%	25%
Open Shrubby Brushbox-Tallowwood	32.1	15%	27%
Richmond Range Spotted Gum-Box	1027.4	15%	7%
Lowlands Spotted Gum-Box	3329.2	15%	10%
Clarence Lowlands Spotted Gum	828.9	15%	6%
Foothill Grey Gum-Ironbark-Spotted Gum	232.4	15%	20%
Sandstone Spotted Gum-Blackbutt	92.7	15%	12%
Lowlands Grey Box	442.3	15&60%	1%
Lowland Red Gum	444.9	15%	8%
Escarpment Redgum	72.2	15%	14%
Dry Heathy Blackbutt-Bloodwood	161.3	15%	19%
Baileys Stringybark	43.5	15%	35%
Rock	101.7	-	-
TOTAL	6863.0		

RFA mapped Forest Ecosystems on State Forests (including the Forestry Corporation purchase lands) within the proposed Sandy Creek Koala Park:
***revised RFA percentages of ecosystems within the CAR reserve system, including both formal and informal reserves, as at 2017.**

Comparison of Forestry Corporation mapping of logging with the subsequently adopted EEC mapping shows 44 ha of Subtropical Coastal Floodplain Forest in the Doubleduke State Forest complaint area as being logged in 2010-2011. An additional area of 1.75 ha of this EEC identified as logged by NEFA is confirmed as this EEC, though erroneously omitted from Forestry Corporation's logging maps.

This area of the EEC Subtropical Coastal Floodplain Forest was logged in 2010 in Doubleduke SF but has been omitted from Forestry Corporation logging data.

As an outcome of that failed case, and other instances of logging of EECs, the EPA resolved to map EECs. with funding from the Environmental Trust. In 2013 the EPA commissioned OEH to map 25 priority threatened ecological communities across native forestry areas, using extensive aerial photo interpretation mapping, model development, expert consultation and survey work. The outcome was detailed maps of the distribution of 15 priority Endangered Ecological Communities, including *Sub-tropical Coastal Floodplain Forest,* and field keys.

The mapping was completed by mid 2016 though was not released publicly until 2017 in response to a GI(PA) Act application, though was available internally from mid 2016, and earlier for the foresters involved in the project.

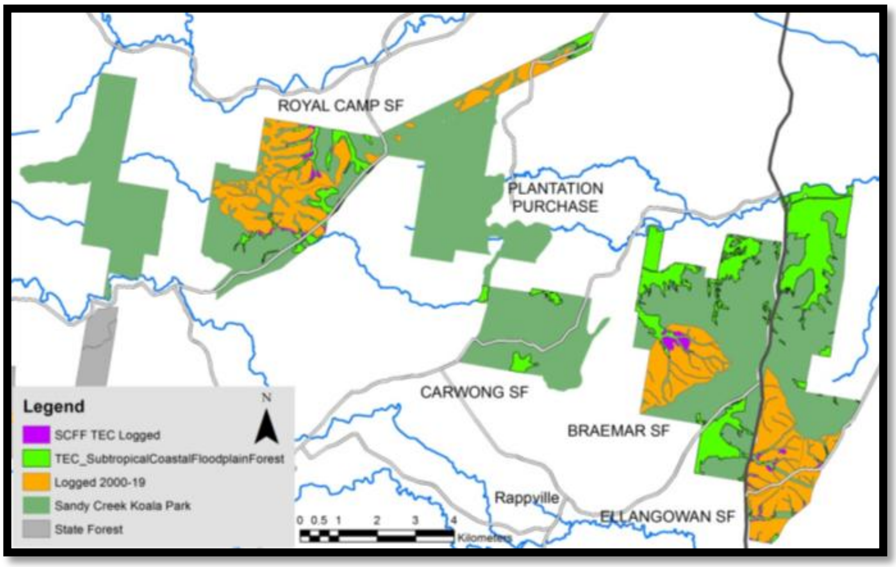
There are now 11,070 ha of *Sub-tropical Coastal Floodplain Forest* mapped on State Forests.

Based on the 1998 CRAFTI Growth Stage mapping this was composed of 28%:oldgrowth (candidate and disturbed), 14% mature forest, 4% young forest and 54% recently disturbed forest at 1998. It has been further disturbed since then.

Key dates are the gazettal of Subtropical Coastal Floodplain Forest as an Endangered Ecological Community in December 2004 and its mapping being completed by June 2016. Comparison of Forestry Corporation logging history maps covering from July 2000 until March 2019, shows 1,646 ha of the mapped Subtropical Coastal Floodplain Forest as having been logged over that time. Since its gazettal in December 2004, 1,269 hectares (11.5%) of this EEC is mapped as logged, with at least 21 ha logged since the EPA's mapping.

Subtropical Coastal Floodplain Forest	Area (ha)
TOTAL AREA	11,070
Logged July 2000-2004	377
Logged 2005-2016	1,248
Logged 2017-March 2019,	21
TOTAL LOGGED	1,646

Logging of the EEC Subtropical Coastal Floodplain Forest since its gazettal in 2004 and mapping in 2016.



Endangered Ecological Community (EEC) Subtropical Coastal Floodplain Forest (which is only mapped for legal State Forests), showing (purple) the overlap with mapped logging extent from 2006 to 2012.

The most extensive logging was in Compartments 108, 109 and 112 of Gibberagee State Forest in 2007 when 579 ha of this EEC was logged.

This proposal encompasses 916ha of Subtropical Coastal Floodplain Forest, of which 612ha was mapped as young or recently disturbed in 1998. From 2006 to 2012, 70 hectares of this EEC was logged.

2.2 Plant Species

The forest is dominated by Large-leaved Spotted Gum (*Corymbia henryi)* and Coastal Grey Box (*Eucalyptus moluccana*). The distribution of most other species is patchy. The red gums, Forest Red Gum (*E. tereticornis)* and Slaty Red Gum (*E. glaucina)* are widespread, dominating wetter low-lying areas. Other common species are Small-fruited Grey Gum (*E. propinqua*), Narrow-leaved Ironbark (*E. crebra*), Grey Ironbark *(E. siderophloia)*, Narrow Leafed White Mahogany (*E. acmenoides*) and Pink Bloodwood (*Corymbia intermedia*). Swamp Box (*Lophostemon suaveolens*) is more common in wetter areas, though there are not many large trees left.

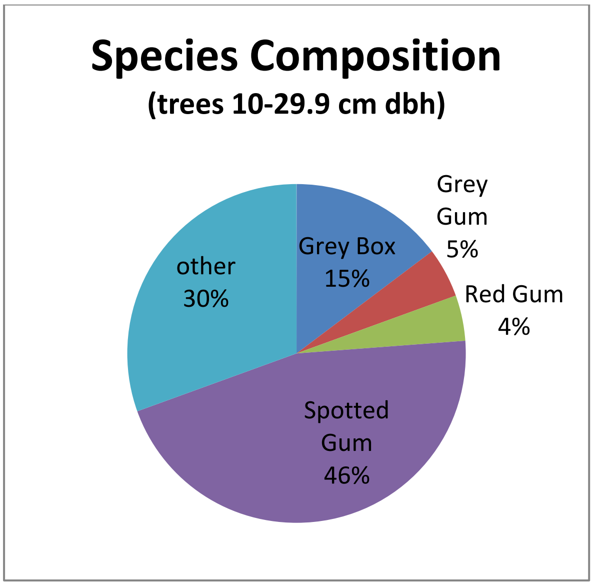
Other Koala feed trees recorded (EPA 2016) are Tallowwood (*E. microcorys*) and Swamp mahogany (*E. robusta*). There are also records of Brush box (*Lophostemon confertus*), Blackbutt (*E. pilularus*), Flooded Gum (*E. grandis)*, Red Mahogany (*E. resinifera*) and Turpentine (*Syncarpia glomulifera*).

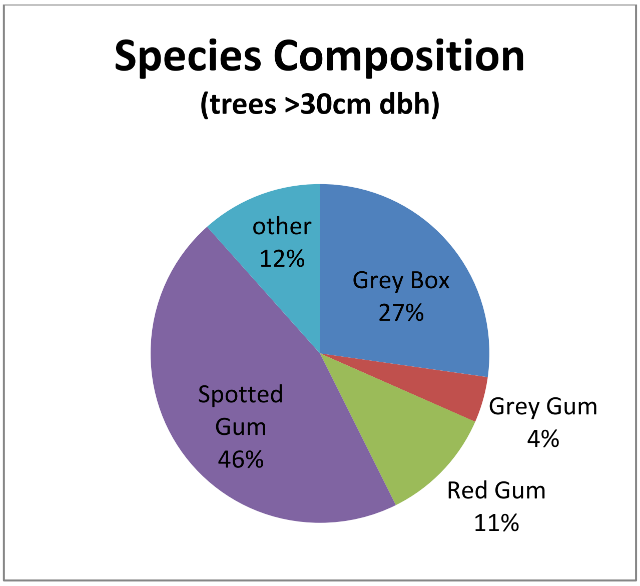
Common small trees are Red Ash (*Alphitonia excelsa),* Forest Oak (*Allocasuarina* spp.), Brush Ironbark Wattle (*Acacia aulacocarpa)*, Hickory Wattle (*Acacia disparrima)* and *Melaleuca* spp*.*

NEFA measured (see section 4.2) 76 structural plots: 47 in the ecosystem Lowlands Spotted Gum-Box, 12 in Clarence Lowlands Spotted Gum, 14 in Richmond Range Spotted Gum-Box, and 3 in Lowlands Grey Box. They thus represent a reasonable sample of the Spotted Gum dominated forests that characterise this proposal.

Weeping Paperbark (*Melaleuca irbyana).* Before the fires many individuals were observed to be significantly drought affected.

NEFA's vegetation plots have identified the forest to be dominated by Large-leaved Spotted Gum (*Corymbia henryi)* (46% of trees over 30cm diameter - dbh) and Coastal Grey Box (*E. moluccana*) (27% of trees over 30cm dbh), and in places the red gums Forest Red Gum (*E. tereticornis)* and Slaty Red Gum (*Eucalyptus glaucina)* (together 11% of trees over 30cm dbh).





Species composition of proposed Sandy Creek Koala Park

Four Endangered plants, one Vulnerable plant and the Endangered Ecological Community Subtropical Coastal Floodplain Forest have been recorded.

The NSW Endangered sedge Water Nutgrass *(Cyperus aquatilis),* Endangered shrub Weeping Paperbark (*Melaleuca irbyana),* the Endangered herbs Native Milkwort *(Polygala linariifolia)* and Oldenlandia *(Oldenlandia galioides),* and the Vulnerable Slaty Red Gum *(Eucalyptus glaucina)* occur in the proposal and are all identified in OEH threatened species profiles as threatened by grazing and logging activities.

Species		**STATUS**	**Logging Prescription**
Water Nutgrass	*Cyperus aquatilis*	Endangered	20m buffer
Weeping Paperbark	*Melaleuca irbyana*	Endangered	20m buffer
Native Milkwort	*Polygala linariifolia*	Endangered	20m buffer
Oldenlandia	*Oldenlandia galioides*	Endangered	-
Slaty Red Gum	*Eucalyptus glaucina*	Vulnerable	20m buffer for mature tree (>30cm)

Threatened plants and logging prescriptions (CIFOA).

Of these only Slaty Red Gum is listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* as Vulnerable.

2.2.1. Case Study Slaty Red Gum

The nationally vulnerable Slaty Red Gum *(Eucalyptus glaucina)* is widespread throughout the proposal, achieving densities of 5-10 per hectare. Due to the difficulty in differentiating mature Slaty

Red Gum from Forest Red Gum (*E. tereticornis),* it was not separately identified in NEFA's or the EPA (2016) assessments.

The previous Threatened Species Licence classed Slaty Red Gum as one of the 11 plants that can be logged indiscriminately subject to the undertaking of a Monitoring Program. The new CIFOA only requires the retention of mature trees >30cm diameter (dbh), with no buffers.

The 'Approved Conservation Advice for Eucalyptus glaucina (Slaty Red Gum)' (3/7/2008) states "*The main identified threats to Slaty Red Gum include clearing and fragmentation of habitat for agriculture and development, timber harvesting activities, and lack of regeneration through grazing pressure (DECC, 2005)*". OEH identify as a threat "*Timber harvesting activities"* and as a management activity *"Protect areas of habitat from timber harvesting activities*".

Slaty Red Gum was identified in the previous Threatened Species Licence (1999) as one of the 11 plants that required Monitoring Programs. The Forests NSW 2000 Monitoring Plan proposed selecting one of every 3 compartments where >100 Slaty Red Gum occurs for establishment of 10 monitoring plots, with compartment 28 in Braemar and compartment 43 in Bungawalbin State Forests selected initially. Results were to be reviewed after 18 months.

The '*Eucalyptus glaucina* Flora Monitoring Program First report' was prepared in 2012 and is the only one prepared. The monitoring found that across 4 sites 30% of trees up to 60 cm dbh were damaged by logging (5 logged) and 3 years after logging there was a population decline. Even though this monitoring was undertaken with the knowledge of the operators (which would suggest increased care), the report identifies that:

> *Overall, 30% (95% CI 24-36%) of trees up to 60 cm dbhob were damaged by logging (Table 1). Most of these recovered (Table 2), either by branch epicormic growth or by basal coppice. Seven percent of trees in this size category were killed or removed. ... Five trees over 30 cm dbhob were felled as sawlogs. ... There is moderately strong evidence that the proportion of plants which were damaged was significantly greater for smaller size classes. ...*
>
> *... There was an increase in the 2 m to 5 cm size class three years after logging, but this was predominantly due to coppice following damage to larger plants. The hypothesised post-disturbance recruitment was lower than predicted and the results provide no evidence that the decrease in the number of medium to large trees is adequately compensated by recruitment.*

A monitoring site for Slaty Red Gum was set up in Braemar SF in January 2001. Operations were complete by November 2001 and post harvest data collection was completed by 2006. Binns (2012) found "*Recruitment rates were low and very variable, from one (1% of post-logging population) in Braemar SF to 17 (18% of post-logging population) at the Bungawalbin site*".

Slaty Red Gum (*Eucalyptus glaucina)* is the only species in this area for which the impacts of logging were partially assessed over the 20 years since the RFA. The results were significant, with 30% of trees up to 60 cm dbhob damaged by logging (5 logged) and a population decline 3 years after logging. The direct impact would have been apparent in 2001, and the poor regeneration apparent by 2006. though the report wasn't written until 2012 and there was no attempt to modify practices to reduce mortality or improve regeneration during the life of the previous IFOA. This is what they ironically call 'adaptive management'.

Table 1. Proportion of damaged and killed plants of *E. glaucina* one year following logging.

Killed or removed category comprises all plants which died prior to the one-year post-harvest assessment one year after being damaged by logging or which could not be relocated after logging and were presumed destroyed. The 'damaged' column includes plants which died but not those which could not be relocated.

Size class (cm dbhob)	Damaged		Killed or removed	
	Proportion	95% CI	Proportion	95% CI
<10	0.38	0.29-0.47	0.09	0.05-0.16
10 to <30	0.21	0.12-0.33	0.05	0.01-0.13
30 to <60	0.21	0.10-0.37	0.05	0.006-0.16
10 to <60	0.21	0.14-0.30	0.05	0.02-0.11
all <60	0.30	0.24-0.36	0.07	0.04-0.11
>=60	0.05	0.001-0.24	0	0-0.16

Table 1 from Binns 2012: shows the significant logging damage to Slaty Red Gum even when loggers try to avoid them.

It is clear that damage to mature Slaty Red Gum will continue with ongoing logging, particularly with no protection for trees under 30cm diameter. Coupled with increased logging intensity, and poor regeneration, it is expected to decline significantly with ongoing logging.

Slaty Red Gum, fire regrowth.

3. ANIMAL VALUES

These dry lowland eucalypt forests are of particular value for a suite of forest dependent species. The most significant, and the species on which this proposal is focussed, is the Koala. Since NEFA stopped logging of Koala High Use Areas in Royal Camp State Forest in 2012 the evidence of the importance of first Royal Camp, then Carwong, and then Braemar State Forests for Koalas has accumulated and put beyond doubt the importance of these forests for Koalas. From our findings it is apparent that remnant forests with numbers of mature Small-fruited Grey Gums, Coastal Grey Box, Forest Red Gum and/or Slaty Red Gum, on and adjoining the Richmond River floodplain, provide habitat that is highly significant to maintenance of the regional Koala population, along with 34 other threatened animals.

Koalas within the proposed Sandy Creek Koala Park have been shown to preferentially choose larger trees for feeding, rarely using trees less than 20 cm diameter at breast height (dbh) and preferring trees >30cm dbh, with use increasing with tree size (Section 3.1.3.2). Before the fires it was expected that the high numbers of Koalas found in some areas was due to partial recovery from logging over 2 decades previously. While it is apparent that there were pockets of higher density, if the conservative estimate of one Koala per 20 ha is adopted this suggests there was a population of around 350 Koalas. It appeared that Koala numbers could more than double if the forest was left to mature. Conversely it was considered that relogging could more than halve recovering populations.

This all changed on the night of 8 October 2019 when the Busby's Flat fire burnt most of the proposal, eliminating Koalas from the most heavily burnt forests. After the fires drought persisted for two and a half months. NEFA's assessment of the impacts of the 2019 wildfire and drought on the proposed Sandy Creek Koala Park indicates the loss of 78-89% of Koalas and a surviving population of just 38-76 Koalas.

While Koalas have been decimated, NEFA have found pockets of surviving Koalas and that most feed trees have survived, meaning that Koalas can rebuild their populations over time and this can once again become a nationally significant Koala population. It may take decades, but if we stop cutting down their feed trees and instead allow them to grow, the prognosis is good. The proposed Sandy Creek Koala Park is still being pursued to enable this Koala population to recover and grow.

Worldwide populations of forest species are crashing, with monitored forest vertebrate populations declining by 53% between 1970 and 2014 (Green *et. al.* 2020). The Threatened Bird Index for New South Wales gives population trends for 16 threatened species in NSW finding "*the relative abundance of threatened birds for which we have information has decreased by 76% between 1985 and 2015*".

The Koala is only one of the 35 threatened animals known or expected to occur within the proposed Sandy Creek Koala park. Thirty four of these are listed under NSW's *Biodiversity Conservation Act 2016*:

Critically Endangered: Regent Honeyeater, Red Goshawk,

Endangered: Swift Parrot (Critically Endangered under EPBC Act), Black-striped Wallaby.

Vulnerable: Square-tailed Kite, Little Eagle, Masked Owl, Powerful Owl, Barking Owl, Glossy Black-Cockatoo, Turquoise Parrot, Little Lorikeet, Black-chinned Honeyeater, Brown Treecreeper, Grey Crowned Babbler, Dusky Woodswallow, Hooded Robin, Diamond Firetail, Speckled Warbler, Varied Sittella, Common Planigale, Brush-tailed Phascogale, Koala, Rufous Bettong, Squirrel Glider, Yellow-bellied Glider, Grey-headed Flying Fox, Hoary Wattled Bat, Large Bent-wing Bat, Little Bent-wing Bat, Yellow-bellied Sheathtail-bat, Eastern False Pipistrelle, Southern Myotis and Greater Broad-nosed Bat

Five of these are also listed as threatened under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, along with the additional nationally Vulnerable Greater Glider.

The Endangered fish Purple Spotted Gudgeon has been recorded downstream from this proposal in Sandy Creek (Brooks 2009). Therefore it is directly affected by management of these lands. particularly logging and roading, as well as stochastic events such as wildfires.

Importantly, the woodlands/dry open forests of the proposal area are a stronghold for declining woodland/dry open forest bird species, with 18 of the threatened species recorded recognised as dependent or associated with these vegetation types. The former comprise the Swift Parrot, Turquoise Parrot, Barking Owl, Regent Honeyeater and Grey-crowned Babbler, and the latter the Square-tailed Kite, Red Goshawk, Little Eagle, Little Lorikeet, Powerful Owl, Masked Owl, Brown Treecreeper, Speckled Warbler, Black-chinned Honeyeater, Varied Sittella, Dusky Woodswallow, Hooded Robin and Diamond Firetail. This group of bird species has been identified as of particular conservation concern for more than 20 years and the various species are continuing to experience major population declines throughout their ranges. However, their more easterly habitats, such as those represented by the proposal area are considered to be of special value for the conservation of this group due to the severe climate change-induced droughts now impacting the western parts of their ranges.

All the threatened vertebrate species have suffered from past management for logging that has resulted in the significant loss of essential resources as the ages and sizes of trees have been diminished over the past century. Trees provide an increasing abundance of food resources for animals as they age, including flowers, seeds, manna, lerp, honeydew, browse and sap. Older trees also provide more stable sites for nesting and roosting, though most importantly once they are over a hundred years old they begin to develop the hollows that provide homes for an abundance of animals.

Because of the progressive conversion of these forests to ever younger regrowth, populations of many native animals have lost the food and shelter resources they need, and thus been severely depleted or eliminated from the forest.

Larger trees, particularly once over 40 cm diameter (dbh), flower more frequently and abundantly. Past logging is likely to have reduced nectar production by at least 43%. The loss of nectar, and the more infrequent flowering, has had a significant impact on the 7 threatened nectarivore utilising these forests, particularly those dependent upon winter flowering, such as the Critically Endangered Regent Honeyeater and Swift Parrot.

Within the proposed Sandy Creek Koala Park there has been a dramatic reduction in big old trees and thus the hollows they provide for the 17 threatened hollow-dependent species in these forests dependent upon them for nesting, denning and roosting. Due to past logging there has been a

98.4% loss of large hollow-bearing trees and 78% reduction of trees with small hollows. This loss has devastated populations of many hollow- dependent species.

All species will benefit from the cessation of logging and the slow increase in forest maturity that will result. For the future of many of these species it is essential that currently mature trees be allowed to further age to restore the resources needed for food and shelter, which are essential for forest ecosystem functioning, and sustaining or restoring the full range of biodiversity.

Threatened fauna species known or expected in the proposed Sandy Creek Koala Park.

SPECIES		NSW Status	CW Status	OEH Identified Threats	Key Tree Resources	Reserve Target Achieve[2]
Square-tailed Kite	Lophoictinia isura	V		Logging, grazing, burning		31%
Little Eagle	Hieraaetus morphnoides	V				-
Red Goshawk	Erythrotriorchis radiatus	CE	V	Logging,		23%
Masked Owl	Tyto novaehollandiae	V		Logging, grazing, burning	hollows	22%
Powerful Owl	Ninox strenua	V		Logging, burning	hollows	61%
Barking Owl	Ninox connivens	V		Logging, burning	hollows	14%
Glossy Black-Cockatoo	Calyptorhynchus lathami	V		logging, grazing,	hollows	100%
Turquoise Parrot	Neophema pulchella	V		Logging, burning	hollows	13%
Swift Parrot	Lathamus discolor	E	CE	Logging, burning	nectar	30%
Little Lorikeet	Glossopsitta pusilla	V		Logging, burning	hollows	-
Regent Honeyeater	Anthochaera phrygia	CE	CE	logging, grazing, burning	nectar	31%
Black-chinned Honeyeater	Melithreptus gularis gularis	V		grazing	nectar	-
Brown Treecreeper	Climacteris picumnus victoriae	V		logging	hollows	-
Grey Crowned Babbler	Pomatostomus temporalis temporalis	V		grazing, burning		68%
Dusky Woodswallow	Artamus cyanopterus cyanopterus	V		logging, grazing		-
Hooded Robin	Melanodryas cucullata cucullata	V		logging, grazing, burning		14%
Diamond Firetail	Stagonopleura guttata	V		grazing, burning		-
Speckled Warbler	Chthonicola sagittata	V		grazing, burning		-
Varied Sittella [1]	Daphoenositta chrysoptera	V		grazing, burning		-

Common Planigale [1]	Planigale maculata	V		grazing, burning		100%
Brush-tailed Phascogale	Phascogale tapoatafa	V		logging,	hollows	32%
Koala	Phascolarctos cinereus	V	V	burning	browse	83%
Rufous Bettong	Aepyprymnus rufescens	V		logging, grazing, burning		18%
Black-striped Wallaby [1]	Macropus dorsalis	E		grazing, burning		36%
Greater Glider	*Petauroides volans*		V	Logging, burning	Hollows browse	64%
Squirrel Glider	Petaurus norfolcensis	V		Logging, burning	Hollows , nectar	17%
Yellow-bellied Glider	Petaurus australis	V		Logging	Hollows , nectar	17%
Grey-headed Flying Fox	Pteropus poliocephalus	V	V		nectar	79%
Hoary Wattled Bat	Chalinolobus nigrogriseus	V		logging, grazing, burning	hollows	42%
Yellow-bellied Sheathtail-bat	Saccolaimus flaviventris	V		logging	hollows	-
Greater Broad-nosed Bat	Scoteanax rueppellii	V		logging	hollows	38%
Southern Myotis	Myotis macropus	V			hollows	39%
Eastern False Pipistrelle	Falsistrellus tasmaniensis	V		logging	hollows	38%
Large Bent-wing Bat [1]	Miniopterus orianae oceanensis	V				100%
Little Bent-wing Bat [1]	Miniopterus australis	V		burning	hollows	100%

1: Expected (D. Milledge pers. com.). Status: CE-Critically Endangered, E-Endangered, V-Vulnerable.
2. Reserve Target Achievement: average target achievement across all populations (from Flint *et. al.* 2004)

There are a variety of other threatened species recorded in the vicinity which may utilise the proposal: Black-necked Stork (E) , Black Falcon (V) Scarlet Robin (V), Flame Robin (V), Spotted-tailed Quoll (V, E), Large-eared Pied Bat (V, V), and Eastern Long-eared Bat (V).

OEH Threatened biodiversity profiles (https://www.environment.nsw.gov.au/threatenedspeciesapp/) identify logging as a threat to most of these species.

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",* 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 the owls recorded within this proposal:

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.*

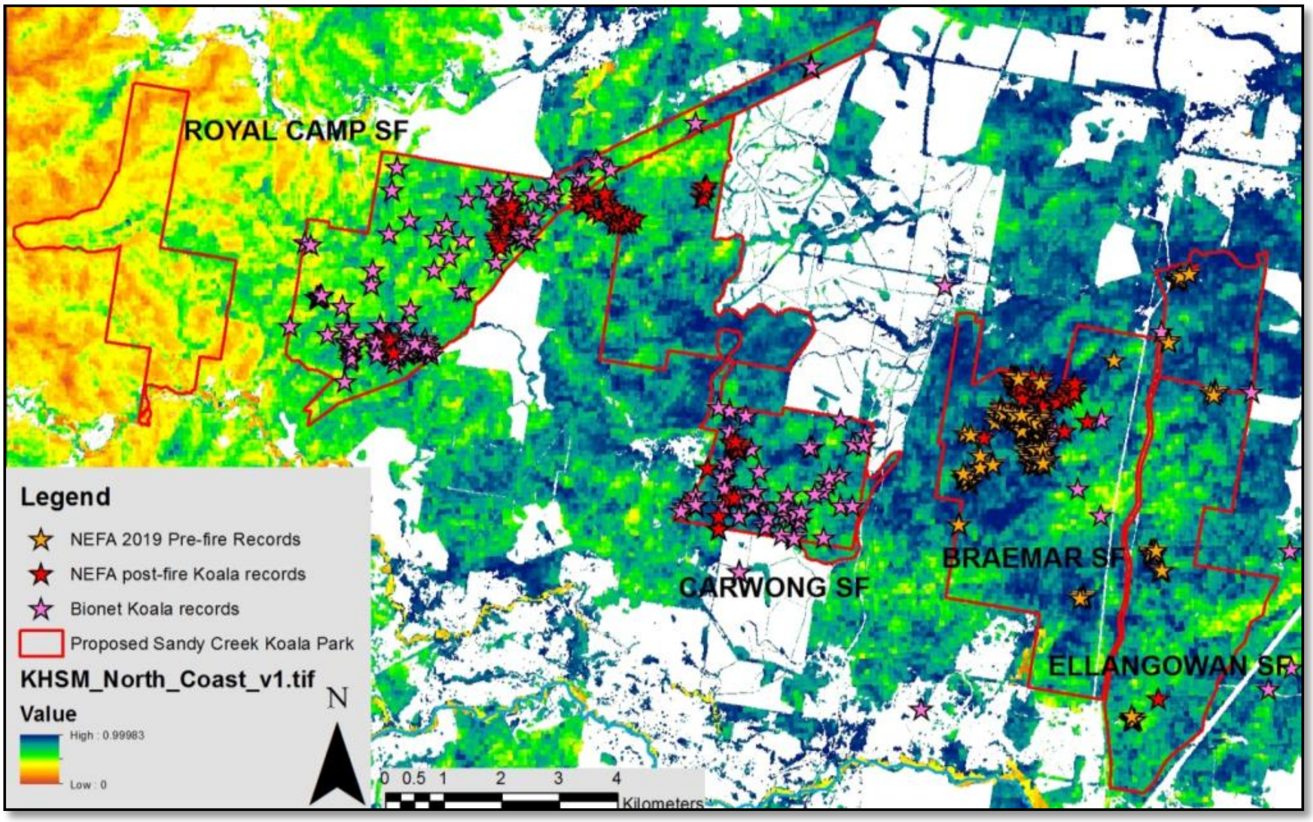
Of the 26 known or expected threatened species within this proposal for which reserve targets were set, only 4 (15%) have met targets, and 17 (65%) have achieved less than half their minimum reservation targets (Flint et. al. 2004).

The proposed Sandy Creek Koala Park will significantly improve the satisfaction of reserve targets set for numerous species, particularly the declining woodland/dry open forest bird species. in accordance with the national forest reserve criteria (JANIS 1997) and thus enhance their long-term viability. However, given the degraded nature of these forests it will take considerable time before habitat and its carrying capacity is restored to a balanced state.

3.1. Koalas

Some 6,545 ha (94%) of the proposed Sandy Creek Koala Park is comprised of forest ecosystems dominated by the Koala feed trees Coastal Grey Box (*Eucalyptus moluccana*), Forest Red Gum (*E. tereticornis)*, Slaty Red Gum (*Eucalyptus glaucina)* and/or Small-fruited Grey Gum (*E. propinqua*). Koalas prefer areas with 2 or more of these species. The evidence is that Koalas rarely utilise smaller trees (under 20cm diameter) and that their use of trees increases in concert with tree size. So it is the larger of these four species that are the key determinants of Koala habitat values.

Though Koalas will preferentially choose individual trees, even out of groups of the same species with similar sizes.



All Koala records overlaid on DPIE model of likely Koala habitat. Note that while the EPA undertook systematic surveys of the eastern section of Royal Camp SF and Carwong SF, other areas have not been comprehensively assessed.

Past logging has removed most trees over 45cm diameter (dbh) and thus significantly diminished food for Koalas, with the impact variable across the landscape depending on logging intensity and time since logging. As the feed trees left behind from past logging grow, so to can Koala numbers.

NEFA had found Koalas to be widespread throughout the proposal, with large patches of high and persistent occupancy, and different sized scats, indicating stable breeding colonies. There were estimates of Koala densities of one Koala per 2.8 ha in Royal Camp SF (Shields 2018), though the EPA (2016) adopt "*a conservative estimate of a 20 hectare home range for low density koala populations*". Koala's have overlapping home ranges, meaning occupation would be more than one per 20ha.

The proposed Sandy Creek Koala Park is 6,938 ha, while the distribution and density of Koalas across this area is variable, if a conservative average density of one Koala per 20 ha (EPA 2016) is applied then the overall population before the fires would be something like 347 Koalas.

This all changed on the night of 8 October 2019 when the Busby's Flat fire burnt most of the proposal, eliminating Koalas from the most heavily burnt forests. Then the drought persisted for two and a half months, with around 70% of the surviving Koalas being eliminated from the partially burnt forests as the NSW Government ignored their plight.

NEFA's assessment of the impacts of the 2019 wildfire on the proposed Sandy Creek Koala Park indicates the loss of 78-89% of Koalas. This suggests the loss of 271-309 Koalas due to the fires and a surviving population of 38-76 Koalas.

There has been extensive death of Spotted Gums in the most heavily burnt patches, though most larger Koala feed trees have now re-sprouted. While the habitat is recovering, it is going to take a long time for the Koala population to rebuild. So while Koalas have been decimated, the proposed Sandy Creek Koala Park is still being pursued to restore what can, over time, once again become a nationally significant Koala population.

While the wildfire has caused a significant reduction in the Koala population, the habitat has only suffered relatively minor long-term damage. Koalas are capable of recovering from the fires over time provided their feed and roost trees are not logged in the interim. The danger is that continued logging of this core Koala habitat will significantly compound the effects of the fire and interfere with the recovery process, potentially risking the survival of this important Koala population.

The new logging rules remove the need to identify and protect Koala High Use Areas, remove the need to retain most mature trees, and allow for an increase in logging intensity, so they will significantly increase future impacts on this important Koala population.

Degradation of these source areas, and the continuing loss of mature trees, by logging is likely to result in their conversion to sink habitat where reproduction no longer exceeds mortality, leading to the decline and eventual extinction of this local Koala population over time.

It is obvious that the creation of the Sandy Creek Koala Park will stop the principal ongoing long-term cause of degradation of these forests and allow habitat values to improve over time. Given the widespread distribution and use of Koala feed trees throughout the proposal, it is evident that as feed trees age and core breeding areas expand, the Koala population will increase concomitant with the increasing resources they will provide.

The importance of increasing the extent of core breeding habitat, and the availability of suitable feed trees, in these forests to maintain Koala populations in an era of increasing threats from droughts, heatwaves and bushfires due to climate heating cannot be under-stated.

3.1.1. Regional Considerations

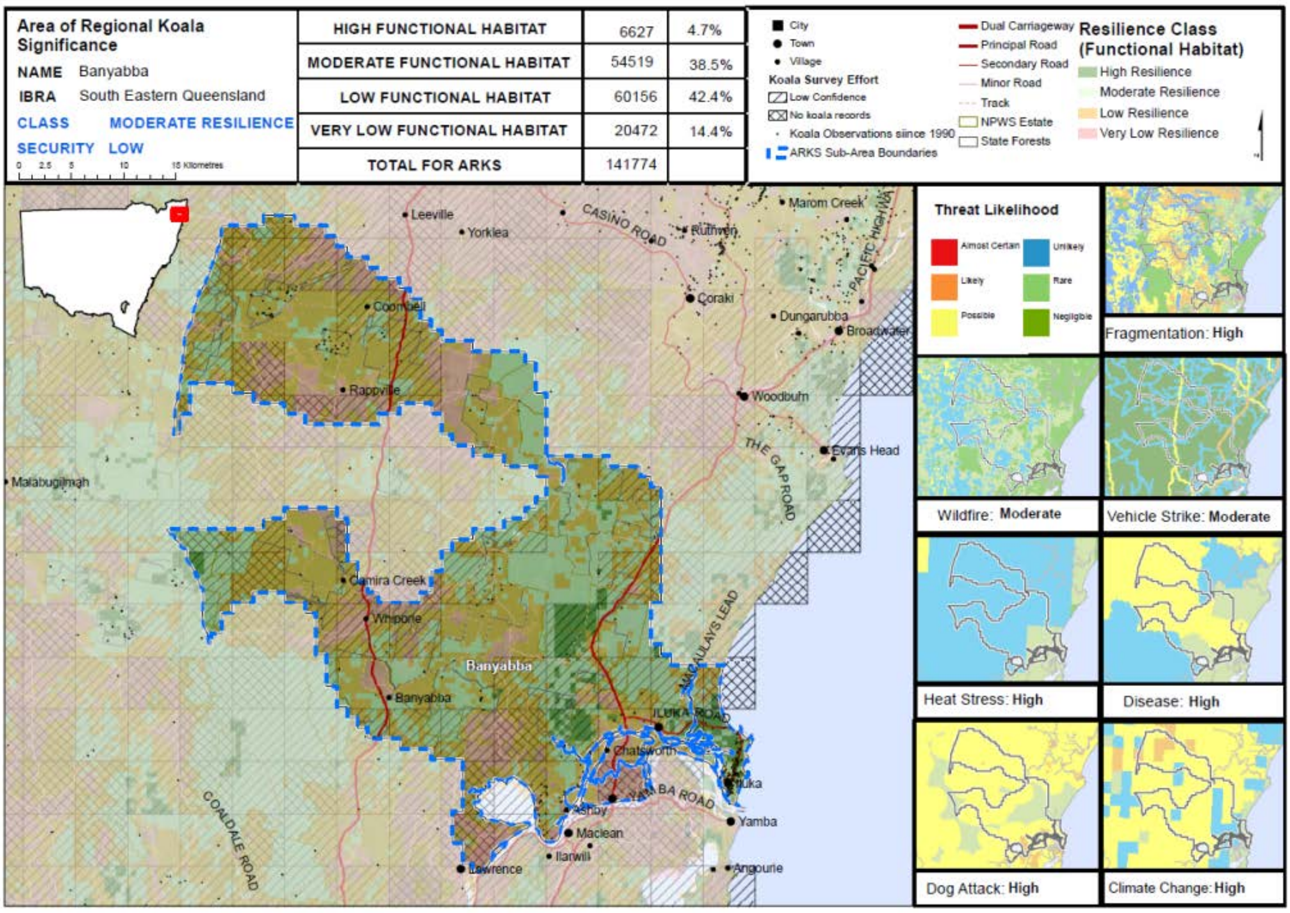
In 2012 an expert panel was asked to estimate Koala populations and trends across Australia (Adams-Hosking *et.al* 2016). The experts were asked to estimate population size for each bioregion, and declines or increases in koala numbers that capture the largest change in any three-generation period of three past and three future koala generations (15–21 years). For the NSW North Coast (which included that portion of the South East Queensland Bioregion in NSW) the identified mean Koala population was estimated as 8,367 (range 4,048 - 14,618), with a 50% decline (range 32-72%).

As part of developing a Koala Strategy the then Office of Environment and Heritage undertook a variety of studies, including a bioregional assessment (Rennison 2017). This identified that the NSW section of the South Eastern Queensland Bioregion has an "inadequate" reserve system, with 14% reserved compared to the 17% target. This declines significantly for Koalas, with "Low" (10%) representation of Koalas in reserves (the NSW North Coast Bioregion fared marginally better with 12% representation of Koalas in reserves). The region is ranked as a "Moderate-High" priority for increased reservation for Koalas. Rennison (2017) observes:

While hinterland sub-populations are not subject to the same degree of habitat loss associated with coastal development, timber harvesting presents an ongoing threat to habitat condition where it occurs. A recent study (EPA 2016) within this proposal identified Koala's preference for larger diameter feed trees present in structurally mature dominated forests, which has been confirmed by this assessment.

A complimentary state-wide assessment was undertaken by Rennison and Fisher (2018) to identify Areas of Regional Koala Significance (ARKS). ARKS are *"key koala populations and management areas which have the potential for long-term viability"*. Altogether, 4,195,549 hectares, around 5% of NSW, is mapped as being of significance for Koalas in 48 ARKS.

The proposed Sandy Creek Koala Park occurs within the Banyabba ARKS, which covers 141,774 ha of land, with 42.3% of this identified as moderate-high functional habitat.



Koalas have long been assessed as in decline in the Banyabba ARKS. A study of Koalas in the south-east of the Banyabba ARKS (White *et. al.* 2015) found:

> *Koala numbers within the Ashby area are under threat due to continuing fragmentation of suitable habitat. The Woombah koala population is in imminent danger of extinction and there is only evidence of recent activity in the North Western part of Woombah. The NSW recovery plan (research by Luney et al 2002) suggests that the Iluka koala population was extinct in 1999 but ongoing sightings in the village and along Iluka Road suggest there may be a viable population in the National Park to the North.*

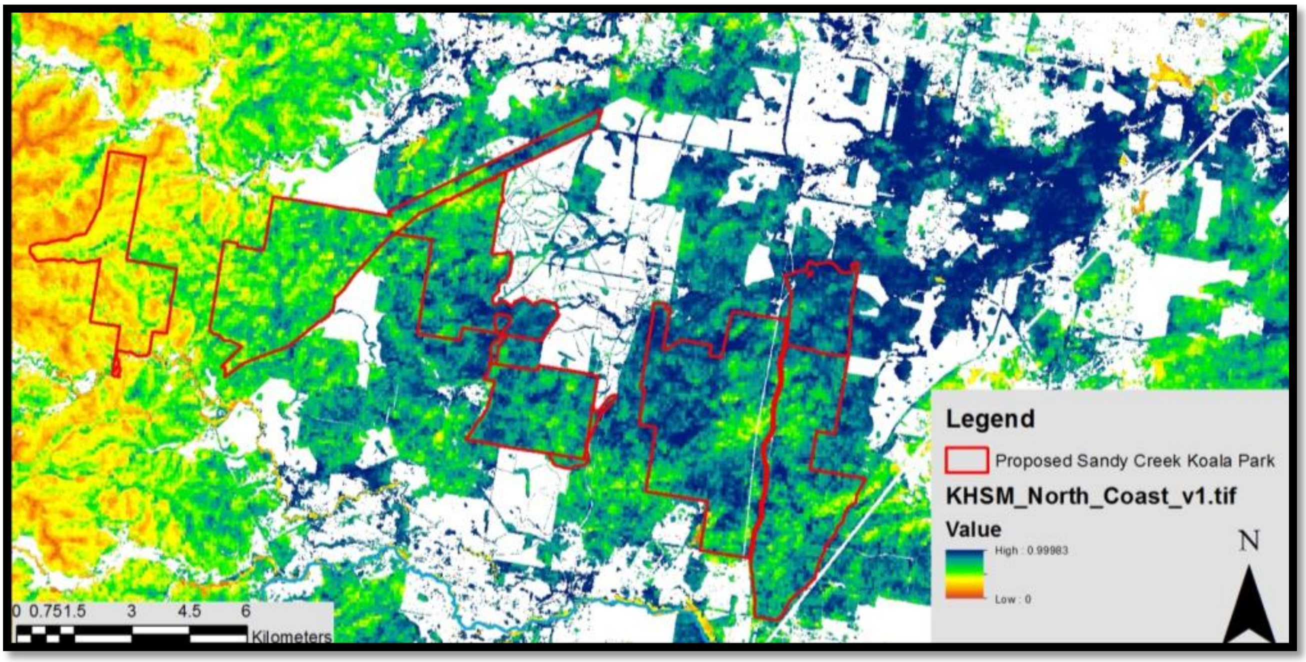
A study of Koalas across the Richmond Valley LGA (Phillips and Weatherstone 2015) identified:

> *Extent of Occurrence of koalas across the RVLGA has remained relatively unchanged over time. However, further analyses of habitat occupancy rates has indicated a statistically significant decrease over the last 3 koala generations of ~33% in the amount of habitat actually being occupied by koalas. This trajectory, if left unchecked, will lead to increasing endangerment of the RVLGA's koala populations over coming years.*

The principal factors affecting this population to date have been land clearing, habitat degradation and fragmentation, though Koalas are becoming increasingly imperilled by intensifying droughts, heatwaves and wildfires due to climate heating.

Another component of the Koala Strategy was the preparation of a Koala Habitat Suitability Model (KHSM) that predicts the spatial distribution of potential koala habitat across NSW using a value between 0 and 1 (i.e. a higher value represents a higher probability that a specific location will contain habitat suitable for koalas). The model provides an indication of where koalas have the potential to reside but are not necessarily currently occupied. The Government's recent Koala SEPP incorporates a 'Koala Development Application Map' which identifies this highest classes of the KHSM as '*highly suitable koala habitat ... likely to be occupied by koalas*'. This model confirms the importance of the Richmond River lowlands and highlights it as one of the most important areas of likely Koala habitat in north east NSW.

For this analysis the model was converted to shapefiles, which creates some fragment issues, though provides a reasonable approximation of representation of the various probabilities of suitable habitat being present. The outcome is that 38% of this proposal provides very high suitability for Koalas and 41% high suitability. This conforms with NEFAs Koala records, which has found most of the lowland forests to provide potential Koala habitat, though with occupancy limited by past logging and the loss of larger feed trees.

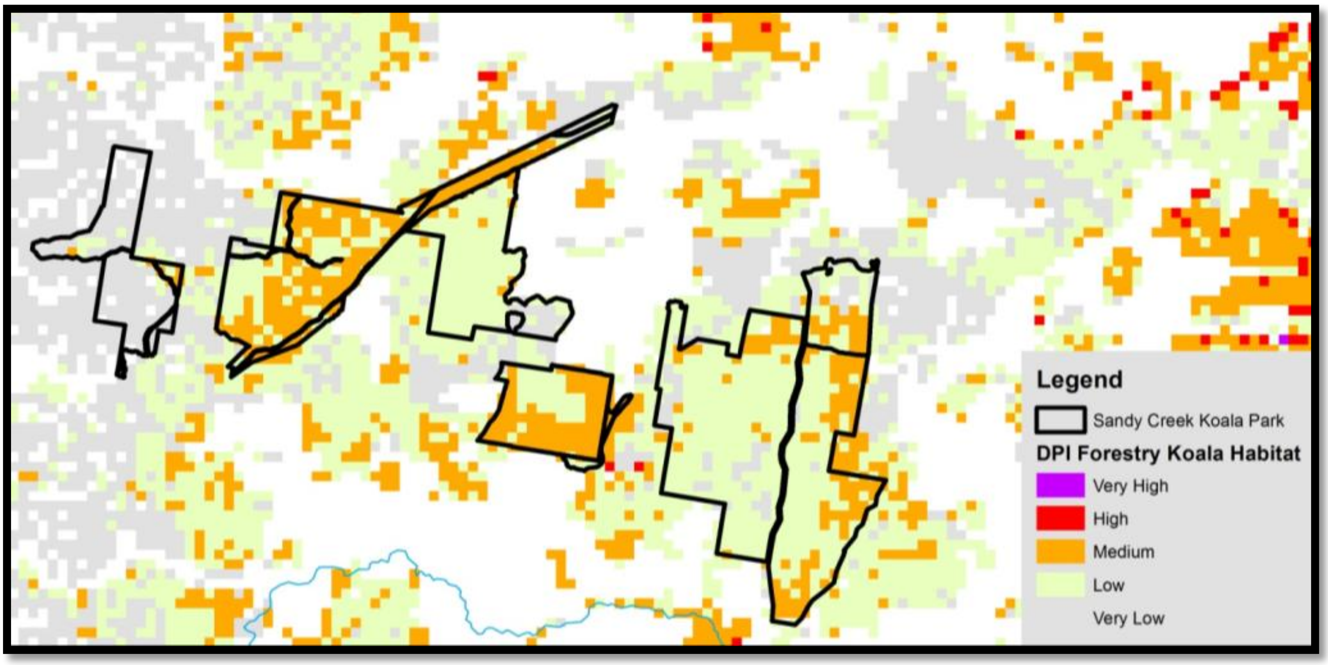


DPIE 2019 Koala Habitat Suitability Model. This model emphasises the high importance of the Richmond River lowlands for Koalas, though does not account for the patchy distribution of feed trees and the extensive logging degradation.

KHSM	Area (ha)	%
Very High Suitability	2518	37.5%
High Suitability	2742	40.9%
Medium Suitability	1126	16.8%
Low Suitability	325	4.8%
Very Low Suitability	1	0%
TOTAL	6711	

Proposed Sandy Creek Koala Park, approximate Koala Habitat Suitability Model rankings

The DPIE 2019 Koala model differs significantly from the DPIE-Forestry model (Law *et. al.* 2017) which classes many of the areas identified by NEFA as having high Koala occupancy as low to very low habitat quality. This model bears little resemblance to reality. This case exemplifies the folly of relying on the DPIE-Forestry model's identification of high and medium quality habitat for determining minimal tree retention prescriptions for public lands across north-east NSW.



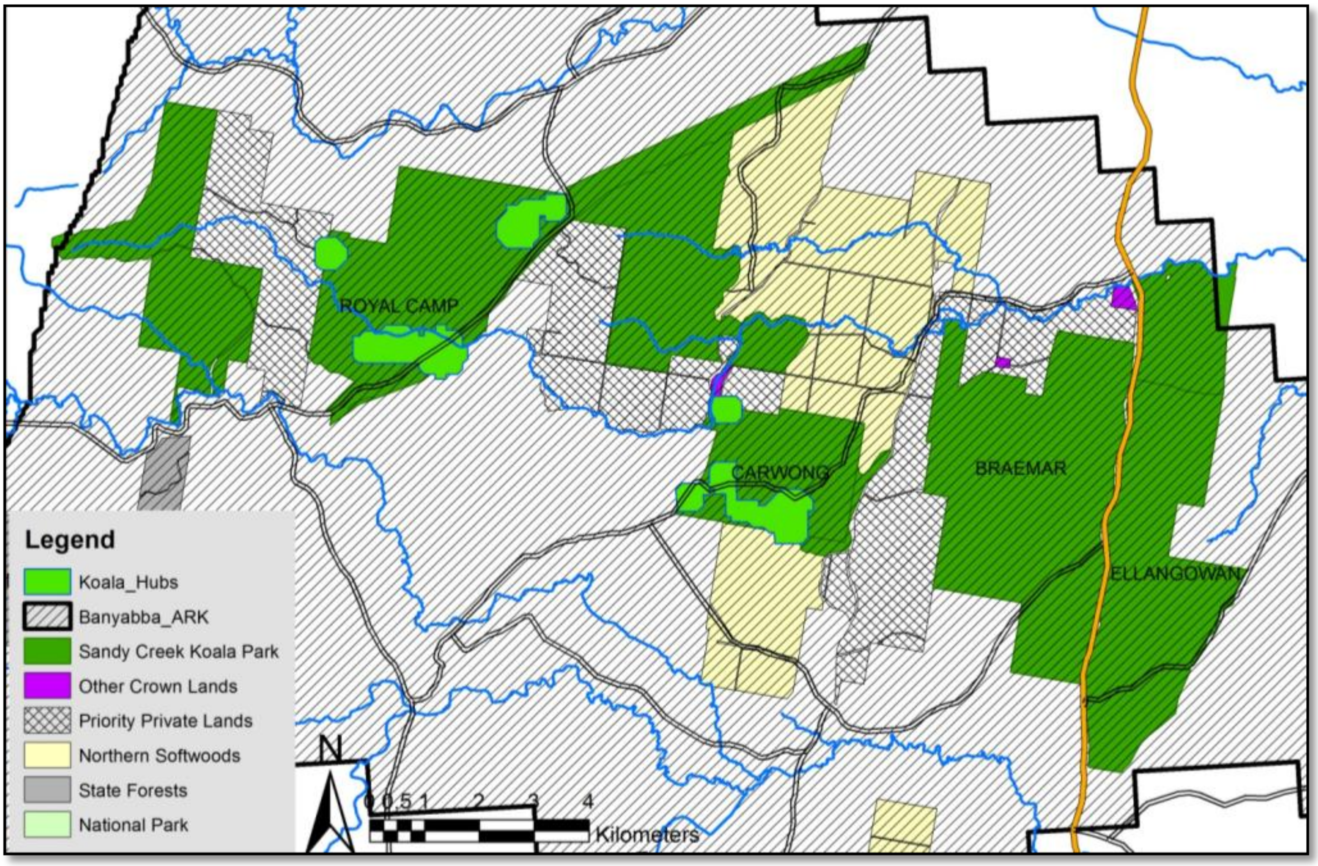
DPI Forestry (Law *et. al.* 2017, 2018) Koala Habitat mapping. Note that this bears little resemblance to the more recent KHSM, with many areas classed as very low habitat value by DPI Forestry reclassed as very high by KHSM. NEFA's scat surveys have found high densities of Koalas, including extensive areas qualifying as Koala High Use Areas, in habitat classed as low and very low by the DPI Forestry model. It is demonstrably wrong. It is no wonder that the expert review by EPA (2016) recommended against using the Law *et. al.* model for forestry regulation. Regrettably the EPA didn't listen to their own experts and now rely upon this shonky model for setting tree retention requirements for Koalas in public-land logging across north-east NSW.

As part of the Koala Strategy process the Office of Environment and Heritage (undated) also analysed Koala records *"to delineate highly significant local scale areas of koala occupancy currently known for protection",* noting:

> *These areas are not designed to be an exhaustive account of all koala presence across NSW, but rather define areas of currently known significant koala occupancy that indicate clusters of resident populations known as Koala Hubs.*

A total of 567 Hubs were identified. Altogether, 101768 hectares, or around 0.13% of NSW is mapped as Koala Hubs.

Of the OEH-mapped Koala Hubs in NSW, 19,755 ha (19%) are on State Forests. Of these highest priority Koala locations, 439 ha occurs in this proposal. Given that these are based on records, there can be no doubt that further surveys within this proposal would have identified more Koala hubs, for example the extensive high use area in compartment 6 of Braemar would also qualify as a Koala Hub, based on our findings and corresponding long-term records dating from 1986, 1998 through to 2016, which show long-term occupancy. Similarly a site in Ellangowan SF where we identified extensive use in 2019 also has a 2005 record.



Map showing Koala Hubs and detail of Banyabba ARKS. There can be no doubt that Koala Hubs are more widespread than documented.

As part of the new whole of Government approach the Koala Hubs have not been publicly released, likely because they have been targeted for logging. For example Pugh (2019) found

> *This review found that of the OEH Koala Hubs on State forests in north-east NSW, 2,546 ha has been logged over the 4 year assessment period 2015-2018, which is an average of 636 ha logged per annum within Koala Hubs. It is assumed that some 430 ha of Koala hubs have so far been logged since they were identified. Many more are proposed for logging in current harvesting plans,*
>
> *Outside exclusion zones and plantations there are 12,253 ha of Koala Hubs identified on State Forests, which means that over the past 4 years 21% of the loggable area of Koala Hubs within native forests on State Forests have been logged. Many of these have been logged well in excess of allowable logging intensities, with significant areas subjected to the unlawful logging practices of heavy and regeneration Single Tree Retention.*

3.1.2. Koala Habitat Assessments

NEFA first started assessing these forests as part of our auditing program in 2012 when logging was underway. These audits were focussed on assessing compliance with the requirements of the Threatened Species Licence. In Royal Camp State Forest it quickly became apparent that we were finding large numbers of Koala scats where the Forestry Corporation weren't finding many.

The Threatened Species Licence required the Forestry Corporation to thoroughly search for Koala scats (faecal pellets) ahead of logging. Where they found a 'trigger tree' with >20 Koala scats beneath it, or scats from a mother and joey or a live Koala, then they had to do 8x100m transects radiating out from the trigger tree. Where 3 trees in a row were found with at least 1 Koala scat beneath them, then a 20m buffer was required to be placed around all the used trees and it was designated a Koala High Use Area from which logging was excluded.

So NEFA's searches were opportunistic and focussed on trying to find trigger trees, after which more thorough surveys were undertaken in surrounding areas. As per requirements, thorough searching was focussed within a metre of tree bases. Once 21 scats were found, or if it was apparent that such numbers were unlikely, searches were not necessarily completed.

NEFA's surveys for Koala scats in Royal Camp State Forest in 2012 and 2013 identified extensive areas qualifying as Koala High Use Areas, which the then Threatened Species Licence required be excluded from logging, these were subsequently verified by the Environment Protection Authority (EPA 2016).

Even after the Forestry Corporation prepared a new Harvesting Plan for Braemar State Forest in August 2019 that removed the requirement to identify and protect Koala HUAs, NEFA persisted with this methodology.

In 2014 NEFA proposed the Sandy Creek National Park to encompass Koala high areas we had identified in Royal Camp State Forest, along with the nearby Carwong State Forest where Forestry Corporation pre-logging surveys in 1998 had also identified extensive Koala habitation. Intensive systematic ground surveys undertaken for the EPA (2016) in 2013 and 2015 confirmed these forests to be of outstanding significance for Koalas.

In response to a proposal to log in (renumbered) compartments 6 and 7 of Braemar State Forest NEFA began undertaking Koala scat searches in July 2019 that progressively revealed extensive Koala habitation, observing one Koala and recording tree species and diameters for 168 trees we found Koala scats under. As part of the assessment of areas to incorporate into the proposed Sandy Creek Koala Park, before the fires NEFA began to sample representative areas of potentially suitable habitat in the balance of Braemar and Ellangowan State Forests, demonstrating widespread Koala usage. There was no doubt that these forests supported a Koala population of regional and national significance.

The areas of significant Koala occupancy identified by NEFA all adjoin the Richmond River floodplain. These lowland forests are dominated by Large-leaved Spotted Gum with significant numbers of the Koala preferred feed trees of Small-fruited Grey Gum, Coastal Grey Box, Forest Red Gum and/or Slaty Red Gum. Koalas have a particular preference for Small-fruited Grey Gum, showing it is a key resource, and prefer areas with 2 or more feed trees (Section 3.1.2.3.). It has also been demonstrated that Koalas prefer larger trees (Section 3.1.3.2.).

On the night of 8 October 2019, and over subsequent days, most of the proposed Sandy Creek Koala Park was burnt in the Busby's Flat fire. Since the fire these counts have continued, with more comprehensive counts of recent scats, the results are presented in 3.2.1. Busby's Flat Fire.

3.1.2.1. Royal Camp and Carwong SFs 2012

In 2012 the North East Forest Alliance (NEFA, Pugh 2012) stopped the Forestry Corporation illegally logging a Koala High Use Area in Royal Camp SF, with 4 other Koala HUAs about to be logged. The EPA found that the Forestry Corporation had not adequately looked for Koala scats and had logged 61 trees and constructed 405m of snig tracks within a Koala High Use Area.

NEFA's Koala scat searches focused on identifying trees that qualified under the Threatened Species Licence (as applied under the previous IFOA) as high use "trigger" trees around which "star searches" comprising 8 radiating 100m transects were required to be undertaken to delineate and protect Koala High Use Areas (HUAs). High use trees comprised those with more than 20 scats, or different sized scats or the presence of a Koala. Where 3 or more trees on a radiating transect were found to have at least 1 scat then they, and the high use tree, were required to have 20m buffers applied around them from which logging had to be excluded.

When the Forestry Corporation resumed logging nearby in compartment 16 a few days later NEFA again caught them out. The EPA confirmed that the unrepentant Forestry Corporation had not adequately looked for Koala scats and had logged 7 trees and constructed 230m of snig tracks within another Koala High Use Area. The Forestry Corporation continued logging and were later found by NEFA to have logged another Koala HUA.

The outcome was for the EPA to issue just 3 Penalty Notices for the first offence, amounting to a total of $900 in fines. The Forestry Corporation treated these as inconsequential, commenting they "*were administrative, and akin to staying too long in a parking lot".*

When the Forestry Corporation proposed to begin logging in compartment 13 of Royal Camp in 2013, claiming no Koalas were present, NEFA (Pugh 2013) found extensive Koala HUAs within the proposed logging area. Based on his inspections of Royal Camp State Forest for NEFA, wildlife expert David Milledge concluded:*"The level of Koala activity revealed by these searches is amongst the highest I have recorded in my experience of over 20 years conducting Koala scat surveys in coastal and escarpment forests in north-eastern NSW. This highlights the significance of Royal Camp State Forest in supporting a dense local Koala population and possibly one of the most important on public land in the region".*

The Environment Protection Authority (24 July 2013) again confirmed NEFA's findings, informing the Forestry Corporation that they found "*areas that indicate koala high use that is ongoing and contemporary",* noting "*Based upon these findings and recent findings made from investigations undertaken in compartments 14, 15 and 16 of Royal Camp State Forest, the EPA considers these areas contain koala habitat and play an important role to Koala populations in the region".* In August the EPA requested that forestry operations cease in Royal Camp SF, with the Forestry Corporation agreeing to a postponement until after October.

The extensive searches undertaken by NEFA in 2012 and 2013 to identify Koala High Use Areas in proposed logging areas in compartments 15, 16 and 13 Royal Camp State Forest revealed one live Koala and recorded tree species and diameters for 178 trees we found Koala scats under.

The then Minister for the Environment requested the EPA to determine the regional significance of the koala population, with the subsequent report by Dr. Steve Phillips (2014) for the EPA finding a resident koala population within Royal Camp that *"should be considered important at all levels of assessment"* due to the koala populations of the encompassing Richmond Valley LGA being found to be *"endangered on the basis of international, national and state-based conservation criteria",* concluding:

> *There is a resident koala population occupying some parts of Compartment 13. In the absence of further survey work the full extent of habitat currently being occupied by the resident populations is not known, nor can the size of the resident population be determined.*
>
> *Within Compartment 13 the tree species of most importance to the resident koalas are Grey Gum E. propinqua, Grey Box E. molucanna, Tallowwood E. microcorys and Forest Red gum E. tereticornis. The removal of any trees of these species that are greater in girth than 350mm diameter at breast height from within the area encapsulated by to 10% activity contour will have a negative impact upon individual koalas comprising the resident population in this instance.*
>
> *Analyses of historical koala records indicates that there has been a significant reduction in the key range parameter Area of Occupancy across the Richmond Valley LGA, the extent of which is of an order of magnitude sufficient to qualify koala populations of the LGA as endangered on the basis of international, national and state-based conservation criteria.*
>
> *On this basis and specifically because of the estimated level of endangerment evident at LGA level, the local koala population inhabiting parts of Compartment 13 in the Royal Camp State forest should be considered important at all levels of assessment.*

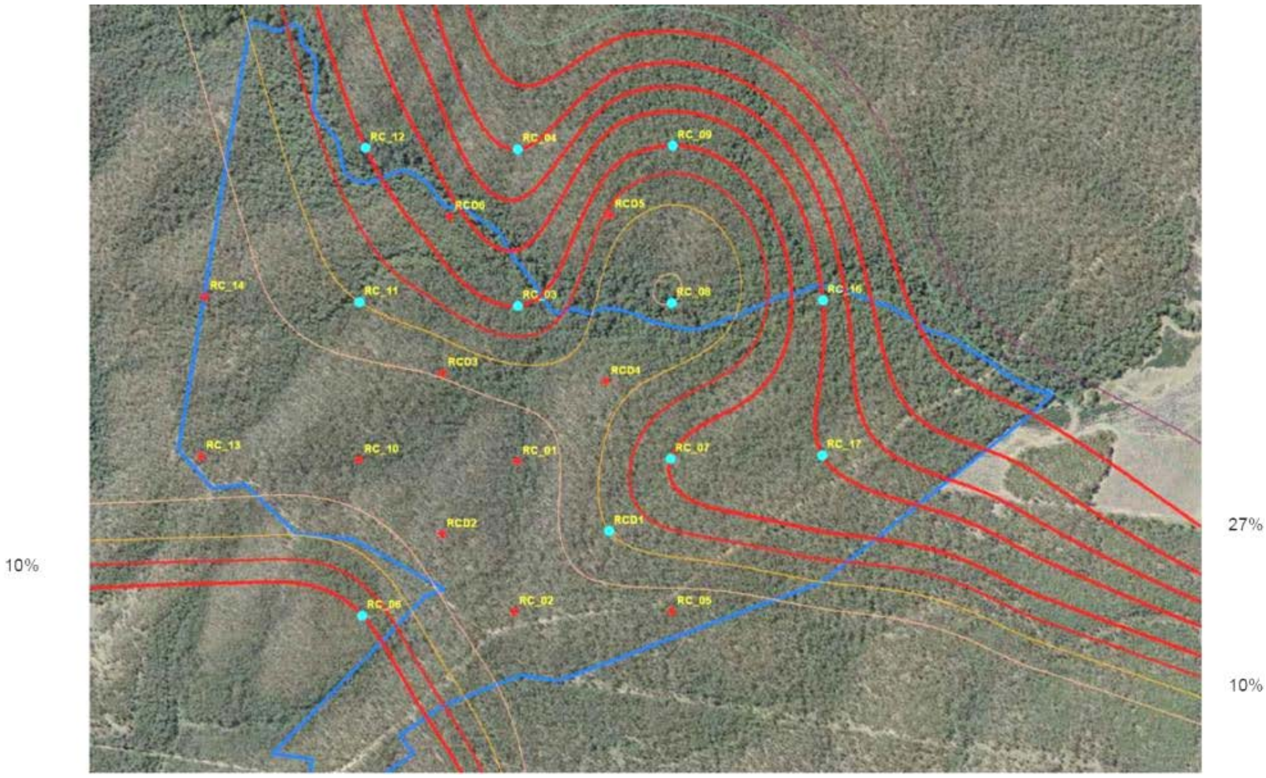


Figure 1 from Phillips 2013. Distribution of koala activity in Compartment 13, Royal Camp State Forest (blue polygon refers). Highlighted field sites indicate those in which koala activity was recorded, while

contour intervals marked in red indicate commencement and thereafter extent of significant koala activity commencing at 10% and thereafter 13, 17, 20, 23 and 27% respectively.

