DPI Forestry's claim that logging has no impacts on Koalas is invalid.

Dailan Pugh, North East Forest Alliance, April 2022.

Law *et. al.* (2022) from DPI Forestry used male Koala recordings from song-meters to assess the impacts of logging on Koalas in 3 State Forests in the north-east NSW. This is a preliminary review of the Law *et. al.* (2022) paper 'Regulated timber harvesting does not reduce koala density in north-east forests of New South Wales' to assess the veracity of their claims "*There was no significant effect of selective harvesting on density and little change evident between years*" and "*that native forestry regulations provided sufficient habitat for koalas to maintain their density*".

While this review of the data is limited to that presented in Law *et. al.* (2022), it shows that there were large decreases in male Koala calling activity across recently logged areas and a large increase in areas with no or minimal calling activity, suggesting that Law *et. al.*'s (2022) conclusions are invalid and logging appears to have had a large impact. Averaged across the forests actually logged in 2020 within the 3 State Forests assessed by Law *et. al.* (2022) from the extreme drought in Spring 2019 to Spring 2020 there appears to have been around a 23% decline in areas with relatively high male Koala calling frequency (hot spots), a 27% decrease in areas with moderate calling frequency and a 36% increase in areas of no or very low male Koala calling frequency. This is despite the breaking of the drought.

Two of the 3 previously logged National Parks used as controls by Law *et. al.* (2022) indicate there was a consistent persistence of high Koala call frequency sites (hotspots) between years suggesting stable breeding colonies, whereas in the recently logged forests the smaller calling hotspots were highly variable between years suggesting unstable populations, supporting the concern that that logged forests may constitute sink habitat where mortality exceeds reproduction.

The impression gained from this review is of unstable Koala colonies in logged forests, declining as mature feed trees are progressively removed, at risk of collapse from the combination of logging, drought and fire. The assumptions and conclusions of the study by DPI Forestry (Law *et. al.* 2022) misrepresent the threat to the ongoing survival of Koalas, and is therefore a threat itself. The data collected needs a full reassessment and critical review by independent experts.

The Law *et. al.* (2022) study was undertaken using acoustic sensors at 3 sites before and after logging in State Forests to assess logging impacts, and 3 sites in previously logged National Parks as controls. The sensors were typically deployed in a 5 × 5 array, with 400 m spacing covering around 400ha, though only parts of these were logged. The initial sampling was undertaken for 2 weeks during the severe drought in Spring 2019, with second assessments undertaken following widespread rains in Spring 2020, so this is likely to have confounded results as breeding activity is likely to have been greater in the more favourable 2020 climate. There was a significant flush of new growth when the drought broke, NRC (2021) noting "*At the control sites, the canopy cover had increased by an average of 10 percent between the 2019 and 2020 assessments due to foliage growth from drought recovery*".

Aside from drought affects, there are many variables that could affect male calling rates, including activity at the time of samplings, weather and time since logging, emphasizing the need for repeated samplings over a number of seasons both before and after logging to accurately characterise pre and post logging occupancy. One-off sampling is unlikely to be a true representation of Koala activity, particularly when based on a record drought.

The male Koala calls are taken by Law *et. al.* (2022) to equate to Koala densities of between 0.03 to 0.08 males per hectare. Law *et. al.* (2022) base their density conversions on the assumption that male Koalas are calling from within average home ranges of 30ha, though Koalas are not necessarily residing in the areas where they were recorded, therefore it is wrong to assume that their calling represents occupancy of a

home range. The method used to calculate density from acoustic data is unpublished, has not been independently tested over time, and should be considered invalid.

It is not considered that calling is necessarily representative of a home range or breeding colony. The calling of males could be from males dispersing looking for mates, males displaced by logging and migrating or moving in search of new territories, males visiting isolated feed trees in otherwise unsuitable habitat, males venturing further from drought refuges, the frequency at which individuals called during the sampling period (particularly during the drought), or a number of other factors. Individual Koalas could be searching for remaining feed trees over greatly expanded areas or simply passing by.

These concerns are amplified by Law *et. al.*'s (2022) claims that between sampling periods in Cowarra State Forest there was an overall 11% decline in the "density" of male Koalas, but a 27% increase in "density" in recently logged areas. Similarly, they claim that in Kalateenee State Forest there was a 37% increase in the "density" of male Koalas, including a 486% increase in oldgrowth forest, effectively requiring an influx of 6 new breeding males after logging (Note: conversely NRC (2021) show a slight decline in the "density" of male Koalas after logging in Kalateenee S.F.). These results are more suggestive of increased Koala movements rather than actual increased densities of Koalas.

It is also considered invalid for Law *et. al.* (2022) to assume that each male territory corresponds to a female territory. In better Koala habitat male home ranges may encompass a number of female home ranges, while some of the male calling may not encompass any female territories. The relationship between males calling and female breeding success and longer term koala density has not been established.

For this review their claims of relative Koala densities are taken to just represent relative calling frequencies. Areas with relatively high calling frequencies (hotspots) are most likely to represent a patch of good feed trees, with those sites recording high calling frequencies in both 2019 and 2020 most likely to be situated within permanent home ranges.

