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Investigating the effect of disturbance on tree species composition in coastal state forests

This note summarises analysis of the effect of timber harvesting and fire on tree species composition in eucalypt forests with a focus on arboreal marsupial feed trees. This work was carried out by Forest Science researchers at the Department of Primary Industries and Regional Development as part of the Coastal Integrated Forestry Operations Approvals (IFOA) Monitoring Program. This work was designed to understand if the Coastal IFOA conditions are effective in ensuring regenerating harvested forests are meeting benchmarks for floristic composition.

The results suggest that overall, timber harvesting or fire disturbance have minor and transient effects on tree species composition measured by basal area, with lower intensity, selective harvesting having less effect than more intensive harvesting or multiple disturbances. This conclusion also applies to many key feed tree species for koala, yellow-bellied glider and southern greater glider, although the response to harvesting was variable between tree species, regions, and harvest intensity. Notably, the researchers did not find significant changes in basal area favouring preferred commercial species following harvesting.

The researchers suggest that together with the substantial body of previous research on arboreal marsupials, the tree composition changes identified in this study are unlikely to be a severe risk to arboreal marsupials under the conditions assessed. However, the researchers note there were a range of data limitations including limited historic disturbance records, limited measurements for some tree species, change in plot size over time, fewer plots for regions outside the North Coast and fewer plots measured after 2020. Further data and work are needed to better understand habitat recovery and the influence of other disturbances and climate on tree species composition.

Tree species composition has the potential to change over time due to disturbance regimes (e.g., timber harvesting, fire) or changing climate. These changes can have flow on effects to alter habitat quality for wildlife dependent on resources such as foliage from specific tree species.

Forestry permanent growth plot measurements from 1979 to 2023 were analysed to assess change in tree species composition – the tree species that make up a forest – over time. The study particularly focused on tree species that provide important feed resources for koala (*Phascolarctos cinereus*), yellow-bellied glider (*Petaurus australis*), and southern greater glider (*Petaurus volans*). Most records were from the initial measurement period of 1979-2009, with 50 plots re-measured between 2020-2023. There were few measurements following the 2019-2020 fires due to their recent occurrence and any long-term effects of these fires on tree species composition measured in the plots are unlikely to be apparent for years to decades. The researchers collated measurements from 639 plots located in a mix of regrowth and mature forests across the north and south coasts, northern tablelands, and Eden. Plots were measured an average of four times each, totalling more than 2,800 measurements over time.

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Using existing literature, the researchers identified key tree species from different regions of NSW for three arboreal marsupials: koala, yellow-bellied glider and southern greater glider (**Table 1**). The tree species provide leaves for browsing or, in the case of yellow-bellied glider, are important sap trees. While many more tree species are fed upon than listed in this table, the researchers' review found these species provide primary sources of forage.

A range of different analyses were used to assess change in tree species composition over time in relation to region, harvesting and fire, and particularly for key feed tree species for arboreal marsupials. To allow for comparison across plots, the study focused only on the effect of a first harvesting or burning event. The influence of other disturbances and climate was not considered in the analysis.

Table 1: Tree species providing important feed for koala, yellow-bellied glider and greater glider

Tree species	Region	Koala	Yellow-bellied glider	Southern greater glider
Forest red gum (*E. tereticornis*)	North	✓		✓
Tallowwood (*E. microcorys*)*	North / Tablelands	✓		
Grey gum (*E. propinqua/punctata*)	North / Tablelands	✓	✓	
Swamp mahogany (*E. robusta*)	North	✓		
Spotted gum (*C. maculata*)*	North / South		✓	✓
Blackbutt (*E. pilularis*)*	North / South			✓
Brown barrel (*E. fastigata*)*	South / Tablelands / Eden		✓	✓
Manna/ribbon gum (*E. viminalis*)	South / Tablelands	✓	✓	✓
Messmate (*E. obliqua*)	South / Tablelands / Eden		✓	
New England blackbutt (*E. campanulata*)*	North / Tablelands			✓
Silvertop stringybark (*E. laevopinea*)*	North / Tablelands			✓
Monkey gum (*E. cypellocarpa*)*	South / Eden			✓
Mountain gum (*E. dalrympleana*)	North / South / Eden			✓

*Note: E = Eucalyptus, C = Corymbia. * = key timber harvest tree species*

Multiple disturbances have a greater effect on tree species composition

The effect of harvesting and harvest intensity was species-specific and varied by region and time since disturbance. In the final measurements of this dataset both harvested and burnt plots supported slightly different tree composition from plots not disturbed during the measurement period, but differences were mainly restricted to species that occurred in few plots. Differences in tree species basal area following harvesting alone varied by region, with 92 percent of species remaining stable in the North Coast, 83 percent in the South Coast, 85 percent in the Tablelands and 46 percent in Eden. Fire (a mix of wildfire and prescribed burns) affected species composition more than harvesting on the North Coast, with a greater proportion of species showing significant basal area change (although not for key feed species). Harvesting affected species composition more than fire in Eden. The effect of fire or harvesting alone on tree species composition was similar in the South Coast and Tablelands.