The EPA (M. Gifford, I July 2014) provided Dr. Phillips' report to the Forestry Corporation, noting that:

> *The report supports the EPAs view that koala conditions in the remade Integrated Forestry Operations Approval need to move away from record based triggers to focus on broader landscape management. This includes incorporating improved protection measures and clear exclusion zones around habitat of regional significance.*
>
> *As part of the remake , both of our agencies have committed to moving to koala habitat mapping. ...The outcome ... will be used to inform appropriate conditions including exclusion zones ...*
>
> *The EPA recommends that no forestry activities occur in Royal Camp State Forest until such time as ... Regional refinement of the EPAs koala habitat mapping project is undertaken in the Royal Camp area.*
>
> *The EPA will consider any other information that FCNSW can supply which clearly demonstrates how this important and declining koala population would be adequately protected from future forestry operations in Royal Camp State Forest.*

In August 2014 the Forestry Corporation engaged Jim Shields (2014) to search for Koalas using a sniffer dog, which resulted in the detection of 14 Koalas at a mean density of 0.36/ha in 11 hours of searching over 54ha in compartment 13 of Royal Camp State Forest. This equates to one Koala per 2.8 ha.

There were also numerous Koala records from Carwong State Forest. Pre-logging fauna surveys by the Forestry Corporation in 1998 found Koala scats throughout the forest, with numerous high use trees, including many with both small and large scats indicating the presence of females with young.

Based on Koala records, in November 2014 NEFA first proposed the creation of the 2,100 ha Sandy Creek National Park incorporating both Royal Camp and Carwong State Forests.

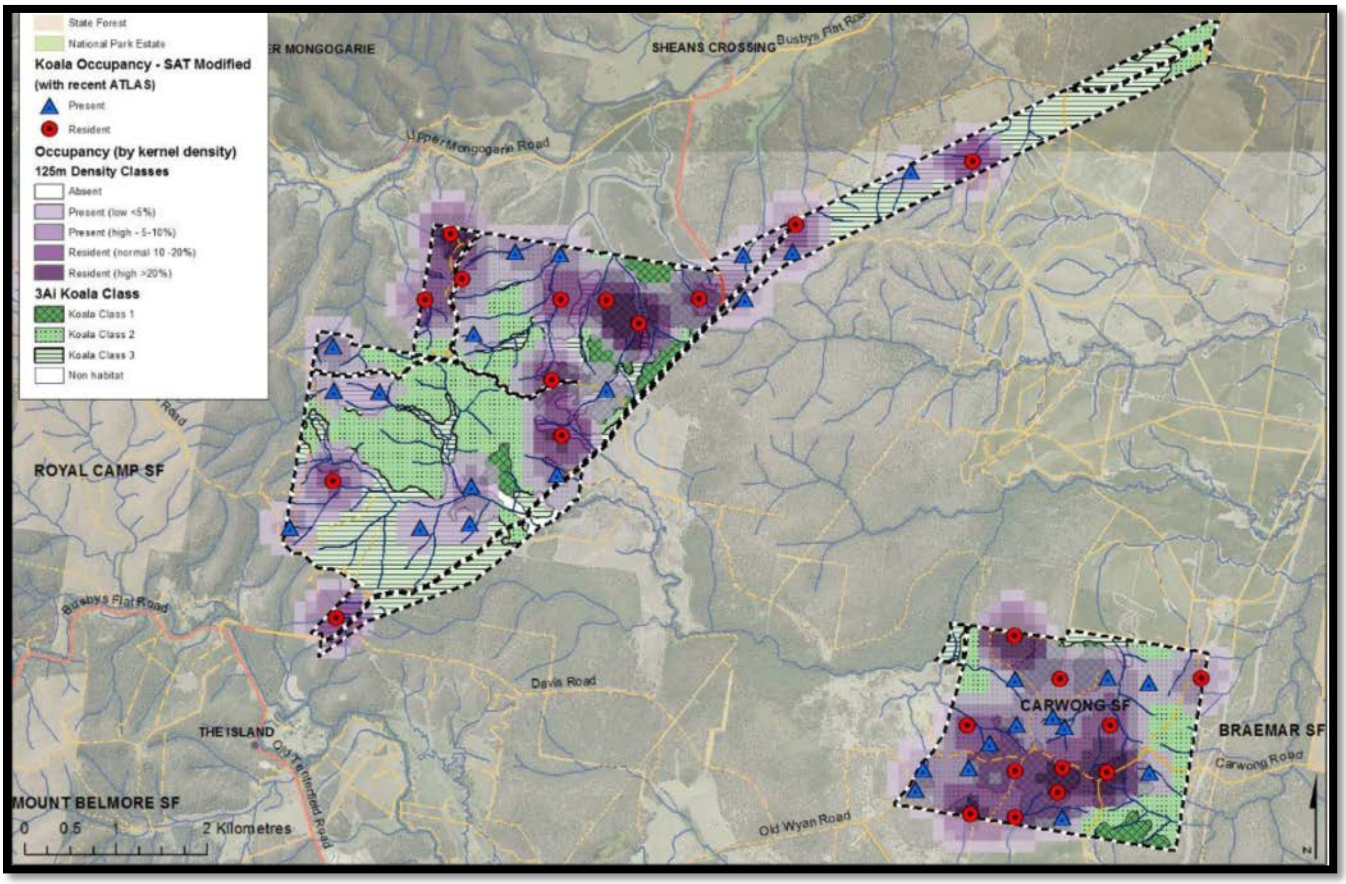
An EPA (2016) study of 4 key areas of State forests known to once have had good Koala populations again verified that Royal Camp and Carwong State Forests have significant populations of resident Koalas:

> *The activity results and Phillips' (2013) report both indicate that Royal Camp and Carwong state forests support extensive areas of koala occupancy and habitat utilisation, and that in compartment 13, at least 50% of the habitat is utilised and conforms to optimal utilisation of secondary habitat by a low density population. The project found that 80% of Carwong and 58% of Royal Camp State Forest is utilised, which supports Phillips' (2013) results. On this basis it can be concluded that habitat in Royal Camp and Carwong is source habitat, where reproduction exceeds mortality on average over time. (p84)*

It is further noted (p86):

> *In relative terms, Carwong appeared to be the least disturbed by logging and fire. Having both wildfire and multiple recent logging events absent for approximately 20 years, appears to correlate with overall highest occupancy compared with other pilot areas that have*

experienced multiple, more recent silviculture treatments. This result aligns with Smith's (2004) findings that koala prefer areas of least disturbance.



EPA (2016) mapping of Koala habitat classes and 'present' and 'resident' Koalas

From their scat searches using a scat-detection dog as part of the EPA project, Owad Environment (2015) found for Royal Camp State Forest "*it appears Koalas also occur at relatively high density in this State Forest. ... These findings tend to support that there is a significant amount of Koala movement and activity across this State Forest*". For Braemar State Forest they note "*it appears that Koalas occur at very high density in this State Forest. ... These findings tend to support that there is a very significant amount of Koala movement and activity across this State Forest*".

It is also important to recognise that these forests are regionally and nationally significant, as a study of Koalas across the Richmond Valley LGA (Phillips and Weatherstone 2015) identified *"two "Important Populations" as defined for purposes of the Federal Government's Environmental Protection and Biodiversity Conservation Act 1999",* as "*key source populations for breeding and/or dispersal*", including "*Habitat to the north of Rappville in the general vicinity of Royal Camp and Carwong State Forests and associated lands".*

3.1.2.2. Braemar State Forest 2019

On [28 July 2019](#) NEFA undertook scat surveys over what were then compartments 23 and 24 of Braemar State Forest that was to be logged under a November 2017 Harvesting Plan (HP) that applied the requirements of the 1999 Threatened Species Licence (TSL). The area had recently been marked up for logging which was due to start in August. The Harvesting Plan identified one Koala High Use Area (HUA) of 0.9ha, 3 Koala records from 1998 and 2 records from 2016. In one afternoon NEFA identified 42 trees with Koala scats, an additional Koala High Use Area (HUA) over 3ha in size and the likely presence of other Koala HUAs.

It was apparent that we had found an extension to the nationally significant Koala population previously identified by NEFA in Royal Camp and Carwong State Forests.

At that time, in accordance with the 1999 Threatened Species Licence, the 2017 Harvesting Plan required thorough searches for Koalas ahead of logging and the protection of all Koala HUAs, as well as the retention of 5 Koala feed trees >30cm diameter per hectare. NEFA assumed that whatever Koala HUA's we identified would have to be protected, therefore we were doing something of direct benefit to Koalas.

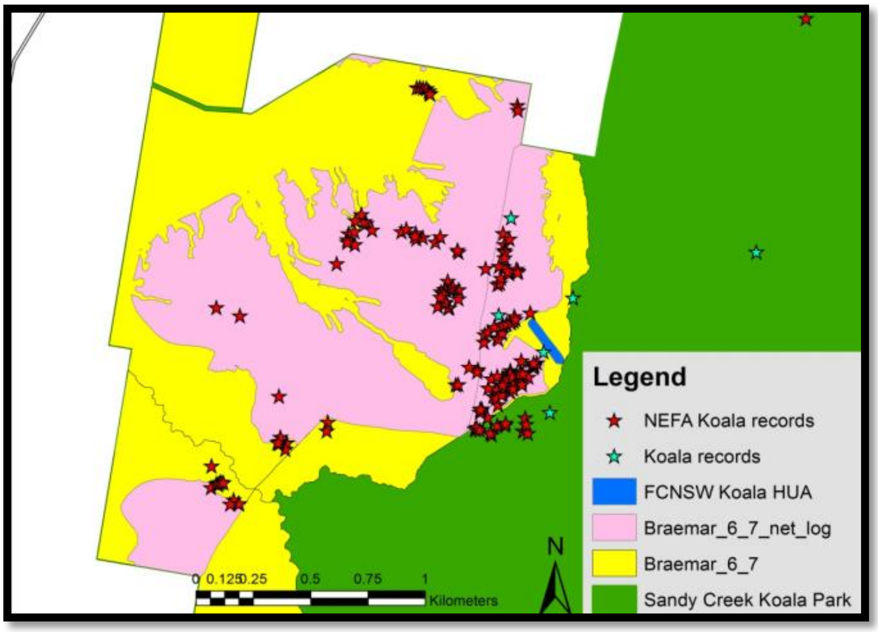
NEFA wrote to Premier Gladys Berejiklian on 30 July 2019 asking her to urgently intervene to ensure that independent surveys were undertaken to identify all important Koala habitat in Braemar State Forest before logging started, and to ensure that a full assessment would be undertaken of Koala habitat on the Richmond River lowlands given their demonstrated importance as Koala habitat.

In response to our letter to the Premier, NEFA was informed that the area would now be logged under the rules of the new 2018 Coastal Integrated Forestry Operations Approval (CIFOA), which no longer require searches for, and protection of, Koala HUAs or any other exclusion areas for Koalas. Sometime after July 2014 the EPA abandoned their stated intent to protect "*clear exclusion zones around habitat of regional significance*" for Koalas. They, with the support of the NSW agency "expert" committee, had at least recommended retention of 15-25 potential koala feed trees over 25cm diameter (dbh) per hectare in modelled medium to high quality habitat, though the Natural Resources Commission (NRC 2016) sided with the Forestry Corporation to over-ride this and impose a retention rate of only 5-10 potential feed trees over 20cm diameter.

A new Harvesting Plan for renumbered compartments 6 and 7 of Braemar State Forest was released on 31 August 2019 (while the compartments had been renumbered the logging area remained the same). Under the new rules only 5 small potential Koala feed trees per hectare need to be retained, and if a Koala is seen in a tree the Forestry Corporation need to wait for it to leave before cutting it down. The previously identified 0.9ha Koala HUA has been incorporated into a protected Wildlife Habitat Clump, though there were no Koala records within the rest of the 5% of the net logging area proposed to be incorporated into Wildlife Habitat Clumps. In a cynical move the Forestry Corporation had gone so far as to actively avoid protecting the Koala HUAs NEFA had identified by then.

Across the 4 assessments of Braemar undertaken by NEFA before the fire, 165 trees with Koala scats beneath them were identified, including 67 high use trees. Only a small part of the 185ha 'Potential Net Harvesting Area' in the renumbered compartments 6 and 7 had been assessed. It was obvious that Koalas were ranging over the whole of the proposed logging area, with even relatively isolated Grey Gums in areas dominated by Spotted Gums with Koala scratches. It is likely that over 100ha (>54%) of the 185ha 'Potential Net Harvesting Area' would have been likely to qualify as Koala High Use Areas under the previous IFOA rules and thus would have required logging to be excluded.

Given that the Forestry Corporation had only identified some 200 ha of Koala HUAs over the past 20 years (NRC 2016), and this was the highest density of Koala scats NEFA had found in our audits since 2009, this area was of outstanding significance.



Proposed logging area, pre-existing Koala records and NEFA Koala scat records for Braemar State Forest compartment 6 and 7 up until October 2019.

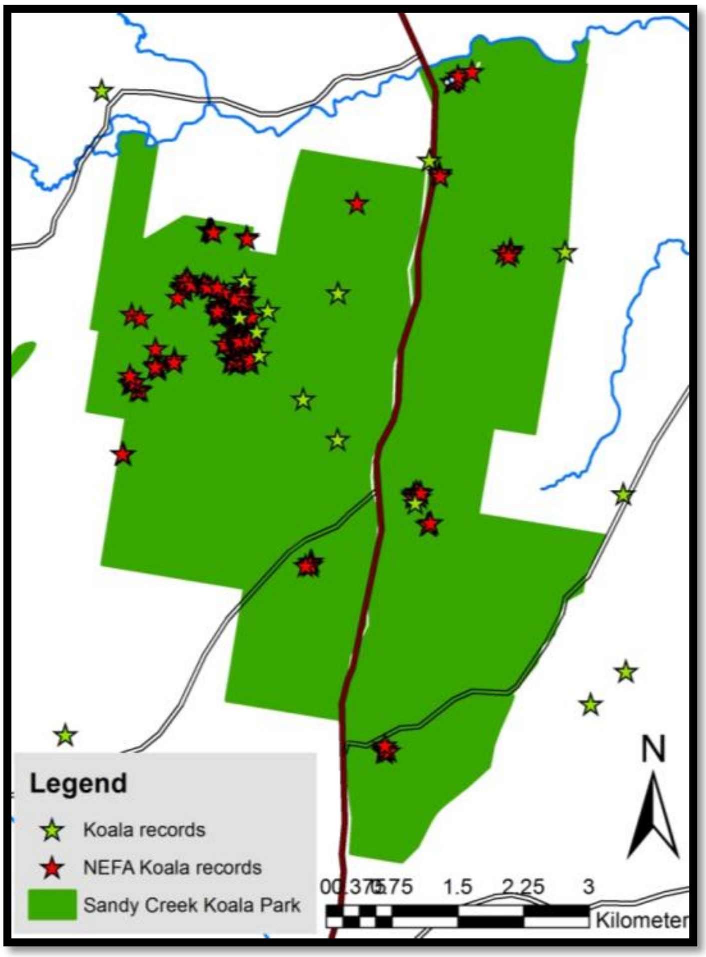
Note that despite requirements for thorough scat searches before logging, logging occurring in 2000 and the area being marked up for logging in 2019, the only records within these compartments before NEFA's surveys were from a call heard in 1998 and 2 trees with scats found in 2016. In addition the Forestry Corporation had identified a 0.9ha Koala High Use Area (without identifying any records within it).

NEFA's records appeared representative of the overall logging area, with scats found in all surveyed areas, and indicated that Koalas were utilising the entire logging area. It was apparent that Koalas occurred at lower densities in areas with smaller and less feed trees, though extensive Koala High Use Areas were likely to encompass most of the logging area. The vastly different results obtained by NEFA compared to the results presented in the Forestry Corporation's Harvesting Plan are another demonstration of the Forestry Corporation's abject failure to comply with their legal obligations to identify and protect Koala High Use Areas over the 20 years leading up to application of the new IFOA rules. Of even greater concern, NEFA’s results highlight the substantial weakening of Koala protection measures applied in logging operations on State Forests under the new IFOA rules, as Koala High Use areas no longer require protection.

For preparation of this proposal, before the fire, NEFA began to assess the extent of Koala usage across the balance of Braemar and the adjacent Ellangowan State Forests from random samples (Appendix 1) to identify boundaries for the proposal. It is apparent that these forests have been extensively degraded by logging, though there are numerous patches remaining with reasonably sized (i.e. 30-90 cm dbh) feed trees (particularly Coastal Grey Box). Patches distributed throughout the forests that had reasonable numbers of mature feed trees were randomly selected while driving along tracks and then searched for Koala scats. Trees considered to be likely preferred feed trees were targeted for searches. Around 10-15 feed trees were searched per patch. All scats were photographed.

Of the 8 patches searched, 7 were found to have 3-8 trees with Koala scats, with 1-3 trees per patch having >20 scats. Reasonably fresh scats were found at all sites. Only 1 patch had no evidence of Koala usage. All Small-fruited Grey Gums in the occupied patches had distinctive Koala scratches, even when scats couldn't be found under these trees. This showed that Koalas were widespread within suitable habitat in Braemar and Ellangowan State Forests.

Unfortunately this assessment was curtailed by the fires, so sampling could not be completed.



NEFA Koala scat records from Braemar and Ellangowan State Forests, with the clusters of records showing pre-logging surveys and the scattered records showing the beginning of NEFA's systematic surveys to determine Koala's distribution. Most potential habitat sampled had Koalas.

The conclusion was that the whole of Braemar and Ellangowan State Forests warranted inclusion with Carwong and Royal Camp State Forests in the proposed Sandy Creek Koala Park.

3.1.2.3. Koala Habitat Preferences

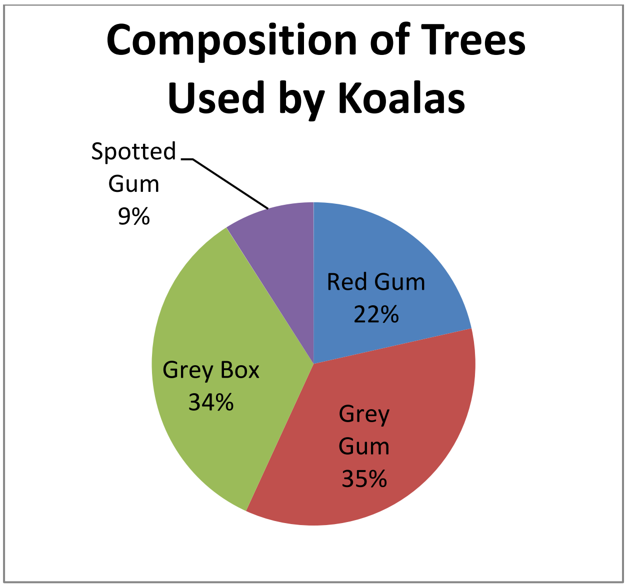
Habitat value for Koalas is primarily determined by the number, diversity and size of preferred feed trees, and the availability of nearby trees for roosting. To maintain Koala populations suitable feed trees and high use areas need to be retained, and to restore populations feed trees need to be allowed to age and high use areas expand.

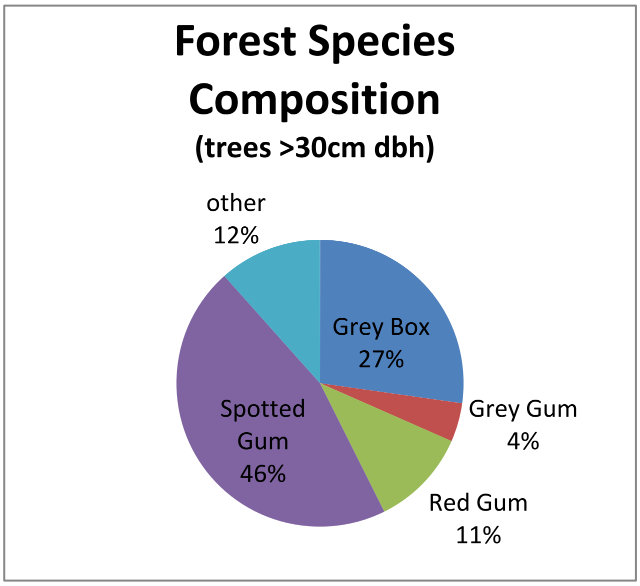
Over all assessments within the proposed Sandy Creek Koala Park NEFA recorded 477 trees (for which we recorded species and diameters) with Koala scats beneath them. These were comprised of 6 species, with a single record each of Ironbark and Tallowwwood (*E. microcorys*). The ironbark was taken to be an anomaly (possibly a roost tree), and while Tallowwood is a known feed tree it is rare in the area. These were excluded from further analysis.

Large-leaved Spotted Gum (*Corymbia henryi)* is used occasionally by Koalas, though its use was primarily associated with the use of nearby feed trees. Most Spotted Gum found to be used before the fire had low numbers of scats, and many of those found since the fire were only used for a short time. Though some Spotted Gum used since the fire have shown regular usage, with 2,022 scats of various sizes found under an exceptional tree 75 days after the fire. Subsequent video footage and sightings indicated the tree was then being used daily by at least one Koala. In a partially burnt area the tree had a dense canopy and a good branch structure for roosting. Use of select Spotted Gum for browse is possible.

An exceptional 2022 Koala scats were found under a Spotted Gum on 23 December, with scats of various sizes and some burnt scats indicating use before the fire. The tree had an intact canopy and a good structure for roosting. Subsequent video footage and observations showed this tree was being used on an almost daily basis, likely primarily as a roost tree. TOP LEFT: before collection, TOP RIGHT: after collection.

There can be no doubt that the primary Koala feed trees within the proposed Sandy Creek Koala Park are Coastal Grey Box (*E. moluccana),* Small-fruited Grey Gum (*E. propinqua*), and the red gums Forest Red Gum (*E. tereticornis)* and Slaty Red Gum (*Eucalyptus glaucina)* (which were generally not differentiated and classed as Red Gums in the assessment). Together these make up 91% of the trees which had Koala scats: Grey Box 34%, Grey Gum 35% and Red Gum 22%.





Species composition of trees utilised by Koalas (LEFT) from 476 of the trees identified with Koala scats by NEFA, compared to composition of trees in the forest (RIGHT) identified by NEFA from structural plots.

Structural plots identified the sizes and species of 1,337 trees over 10cm diameter across 75 plots (see Section 4.2). These were used to identify species availability. When limited to trees over 30cm diameter (Koalas preferred size) these data show that only a small proportion of the available Spotted Gum is used and that Grey Gum is used disproportionate to its availability.

High Use (>20 scats) Koala feed tree marked by the Forestry Corporation in Royal Camp State Forest in August 2012, and photographed in January 2020. While this tree is an exception as most Grey

Gums had shed their bark long before, this illustrates the longevity of some bark on Grey Gums and the ability to use distinctive Koala scratches to identify long-term Koala usage.

Grey Gum appears to be a particularly important feed tree as it is used disproportionally more than what would be expected from its distribution. It is even more important for Koalas than indicated by these results. Grey Gums, and to a lesser extent Red Gums, often shed their remaining leaves soon after the fires, though they were also amongst the first trees to reshoot. Grey Gum are readily marked by Koala claws, with many trees showing distinctive Koala scratches, even where no scats were found. Some bark on the lower trunks of Grey Gum can persist for many years, showing use years before. It appears that Koalas will make occasional use of Grey Gums even when not part of their core habitat. Given the apparent particular importance of Grey Gum, their relatively low numbers and the scratch evidence of widespread usage, all Grey Gums must be retained.

With Grey Box a co-dominant and Red Gum and Grey Gum relatively common it is obvious why these forests comprise high quality habitat for Koalas.

Tree Species	Status	Royal Camp	Carwong
Tallowwood	Feed	50%	20%
Red Gums	Feed	31%	24%
Small-fruited Grey Gum	Feed	20%	32%
Grey Box	Feed	13%	13%
Swamp mahogany	Feed	0%	0%
Melaleuca	Habitat	50%	0%
Other sclerophyllous	Habitat	47%	0%
Wattle sp.	Habitat	0%	13%
Forest Oak	Habitat	0%	11%
Stringybark	Habitat	13%	0%
Spotted Gum	Habitat	7%	7%
Ironbark	Habitat	10%	2%
Bloodwood	Habitat	5%	3%
Mahogany	Habitat	20%	0%

Tree species usage in Royal Camp and Carwong State Forests (EPA 2016), showing categorisation of trees into those considered feed trees and those habitat trees, and the percentage of trees (all sizes) at sites with Koala scats.

NEFA's results mirror the EPA's (2016) findings for Royal Camp and Carwong State Forests:

> *The main feed tree species in Royal Camp State Forest is small-fruited grey gum. To a lesser extent, grey box and forest red gum are also significant. In the major gully line (Sandy Creek), tallowwood was recorded in an active site but is only present at a low frequency.*
>
> *The major outlier in the data are the scats found under 'other sclerophyllous' trees. These records are mainly Lophostemon suaveolens (swamp box) and are associated with overtopping, mature and over mature forest red gum. Spotted gum utilisation in Royal Camp State Forest was widespread, with scats recorded under this species across 16 sites. Scats recorded under spotted gum were always in association with a feed tree.*
>
> *The main feed tree species of note in Carwong State Forest are small-fruited grey gum, red gum (mainly slaty red gum – Eucalyptus glaucina but recorded as forest red gum) and grey*

> *box. The records of tallowwood in the data are unconfirmed and are at low frequency in any case. The diversity of feed tree species is also high, with most active sites containing at least two species of feed tree. The abundance of feed trees at active sites is also high, with about a quarter (8%) of all trees at active sites being feed trees.*
>
> *As with Royal Camp State Forest, of the non-feed trees being utilised at active sites, spotted gum is the most significant, with 30 scats being found across four sites. In all of these four sites, spotted gum is occurring with grey box or small-fruited grey gum.*

The EPA's results confirm that Koalas are primarily reliant upon Forest Red Gum (*Eucalyptus tereticornis*), Slaty Red Gum (*E. glaucina)*, Small-fruited Grey Gum *(E. propinqua)* and Coastal Grey Box *(E. moluccana)* as feed trees in this area. Tallowwood *E. microcorys* and Swamp Mahogany *E. robusta* are rare in the area, though used when available. Koalas also frequently utilise a large variety of other trees for other purposes, likely mostly roosting, though also possibly occasional browse.

What is also apparent from NEFA's observations is that Koalas have distinct preferences for individual trees of the same species, even where they are near each other and appear visually similar. Often scats are found under only one tree in a cohort of a species of similar age, or the age and density of scats indicate preferential and more frequent use of individual trees. This is a significant issue when logging operations arbitrarily select individual trees for retention as they may be removing those preferred by Koalas. It is highly irresponsible for the CIFOA rules not to require assessments of Koala usage when identifying Koala feed trees for retention.

Food tree diversity in an area has been identified as an important influence on Koala presence (Lunney *et. al.* 1992, Lunney et. al. 1999, Smith 2004, EPA 2016). Smith (2004) found "*koala scat abundance peaked in sites with three or more preferred food trees*", and cites analyses that found *"17 tree species in koala scats and an average of more than four tree species per scat"*. In the forests of the proposal Koalas have been found to prefer areas with at least two feed trees. In their review of variables affecting Koala distribution, the EPA (2016) found:

> *Limited areas of higher koala activity corresponded with; a higher abundance and diversity of local koala feed trees, ... Overall koala numbers, however, were most abundant in habitat areas with greater than 15% local koala feed trees in the canopy.*

NEFA's observations support the EPA's findings that Koalas prefer sites with 2 or more feed species, with apparently increased usage of secondary feed trees where they are rarer (i.e. a Coastal Grey Box in a stand of red gums appeared more likely to be utilised and vice-versa). Though NEFA found that Koalas do use isolated feed trees, particularly Grey Gum, so question the observation that they need patches with *15% local koala feed trees in the canopy.*.

3.1.3. Logging Impacts on Koalas

The forests of Carwong, Braemar, Ellangowan and eastern Royal Camp State Forests have been intensively and extensively affected by logging (mostly over 20 years ago) and have very little oldgrowth in their vicinity, yet they support a widespread population of Koalas with patches of exceptional density . On face value this could be interpreted as showing that logging has been benign, though this is not what is apparent from the EPA's (2016) more rigorous assessments and NEFA's observations.

In these forests core areas (i.e. High Use Areas) of Koala habitat comprise stands with a relatively large number of mature feed trees of more than one species. It is apparent that there are extensive areas where the forest has been reduced to small trees, with feed trees too depleted, that are not currently utilised by Koalas.

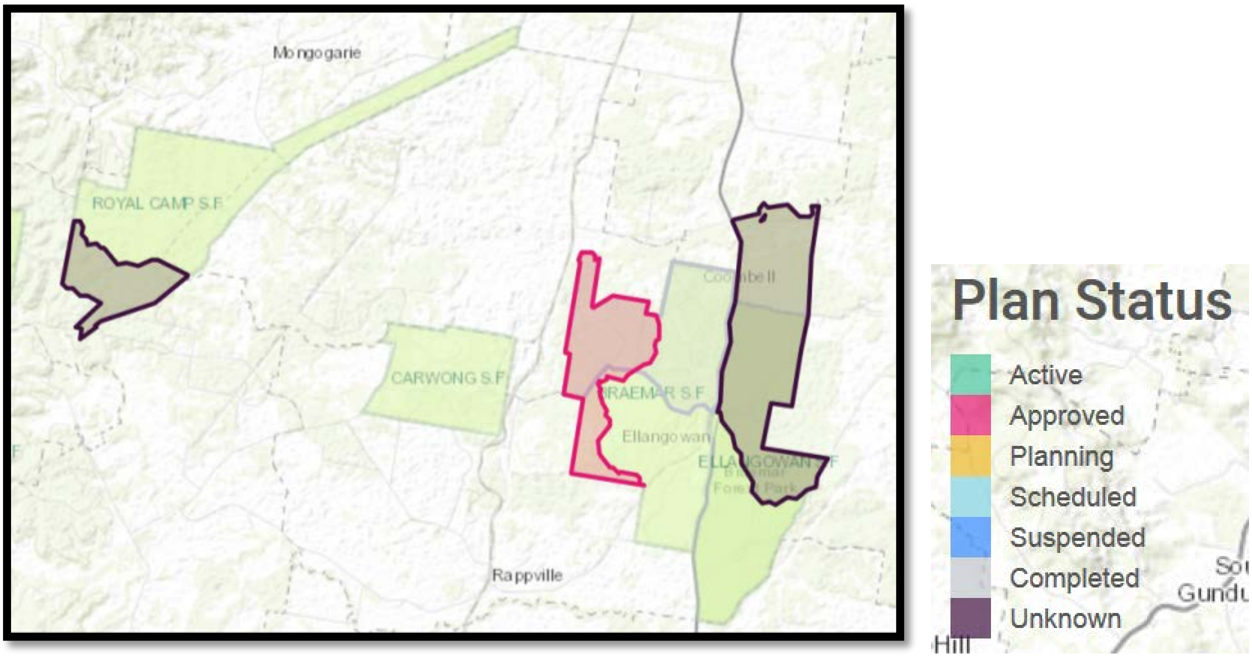
Regrettably there have been no comprehensive surveys in the past that identify a baseline to judge changes due to logging. While the Forestry Corporation have been required since 1997 to undertake thorough searches for Koala scats ahead of logging, it is apparent that they don't (Sections 3.1.2.1, 3.1.2.2.).

These forests have been significantly degraded by past logging reducing the sizes of trees and diminishing the numbers and diversity of Koala feed trees. It is considered likely that the Koala population has been significantly diminished as the forests have been degraded, though is currently increasing in those larger patches where sufficient feed trees were retained in the last logging to now be maturing. It is likely that these patches are source areas essential for maintaining Koalas in more degraded areas where only small patches or individual preferred feed trees remain.

As identified (Section 3.1.3.2) Koalas have a preference for select individuals of the largest trees, particularly over 30cm diameter (dbh). Trees over 45 cm are apparently key Koala feed trees, though also qualify as sought after large High Quality Sawlogs targeted for maximum removal in the next logging operation.

If we want to give these Koalas a future it is essential that we protect their habitat from further degradation and restore it to better enable them to withstand the growing threats as droughts, heatwaves and wildfires increase due to climate heating.

This proposal was initiated due to the threat from logging, in September 2019 logging was due to start in (renumbered) compartments 6 and 7 of Braemar SF imminently, and logging within the next 12 months of compartments 28 of Braemar, 29 and 30 of Ellangowan, and 13 of Royal Camp State Forests.



Forestry Corporation's 12 months Plan of Operations (Accessed 20 September 2019)

Currently the Forestry Corporation only identify Compartments 6 and 7 in Braemar State Forest as proposed for logging, with logging currently scheduled for February 2021.

3.1.3.1. Changing the Logging Rules

In 2018 NSW Government changed the logging rules for public forests with the adoption of the Coastal Integrated Forestry Operations Approval (CIFOA), though a transition period was allowed. On 28 July 2019 NEFA undertook scat surveys over what were then compartments 23 and 24 of Braemar State Forest that was to be logged under a November 2017 Harvesting Plan (HP) that applied the requirements of the 1999 Threatened Species Licence (TSL). The area had recently been marked up for logging which was due to start in August. (see Section 3.1.2.2).

At that time the Harvesting Plan required thorough searches for Koalas ahead of logging and the protection of all Koala High Use Areas, as well as the retention of 5 Koala feed trees >30cm diameter per hectare. In one afternoon NEFA identified 42 trees with Koala scats, an additional Koala High Use Area (HUA) over 3ha in size and the likely presence of other Koala HUAs. We had found an area of outstanding Koala significance that we thought we could deliver real protection for by delineating Koala HUAs. Over 3 subsequent searches we estimated that over 100ha (>54%) of the 185ha 'Potential Net Harvesting Area' qualified as Koala HUAs and under the old rules would have to be protected from logging.

A new Harvesting Plan for renumbered compartments 6 and 7 of Braemar State Forest was released on 31 August 2019 (while the compartments had been renumbered the logging area remained the same). Under the new CIFOA rules Koala HUAs were no longer required to be identified and protected, only 5 small potential Koala feed trees per hectare needed to be retained, and if a Koala was seen in a tree the Forestry Corporation needed to wait for it to leave before cutting it down.

From 1997 until 2018 the logging rules required the Forestry Corporation to thoroughly search for Koala scats ahead of logging and establish 20m exclusion zones around Koala High Use Areas (the buffer was reduced from 50m to 20m in 1998). Where some evidence of Koalas (i.e. scats) was found the compartment was identified as 'intermediate use' and 5 Koala feed trees per hectare were required to be retained (and marked for retention). For some inexplicable political reason no minimum size for retained trees was specified, meaning that trees 1 or 5 cm in diameter could satisfy this requirement. In practice this mean that the Forestry Corporation usually ignored the Koala feed tree retention requirement as, while mature trees are often limited, there are no shortage of saplings. Being unenforceable the EPA also ignored it.

After NEFA caught the Forestry Corporation logging Koala High Use Areas in Royal Camp SF in 2012 . (see Section 3.1.2.1) the EPA found similar instances of the failure to thoroughly search for Koala scats in Wang Waulk and Bulahdelah State Forests. The EPA and Forestry Corporation met in January 2013 to discuss these failings. As part of those discussions the Forestry Corporation (2013b) identified the problem with having no size limit for the retention of trees in "intermediate use" areas and proposed a "short-term" interim change to the TSL which was never implemented:

> *... a preference for mixed species forests with a high proportion of preferred browse trees, and trees between 30-80 cm dbh. Tree size preference has been linked to climbing efficiency, tree vigour/nutritional value or even lack of competition with Greater Gliders in areas with few large, old trees.*
>
> *...*

> *The intermediate-use condition, which FCNSW considers could be the most relevant and practical protection measure, has a flawed definition of 'primary browse trees', with no minimum tree size limit, quality requirements or protection requirements.*
>
> *...*
>
> ***Short-term** – in compartments in which the intermediate use prescription is triggered, FCNSW will apply a higher standard to identification and management of primary browse trees. That is, FCNSW will add to the end of the intermediate use prescription ' primary browse trees should have as many of the following characteristics as possible; >30 cm dbh, mature and have a healthy crown. Retained primary browse trees must be protected from damage to the greatest extent practicable. When locating and marking these trees, the thorough search for evidence of koala scats must include disturbance of the grass and/or leaf-litter layer, where visibility for the detection of koala scats is compromised.*

For no apparent reason the EPA failed to implement this short term measure suggested by the Forestry Corporation, preferring to leave the intentionally vague prescription with no minimum size for tree retention. The 2017 Harvesting Plan for Braemar did specify that retained Koala feed trees should be >30 cm dbh, though this was not legally enforceable.

For the new Coastal Integrated Forestry Operations Approval (CIFOA) the agency experts advising on prescriptions recommended the retention of 25 Koala feed trees over 25cm diameter a breast height (dbh) per hectare in modelled high quality habitat and 15 in medium quality habitat, though because of the Forestry Corporation's claims of timber impacts the Government reduced retention rates down to 10 and 5 trees respectively, and tree size down to 20 cm dbh (NRC 2016). Even where they are applied these small trees will do very little to mitigate impacts.

Despite having removed the requirement to protect Koala High Use Areas, and contravened the advice of the EPA and the Expert Fauna Panel on the numbers and size of feed-trees to retain, the Natural Resources Commission (2016) claimed:

> *The agreed and proposed settings are designed to not erode environment values ... koala protections are key advances in environment protection.*

Going so far as to maintain:

> *The Commission's recommended koala protections are likely to impact the native timber industry across the North Coast. ... An analysis of the impacts of North Coast koala settings on high quality sawlogs indicates around a 9 percent reduction in harvestable volumes of Koala browse tree species is expected (around 3,500 cubic metres per year).*

The NRC (2018) later recommended the opening up of oldgrowth forest protected in 1998 for logging to compensate for this claimed reduction in timber.

It is important to recognise that up until that time, as well as 5 Koala feed trees per hectare, the Forestry Corporation was required to retain all trees under 20 cm dbh in most operations. The new rules only require the temporary retention of 5-10 Koala feed trees >20 cm dbh per hectare, with new small trees able to be selected in subsequent operations.

In its media response to NEFA's July 2019 media about Braemar SF the EPA claimed *"The Coastal IFOA uses new koala habitat maps to predict where koala habitat occurs and requires specific koala feed tree protections regardless of the presence of a koala".*

In 2016 the EPA (2016) undertook a project overseen by an expert panel to review various approaches to map potential Koala habitat, with extensive groundwork to test the mapping. The project found that neither modelling nor ecosystem mapping were accurate enough to identify the "*occurrence of feed trees and therefore habitat class at the level of detail required for management in state forests*", with the panel unanimously agreeing that "*the primary intent and focus should be to identify the location, distribution and extent of areas that are supporting extant/resident koala populations*".

In his review for the EPA's (2016) Pilot Mapping Project, Phillips (2015) stated:

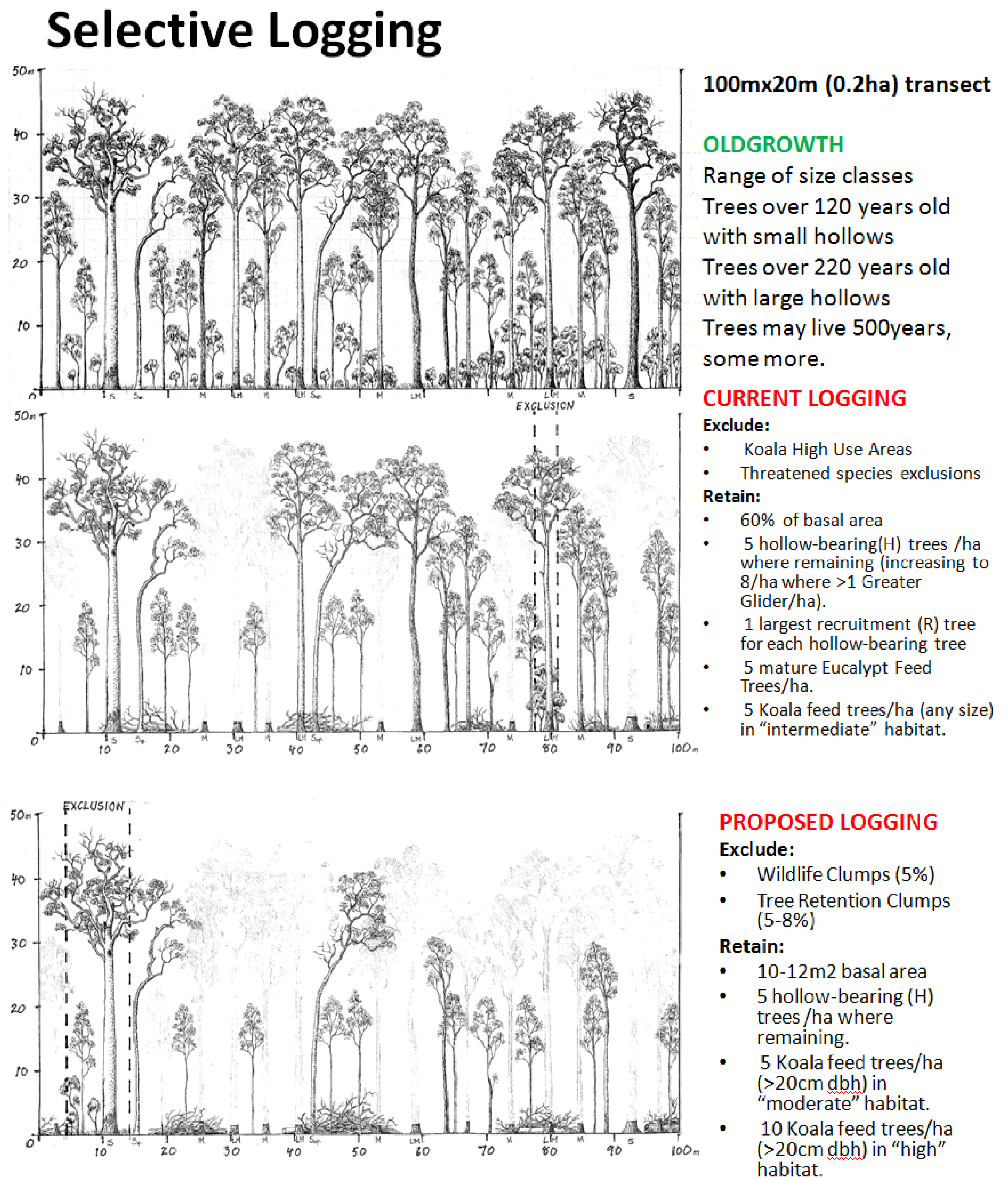
> *... note that the question of what is being protected has also been raised. I would have thought that this was a question that should not have required an answer when surely the most important thing to protect are remaining areas of habitat that are currently supporting resident koala populations. This consideration remains independent of the issue of habitat quality and so should be the primary objective of management.*

Despite being heavily criticised by the expert panel, the EPA adopted a Koala model prepared by DPI Forestry (Law *et. al.* 2017) as the basis for Koala regulation (see Section 3.1.1.). It was always apparent that this model did not identify the core Koala habitat in the proposed Sandy Creek Koala Park, though the EPA was fixated on removing the need for pre-logging Koala surveys, so didn't care despite their surveys showing core Koala habitat in Royal Camp and Carwong SFs was not identified as high quality habitat (see Section 3.1.2.1).

Under the new Koala rules only 10 small (20cm) feed trees per hectare need to be retained in modelled high quality habitat (Prescription 1) and 5 feed trees in compartments with more than 25% modelled medium quality habitat (Prescription 2). Because reliance is placed upon the shoddy modelling by Law et. al. (2017), most of the compartments within the proposed Sandy Creek Koala Park qualify as Prescription 2 areas because >25% are modelled as 'medium' quality`.

One of the most significant changes made by the 2018 CIFOA is the allowance for an increase in logging intensity. Before the CIFOA the most widespread silvicultural practice was Single Tree Selection (STS) under which all trees <20 cm diameter had to be retained and no more than 40% of the basal area could be removed. Since 2007 the Forestry Corporation began to offset basal areas by including adjacent areas not intended for logging and averaging basal areas across both logged and unlogged areas, enabling them to remove up to 85% of the basal area in the logging area. This application of offsetting was a perversion of the STS prescription. NEFA have been complaining about this for years, leading the EPA (2016), on behalf of the Environment Minister, to acknowledge that this *"is not consistent with the definition and intent of STS (Single Tree Selection) in the Integrated Forestry Operations Approval (IFOA) as well as FCNSW's own silvicultural guidelines*."

Despite its illegality the NRC (2016) consider that as the Forestry Corporation had been practicing "Regeneration Single Tree Selection" since 2007 they would adopt this as **Current harvesting practice** to reference proposed changes against. They give the parameters as **"***no upper coupe size limit, coupes range in size from 5 hectares to over 100 hectares, 4 harvest cycles, 7 year average gap, 21 years until all harvested*". This is a big difference from 60% basal area retention and retention of all trees <20cm., which was the current regime that the EPA recommended should be the benchmark.



Differences between logging regimes when applied to a natural oldgrowth forest. Based on a 100m x 20m transect (0.2ha)

Under the new rules 10% of the loggable area in the "regrowth" zone, and 13% of the loggable area in the non-regrowth zone will be required to be set aside in as wildlife or habitat tree clumps. The only limit on selective harvesting in the remaining 87-90% is that in the regrowth zone the minimal basal area required is $10m^2$ ha and in the non-regrowth zone $12m^2$ ha. The EPA (NRC 2016) recommended basal area retention of 12 and $14m^2$ ha respectively though they were over-ridden by the Natural Resource Commission (2016).

In the proposed Sandy Creek Koala Reserve the basal area (for trees >10cm dbh) retention requirement is $10m^2$ ha.

The EPA (2019) also claimed that "*The Coastal IFOA requires FCNSW to consider permanently protecting important koala habitat in new exclusion zones called wildlife habitat clumps and tree retention clumps*".

To compensate for the multiple reductions in tree retention and species-specific prescriptions there is a requirement to permanently protect 5% of the loggable area in Wildlife Habitat Clumps. However these are intended to include areas that are otherwise required to be retained such as unmapped rocky outcrops, cliffs, heath and scrub, wetlands, as well as "carry-over" exclusion areas, and habitat trees. As noted by the EPA "*it is anticipated most wildlife clumps will be made up of 'carry over exclusion zone' – being large exclusion zones previously applied for koalas, squirrel gliders and phascogales or the specified habitat features".* So they were never really intended to protect anything additional.

There are a range of selection criteria, though there are no specified targets, leaving it open to the Forestry Corporation to chose virtually any area they want. These in no way compensate for the previous requirements to survey for and protect occupied habitat for a range of threatened species, including Koala High Use Areas. For compartments 6 and 7 of Braemar State Forest NEFA found that the Forestry Corporation mostly used areas identified as inaccessible for logging (with no recognised wildlife values) or with no identified wildlife values as Wildlife Habitat Clumps. In Myrtle State Forest NEFA found that the principal criteria used for selecting Wildlife Habitat Clumps was minimising timber impacts, with the most severely burnt forests, where most trees had been killed, preferentially selected.

In addition to this, 5% of the logging area is to be set aside in Habitat Tree Retention Clumps encompassing hollow-bearing trees and recruitment trees as determined by the foreman ahead of logging. In a cynical exercise, the 2019 HP for compartments 6 and 7 of Braemar included an unloggable erosion gully as a Habitat Tree Retention Clump and intentionally avoided a Koala High Use Area identified by NEFA. The lack of quantifiable targets, and the subjective nature of their selection provides no assurance these will provide any meaningful protection for Koalas.

In their submission to the new logging rules, the Office of Environment and Heritage (2018) complained that the new Koala feed tree retention rates are less than half the number and of a smaller size than proposed by the Expert Fauna Panel, concluding that the increased logging intensity proposed under the new rules is expected to impact Koalas through diminished feed and shelter tree resources:

> *Koalas are selective both in their choice of food tree species and in their choice of individual trees. The scientific basis for proposed tree retention rates in the Draft Coastal IFOA is not clear, and the rates are less than half those originally proposed by the Expert Fauna Panel.*
>
> *While Koalas will use small trees, research has shown that they selectively prefer larger trees. In our experience, the proposed minimum tree retention size of 20cm dbh will be inadequate to support koala populations and should be increased to a minimum of 30cm dbh. Many Koala food trees are also desired timber species, so there is a high likelihood that larger trees will be favoured for harvesting, leaving small retained trees subject to the elevated mortality rates experienced in exposed, intensively-logged coupes.*

> *Koalas require large areas of connected habitat for long-term viability. The increased logging intensity proposed under the draft Coastal IFOA is expected to impact Koalas through diminished feed and shelter tree resources. Animals will need to spend more time traversing the ground as they move between suitable trees that remain, which is likely to increase koala mortality.*

Many studies have identified the Koala's preference for larger trees (Hindell and Lee 1987, Lunney *et. al.* 1991, Sullivan *et. al.* 2002, Moore *et. al.* 2004b, Smith 2004, Moore and Foley 2005, Matthews *et. al.* 2007, EPA 2016). Tree size has been found to be the most significant variable after tree species in a number of studies, though this seems to be often ignored or downplayed for resource and political reasons.

The NSW Recovery Plan for the Koala (DECCW 2008) identifies that Koalas have been found to have a preference for larger mature trees of specific species, stating:

> *Smith and Andrews (1997) found that koala activity was greater in structurally diverse forest with the majority of trees 50–80 cm diameter at breast height (dbh). White (1999) found that koalas preferentially utilise trees between 25.5–80 cm dbh, with under-utilisation of trees less than 25.5 cm dbh. Lunney et al. (2000a) found that the koalas in the Coffs Harbour area favoured trees of 50–60 cm dbh and greater than 120 cm dbh".*

A 2004 study by Dr. Andrew Smith (Smith 2004) of Pine Creek State Forest found that:

> *Koalas preferred structurally complex, uneven-aged forests with some mature and oldgrowth elements, a large basal area, and mixed species associations dominated by tallowwood, grey gum and forest oak. Koalas were least abundant in plantations and structurally uniform, blackbutt dominated regrowth native forests with a low tree species diversity. Trees of 40-80 cm dbh and stands with more than three koala food tree species per survey plot (50 by 50 m) were preferred. Historical timber harvesting practices involving low intensity harvesting of large diameter stems were successful in maintaining koala populations. Modern, high intensity harvesting practices including extensive gap clearfelling and Australian group selection that remove a high proportion of stand basal area and leave only small diameter stems (<50 cm dbh) are incompatible with koala conservation.*

A Biolink (2013) study for Port Macquarie-Hastings Council found that State Forests had less than half the number of active Koala sites than nearby National Parks and concluded that logging had decimated the once substantive local Koala populations, commenting:

> *... koala activity was recorded less commonly from areas of State Forest where field data and other knowledge strongly points to cumulative impacts of logging over time resulting in significantly lower size classes of preferred food tree species which in turn results in a lower koala carrying capacity.*
>
> *...*
>
> *It is significant that koala activity was least commonly recorded from State Forests generally; these being areas wherein both the historical record and local knowledge can attest to the presence of once substantive local populations. However, data arising from this survey supports an assertion that the long-term logging of tree species preferred by koalas is having an effect on koala carrying capacity in these forests, ...*

The Forestry Corporation choose to ignore this research. The forestry industry, and their parliamentary representatives, have been touting DPI-Forestry research that they claim proves that logging has no impact on Koalas, when it clearly doesn't. DPI-Forestry (Law *et. al.* 2018) undertook a survey using acoustic recorders to record male Koala calls for a week during the breeding season at 171 sites in modelled medium-high quality Koala habitat throughout northern NSW, recording one or more calls at 106 sites, concluding:

> *... probability of occupancy was influenced by elevation (-ve), cover of important browse trees (+ve), landscape NDVI (+ve) and extent of recent wildfire (-ve, but minor effect). Elevation was the most influential variable, though the relationship was non-linear and low occupancy was most common at tableland elevations (〉 1000 m). Neither occupancy nor bellow rate were influenced by timber harvesting intensity, time since harvesting or local landscape extent of harvesting or old growth. Extrapolation of occupancy across modelled habitat indicates that the hinterland forests of north-east NSW support a widespread, though likely low density koala population that is considerably larger than previously estimated*

Though Law *et. al.* qualify their results in the discussion:

> *Resilience of koalas to recent, heavy harvesting is most likely explained by the landscape mosaic of forest types and disturbance history in north-east NSW; especially the level of harvest exclusion in the landscape. Over the last 20 years exclusions averaged ~ 40% of the State forest area in the region [7]. In our study, about 50% of the 1 km area surrounding our recent, heavy harvest sites received this treatment in the last 10 years. The remainder comprised temporary off-set zones, but also permanent riparian buffers, old growth and rainforest exclusion areas and habitat protection for owls. In addition, large trees (40–80 cm dbh) provide important shelter and browse for koalas [31, 32]. Within the harvest area, scattered habitat trees, recruit/seed trees and feed trees for other species assist in providing a scattered uneven age structure, even where harvesting is heavy [7].*

It is interesting that Law et. al. found "*Koala high-use areas supported nearly three times the bellow rate (3.1 bellows night^{-1}) as other treatments",* though they downplay this by stating "*Koala high-use exclusion areas represent one method of retaining patches (mean size = 4 ha) of large browse trees where an accumulation of koala scats had been identified prior to harvest, but we found occupancy was no greater in these areas than other treatments, and although bellow rate was greater, the difference was not significant.*"

The first problem with Law *et. al.*'s methodology is that they are hearing Koalas within at least 300m (28ha) around the recorder (and could be up to 2km) which means the Koala could be anywhere within the sampled area. Yet their site habitat variables (including logging) are only measured within 50m (0.8ha) of the recorder, in an area the Koala may not be using. The use of co-variates such as % of harvesting (<10 years), heavy harvesting (<10 years), and oldgrowth within a kilometer of sites does not compensate for this as they do not necessarily reflect the abundance, diversity and size of available feed trees (i.e. an oldgrowth patch may be on a steep slope or in an area of poor site quality with few Koala resources) or the Koala's use of such areas. Deriving conclusions about habitat usage and logging impacts from such data cannot be justified.

The second problem is that they are only recording the presence of a male Koala, with no indication of whether it is a lone individual wandering in search of a mate or an indicator of a nearby colony. This merely represents presence/absence data with no indication of Koala habitation or densities.

The only ground-truthing reported by Law *et. al.* (2017) for Koala occupancy in the DPI-Forestry study were searches of 40 trees at each of 65 sites for Koala scats, with no scats found at 54 sites and just 1-2 scats found at 11 sites. When compared to NEFA's results for the proposed Sandy

Creek Koala Park, this represents a very poor result and indicates very low usage of the sites that did contain scats.

Koalas were recorded calling one or more times at 19 of the 65 ground-truthed sites, with no scats found at 16 sites and only single scats found at 3 sites. This suggests either very low usage of the sites by Koalas or that the calling Koalas were outside the sampled area.

It is noteworthy that at their Royal Camp State Forest site Law *et. al* (2017) only found one Koala scat and recorded no Koalas calling, and at their Braemar State Forest site they only found one Koala scat, though recorded 62 Koala calls, the highest number of any documented sites. This indicates substantial flaws in the methodology.

The DPI-Forestry data do show that Koalas are present in the vicinity of 62% of sites in modelled medium and high quality habitat, though no valid conclusions can be made from these data about the density of Koalas or the effects of logging upon them. It is considered that these data have been misrepresented.

The worst outcome from this 'research' is that acoustic recorders are now adopted as the standard method for monitoring Koalas on State Forests, meaning that precipitous population crashes will not be identified until it is too late to recover populations.

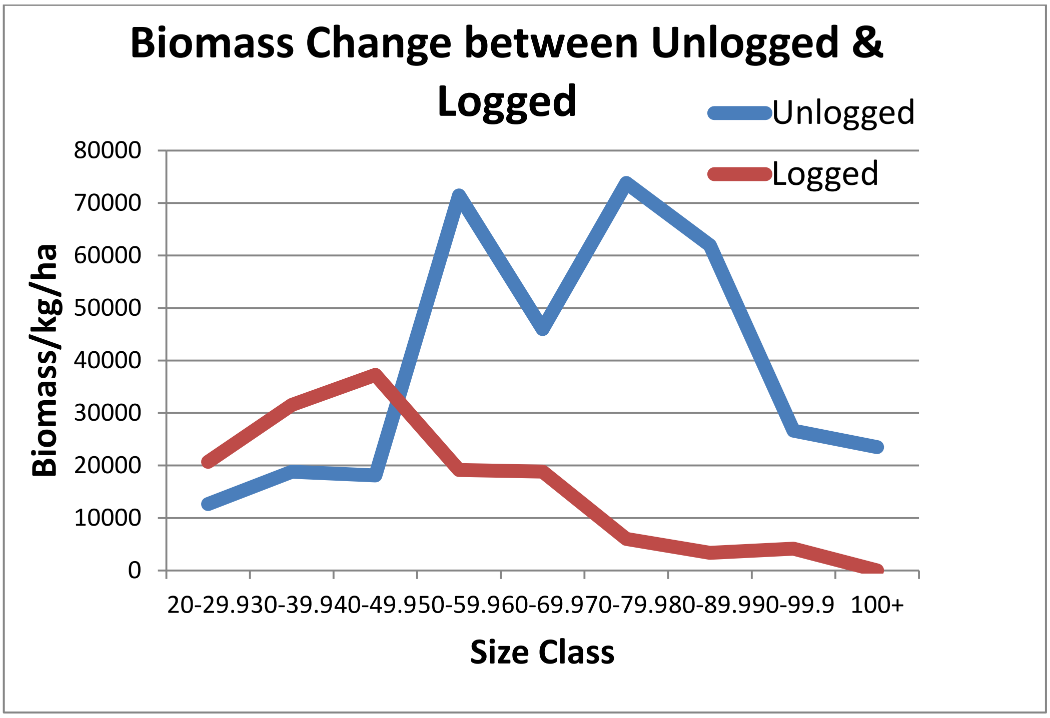
3.1.3.2. Logging impacts on the Sandy Creek Koalas

It is evident that while Koalas are widespread there are key trees and patches of forests that are core to maintaining viable populations, such as the extensive Koala High Use Area identified by NEFA in compartment 6 of Braemar State Forest. Any further removal of the feed and roost trees that Koalas rely upon is likely to diminish existing populations, whereas allowing feed trees to mature will increase food resources and thus Koala numbers and population viability over time.

The new Coastal IFOA logging rules significantly increases impacts on Koalas in these forests by removing the need to protect Koala High Use Areas (even though this was rarely voluntarily implemented), reducing the size of Koala feed trees that need to be retained from >30cm down to >20cm dbh, removing the need to retain mature recruitment trees for the declining numbers of hollow-bearing trees, removing the requirement to retain 3-5 mature eucalypt feed trees per hectare (except near recent records of Swift Parrot and Regent Honeyeater), removing the need to create exclusion areas around records of a variety of threatened species (most notably in these forests 8ha around Squirrel Glider records and 20ha around Brush-tailed Phascogale records), and reducing buffers on headwater streams from 10m to 5m.

It is important to recognise that a century of logging has already had a significant impact on Koalas within the proposed Sandy Creek Koala Park. There is no baseline data to assess these impacts against. Given Koala's reliance upon eucalypt leaves for browse it is possible to infer impacts based on the reduction in potential food, assuming that this is the principle factor limiting Koala numbers.

Logging has reduced the live above ground biomass of these forests by 59% (Section 4.2), with a similar decline in canopy volumes and thus the availability of resources for Koalas. This increases to a loss of 65% of biomass for trees above 30 cm dbh and to 84% of biomass for trees above 50 cm dbh. Given the distinct preferences of Koalas for larger trees the impacts of canopy loss on Koalas is likely to be greater than just the volume of browse lost. Given that Grey Gum appears to be one of the species most significantly affected by the loss of mature trees, and Koala's apparent preference for it, then this too can be expected to have magnified impacts.



Reductions in above ground biomass (an indicator of canopy volume) for logged forests within the proposed Sandy Creek Koala Park compared to unlogged reference sites.

As well as the loss of preferred feed and roost trees, and direct impacts on individual Koalas, there are significant impacts from logging practices on Koalas consequent from the conversion of multi-aged forest to young regrowth, which:

- increases the time spent by Koalas on the ground moving between feed trees and thus their vulnerability to predation.
- increases transpiration of the forest while decreasing rooting depth (and thus access to deeper watertables) drying the forest and increasing water stress for Koalas during droughts and heatwaves.
- changes forest structure by reducing tree height and increasing tree density, while promoting dense weedy understories (i.e. lantana), thereby increasing fire intensities and the risk of crown fires affecting Koalas.
- removes tall broad crowned trees, with shaded understories, that function as fire refuges.

Based on the decline in potential browse, it is reasonable to assume that Koala populations within the proposed Sandy Creek Koala Park have already been reduced by more than 60% due to logging alone.

For Royal Camp and Carwong State Forests the EPA (2016) found a strong positive relationship between the size class of feed trees and usage by koalas, noting "*Analysis of size class data for Carwong, Royal Camp and Clouds Creek indicate that koalas preference for utilisation of feed trees by koalas is towards larger trees (higher diameter at breast height >30 centimetres)*".

The EPA found that Koala usage of Small-fruited Grey Gum increased from 1 in 6 trees <20cm diameter to 1 in 4.5 trees 20-55 cm diameter, to 1 in 2 trees >55 cm diameter, and that Koala usage of Grey Box increased from 1 in 13.5 trees <20 cm diameter, to 1 in 7.5 20-50 cm diameter and 1 in 5 >50cm diameter.

Dbh class	Scat	No scat	Total	Strike rate
150 (100–199 mm)	8	40	48	16.7%
225 (200–249 mm)	6	20	26	23.1%
300 (250–349 mm)	6	35	41	14.6%
400 (350–449 mm)	5	11	16	31.3%
500 (450–549 mm)	5	12	17	29.4%
700 (550–1049 mm)	9	9	18	50.0%
Total	39	127	166	23.5%

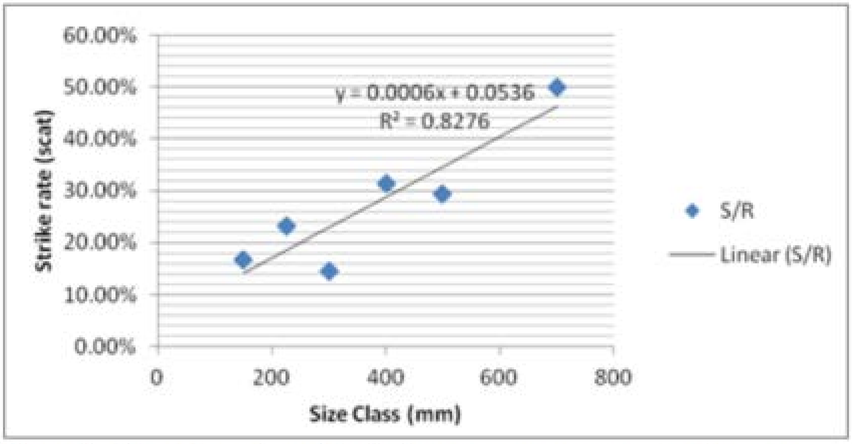


Figure 4: Size class of small-fruited grey gum versus scat strike rate

EPA (2016) observed data for pooled size classes (diameter at breast height) of Small-fruited Grey Gum (*E. propinqua*) with and without scats.