Koalas are known to prefer certain tree species within a region for feeding, and from those species to select individual trees with relatively low levels of toxins. They are known to prefer areas with a variety of species of feed trees (Smith 2004, EPA 2016). They are also known to have a 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, EPA 2016, Pugh 2020), usually taken to be over 30 cm diameter at breast height. It is therefore assumed that Koala home range sizes are related to the abundance and variety of suitable feed trees needed for sustenance. It is the loss of feed trees that should be the metric for assessing logging impacts, not the total timber volumes used by Law *et. al.* (2022).

NRC (2021) report on the canopy changes at the treatment (partially logged) and control sites, without identifying the changes in the actual areas logged. According to NRC (2021) in areas that "*experienced direct harvesting, canopy cover declined by an average of 7 percent*", whereas in the control sites recovering from drought "*the canopy cover had increased by an average of 10 percent*". NRC (2021) also identify that the preferred Koala feed species, Tallowwood (*Eucalyptus microcorys*) "*contributed an average of three percent of the canopy in control sites and five percent in treatment sites*", an increase in Tallowwood canopy cover at both the treatment and control sites in 2020 (due to drought recovery), and a decrease of the feed tree Blue Gum (*E. saligna*) in the control sites. These results indicate that the availability of potential feed trees was less in the control sites, and confirm that the drought had confounding effects on such limited sampling.

In general the current logging rules only require the retention of 10 potential Koala feed trees >20cm diameter (dbh) per hectare in modelled high quality Koala habitat, and 5 per hectare in moderate habitat. To put this into perspective, NEFA (Pugh 2020) undertook numerous transects in moderate quality Koala habitat, in forests last logged over 20 years ago, for their proposed Sandy Creek Koala Park, recording an average of 56.9 potential Koala feed trees >20cm dbh per hectare, meaning that only 8.8% of these require

retention under the current logging rules (CIFOA). It is ludicrous to suggest that the loss of most feed trees will have no effect on Koalas.

Law *et. al.*'s (2022) simplistic categorisation of logged forests as regrowth belies the variable logging intensities that occur across a logging area and the variable retention of mature and oldgrowth Koala feed trees found in logged forests, particularly older logging.

A variety of more robust studies have found that Koala activity is related to the presence of mature feed trees and less disturbance, for example from their intensive searches for Koala scats in 4 State Forests in north-east NSW the EPA (2016) found *"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".*

Similarly from his study in Pine Creek State Forest near Coffs Harbour, Smith (2004) found *"Koalas preferred structurally complex, uneven-aged forests with some mature and oldgrowth elements, a large basal area, and mixed species associations ... 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".*

While Law *et. al.* (2022) acknowledge the Smith (2004) study, as an example of their bias they ignore these contradictory findings in their discussion, instead relying upon studies undertaken in Victorian Bluegum plantations and the Piliga as corroborating their findings "*that during and after selective harvests koalas will continue to occupy their home ranges*". The Piliga study by Kavanagh *et.al.* (2007) specifically excluded all Koala feed trees from logging and was limited to "*about one-quarter of the stand basal area*" of cypress pine. In relation to the Victorian Bluegum, NRC (2021) note "*After harvest, most koalas moved up to 5.5 km from the harvested plantation, with a small proportion remaining in patches of unharvested trees in the harvested area*". No corroboration in either case.

There is no doubt that Koalas can handle a level of disturbance, though loss of feed trees will affect the carrying capacity of a forest and therefore the density of Koalas. The concern is that Koala populations in many State forests have been so reduced that they have become sink habitats where mortality exceeds reproduction (EPA 2016), meaning the depleted populations are in decline. The mapping by Law *et. al.* is extremely concerning as it shows high variability from 2019 to 2020 in the location of areas with high calling frequencies within most logged forests, except around two patches of oldgrowth forest in Lower Bucca State Forest. Conversely in the control Kumbertine and Ulidarra National Parks there are a number of sites that persisted over the two assessments. The general lack of persistence of Koala hotspots in logged areas between samplings shown by Law *et. al.* (2022) supports the EPA (2016) concerns that many logged areas do not have stable Koala colonies and may be sink habitat.