The effect of fire only on species composition was variable with some species decreasing in basal area (e.g. turpentine, flooded gum, brown barrel and rainforest stems), while others increased (e.g. red mahogany, white stringybark, forest red gum and bloodwood). A similarly variable response was evident in relation to fire severity, but a change among key species was only evident for grey gum, which decreased in basal area, and forest red gum, which increased. Fire tended not to reduce basal area of most key species below pre-fire levels.

Multiple disturbances from harvesting and fire caused more compositional change than either harvesting or fire alone (except in Eden), particularly for key species. For example, models showed tallowwood on the North Coast had slightly (but statistically significant) lower basal area in plots with multiple disturbances. Additionally, there was a weak, negative correlation between change in basal area and number of disturbances for tallowwood, blackbutt and spotted gum, but not for the five other key species assessed. On average across the different regions, 68 percent of species were stable with multiple disturbances, 77 percent were stable with harvesting only and 80 percent were stable with burning only.

Harvesting had variable effects on basal area for key feed tree species

Detailed assessments were undertaken on key feed tree species important to arboreal marsupials by tracking changes in basal area over time after disturbance (16+ years). Recovery to pre-harvest basal area was variable among species and strongly influenced by harvest intensity and region (for species with sufficient data). Harvesting method was not recorded in the plot data before 2020, therefore the researchers used basal area change following a harvesting event to categorise harvesting into either ‘Intensive’ (greater than 40 percent reduction in basal area), ‘Moderate’ (greater than 20 percent and less than or equal to 40 percent reduction) or ‘Light’ (less than or equal to 20 percent reduction). It is important to recognise that this reflects harvesting at the plot scale and the actual method of harvesting applied at the stand level may differ from these assigned categories.

Sufficient data was only available for the North Coast and the Tablelands to assess harvest intensity. On the North Coast, recovery to average pre-harvest basal area after light harvesting occurred for all species (blackbutt, tallowwood, spotted gum, grey gum) within 6-10 years. On the Tablelands, after light harvesting some species saw recovery of basal area to pre-harvest levels within 6-10 years (silvertop stringybark and New England blackbutt), while others, tallowwood and messmate, had not reached average pre-harvest basal area by the end of the measurement period (greater than 11-15 years post-harvest).

Following moderate-intensive harvesting, few species in the North Coast and Tablelands recovered to average pre-harvest basal area before the final measurement in the dataset. Average basal area change after moderate-intensive harvesting was less than 10m^2 per hectare for most key species. Recovery to average pre-harvest basal area after moderate-intensive harvesting was seen on the North Coast after 11-15 years for tallowwood and 16+ years for spotted gum, and on the Tablelands after 6-10 years for silvertop stringybark. Recovery to average pre-harvest basal area after moderate-intensive harvesting was not seen for blackbutt and grey gum on the North Coast after more than 16 years, and for tallowwood, New England blackbutt, messmate and manna/ribbon gum in the Tablelands after 11-15 years. Early recovery to pre-disturbance basal area levels was seen in some plots within 10 years for blackbutt and tallowwood on the North Coast, and within 15 years for tallowwood, New England blackbutt and messmate in the Tablelands. The implication is that intensive harvest practices will lead to reduced basal area of several species, including blackbutt and grey gum on the North Coast and tallowwood, New England blackbutt, messmate and manna/ribbon gum on the Tablelands, for at least one to two decades in the harvested area.