DBH class	Scat	No scat	Total	Strike rate
150 (100–199 mm)	5	62	67	7.46%
250 (200–299 mm)	9	65	74	12.16%
350 (300–399 mm)	8	52	60	13.33%
450 (400–499 mm)	6	35	41	14.63%
775 (500–1049 mm)	6	23	29	20.69%
Total	34	237	271	

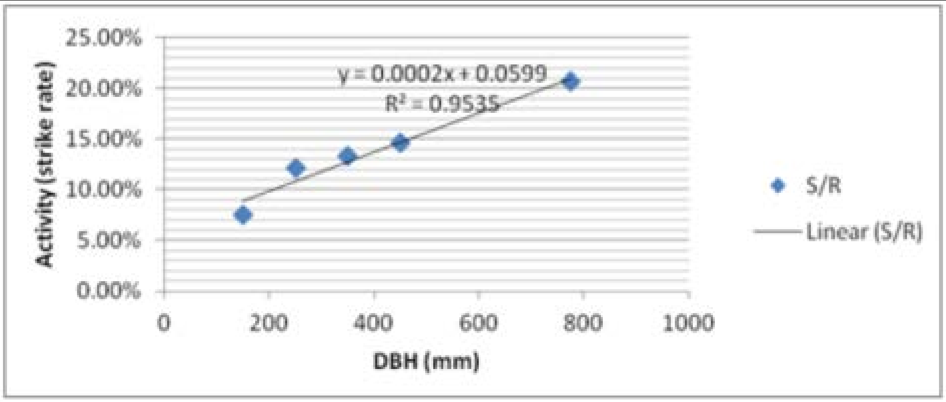


Figure 5: Size class of grey box versus scat strike rate

EPA (2016) Observed data for pooled size classes (diameter at breast height) of Grey Box (*E. moluccana*) with and without scats

For Carwong State Forest, the EPA (2016) found that Coastal Grey Box had a relatively low strike rate, although it comprised 27 (50%) of the 54 feed trees identified with scats beneath, with 8 (15%) red gums and 18 (33%) Small-fruited Grey Gum.

With the EPA finding use of up to 50% of larger Grey Gums and just 21% of larger Grey Box, this shows Koalas selective use of feed trees. While this data just reflect usage at one point in time, with additional trees likely to be used over time, they reflect NEFA's observations that Koalas preferentially select certain trees, even between similar sized individuals of the same species, for browse.

The EPA (2016) also found Koalas had a clear preference for areas with >50% mature and over mature trees in the vicinity, noting "*Seventy-four per cent (74%) of all activity resides in the high class of structural maturity*" (p.62). This demonstrates the Koala's preference for forests with numbers of larger trees.

Table 30: Koala activity by structure

Row labels	Mature and over mature (>50% of polygon)	Mixed (50:50)	Regeneration (>50% of polygon)	Unassigned	Total
High activity	9	1		1	11
Normal activity	17	5	4	1	27
Low activity	17	2	1		20
Total	43	8	5	2	58
As a percentage	74%	14%	9%		

EPA (2016) Koala activity by structure.

The EPA note (p85):

> *The structural component of a forest comprises trees of different size classes, and both size and structural diversity of forests correlates with higher koala occupancy (Lunney et al. 1996; Phillips' 2013; Smith 2004). This study found koala activity correlated with larger tree size classes and mapped mature forest components of the pilot areas. Smith (2004) found forest structure to be a key predictor of koala scat density after food tree species diversity and abundance, where scat abundance was greatest under trees with a diameter at breast height (dbh) of 40–80 centimetres. Phillips' (2013) reports similar preferencing for trees >30 centimetres in low fertility areas.*

The EPA (2016) "*found that 80% of Carwong and 58% of Royal Camp State Forest is utilised",* which is illustrated by the EPA's (2016) mapping of occupational density, along with 'present' and 'resident' Koalas (see Section 3.1.2.1). This is hardly surprising given that we found that Royal Camp had a significantly smaller basal area than Carwong, which in part reflects the 2012 logging of large areas before NEFA stopped logging. From their studies in Royal Camp and Carwong State Forests, along with 2 other State Forests, the EPA (2016) concluded:

> *While resident populations of koala were found in all pilot areas, habitat utilisation was variable across the landscape. Areas of higher activity positively correlated with greater abundance and diversity of local koala feed trees, trees and forest structure of a more mature size class, and areas of least disturbance.*

EPA (2016) state:

> *In relative terms, Carwong appeared to be the least disturbed by logging and fire. Having both wildfire and multiple recent logging events absent for approximately 20 years, appears to correlate with overall highest occupancy compared with other pilot areas that have experienced multiple, more recent silviculture treatments. This result aligns with Smith's (2004) findings that koala prefer areas of least disturbance.*

NEFA considers that the patchy distribution of Koalas primarily reflects the distribution and diversity of large feed trees, though is likely influenced by the availability of water (both in the soil and/or as standing water) during dry periods, fires, logging, predation, home range requirements and other factors.

Before the fires NEFA undertook a variety of searches for Koala scats in Braemar State Forest. The leaf litter and grass was fairly dense making it difficult to find scats in places, searches were mostly limited to near the bases of potential feed trees, and searches were not systematic. As not all trees utilised by Koalas were likely to have been identified, our findings of tree usage are conservative.

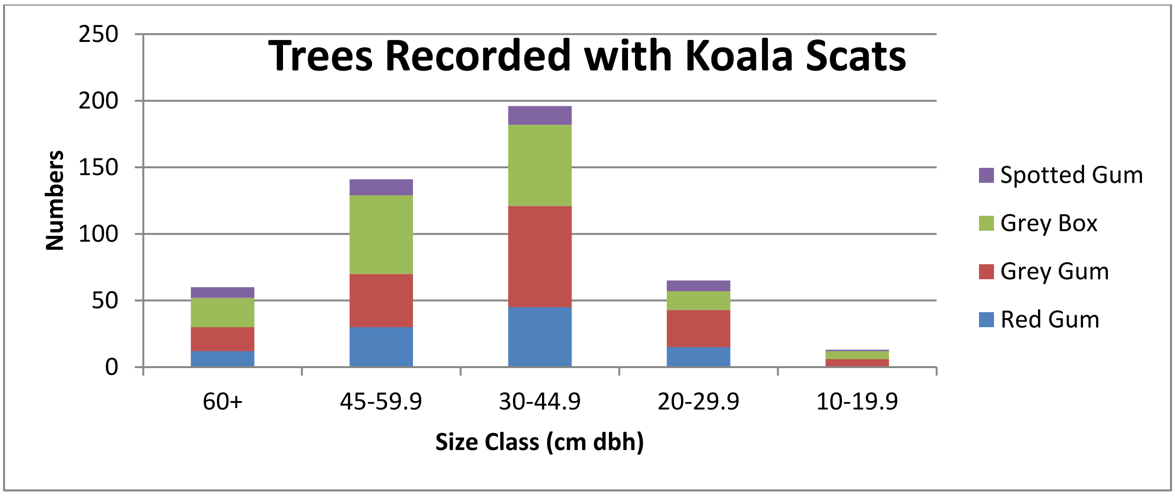
Four sites totalling 8 ha of Koala High Use Areas were considered to have been relatively well surveyed before the fires, these areas contained 104 trees beneath which Koala scats were found, this is a density of at least 13 feed trees per hectare being utilised. Those trees without scats were not counted, though scats were not found under many potential feed trees. Seventy percent of those used were over 30 cm dbh and only 3 were under 20 cm dbh. It is emphasised that these are only the trees under which scats were found and do not show the full number of trees used within the areas, particularly over time, though they provide an indication of the minimum numbers of feed trees needed to support a core population..

From NEFAs results, aside from species, the most obvious influence on tree usage by Koalas is tree size. Of the 475 trees found to be used by Koalas (where species and diameters were recorded) across all our surveys within the proposed Sandy Creek Koala Park, 85% were 30cm diameter (dbh) or larger. Despite being most abundant, trees under 20 cm dbh comprised only 2.7% of trees used. Overall tree usage increased with tree size relative to tree availability.

	Diameter Class (dbh) cm					
Species	60+	45-59.9	30-44.9	20-29.9	10-19.9	TOTALS
Red Gum	12	30	45	15	0	102
Grey Gum	18	40	76	28	6	168
Grey Box	22	59	61	14	6	162
Spotted Gum	8	12	14	8	1	43
TOTALS	**60**	**141**	**196**	**65**	**13**	**475**

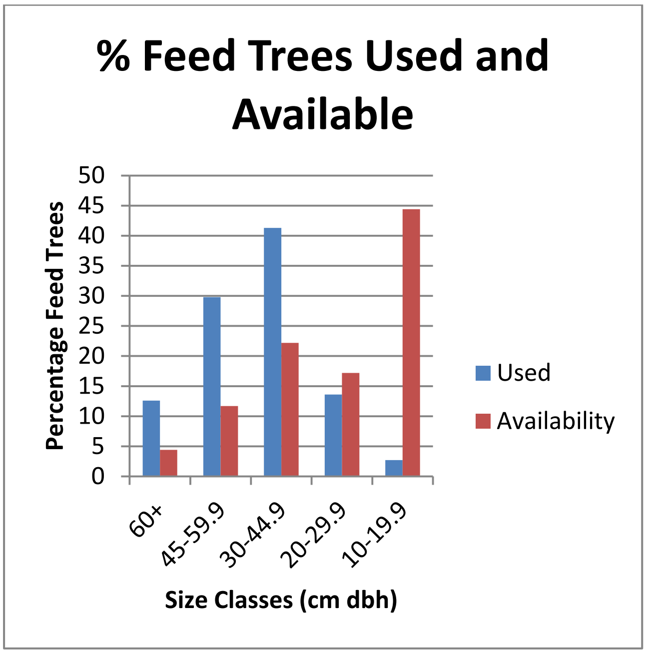
Size classes of tree species found with Koala scats across all NEFA's searches in the proposed Sandy Creek Koala Park.

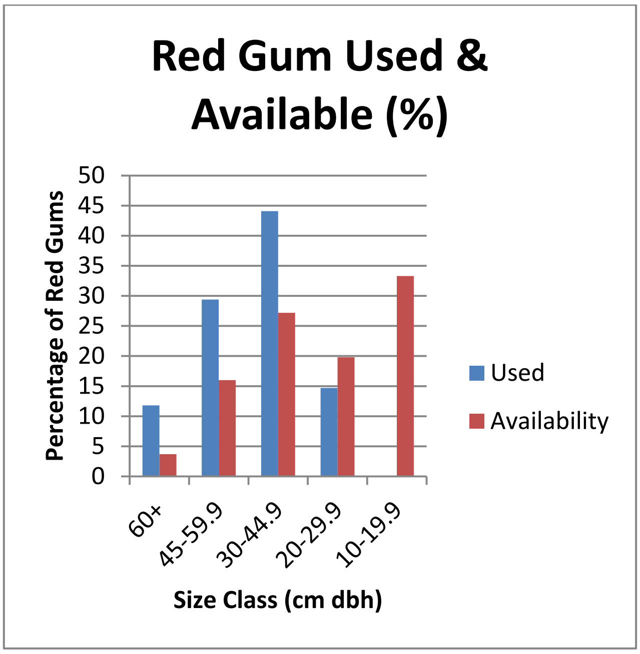
The size classes were chosen to reflect logging intent. In general trees over 45 cm dbh comprise Large High Quality Logs and those over 30cm dbh Small High quality sawlogs. The 2017 Harvesting Plan for Compartments 6 and 7 of Braemar State Forest required the retention of 5 Koala feed trees >30cm dbh per hectare, as well as the protection of all Koala HUAs. Under the new CIFOA The new Harvesting Plan released on 31 August 2019 only requires the retention of 5 potential Koala feed trees per hectare over 20 cm dbh. This lower threshold was set so as to minimise timber impacts. Numerous experts have supported a minimum size of 30cm dbh.



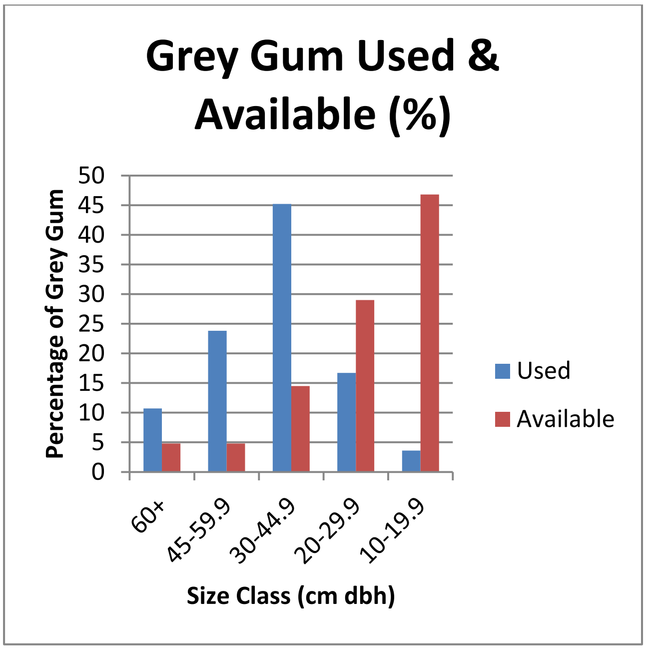
Size classes and species of trees found to be utilised by Koalas. Note that their use of trees is relative to their availability.

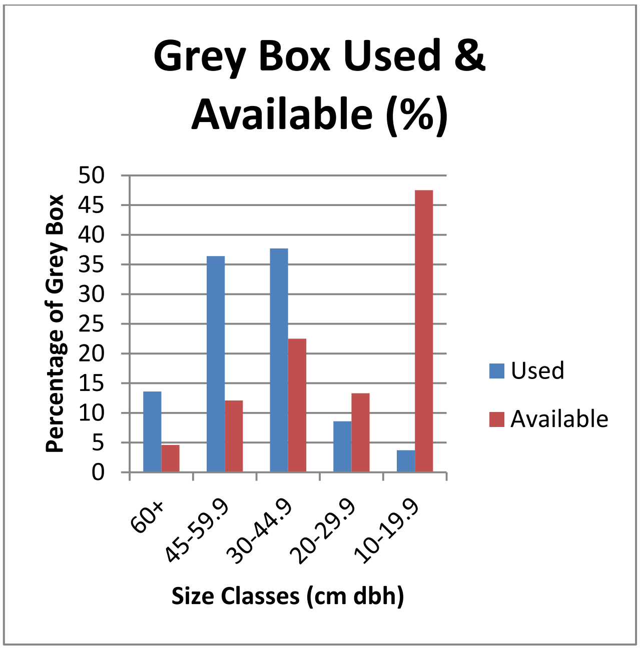
Structural plots measured by NEFA identified the sizes and species of 1,337 trees over 10cm diameter across 76 plots (Section 4.2). These were used to identify species availability according to size classes. Across all primary feed species, Koalas clearly show a preference for larger trees compared to their availability across he forest.





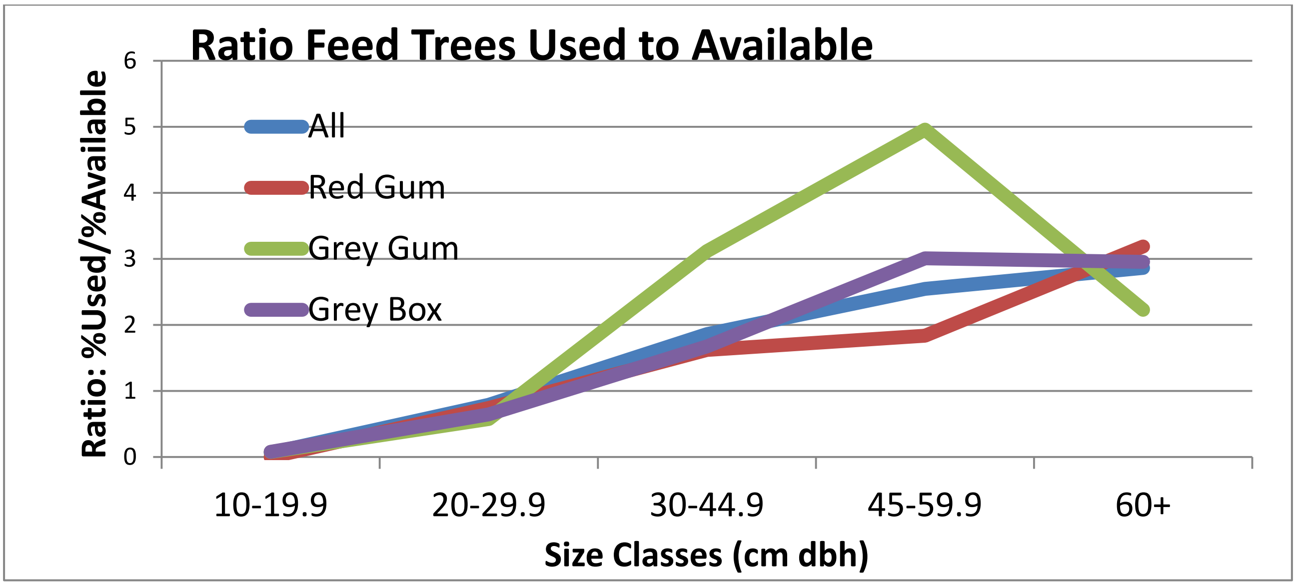
Koala scats, from adult and juvenile.





The above graphs illustrate the percentages of Koala feed tree species identified by NEFA according to size classes, compared to the relative availability of trees of those size classes as determined from plots. These clearly show a preference for trees over 30cm diameter (dbh) relative to their availability and a low usage of trees under 20cm diameter (dbh) relative to their availability.

This preference is more clearly shown by the ratio of the percentage of tree usage compared to availability. Across all Koala feed species together these show increasing usage with tree size. Individually Koala usage of Grey Gums peaked in the 45-59.9 cm dbh size class, which is not reflected in the EPAs (2016) results and requires further assessment (there may have been below average large Grey Gums in the searched areas).



Ratio of trees found to be utilised by Koalas in NEFA searches compared to their availability across the forest found from NEFAs structural plots (Section 4.2).

Across the State Forests of the proposed Sandy Creek Koala Park the requirement is to only retain (at best) 5 Koala feed trees >20cm dbh per hectare. Across the logged forests of the proposed Sandy Creek Koala Park there are currently 56.9 potential Koala feed trees >20cm dbh per hectare.

This means that only 8.8% of existing Koala feed trees need to be retained. Of the trees 20-29.9 cm dbh, 17.7 are Koala feed species (8.6 Grey Box, 4.8 Grey Gum, 4.3 red gum), meaning that only 28% of these small trees are required to be retained to satisfy tree retention requirements..

Size Class	Grey Box/ha	Grey Gum/ha	Red Gum/ha	Other trees/ha	Koala feed trees/ha	Koala feed % trees
60+	3.0	0.8	0.8	4.0	4.6	53.1
45-59.9	7.8	0.8	3.2	9.1	11.8	56.4
30-44.9	14.5	2.4	5.9	40.2	22.8	36.2
20-29.9	8.6	4.8	4.3	51.5	17.7	25.6
10-19.9	11.5	7.8	7.2	170.3	26.6	13.5
Grand Total	64.4	16.6	21.5	256.1	102.5	28.6

Average numbers of Koala feed trees per hectare and size class across the proposed Sandy Creek Koala Park. Note that the new logging rules (CIFOA) only require the temporary retention of 5 (8.8%) of the 56.9 Koala feed trees >20cm dbh per hectare, though in practice retention will be higher.

As there are no requirements to search for Koalas ahead of logging or select retained feed trees based on actual Koala usage (i.e. presence of scats or scratches), none of the required 5 potential Koala feed trees per hectare may actually be used by Koalas.

Because Koala High Use areas no longer require identification or protection, the retention of just 5 arbitrarily chosen small potential feed trees per hectare in such core Koala habitat will do little, if anything, to mitigate impacts.

There is a requirement to retain all hollow-bearing trees, from the measured plots there is an average of 2.2 Coastal Grey Box, 1.1 Small fruited Grey Gum and 0.8 red gums with potential hollows (mostly small and often in suppressed trees) per hectare. There is also a requirement to retain all Slaty Red Gums >30cm dbh in these forests on the grounds that they are a Vulnerable species, as it is hard to distinguish Slaty and Forest Red Gums all red gums >30 cm require retention, meaning an additional 10.2 red gums per hectare require retention on this basis. This gives a total of 13.5 Koala feed trees that require retention for other reasons, which are more than enough to satisfy the Koala feed tree retention requirements, though this is still only 24% of Koala feed trees >20cm and does not reflect the species diversity needed by Koalas.

Given the bias for retention of red gums and Koala's identified reliance on 2-3 larger feed species, in particular Small fruited Grey Gum, it is apparent that (without accounting for fire effects) the already diminished Koala carrying capacity of the forest could be further reduced by 75% due to the loss of 75% of potential feed trees.

Regrettably, despite the retention of 5 Koala feed trees per hectare being applied as a logging prescription for over twenty years neither the Forestry Corporation nor the EPA have ever bothered to assess its effectiveness. They don't know and don't care.

Unfortunately the Koala High Use Areas were heavily impacted by the fires, with no signs of Koala usage found in the most severely burnt areas and Koalas significantly diminished in partially burnt areas. While it will take a long time for the Koala population to recover, most feed trees are now recovering - unless they are logged.

3.1.4. Impact of Wildfire on Koalas

On the night of 8 October 2019, and over subsequent days, 93% of the proposed Sandy Creek Koala Park was burnt in the Busby's Flat fire. Koalas were apparently eliminated from the most heavily burnt forests, though some survived in the partially burnt forests. The fires were followed by two and a half months of drought which delayed recovery and compounded impacts.

After the fires on 8 October, NEFA initially focussed on identifying where Koalas had survived in known core areas in Braemar, Royal Camp and Carwong state Forests, which was informed by our own canopy scorch mapping. We also assessed part of the purchased plantation land.

Our initial aim was to convince the NSW Government to mount a rescue/assistance mission as the forest was still closed to the public. Given the extensive bare ground, scats were readily found and attempts were made to count all scats and leave them in piles at bases of trees. We put out water where we found Koalas or extensive use. A variety of people were initially involved in NEFA's identification of refugia and the provision of temporary water, with all scat locations recorded.

By November these firegrounds were safe as the entire area had been burnt, burnt trees had stopped falling and ashes cooled, but the firegrounds remained closed to the public. When it became apparent that no help was to be provided by the Government, NEFA felt we could not continue group searches or encourage people to support the colonies we had found. I continued to assess and support survivors in the Braemar colony on my own.

We undertook a series of 76 plots on 10 transects to assess forest structure across the proposal, where incidental searches for Koala scats in the vicinity were undertaken, as well as revisiting identified post-fire feed trees in Royal Camp and Carwong SFs, and on the purchased plantation block. A number of people assisted, though particular acknowledgement is due to Andrew Murray and Jim Morrisson.

Given the loss of most leaf litter, Koala scats were readily found. On each visit all scats were collected from under trees, counted, photographed, documented (along with tree species and diameter) and left in a pile next to the base of the tree. This enabled new scats to be identified on subsequent visits. These searches confirmed research that 80% of scats may be outside the 1m search area around the base of trees, thereby showing how excessive the requirement to find 20 scats to identify a Koala high use tree is.

Because the aims and objectives of Koala scat searches varied over time, time constraints and the forest being closed, data collection was not undertaken as systematically as would have been desirable.

Rainfall in late December resulted in significant wash and transport of scats at some localities, with flash flooding of some low-lying sites. The post-fire Koala surveys were discontinued in mid-January as rain was becoming regular, scats were being washed around too much, and regeneration of Koala feed trees was starting. With pools in creeks filled the water stations were removed on 10 January 2020.

Overall from 15 October 2019 until 10 January 2020 we located 3 dead Koalas, 7 live Koalas, and recorded tree species and diameters for 131 trees we found Koala scats under. Many of these trees were visited on a number of occasions to ascertain ongoing use.

NEFA's assessment of the proposed Sandy Creek Koala Park indicates that across the burnt forests there was a total loss of around 90% of Koalas, with around 14% of this due to the ongoing drought after the fires and lack of comprehensive assistance to survivors. It is reprehensible that it appears likely that some 70% of the Koalas that survived the initial fire subsequently died or moved to refugia while the Governments ignored their plight.

Of particular concern is the loss and degradation of core Koala colonies, which would have been essential for maintaining Koalas in the marginal habitat that characterises much of the area. As the bush recovers there will be abundant resources for the surviving Koalas, though it will take decades for their population to rebuild.

NEFA's assessment of the impacts of the 2019 wildfire on the proposed Sandy Creek Koala Park indicates the loss of 78-89% of Koalas across the proposal, which suggests the loss of 271-309 Koalas due to the fires and a surviving population of 38-76 Koalas.

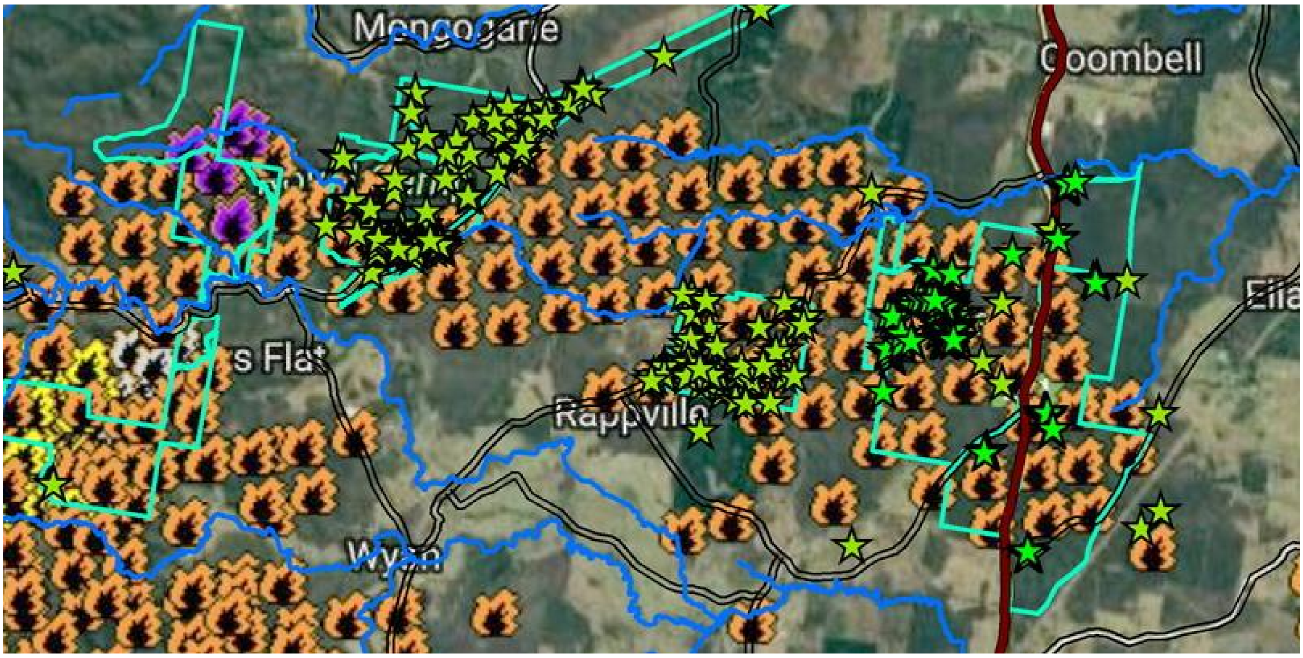
Logging has made these forests, and thus Koalas, more vulnerable to wildfires by drying them, increasing fuel loads, promoting more flammable species, and changing forest structure. This includes increasing the risks of canopy fires by reducing canopy height, increasing tree density and increasing fuel connectivity from the ground into the canopy (Section 4.5).

It is apparent that Koalas are most likely to survive fires in large trees where they and the canopy are most likely to escape the heat of a fire, with the intact canopies providing essential browse until the forest recovers.

Photos of a badly burnt section of Ellangowan State Forest in late March 2020, almost 6 months after the fires. Due to the combination of fire and drought there has been significant death of trees in the most heavily burnt stands. The consequences of this have not yet been assessed, though most trees have survived, and aside from the Coastal Grey Box which disproportionally collapsed soon after the fires, Koala feed trees appear to have recovered quicker and better than Spotted Gums.

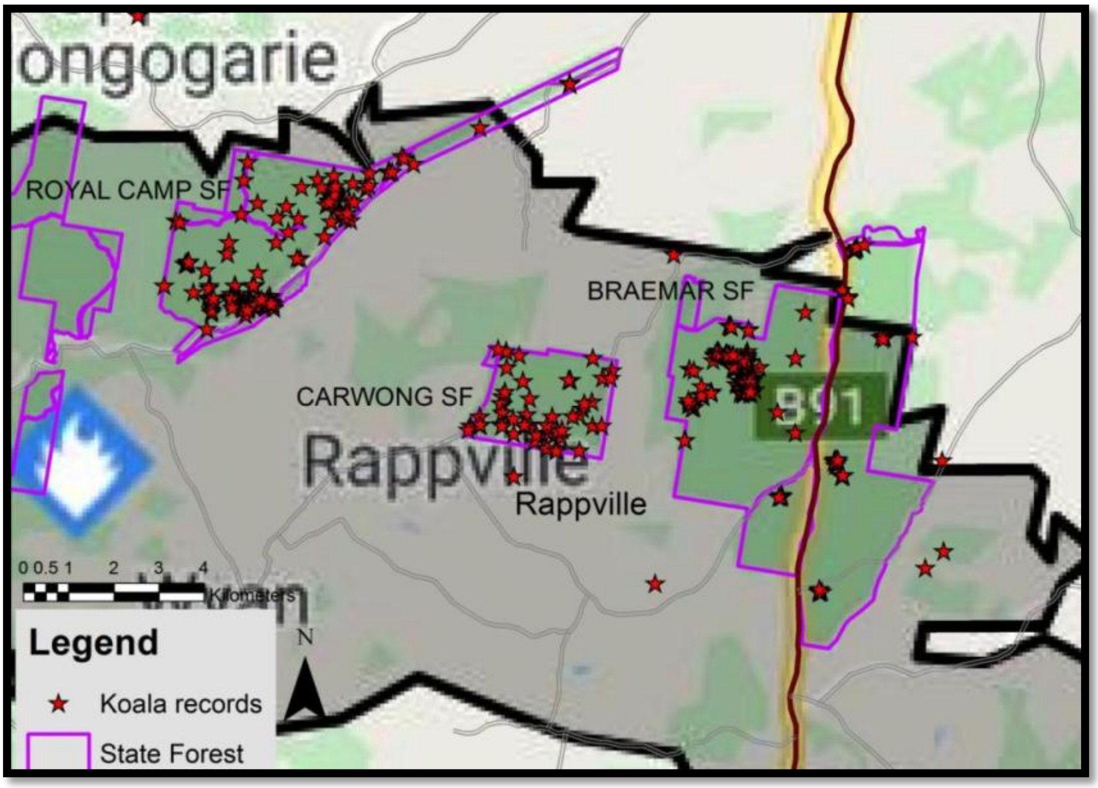
3.1.4.1. Busby's Flat Wildfire

By the afternoon of the 8 October 2019 the Busbys Flat fire had burnt a long strip of land immediately to the south of the proposed Sandy Creek Koala Park. That night a wind change redirected the fire into these forests, and by the morning Carwong State Forest and most of Ellangowan, Braemar and Royal Camp State Forests had been burnt.



Sentinel mapping of fire at 7am 9 October 2019, with Koala records overlaid.

Over the next few days it extended further into Royal Camp State Forest, burning 6,458ha (93%) of the proposed Sandy Creek Koala Park.



Pre-fire Koala records (wildlife atlas and NEFA) over laid on RFS Fires Near Me mapping for 13 October 2019. Shows the extent of the fire, with only small parts of Braemar and Royal Camp State Forests escaping. Most of the understorey was incinerated in the fire's footprint.

The fire moved rapidly through most of these areas, incinerating the ground litter and most logs, stumps and understory shrubs, but rarely crowning. Though the heat from the fire dried out and ultimately killed canopy leaves over extensive areas. Few ground refugia escaped the fires, with riparian vegetation incinerated, though some scattered tree crowns survived and became refugia for surviving Koalas.

LEFT: The understorey was very dry, with incineration of most leaf litter, dead wood and stumps. RIGHT: Many Koala feed trees, notably Coastal Grey Box were burnt out at the base and later collapsed.

LEFT: Koala feed tree burnt out at the base - (CENTRE) later found collapsed. RIGHT: One of the many hollow-bearing trees, which are also Koala feed trees, lost.

The fire was hot and quick, burning out most of understorey of the proposed Sandy Creek Koala Park on the night of Tuesday 8 October. The consequence of this for Koalas is that most appear to have been killed in the most intensively burnt areas, as no evidence (i.e. scats) of surviving Koalas was observed where we had identified active Koala usage before the fires, including Koala High Use Areas. Some Koalas did survive in those forests where a significant proportion of the canopy survived. For days later there was also a significant loss of larger Koala feed trees (mostly Coastal Grey Box) due to their being burnt out at the base and collapsing.

LEFT: This sick male Koala, found in Braemar State Forest on 14 October, survived the fire, though the heat of the understorey fire desiccated the eucalypt foliage throughout large areas of the forest, leaving him with limited moist foliage or access to free standing water. Six days after the fire he was still generating faeces (25 scats were found under this tree), so apparently he was still feeding.

After an initial visit, NEFA wrote to Environment Minister Kean (13 October 2019) and the Forestry Corporation CEO Nick Roberts asking for NEFA to be allowed to engage a Koala scat-detection dog to undertake searches of burnt Koala habitat in Braemar State Forest, and potentially Carwong and Royal Camp State Forests, in order to identify surviving Koalas and assess their health and need for assistance (such as providing browse and water).

The principal problem was that the fire-ground was under Section 44 Management and under the control of the RFS Commissioner. Nick Roberts advised (14 October) "*As the Commissioner's delegate the Incident Controller, under the advice of his Incident Management Team, has recommended that access to the area be denied as it is still an active fireground and a safety threat to members of the public*".

While the forest remained closed, once sufficient time had passed for scats to accumulate NEFA began to undertake searches of known Koala colonies a few weeks after the fire. On 23 October 2019 NEFA wrote to Minister Kean detailing our finding of surviving Koalas in a search of known Koala High Use Areas in Royal Camp State Forest:

> *Given our initial poor results from ground searches we suggested scat dogs and infrared detection using drones. Though now that two weeks have passed we decided to trial ground searches again yesterday. We assessed two Koala colonies in Royal Camp State Forest that we had protected over 6 years ago, which were subjected to further surveys by the EPA in 2015, and which were recently identified as Koala Hubs by the Office of Environment and Heritage. We were relieved to find that while they have been affected by the fires, they have survived.*
>
> *At the first site (which was the one we took you to) we located one apparently healthy Koala, and identified another 12 trees with scats beneath them. The scats indicated the presence of 2 other Koalas, one with a joey.*
>
> *At the second site our search was more limited, though we located another live healthy Koala and another 4 trees with Koala scats. The scats indicated two additional Koalas, one with a joey.*
>
> *...*
>
> *Our principal concern remains the identification of extant colonies within the fire grounds. Though our inspections yesterday make it clear that the OEH identified Koala Hubs provide a good starting point and the persistence of these known clusters of resident populations can be easily verified on the ground.*
>
> *Our review of Koala Hubs (see maps below) identifies 21 burnt in recent fires:*
>
> > *Busbys Flat fire: 3 Royal Camp SF, 3 Carwong SF*
> >
> > *Bees Nest fire: 3 Marengo SF, 7 Clouds Creek SF, 3 Moonpar SF, 2 Chaelundi NP*
>
> *We request that the Government helps Koalas by undertaking rapid on ground assessments of identified Koala Hubs, taking any injured animals into care, and placing watering stations (where free water is not currently available) in the occupied areas of all the Koala Hubs burnt in recent fires to limit ongoing impacts on survivors. We recommend that cameras be set up at watering stations to monitor their effectiveness.*

Details of locations of surviving Koalas were provided to the Minister, yet the requested assessments and rescues were not apparently undertaken. The request was also *"that a moratorium is placed on the logging of burnt Koala habitat on State Forests to enable Koala populations to recover"*.

NEFA continued its assessments, focussing on patches identified by NEFA's (undertaken by Greg Hall) analysis of Sentinel-2B L1C satellite data to identify areas with significant retained canopies. We found little evidence of Koalas where most of the canopy had been killed. The four live Koalas found were in areas where there were different sized and shaped scats showing the presence of a number of other Koalas, including mothers and joeys. We found two dead Koalas in Carwong State Forest in what used to be a high use area, though also found evidence of use of another patch by a mother, joey and likely another Koala.

Dead Koalas found in Carwong State Forest on 29 October. LEFT: apparently burnt in fire. RIGHT: apparently died soon after the fire as its fur is intact.

On 1 November 2019 NEFA's interim report "Sandy Creek's Koalas in Need of Urgent Help, Post Fire Koala Assessment of Proposed Sandy Creek Koala Park" identified additional surviving Koalas and likely partially-burnt refuges. NEFA documented 74 trees with post-fire Koala scats beneath them, including 4 with live Koalas. It was provided to Minister Kean:

> *In 2017 the OEH identified 439 ha of Koala Hubs in these forests that they describe as "highly significant local scale areas of koala occupancy currently known for protection". Recently NEFA identified additional areas that would qualify as Koala Hubs in Braemar and Ellangowan State Forests. ...*
>
> *On 4 days over the past 2 weeks NEFA have undertaken searches for Koalas, and their scats (faecal pellets) to ascertain the impact of the fire upon known core Koala colonies. These have sampled portions of known colonies in Braemar, Royal Camp and Carwong State Forests, as well as finding a new colony in an extensive area of native forest on land purchased by the Forestry Corporation for pine plantations (which were also partially burnt).*
>
> *In the extensive areas where the leaves are now mostly dead we are not finding a lot of usage, and we expect that much of what we find is from soon after the fires. There appears to have been a significant decline in Koalas, with Koalas apparently eliminated from those parts of their core habitat most significantly affected. NEFA have only found 2 dead Koalas in Carwong State Forest (not far from an incinerated pine plantation), one of which was burnt and the other apparently died soon after the fire, though we are aware of unconfirmed reports of a landholder finding 20 dead Koalas on one property.*
>
> *We are finding a fair bit of post-fire usage by a variety of Koalas (including mothers with joeys at all locations) in more intact parts of known Koala colonies in Braemar, Carwong and Royal Camp State Forests, and on the Forestry Corporation purchase lands. Though given*

the extensive nature of the fire, and widespread crown scorch, all the assessed colonies have lost a significant proportion of their food trees (until they reshoot), with many Koalas suffering dehydration.

...

The surviving Koalas are suffering from the loss and drying of feed, with some affected by severe dehydration. The crowns of most trees were heated rather than burnt, so the trees should quickly recover following rain. The Koalas need help to survive until the rains come and the trees reshoot.

...

The principal immediate issues are rescuing any seriously affected Koalas and helping those that remain. A number of Koalas appear severely dehydrated or fire affected and in need of finding to be taken into care. Most need assistance to stay and survive in their homes. As a temporary measure NEFA have been leaving water at sites where we find Koalas and active use, though while the dry weather continues it needs a concerted effort to systematically deliver water (and forage?) to assist remaining Koalas survive until trees reshoot.

If the Koalas could get some temporary assistance on site, the prognosis is good, as once there is sufficient rain the trees should rapidly recover. Neither NEFA nor Friends of the Koala have the resources to mount the required comprehensive assessment, rescue and home support needed to provide these Koala colonies the help they urgently need to survive this ongoing disaster.

The NSW Government must show some compassion and take immediate action to save the surviving Koalas.

NEFA also has grave concerns for Koalas in the 15 Koala Hubs burnt in the Bees Nest fire. It appears that only the Port Macquarie Koalas are getting the assistance they need.

LEFT: Apparently healthy scats from mother and young joey making intensive use of an area of feed trees (including a large Spotted Gum) in a small patch with intact canopies. RIGHT: One of the temporary water stations placed by NEFA, many more were needed.

Help was not forth coming, and the forest didn't then recover. For a month after the fire, in the partially burnt areas numerous large Grey Box collapsed from having their bases and roots burnt out, while the thin barked Grey Gum and some red gums shed most of their leaves. Unfortunately these are Koala's primary feed trees.

Then the forest stood still for 2 months. It was an eerie feeling as we waited for the regrowth. With continuing drought, desiccated canopies, black ash heating the ground, and a series of heatwaves, the stresses on the surviving Koalas were immense.

LEFT: Male Koala found in Braemar State Forest on 25 October. CENTRE and RIGHT: Koalas found in Royal Camp on 22 October, from photos Friends of Koala advised that the scats are a terrible colour suggesting bad food source and dehydration, and identified these Koalas in need of rescue due to visual indicators of dehydration, poor body condition, suggestions of lungs being compromised and failing kidneys.

Deformed scats found on Forestry Corporation purchased lands on 30 October indicating severe dehydration.

On 25 December there was heavy rainfall, which moved extensive areas of ash and soil and caused flash flooding of some streams with ash laden runoff. It took some weeks for the forest to begin to respond with flushes of growth. Further heavy falls in mid January moved many piled scats around, as well as boosting regrowth. It was decided to remove NEFA water stations and complete the initial assessment of post-fire impacts.

The only apparent Government action was the Forestry Corporation placing a line of 6 water stations in Braemar State Forest on 25 October. These were not apparently refilled as they were dry when visited on 25 November and 5 December. They were refilled after NEFA's complaint to the Koala Inquiry on 9 December. Aside from NEFA's work, the only other assessments we are aware of were a single drive through of Braemar State Forest by Friends of the Koala in company with the RFS and Forestry Corporation, without undertaking any searching, and a later search of the nearby Bungawalbin National Park where no Koalas were found.

3.1.4.2. Fire Impacts on Sandy Creek Koalas

Dead Koala found in Ellangowan SF, note that it still has fur. Before the fire scats from a mother and joey Koala had been found nearby, though a search of the identified feed trees and the area did not reveal any scats after the fire. All trees in this vicinity were defoliated.

Across the proposed Sandy Creek Koala Park 6,458ha (92.4%) was burnt to varying intensities, with just 487 ha (7%) of forests escaping burning. The fire had a direct and major impact on Koalas, though this impact was accentuated by the lack of rain for 77 days, meaning that the recovery of browse did nor commence until after then.

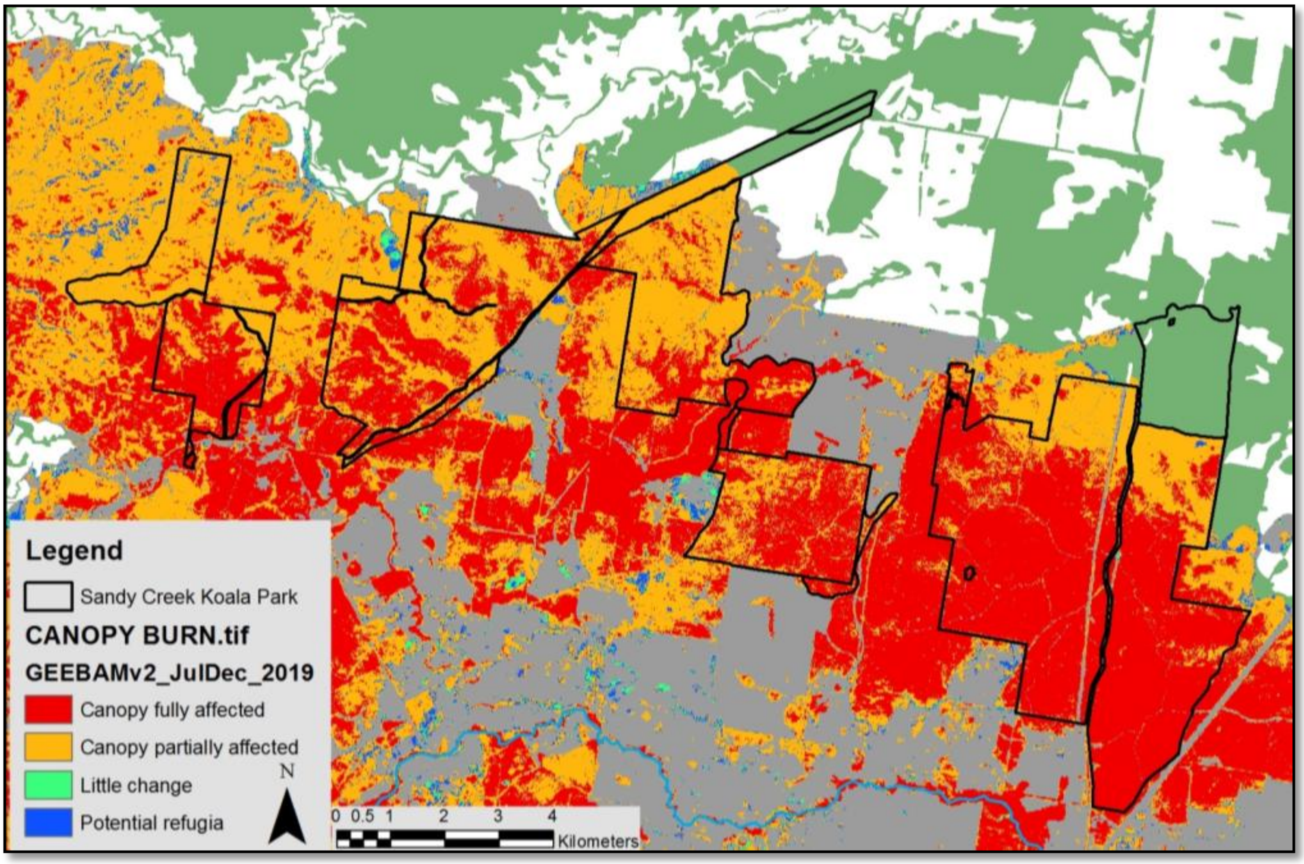
The impacts on Koalas was directly related to the severity of the fire, which was reflected by the canopy loss. Initial inspections showed that the worst affected areas the crowns had mostly escaped burning, and instead had been heated and dehydrated. Though over time these canopies turned brown.

NEFA's post fire searches found little evidence (scats) of post-fire Koala use of areas of fully fire affected canopies. NEFA searched some previously identified extensive Koala High Use Areas, known Koala locations, as well as random searches in areas where canopies were fully affected, with no post-fire Koala scats found in most heavily affected areas. Koala scats were found in a few marginal sites, though in most cases they were one-off uses (i.e. before Grey Gums shed their remaining canopy).

Given the rapidity with which the area burnt, and the reported propensity for Koalas to escape fires by climbing higher, the lack of post-fire scats indicates the Koalas were killed. Though only 3 dead Koalas were found, with only one of these with its fur burnt off. The rarity of finding dead Koalas following fires where they are known to be present has been commented upon by a variety of observers, with incineration or predation of bodies postulated. It remains a mystery. The lack of scats does not indicate survivors, and with little food, any surviving Koalas would have soon been in trouble.

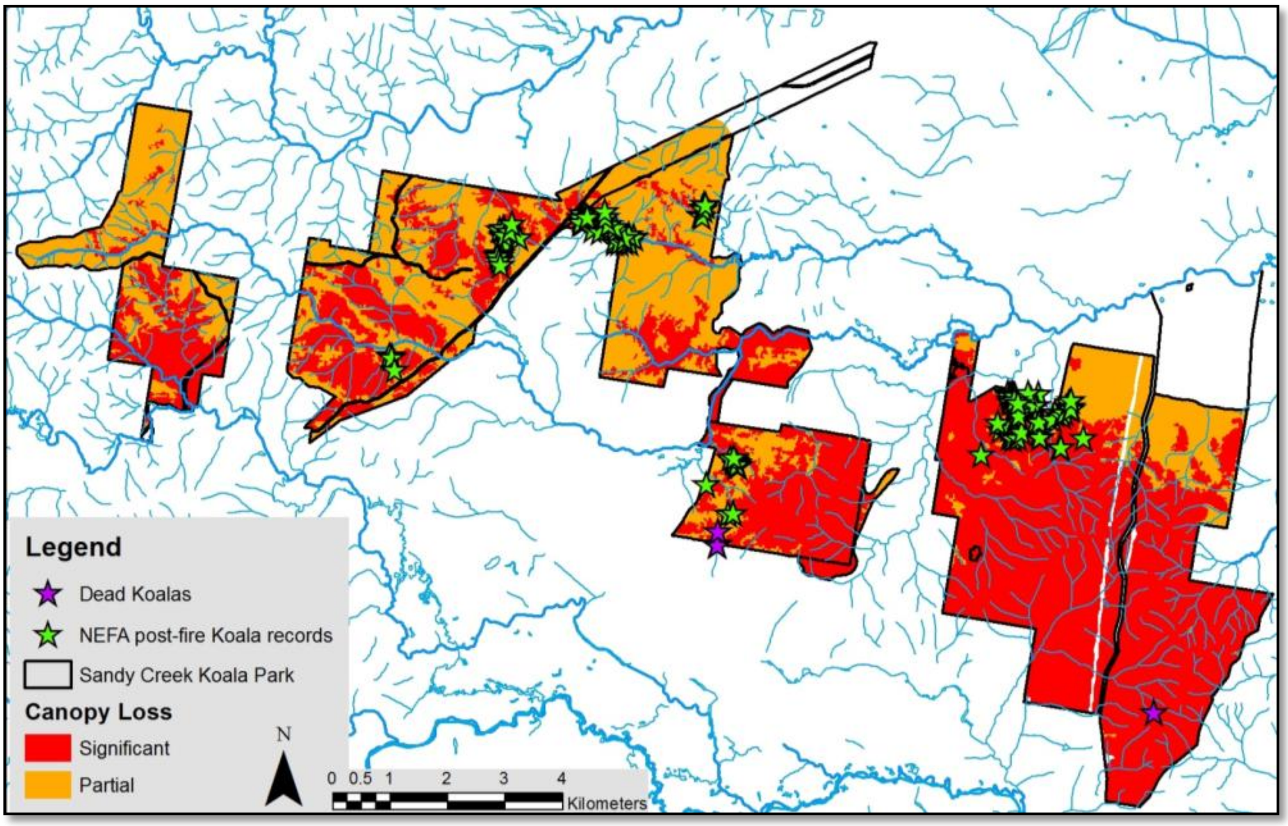
Koalas were found to persist in areas with some intact tree canopies, though continued to decline over the assessment period.

So the primary requirement for assessing impacts of the fires on Koalas is assessing the extent of fully fire affected canopies. NEFA initially relied upon our own burn mapping (compiled by Greg Hall) to identify potential refugia. As the Government released its own burn mapping we used that to assist searches, and adapted it for this assessment of impacts.



Mapping of the effects of fire on canopy loss (GEEBAM v2). One of many iterations of fire mapping, all similar but with significant variations. This version was considered most relevant for assessing impacts on Koalas.

Five versions of the NSW Government's fire mapping were considered during the course of this assessment. While the versions are generally consistent there are significant differences between most iterations. Based on our observations, 'GEEBAM v2_20191218_JulDec_Comb_dNBR_Classes' was considered to be the most suitable basis for assessing impacts on Koalas. This was manually digitised into 2 canopy-loss classes for the purposes of this assessment: significant where most canopy was lost, and partial canopy loss.



Post-fire Koala records overlaid on a compiled map of crown scorch due to the October fires based on a simplified version of the NSW Government's Geebam mapping.

Data on tree canopy condition was collected at 47 of the structural plots (see Section 3.2), where canopies were visually classed as no green leaves, < 25% of canopy with green leaves, 25-75% with green leaves and >75% of canopy with green leaves. This was combined with tree size data (above ground biomass was used as a surrogate for relative canopy size) to derive estimates of canopy losses for the two burnt canopy classes.

Canopy burn	Area		Canopy Plots	Canopy loss
	ha	%		
Cleared	43	0.6	-	0%
Unburnt	487	7.0	-	0%
Partial	2,531	36.2	27	56%
Significant	3,927	56.2	20	97%
TOTALS	6,988			

Canopy loss of trees derived from plots, grouped according to mapped burn classes.

Across the 6,458 ha of burnt forest a total of 73% of the canopy is estimated to have been lost due to the fires and associated drought. Some 3,927 ha had significantly affected canopies, losing most canopy. Some 2,531 ha lost an average of 56% of its canopy.

Averaged canopy losses are one indication of impacts on potential Koala feed, and thus the forest's Koala carrying capacity. Because of the paucity of data on the distribution of Koalas and large feed trees , and in particular the location of high density colonies, this data is only indicative of the scale of Koala losses. The actual significance of impacts is related to the loss of the patchily distributed core breeding colonies.

Based on our observations it is apparent that all Koalas were lost from the 3,927 ha with significantly affected canopies, comprising 61% of the burnt area and 57% of the forest area. If some Koalas did survive the fires in these areas, the loss of nearly all feed trees, and the prolonged drought, made these forests uninhabitable. It is therefore estimated that the loss of Koalas from these areas comprised 57% of the population within the proposed Sandy Creek Koala Park.

It is harder to quantify the likely impacts on Koalas across the 2,531 ha mapped as 'partially affected', where around 56% of canopy was lost. There was a likely loss of Koalas during the fires as the 2 dead Koalas found in Carwong SF were in partially burnt forests.

As expected, canopy loss decreased in line with tree size, with the larger trees retaining most canopy.

Size Class (cm dbh)	No	Canopy Loss (%)
60+	15	45.9
45-59.9	23	45.3
30-44.9	82	61
20-29.9	94	63.9
10-19.9	242	79.3
TOTAL	456	56

Percentage of canopy loss by size class within partially burnt canopy areas

These results show that tree size has a significant effect on canopy loss, with the taller trees retaining a higher percentage of their larger canopies. The larger trees were generally the least affected by the heat of the groundfires and thus retained the most canopy. It is obvious that the larger trees would have provided the best refuge for Koalas from the heat of the fires. This emphasises the importance of retaining large trees both as Koala fire refuges and for food after fires.

Koala Feed Trees	Canopy loss on partially burnt sites (%)
Small-fruited Grey Gum	79.2
red gums	63.1
Coastal Grey Box	28.4
TOTAL	49.2

Percentage of canopy loss of Koala feed species (>20cm dbh) within partially burnt canopy areas (note Forest and Slaty Red Gums are combined)

The plot data support the observation that of the Koala feed trees >20cm dbh, Small-fruited Grey Gum was disproportionately affected by the fire with 79% loss of canopies. This will have had a disproportionate affect on Koalas given that Grey Gums are favoured feed trees and Koala's preference for a variety of feed trees. Conversely Coastal Grey Box was relatively least affected with 28% loss of canopies, which partially reflects the relatively higher numbers of larger trees, though also indicates higher resilience to fires. The canopies of the smooth trunked Grey Gum and Red Gum continued to die for a month after the fires (even where not apparently desiccated). After then Coastal Grey Box became the mainstay of Koalas. Overall there was a 49% decline in canopies of Koala feed trees over 20 cm diameter.

While the canopies of Coastal Grey Box were relatively resilient, their bases were particularly susceptible to burning leading to tree collapse. Numerous larger trees were burnt out at the base and collapsed over the few weeks after the fire front passed through. A random sample of a total of 73 collapsed trees from 4 sites found that they had an average diameter of 40.4 cm dbh (range 15-100cm dbh), with Grey Box comprising 83% (61) of fallen trees, Red Gum 7% (5) and Spotted Gum 10% (7). Grey Box are the most abundant Koala feed trees in the proposal, so the impacts of the loss of a proportion of mature feed trees will depend on whether the lost trees were some of those preferentially utilised by Koalas.

While the IFOA rules have long required the minimisation of machinery disturbance within 5m of the bases of retained trees, in practice NEFA audits usually find machinery movements up to and around the base of trees with consequent damage to roots and tree bases. Our frequent complaints about this breach have been in vain as the EPA have never taken action for this specific breach. It is considered likely that past logging damage to roots and tree bases contributed to their being susceptible to burning.

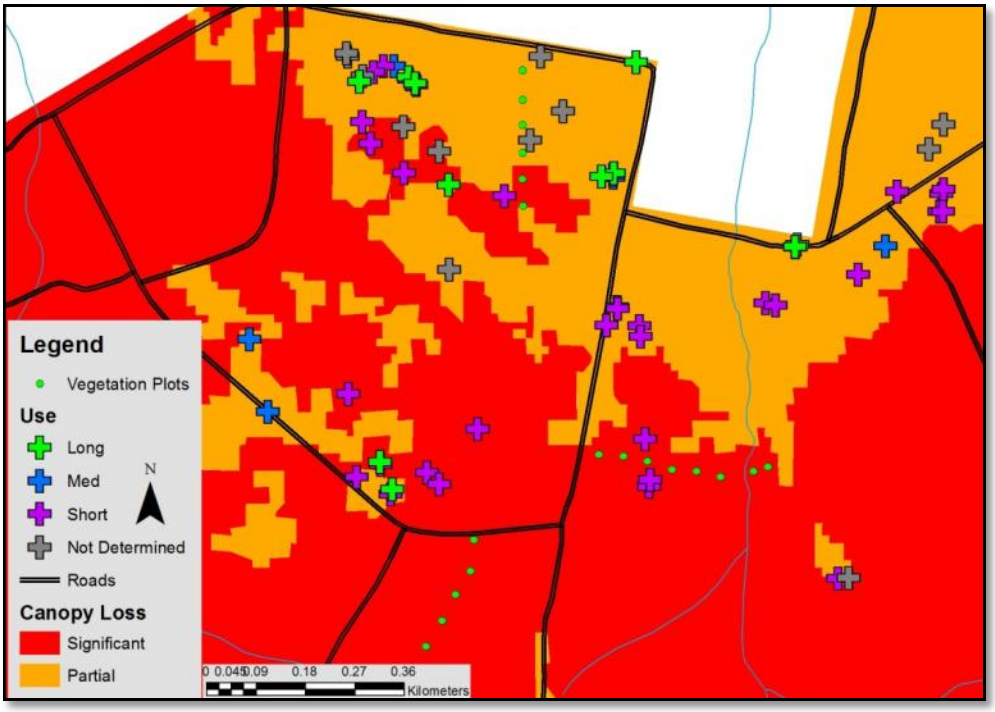
Within the partially burnt forests in Braemar SF a significant number of trees identified as used by Koalas before the fires were not used after the fires, indicating an initial population decline as a direct result of the fires. It is reasonable to assume that the 49% reduction in the canopy of Koala feed trees in the partially burnt forests reflects a similar initial decline in Koalas. NEFA's post-fire monitoring showed an apparent further decline in Koalas in the three months following the fire.

A total of 136 individual trees with Koala scats beneath them were located over the period 14 October 2019 until 10 January 2020. Live Koalas were seen in 7 trees (one on multiple occasions). In addition 3 dead Koalas were located, one burnt in the fire and the others apparently dying after the fire.

Many of these trees were revisited to ascertain ongoing use. Initially revisits were focussed near water stations in Braemar State Forest, though as time allowed other identified use trees in Braemar were revisited to assess ongoing use and more fully identify trees being used. Revisits were irregular, though some trees were revisited up to 8 times. Because Koala scats were obvious it was readily apparent whether there had been significant reuse between visits. A number of identified use trees were later revisited in Carwong and Royal Camp State Forests and the plantation purchase lands.

Of the 64 trees identified as being used by Koalas in Braemar State Forest, after the fires, 48 were considered to have been sufficiently revisited, along with consideration of scat numbers, to ascertain whether they had been used for a short, medium or long term.

Ten trees were identified as being used throughout the assessment period, comprising 7 Grey Box, 2 red gums, and one Spotted Gum. A cumulative total of >250 scats were found under each of 7 trees. An exceptional 2,022 scats were found under one Spotted Gum in a partially burnt area, with scats of various sizes indicating initial use by a mother and joey, and some burnt scats indicating use before the fire. The tree had an intact canopy and a good structure for roosting. Subsequent video footage and observations showed this tree was being used on an almost daily basis, likely primarily as a roost tree (see above) by a single young Koala later in the assessment. Three other trees with cumulative totals of 106-165 scats were found to have been used over the assessment period. In total, at least 3 of these trees were used before the fire.



Trees found with Koala scats, identifying those considered to have been sufficiently revisited to identify ongoing use and the period of use. Basically, use of many trees used initially was found to decline over time, with only ten trees used consistently,

Six trees were identified as having medium use, comprising 3 Grey Box, 2 Red Gum and one Grey Gum. Cumulative totals of >250 scats were found under 3 of these, one with 606 scats, though they apparently ceased being used late in the assessment period. Another 3 showed use on 2 or more visits, one of these had a total of only 55 scats and the others 142 and 189 scats, though they too apparently ceased being used. At least 4 of these were also used before the fire.

The remaining 32 apparently were not reused after their initial identification, comprising 17 Grey Box, 7 Red Gums, 2 Grey Gums and 6 Spotted Gums. Two Grey Box had >100 scats indicating they may have been used on a number of occasions before being identified. 26 had less than 70 scats. Some were apparently only used briefly after the fires, in some cases because their canopy continued to decline (i.e. Grey Gum and some red gums) or because they were only briefly used as roost trees (i.e. of the 13 trees with <25 scats, 4 were Spotted Gums). At least 5 of these were used before the fire.

Overall there was a 67-79% decline in the use of trees over time, which coincided with a decline in the variety of scats being found, indicating a significant population decline in the 3 months after the fires. In Braemar SF Koalas appeared to be lost from most of the eastern assessed area, and contracted in the western area. When limited to just areas mapped as partially burnt, the area of apparent use declined from an initially identified area of around 57ha down to around 20 ha by the end of the assessment, a 65% reduction in occupied habitat.