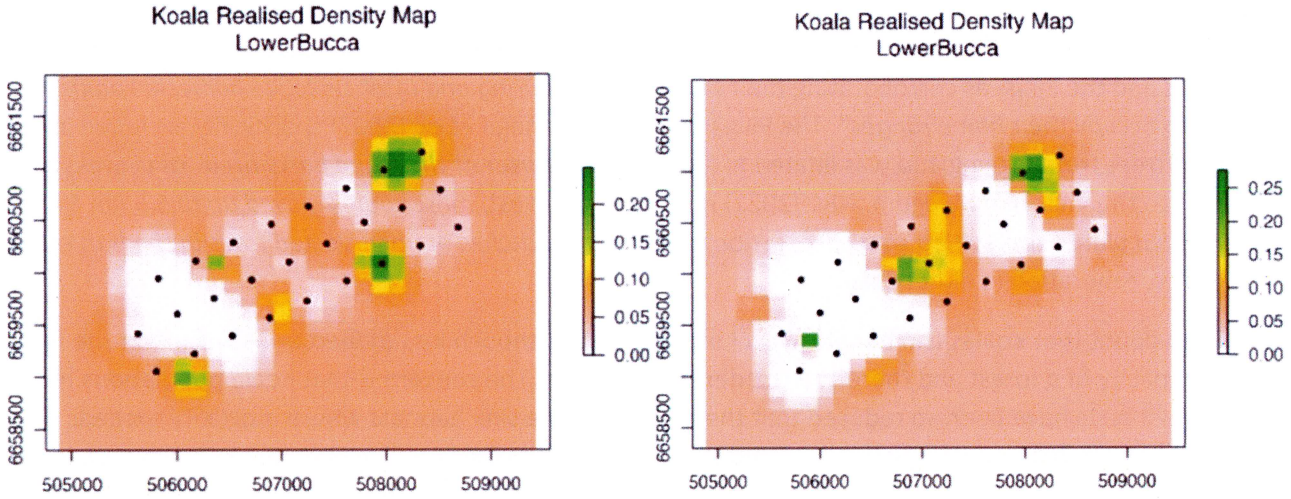
It is evident from this review of Law *et. al.* (2022) that their methodology, analyses and reporting have numerous failings, and their conclusion that logging had no impact on the density of Koalas are invalid. Sampling is not adequate to provide reliable pre and post logging estimates, confounding factors (such as the drought) are not accounted for, the conversion of Koala calls to densities is based on invalid assumptions and is misleading, most reporting of findings are based on areas which were only partially logged, some reporting is inconsistent, and contradictory findings from more robust studies in the region are ignored.

Rather than proving that logging has no impacts on Koala densities, the overall reduction in Koala calling frequency in logged areas shown by Law *et. al.* (2022), and the general lack of persistence of Koala hotspots in logged areas between samplings, supports the EPA (2016) concerns that many logged State Forests do not have stable Koala colonies and may be sink habitat where mortality exceeds reproduction. More logging will compound this problem, with impacts amplified by increasing droughts and heatwaves due to climate heating.

It is of particular concern that the study of Law *et. al.* (2022) was funded by the NSW Koala Strategy and overseen by the Natural Resources Commission (NRC). The NRC (2021) report "Koala response to harvesting in NSW north coast state forests" adopted the findings of Law *et. al.* (2022) uncritically. These findings are now being relied upon by the NSW Koala Strategy and the Koala Recovery Plan to claim that logging has no impact on Koalas and therefore there is no need to protect Koala habitat from logging.

Methodology

The maps provided in Figure 3 of Law *et. al.* (2022) showing "*Spatial variation in male koala density across each array before (2019) and after (2020) harvesting*" (see examples below) and "*Harvest area (coloured), harvest tracks and arrays (dots)*" were extracted and rectified in a GIS. The harvest tracks were used to digitise 2020 logging extent. The mapped "koala density" is more correctly taken to represent male calling frequency, and the location of "hot spots" is only considered to be approximate due to the recorders not discriminating calling distances or directions, meaning this mapping is not necessarily spatially accurate and "hot spots" inside the logging areas but close to exclusions may actually be within them. Law *et. al.* (2022) identify that calls could be anywhere within 0-300 m of recorders, though other factors such as wind strength and direction, and rain, likely affect detection distances.



Examples of Law *et. al.* (2022) maps of "*Spatial variation in male koala density across each array before (2019) and after (2020) harvesting*", with recording locations (black dots). The legends to the right of the maps are claimed to represent "males ha^{-1}" but should be more correctly interpreted as an indication of male calling frequency. Note that the "density" legends of each map have variable scales (and therefore so do the illustrations of mapped density).

For presentation herein the "Koala Realised Density" maps were overlaid with the digitised 2020 logging, and basic exclusions derived from CIFOA data available online. High Conservation Value (HCV) Oldgrowth was identified separately. The approximate areas assessed by Law *et. al.* (2022) were outlined for clarity.

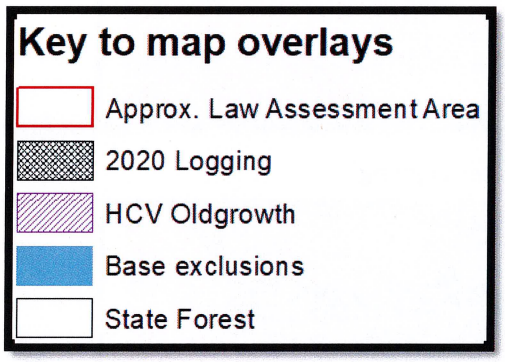
For reporting of this review's findings only those parts of the arrays identified as actually logged were considered. Law *et. al.*'s (2022) density classes were roughly divided into high (green) medium (fawn) and no/low (white and pale fawn). These were digitised within the logged areas. It is emphasised that these classes are only indicative as they were based on colours with no standard cutoff useable because of the coarse maps and the variable scales for each map. The maps do not differentiate from surrounding unassessed areas, grading into them (ie white areas progressively grade into the surrounding matrix, indicating medium use when there were no Koalas records there), and the distances applied around each recording site vary considerably. These limitations mean that the categorisation and data used in reporting herein is only an indicative quantification of what is visible. It is considered accurate enough to identify, but generally understate, broad trends.