Important browse species persisted

The researchers found that for many key tree species basal area often returned to pre-harvest levels within 10 years following light harvesting and fire did not reduce basal area or limit the growth rate of most key species. This indicates basal area changes from light harvesting and fire are largely temporary and important leaf browse or sap tree species for koala, yellow-bellied glider, and greater glider recovered. However, recovery in basal area was slower, on average, after moderate to intensive harvests and following high intensity harvesting many species approached but did not recover to pre-disturbance levels within the time periods they were measured. As basal area is related to crown area,[1, 2, 3] the researchers expect there would be recovery of crown-level feed resources for the target fauna species. Noting the temporary reduction in feed species after disturbance, the multiscale tree retention requirements in the Coastal IFOA are important to support the persistence of fauna species in the environment during this recovery period.[4]

An example is tallowwood, an important feed tree for koalas which occurred in most plots in the Northern region. In plots only lightly harvested or only burnt in the North Coast, tallowwood basal area rapidly recovered to the same pre-harvest basal area seen in undisturbed plots. Following moderate-intensive harvesting tallowwood in the North Coast had a steady trajectory of growth and recovered in 11-15 years. The results indicate tallowwood in the North Coast is largely resilient to disturbance from harvesting or fire, particularly when harvesting is less intensive, likely in part because the species can regenerate from lignotubers. However, in the Tablelands tallowwood in most plots did not recover to pre-harvest basal area within the measurement period (11-15 years). Basal area recovery was slower for some species on the Tablelands and South Coast with intensive harvesting and where climate was cooler. Another example of this is manna/ribbon gum, a preferred browse species for all three fauna species. On the Tablelands, while manna gum did recover to pre-harvest basal area within 5 years following light selective harvesting, growth following this was minimal. Additionally, it was one of the most intensively harvested species, seeing an average reduction in basal area per hectare of 15 m^2, and recovery to pre-harvest basal area was not seen after intensive harvesting within the period measured (11-15 years for this species).

Importantly, although a preferred browse tree species may exist in an environment, this does not mean it will always be suitable or used by arboreal mammals. There are other tree characteristics such as tree size and leaf chemistry that can influence browse habitat quality.

There is some concern that silviculture practices can promote the dominance of fast-growing species of commercial interest over the growth of preferred feed species. However, trajectories of basal area regrowth and contribution to plot species composition makeup of commercial species such as blackbutt and spotted gum were similar between plots that were either harvested or unharvested during the measurement period. Additionally, in the North Coast, intensive harvesting had little detectable effect on the basal area of important commercial timber species, such as blackbutt and spotted gum, in comparison to unharvested plots. Noting, in the last measurements basal area was slightly increased for blackbutt in lightly harvested plots and slightly decreased for tallowwood in intensively harvested plots. In this study the researchers did not observe an increase in the dominance of commercial species over key feed trees following disturbance.

Limitations and future research

There were a range of study limitations, including poor documentation of harvest history prior to the start of measurements, inconsistent records of harvest and fire events, fewer plots for regions outside the North Coast, fewer plots measured after 2020, and changes in plot size over time. Maintaining consistency in data collection during future measurements will better enhance our understanding of post-disturbance trajectories. This includes for plot size and remeasurement frequency. To understand habitat recovery more fully, additional data could also be collected from plots in the future, such as hollow presence and flowering abundance.

Future analysis could include assessing tree species composition change in old growth forests and regrowth forests separately in the North Coast where there was a larger number of plots. This would provide insights on the extent of differences in species compositional change between plots subject to harvesting and plots that have never been harvested.

It is possible that multiple harvesting or multiple fire events over time would have different effects than what was seen here, as the study focused only on the effect of a first harvesting or burning event and the combined effect of multiple harvesting and fire events. It is also possible other disturbances and drivers of growth that were not considered in the analysis, such as drought, had an influence on observed patterns.

Despite the complexity and limitations of the data, the permanent growth plot dataset is extensive spatially and temporally. It offers further opportunities to investigate and increase understanding of the complex interactive effects of disturbance on forest structure and composition.

More information

This work is part of the monitoring forest structure and health strategy within the Coastal IFOA monitoring plan and is related to the regeneration condition that harvested areas are adequately stocked with a natural floristic composition to maintain ecological function and sustainable timber supplies. The report detailing the project findings can be found on the Commission's website.

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[1] Curtin R A (1970) *Analysis of growth in a mixed eucalypt forest*, Forestry Commission of New South Wales, Research Note no. 24, Sydney.

[2] Pook EW (1984) 'Canopy dynamics of *Eucalyptus maculata* Hook. II. Canopy leaf area balance', *Australian Journal of Botany* 32, 405–13.

[3] Verma N K, Lamb D W, Reid N, Wilson B (2014) 'An allometric model for estimating DBH of isolated and clustered Eucalyptus trees from measurements of crown projection area', *Forest Ecology and Management*, 326, 125–132.

[4] Slade C, Law B (2017) 'The other half of the coastal State Forest estate in New South Wales; the value of informal forest reserves for conservation', *Australian Zoologist*, 39, 359–370.