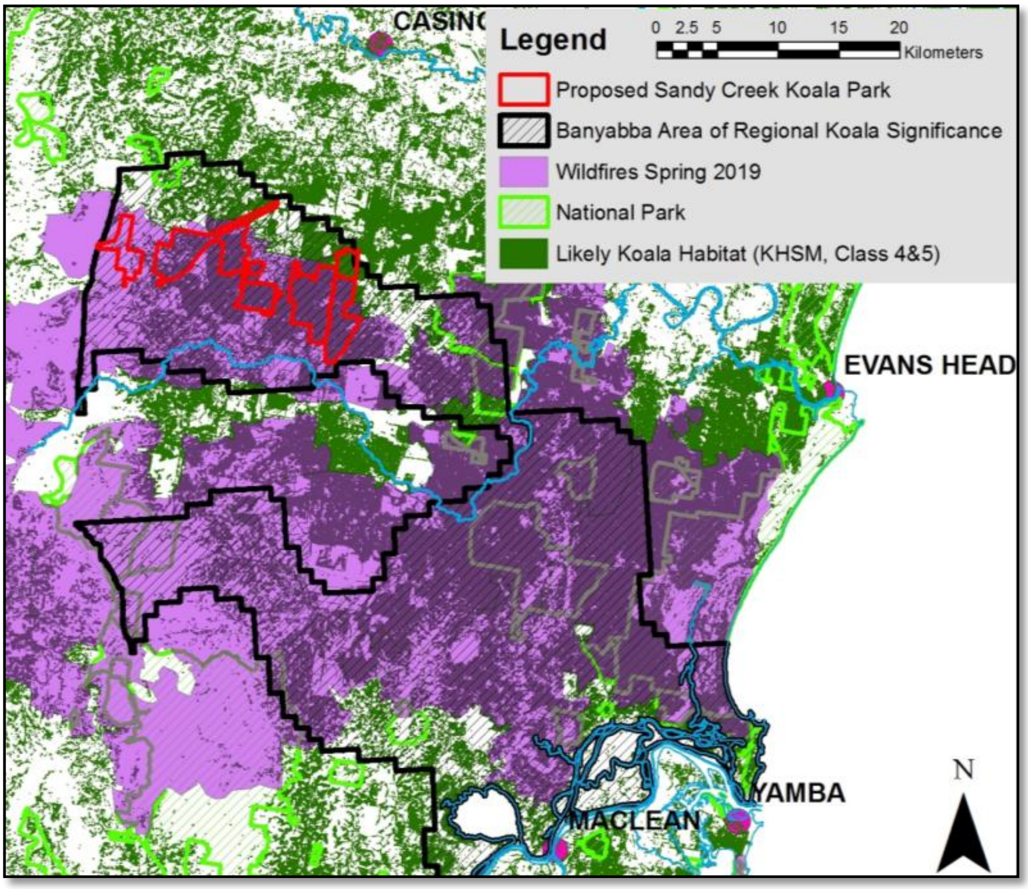
Of the 38 initial scat trees revisited in Carwong, Royal Camp and the plantation purchase lands, 11 were considered to indicate long-term use, 4 medium term-use and 23 short-term use (i.e. no reuse). This indicates a 60-70% reduction in use over time.

There are numerous compounding factors influencing Koala usage, including habitat suitability before the fires, varying use of feed trees over time, and damage to preferred feed trees. Surviving Koalas are likely to have expanded their ranges to find forage, and it is hoped that some of the ongoing decline in Koalas was due to Koalas moving to refuges outside the assessment areas.

It is also considered that the provision of water to the Braemar SF Koalas is likely to have mitigated post-fire decline of Koalas. The decline of Koala usage in the other colonies appeared to have been greater, as by the time of the revisit it seemed that many of the additional Koala scats found were old, with little evidence of current usage in many areas.

The lines of evidence relating to the decline of Koalas in the partially burnt forests show a decline in Koala tree usage and Koalas post fire, a 49% loss of canopies of suitable Koala feed trees, and a further 60-80% decline in Koala feed tree usage over the 3 months after the fires. Based on this it is estimated that there has been a 60-90% loss of Koalas from the partially burnt forests, which increases the Koala losses from burnt forests to 84-96%. This equates to a 78-89% loss of Koalas across the proposed Sandy Creek Koala Park.

Based on the previously identified ball-park estimate that there may have been 347 Koalas present before the fires, this suggests the loss of 271-309 Koalas due to the fires and a surviving population of 38-76 Koalas.



Extent of fire within the Banyabba ARKS. The 2019 Busbys Flat and Myall Creek fires burnt 59,000 ha (83%) of Banyabba ARKS' likely Koala habitat.

It is emphasised that these are averaged losses, whereas Koalas are variably distributed in relation to feed trees, large trees and other factors. The loss and decimation of core Koala colonies is the biggest threat to the ongoing viability of the Banyabba population. With the known core colonies identified in Royal Camp, Carwong and Braemar State Forests, along with over 800ha of the Ashby core Koala habitat, all significantly affected by fires, the 2019 fires are likely to have significantly increased the vulnerability of this population to extinction.

3.2. Other values of old forests

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 these forests as they are progressively converted into younger stands.

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.

3.2.1. 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 Sandy Creek Koala Park to identify the indicative reduction in nectar likely to have been caused by logging to date.

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 proposal 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.

There is a 1978 record of the Critically Endangered Regent Honeyeater (*Anthochaera phrygia)* from Royal Camp State Forest, several 1994 records in the vicinity of this reserve proposal and records from the Richmond catchment as recently as 2009, showing this nomadic species is likely to be using these forests for foraging. There is also a 1983 record of the Endangered Swift Parrot from Braemar, with a nearby 2018 record indicating this migratory species is also periodically foraging for nectar in these forests. These records highlight the importance of lowland Spotted Gum forests for a suite of migratory and nomadic threatened bird and other nectarivorous vertebrate species.

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.

For these forests Forest Red Gum *Eucalyptus tereticornis*, Swamp Mahogany *E. robusta,* Spotted Gum *Corymbia macula* and Coastal Grey Box *E. mollucana* 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:

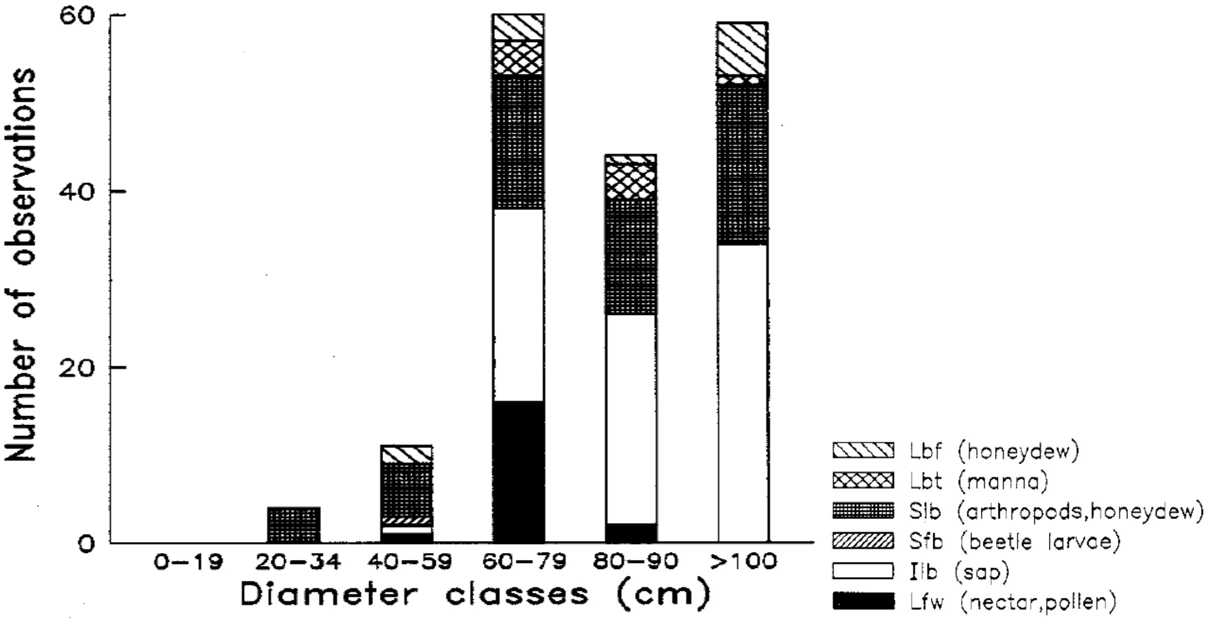
The greatest variability in use of habitat in this study occurred on the central and northern coasts of NSW. Although these coastal regions often supported small numbers of Swift Parrots, this changed dramatically during drought conditions in 2002 (Bureau of Meteorology 2002; Bureau of Meteorology 2006). 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.*

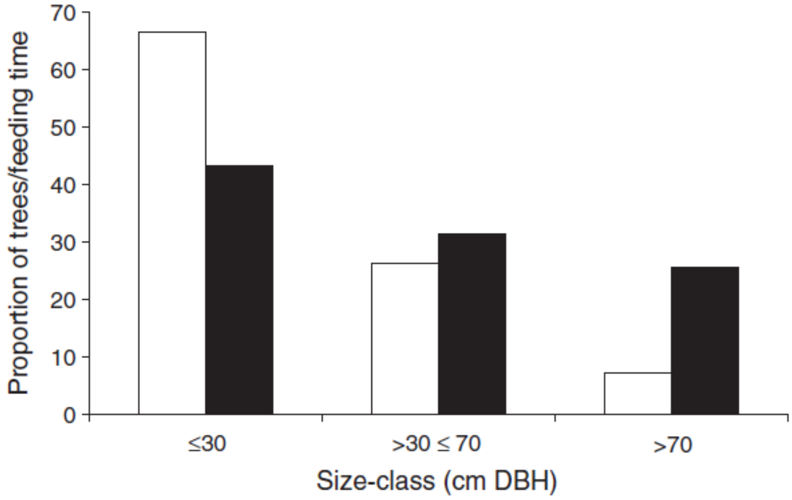


Fig. 3. from Holland *et. al.* (2007):The proportion of total *Eucalyptus microcarpa* trees in each size category (clear bars), and the proportion of total feeding time of squirrel gliders within trees in each size category (shaded bars) near Euroa, Victoria.

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".*

	D-J	F-M	A-M	J-J	A-S	O-N
Corymbia henryi	X					X
C. intermedia	X	X				
Eucalyptus acmenoides	X					X
E. moluccana		X				
E. propinqua	X	X				
E. siderophloia	X				X	X
E. tereticornis	X	X		X	X	X

Extract from Ebby and Law (2008): Table 4.5. The flowering phenology of Sandy Creek species contributing nectar and pollen to the diet of Grey-headed flying foxes assessed across the range of the animals. Note the contribution of Forest Red Gum *(E. tereticornis)* to winter resources.

Of the common species within the proposed Sandy Creek Koala Park, Ebby and Law (2008) identify Coastal Grey Box (*E. moluccana*) , Forest Red Gum (*E. tereticornis)* Grey Ironbark *(E. siderophloia)* and Pink Bloodwood (*Corymbia intermedia*) as particularly significant nectar sources for Grey-headed Flying foxes. Of the 13 species specifically considered by Ebby and Law, Forest Red Gum had the highest score for annual reliability of flowering, making it a staple nectar source. They also identify Large-leaved Spotted Gum (*Corymbia henryi),* Small-fruited Grey Gum (*E. propinqua*), and Narrow Leafed White Mahogany (*E. acmenoides*) as important nectar sources.

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).

Eucalypt nectar feed trees include the local Coastal Grey Box (*E. moluccana*), Grey Ironbark *(E. siderophloia)*, Narrow Leafed White Mahogany (*E. acmenoides,*) Forest Red Gum (*E. tereticornis)* Large-leaved Spotted Gum (*Corymbia henryi),* and Pink Bloodwood (*Corymbia intermedia*).

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.

The 2018 record of the Swift Parrot near Ellangowan State Forest still triggers the retention of mature eucalypt feed trees in its vicinity, though protection is removed elsewhere. The Regent Honeyeater record in Royal Camp is considered too old to count. However the requirement to retain all Vulnerable Slaty Red Gums >30cm dbh in these operations, and the difficulties in differentiating them from Forest Red Gums, means that all red gums >30cm dbh require retention.

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.

The removal of protection for most mature trees 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.

3.2.2. Hollow-bearing trees

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 is an urgent need to restore hollow-bearing trees to recover these species.

Within the proposed Sandy Creek Koala Park there has been a dramatic reduction in big old trees and thus the hollows they provide for a plethora of species dependent upon them for nesting, denning and roosting. Remnant majestic oldgrowth trees over a metre diameter (dbh) and with abundant large hollows are scattered throughout the proposal, though there are not many survivors of the original forest. The dramatic reduction in old trees means that hollows are a limiting resource, eliminating many hollow-dependent species and creating strong competition for those remaining.

Species	DBHOB	Height
Spotted Gum	111.8	30
Red Gum	116.4	20
Red Gum	123.2	25
Swamp Box	140.5	25
Red Gum	126.6	30

Incidental sightings of large old trees with large hollows made when doing plots. These indicate the original stature and habitat potential of these forests.

For our plot assessments of the proposed Sandy Creek Koala Park (Section 4.2) we measured plots in unlogged Spotted Gum forests in the nearby Banyabba State Forest in order to be able to assess structural changes resultant from past logging. On the plots we identified trees with large and potential small tree hollows. Large hollows were readily discernible, though potential small hollows were often inferred from the presence of dead broken branches, meaning they are likely an over-estimation. While tree age and size is the principle determinant of tree hollows, many trees can be suppressed or suffer physical damage and thus develop hollows, or indications of them, at a smaller size. Only a subset of potential hollows will actually be suitable for dens or nests.

Based on our comparison there has been a 98.4% reduction in trees with large (and small) hollows in the logged forests of this proposal. Extrapolating across the 6,988 hectares of the proposal, indicates the loss of 123,600 (96.7%) large hollow-bearing habitat trees, that is a lot of potential homes. The loss of trees with potential small hollows has not been as dramatic, with a 78% reduction, though due to the relatively small sizes of many trees, many of the potential hollows are likely to be unsuitable for habitation. This equates to an overall 85% reduction in hollow-bearing trees.

Species	Unlogged (hollow trees/ha)			Logged (hollow trees/ha)		
	Large	Small	Total	Large	Small	Total
Coastal Grey Box				0.3	1.9	2.2
Small-fruited Grey Gum				0.0	1.1	1.1
Red gums				0.0	0.8	0.8
Orange Gum	6.7	0.0	6.7			
Large-leaved Spotted Gum	11.7	23.3	35.0	0.0	3.8	3.8
Bloodwood				0.0	0.3	0.3
Ironbark	0.0	8.3	8.3	0.0	0.3	0.3
Swamp Box	0.0	5.0	5.0			
TOTALS	**18.3**	**36.7**	**55.0**	**0.3**	**8.0**	**8.3**

Numbers of hollow-bearing trees per hectare with possible hollows in unlogged and logged plots

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.

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".*

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.

Few areas within this proposal have escaped 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.

There are currently only 9.7 trees per hectare in the 60+ cm dbh size class within the proposed Sandy Creek Koala Park, 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. Meaning that unless all large trees are retained there will be a continuing attrition of large-hollow bearing trees into the future.

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 these 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 (adjacent to this proposal) 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 (with current prescriptions):

> *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, 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 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.

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. 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 (Section 3). 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 such species into the future.

Both mature nectar feed trees and hollow-bearing trees are limiting wildlife populations in the proposed Sandy Creek Koala Park. 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.

4. FOREST STRUCTURE

The structure of these forests have been fundamentally altered by over a century of logging. It is evident that nearly all of the forest has been heavily disturbed in the past, including areas now counted as exclusion areas.

The Forestry Corporation's logging and fire histories were found to be inadequate and often contradictory, so could not be relied upon except at a broad level to indicate approximate times since logging.

The principal means of assessing structural change were 76 vegetation plots measured on 10 transects chosen to reasonably sample the range of logging histories and environmental variation across the proposal. To obtain a reference to assess logging changes against, 12 plots on 2 transects in CRAFTI mapped oldgrowth forest in Banyabba State Forest were measured.

Comparison between the logged and unlogged forests identify a reduction in basal area from 40.7 m^2 per hectare down to 20.2 m^2, showing the unlogged forest has twice the basal area of the logged forests. The starkest difference is in trees greater than 45cm dbh, which is not surprising as these constitute the sought-after large high quality sawlogs. The logged forests had an average basal area of trees >45cm dbh of 7.6 m^2/ha, compared to a basal area of 31.8 m^2/ha in the unlogged forests, which is 4.2 times as much.

The tree data indicate that there has been an overall decline of 25% of the number of trees over 30 cm dbh due to logging over the past century, with 57% of trees 45-60 cm dbh and 79% of trees over 60cm dbh removed. There has been a corresponding 215% increase in trees 30-45 cm dbh, showing the significant reduction in the age of the forests.

The tree dbh data was transformed to biomass estimates using an allometric equation showing there has been an overall loss of 59% of above ground biomass from these forests, which increases to 65% of biomass for trees above 30 cm dbh and to 84% of biomass for trees above 50 cm dbh. It is abundantly clear that there has been a significant reduction in the larger trees targeted for logging.

An assessment of the likely exclusion areas under the new CIFOA logging rules indicate that outside the 43 ha of land cleared for a powerline and rest area, 2,414 ha (35%) will be excluded from future logging, with 4,530 ha subject to ongoing logging.

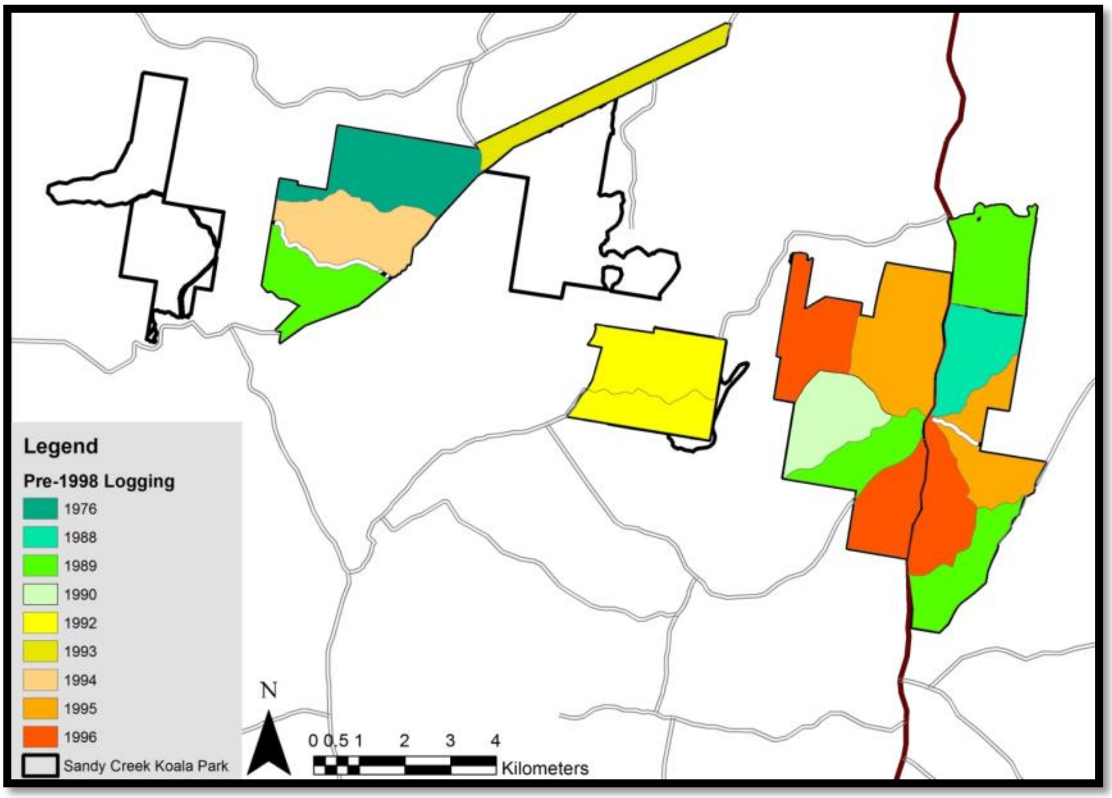
Structural change has enabled the invasion of lantana, forming dense stands in some locations along Sandy Creek and in some gullies. This has enabled the proliferation of Bell Miners and the initiation of Bell Miner Associated Dieback in limited areas. This is ecosystem collapse. The fires have killed most lantana providing an opportunity to control the lantana and stop its resurgence.

Structural change has also made the forests more vulnerable to wildfires 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.

The 2019 fires have had a significant impact on the structure of the forests, with widespread deaths of small trees and extensive death of mature trees in the heavily burnt forests. This will have had a significant impact on future timber yields due to the death of many Spotted Gums. While some of NEFA's plots were within badly burnt stands, they were assessed soon after the fires before it could be ascertained which trees would not reshoot. Visual assessments since have shown high mortalities in some stands These impacts were not able to be assessed for this proposal, and therefore have not been accounted for.

4.1. Logging History

These forests have mostly been heavily disturbed in the past, which has had significant effects on their biodiversity values. The key issues with logging relate to how it has affected the structure of the forest, which is not necessarily reflected by the history of logging events. Logging events may only affect part of an area or be limited to certain products, but are historically attributed to the whole compartment. There are also significant differences between various logging histories. So old logging history is of questionable veracity and little weight can be placed upon it.



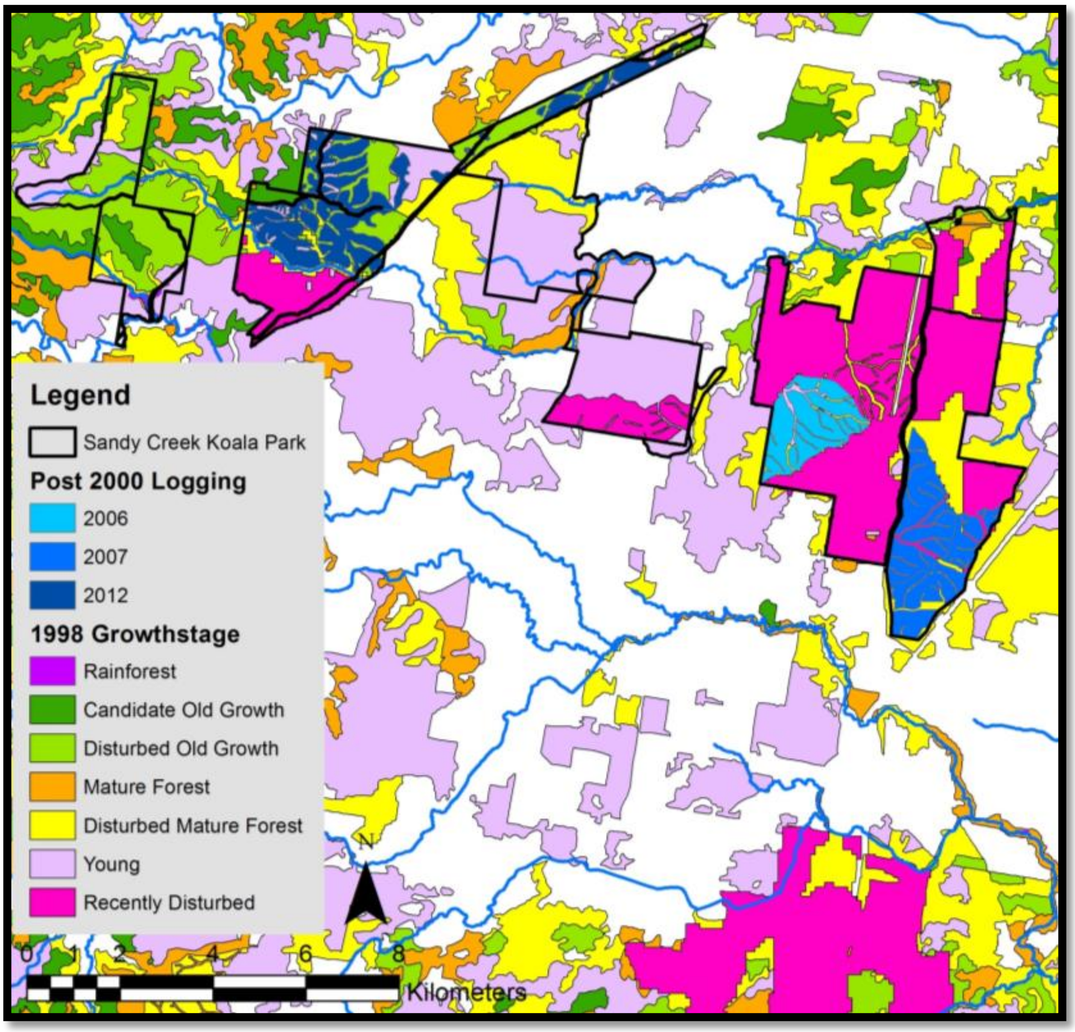
Logging history collated for the Comprehensive Regional Assessment, which only shows the most recent event. Note the lack of history for the western section of Royal Camp SF (which other data indicates was logged in 1998 and 1992), and the plantation purchase land (which was previously private land).

The growth stage mapping undertaken as part of the Comprehensive Regional Assessment in 1998 provided a valuable snap-shot of forest structure. The 1998 mapping of growth stages shows that the old senescent trees that define oldgrowth had been significantly diminished by then, with very small patches of oldgrowth and disturbed oldgrowth forest remaining. The western part of Royal Camp State Forest is the most intact, and doesn't appear to have been logged since then.

Unfortunately the structural mapping for most of these compartments was over-written on the basis of claimed recent (post-photo) logging - some of which doesn't appear to have taken place. The recent logging history data available for this assessment is that collated by the EPA (2016) and detailed post-2000 logging history (though this too seems to have missed some events).

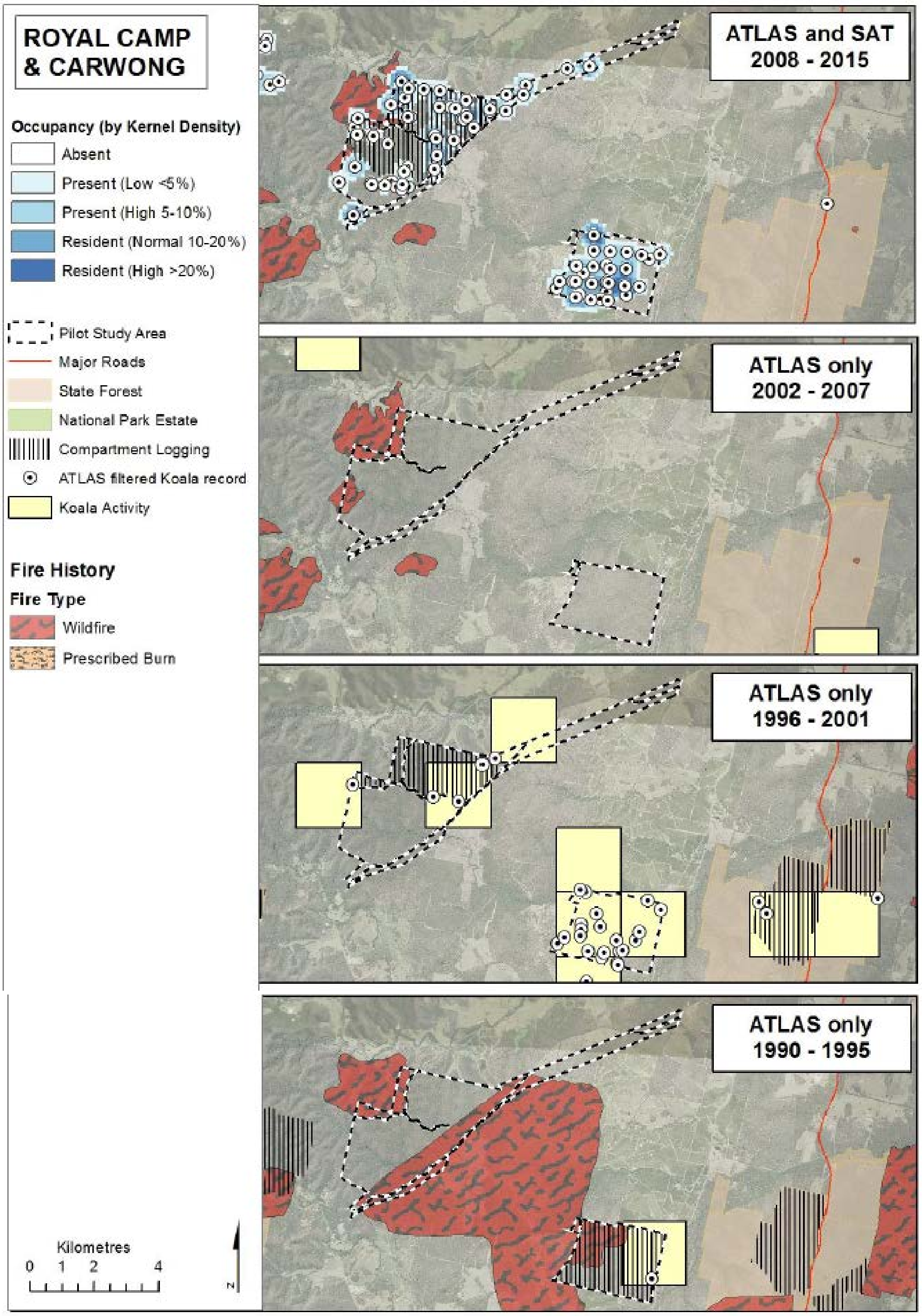
The CRA CRAFTI mapping shows compartment 13 of Royal Camp State Forest as being "recently" logged, though the EPA (2016) data shows it as not being logged since at least 1990, yet the draft 2013 Harvesting Plan does refer to regeneration "*from 1997-98 harvest events".* Similarly while compartment 22 of Carwong SF is shown as "recently" logged this is not substantiated by the EPA data, with the last logging apparently in 1992.

The "recently" logged areas of Braemar and Ellangowan State Forest do appear to be have been at least partially logged in 1995 and 1996, though this is at odds with the Forestry Corporation's latest online data, which claims the new compartment 6 of Braemar (which was previously mostly compartment 23) was logged in 2000, and compartment 7 of Braemar (which was previously mostly compartment 25) was logged in1995. The EPA (2016) data show neither compartment as having been logged since 1990. The evidence is that compartment 6 was last logged in 1995/6 and compartment 7 in 1996/2006. It is hard to understand where the agencies get their data from.



Available 1998 Growth Stage Mapping undertaken for the RFA overlaid with post 2000 logging records. Most of the forest is identified as regrowth or "recently disturbed", though the accuracy of this is questioned. The western part of Royal Camp appears the most structurally intact, with patches

of oldgrowth and disturbed oldgrowth. Most of the stand of disturbed oldgrowth in the eastern part of Royal Camp State Forest was logged in 2011-2012 and there was extensive logging in part of Braemar State Forest in 2006 and in Ellangowan in 2007. The rest of the forests are shown (EPA 2016) not to have been logged at least since 2001.



Map 22 from EPA (2016): Disturbance intervals for fire and logging – Royal Camp and Carwong state forests. These maps cover most of the proposed Sandy Creek Koala Park though they do not correlate with other data, for example they do not show the logging of half of compartment 16 in Royal Camp in 2012. Similarly they show (new) compartments 6 and 7 of Braemar to not have been logged

since before 1990, yet the above growth stage mapping claims compartment 6 to have been recently logged in 1998 and conversely the current 2019 HP claims it was logged in 2000. The Forestry Corporation's record keeping has always been a mess.

4.2. Current Forest Structure

The forest is dominated by Large-leaved Spotted Gum (*Corymbia henryi)* and Coastal Grey Box (*E. moluccana*). The distribution of most species is patchy. The red gums, Forest Red Gum (*E. tereticornis)* and Slaty Red Gum (*Eucalyptus glaucina)* are widespread, dominating wetter low-lying areas. Other common species are Small-fruited Grey Gum (*E. propinqua*), Narrow-leaved Ironbark (*E. crebra*) and Grey Ironbark *(E. siderophloia)*, Narrow Leafed White Mahogany (*E. acmenoides*) and Pink Bloodwood (*Corymbia intermedia*). Swamp Box (*Lophostemon suaveolens*) is more common in wetter areas, though there are not many large trees left.

Other Koala feed trees recorded (EPA 2016) are Tallowwood (*E. microcorys*) and Swamp mahogany (*E. robusta*). There are also records of Brush box (Lophostemon confertus), Blackbutt (*E. pilularus*), and Turpentine (Syncarpia glomulifera).

Common small trees are Red Ash (*Alphitonia excelsa),* Forest Oak (*Allocasuarina* spp.), Brush Ironbark Wattle *Acacia aulacocarpa*, Hickory Wattle *Acacia disparrima* and *Melaleuca* spp*.*

PLEASE NOTE: When undertaking plot work it was not feasible to differentiate the red gum species and stringybark species because of time constraints, and loss of leaves and other fire damage sometimes precluded the differentiation of ironbarks and some smaller trees. These were not considered problems for the purposes of this assessment.

There are 43 ha that have been cleared for powerlines and a rest area, some small areas totalling 132 ha that were mapped as oldgrowth in 1998, and the balance has been subject to repeated logging with a scattering of large oldgrowth trees, along with some mature trees, left amongst extensive regrowth.

To provide baseline data on the structure of the Spotted Gum-Grey Box forests of the proposed Sandy Creek Koala Park, vegetation plots were measured at 76 plots on 10 transects chosen to reasonably sample the range of logging histories and environmental variation across the forests. Sites were chosen without prior inspections, with plots located at approximately 50m paced intervals. When plots were located close to riparian areas they were relocated to the centre of streams to better sample this habitat.

Initially 12.3m radius plots were utilised, with these increased to 12.6m radius plots for ease of analysis. On each plot the diameters at breast height over bark (dbh) of all trees 10cm dbh and larger were recorded, along with species and fauna features. Sampling began after the fires and continued up until regeneration was just beginning. The fires had thus eliminated most evidence of fauna usage (and dramatically reduced fauna populations) and it was too early to ascertain tree mortality from the fires. With the understorey and coarse wood debris heavily burnt no assessment could be made of it.

In Braemar State Forest 29x475.3m^2 plots on four sites in compartment 6 were assessed, giving an assessed area of 13,784m^2. Thereafter plot size was increased to 500m^2, with 14x500m^2 plots at 2 sites in Royal Camp State Forest, 9x500m^2 plots in Carwong State Forest, 12x500m^2 plots at 2 sites in Ellangowan State Forest, and 12x500m^2 plots on land Forestry Corporation bought for pine plantations adjacent to Royal Camp SF, giving an assessed area of 23,500m^2. The total area of logged forests assessed was therefore 37,284m^2, with 1,337 trees measured on 76 plots.

STATE FORESTS	Trees per hectare (by DBH classes in cm)					
	10-19.9	**20-29.9**	**30-44.9**	**45-59.9**	**60+**	**TOTALS**
Braemar	226.4	65.3	68.9	27.6	7.3	**395.4**
Royal Camp	230.0	84.3	65.7	10.0	4.3	**394.3**
Carwong	177.8	57.8	51.1	17.8	22.2	**326.7**
Ellangowan	128.3	68.3	60	15	8.3	**280**
Plantation Purchase	173.7	70.1	58.5	26.7	6.7	**335.7**
AVERAGES	**187.2**	**69.1**	**60.8**	**19.4**	**9.7**	**346.3**

Summary of plot results for trees per hectare in size classes across proposed Sandy Creek Koala Park. DBH: Diameter at breast height.

STATE FORESTS	Basal Area, m^2 per hectare (by DBH classes in cm)					
	10-19.9	**20-29.9**	**30-44.9**	**45-59.9**	**60+**	**TOTALS**
Braemar	3.6	3.0	7.3	5.6	2.2	**21.7**
Royal Camp	3.5	3.9	6.8	2.2	2.1	**18.5**
Carwong	2.4	2.9	5.3	3.8	7.5	**21.9**
Ellangowan	2.1	3.3	6.4	3.1	4.2	**19.0**
Plantation Purchase	2.7	3.3	6.3	4.9	2.7	**20.0**
AVERAGES	**2.9**	**3.3**	**6.4**	**3.9**	**3.7**	**20.2**

Summary of plot results for basal area of trees in size classes across proposed Sandy Creek Koala Park. DBH: Diameter at breast height.

The average basal area (area of all trees over 10cm diameter at beast height) across the forest is 20.2 m^2/ha. The results are remarkably consistent between forests, varying from 18.5 m^2/ha to 21.9 m^2/ha, with the less recently logged Carwong and Braemar forests with the highest standing volumes. There was significant variability between plots, from 7-40 m^2/ha.

Summary of plot results for unlogged forest in Banyabba State Forest:

	Trees per hectare (by DBH classes in cm)						
	10-19.9	**20-29.9**	**30-44.9**	**45-59.9**	**60-79.9**	**80+**	**TOTALS**
Banyabba 1	326.6	50	23.3	43.3	26.7	10	**480**
Banyabba 2	223.3	33.3	33.3	46.7	36.7	20	**393.3**
AVERAGE	**275.0**	**41.7**	**28.3**	**45.0**	**31.7**	**15.0**	**436.7**

Summary of plot results for trees per hectare in size classes in unlogged forest in Banyabba SF. DBH: Diameter at breast height.

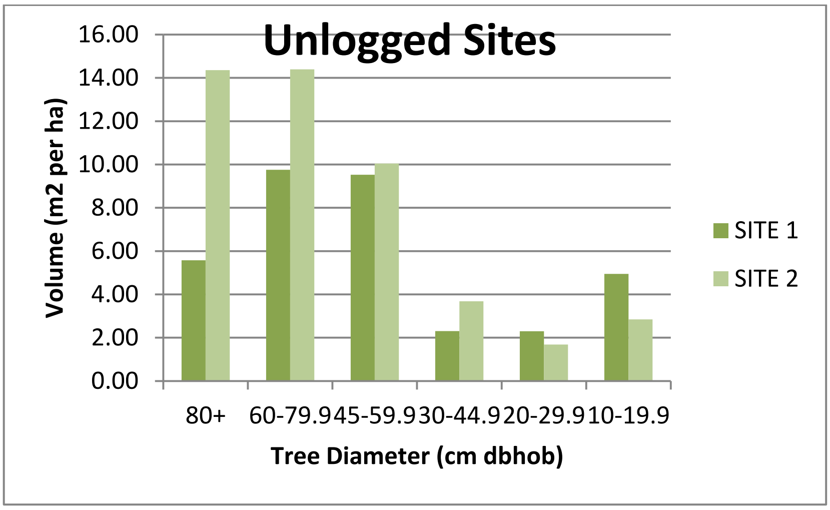
To obtain a reference to assess logging changes against, in particular an indication of the potential carbon carry capacity of the forest, 2 transects comprising 12x500m^2 plots were measured in CRAFTI mapped oldgrowth forest in Banyabba State Forest. There were only small areas of the floristically similar Clarence Lowlands Spotted Gum available, amongst extensive areas of Lowland Redgum. 10 plots were located in Clarence Lowlands Spotted Gum, with 2 plots in Lowland

Redgum. The overstorey was floristically similar, with Orange Gum replacing Grey Gum at Banyabba SF.

	Basal Area m^2 per hectare (by DBH classes in cm)						
	10-19.9	**20-29.9**	**30-44.9**	**45-59.9**	**60-79.9**	**80+**	**TOTALS**
Banyabba 1	4.9	2.3	2.3	9.5	9.8	5.6	**34.4**
Banyabba 2	2.9	1.7	3.7	10	14.4	14.4	**47.0**
AVERAGE	**3.9**	**2**	**3**	**9.8**	**12.1**	**10**	**40.7**

Summary of plot results for basal area of trees in size classes in unlogged forest in Banyabba SF. DBH: Diameter at breast height.

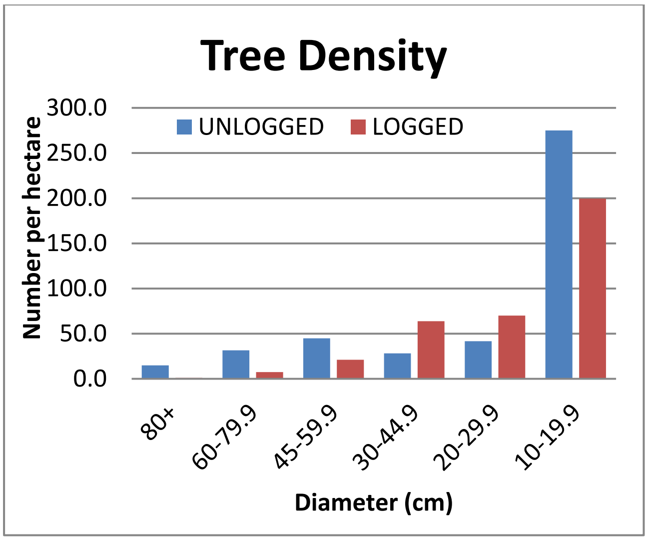
Both sites in the unlogged forests were considered to be lower site quality than Sandy Creek, and Site 1 was likely subject to some historical loss of large hollow-bearing trees due to burning or possibly ringbarking, though evidence of the cause was not apparent. These data are therefore considered to be conservative, and still below the potential carbon storage of the forest. Transect basal areas varied from 34.4 - 47 m^2/ha, giving a combined average of 40.7 m^2/ha. Individual plots recorded up to 57 m^2/ha. Site 2 more closely resembled the expected structure of an oldgrowth stand, suggesting it may be more representative of the structure and carbon carrying capacity of an oldgrowth stand. More plots are required to better characterise an oldgrowth stand, with the averages adopted here considered to be a conservative under-estimation.

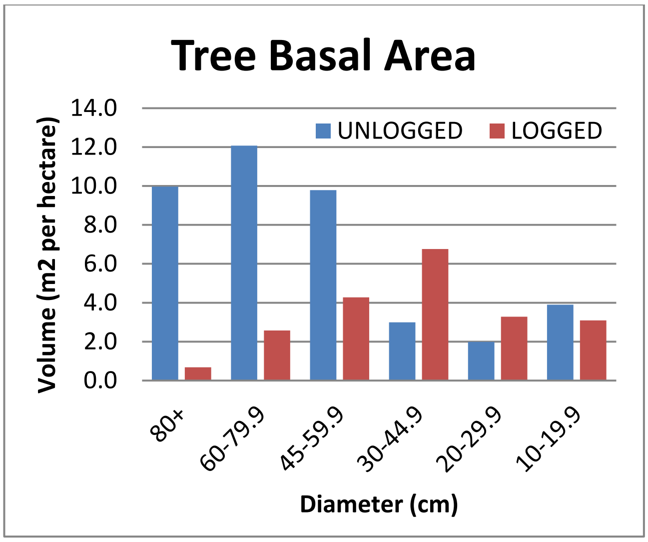


Comparison of the two unlogged sites, showing the relatively low number of larger trees at Site 1 which may reflect the historical loss of large hollow-bearing trees due to wildfire or ringbarking. While the average of these sites has been applied, it is likely that Site 2 is more representative of an average oldgrowth stand.

Comparison between the logged and unlogged forests identify a reduction in basal area from 40.7 m^2 per hectare down to 20.2 m^2, primarily attributable to past logging. Based on these data the unlogged forest has twice the basal area of the logged forests. The increased basal area of the small tree size of 10-19.9 cm dbh in the unlogged forest is primarily due to a high number of Forest oaks. The starkest difference is in trees greater than 45cm dbh, which is not surprising as these constitute the sought-after large high quality sawlogs. The logged forests have an average basal area of trees >45cm dbh of 7.6 m^2/ha, compared to a basal area of 31.8 m^2/ha in the unlogged forests, which is 4.2 times as much.

The tree data indicate that there has been an overall decline of 25% of the number of trees over 30 cm dbh due to logging over the past century, with 57% of trees 45-60 cm dbh and 79% of trees over 60cm dbh and removed. There has been a corresponding 215% increase in trees 30-45 cm dbh, showing the significant reduction in the age of the forests.



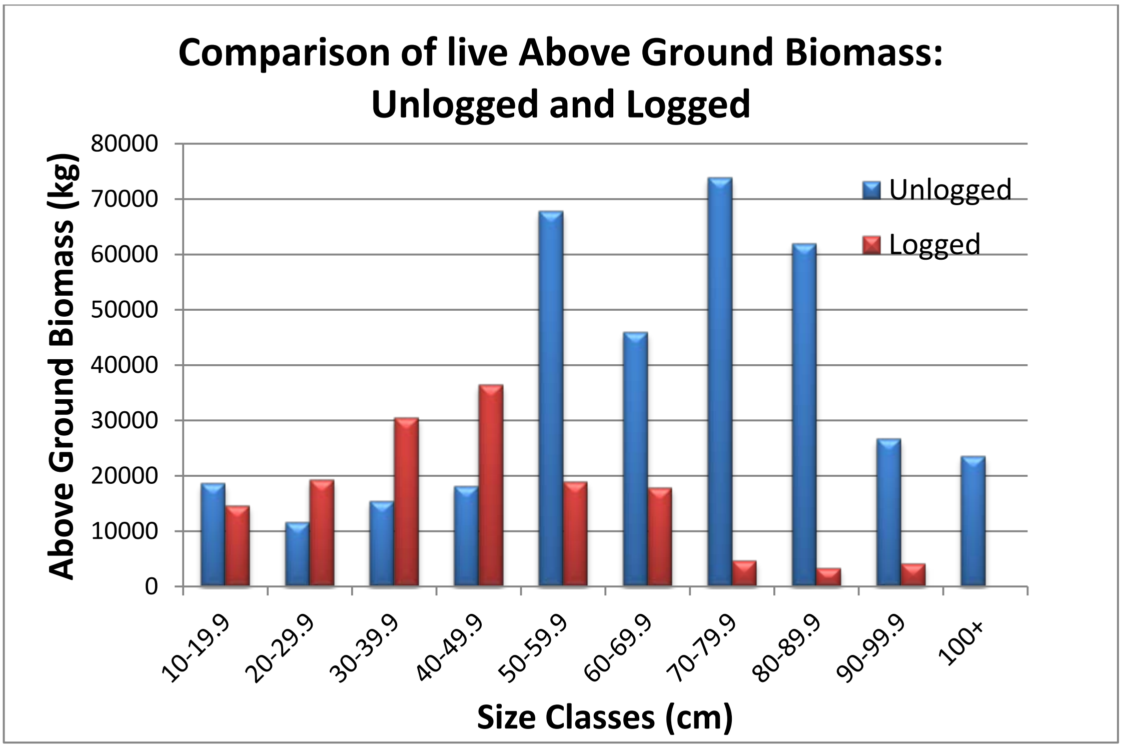


Comparison of trees and basal area according to size class between logged and unlogged forests.

The tree dbh data was transformed to biomass estimates using an allometric equation provided by Heather Keith (Section 5.2.1.). These data show there has been an overall loss of 59% of live above ground biomass from these forests, which increases to 65% of biomass for trees above 30 cm dbh and to 84% of biomass for trees above 50 cm dbh. It is abundantly clear that there has been a significant reduction in the larger trees targeted for logging.

Size class (cm)	Unlogged		Logged		% Change	
	No/ha	Biomass/kg/ha	No/ha	Biomass/kg/ha	No/ha	Biomass/kg/ha
10-19.9	258.3	18,612	188	14,639	-27.2	-21.3
20-29.9	38.3	11,561	64.9	19,193	69.5	66.0
30-39.9	20	15,422	44.8	30,460	124.0	97.5
40-49.9	13.3	18,106	29.2	36,474	119.5	101.4
50-59.9	33.3	67,850	8.6	18.889	-74.2	-72.2
60-69.9	15	45,972	5.9	17,859	-60.7	-61.2
70-79.9	16.7	73,833	1.1	4,665	-93.4	-93.7
80-89.9	10	61,930	0.5	3,319	-95.0	-94.6
90-99.9	3.3	26,627	0.5	4,106	-84.8	-84.6
100+	1.7	23,504	0	0	-100.0	-100.0
Total	410	363,417	343.6	149,604	-16.2	-58.8

Comparison between unlogged and logged tree size classes for numbers of trees and above ground biomass.



Comparison of Above Ground Biomass of logged and unlogged plots showing the dramatic reduction in the biomass of larger trees.

The loss of 217 tonnes per hectare of above ground biomass of trees above 30 cm dbh, a 65% reduction, is part of the cost of a hundred years of logging, and can be costed as both the value of timber lost and part of the volume of carbon released to the atmosphere. While public forestry operates at a financial loss, this depletion of biomass of large trees is part of the uncosted public losses due to forestry. These losses also illustrate the massive contribution these forests can make to climate heating if they are allowed to recover and recapture the lost carbon from the air and store it in their growing trunks and soils.

The 65% reduction of biomass for trees above 30 cm dbh also reflects a loss of the volumes of leaves available for Koalas to eat given their preferences for larger trees. It is likely that this reduction in potential food would have caused a corresponding decline in Koalas before they were decimated by the 2019 fire. Given that losses of biomass increases with tree size it is evident that the increased losses of larger feed trees preferred by Koalas will have had a disproportionate impact on their food and population. These resource losses extend to species using nectar from trees and tree hollows.

4.3. Net Logging Area

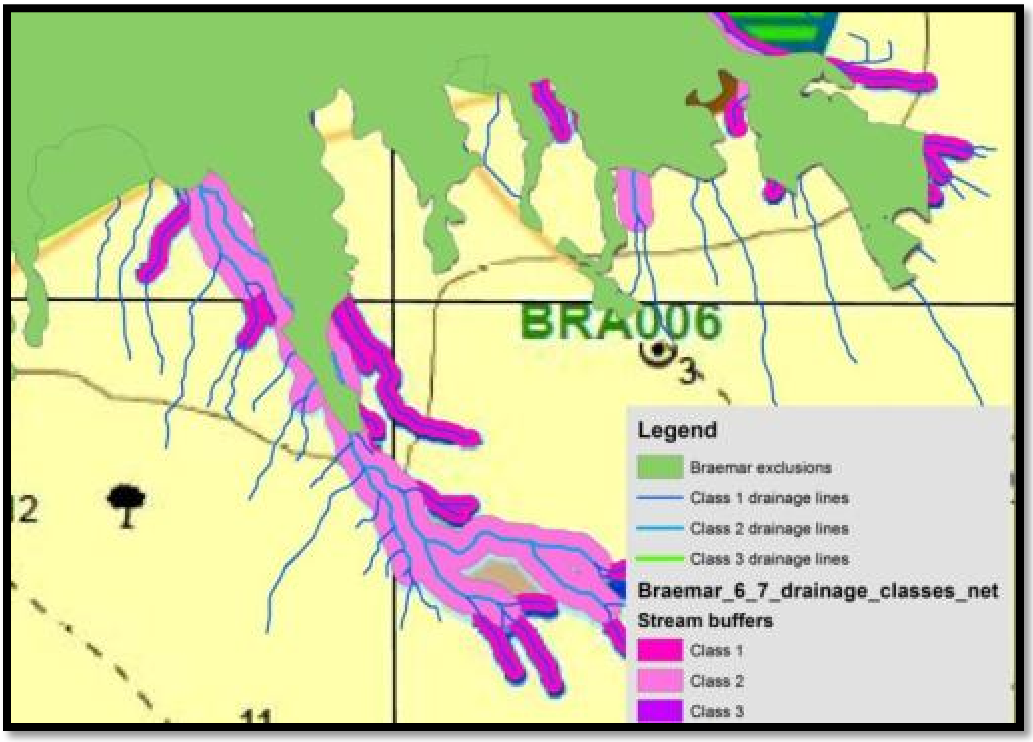
It is apparent that, with the exception of parts of the western part of Royal Camp State Forest, the forests comprising this proposal have been heavily logged in the past. A total of 132 ha is mapped as oldgrowth forest, which is primarily in more rugged terrain in western Royal Camp State Forest. Over the last couple of decades there have been increasing logging exclusions, along with reductions in protections for threatened species and streams, and increases in logging intensity. The outcome is that under the 2018 Coastal Integrated Forestry Operations Approval (CIFOA) around 35% of the forest is now required to be excluded from logging, though most of this has been heavily logged in the past.

As an outcome of the 2000 North East NSW Regional Forest Agreement (RFA) certain parts of the forest were required to be excluded from further logging, mostly oldgrowth, wetlands and riparian zones. These resulted in 649 ha (9.3%) being included in Forest Management Zones 1, 2 and 3A.

In recent years Endangered Ecological Communities have been mapped as exclusion areas, in this area the Endangered Ecological Community Subtropical Coastal Floodplain Forest was identified in 2004, though illegal logging continued (Section 2.1). Within this proposal 716 ha (10.2%) was mapped as this EEC in 2016.

The Environment Protection Licence (EPL) issued as part of the 1999 Integrated Forestry Operations Approval (IFOA) required the protection of riparian buffers, both to mapped (1:25,000) and unmapped streams according to stream order. Both 'first order' and 'unmapped streams', which comprise most headwater streams, required 10m buffers. The EPL was altered in 2004 to allow unmapped streams to be logged, which comprised around half of these vital headwater streams. While the Fisheries Licence still required their protection upstream of threatened fish., it wasn't until NEFA highlighted the illegal logging of unmapped streams in Eastern Freshwater Cod habitat in 2009 that this began to change. NEFA exposed that widespread illegal logging of unmapped streams in Purple Spotted Gudgeon Habitat was still occurring in 2018.

In recent years streams were remapped by LIDAR, providing more accurate delineation of all streams. The new 2018 Integrated Forestry Operations Approval (IFOA) established stream protections based on the LIDAR mapping and catchment size, with the new rules being that all headwater streams in catchments less than 20ha will have buffers reduced from mostly 10m to 5m (except where it is Class 1 Aquatic Habitat). These are termed Class 1 drainage lines. While the EPA informed NEFA that all Class 1 drainage lines require 5m buffers, it is now apparent that these are subject to ground assessments to ascertain whether there is a defined channel.



Example showing stream buffers as mapped in the 2019 HP as compared to mapped drainage lines. Note the extension of numerous Class 1 streams outside mapped buffers.

The 2019 Harvesting Plan for Braemar SF compartments 6 and 7 shows most Class 1 drainage lines with no buffers. It is apparent that on the flat topography of the Richmond River lowlands the Class 1 drainage lines often take the form of shallow braided drainage lines spread across creek flats, that often do not form single deep channels as is normal in steeper country. This means in practice that most Class 1 drainage lines do not meet the definition for protection.

Because buffers are only being applied on a selective basis it is not possible for this assessment of the net logging area to apply buffers to the LIDAR mapping. Therefore for indicative purposes the old 1:25,000 stream buffers were applied. Riparian protection are likely to result in something like an additional 531 ha being protected, though in practice could be less.

The Threatened Species Licence (TSL) under the previous IFOA required surveys for a range of threatened plant and animal species, and the implementation of prescriptions for any of the species found. For example the Brush-tailed Phascogale required the establishment of 20ha exclusion areas around records, and the Squirrel Glider required 8ha exclusion areas. Under the new Coastal IFOA the exclusion areas already protected for these species will be incorporated into Wildlife Habitat Clumps, though there will no longer be requirements to survey for and protect additional areas.

Instead of requiring surveys and prescriptions for most threatened species the new Coastal IFOA Conditions include the requirement to identify Wildlife Habitat Clumps:

> *50.1 At least five per cent of the **base net area** of each **local landscape area** must be identified prior to the commencement of a **forestry operation** (other than **road maintenance**) in each **local landscape area**, and permanently retained as **wildlife habitat clumps** in accordance with **Protocol 22: Wildlife habitat and tree retention clumps***

Requirements to retain up to 5 Hollow-bearing Trees per hectare have been replaced with requirements to retain up to 8 Hollow-bearing Trees, though the requirements to retain a mature 'Recruitment' tree for each Hollow-bearing Tree has been removed. Similarly requirements to retain 3-5 mature eucalypt feed trees per hectare have been removed, except within 2 km of records of Regent Honeyeater and Swift Parrot. The new Coastal IFOA Conditions require the retention of Tree Retention Clumps:

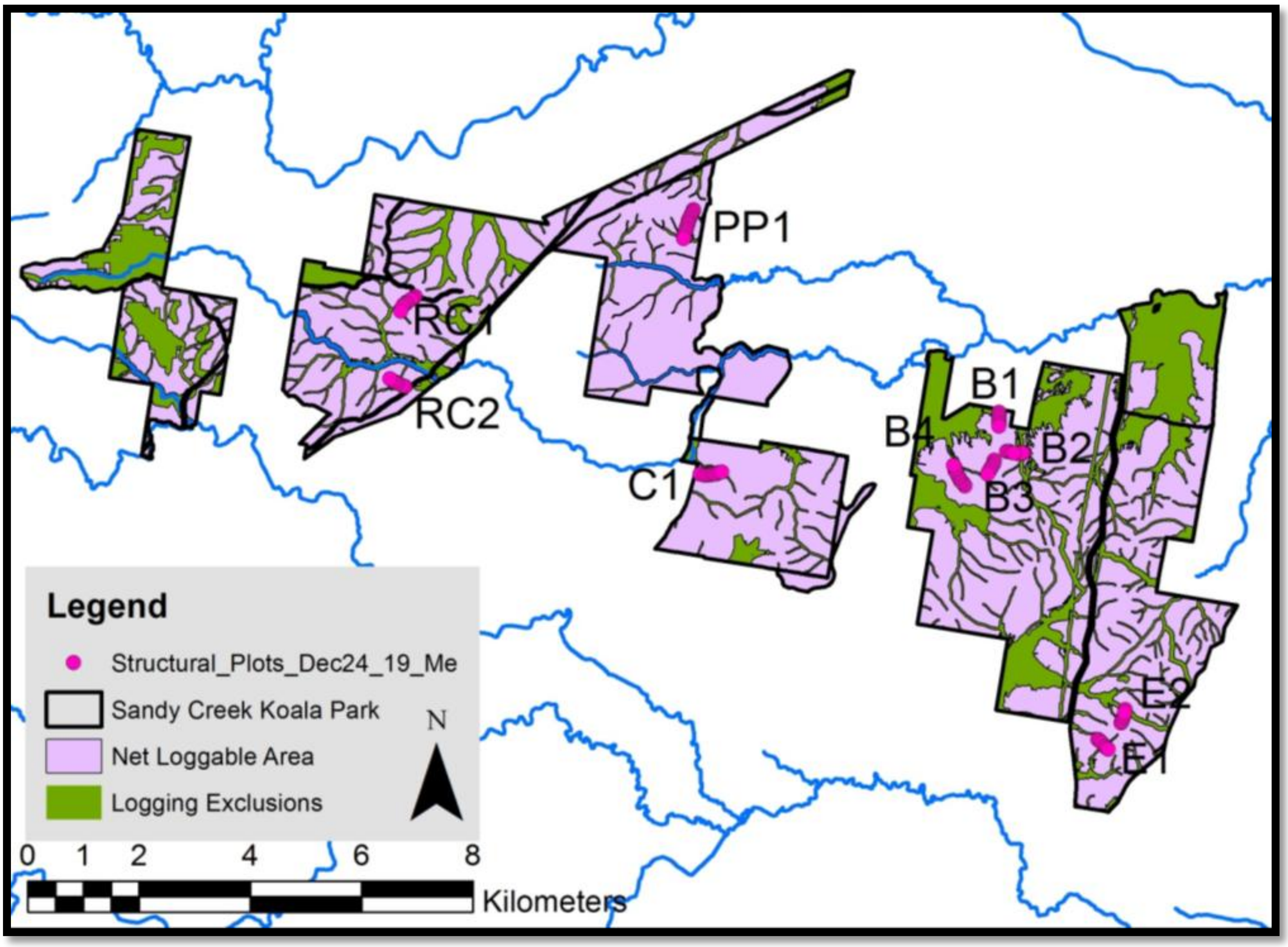
> *63.1 **Tree retention clumps** must be identified and permanently retained at least 100 metres in advance of a **forestry operation** (other than **road maintenance**) in any part of an **operational area**, at the following rates:*
> *at least five per cent of the **base net area** in each **compartment** in the **regrowth zone***

Application of indicative exclusions to identify the net logging area:

	Exclusions	Areas
Total Area		6988 ha
Cleared (43ha)&Crown (14ha)	57 ha	
Add FMZ 123a	649 ha	
Add EEC outside FMZ	716 ha	
Add Stream buffers, outside above	531 ha	
Add habitat tree and wildlife clumps (10% remaining net area)	504 ha	
Net Logging Area		4531 ha

The requirements to protect Wildlife Habitat Clumps and Tree retention clumps will result in the protection of some 504 ha of additional forest. Experience with Braemar State Forest and the nearby Myrtle State Forest demonstrates that in practice the selection of these is primarily based on minimising timber impacts rather than protecting important habitat.

In total these indicative logging exclusions total 2457 ha (35% of gross area), leaving a net logging area of 4,531 ha.



Structural Plot locations and indicative net logging area.

For carbon accounting calculations the net logging area is taken to be 4,530 ha, with 2,414 ha (35%) excluded from logging and capable of regeneration. The 43 ha of cleared land is not accounted for on the grounds that it is comprised of a powerline easement and rest area, which will remain cleared.

Most of the excluded areas have been heavily logged in the past. Despite being excluded from logging in recent years, most riparian plots are within the variability of the harvestable plots, though do have an increased average volume compared to the net logging area, though far less than unlogged forest. Ten of the 76 structural plots were situated in riparian exclusions, with a basal area from 15-30 m^2/ha, averaging 23 m^2/ha, compared to 19.9 m^2/ha for the net logging area.

Other exclusion areas were also mostly heavily disturbed (in the east) and not targeted for plots, so for assessment purposes were taken to be similar to the net logging area. The western section of Royal Camp is the most structurally intact, though was not inspected for this assessment. The exclusion areas makes no material difference when comparing scenarios as they are excluded under both.

The new Coastal IFOA only requires retention of a minimum basal area of 10 m^2/ha in the net logging area of these forests. The 2019 Harvesting Plan (HP) for compartments 6 and 7 of Braemar State Forest identifies an existing basal area of 19m^2, with the intent to remove 47% of the basal area and an emphasis on removing most of the trees over 45cm dbh. This assessment identifies an average basal area of 20.2 m^2/ha, therefore it can be expected that over-time the basal area of the logged forests will be halved down to 10 m^2/ha.

4.4. Structural Collapse

The principal weed observed in these forests is Lantana (*Lantana camara*) and it is primarily limited to wetter gullies and riparian areas along larger streams. Where lantana is dense it has facilitated the development of Bell Miner Associated Dieback (BMAD), with significant occurrences noted along Sandy Creek in Royal Camp State Forest, in the gullies around the Braemar Fire Tower ridge in Braemar State Forest and along a creek in the south of Ellangowan State Forest.

Bell Miner Associated Dieback on boundary of logging area near Sandy Creek in Royal Camp State Forest in 2012. The risk of aggravating the problem was totally ignored despite NEFA's complaints.

Lantana 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. The NSW

Scientific Committee has 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”.*

Logging, fire and cattle grazing are significant contributors to the successful invasion of lantana (Gentle and Duggin 1997, Raizada and Raghubanshi 2010), 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). Gentle and Duggin (1997) concluded “*The effects of biomass reduction and soil disturbance associated with fire and cattle grazing are significant in the successful invasion of* L. Camara”. This is supported by Wardell-Johnson *et. al.* (2006): “*the proliferation of dominant understorey weeds, such as Lantana (Lantana camara), in the north-eastern region of NSW has largely been attributed to the disturbance caused by logging and associated activities”.*

The increasing dominance of forest understoreys by lantana in north-east NSW significantly increases their flammability and poses a significant wildfire threat. Murray *et. al.* (2013) found that the average higher flammability of dry leaves of exotics, combined with their larger leaves, meant "*exotic plant species have the potential to increase the spread of bushfires in dry sclerophyll forest*". 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.

The evidence is clear that by opening up the overstorey and disturbing the understorey, logging can facilitate the invasion and spread of lantana and thereby initiate and promote Bell Miner Associated Dieback (BMAD).

Bell Miner Associated Dieback (BMAD) is spreading through our forests as a consequence of logging opening the canopy and promoting understorey dominance by lantana. It is principally a problem of wet forests and gullies, though is increasingly affecting surrounding forests subject to lantana invasion. For over two decades the Forestry Corporation have intentionally procrastinated over the causes and management of BMAD so that they can go on logging affected and susceptible stands.