Apparent correlations of high Koala call frequency sites with oldgrowth and rainforest are commented on, though generally Koala use of all growth stages will depend on the distribution of mature Koala feed trees within them. Oldgrowth forests will not constitute good Koala habitat if they don't contain any Koala feed trees.

The National Parks used as controls have been subject to earlier logging and are thus variously degraded. These were similarly digitised in a GIS, but only visually assessed to identify general associations with growth stages and changes from 2019 to 2020. There were significant variations between years, with some apparent associations with oldgrowth and rainforest. Patterns are confused by major changes in some map scaling. Overlays of oldgrowth (purple hatching) and rainforest (blue) are applied.

The three additional State Forests assessed once by Law *et. al.* (2022) similarly show fragmented patches of high Koala calling frequency, mostly in or near exclusions, with large areas of no/low occupancy. These are not considered further herein.

Review of data



Legend for map overlays, note that in "control sites" only oldgrowth and rainforest (blue) are depicted.

Lower Bucca State Forest

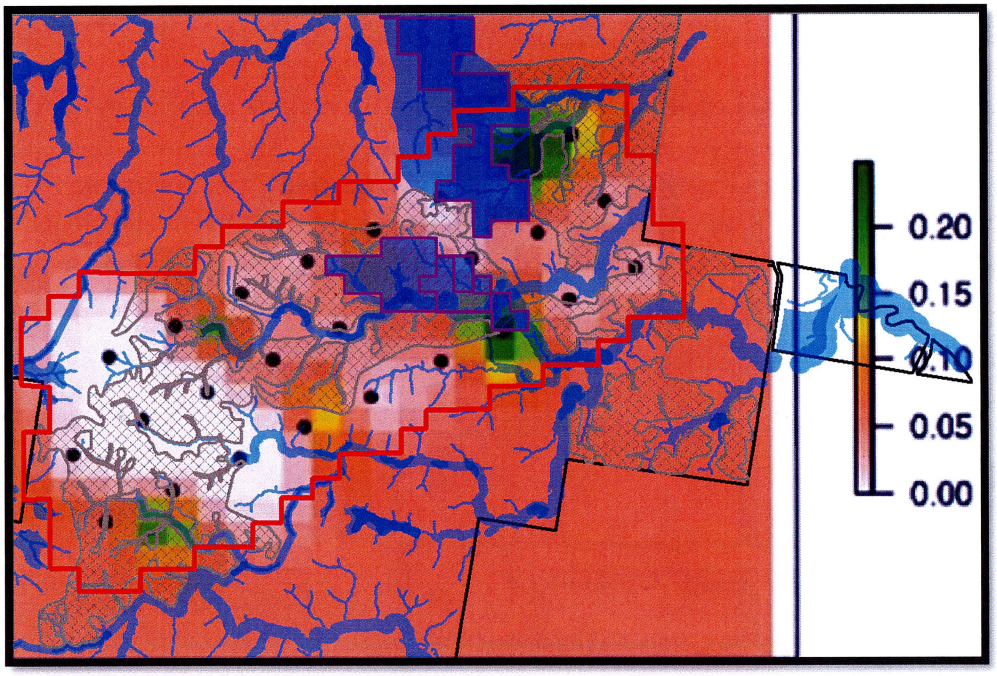
Across both recently logged and unlogged forest in Lower Bucca State Forest, Fig.1 in Law *et. al.* (2022) identifies there was a decrease in the "density" of calling male Koalas from around 0.047 per ha before logging down to around 0.039 per ha after logging, a 17% decline in the "density" of male Koalas. Fig 5 in Law *et. al.* (2022) shows there was a reduction across all exclusions, previously logged areas and recently logged areas.

Within the surveyed area actually logged in 2020, this assessment indicates logging resulted in:

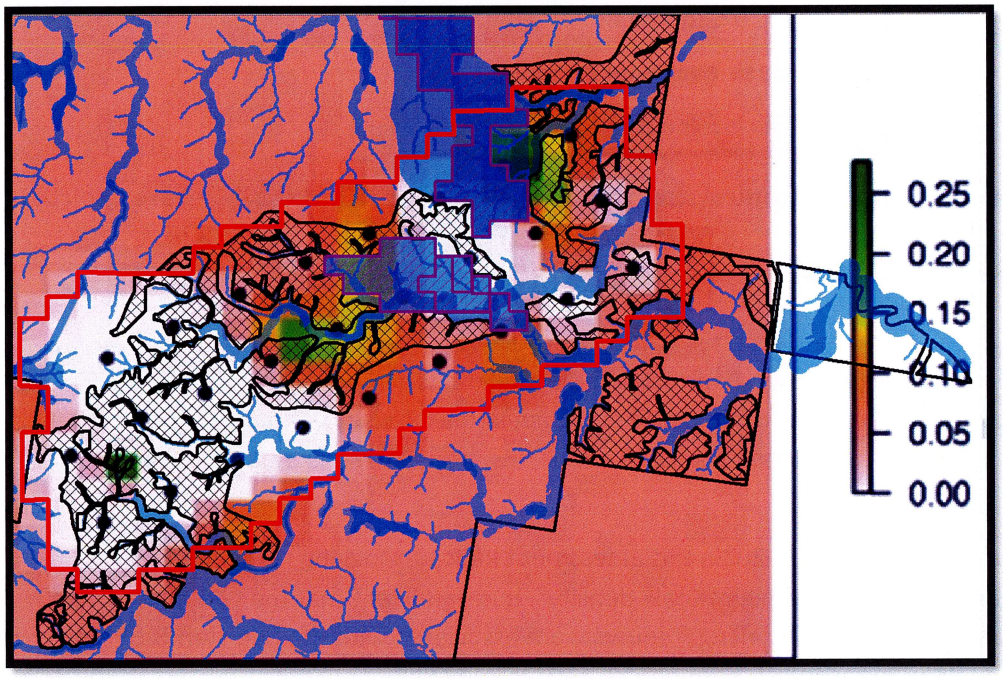
- 11% increase in areas identified as high "Koala density", it is significant that the two highest and most extensive areas of high Koala calling frequency are associated with the two stands of oldgrowth forest (and nearby riparian reserves), both before and after logging
- 40% reduction in areas identified as medium "Koala density"
- 99 % increase in areas identified as having no and very low "Koala density"

The maps below indicate that there are stable (across samplings) territories based around the oldgrowth and adjacent wide riparian exclusions, and a significant decline in Koala activity in logged forests to the south west and between the patches of oldgrowth. This area was last logged 2004-9, and the concern is that this relogging may threaten the long-term viability of the Koala hotspots.

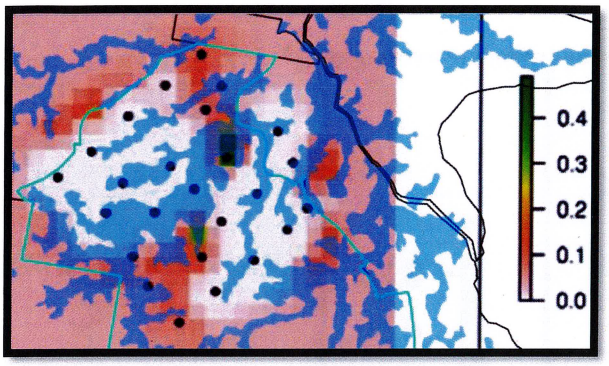
Lower Bucca State Forest 2019 Before Logging (the right hand scale is claimed to represent male Koala density, though is taken to actually represent relative male Koala calling frequency)

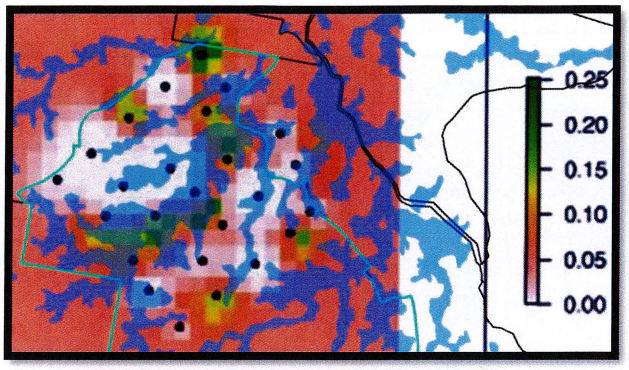


Lower Bucca State Forest 2020 After Logging



In the control site of Ulidarra National Park (below) there was a strong association with mapped rainforest (blue), which is likely related to eucalypt emergents. The 2 patches of high Koala calling frequency (hotspots) identified in 2019 (and the highest of the medium frequency) persisted into 2020, combined with a major increase in patches with high Koala calling frequency and reduction in areas with no/low calling frequencies. Patterns are confused by a major change in map scaling, though indicate a stable breeding colony.