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:

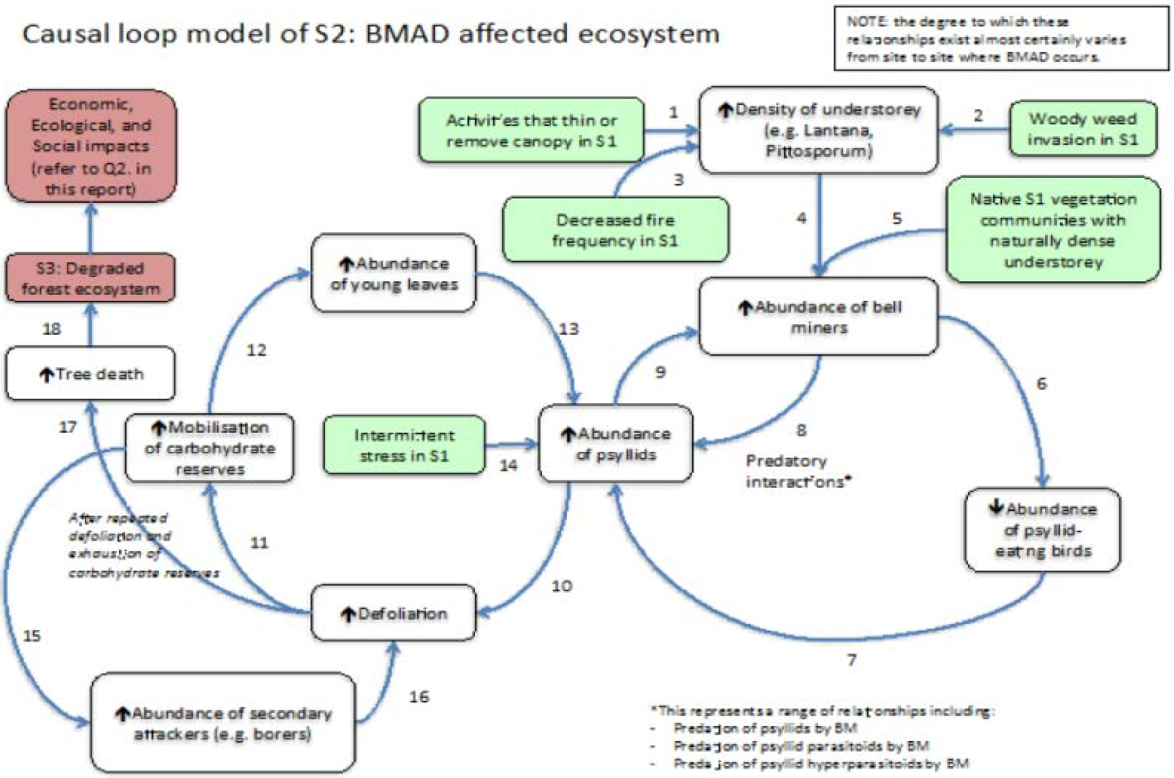
> *Broad-scale canopy dieback associated with psyllids and Bell Miners usually occurs in disturbed landscapes, and involves interactions between habitat fragmentation, logging, nutrient enrichment, altered fire regimes and weed-invasion (Wardell-Johnson et al. 2006).* ... *Over-abundant psyllid populations 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.*

Stone et. al. (1995) found 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.”*

In their review Wardell-Johnson *et. al*. (2006) identify that many authors who have studied BMAD have identified logging as a cause, noting:

Hence, logging operations may be both implicated in the development of BMAD, and affected by changes in yield induced by BMAD. Nevertheless, the literature remains very limited concerning the impacts of logging and associated disturbance on the initiation or development of BMAD.

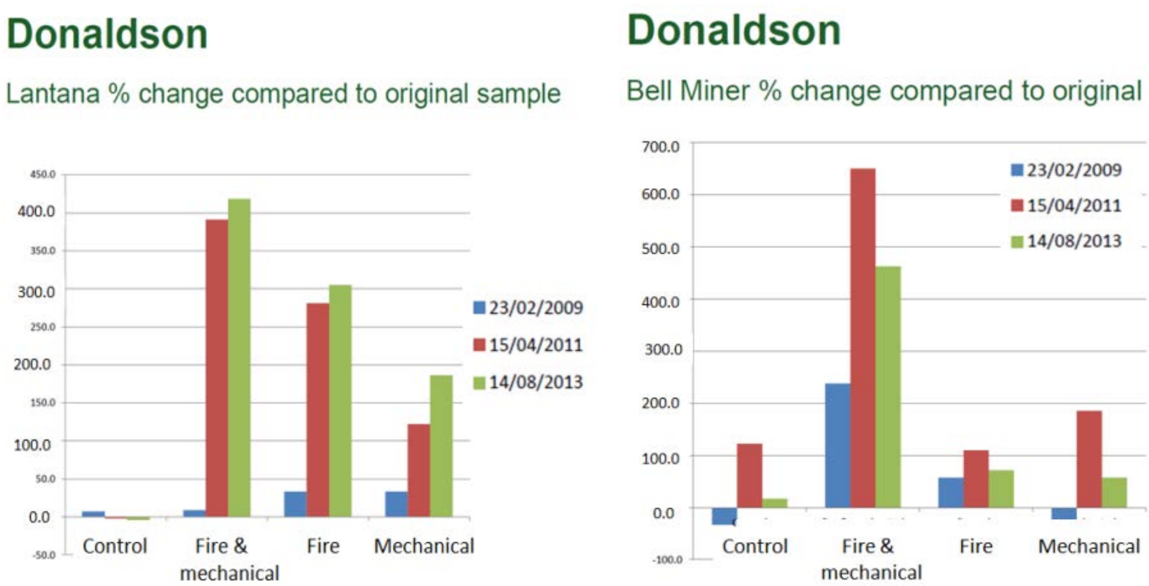
NSW DPI recently completed another literature review of the causes of BMAD (Silver and Carnegie 2017). They derived a conceptual model, which yet again identifies "activities that thin or remove canopy" as the primary cause of BMAD.



Under the auspices of the Bell Miner Associated Dieback Working Group the then State Forests established management "trials" of BMAD in compartments Donaldson State Forest in 2005 and Mt Lindesay State Forest in 2007. It is no surprise that the Forestry Corporation tried to suppress the results (and still tries to) as the Donaldson Trials clearly show that the use of mechanical and fire treatments together resulted in 420% increases in lantana and 460% increases in Bell Miners after 8 years (FCNSW 2015), and the Mt. Lindesay trials found that logging increased lantana 145% and Bell Miners 104%, after 6 years (averaged across all plots, including those not affected by BMAD).

The latest subjective aerial mapping of BMAD (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.

It is recognised that stress may be a factor involved in the proliferation of BMAD and that BMAD becomes worse during periods of low rainfall (i.e. Stone 2005, Jurskis and Walmsley 2012, Silver and Carnegie 2017). This suggests that global warming, with its increasing temperatures, skyrocketing evaporation and intensifying droughts is likely to be a major contributor to increasing BMAD.



Forestry Corporation (2015) results for 2005 trials of the impacts of mechanical disturbance and burning on lantana and Bell Miners in Donaldson State Forest.

NEFA's extensive experience with BMAD leaves us in no doubt that logging and associated disturbances are the principal factor responsible for the alarming spread of BMAD through our forests. The solution to BMAD is to stop logging affected and susceptible forests and to rehabilitate affected areas to reduce their suitability for Bell Miners.

The solution to BMAD is to remove the lantana (or other low dense vegetation) component, thereby removing the habitat favoured by Bell Miners and allowing for regeneration. The 2019 fires have killed most lantana, creating an opportunity to get rid of it before it comes back with a vengeance.

4.5. Structural Change Impacts on Burning

Logging makes forests, and thus Koalas, more vulnerable to wildfires 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. It is also the largest trees, spread out in a multi-aged forest, that provide the best refuges for Koalas during fires.

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*

From their assessment of the flammability of Tasmanian forests, Winto-Lewin *et. al.* (2020) concluded:

> *The lower flammability of older forests, and their importance as an increasing store of carbon, suggests that a cessation of logging outside plantations might have considerable benefits.*

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, Winto-Lewin *et. al.* 2020)
- 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, Winto-Lewin *et. al.* 2020),
- changing the understorey vegetation composition by opening the canopy, increasing disturbance adapted species and reducing fuel moisture (Gill and Zylstra 2005, Lindenmayer *et. al.* 2009, Zylstra 2018, Winto-Lewin *et. al.* 2020)
- 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*". Winto-Lewin *et. al.* (2020) found:

> *Fuel load reaches an equilibrium after 40–70 years [19], but fuel moisture may continue to increase with age as the understorey trees and shrubs form closed canopies and water-holding moss mats and fern beds develop*

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 (Section 5.4.1.). 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.

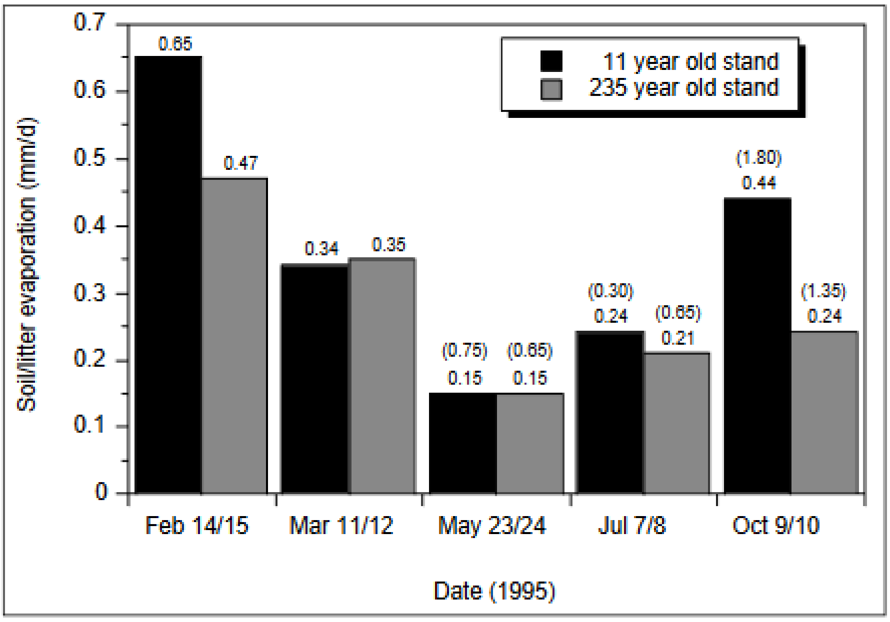
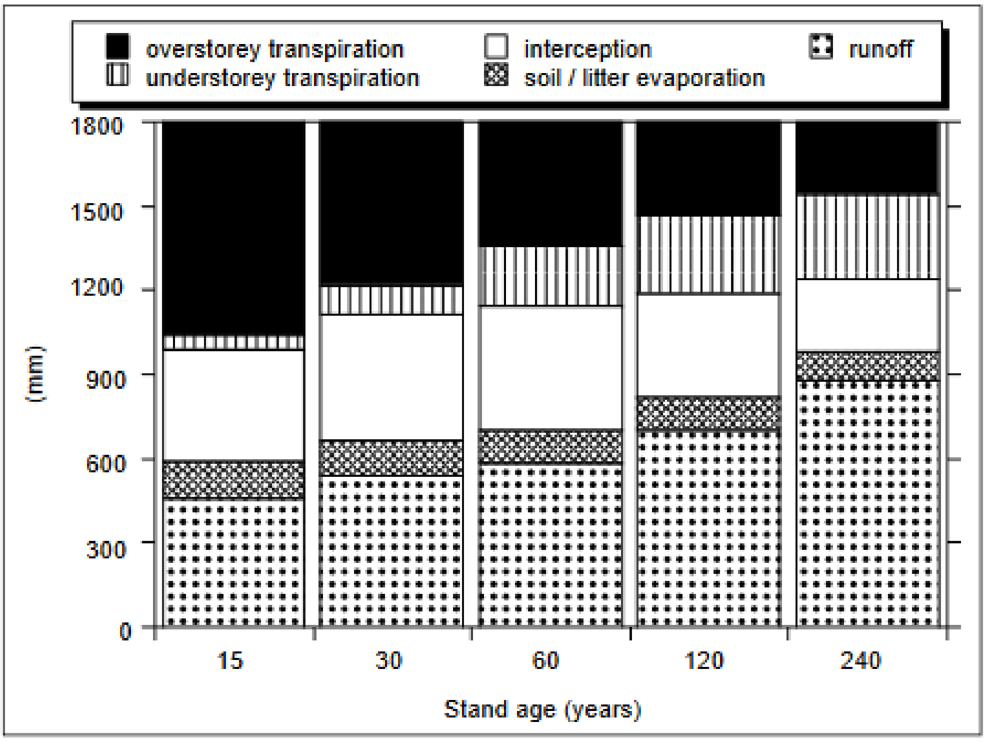


Figure 22 from Vertessy *et. al.* (1998): Comparison of soil/litter evaporation estimates beneath 11 and 235 year old mountain ash forest stands, showing major increases in the hottest months.

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.

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*".

From their investigation of fuel in wet Mountain Ash forests, Cawson *et. al.* (2018) concluded that there was always abundant fuel, therefore fuel moisture is a key factor:

> *Importantly, there appeared to always be high quantities of fuel, irrespective of disturbance history, which demonstrates that fire occurrence is not fuel-limited in wet sclerophyll forests. Under conditions of abundant fuel, fuel moisture is likely to be critical to fire occurrence. This has implications for forest management both now and in the future. Management should prioritize efforts to quantify not only the role of individual fuel components to flammability but also fuel moisture dynamics in wet sclerophyll forests to enable better predictions of wildfire risk. Under climate change, a drier climate could make the fuels in wet sclerophyll forests available to burn more frequently. This poses a major challenge for forest managers as too frequent wildfire threatens the viability of these forests.*

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).

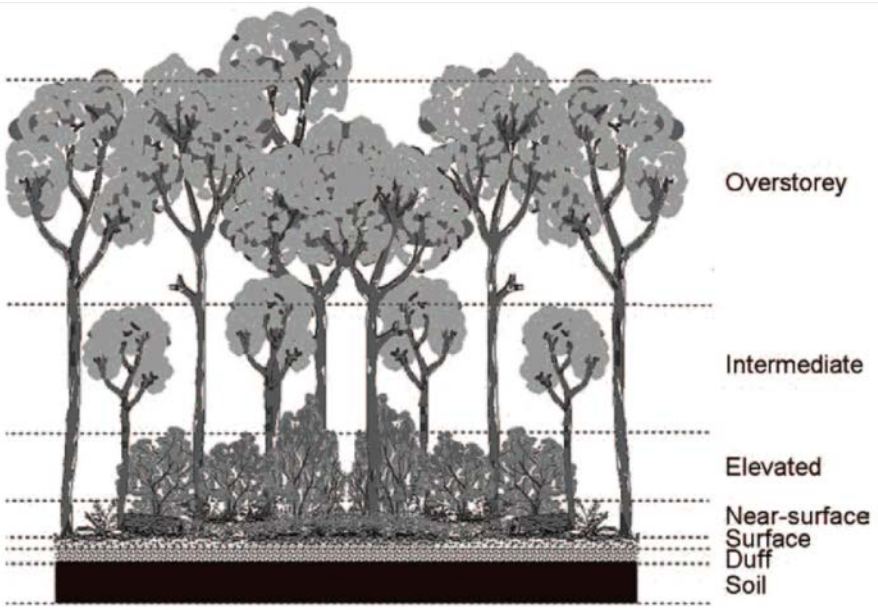


Figure 3.6 from Sullivan *et. al.* (2012) showing categories of forest fuel strata.

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, Cawson *et. al.* 2018, Winto-Lewin *et. al.* 2020). 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).

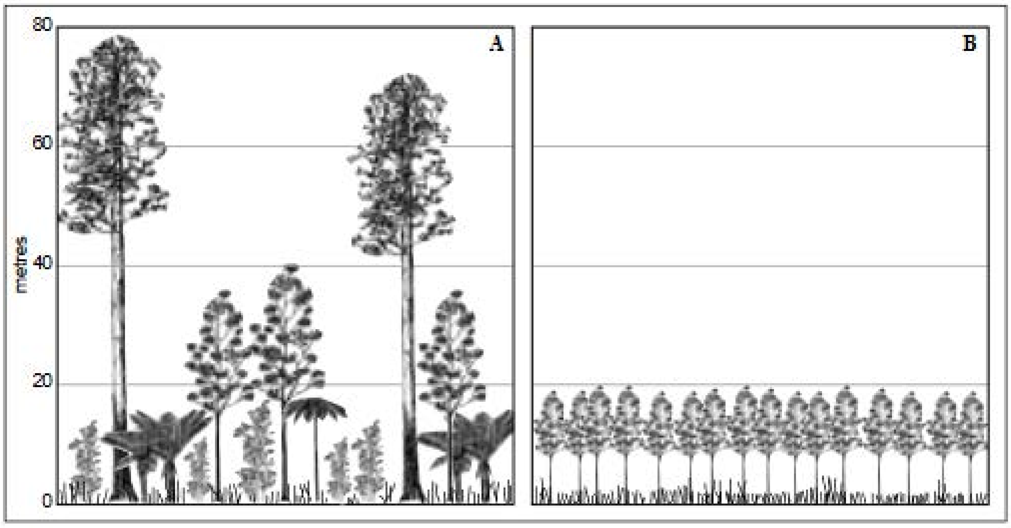


Figure 9 from Vertessy *et. al. 1998*: Comparison of forest structure in (A) old growth and (B) regrowth mountain ash stands. It beggars belief the anybody could deny that the reduced canopy height and increased canopy continuity is likely to result in increased canopy fires.

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*"

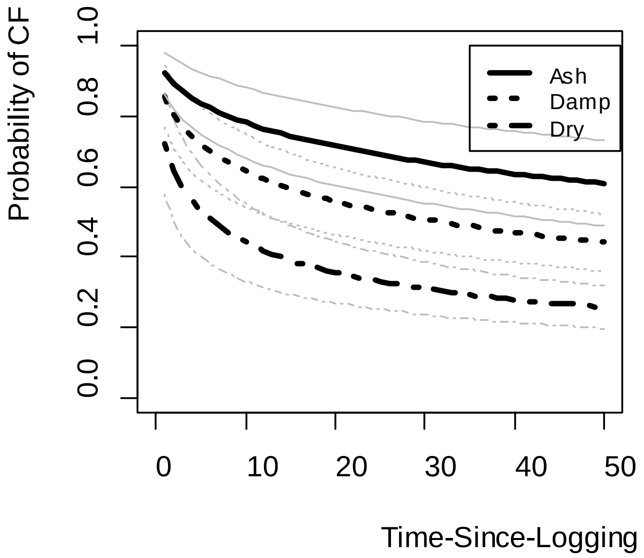
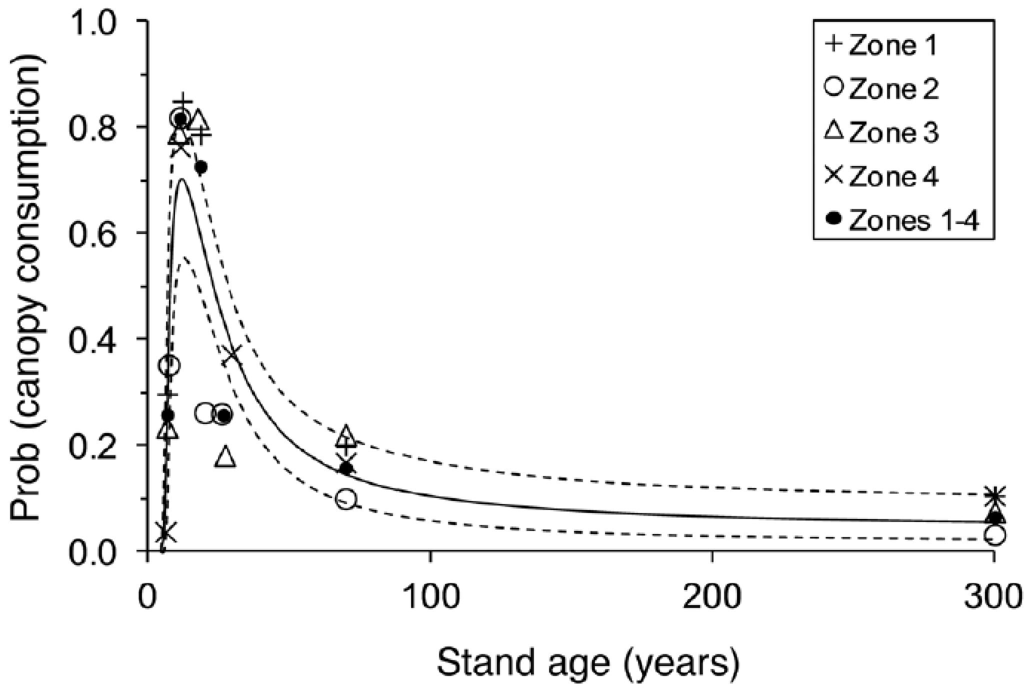


Figure 1 from Price & Bradstock (2012): Model predictions for crown fire against time-since-logging and forest type using the best model. In all cases, the models are for fire weather Moderate, slope = 0, topographic position = 50%, time-since-fire = 25 years, and aspect = East. Confidence limits for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



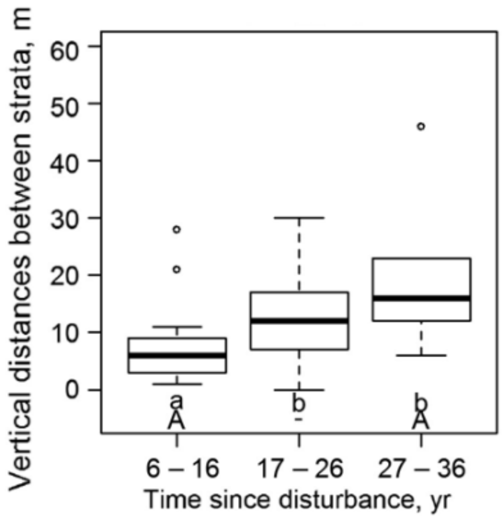
Probability of canopy consumption versus stand age (Fig 7 from Taylor *et. al.* 2014)

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.

Cawson et. al. (2018) found that typically vertical distance between strata increased significantly with time since logging, noting "*The size of vertical gaps is likely to influence the propensity for crown fire with crown fires occurring more often in younger wet sclerophyll forests where the vertical gap is smaller*".



Vertical distances (m) between strata as a function of time since logging. Adapted from Fig 8 in Cawson *et. al.* 2018.

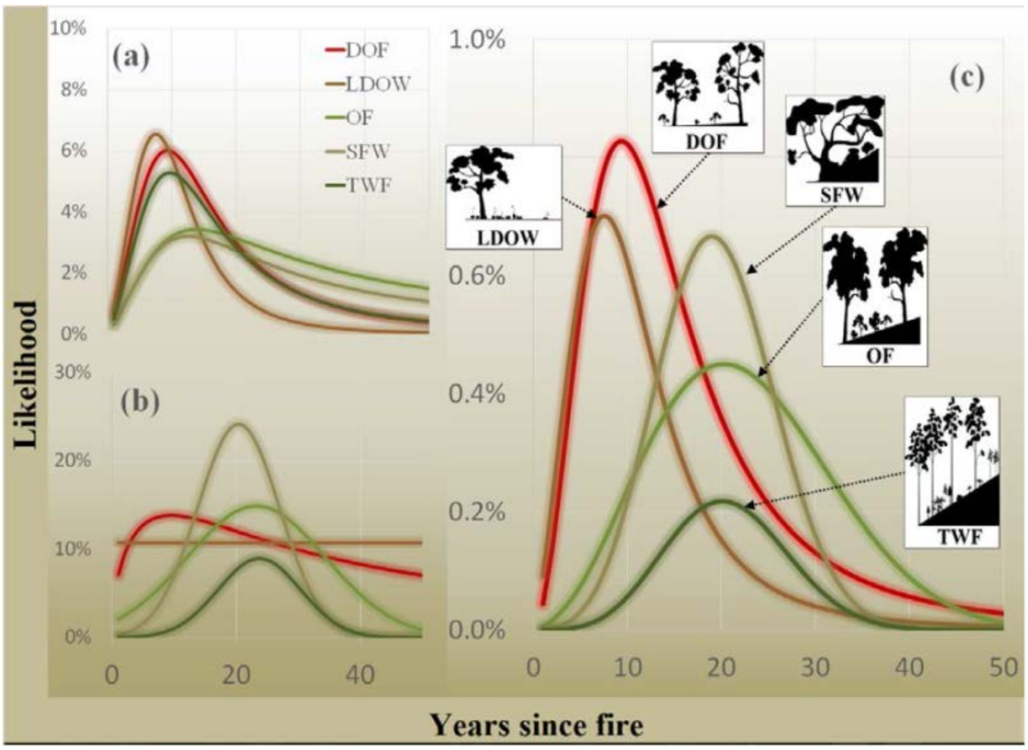
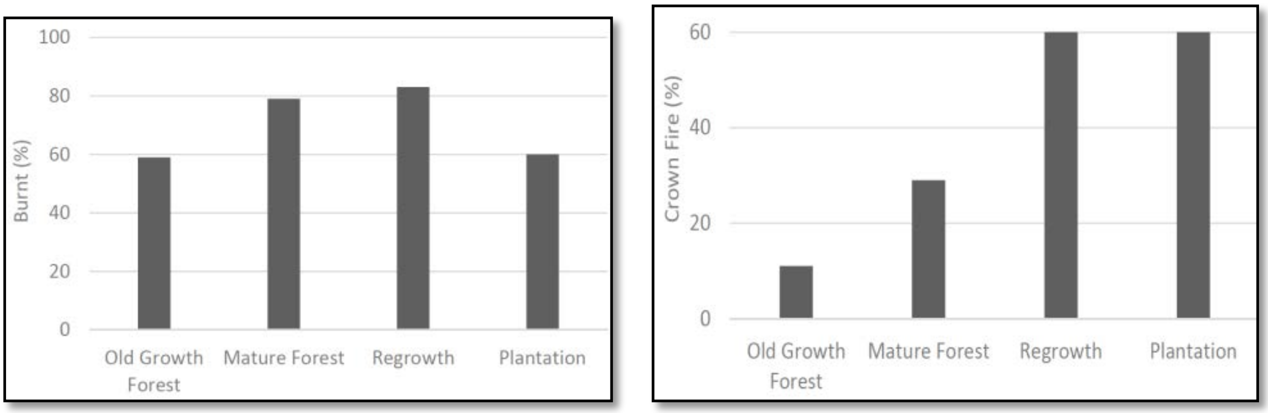


Figure 5 from Zylstra (2018). Flammability trends for each formation, where the *x*-axis gives years since the last fire, and the *y*-axis gives likelihood for (a) fire burning a point (*Lf*), (b) crown fire occurring if that point is burning (*Lcb*); and (c) crown fire occurring at any point (*Lc*).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

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.*

Winto-Lewin *et. al.* (2020) assessed fire severity of the 2019 fires in Southern Tasmania in four forest types: regrowth, mature forest, old growth forest and plantation. They found "*a higher incidence of canopy scorch or consumption by fire in regrowth forests than in both mature and old growth forests*".



Winto-Lewin *et. al.* (2020) found oldgrowth forest burnt less, with significantly less crown fires, than regrowth. LEFT: Figure 2. The percentage of sites burned in each forest type. RIGHT: Figure 3. The percentage of sites that experienced crown fire.

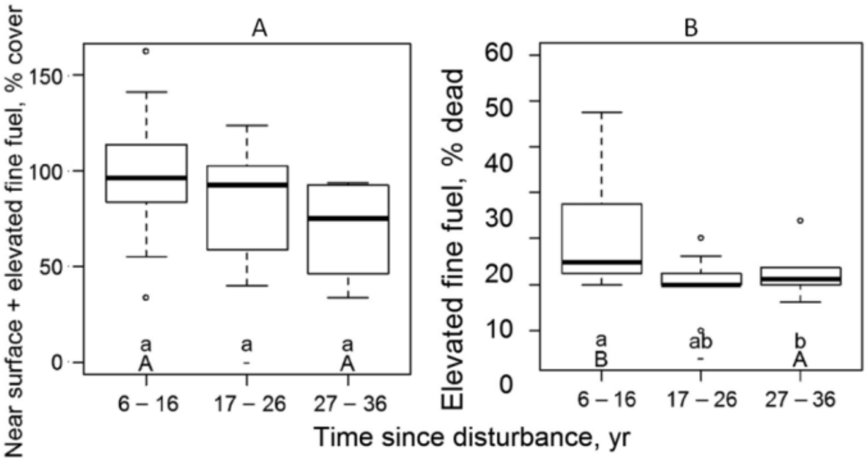
Winto-Lewin *et. al.* (2020) concluded:

> *Our study predicts a positive feedback mechanism by which the high intensity fire that is used to regenerate clearfelled coupes in wet forests increases the severity of fire in regenerating forests. This feedback will cause wet eucalypt forests to be maintained in a younger age class. If the frequency of canopy-consuming fire increases to more than two fires within 20–30 years, this may cause the localised extinction of obligate seeders, such as E. regnans*

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*

The study by Cawson *et. al.* (2018) found there were no significant differences in fuel depth between the age classes for the logged sites. The changes in cover of near surface and elevated fine fuels was not considered significant, however there was a significantly higher proportion of dead, elevated fuels between the most recently disturbed (6–16 yr) and older (27–36 yr) logged sites. Though they considered "*Low levels of dead material within the elevated fuel of Mountain Ash forest mean it is unlikely to have a major impact on fuel hazard and flammability*".



A: cover of near surface and elevated fine fuel as a function of time since logging. B: proportion (%) of elevated fine fuel that was dead as a function of time since logging. Adapted from Figs 3 and 4 in Cawson *et. al.* 2018.

Changes in the species composition of understorey has also been attributed as a factor affecting flammability. Lindenmayer *et. al* (2009) observe "*logging in some moist forests in south eastern Australia has shifted the vegetation composition toward one more characteristic of drier forests that tend to be more fire prone*".

In their study of Mountain Ash forests following logging, Cawson *et. al.* (2018) found the dominance of ferns increased with time since logging, although this was not statistically significant. They note:

> *Soil disturbance during the clear-felling operation is thought to damage propagules for resprouting species including ferns (Ough 2001). Ferns and other mesic species are thought to reduce forest flammability (McCarthy et al. 2001), but the magnitude of their effects nor their mechanisms for influencing flammability have not been formally quantified.*

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 within the gullies in the proposed Sandy Creek Koala Park poses a significant wildfire threat. Within this proposal, Lantana has already initiated Bell Miner Associated Dieback which will further open the canopy, increase lantana and increase flammability. Making the wet gullies more vulnerable to burning.

Winto-Lewin *et. al.* (2020) concluded:

> *the retention of older forests across the landscape may decrease fire risk. Allowing eucalypt forests to mature further than the normal cycles of 40 to 90 years could help reduce fire hazards. This is especially pertinent around built assets and vegetation types vulnerable to fire.*

Powerful Owl, one of the species dependent on large hollows for nests.

5. SOCIO-ECONOMIC CONSIDERATIONS

The community have clearly identified over decades their over-whelming support for conservation, with Koalas of particular importance. It is evident that logging has been an economic disaster for community assets, running down large trees, carbon storage, water yields, nectar (i.e. honey), tree-hollows and wildlife populations, while spreading weeds and dieback. Stopping logging stops running down these assets and allows them to recover over time. There are direct significant economic benefits available by increasing carbon storage, tourist visitation and water yields. There is no doubt that the creation of the Sandy Creek Koala Park is in the best socio-economic interests of the community.

Over the past century logging has dramatically devalued this public asset. This proposal is all about stopping logging to restore degraded environmental and economic values. While private sawmillers have profited from logging, and this has provided a limited number of jobs and economic stimulus to the regional economy, the degradation of this public asset has been subsidised by taxpayers. Royalties paid by sawmillers have never covered the costs of management, or compensated the public for the loss of environmental services.

With climate heating gathering momentum we cannot afford to wait any longer to begin restoring the values of this forest as there is a growing risk that their resilience will be overwhelmed, as illustrated by the spread of dieback and the recent bushfires. We urgently need to restore forest's resilience to withstand the unfolding climate chaos.

A Cost Benefit Analysis is a method for organising information to allow comparison of the worth of competing alternatives to society as a whole, as an aid in making decisions about the allocation of resources. Not all costs and benefits can be easily priced, though natural values are increasingly being commodified, with prices now attached to water, carbon and increasingly to species and ecosystems through biobanking. While timber prices have long been established, and the economic value of recreation measured by how much people spend, the process of commodifying the environment is still in its infancy and biased to how much profit someone can make by selling something.

An alternative approach is Ecosystem Accounts. Keith *et. al.* (2017) consider:

> *Ecosystem accounts create a structure for integrating complex biophysical data, tracking changes in the condition and extent of ecosystems, and linking these changes to economic and other human activity, and the benefits they provide to society. The accounts are an integrated presentation of the environmental and economic characteristics of the region, showing both ecosystem assets (in terms of extent and condition), together with the flows or uses of these assets by people (in terms of ecosystem services and derived products). Ecosystem accounts synthesize data on all assets, goods, services and values, both those accounted for within economic systems of markets, calculations of GDP and the System of National Accounts (ABS 2016a), and those that lie outside these systems as unrecognised non-market contributions of ecosystems to economic activity and human well-being (UN et al. 2014b).*

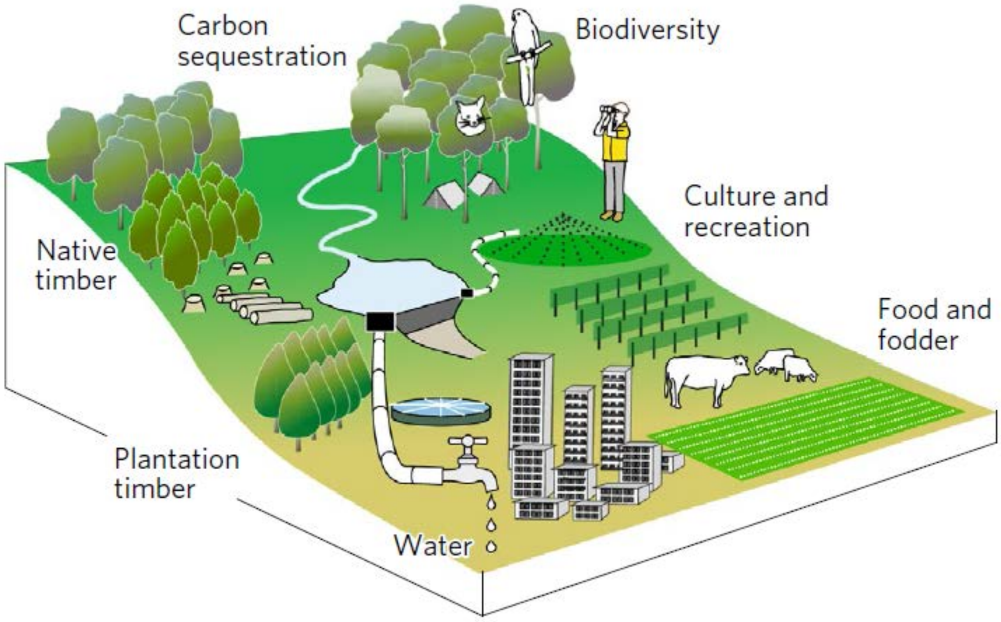


Fig. 2 from Keith *et. al.* (2017): Landscape context of ecosystem assets and services. Ecosystem accounting describes interactions of living organisms and components of the environment within specific geographical areas. Ecosystem assets and the services they provide to support human well-being are located spatially across the landscape.

Keith *et. al.* (2017) compiled Experimental Ecosystem Accounts for the Central Highlands of Victoria to assess the relative economic benefits of various uses. Theirs was a regional study encompassing a variety of land uses, including towns, concluding:

> *Our results revealed that native forests would provide greater benefits from their ecosystem services of carbon sequestration, water yield, habitat provisioning and recreational amenity if harvesting for timber production ceased, thus allowing forests to continue growing to older ages.*

Keith *et. al.* (2017)'s key findings of their ecosystem account were:

- *The value of ecosystem services used in 2013-14 for agricultural production was $121m while the water provisioning service was $101m, which were an order of magnitude greater than the native timber provisioning service ($19m).*
- *The contribution to GDP (Industry Value Added value) of the agriculture ($312m), water supply ($310m) and tourism ($260m) industries were all more than twenty times higher than for the native forestry industry ($12m).*
- *The potential IVA of carbon sequestration was estimated at $49m, based on the recent national carbon price, which is higher than the IVA of native timber production ($12m). Access of native forests to the carbon market is currently excluded by government regulation.*

As found by Keith *et. al.* (2017) forests provide numerous measurable, mappable and quantifiable benefits to the broader community that far outweigh the economic benefits of logging, and are diminished by it. This emphasises the importance of considering all forest values when making decisions on the use of public forests.

This too is reflected in the value of tourism compared to forestry. Heagney *et. al.* (2019) "*estimate the gross value of tourism and recreation expenditure arising from the NSW protected area network at $10.4 billion per annum*", compared to "*public forestry production value is estimated at $0.46 billion per annum*".

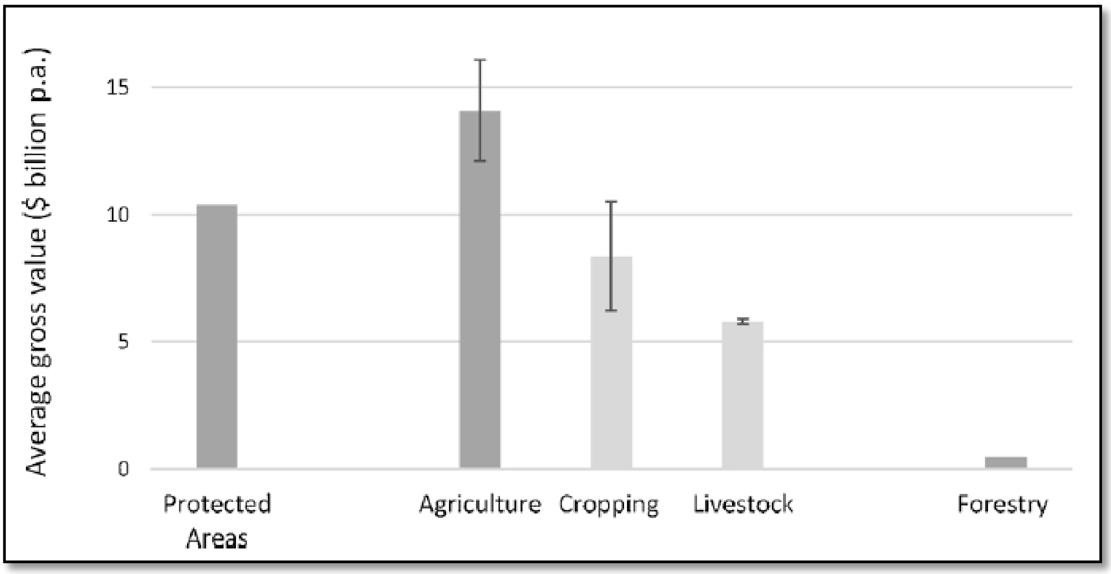


Fig. 1. from Heagney *et. al.* (2019) Average gross expenditure value of tourism and recreation in NSW protected areas compared with gross value of agriculture and forestry production. Error bars show range from 2 years of agricultural production data: 2008 (drought year) and 2014 (non-drought year).

Heagney *et. al.* (2019) note:

> *Protected areas provide a broad range of ecosystem services, like carbon sequestration and water filtration (Chan et al., 2006; Dudley and Stolton, 2010; Palomo et al., 2013). Global growth in carbon markets, water trading schemes, and biodiversity offset markets provide increasing opportunity to attach monetary values to some of these services, which could be added to the value estimates for tourism and recreation provided here. Protected areas also have a range of non-use values, like existence and bequest values (Turner et al., 1994; Phillips, 1998; Haefele et al., 2016). Under a total economic valuation framework (Turner et al., 1994) these are generally considered to be additional to the value of ecosystem service provision. A recent choice modelling survey undertaken in the US concluded that the non-use values of protected areas and associated conservation and education programs was at least as large as the estimated recreation value (Haefele et al., 2016).*

There is a need for decision makers to consider the 'irreplaceability' of conservation values along with the 'replaceability' of resource values when making decisions. As noted by Bennett (1998):

> *In general, forest protection benefits are likely to increase through time whereas the opportunity costs will most probably remain static. These differential growth rates are largely the result of the degree to which substitute goods are available for both the timber and non-timber forest products. Timber products are easily substituted. … The non-timber, or protection values, of forests are, however, much more difficult to substitute. For instance, habitat for endangered species cannot be readily "manufactured". Recreation in constructed or artificial sites may not be considered as providing the same experience as time spent in a protected forest reserve.*

The approach taken herein has been to collate available socio-economic information, and relate this to the plot data we collected where relevant, so some of the costs and benefits of the proposed Sandy Creek Koala Park can be quantified and compared. Undertaking a full Cost Benefit Analysis or Ecosystem Accounting using a modelling approach is beyond the scope of this study. The approach adopted herein is to identify quantifiable values, along with indications of their current market values where relevant (without adjustments for Net Present Value or forecasts of future values), so that their relative values and benefits can be considered. This is not a comprehensive assessment, with only some attributes affected by forestry quantified, and most of these based on conservative estimates rather than detailed modelling.

Despite the limitations of this study, it provides an indicative assessment of the magnitude of benefits and costs that will accrue from protecting this forest, and thus enables a realistic comparison of the costs and benefits of the two scenarios considered:

1. Conservation: protection of the whole area as a national park
2. Continued Logging (Business as Usual): protection of 35% of the area in exclusions and continued logging of the balance using current prescriptions, with the forest's minimum basal area reduced to $10m^2$ per hectare.

COSTS AND BENEFITS OF THE PROPOSED SANDY CREEK KOALA PARK

CONSERVATION BENEFITS
Honouring the will of the majority of community (>65-70%) who want logging stopped and Koalas protected in reserves.
Past logging has reduced the carbon stored in these forests by 59% allowing these forests to regrow will reabsorb over 3.3 million tonnes of atmospheric CO_2 over the next century, which has an indicative current market value of over $56.8 million.
Relative to business as usual, over 30 years the net benefit from stopping logging is the sequestration of 40,200 tonnes of CO_2 per annum, currently worth $686,600 per annum
Each 10,000 visitors per annum to the proposed Sandy Creek Koala Park are expected to generate $1.3 million in regional spending,10.6 jobs, value added of $1 million, gross regional product of $1.2 million, tourist consumption of $1.7 million, and a consumer surplus of $450,000 to $900,000
Recreation in natural areas improves people's physical and mental health, thereby reducing public health costs.
Past logging has reduced water yields by some 14,000 ML per annum, allowing these forests to regrow will ultimately restore yields worth $7 million per annum.
A compounding annual increase in water yields of some 140 ML worth a compounding $70,000 per annum
More than doubling pre-fire Koala population - priceless.
Restoration of larger trees that flower more frequently and prolifically, thereby more than doubling nectar essential for numerous native species threatened with extinction, which is priceless, and in a good year would represent over $100,000 worth of honey.
Begin the slow process of restoring the large tree hollows essential for restoring populations of numerous threatened hollow-dependent species - priceless.
CONSERVATION COSTS
Employment of 5.4 persons in logging industry
Gross hardwood output processing value of sawmills claimed as $2 million per annum
ONGOING LOGGING COSTS
Across 65% of area increasing logging intensity will result in further declines in carbon storage, stream yields, pre-fire Koala populations, nectar availability, and tree-hollows, while further promoting lantana, BMAD and flammability.

It needs to be recognised that under the business as usual approach it is intended to exclude some 35% of the forest from future logging, meaning that around a third of the conservation

benefits (aside from recreation) will potentially be realised, though to variable levels off-set by increasing losses within the logging area..

In summary consideration of the relevant costs and benefits concludes:

COMMUNITY PREFERENCE (Section 5.1.1.)

For 23 years the north coast community have demonstrated a clear and abiding preference for conservation over exploitation of public forests. A 2016 survey on behalf of the timber industry found 65-70% of Australians consider logging of native forests unacceptable (compared to 10-17% who consider it acceptable), and a 2018 ReachTEL survey found 71% of Lismore and Ballina residents *support the creation of national parks to protect koalas from logging* (compared to 16% opposed). There can thus be no doubt that creation of the proposed Sandy Creek Koala Park is in accord with the community's preferences and aspirations.

CARBON VALUE (Section 5.1.2.).

The total carbon carrying capacity of the forests of the proposed Sandy Creek Koala Park is estimated to be at least 1.6 million tonnes. Past logging has run down these carbon stores by 910,000 tonnes, releasing some 3.3 million tonnes of CO_2 into the atmosphere. This is therefore the carbon sequestration potential if the forests are allowed to regain their lost stores, which at current values ($17 tonne) is worth $56.8 million. While it will take a long time, the protection of these forests has the potential to make a significant contribution to ameliorating climate change.

If these forests are protected from logging they have the capacity to sequester an annual average of 44,200 tonnes of CO_2, currently worth $750,600 per annum. Over the next 30 years (by 2050) some 1.3 million tonnes of atmospheric CO_2, with an indicative current market value of $22.5 million, is recoverable.

The intent of business as usual is to protect 35% of the forest in logging exclusions with 65% subject to continued logging. Continued logging of 4,500 ha will release 347,400 tonnes net of CO_2 into the atmosphere over the next 30 years, though across the whole area this will be offset by the uptake of 460,400 tonnes of atmospheric CO_2 by the 2,500 ha of logging exclusions, resulting in the net removal of 113,000 tonnes of atmospheric CO_2 over the next 30 years. With exclusion offsets, logging thus results in a net annual gain of 3,800 tonnes of $CO_{2.}$.

Compared to continued logging, protection of the Sandy Creek Koala Park will result in the annual sequestration of an additional of 40,200 tonnes of CO_2. At the current value of $17 a tonne for an Australian Carbon Credit Unit this is worth $686,600 per annum., over 30 years totalling 1.21 million tonnes of CO_2, worth $20.6 million dollars.

RECREATIONAL VALUE (Section 5.1.3.).

While tourism has taken a hit from COVID 19, it is one of the most rapidly expanding sectors of the north coast economy. In 2019 there were 35 million visits to the north coast generating $4,709 million in regional expenditure and 33,000 jobs. Natural areas are a major attraction for tourists and a major reason for visiting the region, with some 7.5 million visits to national parks in the NPWS North Coast region in 2019.

According to the National Visitor Survey, in 2018 each 10,000 visitors to the north coast spent $1.4 million and employed 10.6 people.

Depending on provision of infrastructure and the return of Koalas, the proposed Sandy Creek Koala Park is expected to attract tens of thousands of people a year who will spend money within the region. Based on current values, each 10,000 visitors per annum are expected to generate $1.4 million in regional spending,11 jobs, and a consumer surplus of $450,000 to $900,000. This park will increase tourists using the Summerland Way and be a particular boost to the economy of Casino.

There is abundant evidence that recreating in natural areas significantly enhances most people's mental and physical health, which has flow-on effects on the nation's health costs. Relating this to the self-perceived Personal Wellbeing Index has resulted in an estimation of the annual health services value of Australia's national parks as ~ $145 billion. Reserves that encourage increased recreation contribute to increasing this health benefit and reducing health costs.

WATER VALUE (Section 5.1.4.).

Increased transpiration of regrowth forests makes them heavy water users compared to oldgrowth forests. and thereby significantly reduces streamflows. By converting oldgrowth forest to regrowth, past logging has increased tree transpiration and reduced streamflows from the proposed Sandy Creek Koala Park by in the order of 14,000 ML per annum. This water volume is recoverable over time if these forests are allowed to mature, as streamflows increase and aquifers recharge.

With continued logging it is proposed that 35% of these forests will be protected in logging exclusions where streamflows will slowly recover, while maintaining the rest of the forest around maximum water use, in effect stopping restoration of some 9,000 ML per annum.

In 2020 the NSW Government set a minimum bid price of $500 per unit share for the Richmond Coastal Sands Groundwater Source, though the new Rocky Creek dam has a NPV of $15,000 per ML. The value of water will only increase over time as droughts become more frequent.

Based on the current minimum value of $500 per ML per annum, the potential value of the restored 14,000 ML of water yield is $7 million per annum. Continued logging will stop most of this streamflow being restored, equating to a future cost of $4.5 million per annum from continued logging. While it will take time for full yields to be restored, yields will increase relatively rapidly over the next few decades.

If it takes 100 years to restore water yields, the cessation of logging represents an annual compounding increase in water yields of 140 ML worth $70,000 per annum (i.e. in ten years it would be 1,400 ML p.a. worth $700 thousand p.a.), whereas the business as usual allows an annual compounding increase of 50 ML worth $25,000 per annum, with the logging area perpetually maintained around the minimum yield levels.

TIMBER VALUE (Section 5.1.5.).

The history of logging north-east NSW's public forests has been one of public subsidisation of the depletion of large trees, and along with them declining nectar, tree-hollows, wildlife, sawlogs, and streamflows. The 2000 North East NSW Regional Forest Agreement was intended to herald an era of Ecologically Sustainable Forest Management, though yields of large high quality sawlogs have since declined by 41% and forests continue to be over-logged.

Within the proposed Sandy Creek Koala Park logging has run-down tree biomass by 59% over the past century, which increases to 65% of biomass of trees above 30 cm dbh and to 83% of biomass for trees above 50 cm dbh. Continued logging is likely to reduce biomass by a further 39% over the next 20-30 years. The Forestry Corporation is seeking to develop a biomass market to make ongoing logging viable as they run out of sawlogs. It is timber mining.

Historically the Forestry Corporation have operated at a loss, with only private sawmill owners making a profit from logging public forests. The public have further subsidised private sawmill owners by purchasing land for logging and plantations, grants to subsidise transport costs and upgrade sawmills, and compensation payments for failure to supply non-existent timber given to sawmillers for free.

By including hardwood plantations, and excluding Community Service Obligations, EPA regulation and DPI Forestry research, in recent years the Forestry Corporation have returned a notional profit on its hardwood operations, for example in 2018/19 an average profit of $0.63 per hectare for hardwoods. Government's also provide a variety of grants to the Forestry Corporation and sawmill owners which significantly increase the public subsidy to the declining native-forestry industry. There is no resource rent paid to taxpayers. By comparison softwood plantations return a profit of $301 per hectare. The sooner the Government transitions to plantations the better off taxpayers will be.

Proportionally the proposed Sandy Creek Koala Park represents timber industry employment of 5.4 persons in north-east NSW. To put the potential loss of jobs into perspective, ABARE identifies over the ten years from 2006 until 2016 the NSW timber industry shed 7,400 jobs through restructuring and mechanisation without any politicians or unions complaining.

The net economic benefits of logging public land accrue to private sawmill owners. Applying the industry's unverified claims of hardwood output processing values for north-east NSW proportionately, without deducting costs, indicates the claimed gross economic value of continuing logging of the proposed Sandy Creek Koala Park is in the order of $2 million per annum.

ECOSYSTEM VALUE (Section 3).

Koalas within the proposed Sandy Creek Koala Park have been shown to preferentially choose larger trees for feeding, rarely using trees less than 20 cm diameter a breast height (dbh) and preferring trees >30cm dbh, with use increasing with tree size (Section 3.1.3.2). It is expected that the high numbers of Koalas found in some areas is due to recovery from logging over 2 decades previously. Without accounting for other threats (such as fire) it is expected that Koala numbers (from before the fires) could more than double if the forest was left to mature. Conversely it is considered that relogging could more than halve populations.

Many of the species inhabiting or frequenting these forests are nectarivores. The larger eucalypts flower more frequently and prolifically, with trees over 40cm diameter flowering over twice as frequently and producing 9 times as many flowers as trees 25-39 cm diameter (Section 3.2.1.). Protection of the proposed Sandy Creek Koala Park would more than double the nectar available in a good year, which would represent over $100,000 worth of honey. Though with nectarivorous species such as Regent Honeyeater and Swift Parrot in imminent danger of extinction and Flying Foxes starving to death, maintaining and increasing nectar is priceless.

Tree-hollows provide dens and nests as essential homes to a multitude of species. The large hollows essential for large hollow-dependent animals are provided by trees over 200 years old. Within these forests large hollow-bearing trees have been reduced from 18.3 trees/ha down to 0.3 trees/ha, a 98.4% reduction in these vital resources (Section 3.2.2.). The loss of small hollows has been less severe (78%), though many of those left may be uninhabitable. The consequence is that populations of hollow-dependent species have been significantly reduced and eliminated from extensive areas because of the lack of homes. Given that many of these species are threatened with extinction, and the long time it takes to develop hollows, hollow-bearing trees are priceless.

HEALTH VALUES (Section 4.)

It is of concern that logging's promotion of lantana had, before the fires, enabled Bell Miners to proliferate in wetter gullies, initiating the Threatening Process of Bell Miner Associated Dieback, whereby Bell Miners exclude most other native species and promote sap-sucking psyillids which cause eucalypts to sicken and die (section 4.4.). BMAD requires active intervention to repair.

It is evident that logging increases flammability of forests by promoting dense even sized regeneration and canopy continuity, decreasing separation of canopy from ground fuels, increasing transpiration of regrowth which dries the understorey, increasing understorey fuels by logging debris and promotion of dense growth of short lived species (section 4.5), so conservation will reduce fire threat over time as the forest recovers.

5.1. Community Preferences

The latest community attitude surveys again confirm that the community overwhelmingly supports protection of public lands for wildlife habitat, water yields, carbon storage and recreation, with logging of native forests considered unacceptable by the vast majority of rural and urban residents.

Recently an industry survey found 65-70% of Australians consider logging of native forests unacceptable (compared to 10-17% who consider it acceptable), and a ReachTEL survey found 71% of Lismore and Ballina residents *support the creation of national parks to protect koalas from logging* (compared to 16% opposed). There can thus be no doubt that creation of the proposed Sandy Creek Koala Park is in accord with the community's preferences and aspirations.

A valid economic assessment must identify socially optimal outcomes of the use of public forests. 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 individual are often used to decide uses of public lands, though on their own economic benefits do 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.

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."*

The Community Attitude survey for the Upper North East (UNE) CRA (McGregor *et. al.* 1997a) established that the priorities respondents gave to *"various activities with relation to public forests"* were;

- protecting native plants and animals (100%),
- maintaining sites of natural beauty (99%),
- educational/scientific (97%),
- maintaining water quality (96%),
- aboriginal sites (89%),
- bushwalking/picnics (87%),
- protecting wilderness (87%),
- camping (79%), and
- eco-tourism (75%).

Exploitative uses of public lands received a lot less support (timber production 24%, woodchipping 7% and mining 13%), with the highest opposition being to mining (72%), hunting (70%) and woodchipping (65%).

In response to the question *"what is it about forests that you value?",* those values ranked highest were aesthetic (80%), conservation reasons (46%), spiritual (25%), intergenerational equity (14%) and recreation (10%) as compared to relatively low values for economic/employment (6%) and economic goods and use (5%).

The UNE Community Attitudes survey (McGregor *et. al.* 1997a) showed that at both the macro and micro scales more respondents put environmental principles before economic principles when faced with conflict between the two, finding that:

- 56.3% of the people surveyed agreed that they *"would like to see more forested land conserved, even if it means a loss of state income from timber harvesting"* as compared to 23.2% disagreeing
- When asked if it is the case that *"Timber harvesting in native forests may have an adverse impact on the abundance of native plants and animals"*, 66.1% of people surveyed considered *"The environmental costs are too high, it might be better to compromise on forestry activities"* as compared to 15.6% considering *"This is unfortunate but we need forestry products and employment."*
- When asked if it is the case that *"Forestry jobs may be lost to create new environmental reserves. This may affect some small communities adversely, by reducing their access to basic services"*, 45% considered this *"Unfortunate for these communities but we need environmental reserves for the benefit of future generations"* as compared to 31.5% considering *"The social costs are too high, it may be better to compromise on creating environmental reserves than reduce people's access to basic services."*

Duthy (1998) undertook a 'contingent valuation study' to determine the level of community support for the dedication of Whian Whian State Forest as a new national park. Consistent with regional attitudes, local respondents to his survey identified catchment protection, endangered species habitat and preservation for future generations as the most important uses of the Whian Whian area.

As an example of the weighting provided by local communities, out of a scale of 1 to 10, use of Whian Whian as a commercial timber resource achieved a mean ranking of 3.79, compared to camping and recreation achieving 6.38, endangered flora and fauna habitat achieving 8.77 and catchment protection achieving 9.03 (Duthy 1998). Catchment protection was considered extremely important by 63% of respondents, endangered flora and fauna habitat by 60% of respondents, and enjoyment of future generations by 56%, as compared to 8% considering commercial timber resource as extremely important (Duthy 1998).

In response to the request for local people to indicate their relative priorities between sometimes opposing environmental issues, Duthy (1998) found a similar preference for environmental concerns over economic concerns as McGregor *et. al.* (1997). For example when respondents were asked to rank utilisation versus conservation of natural resources; 43% indicated that they considered they had a balanced view, a further 43% indicated that conservation was the priority and only 14% indicated utilisation as the priority. When the issue related to employment versus the environment less people considered they had a balanced view, with those favouring employment increasing to 25% and 41% still placing environment protection above employment. Conversely, when the issue related to private development issues versus environmental protection those favouring development declined to 7% while those favouring environmental protection increased to 71%. (Duthy 1998).

It is therefore not surprising that over 20 years later a survey of Lismore and Ballina residents showed that community opposition to logging of native forests remains strong and that the community's overwhelming preference is still for increased environmental protection.

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.

5.2. Climate Mitigation

The total carbon carrying capacity of the forests of the proposed Sandy Creek Koala Park is estimated to be at least 1.6 million tonnes. Past logging has run down these carbon stores by 910,000 tonnes, releasing some 3.3 million tonnes of CO_2 into the atmosphere. This is therefore the carbon sequestration potential if the forests are allowed to regain their lost stores, which at current values ($17 tonne) is worth $56.8 million. While it will take a long time, the protection of these forests has the potential to make a significant contribution to ameliorating climate change.

The intent of business as usual is to protect 35% of the forest in logging exclusions with 65% subject to continued logging. Continued logging of 4,500 ha will release 347,400 tonnes net of CO_2 into the atmosphere over the next 30 years, though across the whole area this will be offset by the uptake of 460,400 tonnes of atmospheric CO_2 by the 2,500 ha of logging exclusions, resulting in the net removal of 113,000 tonnes of atmospheric CO_2 over the next 30 years. With exclusion offsets, logging thus results in a net annual gain of 3,800 tonnes of CO_2..

Across the proposed Sandy Creek Koala Park the net benefit from stopping logging is the removal of some 44,200 tonnes more CO_2 (worth $687,000) per annum over the next 30 years, totalling 1.2 million tonnes more CO_2 (worth $20.6 million) over 30 years.

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).

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 droughts, heatwaves and 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.

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 as natural 'carbon capture and storage'. 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 on the other hand directly kills trees, halting their carbon sequestration, and removing 40% of their biomass (and carbon) from the forest as logs, while leaving most of their biomass (leaves, branches, offcuts, stumps, roots) behind to be burnt or slowly rot. The logs removed may be directed to short-lived products (pulp, woodchips, biomass) or lose a further 60% of their biomass (offcuts, sawdust) in conversion to sawn products.

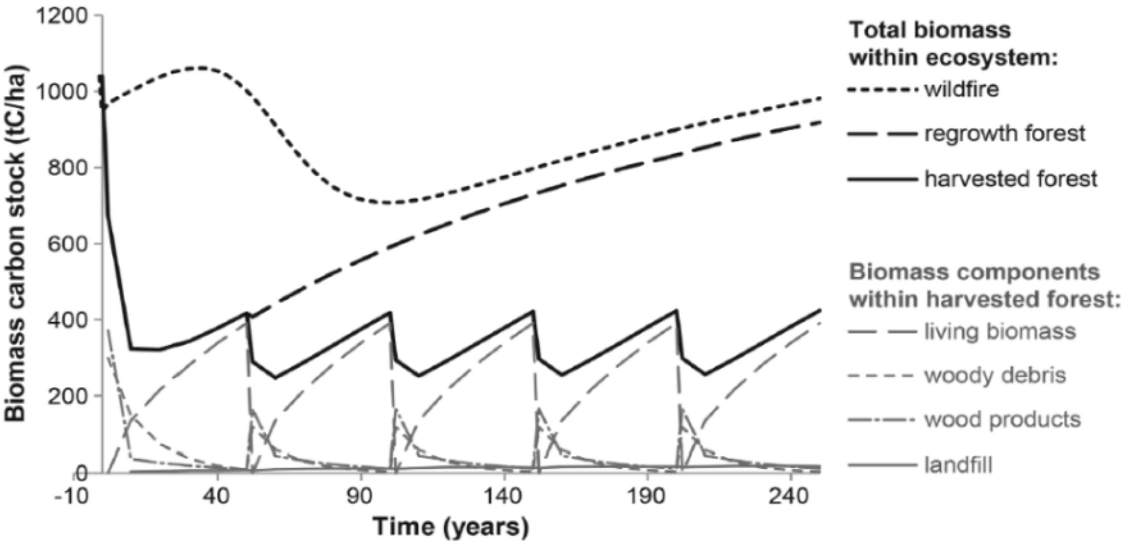


Fig. 10. from Keith *et. al.* (2014b): Changes in total biomass carbon stock of the ecosystem over time under three scenarios (shown as black lines) from an initial stock of a native forest: (1) wildfire that

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

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).

Carbon storage within the forests of the proposed Sandy Creek Koala Park has been reduced by 910,000 tonnes (59%) due to past logging.

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^{o}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.*

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*".

	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*".

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.

Application of the Mackey *et. al.* (2008) methodology indicates that 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 (Pugh 2020). 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. 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.

5.2.1. Current and Future Carbon

The current structure of the proposed Sandy Creek Koala Park was measured directly with 76 plots in logged forests on 10 transects, and the proforestation carbon carrying potential was estimated from 12 plots on two transects in similar unlogged forests (See Section 4.2).

Heather Keith, Griffith University,(pers comm 5/5/2020) advised on the appropriate allometric equation to use to convert our plot data to both above ground and below ground carbon. A species-specific equation for Spotted Gum *Corymbia maculata* (adapted from Ximenes *et. al.* 2004, Paul KI *et al.* 2016) was applied to all species recorded on our plots to estimate above ground biomass. This does not consider species differences or tree heights, though does provide a reasonable indication of biomass and therefore carbon stocks. Below ground biomass was derived from the average root:shoot ratio for forests of 0.25 (Snowdon *et al.* 2000). Carbon was taken to be half of biomass.

Allometric equation to relate tree diameter to aboveground biomass (AGB)

Form of the equation: $\ln(AGB) = \ln(a) + b.\ln(X) + \varepsilon$

Transformed: $AGB = \exp[\ln(a) + b.\ln(X)] * CF$

Species-specific equation for *Corymbia maculata*:

$AGB = \exp[-2.118 + 2.433.\ln(X)] * 1.0265$

where: AGB in kg

X = DBH in cm

CF is the correction factor for bias in back-transforming an exponential equation

	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	150	75	37	19	187	94
Reduction	214	107	54	27	267	134

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.

Ximenes *et. al.* 2004 measured dry above-ground biomass (AGB) of low, medium and high productivity Spotted Gum stands "*thought to be near maturity or maximum carbon-carrying capacity*" in the Batemans Bay region on the south coast of NSW, finding 220, 287 and 397 tonnes/ha for the LQS, MQS and HQS, respectively. NEFA's results are consistent with those results.

It is important to recognise that NEFA's assessment does not account for dead biomass which makes a significant contribution to total biomass. For dry sclerophyll forests Woldendorp *et. al*. (2002) identify a mean forest floor Coarse Woody Debris (CWD) of 50.9 t ha^{-1}, standing dead wood of 9 t ha^{-1} and litter of 14.3 t ha^{-1}. The mean proportion of total above-ground biomass as forest floor CWD was approximately 18%.

	Area (ha)	Carbon t/ha	Total Carbon (t)	CO2 equivalent (t)
Original Carbon	6,945	227	1,577,210	5,788,359
Remaining oldgrowth	132	227	29,977	110,016
Logged Forest	6,813	94	637,016	2,337,847
Change			-910,217	-3,340,496

Proposed Sandy Creek Koala Park carbon balance. Note: 43 ha cleared area for powerline and rest area omitted.

Forty three hectares of the proposed Sandy Creek Koala Park has been cleared for a powerline and a rest area, and thus is not accounted for as it does not have rehabilitation potential. Of the remaining 6,945 ha, 132 ha was mapped as oldgrowth back in 1998, and biomass calculations account for this. The inconsistencies in logging histories, and the variable effects, did not allow further stratification, though sites were selected to reasonably sample variations in topography and logging histories (Section 4.2).

It is estimated that past logging has reduced carbon stocks by 134 tonnes of carbon per hectare (59%). This equates to a reduction of some 910,000 tonnes of carbon due to past logging across the assessed 6,945 ha, most of which would have been released into the atmosphere as carbon dioxide long ago. This lost carbon reflects the carbon sequestration potential, which is the amount of carbon the forest can take up and store as it ages if protected from further logging. Application of conversion factor of 3.67 for tonnes of carbon to tonnes of carbon dioxide, shows currently these forests have the potential over time to remove 3.3 million tonnes of atmospheric CO_2 and store it in biomass and soils.

Logging to date has run down the carbon storage of the proposed Sandy Creek Koala Park by 58% over the past 100 years, the choices now are:

> **Natural climate solution:** Protecting all the 6,988 ha of the Proposed Sandy Creek Koala Park, resulting in the gradual capture of 910,000 tonnes of lost carbon, and the removal of 3.3 million tonnes of atmospheric CO_2 over the next century.
>
> **Continued Logging (Business as usual):** Retaining intended protection of 2,457 ha of exclusions (including 43 ha cleared and 132 ha oldgrowth), where 305,800 tonnes of lost carbon can be gradually captured and stored in the recovering forest, removing 1.1 million tonnes of atmospheric carbon over the next century. While continuing running down carbon stores in the remaining 4,500 ha, likely by around 39% over the next 30 years, releasing another 347,400 tonnes of CO_2 into the atmosphere. (Section 5.2.3).

So the business as usual scenario basically allows 35% of the forest to recover its lost carbon over time. While for the other 65% (4,531ha) live biomass and carbon has so far been reduced by 59%, with logging likely to reduce live biomass and carbon by another 39% down to 25% of the original forest. Rather than continuing to run down this forest's carbon stores it is in the community's best interests to allow these forests to recapture the 3.3 million tonnes of CO_2 that have so far been lost to the atmosphere.

5.2.2. Growing Carbon

A key attribute is the rate at which carbon is sequestered by vegetation, which governs how quickly the carbon can be removed from the atmosphere as the forests recover. 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.*

Mackey *et. al.* (2008) note:

> *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 Victorian Central Highlands forests Keith *et. al.* (2017b) found:

> *The difference in net change in carbon stock density between the area logged and the area unlogged but available for logging indicates the carbon sequestration potential, which was 2.98 tC ha^{-1} $yr^{-1}{}_{1}$ averaged over 1990 – 2015*

For the proposed Sandy Creek Koala Park we only measured limited plots and have no specific growth data to be able to determine current annual carbon sequestration potential. Instead annual growth rates derived from south-east Queensland were applied to NEFA's plot data to estimate future basal area growth after 10 and 30 years, then the allometric equation for Spotted Gum (5.2.1) was applied to convert this into biomass.

Species	Mean diameter growth rates (cm yr^{-1})		
	1000mm/yr	1200mm/yr	**ADOPTED**
Allocasuarina torulosa	0.20	0.14	0.17
Acacia aulacocarpa		0.27	0.27
Alphitonia excelsa		0.13	0.13
Corymbia species [1]	0.14	0.23	0.185
C. intermedia	0.13	0.18	0.155
Eucalyptus acmenoides	0.13	0.27	0.20
Eucalyptus moluccana	0.26	0.36	0.31
Eucalyptus propinqua	0.21	0.27	0.24
Eucalyptus siderophloia	0.15	0.27	0.21
Eucalyptus tereticornis	0.19	0.28	0.235
Lophostemon suaveolens	0.16	0.15	0.155
Melaleuca alternifolia	0.10	0.16	0.13

Mean diameter growth rates (cm yr^{-1}) in relevant rainfall zones, for dominant trees within the proposed Sandy Creek Koala Park (adapted from Ngugi *et. al.* 2015)

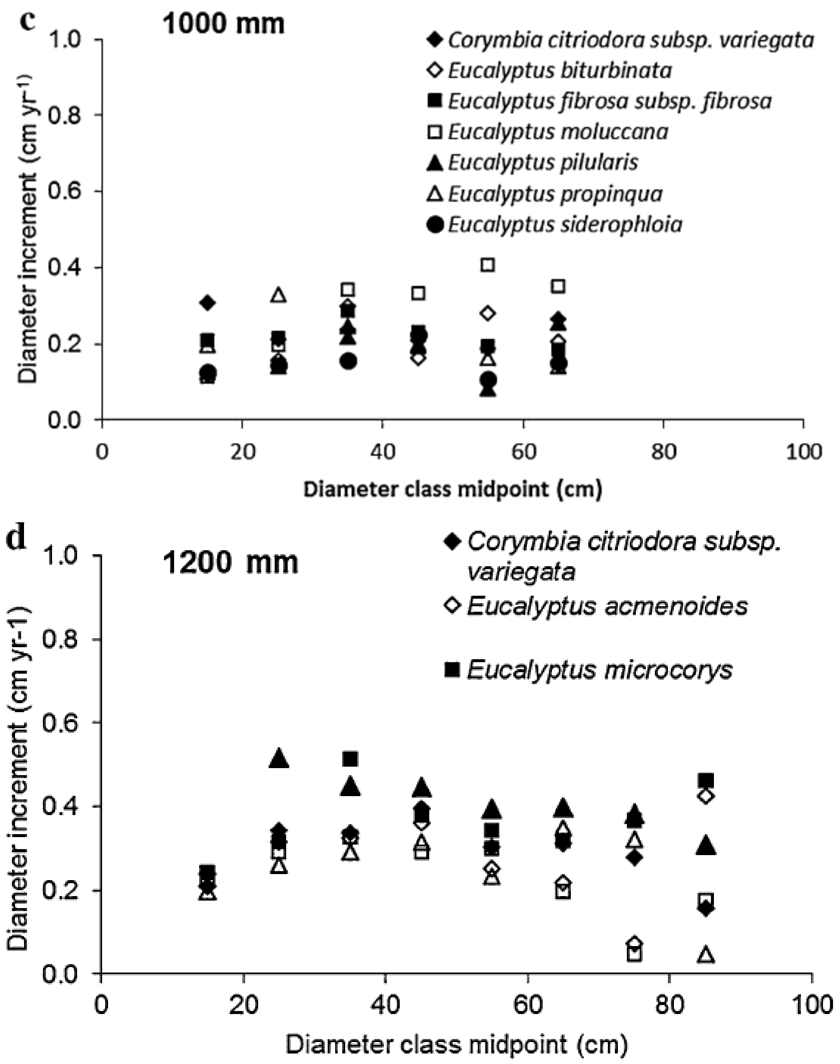
1. *Corymbia citriodora* is considered to be the most appropriate surrogate for C. henryi in the data provided by Ngugi *et. al.(2015),* they provide different growth rates for different subspecies, in the 1000 mm zone 0.14-0.23, and in the 1200 mm zone 0.23-0.31. For the purposes of this assessment the lowest values were conservatively adopted for application to C. henryi.

Ngugi *et. al.* (2015) used long-term growth plot data from across native forests in south-east Queensland to identify growth rates of native species across rainfall gradients. The average annual rainfall for this proposal is some 1097.4mm per annum (Casino Airport), which is intermediate between the 1,000 and 1200 mm classes identified by Ngugi *et. al.* (2015). In general mean diameter increment for similar forest types are around 0.2 cm per annum. For the purposes of this assessment growth rates of species were adapted from Ngugi *et. al.* (2015), as shown in the table below*.* Lemon Gum was used as a surrogate for *Corymbia henryi*, ironbarks were grouped with *Eucalyptus siderophloia*, stringybarks with *E. acmenoides,* wattles (and one tree-heath) with *Acacia aulacocarpa* and paperbarks with *Melaleuca alternifolia*. Dead trees were excluded from the assessment.

It is recognised that diameter increments will vary with tree size though because of the lack of specific data this was not able to be accounted for. Ngugi *et. al.* (2015) identify that

The highest growth rates for most species in all rainfall zones were observed in trees with DBH between 20 and 60 cm. In these native forests, trees in the <20 cm DBH class are often in the understorey and their growth is often suppressed by larger trees.

It is apparent that applying a standard diameter increment to trees <20cm diameter will skew results in favour of regrowth. Similarly they may be issues with trees over 70cm dbh, though this is less clear.



Ngugi *et. al.* (2015) Fig. 3 Comparative species diameter increments within each rainfall zone.

The mean diameter growth rates (cm yr^{-1}) adapted from Ngugi *et. al.* (2015) were applied to each tree on NEFA's structural plots across the proposed Sandy Creek Koala Park to identify indicative carbon sequestration volumes per hectare if the forests were allowed to grow for 15 and 30 years. This gave a carbon sequestration rate of 1.73 tonnes per hectare per annum over 30 years, totalling 52 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	149.6	74.8	37.4	18.7	187	93.5
Increase by 2050	83.2	41.6	20.8	10.4	103.9	52.0
Average annual increase	2.77	1.39	0.69	0.35	3.46	1.73

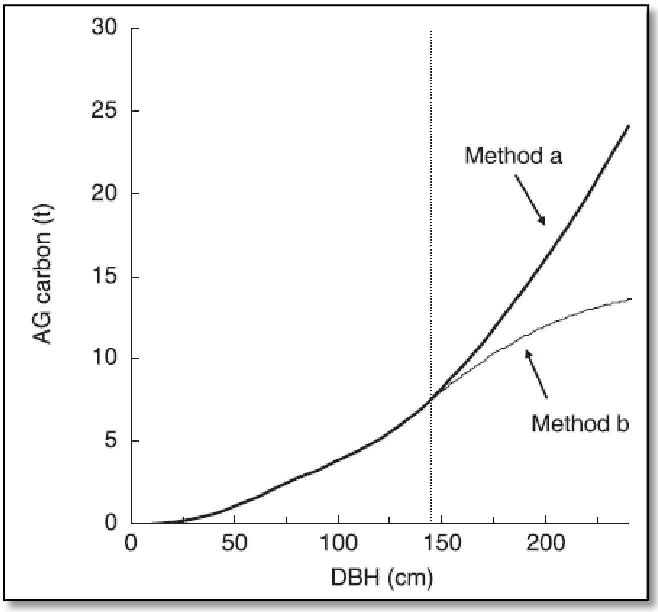
Estimates of Carbon sequestration potential from application of growth rates derived from Ngugi *et. al.* (2015) to plot data for the proposed Sandy Creek Koala Park (dead standing trees and logs omitted)

These data were applied across the proposed Sandy Creek Koala Park to identify total potential biomass growth and carbon storage increases by 2050, being a key date for implementing reductions of CO_2 by. By allowing these forests to grow they have the potential to remove ever increasing volumes of carbon from the atmosphere as they age. Across the proposal, over the next 30 years there is the ability to sequester an average of 12,031 tonnes of carbon per annum, which would remove 1.32 million tonnes of CO_2 from the atmosphere by 2050.

	Biomass t ha^{-1}	Area [A]	Biomass (tonnes)	Carbon (tonnes)	CO2 equivalent (tonnes)
Oldgrowth	454.26	132	59,962	29,981	110,031
Logged	187	6,813	1,274,031	637,016	2,337,847
SUB-TOTAL			**1,351,366**	**675,683**	**2,447,877**
Add by 2050	103.9	6,945[B]	721,877	360,939	1,324,645

Live carbon balance across 6,988 ha proposed Sandy Creek Koala Park . A: 43ha cleared area removed. B: Sequestration is assumed across all forests.

Application of a growth rate of 3.46 t/ha^{-1} yr^{-1} to the current biomass suggests that the volumes recorded for unlogged forests could be achieved in 77 years, though this does not take into account ongoing mortality due to fires and self thinning processes as forests age. In natural forest there is a self thinning process that results in significant mortality as trees mature (Mackowski 1987, Smith 1999). Mackowski (1987) found that in Blackbutt forests there is a 50% mortality of large trees every 80 years, noting *"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."* Also individual trees go on accumulating carbon as they age, though their net rate of accumulation may be offset by internal decay in the oldest trees of some species.



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.

While forests will go on accumulating carbon in wood and soils as they age, not all individual trees will, and there will be new young recruits, so it is considered unreliable to apply this growth to each tree beyond 30 years.

5.2.3. Logging Impacts on Carbon.

While these forests have mostly been degraded by a century of logging, relatively recent changes over the past 20 years now require around 2,414ha (minus 43ha cleared land) to be excluded from logging (35% of gross area), leaving a net logging area of 4,531 ha.

The 2,414 ha of excluded areas (excluding 132ha oldgrowth) should over time regain their lost carbon, with the potential to regain 305,000 tonnes of carbon and take 1.1 million tonnes of carbon out of the atmosphere.

The data in Section 5.2.2 were applied to the 2,457 ha of logging exclusions in the proposed Sandy Creek Koala Park to identify total potential biomass growth and carbon storage increases by 2050. By allowing these forests to grow over the next 30 years there is the ability to sequester 125,500 tonnes of carbon, which will remove 460,000 tonnes of atmospheric CO_2.

	Biomass t ha^{-1}	Area [A] ha	Biomass (tonnes)	Carbon (tonnes)	CO2 equivalent (tonnes)
Oldgrowth	454.26	132	59,962	29,981	110,031
Logged	187	2,282	426,734	213,367	783,057
SUB-TOTAL			486,696	243,348	893,087
Add by 2050	103.9	2,414	250,916	125,458	460431

Carbon balance across 2,457ha exclusion areas. A: 43ha cleared area removed. B: Sequestration is assumed across all forests.

This leaves 4,531ha of forests prevented from regaining their carbon by repeated logging, which will further reduce carbon storage. The effects of 2 logging events over 30 years on carbon stocks is assessed as releasing 347,375 tonnes of CO_2 into the atmosphere over the next 30 years, compared to the conservation option of stopping logging which results in the sequestration of 864,197 tonnes of CO_2 from the atmosphere. Over the next 30 years, across the 4,531 ha the conservation option will remove 1.21 million tonnes more atmospheric CO_2 than continued logging, this is an average of 40,400 tonnes CO_2 per annum

The current basal area is 20.2 m^2/ha. The new Coastal Integrated Forestry Operations Approval (CIFOA) allows for increased logging intensity by only requiring a minimum basal area of 10 m^2/ha be retained. This minimum is unlikely to be achieved under current logging regimes because of the lack of a market for small and defective logs, though the Forestry Corporation is intent on creating a market for these logs as biomass to be burnt for electricity generation, which will allow for heavier logging and further reductions in carbon storage down to the new minimum.

Ximenes et. al. (2017) identify "*Since 2013 the demand for pulp logs has decreased dramatically, resulting in large volumes of biomass left in the forest following extraction of high-value logs*". Accordingly the Department of Primary Industries undertook a study to identify the potential volumes of pulplogs available from north-east NSW for conversion into wood pellets for electricity generation. Pulplogs are defined as at least "*10 cm small end diameter overbark, and a minimum of 2.5 m in length – no species restrictions*", with the crown, "*stump, bark, leaves, small branches, large and defective stem sections*" left in the forest.

Ximenes et. al. (2017) state "*Working within the prescriptions of the harvest plan, the contractors harvested the plot as they routinely would but with the additional requirement to extract logs that met pulp specifications*". In general they identified a similar volume of pulplogs available as high quality (HQ) logs, with residues from the Spotted Gum forests in Bungawalbin and Mount Marsh State Forests assessed as 68 and 58 tonnes/ha respectively. Given that current above ground biomass (including branches, stumps, small trees and foliage) in these forests is 150 tonnes per hectare and 69 tonnes of this needs to be retained under the new rules it is evident that the intent is to fully remove all allowable biomass, and unlikely that anything like Ximenes *et. al.* (2017)'s volumes could be realised after the next logging unless logging intensity is further increased to a clearfelling regime..

Never-the-less it is assumed that the Forestry Corporation will achieve their aim of getting a market for small and defective trees and thus realise their objective of increasing removal of pulp logs.

To assess the effects of logging on carbon stores over the 4,531 ha proposed for logging, an assessment was undertaken based on logging the forests now, re-logging them in 15 years, and then growing the forests on to year 30. The mean diameter growth rates (cm yr^{-1}) adapted from Ngugi *et. al.* (2015) (Section 5.2.2.) were applied to individual trees in NEFA's plot data to identify growth achieved at year 15 and year 30, with diameters converted to biomass using Keith's allometric equation (Section 5.2.1.).

Currently logging is taking place on about a 15-20 year rotation, though the Harvesting Plan for Braemar SF proposes a second logging in 10 years, so assumption that the logged forests will average 15 years since the last logging event is conservative. While the timing of logging will vary, this will not materially affect the outcome as it is intended to log these forests at least twice in the next 30 years and the intervening growth will not make a significant difference if they are logged now and in fifteen years or in 5 years and again in 20 years, or if they are logged more lightly now and more heavily in 15 years, as after the initial logging most of the growth is provided by the larger trees required to be retained under the IFOA. This review doesn't account for the growth of recruits into the 10-20cm sizeclass over the 30 year period, though because of their small size and occurrence in both logged or conservation scenarios such small trees will not materially affect outcomes.

The CIFOA logging rules have increased logging intensity, now only requiring a minimum basal area of 10 m^2/ha be retained, and this is cited as the minimal basal area that will be retained in current Harvesting Plans. NEFA's plot data shows that if logging is conducted now the required minimum basal area retention of 10m^2/ha and all tree retention requirements can be satisfied by retaining all potential hollow-bearing trees (2.1 m^2/ha), retaining all red gum >30cm dbh (1.6 m^2/ha), and all live trees 10-31.5 cm dbh along with an average of 6.5 trees >30cm dbh. It is recognised that in practice the retention of trees may vary, though this indicates the minimum retention required to satisfy the new CIFOA logging prescriptions. Logging at year 0 removed 100.3 tonnes/ha of live biomass, and left 86.6 tonnes/ha of live biomass.

The retained trees (86.6 tonnes/ha) were then grown on for 15 years and all trees surplus to retention requirements (the hollow bearing trees and red gum >30cm dbh, along with the smaller trees needed to make it up to 10m^2 ha) were then assumed to be logged. Given the slow growth rates of these forests this entailed logging all available trees over 20.5 cm diameter. Logging at year 15 removed 24.5 tonnes/ha of live biomass (of which 5.8 tonnes/ha were growth increment), and left 90.0 tonnes/ha of live biomass (of which 22.1 tonnes/ha were growth increment).

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, Keith *et. al.* 2017). Keith *et. al.* (2017b) note:

> *In the context of carbon accounting, logging represents transfers of carbon stocks within the forest and production system. Biomass carbon is removed off-site and a proportion is stored in wood products and landfill. Carbon is emitted through combustion where the slash is burnt, as well as from decomposition of dead biomass from the slash remaining after harvesting and waste during processing. Carbon is sequestered in the regenerating forest.*

When a tree is logged most of it is left behind in the forest to rot or burn, larger logs and stumps may persist for some decades. Of the logs removed, most may end up as offcuts or sawdust in the production of sawntimber, or the whole logs may be chipped or pelletised, with only the sawntimber component being used for longer-term products which may store the carbon for a few decades. An indicative assessment of volumes of logged biomass likely to persist for more than 15 or 30 years after logging was made.

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.*

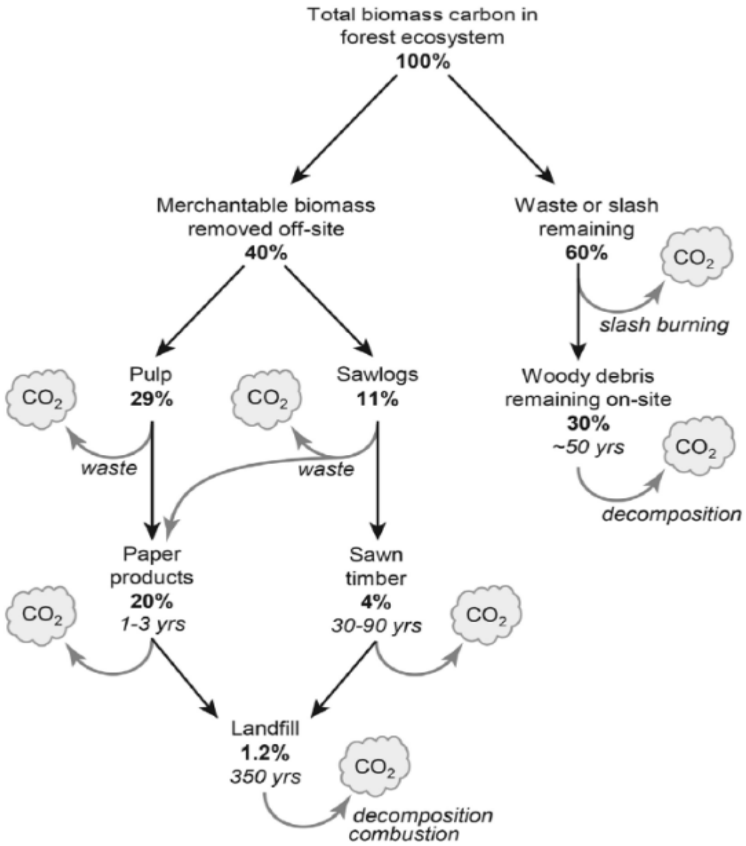


Fig. 8 from Keith *et. al.* (2014b). Transfer of biomass carbon during harvesting and processing of wood products. Numbers in bold represent the proportion of the total biomass carbon in the forest that remains in each component. Numbers in italics are the average lifetime of the carbon pool.

Since the collapse of the export woodchip industry in north-east NSW the market for low quality trees is limited, meaning that compared to the Central Highlands, less trees are felled, more small logs are left as waste in the forest, and lower volumes are directed to the short-term pulp stream. The assumption is that the Forestry Corporation will be successful in efforts (Ximenes *et. al*. 2017) to create a market for pulplogs, and therefore within a decade the wood utilisation demonstrated in southern NSW (Ximenes *et. al.*2004), where there is a pulp market will be relevant to the forests of this proposal.

DBH range (cm)	Number of trees	Recovery (%)	Standard deviation	Range
27-35	16	55.8	7.8	40.4-66.2
35-40	20	49.0	9.0	30.6-67.1
40-45	19	57.1	11.9	32.8-78.6
45-50	21	58.2	15.1	31.1-79.4
50-55	14	60.6	15.3	34.9-84.2
55-65	15	64.1	10.6	46.4-84.2
> 65	19	58.1	15.7	32.3-84.5
Total	**124**	**58.2**	**14.1**	**30.6-84.5**

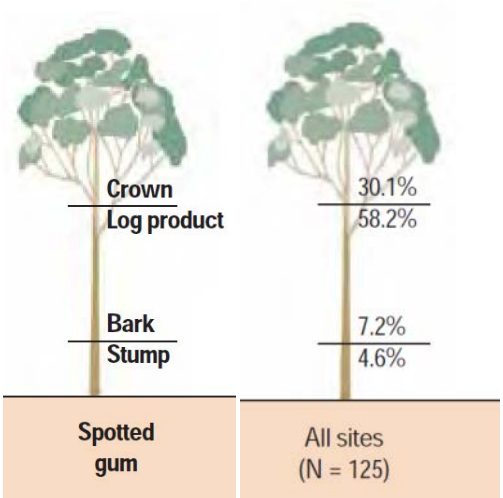


Table 12 and Figure 11 from Ximenes *et. al.* (2004) Average recovery to log products for spotted gum at a range of DBH classes, and proportion of the biomass allocated to tree components.

From their assessment of Above Ground Biomass (AGB) of commercial trees in south coast Spotted Gum forests Ximenes et. al. (2004) found "*When data from all sites were grouped, the total recovery to log products is 58.2%. The remaining biomass (41.8%) is left in the forest after harvesting as residue*". The above ground residue is comprised of tree heads (30.1%), logs, bark and stumps (4.6%). The bark component represented on average 7.2% of the total weight of commercial spotted gum trees, and thus 17.2% of AGB residues.

The recovery of 58.2% of AGB equates to around 46.6% of total biomass (with the inclusion of below ground biomass), which is adopted as the log recovery for this assessment.

Leaves, bark and small branches will rapidly decompose, releasing their carbon in the process, though large branches, stumps and roots will decompose more slowly. In dry environments standing dead trees and other CWD may remain for decades, with longevity dependent on species (Woldendorp *et. al*. 2002) Keith *et. al.* (2014b) assume that half the logging debris will have a life of around 50 years, though because of the dryness of these forests, the low numbers of large trees and thus logs, and the increasing fire frequency and intensity, the volume and longevity of logging debris is significantly less. NEFA's plot work was undertaken after the 2019 fires which had consumed most stumps, large roots and logs (along with leaf litter), leaving little CWD. It was apparent from before the fires that there were relatively low numbers of stumps and large logs. It is apparent that the volume and persistence of woody debris is significantly less than in the Central Highlands, though this has not been quantified.

For the purposes of this assessment it is assumed that 50% of logging residues (roots, stumps, bark and tree heads) would have a life of up to 30 years, with a half life of 15 years. This means that of the 53.6 tonnes/ha of CWD left after the initial logging at year 0 (26.8 t ha^{-1}) 13.4 tonnes/ha may persist for 15 years and 13.4 tonnes/ha may persist for 30 years. The second year 15 logging results in just 13.1 tonnes/ha of CWD, of which 6.5 tonnes/ha is taken to persist to year 30.

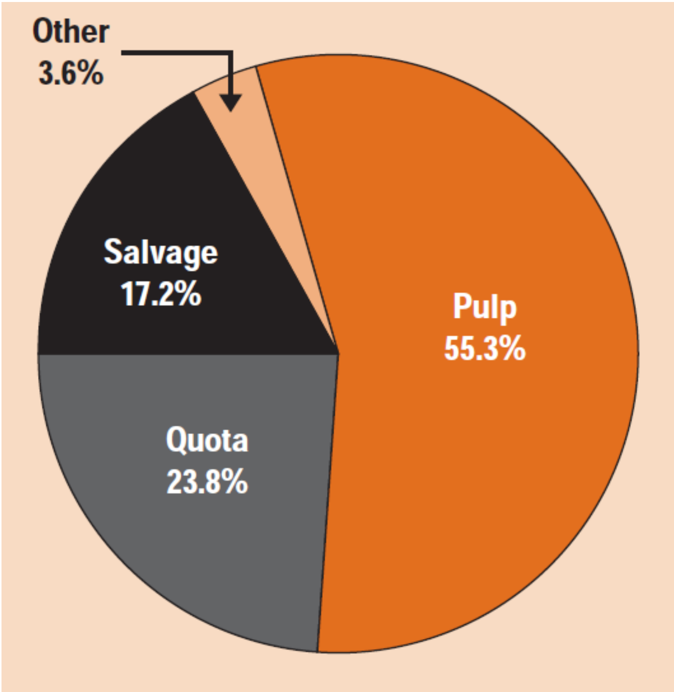


Figure from 20 from Ximenes *et. al.* (2004). Proportion of log products obtained after harvesting of spotted gum trees from all sites.

The other question is what proportion of the biomass removed from the site is likely to end up in products with a lifetime of more than 30 years. For their Spotted Gum forests Ximenes *et. al.* (2004) identify an allocation of logs to specific products, finding:

> *Pulp logs accounted for 55% of the total biomass in log products from spotted gum trees from all sites (Figure 20). The proportion of higher quality logs increased with an increase in site quality – from 15% at the LQS, to 35 and 48% at the MQS and HQS, respectively. (Figures 21-23). 'Other' logs included mostly log products used to produce firewood and round posts.*

Ximenes *et. al*. (2017) observe that residues arising from native timber sawmills generally are about 50% of log intake, noting:

> *In wood-processing facilities, residues are defined as the by-product of wood processing. In many cases, at least part of the residue fractions are already committed to an existing market, such as horticultural applications, energy generation and as feedstock for pulp or engineered wood product manufacture. For the purposes of this study, we have assumed that all "dry" residues from the dressing of dry timber and green sawdust are already committed to stable markets. We have assumed all "green residues" to be potentially available to a bioenergy market.*

URS (2012) identify that NSW hardwood sawmills have recovery rates of 40.6%.

Much of the sawn products from high quality logs will be further processed into floorboards and decking, resulting in further biomass losses, a high proportion of the salvage logs will have greater waste and be processed into products with short lives (such as pallets, garden stakes etc.), and the pulplogs are intended to be for biomass production which will quickly release their stored carbon.

For the purposes of this assessment it is assumed that recovery of sawn product, with reasonable prospects of long term storage, will constitute 40% of high quality logs and 25% of salvage logs, with all other biomass being either burnt or directed into products with short retention times (<15 years). If there is a market for burning biomass it is doubtful that any significant additional volumes will end up in landfill, though a portion of the sawn product may.

Applying Ximenes *et. al.* (2004)'s averages, of the 23.8% quota sawlogs removed, 40% may end up being stored beyond 30 years, being 9.52% of removed biomass. Of the 17.2% of salvage logs removed 25% may end up in long-term storage, being 4.3% of removed biomass. This gives a total of 13.82% of removed biomass possibly being stored in timber products with a life of over 30 years, which is 6.34% of total biomass logged. This is significantly more than the 4% assessed by Keith *et. al.* (2014b), so is considered conservative.

In total it is assumed that some 6.46 tonnes/ha of biomass removed from the forest at year 0, and 1.58 tonnes/ha removed a year 15 may end up being stored in timber products for more than 30 years.

With continued logging, at year 30 there is estimated to be 117.24 tonnes/ha of biomass left standing, an additional 19.94 tonnes/ha of dead biomass left from logging, and 8.04 tonnes of biomass stored offsite in timber products, giving a balance of 145.2 tonnes/ha of biomass storing 72.6 tonnes/ha of carbon.

If the land is protected for conservation, at year 30 growth would increase live biomass to 290.9 tonnes/ha storing 145.5 tonnes/ha of carbon.

Across the 4,531 ha intended for logging, logging will release 347,375 tonnes of CO_2 into the atmosphere over the next 30 years, whereas stopping logging and conserving the forest will remove 864,197 tonnes of CO_2 from the atmosphere. The conservation option will therefore remove 1.21 million tonnes more atmospheric CO_2 over 30 years compared to continued logging.

	Conservation	Logging		
		Log at yr 0	Log at yr 15	Retained at yr 30
LIVE BIOMASS CHANGE (tonnes biomass/ha)				
Current retain	**187.0**	100.38	18.72	67.9
0-15 yr growth increment	47.72		5.76	22.08
15-30 yr growth increment	56.22			27.26
Sub total	290.94	100.38	24.48	117.24
LOGGING CHANGE (tonnes biomass/ha)				
Log recovery		46.78	11.41	
Coarse Woody Debris		53.6	13.07	
DEAD BIOMASS FATE (tonnes biomass/ha)				
CWD retained at 0yr		>	13.4	13.4
CWD retained at 15yr			>	6.54
Sawn timber stored at 0yr		>	>	6.46
Sawn timber stored at 15 yr			>	1.58
Sub total		>	>	27.98
TOTAL CHANGE (tonnes/ha)				
Biomass total	+103.94			-41.78
Carbon total	+51.97			-20.89
Annual carbon change	+1.73			-0.70
Applied across 4,531 ha logging area (tonnes)				
Carbon Change	+235,476			-94,653
Carbon dioxide total	+864,197			-347,375

Comparison of conservation and logging outcomes for biomass and carbon across 4,531ha logged forests as a result of application of the new CIFOA logging rules over 2 logging events over 30 years. Note this doesn't account for background dead biomass in trees, logs and litter.

OPTIONS		30 yr Changes CO_2 (t)	Annual Changes CO_2 (t)
CONSERVATION	Exclusions	+460,431	
	Logging Areas	+864,197	
	TOTAL	**+1,324,628**	**+44,154**
LOGGING	Exclusions	+460,431	
	Logging Areas	-347,375	
	TOTAL	**+113,056**	**+3,769**
CONSERVATION BENEFIT		**+1,211,572**	**+40,386**

Changes in CO_2 benefits between the Conservation and Logging options over 30 years.

While continued logging of the 4,531 ha will release 347,375 tonnes of CO_2 into the atmosphere over the next 30 years, across the whole area this will be offset by the uptake of 460,431 tonnes of atmospheric CO_2 by the 2,414 ha of logging exclusions, resulting in the net removal of 113,056 tonnes of atmospheric CO_2 over the next 30 years with the logging option. This compares to the removal of 1,324,628 tonnes of atmospheric CO_2 if logging is stopped. The conservation option therefore results in the net removal of 1,211,572 tonnes CO_2 above the logging option over the next 30 years. On an annual basis the creation of the proposed Sandy Creek Koala Park has the net annual benefit of sequestering 40,386 tonnes of CO_2 per annum more than continued logging.

Limitations

Logging confounds assessments of carbon stores. The soil disturbance increases the release of carbon stored in soils, over-time logging reduces the size of trees and thus the volumes of coarse woody debris (CWD) and its longevity, and extensive damage (from machinery and falling trees) to retained trees hastens their demise or reduces their growth.

While logging increases in new Coarse Woody Debris (CWD) are accounted for, the background levels in the form of dead standing trees, logs and litter have not been included. These make a significant contribution to total carbon volumes. Large trees in these forests have mostly been logged, and large logs left as residues from the original forests have long since been incinerated, so CWD have been greatly diminished. Volumes in unlogged forests will increase over time as tree, and therefore log, sizes increase. For dry sclerophyll forests Woldendorp *et. al*. (2002) identify the mean proportion of total above-ground biomass as forest floor CWD was approximately 18%, with a mean forest floor CWD of 50.9 t ha^{-1}, noting:

> *Forest management significantly affects the amount of CWD in a forest (Harmon and Hua, 1991) – while logging operations initially reduce the amount of standing biomass, logging residue left on site can increase biomass in the forest floor CWD pool (Harmon et al., 1986). However, by reducing standing biomass to a small fraction of the amount found in natural forest stands, there is a reduction in potential future volumes of forest floor CWD (Hodge and Peterken, 1998), and stag formation (Cline et al., 1980). ...*
>
> *... Typically, old growth forests contain the largest quantity of CWD, followed by young forests (when forest floor CWD is a relic of the previous stand), and with mature or intermediate forests containing the least (Spies et al., 1988; Sturtevant et al., 1997; Clark et al., 1998; and Spetich et al., 1999). The volume of standing dead wood, however, tends to be low in young forests (Sturtevant et al., 1997), and increases with forest age.*

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).

From a study of Mountain Ash forests Bowd *et. al.* (2019) found that relative to unlogged forest, clearcut logging resulted in significantly lower levels of organic carbon in the lower 20–30 cm layer of soil, stating:

> *Logging impacts observed in this study were highly significant in both the short and midterm (8 and 34 years), and result from the high-intensity combination of physical disturbance (clearing of forest with machinery) and post-logging 'slash' burning (of remaining vegetation). These disturbances can expose the forest floor, compact the soil, volatilize soil nutrients and redistribute organic matter, resulting in the release of large amounts of CO_2 into the atmosphere (Fig. 4). These impacts can alter plant–soil–microbial dynamics and subsequently decomposition rates and carbon storage, and result in the leaching of dissolved organic carbon and nitrogen, and the depletion of base cations, reducing overall*

> *site productivity. Given the long-lasting impacts of fire, we suggest that the logging-related depletion of key soil measures may act as a precursor for longer-term, and potentially severe changes in soil composition.*

Similarly, for Mountain Ash forests Rab (1996) found:

> *... organic carbon and organic matter content in the topsoil and subsoil disturbed areas was significantly lower than that of the undisturbed areas. Mean organic carbon content in the topsoil and subsoil disturbed areas decreased by about 33% and 66% respectively compared with undisturbed areas.*

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.*

So it is evident that regrowth is unlikely to result in any significant carbon increase between logging events as the volume increment will be small and offset by soil carbon losses.

Fire will also affect carbon stocks, primarily through the consumption of dead Coarse Woody Debris (CWD), and fire intensity and losses will be greater in regrowth forests (Section 4.5). The 2019 fire consumed most ground CWD, including stump roots, though because of the increased abundance of large logs and wetter microclimate losses are likely to have been relatively less in oldgrowth forest.

The 2019 fires, combined with drought, also caused significant death of trees, particularly where fires were hotter and where trees had existing basal damage. While big old hollow-bearing trees are particularly vulnerable, it was found that there was significant loss of small and mature trees, and collapsing of mature Coastal Grey Box. These impacts have not yet been quantified.

These, and other considerations, show that this assessment of carbon losses due to logging are conservative and thus understated.

5.2.4. Pricing Carbon

The reduction in tree sizes and soil degradation due to logging has run down the carbon stores and uptake of this forest. Allowing this forest to mature will increase the capacity of the forest and soils to sequester and store carbon dioxide, while avoiding the carbon emissions associated with logging.

The wisdom of privatising the carbon cycle and making it into a tradeable commodity needs to be questioned given the failure of water privatisation and the high costs of buying back what were once public resources to maintain collapsing wetland environments. Irrespective of this, 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. While used herein, $17 a tonne is a gross under-valuation that will undoubtedly significantly increase over time well above CPI.

There are many ways to apply a carbon price to value the forests of the proposed Sandy Creek Koala Park:

- $56.8 million is the current value of the 3.34 million tonnes of CO_2 released into the atmosphere from these forests due to past logging, and the value of the carbon dioxide these forests have the potential to sequester if protected (Section 5.2.1)
- $22.5 million is the current value of the 1.32 million tonnes of carbon dioxide potentially recoverable by 2050 if these forests are protected.

	Biomass t ha^{-1}	[A] Area ha^{-1}	CO_2 equivalent (tonnes)	Value $
Original forest	454.26	6,945	5,789,124	$98,415,108
Current forest	187	[B] 6,945	2,447,878	$41,613,926
Loss			3,341,246	$56,801,182
Add by 2050	103.94	6,945	1,324,619	$22,518,523

A: 43ha cleared area removed. B:This incorporates the 132 ha of oldgrowth which is accounted for.

The baseline for ACCU's is the additional abatement that occurs because of a project, in this case the abatement that will occur by creating the proposed Sandy Creek compared to allowing its continued management for timber production. Some 35% is intended to be protected in exclusion areas and 65% (4,531 ha) is intended to be logged on an ongoing basis, it is the therefore the difference between continued logging, with increased logging intensity and ongoing reductions in carbon, and increasing carbon sequestration for the next century consequent upon protection of this part of the proposal.

Across the 4,531 ha proposed for logging, over the next 30 years the new logging rules allow for the increased emission of 347,375 t CO_2, which is balanced by the increasing sequestration of 460,431 t CO^2 in the exclusion areas, giving a net sequestration of 113,056 t CO_2. This remains significantly below the value of protection of these forests which will result in sequestration of 1,324,628 tonnes of carbon over 30 years.. Compared to business as usual, protection of the Sandy Creek Koala Park will result in the sequestration of an additional 1,211,572 t CO_2, worth around $686,557 a year, adding up to $20.6 million dollars over 30 years.

by 2050	**30 yr Changes CO_2 (t)**	30 year Value $	Annual Value $
Conservation by 2050	1,324,628	22,518,676	750,623
Logging by 2050	113,056	1,921,952	64,065
Conservation Gain	1,211,572	20,596,724	686,557

A variety of relevant studies have identified that the financial benefits of protecting forests for carbon sequestration far outweigh the returns from logging.

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.*

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.*

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.

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.

5.3. Tourism Benefit

Public land is a highly valued resource, providing the only natural areas for recreation for many local residents. Natural environments are also important components of the recreation and tourism industry and contribute significantly to attracting tourists to north east NSW in order to experience their landscapes and wildlife. Nature-based outdoor recreation is increasingly in demand as urbanization continues around the world.

The proposed Sandy Creek Koala Park occurs on moderate topography and straddles the Summerland Way, between Casino and Grafton. The Summerland Way carries an average of 1,200 vehicles per day and is promoted as a tourist route. It is 20 km from Casino, has easy access to Lismore and Grafton, and is only an hour and half drive from Byron Bay. It thus has significant recreation and tourism potential.

Recreation use is in part dependent upon the facilities provided, such as walking tracks, picnic facilities and camping areas, as well as the attractiveness of the landscape. These forests have been significantly degraded by past logging, though still can provide pleasant recreational experiences with careful selection of routes.

Koalas have a special value. From their study Hundloe and Hamilton (1997) found that koalas have an iconic status in attracting foreign tourists, with their "*best estimate of the contribution of koalas to the Australian tourism industry and thus the Australian economy is $1.1 billion. This translates into* *around 9,000 jobs directly accounted for by koalas*". More contemporarily Conrad (2014) assessed the Koala's annual contribution to international wildlife tourism as "*up to $3.2 billion and near 30,000 jobs*".

While Koala numbers have been significantly affected by past logging and dramatically so by the recent fires, if allowed to, their population will recover over time, along with the chances of visitors encountering them. They have the potential to be the major drawcard of tourists to this proposal.

Initially a minimum visitation of 10,000 visitors per annum can be expected with the provision of basic tourism facilities, though as Koala populations recover and the likelihood of encountering them on walks increases it is considered that this proposal could become a major tourist drawcard, attracting many tens of thousands of visitors per annum.

Based on current values, each 10,000 visitors per annum to the proposed Sandy Creek Koala Park are expected to generate $1.3 million in regional spending,10 jobs, and a consumer surplus of $450,000 to $900,000 per annum. This park will increase tourists using the Summerland Way and be a particular boost to the economy of Casino.

National Visitor Survey 2018 data identifies that each 10,000 visitors to the north coast generated a gross value added of $1,013,000, a gross regional product of $1,120,000, employs 10.6 people, and results in a tourist consumption of $1,713,000.

It is apparent that visiting natural areas makes a significant contribution to people's mental and physical health. Relating this to the self-perceived Personal Wellbeing Index has resulted in an estimation of the annual health services value of Australia's national parks as ~ $145 billion. Reserves that encourage increased recreation contribute to increasing this benefit.

Buultjens et. al. (1998) considered that:

> *The natural environment is perceived to be the one of the most important tourist attractions for Australia, and in particular of the north east NSW region. Forested areas represent a significant proportion of tourism and recreational attractions in natural environments (Commonwealth Department of Tourism, 1994; Northern Rivers Regional Development Board, 1994). Furthermore, demand for nature-based experiences is increasing significantly, with a 48 percent increase in National Park visitation in NSW and a 66 percent increase in bushwalking between 1989 and 1994 (Blamey, 1995)*

While attracting tourists to regional areas is an important value of national parks, it is important to recognise that their principal recreational value is to regional communities, as identified by Heagney *et. al.* (2019):

> *... demographic variables suggest higher rates of visitation by people living in regional areas. This trend was consistent across all surveyed states (Table 3). This suggests that the protected area network across NSW is providing important recreational services to regional communities, who generally experience lower levels of income and higher levels or deprivation than their metropolitan counterparts (Dollery and Soul, 2000).*

The Centre for Coastal Management (1993) note "*as indicated by the recreationalist survey … the most significant source of recreational forest visitation comes from the residents of the local government area*".

The NSW North Coast visitor profile identifies that in 2019 there were 6.4 million domestic overnight visitors, with an additional 8.5 million domestic day trip visitors and 374,900 international visitors. This gives a total of 15,274,900 visitors, spending a total of 37 million days in the region (visitor nights plus domestic day trips).

North Coast	Visitors (millions)	Visitor nights (millions)	Average Nights
domestic overnight visitors	6.4	24.3	3.8
domestic day trip visitors	8.5		
International visitors	0.375	4.2	11.1
TOTALS	**15.275**	**28.5**	

NSW North Coast visitor profile, Year ending December 2019

For a similar tourist region the National Visitor Survey (TRA *pers.comm*.) identifies that in 2019 there were 5,884,000 domestic overnight visitors, with an additional 7,433,000 domestic day trip visitors and 364,000 international visitors. This gives a total of 13,681,000 visitors, spending 34,795,000 visit days (visitor nights plus domestic days). This gives significantly lower overall visitation figures for the North Coast tourism region due to NSW adopting a larger region (including Newcastle).

North Coast NSW	Visitors ('000)	Visitor nights ('000)	Regional expenditure ($M)	Average expenditure per trip $	Average expenditure per night $
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).

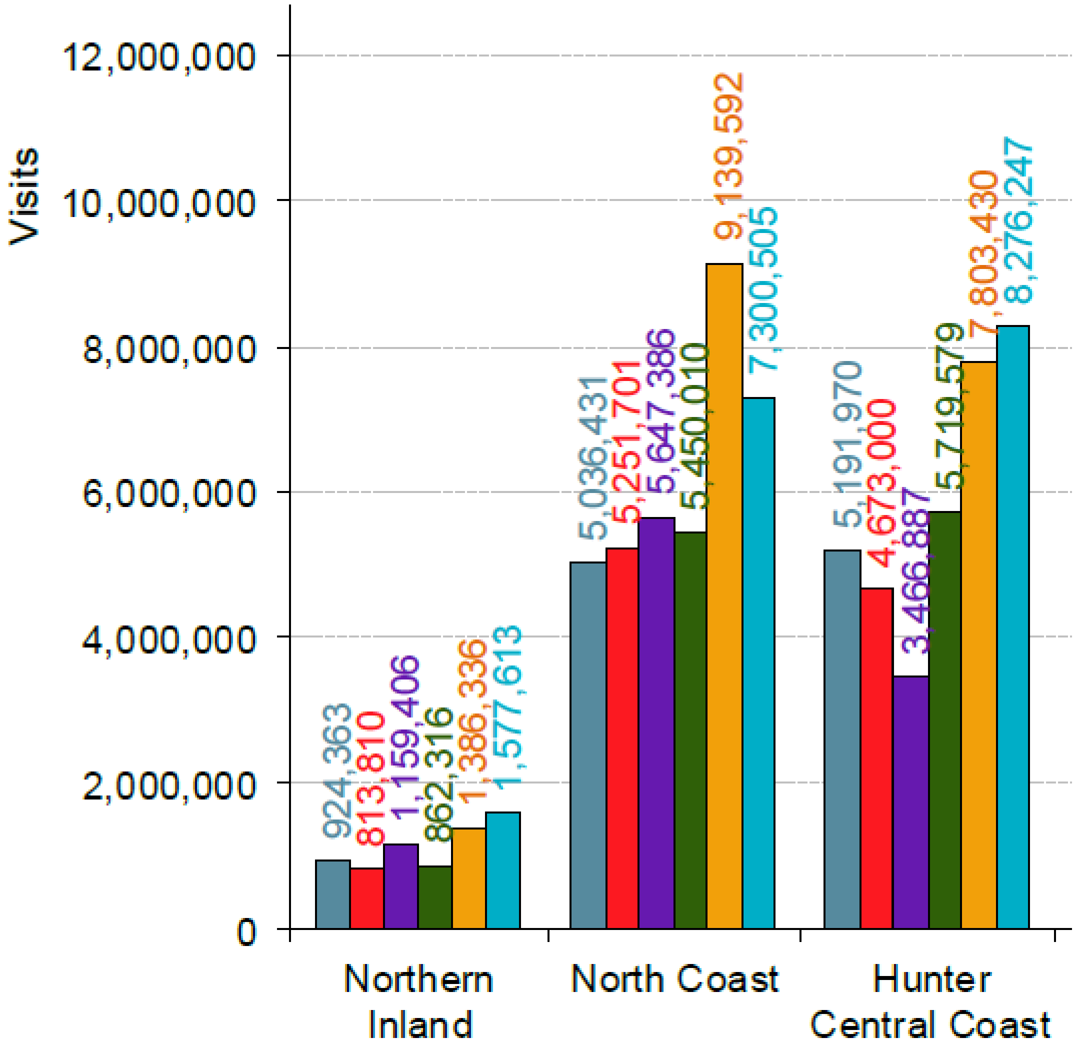
NPWS branches

Tourism Regions Australia

Destination NSW

The visitation to National Parks and reserves in north east NSW, derived from a variety of sources as of 2010, was estimated to be 9.4 million visitors (OEH pers. comm.), representing a 250% increase since 1997 (Buultjens *et. al.* 1998).

Roy Morgan (2019) undertook a series of telephone surveys from 2008 to 2018 to identify visitation (visitor days) to NSW National Parks and reserves, giving a growth rate of 9.7% since 2010, up to 60,236,009 visitors in 2018. North-east NSW basically encompasses the National Parks and Wildlife Service (NPWS) branches of North Coast, Hunter Central Coast, and the tablelands portion of Northern Inland. For the NPWS North Coast region, which best approximates the North Coast tourism region, Roy Morgan (2019) give park visitation rates of 5,251,701 in 2010, increasing to 7,300,505 in 2018, which is an average annual visitation increase of 256,101 p.a. At this rate of growth visitation can be expected have reached 7.5 million in 2019 - before COVID 19.

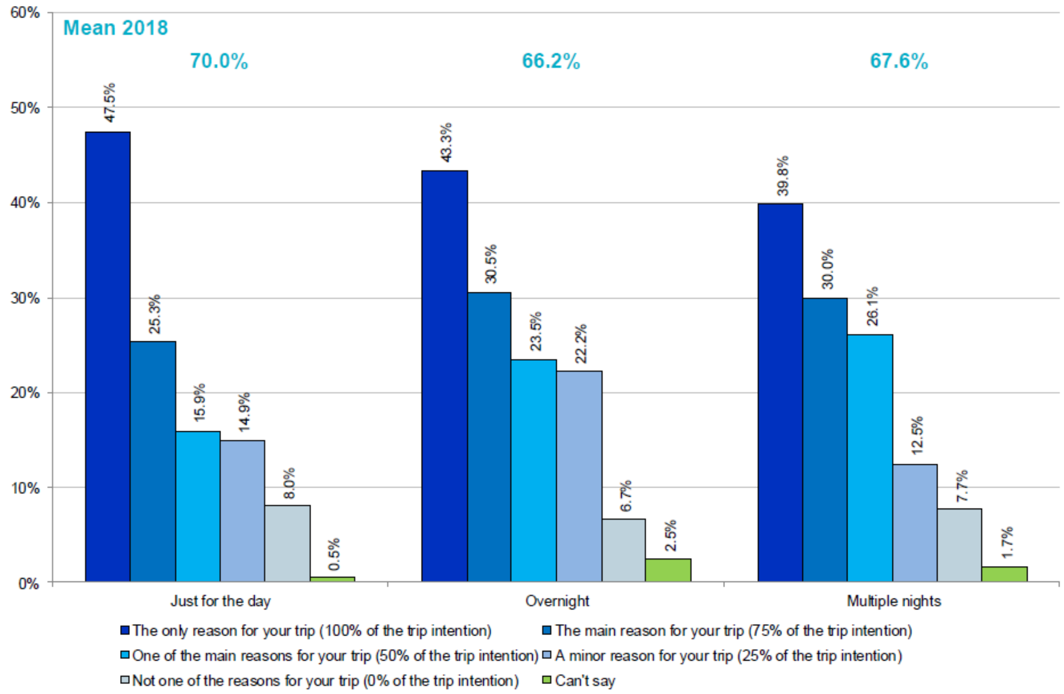


Extract from Roy Morgan (2019) Chart E: NPWS Annual Visitation by NPWS Branch

Given that Roy Morgan is only sampling NSW residents there is no account of international and interstate visitors which are significant contributors to visitation. So these figures significantly understate total visitation.

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.

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.*

Respondents (Roy Morgan 2019) who had visited a NPWS park were asked what activities they undertook on their *most recent* visit. In 2018 the most commonly named activity group undertaken at NPWS parks were *walking* (64%), *water-based recreation* (21%), *picnicking and dining* (14%), *touring and sightseeing* (14%) *enjoyment and appreciation of nature* (6%) and *nature play of children* (4%).

Heagney *et. al.* (2019) consider:

> *While the move towards monetary valuation of ecosystem services is not without its critics (McCauley, 2006; Silvertown, 2015), it is clear that the lack of a robust estimate of economic value puts protected areas and other natural ecosystems at a disadvantage when resource allocation decisions are made on the basis of economic criteria - as they so often are. In decisions about land allocation, protected areas must compete with alternate land-uses like agriculture, forestry and urban development, all of which have economic values that are easily and routinely reported. In these situations, a reliance on economic criteria is likely to yield decisions that maximise private industry gains at the expense of the broader societal values offered by protected areas.*

5.3.1. Recreational Value

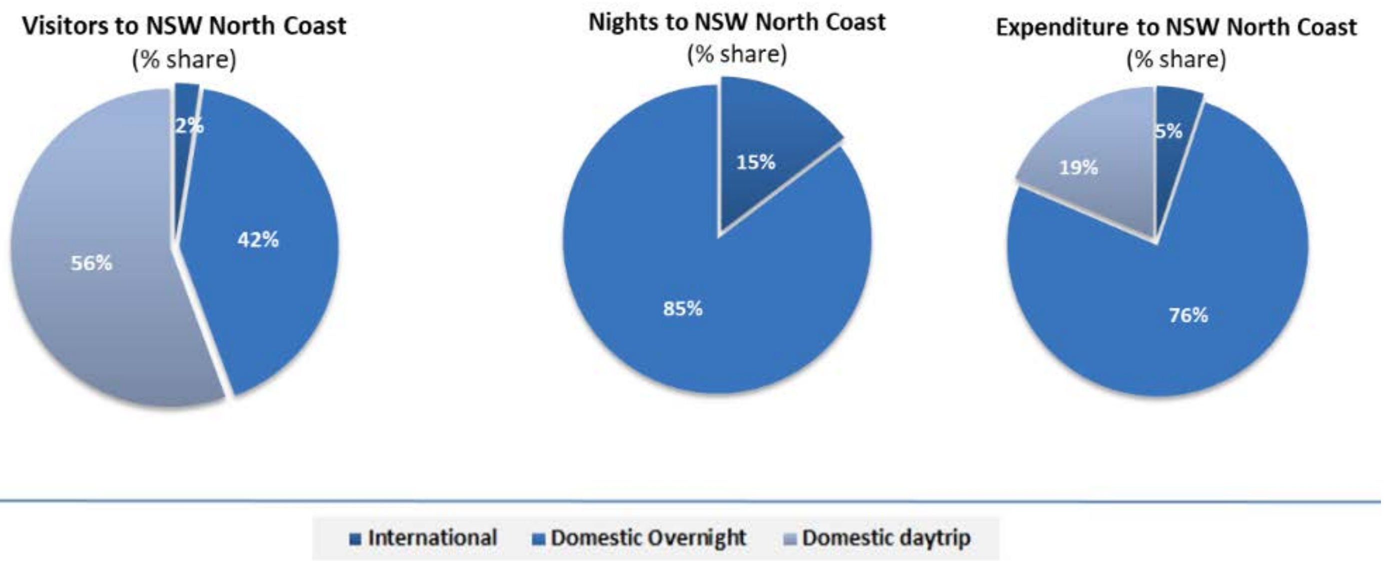
Visitation to, and management of protected areas, provide economic stimulation to regional economies from the associated expenditures that occur within the region. Visitors may buy food, refreshments, fuel, vehicle repairs, accommodation, and/or crafts in local towns, or stay in resorts or on farms, 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.

5.3.1.1. Park Visitor Expenditure

One method has been to account for expenditure of all park visitors made in visiting a park, though this is considered to over-state expenditure attributable to the park itself. There have been a variety of means applied to apportion spending by park visitors to quantify the expenditure directly attributed the parks. At one extreme only the expenditures incurred by over-night visitors who visited a region specifically to visit a park are counted, as noted by Driml (2010) "*Results from these recent studies indicate that the more narrowly defined spending (substitution, NP generated) is less than 20 percent of the more broadly defined spending*". As this doesn't account for day-trippers from within a region, or those for whom the park visit was only part of the motivation for visiting, this needs to be considered a conservative minimum. There are a variety of intermediate evaluations.

Estimation of direct use values has been an evolving process that has been developed and refined in a variety of studies in north-east NSW over the years (Kuring-gai Colledge of Advanced Education 1988, Powell and Chambers 1995, Bennett 1995, Gillespie 1997, Buultjens *et. al.* 1998, Buultjens and Luckie 2004, Gillespie Economics 2006).

Buultjens and Luckie (2004) assessed the economic value of visitation to 7 reserves in north-east NSW, identifying visitor expenditures ranging from $17.80 to $98.50 a day, finding:

> *The NPWS undertook direct expenditure of $3.3m in managing the seven national parks. In addition to direct NPWS expenditure, the annual total expenditure in the north-eastern NSW economy by visitors to the seven national parks was estimated to be $21.0m. The total direct expenditure in was estimated to be $24.3m. In addition to these direct benefits, there were also flow-on or multiplier effects estimated to be in the range from $17.1m to $22.4m. The total economic effect (direct benefits plus flow-ons) of the seven national parks were estimated to be in the range of $41.4m to $46.6m. These figures are an underestimate of the total expenditure undertaken in north-east NSW because only a limited number of towns were listed for each park as 'local' and it is very likely there would have been substantial expenditure undertaken in other towns within the region.*

Buultjens and Luckie (2004) then made significant adjustments to visitor expenditure, with the "*first adjustment was made to reflect the spending patterns of the different categories of visitors, for example local and non-local day and overnight visitors, since expenditure patterns were quite different for each of these visitor categories"*, then "*adjustments were made to the data to also account for leakages*", and finally "*The data was further adjusted to try and determine the expenditure resulting exclusively from the proportion of the trip related to the national park visit*". The outcome was:

> *The fully adjusted data indicated that direct expenditure was $6.2m, the flow-ons ranged from $5.2m to $5.9m and total effect was estimated to be between $11.5m to $12.2m. ... visitor expenditure effects, adjusted for type of visitation, leakages and the proportion of trip related to the national park visit, were between 38 and 68 jobs. The flow-on effects accounted for between 55 and 99 jobs and total effects accounted for 151 to 263 jobs.*

Lindberg and Denstadii (2004) undertook an assessment of 4 Queensland parks, as well as traditional accounting for all park visitors, they accounted for tourists who in the absence of the parks would not come at all and/or would reduce the number of days they would stay in the region. They found:

> *The four parks utilised in this study, with estimated visitation in 2001, were Girraween (47,226), Eungella (90,000), Daintree (only the Cape Tribulation section; 500,000), and*

> *Carnarvon (47,000). Visitor surveys, conducted primarily in 2001, indicate that the average Girraween visitor spent $68 in the Granite Belt region, the average Eungella visitor spent $369 in the Eungella region, the average Daintree visitor spend $369 in the Port Douglas region, and the average Carnarvon visitor spent $134 in the Carnarvon region ... These figures represent all spending by park visitors in the associated regions and reflect the “traditional” measure of park-related visitor expenditure.*
>
> *However, it is recognised the some visitors may visit a local region even if the park did not exist. ... Therefore, a second measure, “conservative,” was also used. This measure is of the expenditure that would be lost if the park did not exist, and thus the expenditure directly attributable to the park. These estimates are $34 for Girraween, $42 for Eungella, $212 for Daintree, and $103 for Carnarvon.*

In their Queensland study of visitor nights Ballantyne *et. al.* (2008) identified 'national parks associated' and 'national park-generated spending'. To value 'national park-generated spending' the approach taken was to attribute to the total spend of visitors who are only visiting a region to visit national parks to the national park, irrespective of how much of their trip was actually spent there. Ballantyne *et. al.* (2008) elaborate:

> *... considered to be the amount which would have either not been spent in Queensland by tourists or, alternatively, spent in another state or overseas had the current parks system not been accessible. This estimate is then used to assess the national parks’ contribution to the Queensland economy based on the amount of income (value added) that would be lost to Queensland if the national parks did not exist.*

For 2006/7 Ballantyne *et. al.* (2008) found direct spending per person per night for visitors who engaged in one or more national park activities varied across the four localities, with mean values 'ranging from $44 per night in Carnarvon to $81 per night on the Gold Coast'. Accounting for CPI increases up until March 2020 the range is now $59-108 per night. It was estimated that 12.2-20.6% of expenditure was attributable to visitors for which parks were their sole reason for visiting.

	National Park Associated Spending $ per 1000 visitors			**National Park Generated Spending $ per 1000 visitors**					
Study	Buultjens and Luckie (2004)	Lindberg and Denstadii (2004)	Ballantyne *et. al.* (2008) 1	Buultjens and Luckie (2004)		Lindberg and Denstadii (2004)		Ballantyne *et. al.* (2008) 1	
Visitor spending	29,560-163,600	106,420-577,520	58,520-107,650	12,900-40,220	44-25%	53,210-331,800	50-57%	10,790-17,810	18-17%

National Park Associated Spending (all park visitors) and National Park Generated Spending (visitors who are only there to visit parks). Dollar values updated to 2020 with the Consumer Price Index adjustment and standardised to 1,000 visitors.

It is evident that estimates of expenditure varies significantly between regions and surveys, as does the proportion attributed solely to parks. It is also apparent that a proportion of all visitor's expenditure, including daytrippers and people visiting a variety of attractions, should be accounted for rather than just those visitors who have only come to visit parks.

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

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).

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.

This National Visitor Survey visitor expenditure is significantly greater than the 'National Park Generated Spending' of $12,900-40,220 identified by Buultjens and Luckie (2004), and more in line with the $53,210-331,800 identified by Lindberg and Denstadii (2004). This difference may in part reflect the difference between localised spending in towns near to the parks and regional spending.

For the purposes of this review the contemporary estimates of the National Visitor Survey of $129,133 per 1,000 visitors are taken to represent expenditure associated with national park visitors. Therefore for each 10,000 visitors per annum to the proposed Sandy Creek Koala Park it will generate $1.3 million in regional spending.

5.3.1.2. Flow-on Effects

Direct spending is only one component of the economic benefits of tourism on regional, state and national economies. As observed by Driml (2010):

> *Measures of direct spending have most use if they are interpreted in terms of their contribution to the economy, for example to employment, to gross (national/state/regional) product and in terms of flow-on effects to other industries. ...*
>
> *... Value added and tourism gross (regional/state/national) product are variations of what is left when the cost of providing goods and services is subtracted from the spending by tourists. They represent the real addition to an economy in the form of wages and salaries, profits, interest and rent. Employment supported by the spending in the tourism sector can be estimated. ...*
>
> *Flow-on effects are created when demand for goods and services from other industries in the economy (excluding imports) is generated by spending in the tourism sector. For example, cafe´s will source some produce from the local agriculture sector as well as from imports. In addition, the spending of wages and salaries by people employed in the tourism sector will have effects in the defined economy. An understanding of the flow-on effects is important to appreciate the extent to which spending by tourists supports the economy. ...*

Driml (2010) summarises a variety of NSW park visitor studies:

> *The results show that the regional value-added can be in the millions of dollars even in the more remote regions and in the hundreds of millions of dollars for the larger regions. Employment can be in the hundreds of jobs in the more remote regions and in the thousands of jobs in the larger regions. In the more remote regions the economic impact of park management expenditure rivals that of visitor expenditure whereas in the larger regions, visitor expenditure has a much greater contribution to overall economic impact.*

Gillespie Economics (2006) expanded on the work of Buultjens and Luckie (2004), using their visitor expenditures, to quantify the economic impacts of 167 National Parks and Reserves in the Upper North East region. Based on previous studies and new information they found that in 2005 the total annual regional economic impact on the economy of Upper North East NSW from the expenditure of 5,891,684 visits to National Parks and reserves to be:

- $225 million in direct and indirect output or business turnover (the gross value of business turnover);
- $107 million in direct and indirect value-added (the difference between the gross value of business turnover and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output);
- $59 million in direct and indirect income (the wages paid to employees including imputed wages for self-employed and business owners); and
- 1,651 direct and indirect jobs (the number of people employed - including full-time and part-time).