Ulidarra National Park 2019 2020

Cowarra State forest

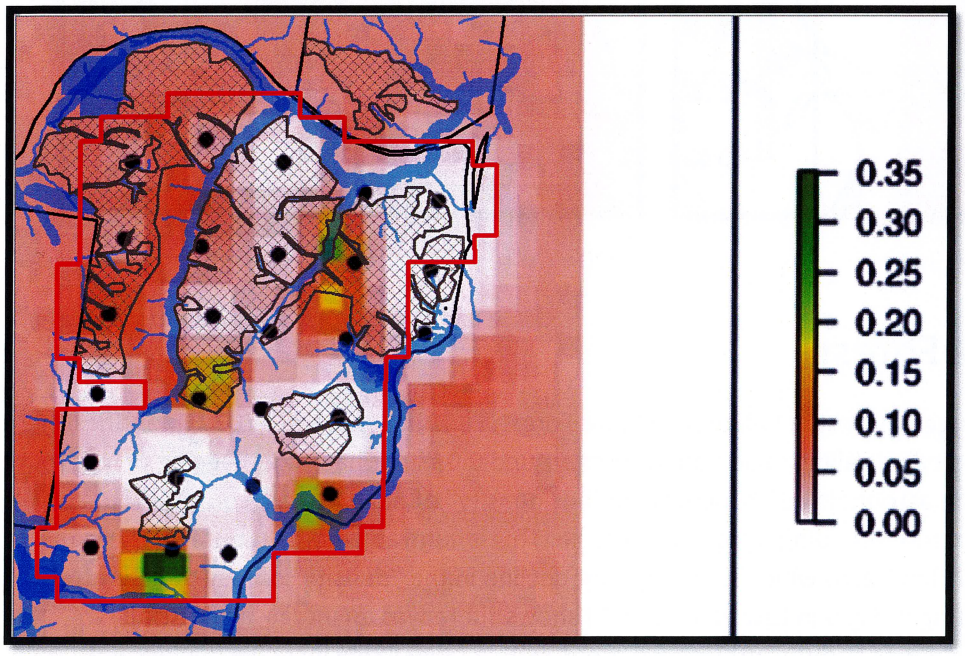
Across both recently logged and unlogged forest in Cowarra State Forest, Fig.1 in Law *et. al.* (2022) identify there was a decrease in the "density" of calling male Koalas from around 0.038 per ha before logging down to around 0.034 per ha after logging, a 11% decline in the "density" of male Koalas. Fig 5 in Law *et. al.* (2022) shows there was a decrease across all exclusions and previously logged areas, and a 27% increase in recently logged areas.

Within the surveyed area actually logged in 2020, this assessment indicates logging resulted in:

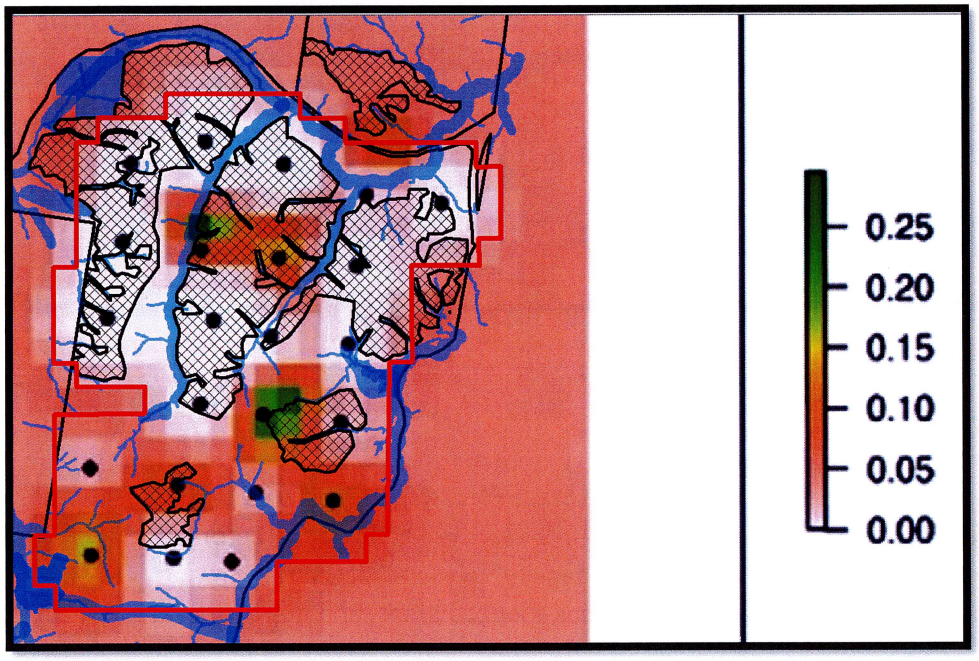
- 15% reduction in areas identified as high "Koala density", two highest areas now in or adjacent to unlogged areas
- 56% reduction in areas identified as medium "Koala density"
- 96% increase in areas identified as having no and very low "Koala density"

The maps below indicate a significant decline in Koala calling to the west and a shifting of all Koala calling hotspots. The apparent increases to the south, and the hotspot to the north west, may be primarily related to the adjacent unlogged areas. This area was last logged in 2006-2009, and now appears to be an unstable colony at risk of collapse.