	Visitor Expenditure	Park Management Expenditure	TOTAL
Total output	$225M	$29M	$254M
Total value-added	$107M	$17M	$124M
Total income	$59M	$13M	$72M
Total jobs	1,651	265	1,916

Table – 2005 Regional Economic Impact of Protected Areas in Upper North East NSW From Gillespie Economics (2006)

Gillespie Economics (2006) found that park management expenditure in the north-east of NSW were estimated to add significantly to the benefits of visitor expenditure.

Applying a similar methodology, Gillespie Economics and BDA Group (2008) undertook an assessment of *Economic Activity of Australia's World Heritage Areas,* finding with an annual visitation of 2.5 million (1.3 million in Queensland and 1.2 million in NSW) in 2006/7 the Gondwana Rainforests of Australia visitation contributed:

- *$357.2 million in annual direct and indirect output or business turnover;*
- *$158.1 million in annual direct and indirect value added;*
- *$87.1 million in annual direct and indirect household income; and*
- *2,314 direct and indirect jobs.*

This data was updated to account for CPI until March 2020 and standardised to per thousand visitors to allow comparisons. These show very different results between the two Gillespie studies, which is surprising given they have many reserves in common. The reasons for this haven't been ascertained.

Regional impacts of park visitation	**North east NSW** Gillespie Economics (2006)		**Gondwana Rainforests of Australia** Gillespie Economics and BDA Group (2008)	
	Total	**per 1000 visitors**	**Total**	**per 1000 visitors**
Total output	$318M	$53,908	$474.9M	$189,960
Total value-added	$151M	$25,636	$210.2M	$84,080
Total income	$83M	$14,135	$115.8M	$46,320
Total jobs	1,651	0.28	2,314	0.93

Regional Impacts of visitors to North East NSW and Gondwana Rainforests of Australia (Dollar values updated to 2020 with the Consumer Price Index adjustment).

These data are for economic affects in local towns, and the economic impacts are far greater for larger regions. The tourism economic impacts (not limited to park visitors) identified across the NSW north coast in the satellite accounts of Tourism Research Australia are more aligned with the World Heritage study when compared per 1,000 visitors.

	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18
Gross value added	**$million – basic prices**							
DIRECT	1,229	1,268	1,409	1,478	1,470	1,546	1,523	1,679
INDIRECT	1,115	1,152	1,260	1,295	1,301	1,359	1,353	1,501
TOTAL	2,344	2,421	2,669	2,773	2,771	2,905	2,876	3,179
Total gross regional product	**$million – basic prices**							
DIRECT	1,312	1,351	1,492	1,564	1,558	1,638	1,621	1,790
INDIRECT	1,286	1,356	1,466	1,481	1,485	1,546	1,564	1,724
TOTAL	2,599	2,707	2,957	3,045	3,043	3,183	3,185	3,514
Persons employed	**000**							
DIRECT	20.6	20.0	20.9	21.1	21.8	22.4	22.0	23.9
INDIRECT	6.8	7.1	7.7	7.9	8.0	8.4	8.3	9.3
TOTAL	27.5	27.1	28.5	29.0	29.8	30.8	30.4	33.2
Tourism consumption	**$million – purchaser's prices**							
CONSUMPTION	3,937	4,072	4,404	4,547	4,596	4,826	4,810	5,377

Regional Tourism Satellite Accounts for north coast of NSW provides information on the importance of tourism using measures of Tourism Gross Value Added, Tourism Gross Domestic Product, tourism employment and tourism trade.

Definitions used are:

Tourism Gross Value Added

Tourism GVA shows only the 'value' added by the producer to the raw material goods before any addition of taxes, such as GST or wholesale sales taxes. It also excludes excise duties on goods supplied to visitors.

Tourism Gross Regional Product

Direct tourism GDP measures the value added of the tourism industry at purchasers' (market) prices. As such, it includes taxes paid (less subsidies) associated with the productive activity. It enables a direct comparison with the national aggregate of GDP and is useful in this macroeconomic context. However, when making comparisons with other industries or between countries, the direct tourism Gross Value Added measure should be used.

Tourism consumption

Consists of tourism expenditure plus imputed consumption by domestic, inbound and outbound visitors on tourism-related products, including those sold at prices that are not economically significant. It is measured in purchasers' prices – the price that visitors pay.

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

National Visitor Survey (TRA pers.comm.) 2018 visitation for north coast NSW

Visitation data was only obtained for calendar years, so are not strictly comparable, though for the purposes of this report the calendar visitation data for 2018 (31,392,000 visitor nights and domestic days) was compared to the Satellite Accounts for 2017-18. Indicating that for the north coast each 1,000 visitors generated a gross value added of $101,268, a gross regional product of $111,939, employs 1.06 people, and results in a tourist consumption of $171,286.

Ballantyne *et. al.* (2008) consider from an economy-wide point of view, total expenditure does not represent the contribution of the sector to the economy, as *"total spending can be thought of as consisting partly of value added (income in the form of wages, profits, interest and rent) and partly of intermediate inputs*". To convert the contribution of national park-generated spending to *gross state product (GSP)* Ballantyne *et. al.* (2008) estimated "*that value added represents approximately 46% of output in this sector*" and that "*the tourist sector contributed approximately 5.8% of gross state product*", to determine "*that the direct contribution of national park-generated tourist spending to the Queensland economy is approximately $345 million per annum or 4.9% of the sector's contribution to GSP*".

> *A conservative estimate, based on actual park visitation within Queensland however, indicates that national parks are a significant contributor to the tourism economy of the state with results revealing that direct spending by tourists visiting Queensland's national parks amounts to approximately $4.43 billion annually—accounting for approximately 28% of total tourist spending in Queensland. Importantly the study also identified that direct spending by tourists which can be attributed exclusively to the existence of the national parks amounts to over $749 million per annum, and contributes around $345 million to gross state product per annum.*

Ballantyne *et. al.* (2008) consider their estimates as conservative, noting:

> *A less conservative estimate of these numbers (see Appendix Table D1) would indicate substantially higher values for national park-associated spending and national park-generated spending. From Appendix Table D3 it can be seen from the simulation results that under the 'maximum estimate' scenario, mean national park associated spending is $6.69 billion and mean national park-generated spending is $1.15 billion, implying a contribution of around $528 million to GSP per annum.*

Ballantyne *et. al.* (2008) compared their results to total over-night expenditure for Queensland's tourist sector, concluding "*National park-associated spending is therefore approximately 28% of the total, while national park-generated spending is approximately 4.7% of the total*".

It is evident that tourism makes a significant contribution to the north coast economy, and increases in tourism can only financially benefit local communities and economies.

For the purpose of this review it is assumed that one person will be employed for every 1,000 tourist visits. Therefore for each 10,000 visitors per annum to the proposed Sandy Creek Koala Park it will generate 10 jobs in the region.

5.3.1.3. Consumer Surplus

The 'consumer surplus' is a commonly used metric for valuing recreation usage, this is the difference between the amount an individual is *willing to pay* and the amount actually spent. Driml (2010) elaborates:

> *Consumer surplus is the benefit gained by consumers when what they are willing to pay for a good or service is greater that what they have to pay. Consumer surplus is considered the relevant measure of economic welfare. Many studies have estimated the value of natural environments, including national parks, to tourists in terms of consumer surplus generated by visits, where willingness to pay is above what visitors actually have to pay. This is the appropriate measure to be used in cost-benefit analysis of proposals (Keske and Loomis, 2008), for example to expand the park estate at the cost of competing land uses.*

Using the Travel Cost Method (vehicle operating costs and opportunity costs of travel time) Gillespie Economics (2006) found that the economic value (consumer surplus) of visits to the seven national parks assessed by Buultjens and Luckie (2004) was estimated at between $25 and $50 per person. At 2020 values this equates to $34.71-69.43 per person. The average value given in 2005 was $31.90, which equates to $45 in 2020 dollars.

Heagney *et. al.* (2019) applied the results of Roy Morgan (2019)'s stratified random phone-surveys of more than 62,000 individuals to estimate the total value of tourism and recreation services provided by the NSW protected area network as $3.3 billion per annum. Heagney *et. al.* (2019) "*estimate that, on average, NSW residents make 5 visits to protected areas each year, and derive $90 in consumer surplus from each visit*". This is significantly more than the updated Gillespie Economics (2006) value. .

The consumer surplus can thus be considered to be something like $45,000 - $90,000 per thousand visits. Therefore a minimal visitation of 10,000 per annum to the proposed Sandy Creek Koala Park is expected to generate a consumer surplus of $450,000 to $900,000 per annum.

5.3.2. Health Value

Exposure to natural environments reduces most people's psychological and physiological (i.e. pulse rate, blood pressure, cortisol, salivary amylase, adrenaline) indicators of stress, while improving their mood and happiness. The experience can overcome mental fatigue and restore cognitive function.

A walk through a forest influences people's well-being through our senses of sight, hearing, and smell. Organic particles suspended in the air appear to be particularly influential. Trees remove human pollutants and contribute beneficial bacteria, negatively-charged ions and phytoncides to the air we breathe. Phytoncides are organic compounds that plants produce to communicate between themselves and with other organisms.

A review by Pugh (2018) identified a large body of evidence attesting to the benefits of the natural environment on the physical health and mental wellbeing of people, summarising the benefits as:

- *People's most common and consistent responses to exposure to nature are reduced stress, anxiety and anger, with improved mood and cognitive function. These affects are confirmed by an array of physical responses indicative of reduced stress, such as reduced cortisol levels, salivary amylase, pulse rate, blood pressure, adrenaline, Skin Conductance Responding, and frontalis muscle tension. Improved cognitive function has been shown in a variety of performance tests, as well as being indicated by increased parasympathetic nervous activity.*
- *Recreating in forests can have other significant health benefits such as reducing cardiovascular disease associated factors, enhancing human natural killer cell (NK) activity,*

increasing anti-cancer proteins, and reducing blood sugars. This has in part been attributed to the quality of the air in forests, particularly the presence of organic compounds (phytoncides) released by trees.

- *Experiencing ancient giant trees, unusual wildlife, spectacular natural landscapes and wilderness can invoke awe and wonder, providing transcendent and spiritual experiences.*
- *Overcoming the challenges that can occur recreating in natural environments improves self-esteem, whether it is a child climbing a tree or an adult conquering a mountain, and doing so in company can result in long-term increases in altruistic and cooperative behaviours.*

Visits to national parks thus have direct public health benefits (Heagney et. al. 2019, Buckley et. al. 2019). Heagney et. al. (2019) observe that "*The frequency of protected area visitation is also relevant in relation to public health objectives. There is increasing evidence that protected areas can contribute to physical and mental wellbeing*".

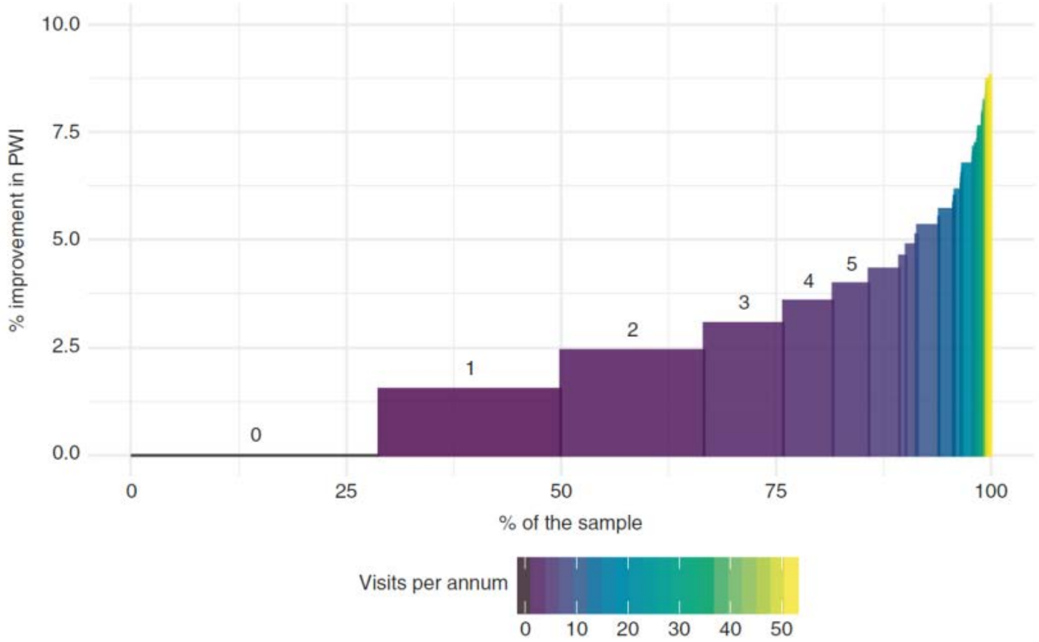


Fig. 2 from Buckley *et. al.* (2019) Distribution of quality-of-life improvement derived from protected area visitation. Distribution of quality-of-life (QOL) improvement derived from protected area visitation across the sample population, pilot trial 2. Vertical axis shows QOL improvement, measured as % increase in self-perceived personal wellbeing index, PWI, controlled for socioeconomic and demographic factors and non-park greenspace use. Horizontal axis shows proportions of sample population. Colours show the number of visits to protected areas during the preceding 12 months. For low annual visit frequencies, 0–5 inclusive, frequencies are also indicated by numerals above the bars. Thirty per cent of the sample had not visited parks at all during the past year, and hence experienced no improvement in PWI. The majority of the sample population, shown in purple, had visited a protected area 1–5 times in the preceding year, yielding small but significant improvements in self-perceived wellbeing. Much smaller proportions of the sample population, shown in blue, green, and yellow, had visited monthly, weekly or daily, with improvements in PWI up to ~8%

Buckley *et. al.* (2019) calculated the economic value of protected areas derived from the improved mental health of visitors, concluding "*A conservative global estimate using quality-adjusted life years, a standard measure in health economics, is US$6 trillion p.a. This is an order of magnitude greater than the global value of protected area tourism, and two to three orders greater than global aggregate protected area management agency budgets*". They comment:

Nature exposure improves human mental health and wellbeing. Poor mental health imposes major costs on human economies. Therefore, parks have an additional economic value through the mental health of visitors. We refer to this as a health services value.
...
We conclude that there is a direct link between protected area visits and individual human mental health and wellbeing, which translates to a very substantial but previously unrecognised economic value for protected areas and conservation. This health services value already exists, since the costs of poor mental health would increase if protected areas ceased to exist, or if people could no longer visit them. Historically, it has not been included in debates over economics and finance for either conservation or health. We argue that it should be recognised, quantified accurately and widely, and included explicitly in policy.

Buckley *et. al.* (2019) identify that each 1% increase in the self-perceived Personal Wellbeing Index has been calculated as equivalent to "quality-adjusted life years" ($QALY) valued as US$150,000-250,000 (A$218,000-364,000), concluding:

Using the conservative estimate ΔPWI = 2.5%, $/QALY = US $200,000 as above, and the Australian adult population as 20 million, the annual health services value of Australia's national parks is ~US$100 billion, in addition to values from biodiversity, ecosystem services, and tourism expenditure. This is about 7.5% of Australia's GDP, 1.6 times the entire annual turnover of Australia's tourism industry, and two orders of magnitude larger than the aggregate annual budget of Australia's national parks agencies.

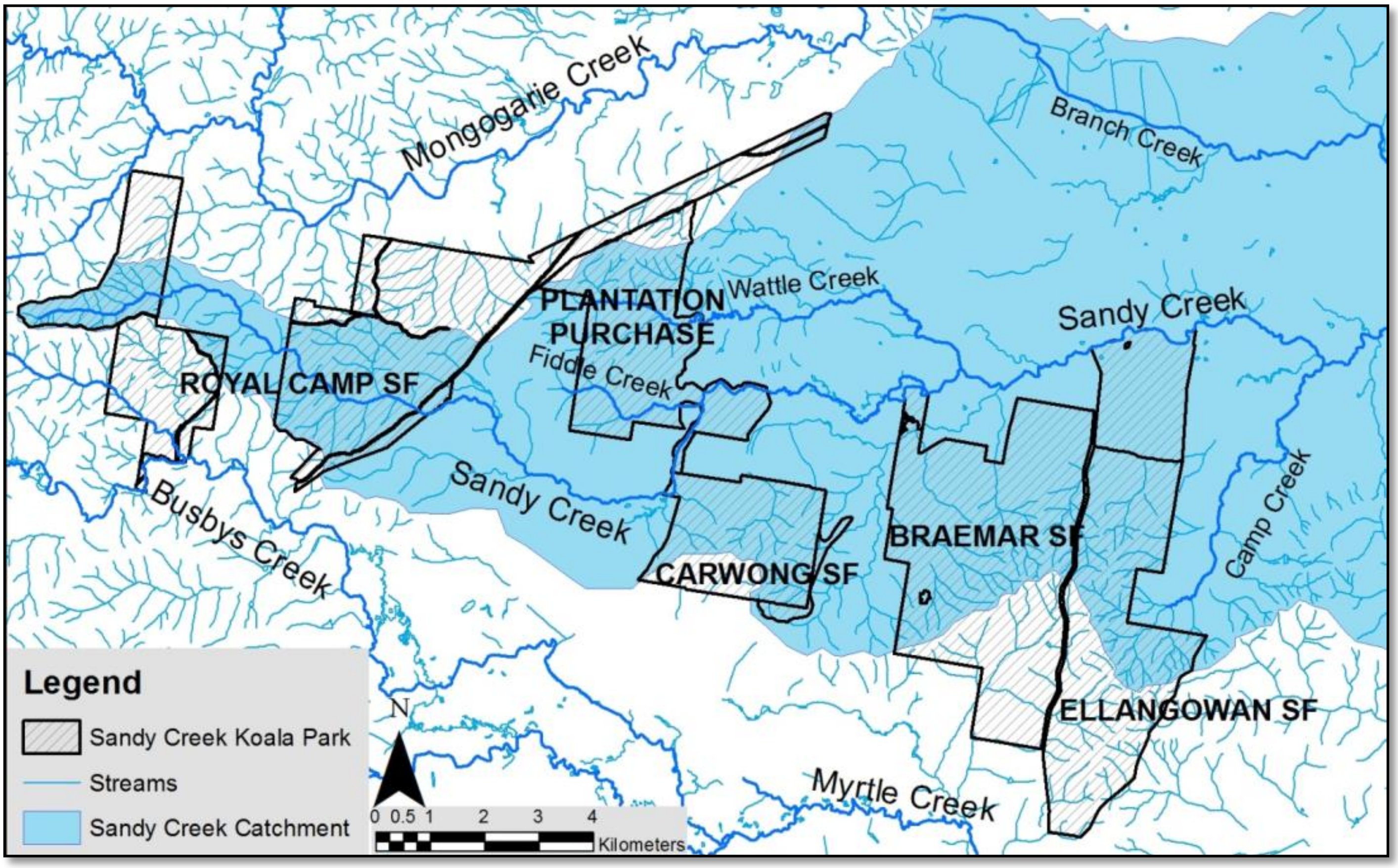
US$100 billion equates to Australian ~ $145 billion. Buckley *et. al.* (2019) consider:

In Australia, the aggregate costs of poor mental health currently amount to ~10% of GDP[25]. The pilot estimates presented here indicate that without protected areas, these costs would be 7.5% greater. For protected area management agencies, the key conclusion is that operational management and infrastructure that encourages individual visitors to visit public protected areas contributes substantially more to national economies than arrangements to increase commercial tourism.

It is apparent that visiting natural areas makes a significant contribution to people's mental and physical health. Relating this to the self-perceived Personal Wellbeing Index has resulted in an estimation of the annual health services value of Australia's national parks as ~ $145 billion. Reserves that encourage increased recreation contribute to increasing this benefit.

5.4. Water Values

The proposed Sandy Creek Koala Park predominantly occurs in the headwaters of Sandy Creek, while also providing runoff to Shannon Brook (via Mongogarie Creek) and Myrtle Creek, all of which flow into the Richmond River Tidal Pool from Tatham to below Coraki and thence enters the sea at Ballina.



It is apparent that through conversion of oldgrowth forest to regrowth, past logging has increased tree transpiration and reduced streamflows from the proposed Sandy Creek Koala Park by some 14,000 ML per annum, which is the water volume recoverable over time as streamflows and aquifer recharge if these forests are allowed to mature. The business as usual option proposes protecting 35% of these forests, which can then restore streamflows, while maintaining the rest of the forest around maximum water use, in effect stopping restoration of some 9,000 ML per annum.

Based on the current minimum value of $500 per ML per annum, the potential value of the restored 14,000 ML of water is $7 million per annum. Continued logging will stop most of this streamflow being restored, equating to a future cost of $4.5 million per annum from continued logging. While it will take time for full yields to be restored, yields will increase relatively rapidly over the next few decades, and water value will rapidly escalate as droughts become more frequent due to climate heating.

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.

5.4.1. Logging Impacts on Water Yields

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:

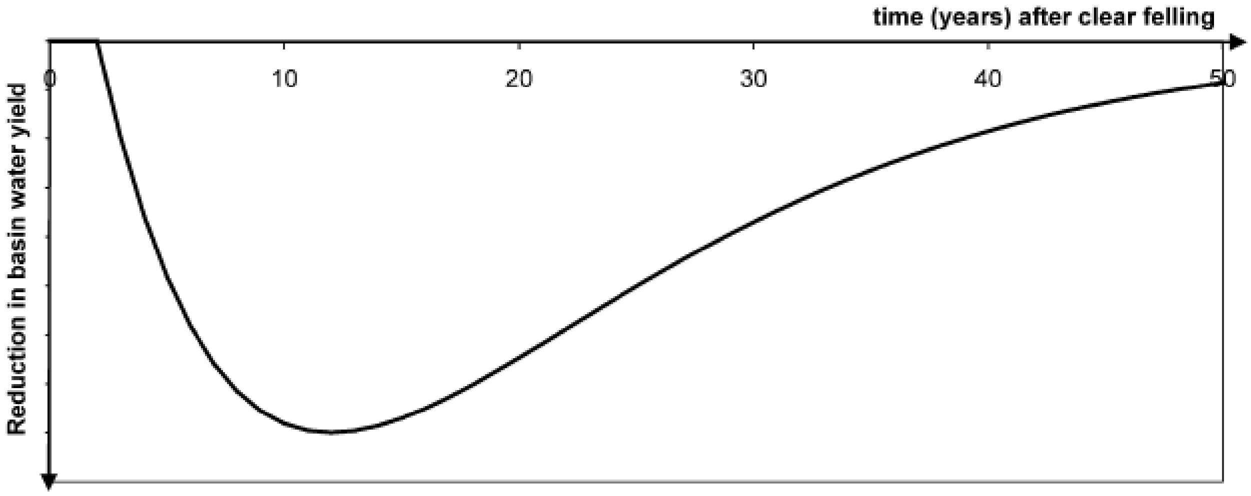
> *All plants evaporate water through their leaves. This water is extracted from the soil root zone, and the rate of evaporation depends on the weather, the available soil moisture, and the total area of leaves in the vegetation (trees and understorey). There are differences between various forest types, 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.*

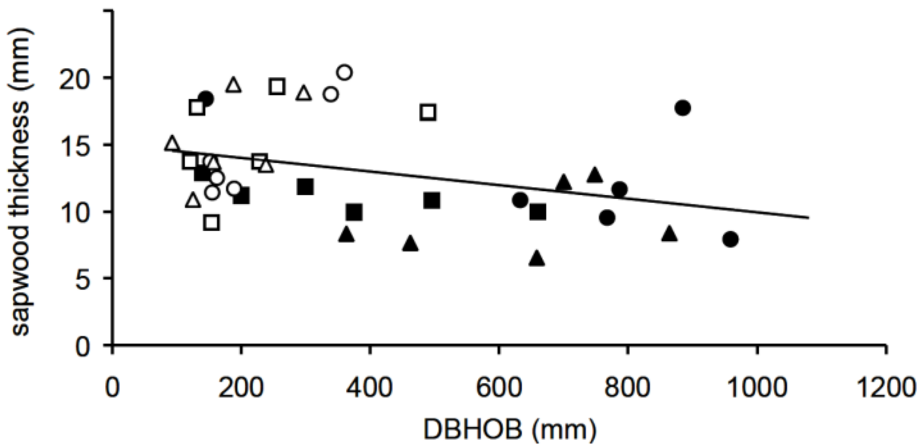


Figure 5 from Macfarlane and Silberstein (2009) sapwood thickness versus tree diameter (measured at breast height over bark, DBHOB) at the old-growth (closed symbols) and regrowth (open symbols) study sites.

For 'actual evapotranspiration' (E_a) Benyon *et. al.* (2017) identify:

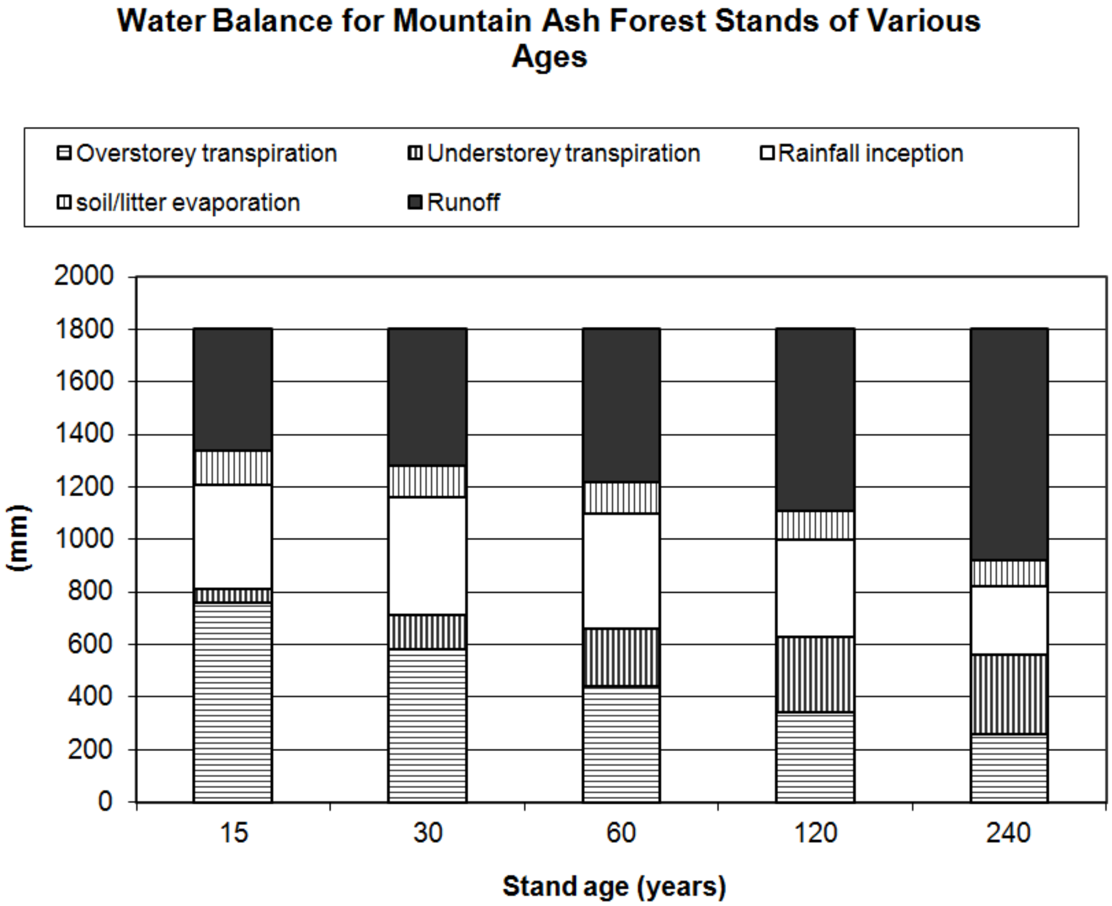
> *... in even-aged eucalypt forests in south-eastern Australia, catchment mean overstorey sapwood area index (SAI), estimated from a relationship between stand mean sapwood thickness and tree density (trees ha^{-1}), applied to repeated measurements of tree density and mean tree diameter over several 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.*

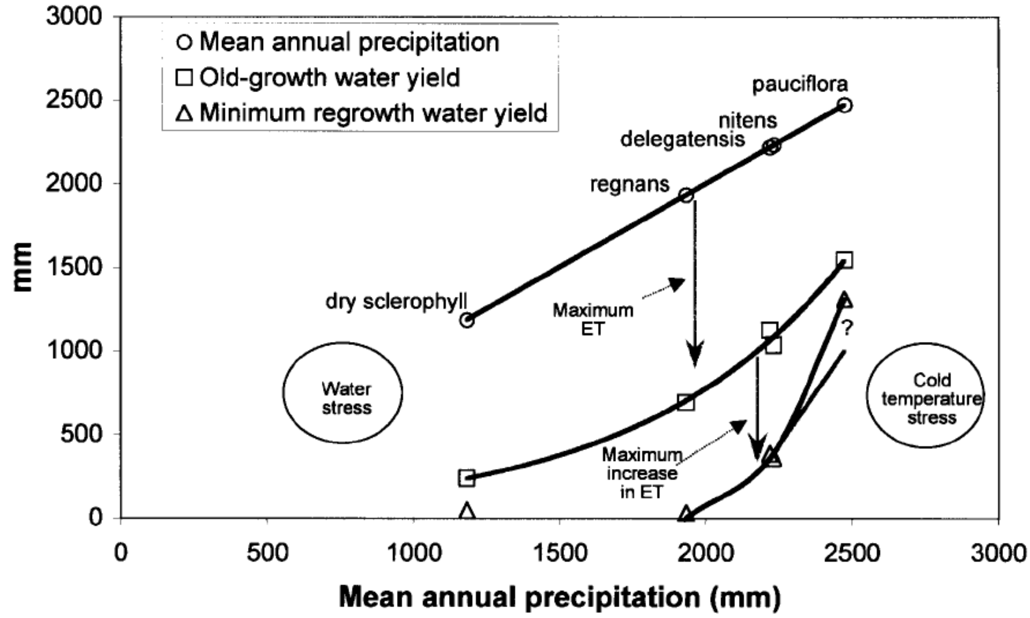
Cornish and Vertessy (2001) elaborate:

> *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.*

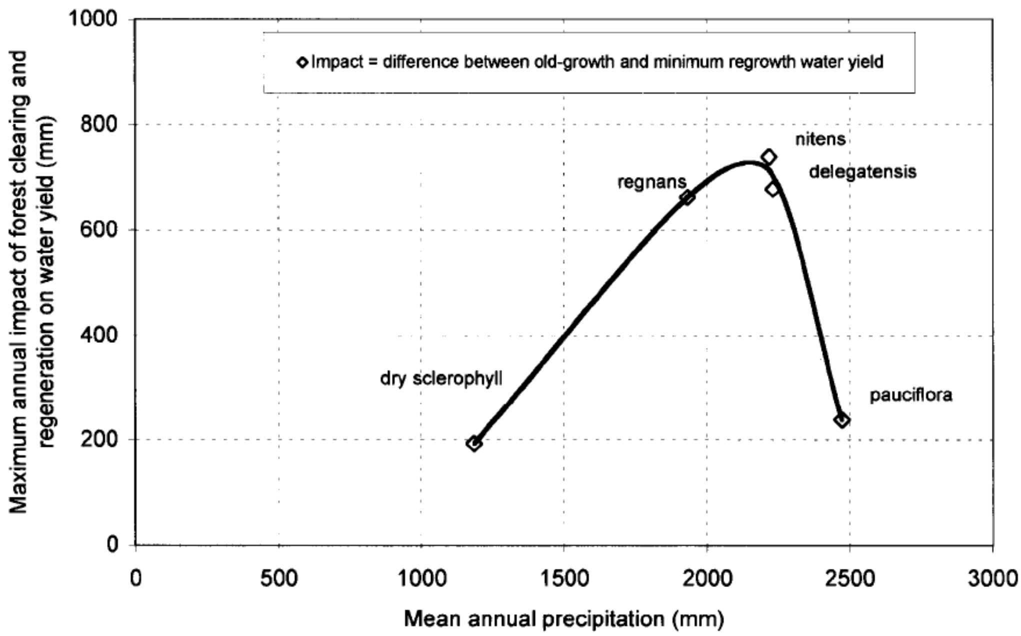
Vertessy (1999) notes that "*the maximum decrease in annual streamflow is over 60 mm per 10% of forest area treated, which is similar to the maximum reductions noted for Victorian mountain ash forests*".

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, such as those of this proposal, it is likely that there are prolonged periods where the regrowth is utilising most of the rainfall, leaving little for runoff into streams.

The average annual rainfall for this proposal is some 1,100 mm per annum (based on 1097.4mm per annum at Casino Airport). It was not feasible to undertake a water balance for this proposal, so for indicative purposes a conservative yield decline of 200mm (equivalent to a water yield of 2 megalitres per hectare) per annum is assumed due to the conversion of the original oldgrowth forests to regrowth. It is emphasised that this assumed decline is only indicative of what could have been expected to occur in these dry sclerophyll forests.

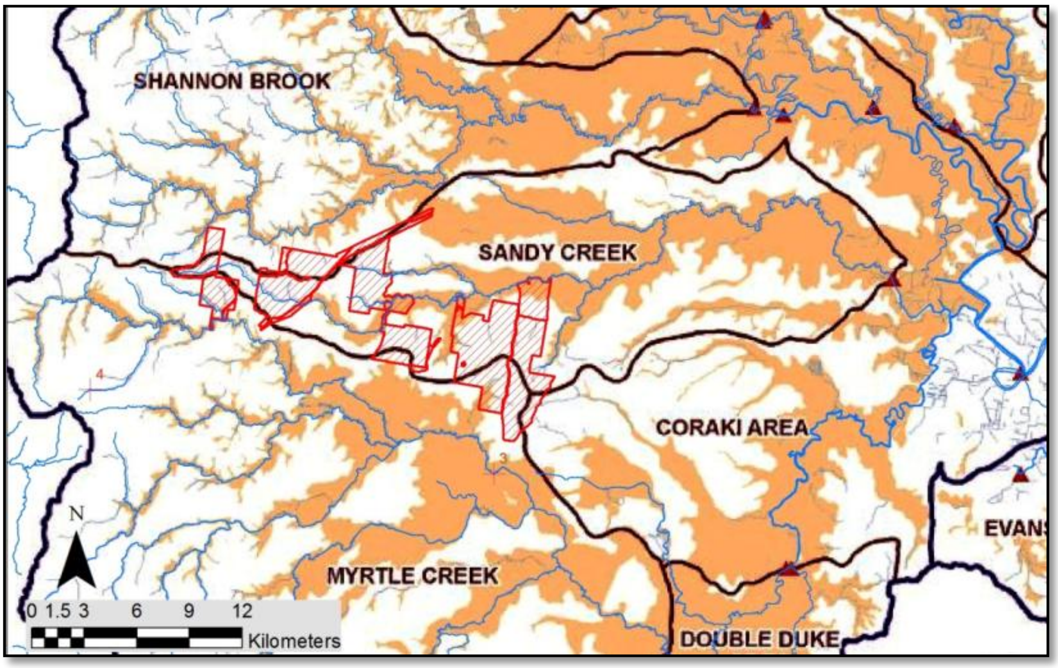
The options are to protect the forest and restore streamflows over the next 100 years, or to continue business as usual which will result in 65% of the forest being maintained for timber production with the forest being maintained a regrowth. Based on the forest area of 6,945ha, the protection option would result in an indicative increase in stream yields of 13,890 ML (megalitres). Based on a business-as-usual approach, 4,531 ha will be subject to ongoing logging and yields will effectively be maintained in their currently depressed state, leaving 2,414 ha to recover lost yields, resulting in a yield increase of 4,828 ML.

So in broad terms the protection of the proposed Sandy Creek Koala Park will result in an increase in stream yields over time to around 14,000 ML per annum. Whereas the business-as-usual approach will ultimately result in a yield increase of around 5,000 ML per annum in the 35% of the area from which logging is excluded, while continued logging in the balance of the area will continue to suppress yields, resulting in 9,000 ML per annum lower yield than ultimately generated by the conservation option.

If it takes 100 years to restore water yields, the cessation of logging represents an annual increase in water yields of 140 ML per annum, whereas the business as usual allows an annual increase of 50 ML per annum, with the logging area perpetually maintained around the minimum yield levels.

5.4.2. Valuing Water

The proposed Sandy Creek Koala Park predominantly occurs in the headwaters of Sandy Creek, while also providing runoff into the Shannon Brook and Myrtle Creek catchments, all of which flow into the Richmond River 'tidal pool' from Tatham to below Coraki, with the water not then consumed entering the sea at Ballina.



Appendix 1 from NSW Office of Water (2010): Water sharing plan area map, overlain with proposed Sandy Creek Koala Park. Orange areas are aquifers.

Water NSW (2018) identifies:

> *The average annual discharge from the Richmond River is 1,920,000 ML. This annual discharge fluctuates significantly from as little as 15 per cent to as much as 233 per cent of the annual average discharge.*

Irrespective of what use is made of the water, it does have an inherent value. NSW Office of Water (2010) classify Shannon Brook, Sandy Creek and Myrtle Creek as having "*medium in-stream values*" , For Shannon Brook and Sandy Creek there is considered to be a "*medium risk to in-stream values*", and for Myrtle Creek and the Coraki Tidal Pool a "*high risk*".

The Endangered fish Purple Spotted Gudgeon has been recorded downstream from this proposal in Sandy Creek (Brooks 2009), and will directly benefit from increased streamflows, as well as reductions in turbidity and sedimentation consequent upon stopping logging.

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 from this proposal, 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.*

The Richmond River Water Sharing Plan (NSW Office of Water 2010) identifies:

> *There are approximately 2,345 water licences in the area covered by the plan, totalling 97,407 ML of entitlement. This is approximately five per cent of the average annual flow. The majority of these licences are for irrigation, with a significant proportion also used for town water supply. There has been an embargo on granting new surface water licences in both the unregulated and regulated systems of the Richmond River catchment since 1995. Alluvial aquifers were embargoed in 2008.*

NSW Office of Water (2010) recognise the Tidal Pool around Coraki as having high economic significance, with *"High value of production from irrigation (orchards and pasture) and relatively high economic dependence on water extraction. ... There are currently over 150 licences located within the Richmond tidal pool making up nearly 25 per cent of the total entitlement for the Richmond unregulated system."*

Water Sharing Plans in NSW allow the trade of allocation water. The Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources 2010 identifies "*It is estimated that the share components of unregulated river access licences authorised to take water from these water sources will total 61,076 unit shares, distributed as follows:*

> *...*
> *(d) 10,078 unit shares in the Coraki Area Water Source,*

...

(n) 1,867 unit shares in the Myrtle Creek Water Source,
(o) 386 unit shares in the Sandy Creek Water Source,
(p) 484 unit shares in the Shannon Brook Water Source,

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. In common with most of the north coast, for the Richmond Coastal Sands Groundwater Source the minimum bid price per unit share is $500.

The value of water in the Richmond 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

Just by stopping logging, with some expenditure on rehabilitation, it would be possible over time to restore the indicative 14,000 ML per annum of water yields lost from the forests of the proposed Sandy Creek Koala Park due to the increased transpiration resulting from converting oldgrowth to regrowth. This may take 100 years to be fully restored, though yields will rapidly increase over the next few decades if these forests are left to mature. Based on the current minimum value of $500 per ML per annum, the potential value of this water is $7 million per annum. Continued logging will stop most of this streamflow being restored, equating to some 9,000 ML worth $4.5 million per annum in the future.

If it takes 100 years to restore water yields, the cessation of logging represents an annual increase in water yields of 140 ML worth $70,000 per annum, whereas the business as usual allows an annual increase of 50 ML worth $25,000 per annum, with the logging area perpetually maintained around the minimum yield levels.

Though it is essential to recognise that with increasingly erratic rainfalls, and increasing droughts, due to climate heating that the value of water will increase over time.

5.5. Logging Values

Of the total log harvest in NSW, approximately 16% arises from harvesting of native forests. Of that, over 90% is supplied from public forests managed by FCNSW.

Public forestry has long-been managed on an unsustainable basis, basically progressively reducing the numbers and volumes of large trees without allowing for the growth needed to replace lost volumes. There have been periodic yield reviews that have inflated predicted yields, followed by periods where actual yields progressively decline below estimates before the next yield review.

Within the proposed Sandy Creek Koala Park biomass has been reduced by 57% of the past century, and is on track to be further depleted over the next few decades, increasing biomass loss to around 75%. It is basically a biomass mining operation. As large high quality sawlogs have become scarcer they were supplemented with a shift to small high quality sawlogs, as these too become progressively depleted the industry emphasis is increasingly on using native forests for biomass to be burnt for electricity generation

Public forestry has historically operated at a loss where taxpayers have subsidised the industry by charging less for timber than the associated management costs, and without accounting for the environmental costs. It is only in the last few years that the Forestry Corporation has notionally returned a marginal return, though this does not account for other Government expenditure on State Forest management.

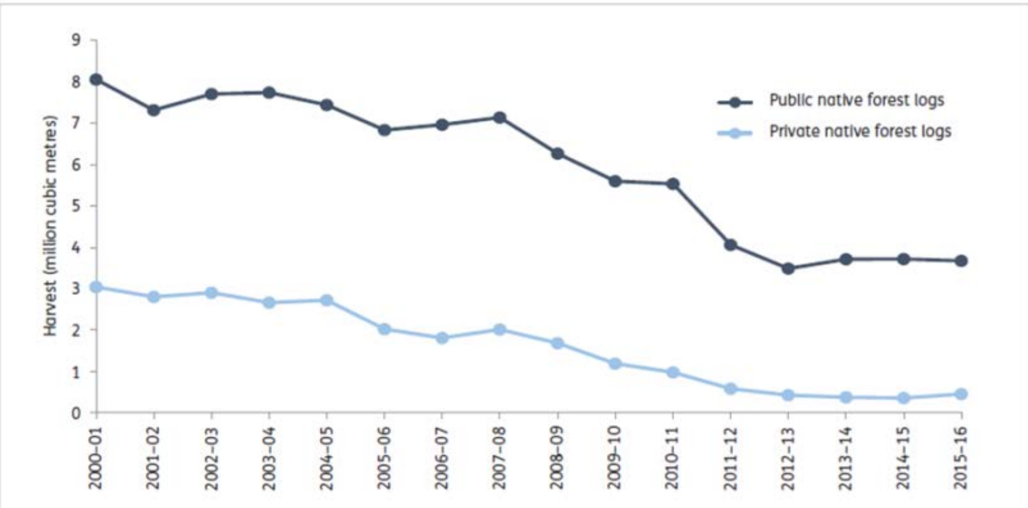
In 2018/19 the Forestry Corporation returned a notional average profit of $0.63 per hectare for hardwoods (including hardwood plantations, and excluding Community Service Obligations, EPA regulation and DPI Forestry research), which compares to a profit of $301 per hectare for softwood plantations. The sooner the Government transitions to plantations the better off taxpayers will be.

Proportionally the proposed Sandy Creek Koala Park represents timber industry employment of 5.4 persons in north-east NSW. To put the potential loss of jobs into perspective, over the ten years from 2006 until 2016 the NSW timber industry shed 7,400 jobs through restructuring and mechanisation without any politicians or unions complaining.

The net economic benefits of logging public land accrue to private sawmill owners. Applying the industry's unverified claims of hardwood output processing values for north-east NSW indicates the gross economic value of continuing logging as in the order of $2 million per annum.

5.5.1. Logging Yields

Ellangowan was declared a Timber Reserve in 1884, Carwong in 1903, an Braemar in 1907. They were dedicated as State Forests from 1913 to 1917. Logging started soon after, with grazing recorded as starting in 1922-3. Royal Camp was belatedly dedicated as State Forest in 1926. (State Forests of NSW 1995b). These forests were identified as part of the Casino Management Area.

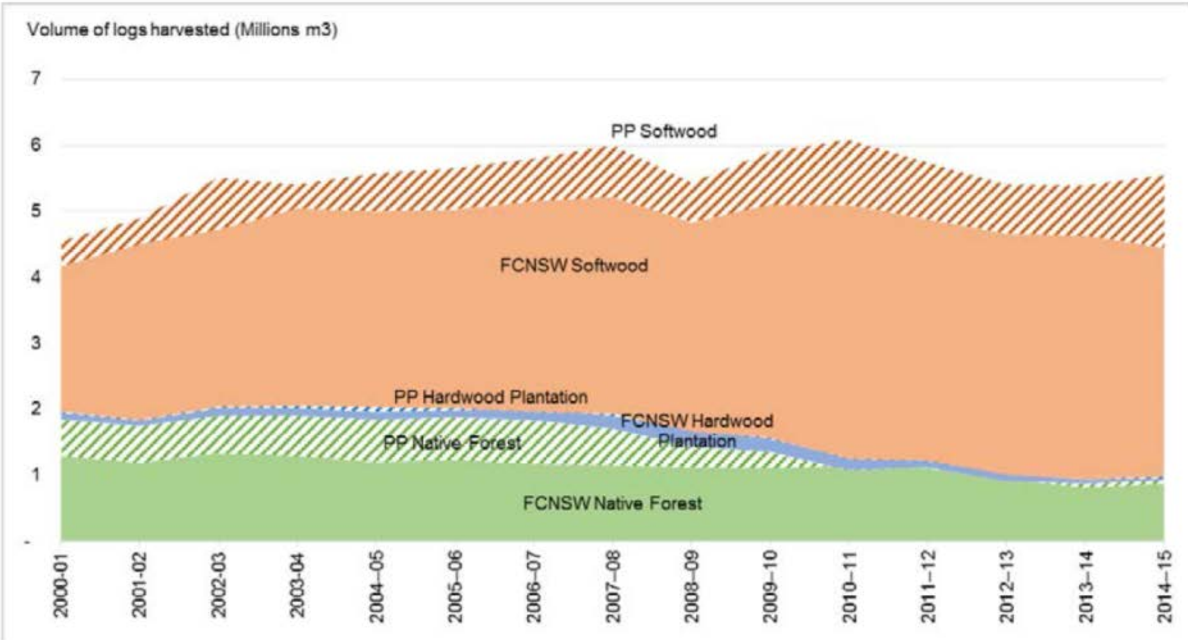


ABARE (2018) Figure 2.25: Annual log harvest from Australia's native forests, 2000-01 to 2015-16.

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.'

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. Within a year monitoring showed that yields had indeed been over-estimated, 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 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. 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.

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

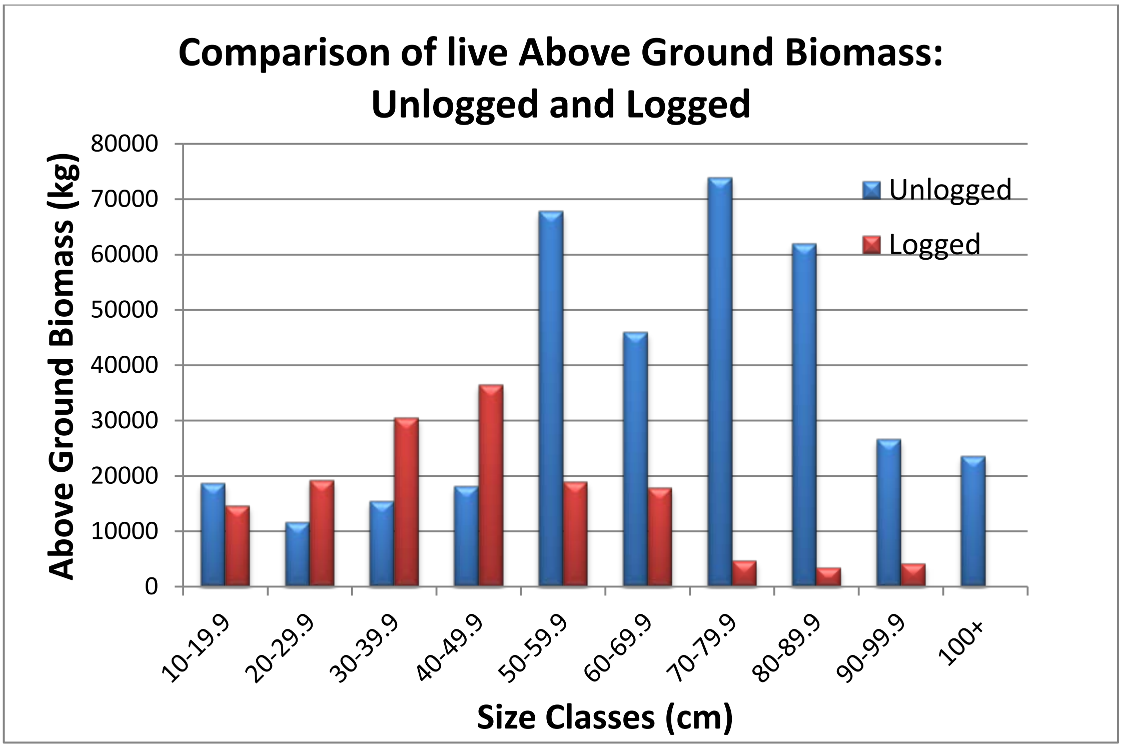
While resources from native forests have declined, yields from plantations have increased. Nationally 26.0 million cubic metres (86% of the total log harvest) was derived from commercial plantations in 2015–16:

- 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.

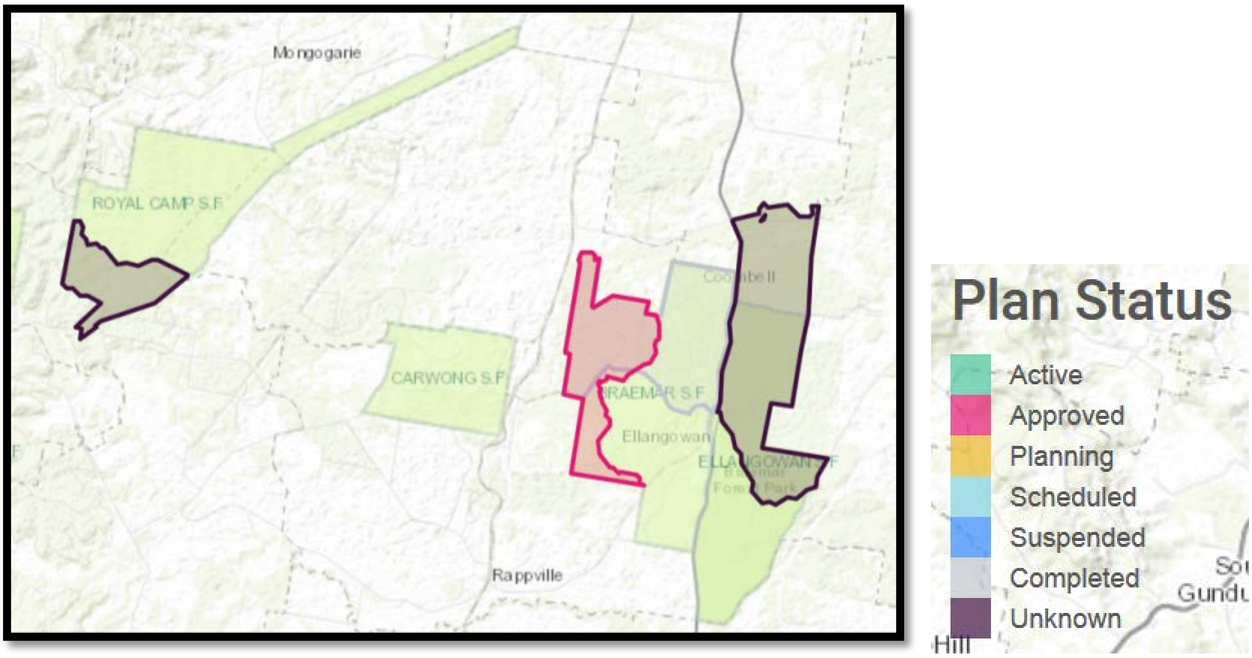
The impact of a century of over logging on the proposed Sandy Creek Koala Park is apparent. Large trees suitable as 'Large High Quality Sawlogs' (i.e. above 45 cm diameter at breast height) have been dramatically reduced, with an increase in small trees.. There has been an overall loss of 59% of above ground biomass from these forests, which increases to 65% of biomass for trees above 30 cm dbh and to 83% of biomass for trees above 50 cm dbh. It is abundantly clear that there has been a significant reduction in the larger trees targeted for logging.



NEFA's data from structural plots comparing the unlogged control with the logged forests of the proposed Sandy Creek Koala Park.

Based on plot data NEFA's assessment identifies there is the potential to remove a maximum of 103 tonnes/ha of live biomass in the next logging operation (Section 5.2.3), which is 85.8 m^3/ha (using conversion 1 m^3=1.2 tonnes). Applying the breakdown of products identified by Ximenes *et. al.* (2004) gives a maximum of 20.4 m^3/ha high quality logs and 14.8 m^3/ha salvage logs

This proposal was initiated due to the threat from logging, in September 2019 logging was due to start in (renumbered) compartments 6 and 7 of Braemar SF imminently, and logging within the next 12 months of compartments 28 of Braemar, 29 and 30 of Ellangowan, and 13 of Royal Camp State Forests.



Forestry Corporation's 12 months Plan of Operations (Accessed 20 September 2019)

The 2019 Harvesting Plan for compartments 6 and 7 Braemar State Forest identifies a potential Net Harvest Area of 185ha of which 5% is required to be protected as Tree Retention Clumps, giving a loggable area of 176 ha. The estimated yield is 1,443 m^3 of HQ logs and 1,359 m^3 LQ logs, noting "*The objective is to ensure enough growers are retained to allow a viable harvest in approximately 10 years*". The anticipated yield is 8.2 m^3/ha HQ logs and 7.7 m^3/ha LQ logs.

The 2020 Harvesting Plan for similar forests in the nearby compartments 10, 11, 12, 13, 14, 15 and 16 Myrtle State Forest identifies a Potential Net Harvest Area of 1,132.8 ha of which 5% is required to be protected as Tree Retention Clumps, and 7% as Temporary Feed Tree Clumps, giving a loggable area of 997 ha. The projected yield is 1,4747 m^3 of HQ logs, 5,301 m^3 LQ logs and 1,475 m^3 residue, with the aim "*to ensure enough growers are retained to allow a viable harvest in approximately 10 years*". This gives a yield of 14.8 m^3/ha HQ logs and 5.3 m^3/ha LQ, as well as residue logs.

These volumes are significantly less than the product estimates derived from Ximenes *et. al.* (2004), which likely indicates that both Ximenes *et. al.* (2004)'s conversion of biomass to products is high for these degraded forests, and that there will be higher retention in the next logging to retain more for logging in 10 years time. NEFA's estimates of product yields over the next 30 years are thus considered conservative.

For the 58.61 tonnes of biomass/ha projected to be able to be removed from these forests over the next 30 years, it is indicated that 13.9 tonnes/ha would be allocated to high quality sawlogs, 10.1 tonnes/ha to salvage logs, 32.4 tonnes to pulp logs (when there is a market) and 2.1 tonnes/ha to other (Section 5.2.3.). Across the 4,531 ha intended for logging this represents a total of 265,562 tonnes of logs, which is equivalent to 221,302 m^3 (using a conversion of 1 m^3 = 1.2 tonnes). This gives an average of 7,377 m^3 per annum, comprised of 1,749 m^3 high quality sawlogs, 1,271 m^3 salvage logs, 4,078 m^3 (4,893 tonnes) pulplogs and 264 m^3 other.

On current trends by 2050 biomass within logging areas is likely to have been reduced by a further 39% from the current 189.55 tonnes/ha down to around 115.70 tonnes/ha (Section 5.2.3.). This would effectively increase the biomass loss to 75% since conversion from oldgrowth.

5.5.2. Paying Resource Rent

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.*

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 offshot of the Forestry Corporation, being move 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.

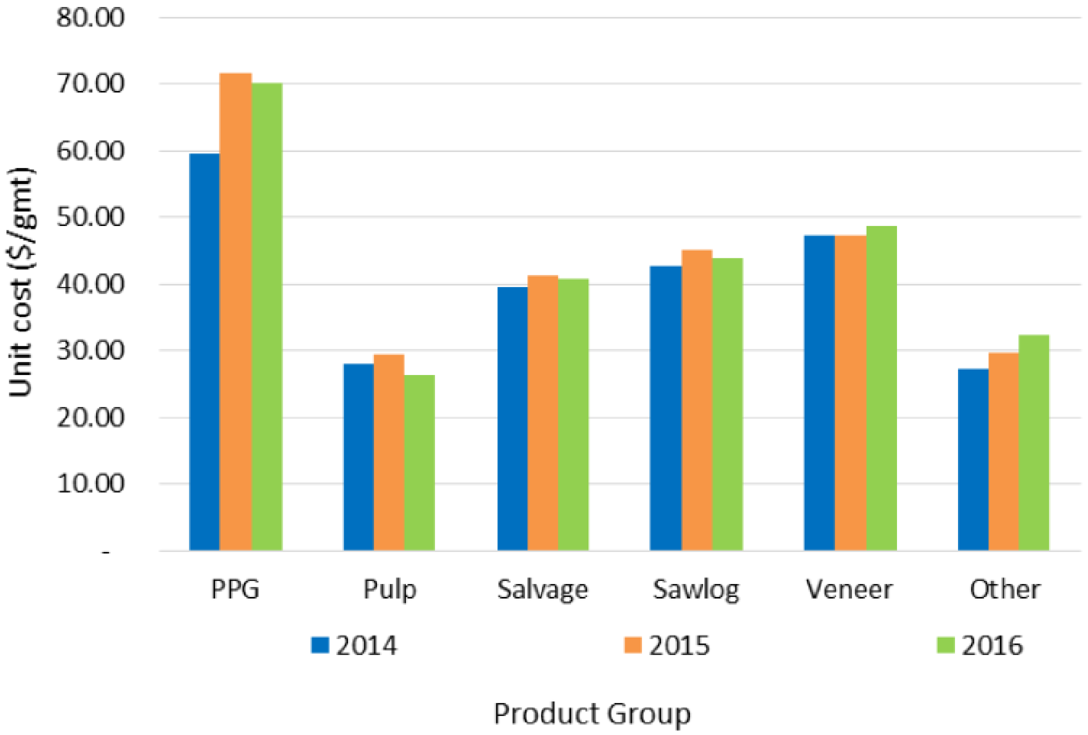


Figure 3-2: from Indufor (IPART 2017) Average Cost by Product 2014 - 2016

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 conservative assessment that over the next 30 years the proposed Sandy Creek Koala Park could yield an average of 7,377 m^3 of logs per annum, the application of the 2016/17 average stumpage value of $56.26, gives an annual stumpage value of $415,000. In practice most of this goes to the costs of management by the Forestry Corporation, with no meaningful '*marginal benefit*'*.* 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), so at best the proposed Sandy Creek Koala Park could be considered to generate a $4,402 return per annum..

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.

5.2.3. Industry Profits

The economic benefits of forestry reside in employment and the economic stimulus generated by private industry profits. While the profits accrue to the sawmill owners, the regional economy benefits from the economic activity.

Directly assessing the economic effects of the timber industry is beyond the scope of this report. So instead an assessment has been made of the proportion the proposed Sandy Creek Koala Park represents of the north-east NSW industry based on the sawmiller's claims of its economic significance. This is based on unverified data and gross values rather than net benefits. As with other data affects outside the region have not been included, and the flow-on affects on other sectors of the economy have not been included because of the unrealistic multipliers used by the industry and the distortions introduced by attributing multipliers to just one sector of the economy.

The proposed Sandy Creek Koala Park represents less than one percent of State Forests in north-east NSW and thus its protection will only have a minimal impact on available resources and timber industry activity. Within the north-east NSW RFA region the total area of State Forest in 2016/17 was 903,162 ha, of which 477,719 ha was identified as available for timber production (DPIE 2018). The proposed Sandy Creek Koala Park encompasses only 6,974 ha of State Forest (0.77% of north-east NSW), of which 4,531 ha is estimated to be loggable (0.95% of loggable).

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 Ernst and Young (2019) report identifies "*The cancellation of WSAs will negatively impact the forestry industry in NSW and the NCFA. Almost 30% of the total output, jobs and value add from the forestry and logging industry will be lost in the NCFA*", while recognising "*the forestry industry is not a major generator of output or employer in the NCFA when looking at the whole economy (1% of total output and jobs)*".

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*.

Proportionally, based on the proposed Sandy Creek Koala Park representing 0.95% of the loggable area of State Forests in north-east NSW, the continuation of logging represents direct timber industry employment in the order of 5.4 persons. 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 Ernst and Young (2019) report claims of economic impacts due to closing down public native forestry in north-east NSW was based solely upon claims made by the industry with no validation or verification:

> *As instructed by industry, the annual direct impact of the cancellation of WSAs is estimated to be a reduction in output of hardwood production of $57m (i.e. forestry and logging) and a reduction in output of hardwood processing of $268m (i.e. sawmill and other wood manufacturing). This is made up of $217m in the NCFA, $37m in the rest of NSW and $14m in the rest of Australia).*

Ernst and Young (2019) consider:

> *In comparing the size of an industry against others, it is generally accepted to discuss this in terms of its industry value add. Industry value add isolates the costs of production (that is, inputs sourced from other sectors) from the industry's outputs. This avoids the inclusion of revenues to other industries and associated double counting. In practice, industry value add largely comprises wages, salaries and the operating surplus of an industry (i.e. the industry's income). The value add measure is commonly put forward as the most appropriate measure of an industry's impact to the national economy.*

Applying the industry's unverified claim that hardwood output processing value is $217m proportionally, based on the proposed Sandy Creek Koala Park representing 0.95% of the loggable area of State Forests in north-east NSW, the continuation of logging represents a hardwood gross processing output value in the order of $2 million per annum.

Multipliers of questionable veracity are often used to inflate the value of the timber industry. Ernst and Young (2019) do not explain the derivation of their multiplier of 2.46, though By comparison DPI 2018 adopts a multiplier of 1.617 to account for production and consumption flow-on into the regional economy, which only totals 349 indirect jobs rather than the 826 claimed.

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.*

6. REFERENCES

ABARES (2018) *Australia's State of the Forests Report 2018.* Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2018, Canberra, December. CC BY 4.0. www.agriculture.gov.au/abares/forestsaustralia/ sofr/sofr-2018 and www.agriculture.gov.au/abares/ publications.

Adams-Hosking, C., McBride, M.F., Baxter, G., Burgman, M., De Villiers, D., Kavanagh, R., Lawler, I., Lunney, D., Melzer, A., Menkhorst, P. and Molsher, R., 2016. Use of expert knowledge to elicit population trends for the koala (Phascolarctos cinereus). *Diversity and Distributions*, *22*(3), pp.249-262.

Alexander J.S.A. (1997) Threatened hollow-dependent fauna in Box-Ironbark forests of Victoria: Bendigo Forest Management Area. Department of Natural Resources and Environment

Ashton, D.H. (1975) Studies of Flowering Behaviour in *Eucalyptus regnans* F. Muell. *Australian Journal of Botany* 23(3) 399 - 411

Attiwill, P.M., Ryan, M.F., Burrows, N., Cheney, N.P., McCaw, L., Neyland, M. and Read, S., 2014. Timber harvesting does not increase fire risk and severity in wet eucalypt forests of southern Australia. *Conservation Letters*, *7*(4), pp.341-354.