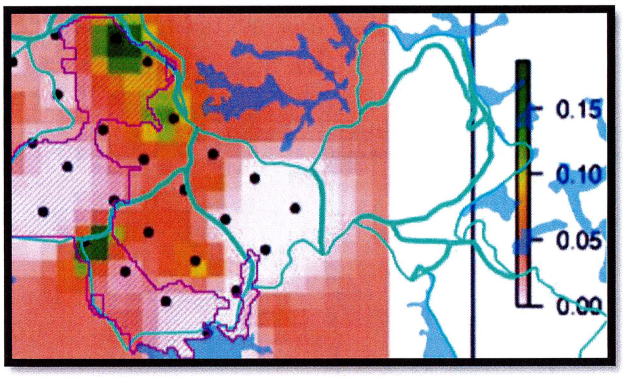
Cowarra State forest 2019 Before Logging (note: the area assessed was reduced after logging)



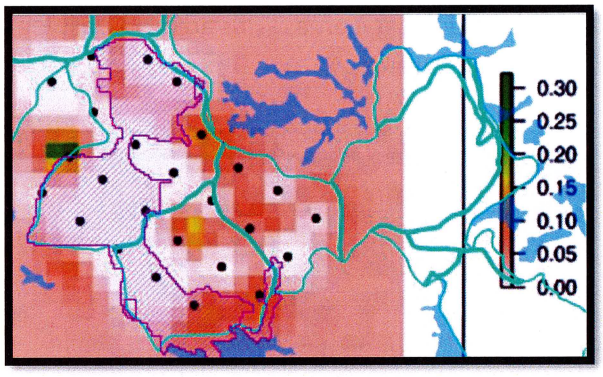
Cowarra State forest 2020 After Logging



In the control site of Bago Bluff National Park (below) there was a strong association with oldgrowth forest in 2019, including the two patches of highest Koala calling frequencies, and the other 2 hotspots in young and disturbed mature forest. In 2020 there was a major decline in patches of high Koala calling frequencies, with the strongest of the three small patches of highest Koala calling frequencies on the boundary of oldgrowth forest, and an increase in areas with no/low calling frequencies. Patterns are confused by a major change in map scaling, though show a concerning decline in koalas and an unstable population. NRC (2021) note "*it is thought that the decline in detection rate may be due to drought and its impact on browse quality, as the drought was especially severe at these two sites*".



Bago Bluff National Park 2019



2020

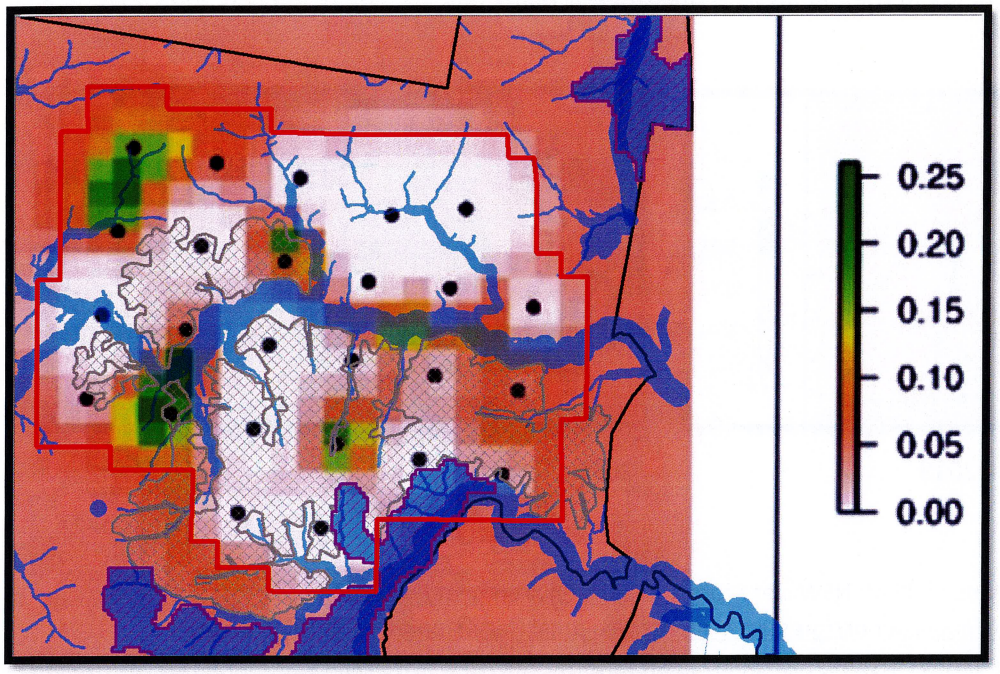
Kalateenee State Forest

Across both logged and unlogged forest in Kalateenee State Forest, Fig.1 in Law *et. al.* (2022) identifies there was an increase in the "density" of calling male Koalas from around 0.038 per ha before logging up to around 0.052 per ha after logging, an astounding 37% increase in the "density" of male Koalas, equivalent to an influx of an additional 5.6 mature breeding males over 400 ha. This is contradicted by reputedly the same data presented by NRC (2021) in Fig.10 which shows a slight decline in the "density" of male Koalas after logging – they both can't be right. Fig 5 in Law *et. al.* (2022) shows there was an increase across all exclusions, previously logged areas and recently logged areas, with a huge 486% increase in oldgrowth forest.

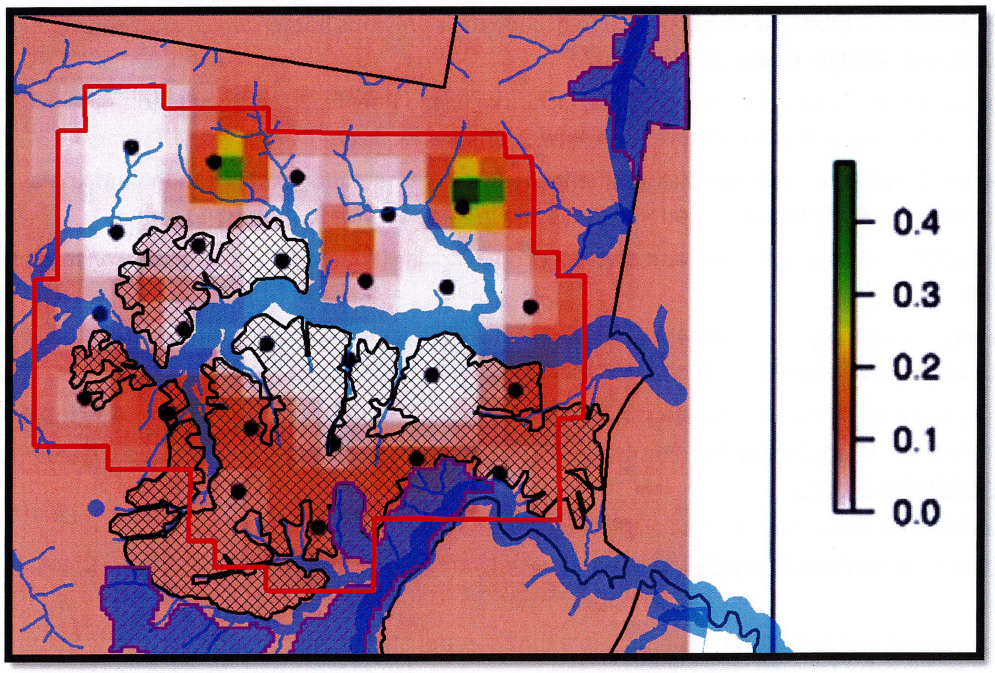
Within the surveyed area actually logged in 2020, this assessment indicates logging resulted in:

- 100% reduction in areas identified as high "Koala density" (including one outside the logging area), and seems to have resulted in more dispersal of koalas through lower use areas
- 71% increase in areas identified as medium "Koala density"
- 34% decrease in areas identified as having no and very low "Koala density"

Kalateenee State Forest 2019 Before Logging

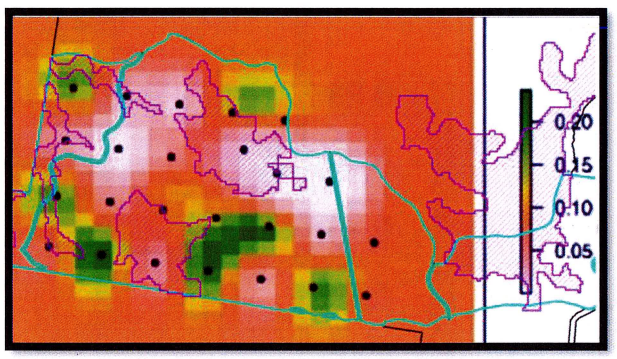


Kalateenee State Forest 2020 After Logging

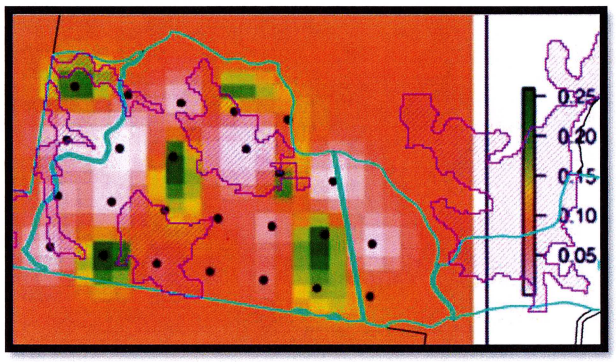


Comparisons of the above maps are confused by a major change in map scaling. They appear in indicate a loss of Koala hotspots in the logging area (and outside to the north west) and increased Koala activity to the south, including in and adjacent to the oldgrowth. Logging history data identifies that this area was last logged in 1989, and had thus had a long time for recovery before the recent logging, which appears to have now destabilised the recovering colony.

In the control site of Kumbertine National Park four of the six patches of high Koala calling frequency (hotspots) identified in 2019 persisted in 2020, indicating stable breeding territories. There was an overall reduction in the extent of Koala hotspots, and similar areas with no/low calling frequencies. The oldgrowth occurs along 2 creeks (narrow strips) which have Koala hotspots, and as two large stands on steep hills which are likely drier forests and, not unsurprisingly, are poorer Koala habitat. This represents a common situation in coastal areas where the steep hilly low productivity forests escaped logging. Law et.al's failure to account for variations in habitat quality in their analysis is one of their many failings. The results are indicative of a stable breeding colony.



Kumbertine National Park 2019



2020

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