Ballantyne, R., Brown, R., Pegg, S. and Scott, N., 2008. Valuing tourism spend arising from visitation to Queensland national parks. *Sustainable Tourism Cooperative Research Centre, Gold Coast*.

Binns, D. (2012) *Eucalyptus glaucina* Flora Monitoring Program. Unpublished report prepared for Forestry Corporation.

Bennett, J. (1995) Economic Value of Recreational Use, Gibraltar Range and Dorrigo National Parks. NSW National Parks and Wildlife Service, Environmental Economic Series, Sydney.

Bennett, J. (1998) Benefit Transfer Threshold Value analysis of non-use values of forest preservation: Upper North East Region. Unpublished report prepared for Resource and Conservation Division of the NSW Dept. of Urban Affairs and Planning.

Benyon, R.G., Nolan, R.H., Hawthorn, S.N. and Lane, P.N., 2017. Stand-level variation in evapotranspiration in non-water-limited eucalypt forests. *Journal of Hydrology*, *551*, pp.233-244.

Berry ZC, Wevill K & Curran TJ (2011). The invasive weed *Lantana camara* increases fire risk in dry rainforest by altering fuel beds. *Weed Research* **51**, 525–533.

Besnard, S., Carvalhais, N., Arain, M.A., Black, A., De Bruin, S., Buchmann, N., Cescatti, A., Chen, J., Clevers, J.G., Desai, A.R. and Gough, C.M., 2018. Quantifying the effect of forest age in annual net forest carbon balance. *Environmental Research Letters*, *13*(12), p.124018.

Beyer, G.L., Goldingay, R.L. and Sharpe, D.J., 2008. The characteristics of squirrel glider (Petaurus norfolcensis) den trees in subtropical Australia. *Australian Journal of Zoology*, *56*(1), pp.13-21.

Binns, D. (2012) *Eucalyptus glaucina* Flora Monitoring Program. First report, 13 March 2012. Unpublished report for Forestry Corporation.

Biolink (2013) Port Macquarie-Hastings Koala Habitat & Population Assessment. Unpublished report prepared for Port Macquarie-Hastings Council.

Bowd, E.J., Banks, S.C., Strong, C.L. and Lindenmayer, D.B., 2019. Long-term impacts of wildfire and logging on forest soils. *Nature Geoscience*, *12*(2), pp.113-118.

Bowman D.M.J.S., French B.J. and Prior L.D. (2014) Have plants evolved to self-immolate? Frontiers in Plant Science, 5, article 590.

Brereton, R., Mallick, S.A. and Kennedy, S.J., 2004. Foraging preferences of Swift Parrots on Tasmanian Blue-gum: tree size, flowering frequency and flowering intensity. *Emu-Austral Ornithology*, *104*(4), pp.377-383.

Brigham, R.M., Debus, S.J.S. and Geiser, F. (1998) Cavity selection for roosting, and roosting ecology of forest-dwelling Australian Owlet-nightjars (Aegotheles cristatus). Aust. J. of Ecology 23, 424-429.

Brooks, D. (2009) Purple Spotted Gudgeon (*Mogurnda adspersa*), in the Richmond River catchment. Unpublished Third Year Undergraduate Report. School of Environmental Science and Management, Southern Cross University, Lismore

Brosofske, K.D., Chen, J., Naiman, R.J. and Franklin, J.F., 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. *Ecological applications*, *7*(4), pp.1188-1200.

Buckley, R., Brough, P., Hague, L., Chauvenet, A., Fleming, C., Roche, E., Sofija, E. and Harris, N., 2019. Economic value of protected areas via visitor mental health. *Nature communications*, *10*(1), pp.1-10.

Buckley, T.N., Turnbull, T.L., Pfautsch, S., Gharun, M. and Adams, M.A., 2012. Differences in water use between mature and post-fire regrowth stands of subalpine Eucalyptus delegatensis R. Baker. *Forest Ecology and Management*, *270*, pp.1-10.

Buultjens, J., Davis, D., Duthy, S. and Tiyce, M. (1998) Forest-based tourism and recreation in the upper and lower north east regions of NSW. Unpublished report prepared by Southern Cross University for the NSW CRA/RFA process.

Buultjens, J. and Luckie, K. (2004) Economic impact of selected national parks in north-eastern New South Wales. CRC for Sustainable Tourism Pty Ltd 2004.

Butt, N., Seabrook, L., Maron, M., Law, B.S., Dawson, T.P., Syktus, J. and McAlpine, C.A., 2015. Cascading effects of climate extremes on vertebrate fauna through changes to low-latitude tree flowering and fruiting phenology. *Global change biology*, *21*(9), pp.3267-3277.

Cameron, M. and Cunningham R.B. (2006) Habitat selection at multiple spatial scales by foraging Glossy Black-cockatoos. Austral Ecology 31, 597-607.

Cawson, J. G., T. J. Duff, M. H. Swan, and T. D. Penman. 2018. Wildfire in wet sclerophyll forests: the interplay between disturbances and fuel dynamics. Ecosphere 9(5):e02211. 10.1002/ecs2.2211

Chen, J., Saunders, S.C., Crow, T.R., Naiman, R.J., Brosofske, K.D., Mroz, G.D., Brookshire, B.L. and Franklin, J.F., 1999. Microclimate in forest ecosystem and landscape ecology: variations in local climate can be used to monitor and compare the effects of different management regimes. *BioScience*, *49*(4), pp.288-297.

Clarke, P.J., Prior, L.D., French, B.J., Vincent, B., Knox, K.J. and Bowman, D.M., 2014. Using a rainforest-flame forest mosaic to test the hypothesis that leaf and litter fuel flammability is under natural selection. *Oecologia*, *176*(4), pp.1123-1133.

Centre for Coastal Management (1993) Report on recreation, scenic and wilderness aspects of forest management, Northern Region, State Forests of New South Wales. Casino Management Area EIS and Murwillumbah Management Area EIS Supporting Document No. 9, State Forests of NSW, Coffs Harbour.

Chen, J., Ustin, S.L., Suchanek, T.H., Bond, B.J., Brosofske, K.D. and Falk, M., 2004. Net ecosystem exchanges of carbon, water, and energy in young and old-growth Douglas-fir forests. *Ecosystems*, *7*(5), pp.534-544.

Cohn, J.S., Lunt, I.D., Ross, K.A. and Bradstock, R.A., 2011. How do slow-growing, fire-sensitive conifers survive in flammable eucalypt woodlands?. *Journal of Vegetation Science*, *22*(3), pp.425-435.

Conrad, E. (2014) The Economic Value of the Koala. Report prepared for Australian Koala Foundation.

Cornish, P.M. (1993) The effects of logging and forest regeneration on water yields in moist eucalypt forest in New South Wales, Australia. J.of Hydrology, 150:301-322.

Cornish, P.M. and Vertessy, R.A., (2001) Forest age-induced changes in evapotranspiration and water yield in a eucalypt forest, Journal of Hydrology 242 43-63.

Craig, S.A., 1985. Social organization, reproduction and feeding behaviour of a population of yellow-bellied gliders, Petaurus australis (Marsupialia: Petauridae). *Wildlife Research*, *12*(1), pp.1-18.

Crowley, G. M. and Garnett, S.T. (2001) Food Value and tree selection by Glossy Black-Cockatoos Calyptorhynchus lathami. Austral Ecology 26, 116-126.

Dan Moore, R., Spittlehouse, D.L. and Story, A., 2005. RIPARIAN MICROCLIMATE AND STREAM TEMPERATURE RESPONSE TO FOREST HARVESTING: A REVIEW 1. *JAWRA Journal of the American Water Resources Association*, *41*(4), pp.813-834.

Dargavel, J, Hamilton, C. and O'Shaugnessy, P (1995) Logging and Water: a study of the effects of logging regimes on water catchment hydrology and soil stability on the eastern seaboard of Australia. Australia Institute.

Davis, K.T., Dobrowski, S.Z., Holden, Z.A., Higuera, P.E. and Abatzoglou, J.T., 2019. Microclimatic buffering in forests of the future: the role of local water balance. *Ecography*, *42*(1), pp.1-11.

Dean, C., Wardell-Johnson, G.W. and Kirkpatrick, J.B., 2012. Are there any circumstances in which logging primary wet-eucalypt forest will not add to the global carbon burden?. *Agricultural and Forest Meteorology*, *161*, pp.156-169.

Department of Primary Industries (2018) North coast private native forest project, NSW planning and regulatory instruments that interact with private native forestry. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/817751/nsw-planning-and-regulatory-instruments-that-interact-with-pnf.pdf

Dobson, M.A.T.T., Goldingay, R.L. and Sharpe, D.J., 2005. Feeding behaviour of the squirrel glider in remnant habitat in Brisbane. *Australian Mammalogy*, *27*(1), pp.27-35.

Downham, R, Gavran, M & Frakes, I 2019, *ABARES National Wood Processing Survey: 2016–17*, ABARES technical report 19.3, Canberra, June. CC BY 4.0. https://doi.org/10.25814/5cf8ebadb377f

DPIE - Department of Primary Industries (2018) NSW Regional Forest Agreements, Assessment of matters pertaining to renewal of Regional Forest Agreements. NSW Department of Primary Industries. State of New South Wales

Driml, S. and McLennan, C. (2010) Handbook on Measuring the Economic Value of Tourism to National Parks. CRC for Sustainable Tourism Pty Ltd.

Driml, S., 2010. The economic value of tourism to national parks and protected areas in Australia. CRC for Sustainable Tourism Pty Ltd.

Dunn, G & Connor, David. (1994). An analysis of sap flow in mountain ash (Eucalyptus-Regnans) forests of different age. Tree physiology. 13. 321-36. 10.1093/treephys/13.4.321.

Eby, P., and B. Law. 2008. Ranking the feeding habitats of Grey-headed flying foxes for conservation management. Department of Environment and Climate Change (NSW) and Department of Environment, Water, Heritage and the Arts.

Ellis, W. A. H., Melzer, A., Carrick, F. N. and Hasegawa, M. 2002. Tree use, diet and home range of the koala (*Phascolarctos cinereus*) at Blair Athol, central Queensland. *Wildlife Research* **29:** 303 – 11.

Ellis, W. A. H., FitzGibbon, S., Melzer, A., Wilson, R., Johnston, S., Bercovitch, F., Dique, D. and Carrick, F. N. (2013) Koala habitat use and population density: using field data to test the assumptions of ecological models. *Australian Mammalogy*, 2013, 35, 160–165

Environment Australia. 1999a. Response to disturbance of forest species in CRA regions in NSW – Upper North East and Lower North East regions. Unpublished report undertaken for the NSW CRA/RFA Steering Committee.

EPA (2016) Koala Habitat Mapping Pilot: NSW state forest Report. Environment Protection Authority

Ernst and Young (2019) The economic impact of the cancellation of NSW North Coast Wood Supply Agreements due to the creation of the Great Koala National Park. Unpublished report for Australian Forest Products Association.

Eyre, T.J. and Goldingay, R.L., 2005. Characteristics of sap trees used by yellow-bellied gliders in southern Queensland. *Wildlife Research*, *32*(1), pp.23-35.

Eyre, T.J. and Smith, A.P., 1997. Floristic and structural habitat preferences of yellow-bellied gliders (Petaurus australis) and selective logging impacts in southeast Queensland, Australia. *Forest Ecology and Management*, *98*(3), pp.281-295.

FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. https://doi.org/10.4060/ca8642en

Fensham, R.J., Fairfax, R.J. and Cannell, R.J., 1994. The invasion of Lantana camara L. in forty mile scrub National Park, north Queensland. *Australian Journal of Ecology*, *19*(3), pp.297-305.Flint *et. al*. 2004

Flint, C., Pugh, D. and Beaver, D., 2004. The good, the bad and the ugly: science, process and politics in forestry reform and the implications for conservation of forest fauna in north-east New South Wales. *Conservation of Australia's Forest Fauna, 2nd edn. Royal Zoological Society of New South Wales, Mosman*, pp.222-255.

Forest, F. (2019) Flora and vegetation assessment; Lot 7002, DP 1050851 and Lot 7007, DP 1050852; Parish of Coombell, County of Richmond, Richmond Valley Local Government Area. "Two Rails" - Travelling Stock Reserve No. R54122. A report prepared for Casino-Boolangle LALC

Forestry Corporation (2015) FCNSW BMAD adaptive management trials: results summary. Forestry Corporation New South Wales.

Gentle, C.B., and Duggin, J.A. (1997) Lantana camara invasions in dry rainforest – open forest ecotones: the role of disturbances associated with fire and cattle grazing. *Australian Journal of Ecology* **22**, 298-306.

Geyle Hayley M., Woinarski John C. Z., Baker G. Barry, Dickman Chris R., Dutson Guy, Fisher Diana O., Ford Hugh, Holdsworth Mark, Jones Menna E., Kutt Alex, Legge Sarah, Leiper Ian, Loyn Richard, Murphy Brett P., Menkhorst Peter, Reside April E., Ritchie Euan G., Roberts Finley E., Tingley Reid, Garnett Stephen T. (2018) Quantifying extinction risk and forecasting the number of impending

Australian bird and mammal extinctions. *Pacific Conservation Biology* , - https://doi.org/10.1071/PC18006

Gibbons, P & Lindenmayer, D 2002, *Tree hollows and wildlife conservation in Australia*, CSIRO Publishing, Collingwood, Vic.

Gibbons, P, Briggs, S, Murphy, D et al 2010, 'Benchmark stem densities for forests and woodlands in south-eastern Australia under conditions of relatively little modification by humans since European settlement', Forest Ecology and Management, vol. 260, pp. 2125-2133.

Gill, A.M. and Zylstra, P., 2005. Flammability of Australian forests. *Australian forestry*, *68*(2), pp.87-93.

Gillespie Economics (2006) Impacts of Protected Areas on the Regional Economy of North-East NSW. A Study Prepared for NSW Department of Environment and Conservation.

Gillespie Economics and BDA Group (2008) *Economic Activity of Australia's World Heritage Areas*. Department of the Environment, Water, Heritage and the Arts.

Goldstein, A., Turner, W.R., Spawn, S.A. *et al.* (2020) Protecting irrecoverable carbon in Earth's ecosystems. *Nat. Clim. Chang.* (2020). https://doi.org/10.1038/s41558-020-0738-8

Green, E.J., McRae, L., Freeman, R., Harfoot, M.B., Hill, S.L., Baldwin-Cantello, W. and Simonson, W.D., 2020. Below the canopy: global trends in forest vertebrate populations and their drivers. *Proceedings of the Royal Society B*, *287*(1928), p.20200533.

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P. and Woodbury, P., 2017. Natural climate solutions. *Proceedings of the National Academy of Sciences*, *114*(44), pp.11645-11650.

Hawkins, B.A. (2017) Birds, fruit and nectar: spatio-temporal patterns of regional bird abundance and food availability in subtropical eastern Australia. A thesis submitted for the degree of Doctor of Philosophy, Monash University.

Heagney, E.C., Rose, J.M., Ardeshiri, A. and Kovac, M., 2019. The economic value of tourism and recreation across a large protected area network. *Land Use Policy*, *88*, p.104084.

Hindell, M. A., and Lee, A. K. (1987). Habitat use and tree preferences of koalas in a mixed eucalypt forest. *Australian Wildlife Research* **14**, 349–360.

Holland, G.J., Bennett, A.F. and van der Ree, R., 2007. Time-budget and feeding behaviour of the squirrel glider (Petaurus norfolcensis) in remnant linear habitat. *Wildlife Research*, *34*(4), pp.288-295.

Houghton, R.A. and Nassikas, A.A., 2018. Negative emissions from stopping deforestation and forest degradation, globally. *Global change biology*, *24*(1), pp.350-359.Hubbard, R. K.; Newton, G. L.; and Hill, G. M., (2004) "Water Quality and the Grazing Animal". *Publications from USDA-ARS /*

Hundloe, T. and Hamilton C. (1997) Koalas and Tourism: An Economic Evaluation. The Australia Institute.

Hydrosphere Consulting 2020 Rous Regional Supply: Future Water Project 2060, Integrated Water Cycle Management Development: Assessment of Augmentation Scenarios. Draft Report for Rous County Council.

IPART: Independent Pricing and Regulatory Tribunal (2017) Review of Forestry Corporation of NSW's native timber harvesting and haulage costs. Final Report

UNL Faculty. Paper 274. http://digitalcommons.unl.edu/usdaarsfacpub/274

IPCC (2018) GLOBAL WARMING OF 1.5 °C, an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for Policymakers.

JANIS (1997) Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia. A Report by the Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee.

Jurskis V and Walmsley T (2012) Eucalypt ecosystems predisposed to chronic decline: estimated distribution in coastal New South Wales. Bushfire Cooperative Research Centre 2012.

Kavanagh, R.P. (1987b), Forest phenology and its effect on foraging behaviour and selection of habitat by the Yellow-bellied Glider, Petaurus australis Shaw. Aust. Wildl. Res. 14, 371-84.

Keith, H., Lindenmayer, D., Mackey, B., Blair, D., Carter, L., McBurney, L., Okada, S. and Konishi-Nagano, T., 2014. Managing temperate forests for carbon storage: impacts of logging versus forest protection on carbon stocks. *Ecosphere*, *5*(6), pp.1-34.

Keith, H., Lindenmayer, D.B., Mackey, B.G., Blair, D., Carter, L., McBurney, L., Okada, S. and Konishi-Nagano, T., 2014b. Accounting for biomass carbon stock change due to wildfire in temperate forest landscapes in Australia. *PloS one*, *9*(9).

Keith H, Lindenmayer D, Macintosh A, Mackey B (2015) Under What Circumstances Do Wood Products from Native Forests Benefit Climate Change Mitigation? PLoS ONE 10(10): e0139640. doi:10.1371/journal.pone.0139640

Keith, H., Mackey, B., Berry, S., Lindenmayer, D. and Gibbons, P., 2010. Estimating carbon carrying capacity in natural forest ecosystems across heterogeneous landscapes: addressing sources of error. *Global Change Biology*, *16*(11), pp.2971-2989.

Keith, H., Vardon, M., Stein, J.A., Stein, J.L. and Lindenmayer, D., 2017a. Ecosystem accounts define explicit and spatial trade-offs for managing natural resources. *Nature Ecology & Evolution*, *1*(11), pp.1683-1692.

Keith, H., Vardon, M., Stein, J.A., Stein, J.L. and Lindenmayer, D., 2017b Experimental Ecosystem Accounts for the Central Highlands of Victoria. Fenner School of Environment and Society, The Australian National University, Acton, Canberra 2601.

Kovács, B., Tinya, F. and Ódor, P., 2017. Stand structural drivers of microclimate in mature temperate mixed forests. *Agricultural and Forest Meteorology*, *234*, pp.11-21.

Kuring-gai Colledge of Advanced Education (1988) New England-Dorrigo tourism study, a report to the New South Wales National Parks and Wildlife Service. Centre for Leisure and Tourism Studies, Kuring-gai CAE

Kuczera, G.A. (1987) Prediction of water yield reductions following a bushfire in ash-mixed species eucalypt forest. J. of Hydrology, 94: 215-236.

Lane, A., Wallis, K., and Phillips, S. 2020. A review of the conservation status of New South Wales populations of the Koala (Phascolarctos cinereus) leading up to and including part of the 2019/20 fire event. Report to International Fund for Animal Welfare (IFAW). Biolink Ecological Consultants, Uki NSW.

Law, B., Mackowski, C., Schoer, L. and Tweedie, T., 2000. Flowering phenology of myrtaceous trees and their relation to climatic, environmental and disturbance variables in northern New South Wales. *Austral Ecology*, *25*(2), pp.160-178.

Law, B. Caccamo, G. Wimmer, J. Truskinger, A. McConville, A. Brassil, T. Stanton, M. Gonsalves, L (2017) A predictive habitat model for Koalas Phascolarctos cinereus in north-east New South Wales: Assessment and field validation. NSW Department of Industry—Lands and Forestry. https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/forestagreements/predictive-habitat-model-koala.ashx.

Law BS, Brassil T, Gonsalves L, Roe P, Truskinger A, McConville A (2018) Passive acoustics and sound recognition provide new insights on status and resilience of an iconic endangered marsupial (koala *Phascolarctos cinereus*) to timber harvesting. PLoS ONE 13(10): e0205075. https://doi.org/10.1371/journal.pone.0205075

Law, B. and Chidel, M., 2007. Effects of Logging on Nectar-Producing Eucalypts. *Electronic Journal on Research and Development Corporation. Publication*, (07/138).

Law, B.S. and Chidel, M., 2008. Quantifying the canopy nectar resource and the impact of logging and climate in spotted gum Corymbia maculata forests. *Austral Ecology*, *33*(8), pp.999-1014.

Law, B.S. and Chidel, M., 2009. Canopy nectar production and the impact of logging and climate in Grey Ironbark Eucalyptus paniculata (Smith) forests. *Pacific Conservation Biology*, *15*(4), pp.287-303.

Lindberg, K. & Denstadii, J. (2004) Impact of National Park Visitation on Rural Economies and Government Expenditure in Queensland, Sustainable Tourism Cooperative Research Centre, Gold Coast.

Lindenmayer, D.B., Hunter, M.L., Burton, P.J. and Gibbons, P., 2009. Effects of logging on fire regimes in moist forests. *Conservation Letters*, *2*(6), pp.271-277.

Lindenmayer, D.B., Laurance, W.F. and Franklin, J.F. (2012) Global Decline in Large Old Trees. Science V 338 7 December 2012

Lindenmayer, D.B., Laurance, W.F., Franklin, J.F., Likens, G.E., Banks, S.C., Blanchard, W., Gibbons, P., Ikin, K., Blair, D., McBurney, L., Manning, A.D. & Stein, J.A.R. (2014). New policies for old trees: averting a global crisis in a keystone ecological structure. Conservation Letters, 7, 61-69.

Loyn, R.H. (1985), Strategies for conserving wildlife in commercially productive eucalypt forest, Aust. For. 48(2), 95-101.

Lunney, D., Moon, C. and Ferrier, S. (1992) Conservation and Management Proposals for Koalas in Coffs Harbour. National Parks and Wildlife Service, unpublished report.

Lunney, D., Moon, C., Matthews, A., and Turbill, J. 1999b. Coffs Harbour City Koala Plan of Management. Part B Coffs Harbour Koala Study. NSW National Parks and Wildlife Service, Hurstville

Luyssaert, S., Schulze, E.D., Börner, A., Knohl, A., Hessenmöller, D., Law, B.E., Ciais, P. and J. (2008) Old-growth forests as global carbon sinks. *Nature* 455, 213-215

Mackey, B., Keith, H., Berry, S.L. and Lindenmayer, D.B. (2008) Green carbon: the role of natural forests in carbon storage. Part 1, A green carbon account of Australia's south-eastern Eucalypt forest, and policy implications. ANU E Press

Mackowski, C.M. (1984), The ontogeny of hollows in blackbutt (Eucalyptus pilularis) and its relevance to the management of forests for possums, gliders and timber. Pages 553-67 in Possums and Gliders, ed. by A.P. Smith and I.D. Hume, Australian Mammal Society, Sydney

Mackowski, C.M. (1987), Wildlife hollows and timber management, thesis for Master of Nat. Res., University of New England, Armidale, N.S.W.

Mackowski, C M (1988), Characteristics of eucalypts incised for sap by the Yellow-bellied Glider in Northern NSW, Aust. Mammal. 11:5-13

Matthews, A., Lunney, D., Gresser, S. and Maitz, W., 2007. Tree use by koalas (Phascolarctos cinereus) after fire in remnant coastal forest. *Wildlife Research*, *34*(2), pp.84-93.

McElhinny, C., Gibbons, P., Brack, C. and Bauhus, J., 2006. Fauna-habitat relationships: a basis for identifying key stand structural attributes in temperate Australian eucalypt forests and woodlands. *Pacific Conservation Biology*, *12*(2), pp.89-110.

Macfarlane, C. and Silberstein, R, 2009. Final Report to the Water Corporation of Western Australia on Water Use by Regrowth and Old-growth Jarrah Forest at Dwellingup, Western Australia. CSIRO: Water for a Healthy Country National Research Flagship.

Macintosh, A., Keith, H. and Lindenmayer, D., 2015. Rethinking forest carbon assessments to account for policy institutions. *Nature Climate Change*, *5*(10), pp.946-949.

Milledge, D. (2019) A survey to estimate population densities of the Barking Owl *Ninox connivens* in two areas of the Northern Rivers, NSW.

McAlpine et.al. (2012) Conserving Koalas in the 21st Century: synthesising the dynamics of Australia's Koala populations, ACEAS, Australian Centre for Ecological Analysis & Synthesis.

McGregor, A., Gibson, C., Miller, F. and Sharma, K. (1997) Thinking about forests, community attitudes towards forests in New South Wales. Dept. Geography, Uni of Sydney.

McGregor, A., Gibson, C., Miller, F. and Sharma, K. (1997a) Thinking About Forests, community attitudes towards forests in the Upper North East CRA region. Unpublished report prepared Department of Geography, University of Sydney, for the NSW CRA/RFA process.

McLean, C.M., 2012. The effects of fire regimes and logging on forest stand structure, tree hollows and arboreal marsupials in sclerophyll forests. Thesis, University of Wollongong.

McLean, C.M., Bradstock, R., Price, O. and Kavanagh, R.P., 2015. Tree hollows and forest stand structure in Australian warm temperate Eucalyptus forests are adversely affected by logging more than wildfire. *Forest Ecology and Management*, *341*, pp.37-44.

MPIG - Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee, 2018, *Australia's State of the Forests Report 2018*, ABARES, Canberra, December. CC BY 4.0. www.agriculture.gov.au/abares/forestsaustralia/ sofr/sofr-2018

Moomaw, W.R., Masino, S.A. and Faison, E.K., 2019. Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good. *Frontiers in Forests and Global Change*, *2*, p.27.

Moore, B. D., Wallis, I. R., Wood, J. and Foley, W. J. (2004b) Foliar nutrition, site quality and temperature affect foliar chemistry of tallowwood (*Eucalyptus microcorys*). Ecological Monographs, 74(4), 2004, pp. 553-568

Moore, B.D. and Foley, W.J. 2005. Tree use by koalas in a chemically complex landscape. *Nature* 435, 488–490.

Munks S., Wapstra M, Corkrey R., Otley H., Walker GB (2007) The occurrence of potential tree hollows in the dry eucalypt forests of south-eastern Tasmania, Australia. Australian Zoologist 34 (1) pp22-36.

Murray BR, Hardstaff LK, Phillips ML (2013) Differences in Leaf Flammability, Leaf Traits and Flammability-Trait Relationships between Native and Exotic Plant Species of Dry Sclerophyll Forest. PLoS ONE 8(11): e79205. doi:10.1371/journal.pone.0079205

Natural Resources Commission (2016) Advice on Coastal Integrated Forestry Operations Approval remake. Final report, November 2016, NSW Government, ISBN: 978 1 925204 19 3.

Natural Resources Commission (2018) Supplementary Advice on Coastal Integrated Forestry Operations Approval Remake, Old Growth Forests and Rainforests - North Coast State Forests. Final report, March 2018, NSW Government, ISBN: 978 1 925204 29 2.

Ngugi, M.R., Doley, D., Cant, M. and Botkin, D.B., 2015. Growth rates of Eucalyptus and other Australian native tree species derived from seven decades of growth monitoring. *Journal of Forestry Research*, *26*(4), pp.811-826.

NSW Auditor-General (2009) Sustaining Native Forest Operations: Forests NSW. NSW Auditor-General

NSW Office of Water (2010) Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources — Background document. December 2010

NSW Scientific Committee (2007) Loss of Hollow-bearing Trees - key threatening process determination. NSW Scientific Committee - final determination

OECD (2019),Taxing Energy Use 2019: Using Taxes for Climate Action, OECD Publishing, Paris,https://doi.org/10.1787/058ca239-en

OEH (?) Koala Hubs for NSW. OEH Records Released Under GIPA 1026

OEH (2018) Submission to the NSW Environmental Protection Agency on the Draft Coastal Integrated Forestry Operations Approval remake. NSW Office of Environment and Heritage Conservation and Regional Delivery Division, North East Branch. Obtained under a GI(PA) request.

Osborne, D., Lewis, T., Hogg, B., Swift, S., Ryan, S., Taylor, D. and Macgregor-Skinner, J. (2010) Growth predictions in private spotted gum dominant forests in Queensland and N NSW to provide landholders with silvicultural tools to assist them in spotted gum stand management. Forest & Wood Products Australia.

Owad Environment (2015) Koala surveys in four NSW State Forests. Report prepared for the NSW Environment Protection Authority.

Paul KI *et al.* 2016. Testing the generality of aboveground biomass allometry across plant functional types at the continent scale. Global Change Biology 22: 2106 - 2124.

Parnaby, H., Lunney, D., Shannon, I. and Flemming, M. (2010) Collapse rates of hollow-bearing trees following low intensity prescription burns in the Pilliga forests, New South Wales. Pacific Conservation Biology Vol. 16: 209–220.

Peel M., Watson, F., Vertessy R., Lau A., Watson I., Sutton, M. and Rhodes, B. (2000) Predicting the water yield impacts of forest disturbance in the Maroondah and Thomson catchments using the Macaque model. Technical Report 00/14. Cooperative Research Centre for Catchment Hydrology.

Perkins, F. and Mackintosh, A. (2013) Logging or carbon credits, Comparing the financial returns from forest-based activities in NSW's Southern Forestry Region. Australia Institute, Tech Brief 23. ISSN 1836-9014

Phillips, S. (2014) Koala Habitat/Occupancy Assessment – Compartment 13 Royal Camp State Forest. Biolink report to EPA.

Phillips, S. and Weatherstone, C. (2015) Koala Habitat & Population Assessment: Richmond Valley Council LGA. Biolink report to Report to Richmond Valley Council.

Powell, R. and Chalmers, L. (1995) Regional Economic Impact, Gibraltar Range and Dorrigo National Parks. NSW National Parks and Wildlife Service, Sydney.

Price, O.F. and Bradstock, R.A., 2012. The efficacy of fuel treatment in mitigating property loss during wildfires: Insights from analysis of the severity of the catastrophic fires in 2009 in Victoria, Australia. *Journal of environmental management*, *113*, pp.146-157.

Pugh, D (1992) How the Rainforest Decision Benefited the Far North Coast, a Reply to "Promises and Reality". North East Forest Alliance.

Pugh, D (2012) NEFA Audit of Royal Camp State Forest. North East Forest Alliance, http://www.nefa.org.au/audits

Pugh, D, (2014) North East Forest Alliance submission to: Performance of the NSW Environment Protection Authority (Inquiry), (vi) the regulation of forestry practices in Royal Camp State Forest. North East Forest Alliance. http://www.nefa.org.au/audits

Pugh, D. (2018) Natural Effects. A review prepared for the North East Forest Alliance.

Pugh, D. (2018) Bell Miner Associated Dieback in the Border Ranges North and South Biodiversity Hotspot - NSW Section. see https://www.nefa.org.au/logging_dieback

Pugh, D. (2019) Forestry Corporation Logging of OEH Koala Hubs. March 2019.

Pugh, D. (2020) Submission to NSW Independent Bushfire Inquiry. North East Forest Alliance. https://d3n8a8pro7vhmx.cloudfront.net/ncec/pages/71/attachments/original/1587207310/NSW_Bushfire_Inquiry_Submission_North_East_Forest_Alliance.pdf?1587207310

Rab, M.A., 1996. Soil physical and hydrological properties following logging and slash burning in the Eucalyptus regnans forest of southeastern Australia. *Forest Ecology and Management*, *84*(1-3), pp.159-176.

Raizada P and Raghubanshi AS (2010) Seed germination behaviour of *Lantana camara* in response to smoke. *Tropical Ecology* 51(2S): 347-352, 2010

Roy Morgan Research Ltd (2011) Annual Visits to PWG Managed Parks in New South Wales -Final Report. Office of Environment and Heritage, Hurstville NSW.

Recher, H.F. (1991), The conservation and management of eucalypt forest birds: resource requirements for nesting and foraging. In Conservation of Australia's Forest Fauna. Ed by D. Lunney. Royal Zool. Soc. NSW: Mosman. Pp. 24-34.

Recher, H.F., Rohan-Jones, W. and Smith, P. (1980), Effects of the Eden woodchip industry on terrestrial vertebrates with recommendations for management, Forestry Commission of N.S.W. Res. Note 42.

Rennison (2017) Bioregional Assessment of Koala Populations in NSW. A report prepared for the Office of Environment and Heritage. OEH Records Released Under GIPA 1026

Rennison, B. and Fisher, M. (2018) Framework for the Spatial Prioritisation of Koala Conservation Actions in NSW, A Report for the Saving our Species Iconic Koala Project. A Report Prepared for the Office of Environment and Heritage. OEH Records Released Under GIPA 1026

Roberts, S., Vertessy, R. and Grayson, R., 2001. Transpiration from Eucalyptus sieberi (L. Johnson) forests of different age. *Forest Ecology and Management*, *143*(1-3), pp.153-161.

Roxburgh, S. H., Wood, S.W., Mackey, B.J., Woldendorp, G., and Gibbons, P. (2006) Assessing the carbon sequestration potential of managed forests: a case study from temperate Australia. *Journal of Applied Ecology* (2006) 43, 1149–1159. doi: 10.1111/j.1365-2664.2006.01221.x

Roy Morgan (2019) Annual Visits to NPWS Managed Parks in New South Wales, Final Report August 2019.

Salcedo, P.G., Maraseni, T.N. and McDougall, K (2012) Carbon sequestration potential of spotted gum (Corymbia citriodora subspecies Variegata) in South East Queensland, Australia, International Journal of Environmental Studies, 69:5, 770-784, DOI: 10.1080/00207233.2012.715833

Saunders, D.A. (1979), The Availability of Tree Hollows for Use as Nest Sites by Whiter-tailed Black Cockatoos, Aust. Wildl. Res., 6: 205-16.

Saunders, D.L. and Heinsohn, R., 2008. Winter habitat use by the endangered, migratory Swift Parrot (Lathamus discolor) in New South Wales. *Emu-Austral Ornithology*, *108*(1), pp.81-89.

Schirmer, J., Dare, L. and Mylek, M. (2018) Community perceptions of Australia’s forest, wood and paper industries: implications for social license to operate. Forests and Wood Products Australia.

Scotts, D.J. (1991), Old-growth forests: their ecological characteristics and value to forest-dependent vertebrate fauna of south-east Australia. In Conservation of Australia's Forest Fauna. Ed by D. Lunney. Royal Zool. Soc. NSW: Mosman. Pp. 147-59.

Sharpe, D.J., 2004. Effect of flowering patterns on a population of squirrel gliders *Petaurus norfolcensis* in north-east New South Wales. *The Biology of Australian Possums and Gliding Possums’.(Eds RL Goldingay and SM Jackson.) pp*, pp.339-349.

Sharpe, D.J. and Goldingay, R.L., 1998. Feeding behaviour of the squirrel glider at Bungawalbin Nature Reserve, north-eastern New South Wales. *Wildlife Research*, *25*(3), pp.243-254.

Sharpe, D.J. and Goldingay, R.L., 2007. Home range of the Australian squirrel glider, Petaurus norfolcensis (Diprotodontia). *Journal of Mammalogy*, *88*(6), pp.1515-1522

Sharpe, D.J. and Goldingay, R.L., 2010. Population ecology of the nectar-feeding squirrel glider (Petaurus norfolcensis) in remnant forest in subtropical Australia. *Wildlife Research*, *37*(2), pp.77-88.

Silver, MJ and Carnegie AJ (2017) An independent review of bell miner associated dieback. Final report prepared for the Project Steering Committee: systematic review of bell miner associated dieback

Smith, A.P. (1991a), Forest policy: fostering environmental conflict in the Australian timber industry. In Conservation of Australia's Forest Fauna ed by D. Lunney. Royal Zool. Soc. NSW: Mosman. Pp. 301-14.

Smith, A.P. and Lindenmayer, D. (1988), Tree hollow requirements of Leadbeater's Possum and other possums and gliders in timber production Ash forests of the Victorian Central Highlands. Aust. Wildl. Res., 15, 347-62.

Smith, A.P. 2004. Koala conservation and habitat requirements in a timber production forest in north-east New South Wales. In *Conservation of Australia's Forest Fauna* (2nd ed.), pp. 591-611. Mosman, New South Wales: Royal Zoological Society of New South Wales.

Snowdon P. et al. 2000. Synthesis of allometrics, review of root biomass and design of futrue woody biomass sampling strategies. NCAS Technical Report No. 17, Australian Greenhouse Office

State Forests of NSW (1995b) Proposed Forestry Operations in the Casino Management Area, Environmental and Fauna Impact Statement, Volume B, Appendices 1 to 19. State Forests of NSW, November 1995.

Stone, C., Spolc, D and Urquhart, C.A. (1995) Survey of Crown Dieback in Moist Hardwood Forests in the Central and Northern Regions of NSW State Forests (Psyllid/Bell Miner Research Programme). Research Paper No. 28. Research Division, State Forests of NSW. Sydney.

Stone, C. (1999) Assessment and monitoring of decline and dieback of forest eucalypts in relation to ecologically sustainable forest management: a review with a case history. Australian Forestry 62: 51–58. **DOI:** 10.1080/00049158.1999.10674763

Stone, C (2005) Bell-miner-associated dieback at the tree crown scale: a multi-trophic process. *Australian Forestry* 2005 Vol. 68 No. 4 pp. 237–241

Stone, C. *et.al.* (2005) Final Report for NRMCA Project NRTB3.03:Remote Multi-Spectral Assessment of Bell Miner Associated Dieback, Appendices - Supplementary Information and Results

Sullivan, B. J., Baxter, G. S., and Lisle, A. T. (2002). Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. I. Faecal pellet sampling protocol. *Wildlife Research* **29**, 455–462. doi:10.1071/WR00110

Sullivan, A.L., McCaw, W.L., Cruz, M.G., Matthews, S. and Ellis, P.F., 2012. Fuel, fire weather and fire behaviour in Australian ecosystems. *Flammable Australia: fire regimes, biodiversity and ecosystems in a changing world*, pp.51-77.

Taylor, C., McCarthy, M.A. and Lindenmayer, D.B., 2014. Nonlinear effects of stand age on fire severity. *Conservation Letters*, *7*(4), pp.355-370.

Traill, B.J. (1991), Box-Ironbark forests: tree-hollows, wildlife and management. In Conservation of Australia's Forest Fauna ed by D. Lunney. Royal Zool. Soc. NSW: Mosman. Pp. 119-24.

Turner, J., Lambert, M.J. and Johnson, D.W., 2005. Experience with patterns of change in soil carbon resulting from forest plantation establishment in eastern Australia. *Forest Ecology and Management*, *220*(1-3), pp.259-269.

URS (2008) Economic Policy Settings in the Forest and Timber Industry – An inter-jurisdictional comparison. Prepared for Victorian Department of Primary Industries.

URS (2012) Investment and Innovation Pathways in the Victorian Hardwood Process Industry. Report to Victorian Association of Forest Industries.

Vertessy,R., Watson, F., O'Sullivan, S., Davis, S., Campbell, R., Benyon, R. and Haydon, S. (1998) Predicting water yield from mountain ash forest catchments. Cooperative Research Centre for Catchment Hydrology, 98/4.

Vertessy, R.A. (1999) The impacts of forestry on streamflows: a review. Pp 93-109 in Forest Management for Water Quality and Quantity, Proceedings of the Second Forest Erosion Workshop, eds. Croke, J. and Lane, P. Cooperative Research Centre for Catchment Hydrology, 99/6.

Wardell-Johnson GW, Keppel G, Sander J (2011) Climate change impacts on the terrestrial biodiversity and carbon stocks of Oceania. Pacific Conservation Biology 17: 220–240.

Wardell-Johnson G, and. Lynch A.J.J. (2005) Landscape processes and eucalypt dieback associated with bell miner habitat in south-eastern Australia. *Australian Forestry* 2005 Vol. 68 No. 4 pp. 242–250/

Webb, A. (2012). Can timber and water resources be sustainably co-developed in south-eastern New South Wales, Australia?. Environment Development and Sustainability. 14. 233-252. 10.1007/s10668-011-9319-3.

White, N *et. al.* (2015) Clarence Valley Comprehensive Koala Plan of Management, For the Ashby, Woombah & Iluke localities of the Clarence Valley LGA. Clarence Valley Council.

Williams, K.J., Ford, A., Rosauer, D., De Silva, N., Mittermeier, R., Bruce, C., Larsen, F.W., Margules, C., 2011. Forests of East Australia: the 35th biodiversity hotspot. In: Zachos, F.E., Habel, J.C. (Eds.), Biodiversity Hotspots: Distribution and Protection of Conservation Priority Areas. Springer-Verlag, Berlin, pp. 295–310.

Wilson, J., 2003. Flowering ecology of a box-ironbark eucalyptus community (No. Ph. D.). Deakin University.

Winoto-Lewin, S., Sanger, J.C. and Kirkpatrick, J.B., 2020. Propensities of Old Growth, Mature and Regrowth Wet Eucalypt Forest, and Eucalyptus nitens Plantation, to Burn During Wildfire and Suffer Fire-Induced Crown Death. *Fire*, *3*(2), p.13.

Woldendorp, G. & Keenan, Rodney & Ryan, M.. (2002). Coarse Woody Debris in Australian Forest Ecosystems. A Report for the National Greenhouse Strategy, Module 6.6 (Criteria and Indicators of Sustainable Forest Management), Commonwealth of Australia.

Wormington, K.R., Lamb, D., McCallum, H.I. and Moloney, D.J., 2002. Habitat requirements for the conservation of arboreal marsupials in dry sclerophyll forests of southeast Queensland, Australia. *Forest Science*, *48*(2), pp.217-227.

Ximenes F, Gardner WD, Marchant JF 2004. Total biomass measurement and recovery of biomass in log products in spotted gum (Corymbia maculata) forests of SE NSW. NCAS Technical Report No. 47, Australian Greenhouse Office.

Ximenes, F., Coburn, R., McLean, M., Samuel, J., Cameron, N., Law, B., Threllfall, C., Wright, K. and Macintosh S. (2017) North Coast Residues, A project undertaken as part of the 2023 North Coast Forestry Project. NSW Department of Primary Industries

Zylstra, P.J., 2018. Flammability dynamics in the Australian Alps. *Austral Ecology*, *43*(5), pp.578-591.

Appendix 1: Additional Koala scat records from random plots

Additional NEFA Koala scat records from random site surveys in Braemar and Ellangowan SFs undertaken for this assessment (in addition to those identified in audit reports).

Site 1

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6790279	501299	4	Red Gum	70	old, scratches	1-20 scats
6790290	501323	3	Red Gum	52	old	1-20 scats
6790311	501363	2	Red Gum	27	old	1-20 scats
6790352	501371	3	Red Gum	54	old, scratches	1-20 scats
6790400	501533	21	Grey Box	70	varied	>20 scats

Site 2

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6789243	501164	21	Grey Box	66	medium	>20 scats
6789254	501161	22	Red Gum	36	medium	>20 scats
6789211	501169	2	Grey Box	40	medium	1-20 scats

Site 4

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6788386	501973	21	Grey Box	80	old	>20 scats
6788373	501975	2	Grey Box	46	old	1-20 scats
6788352	501981	23	Grey Box	47	old	>20 scats
6788346	501893	10	Red Gum	44	old, 2 sizes	2 sizes
6788310	501950	8	Grey Box	65	old	1-20 scats

Site 5

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6782690	500525	5	Grey Box	70	old	2 sizes
6782687	500542	8	Grey Box	43		2 sizes
6782712	500529	6	Grey Box	43		2 sizes
6782697	500585	25	Red Gum	36	various size, age	>20 scats
6782723	500541	25	Red Gum	28		>20 scats
6782762	500537	13	Grey Box	44		1-20 scats

Site 6

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6785639	500900	21	Grey Box	88	fresh	>20 scats
6785622	500873	0	Grey Gum	59		scratches
6785619	500865	23	Red Gum	32		>20 scats
6785595	500864	1	Grey Gum	77		1-20 scats
6785586	500859	0	Grey Gum	60		scratches
6785575	500868	2	Grey Gum	50	very old	1-20 scats

6785570	500931	9	Grey Box	46		1-20 scats
6785624	500946	9	Grey Gum	76	numerous scratches	2 sizes
6785628	500940	4	Red Gum	48		2 sizes
6785625	500946	25	Red Gum	35		>20 scats

Site 7

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6785268	501047	28	Red Gum	37	varied age, size	>20 scats
6785267	501032	20	Grey Gum	46	fresh	1-20 scats
6785264	501022	77	Grey Gum	41	fresh	>20 scats
6785289	501030	0	Grey Gum	70		scratches
6785284	501061	21	Red Gum	43		>20 scats
6785285	501059	2	Grey Box	47		1-20 scats

Site 8

y_proj	x_proj	scats_no	Species	DBH	Comment	scat_class
6784850	499703	54	Red Gum	50		>20 scats
6784839	499685	13	Red Gum	32	old	1-20 scats
6784811	499689	11	Red Gum	38		1-20 scats
6784804	499692	4	Grey Box	51	old	1-20 scats
6784806	499682	30	Red Gum	51		>20 scats
6784806	499686	4	Red Gum	26		2 sizes
6784797	499633	47	Red Gum	57		>20 scats

Appendix 2: NEFA post-fire Koala and scat records

y_proj	x_proj	scats_no	Species	DBH	Place	Use
6787930.0	498999.0	25/Live	Grey Box	54	Braemar	Short
6791338.0	489949.0	438	Grey Box	60	Royal Camp	Long
6787561.0	497981.0	25	Grey Gum	64	Braemar	ND
6791360.2	489703.7	2/Live	Grey Gum	39	Royal Camp	Short
6791348.3	489658.1	62	Grey Gum	47	Royal Camp	Short
6791392.2	489671.8	28	Grey Gum	45	Royal Camp	Med
6791476.8	489612.2	68	Grey Gum	44	Royal Camp	Short
6791500.4	489679.2	53	Red Gum	23	Royal Camp	ND
6791209.1	489697.8	374	Red Gum	31	Royal Camp	Long
6791060.1	489633.8	112	Red Gum	40	Royal Camp	Long
6791047.2	489598.2	1	Grey Gum	47	Royal Camp	Short
6791013.9	489607.5	10	Red Gum	44	Royal Camp	Short
6791016.2	489573.1	38	Red Gum	29	Royal Camp	ND
6791004.2	489569.5	16	Red Gum	46	Royal Camp	Short
6790940.3	489600.7	142	Red Gum	57	Royal Camp	Long
6790863.3	489622.7	8	Red Gum	86	Royal Camp	Short
6789263.9	487733.1	30	Grey Box	41	Royal Camp	ND
6789265.6	487736.4	68	Grey Box	43	Royal Camp	ND
6789288.4	487694.3	23	Red Gum	57	Royal Camp	ND
6789245.8	487728.8	18	Grey Box	30	Royal Camp	ND
6789028.8	487779.5	16/Live	Grey Gum	37	Royal Camp	ND
6787844.4	499764.9	87	Grey Box	58	Braemar	ND
6787675.2	499351.0	90	Red Gum	66	Braemar	Short
6788170.7	498948.2	189	Grey Box	40	Braemar	Med
6788167.3	498948.5	17	Spotted Gum	47	Braemar	Short
6787979.8	498311.7	286	Grey Gum	28	Braemar	Med
6787887.8	498516.3	772/Live	Grey Box	46	Braemar	Long
6788012.3	498457.8	2	Grey Box	60	Braemar	Short
6788111.5	498277.8	606	Grey Box	33	Braemar	Med
6788589.5	498568.0	683/Live	Grey Box	45	Braemar	Long
6788627.0	498456.4	92	Iron Bark	35	Braemar	ND
6788632.9	498454.6	34	Grey Box	40	Braemar	ND
6788582.0	498478.7	2147/Live	Spotted Gum	49	Braemar	Long
6785980.0	493397.8	Dead		0	Carwong	ND
6785998.3	493397.9	228	Red Gum	43	Carwong	ND
6786215.2	493403.5	Dead		0	Carwong	ND
6786518.8	493587.7	63	Grey Box	50	Carwong	ND
6786539.1	493669.2	18	Spotted Gum	34	Carwong	ND
6786533.5	493667.3	18	Spotted Gum	37	Carwong	ND
6787035.2	493206.8	88	Grey Box	47	Carwong	ND
6787481.0	493679.0	166	Red Gum	41	Carwong	Long
6787486.1	493678.2	107	Spotted Gum	53	Carwong	ND
6787449.5	493685.2	186	Grey Box	38	Carwong	Long
6787435.3	493686.9	90	Grey Box	64	Carwong	Med
6787425.7	493698.4	342	Grey Box	49	Carwong	Long
6787418.6	493737.4	25	Spotted Gum	78	Carwong	Short
6787406.8	493736.5	312	Grey Gum	26	Carwong	Long
6787384.1	493743.7	167	Grey Gum	23	Carwong	Long
6787356.1	493748.8	11	Grey Gum	23	Carwong	Short
6787357.7	493752.7	7	Grey Gum	44	Carwong	Short
6787349.3	493744.6	194	Grey Box	47	Carwong	Long

6787372.5	493734.3	104	Spotted Gum	56	Carwong	ND
6791765.9	491092.1	183	Grey Box	63	Purchased	ND
6791752.0	491052.7	52	Grey Box	53	Purchased	ND
6791677.0	491035.1	21	Grey Box	43	Purchased	Short
6791682.9	491030.4	95	Grey Box	54	Purchased	Short
6791598.2	491077.7	29	Grey Box	49	Purchased	Short
6791591.1	491040.5	5	Red Gum	57	Purchased	ND
6791598.4	491028.5	22	Red Gum	43	Purchased	Med
6791476.3	491230.2	16	Red Gum	41	Purchased	Short
6791434.9	491347.7	8	Grey Box	27	Purchased	Short
6791251.7	491617.7	46	Grey Box	83	Purchased	Short
6791301.8	491616.0	275	Grey Box	59	Purchased	ND
6791250.0	491690.1	64	Spotted Gum	69	Purchased	Long
6791261.8	491778.2	54	Spotted Gum	52	Purchased	ND
6791250.5	491866.3	21	Spotted Gum	60	Purchased	ND
6791347.3	491943.4	102	Red Gum	77	Purchased	Short
6791333.7	491945.2	36	Grey Box	57	Purchased	Med
6791381.9	491856.6	105	Grey Box	39	Purchased	Short
6791324.1	491781.5	86	Grey Box	35	Purchased	Short
6791465.9	491645.1	227	Grey Box	26	Purchased	Short
6791520.0	491614.9	47	Red Gum	29	Purchased	Short
6791559.9	491503.5	56	Spotted Gum	82	Purchased	ND
6791689.8	491459.2	86	Grey Box	60	Purchased	ND
6791785.6	491437.8	55	Red Gum	44	Purchased	ND
6791692.2	491136.6	89	Grey Box	49	Purchased	Short
6787861.1	498472.7	25	Grey Box	57	Braemar	Short
6787883.5	498516.4	56	Spotted Gum	42	Braemar	Short
6787829.2	498535.1	21	Spotted Gum	62	Braemar	Short
6787838.1	498538.7	325	Red Gum	41	Braemar	Long
6787869.2	498601.0	22	Grey Gum	33	Braemar	Short
6787847.6	498623.8	18	Spotted Gum	64	Braemar	Short
6787948.1	498693.5	30	Grey Gum	51	Braemar	Short
6788137.7	498928.5	69	Grey Box	33	Braemar	Short
6788136.0	498988.6	25	Spotted Gum	38	Braemar	Short
6788116.7	498990.3	56	Grey Box	44	Braemar	Med
6788178.1	499218.0	24	Grey Box	74	Braemar	Short
6788174.2	499236.7	64	Grey Box	53	Braemar	Short
6788229.6	499387.3	61	Grey Box	40	Braemar	Short
6788281.6	499437.3	277	Grey Box	44	Braemar	Med
6788458.2	499516.4	Live	Grey Box	50	Braemar	ND
6788385.3	499543.1	108	Grey Box	47	Braemar	Short
6788344.8	499542.0	47	Grey Box	42	Braemar	Short
6788578.5	498579.6	262	Red Gum	0	Braemar	Long
6787843.4	499006.1	31	Red Gum	34	Braemar	Short
6787855.8	499008.2	5	Red Gum	20	Braemar	Short
6787676.9	499370.4	118	Grey Box	52	Braemar	ND
6788406.8	498940.3	55	Red Gum	35	Braemar	Med
6788411.6	498940.0	81	Spotted Gum	60	Braemar	Short
6788414.7	498941.9	165	Grey Box	40	Braemar	Long
6788408.4	498919.3	106	Grey Box	47	Braemar	Long
6788575.8	498581.7	69	Grey Box	0	Braemar	Short
6788585.8	498569.8	40	Grey Box	27	Braemar	Short
6788474.3	498788.9	65	Grey Box	33	Braemar	ND
6788527.9	498849.4	78	Grey Box	49	Braemar	ND

6788616.9	498982.6	389	Grey Box	77	Braemar	Long
6787491.3	493620.3	100	Red Gum	42	Carwong	ND
6787501.3	493688.7	53	Grey Gum	50	Carwong	ND
6788377.4	499538.2	20	Grey Box	42	Braemar	Short
6788345.1	499535.5	55	Grey Box	34	Braemar	Short
6788381.0	499457.8	38	Grey Box	34	Braemar	Short
6788281.0	499271.9	375	Grey Box	65	Braemar	Long
6788279.6	499273.4	150	Grey Gum	30	Braemar	ND
6788284.3	499276.4	150	Grey Box	36	Braemar	ND
6788609.7	498540.9	142	Red Gum	47	Braemar	Med
6788609.9	498521.8	64	Red Gum	54	Braemar	Med
6788599.2	498503.9	91	Red Gum	42	Braemar	Short
6788591.6	498484.5	54	Grey Box	32	Braemar	ND
6788507.9	498483.7	118	Grey Box	30	Braemar	Short
6788468.8	498498.9	74	Red Gum	57	Braemar	Short
6788414.4	498559.3	3	Red Gum	33	Braemar	Short
6788393.2	498640.6	123	Grey Box	53	Braemar	Long
6788373.3	498742.6	18	Grey Box	48	Braemar	Short
6788503.2	499543.1	113	Grey Box	36	Braemar	ND
6788627.0	498808.8	286	Grey Box	43	Braemar	Long
6788239.4	498641.7	51	Grey Box	40	Braemar	ND
6791917.2	493165.0	74	Spotted Gum	41	Purchased	ND
6791908.5	493195.0	21	Spotted Gum	55	Purchased	ND
6791854.0	493136.5	15	Red Gum	49	Purchased	ND
6791833.1	493151.1	127	Red Gum	87	Purchased	ND
6791726.7	493110.9	433	Grey Box	50	Purchased	ND
6791698.6	493128.5	28	Red Gum	0	Purchased	ND
6783064.8	500989.5	Dead		0	Ellangowan	ND
6788499.2	498558.5	271	Grey Box	0	Braemar	Long
6788454.2	498623.9	35	Spotted Gum	0	Braemar	ND
6791502.8	489685.0	55/Live	Spotted Gum	36	Royal Camp	ND
6791370.1	489706.1	12	Grey Gum	35	Royal Camp	Short
6791440.7	489788.4	36	Red Gum	36	Royal Camp	ND
6791573.6	489822.7	33	Red Gum	53	Royal Camp	ND

Appendix 3: Structural Plots

State Forest	Plot	y_proj	x_proj	Topographic Position	CRA_Ecosystem	Disturbance History	m^2ha
Banyabba	BY1a	6753859	500241	contour	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	41
Banyabba	BY1b	6753845	500203	contour	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	25
Banyabba	BY1c	6753813	500170	contour	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	42
Banyabba	BY1d	6753835	500119	contour	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	28
Banyabba	BY1e	6753831	500067	contour	Lowland Red Gum	Oldgrowth (CRAFTI)	28
Banyabba	BY1f	6753859	500024	Riparian	Lowland Red Gum	Oldgrowth (CRAFTI)	45
Banyabba	BY2a	6752940	500702	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	57
Banyabba	BY2b	6752894	500709	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	31
Banyabba	BY2c	6752842	500707	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	44
Banyabba	BY2d	6752793	500778	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	51
Banyabba	BY2e	6752731	500782	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	53
Banyabba	BY2f	6752694	500795	ridge	Clarence Lowlands Spotted Gum	Oldgrowth (CRAFTI)	46
Braemar	B1a	6788601	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	11
Braemar	B1b	6788548	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	15
Braemar	B1c	6788502	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	26
Braemar	B1d	6788451	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	12
Braemar	B1e	6788404	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	14
Braemar	B1f	6788355	498775	contour	Lowlands Spotted Gum-Box	1996 Logging	20
Braemar	B2a	6787901	498914	ridge	Lowlands Spotted Gum-Box	1995 logging	23
Braemar	B2b	6787899	498959	slope	Lowlands Spotted Gum-Box	1995 logging	26
Braemar	B2c	6787889	499003	slope	Lowlands Spotted Gum-Box	1995 logging	20
Braemar	B2d	6787874	499047	slope	Lowlands Spotted Gum-Box	1995 logging	20
Braemar	B2e	6787871	499092	slope	Lowlands Spotted Gum-Box	1995 logging	22
Braemar	B2f	6787860	499136	Riparian	Lowlands Grey Box	1995 logging	21
Braemar	B2g	6787871	499196	flat	Lowlands Grey Box	1995 logging	27
Braemar	B2h	6787879	499222	flat	Lowlands Grey Box	1995 logging	16
Braemar	B3a	6787746	498687	contour	Lowlands Spotted Gum-Box	1996 Logging	28
Braemar	B3b	6787689	498680	contour	Lowlands Spotted Gum-Box	1996 Logging	11
Braemar	B3c	6787646	498653	contour	Lowlands Spotted Gum-Box	1996 Logging	31
Braemar	B3d	6787599	498628	contour	Lowlands Spotted Gum-Box	1996 Logging	28
Braemar	B3e	6787552	498600	contour	Lowlands Spotted Gum-Box	1996 Logging	15
Braemar	B3f	6787499	498574	contour	Lowlands Spotted Gum-Box	1996 Logging	19
Braemar	B4a	6787283	498161	contour	Lowlands Spotted Gum-Box	1996 Logging	14
Braemar	B4b	6787328	498134	contour	Lowlands Spotted Gum-Box	1996 Logging	22
Braemar	B4c	6787366	498093	contour	Lowlands Spotted	1996 Logging	22

					Gum-Box		
Braemar	B4d	6787413	498059	contour	Lowlands Spotted Gum-Box	1996 Logging	29
Braemar	B4e	6787463	498047	contour	Lowlands Spotted Gum-Box	1996 Logging	26
Braemar	B4f	6787507	498023	contour	Lowlands Spotted Gum-Box	1996 Logging	18
Braemar	B4g	6787554	497991	contour	Lowlands Spotted Gum-Box	1996 Logging	32
Braemar	B4h	6787599	497986	contour	Lowlands Spotted Gum-Box	1996 Logging	24
Braemar	B4i	6787649	497960	contour	Lowlands Spotted Gum-Box	1996 Logging	26
Carwong	C1a	6787498	493404	contour	Lowlands Spotted Gum-Box	1992 Logging	31
Carwong	C1b	6787484	493450	contour	Lowlands Spotted Gum-Box	1992 Logging	23
Carwong	C1c	6787481	493495	contour	Lowlands Spotted Gum-Box	1992 Logging	12
Carwong	C1d	6787476	493546	contour	Lowlands Spotted Gum-Box	1992 Logging	25
Carwong	C1e	6787488	493601	contour	Lowlands Spotted Gum-Box	1992 Logging	24
Carwong	C1f	6787493	493648	contour	Lowlands Spotted Gum-Box	1992 Logging	28
Carwong	C1g	6787500	493692	contour	Lowlands Spotted Gum-Box	1992 Logging	13
Carwong	C1h	6787520	493740	contour	Lowlands Spotted Gum-Box	1992 Logging	19
Carwong	C1i	6787532	493794	Riparian	Lowlands Spotted Gum-Box	1992 Logging	22
Ellangowan	E1a	6782730	500549	ridge	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	17
Ellangowan	E1b	6782704	500586	slope	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	28
Ellangowan	E1c	6782669	500622	slope	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	11
Ellangowan	E1d	6782614	500668	Riparian	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	23
Ellangowan	E1e	6782581	500704	slope	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	12
Ellangowan	E1f	6782550	500736	ridge	Lowlands Spotted Gum-Box	2207 STS Medium, 1989	15
Ellangowan	E2a	6783022	500968	Riparian	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	25
Ellangowan	E2b	6783063	500986	contour	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	13
Ellangowan	E2c	6783116	501002	contour	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	24
Ellangowan	E2d	6783166	501019	contour	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	27
Ellangowan	E2e	6783215	501029	contour	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	9
Ellangowan	E2f	6783266	501044	Riparian	Lowlands Spotted Gum-Box	2007 STS Medium, 1996	26
Plantation Purchase	PP1a	6792243	493288	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	12
Plantation Purchase	PP1b	6792206	493280	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	21
Plantation Purchase	PP1c	6792160	493247	Riparian	Clarence Lowlands Spotted Gum	Young (CRAFTI)	20
Plantation Purchase	PP1d	6792111	493229	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	17
Plantation Purchase	PP1e	6792069	493205	ridge	Clarence Lowlands Spotted Gum	Young (CRAFTI)	18
Plantation Purchase	PP1f	6792023	493193	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	7
Plantation Purchase	PP1g	6791981	493185	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	23

Plantation Purchase	PP1h	6791928	493169	Riparian	Clarence Lowlands Spotted Gum	Young (CRAFTI)	29
Plantation Purchase	PP1i	6791880	493155	slope	Clarence Lowlands Spotted Gum	Young (CRAFTI)	22
Plantation Purchase	PP1j	6791834	493137	ridge	Clarence Lowlands Spotted Gum	Disturbed Mature (CRAFTI)	14
Plantation Purchase	PP1k	6791776	493118	slope	Clarence Lowlands Spotted Gum	Disturbed Mature (CRAFTI)	17
Plantation Purchase	PP1l	6791726	493112	flat	Clarence Lowlands Spotted Gum	Disturbed Mature (CRAFTI)	40
Royal Camp	RC1a	6790690	488292	Riparian	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	19
Royal Camp	RC1b	6790656	488249	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	25
Royal Camp	RC1c	6790629	488219	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	20
Royal Camp	RC1d	6790572	488128	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	8
Royal Camp	RC1e	6790571	488129	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	13
Royal Camp	RC1f	6790540	488085	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	17
Royal Camp	RC1g	6790493	488059	contour	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	24
Royal Camp	RC1h	6790422	488029	Riparian	Richmond Range Spotted Gum-Box	2012 STS Light, 1994	30
Royal Camp	RC2a	6789072	488101	ridge	Richmond Range Spotted Gum-Box	1989 logging	24
Royal Camp	RC2b	6789086	488058	slope	Richmond Range Spotted Gum-Box	1989 logging	12
Royal Camp	RC2c	6789120	487968	Riparian	Richmond Range Spotted Gum-Box	1989 logging	15
Royal Camp	RC2d	6789153	487928	slope	Richmond Range Spotted Gum-Box	1989 logging	15
Royal Camp	RC2e	6789172	487880	slope	Richmond Range Spotted Gum-Box	1989 logging	19
Royal Camp	RC2f	6789205	487836	ridge	Richmond Range Spotted Gum-Box	1989 logging	16