NSW GOVERNMENT | Chief Scientist & Engineer

Advice on koala protection in the proposed new Private Native Forestry Codes of Practice

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NSW GOVERNMENT | Chief Scientist & Engineer

Gary Barnes
Secretary
Regional NSW
11 Farrer Place
Queanbeyan NSW 2620

Dear Gary

In June 2021, you requested advice on the proposed final Private Native Forestry Codes of Practice (PNF Codes). This advice was to consider amendments to the prescriptions for koalas and previous advice provided on basal area, and whether the elements as drafted ensure robust protections for koala in areas of high value habitat, and certainty and consistency for primary producers.

Given the limited information provided to the Office of the Chief Scientist and Engineer about current impacts and projected future impacts of PNF; information on efficacy of current and proposed prescriptions; uncertainty around the new Forest Operation Plans and Forest Stewardship Plan guidelines; and deficiencies in the coverage of maps over high value habitat that trigger prescriptions, this request to assess the adequacy of the proposed PNF Codes seems premature. There is more work to be done if the PNF Code is to ensure robust protection for koalas. Significant areas with the largest koala populations and having some of the largest and most fertile forests are also those sites that will have the biggest increase in allowed forestry intensity per hectare, and also have the majority of PNF Plans. The proposed PNF Codes as they stand do appear to provide certainty and consistency for primary producers, but it is not clear that this is the case for koalas.

The recommendations included in this report outline a set of actions that can be undertaken to improve the knowledge base, encourage forest heterogeneity, improve outcomes for Areas of Regional Koala Significance, ensuring ‘high value habitat’ is captured in prescriptions, tighten up some of the prescription triggers, and have an approach for risk management in PNF that promotes a balance between risks and mitigations.

Sincerely

[redacted]

Professor Hugh Durrant-Whyte
NSW Chief Scientist & Engineer

9/9/2021

Findings and Recommendations

Findings

- There is insufficient evidence available to demonstrate that the protections offered by the koala prescriptions in the proposed PNF Codes are sufficient to ensure "*robust protections for koalas*".
- There are advantages to forest health of undertaking forest practices such as thinning and single tree selection if undertaken in a way to achieve associated biodiversity and ecological outcomes, so there will be pathways forward where foresting can be undertaken in an efficient and secure way to benefit landholders and provide certainty and consistency for producers, as well as adequate protections for biodiversity including koalas.
- This Review has considered the impacts and risks of the proposed approach, their measurement; management and regulatory procedures that would mitigate the risks; whether these appear to be covered in the proposed PNF Codes; are the risks tolerable and what is the risk appetite? In examining from this angle, it allows an understanding of the *potential* implications for koalas, however we don't know the *actual* implications as there is limited data on how koalas respond in the short and long term to silviculture operations at different intensities and scales. This level of information is and will continue to improve.

Certainty and consistency

- The increase in timber that would be available by decreasing basal area limits will likely maintain (or increase) certainty and consistency for primary producers. The Review hasn't seen modelling on either the amount of timber that could be taken (deriving from increased intensity per hectare and possible increased participation of landholders), the capacity of the mills, or the impact on regeneration of new trees and biomass over time (30 to 70 years for commercial maturity) from the decreased basal area.
- Certainty for landholders and primary producers will come about through making processes for PNF Plan, FOP development and outcomes clear and transparent, as well as clarifying the roles and standards of land holders, forest managers, contractors, regulators and compliance authorities.
- Certainty for landholders and primary producers will be enhanced by maximising the likelihood that their PNF Plans, as approved, will be stable over their 15-year lifetime. However, this cannot be guaranteed due to stochastic events, and unfavourable climate conditions which may impact the forest. Further, not all landholders and/or primary producers have the same goals, as 'primary producer' includes those growing, felling or transporting trees (or parts of) and therefore includes a wide range of activities that would have associated uncertainties.
- Science and risk management are typically directed toward reducing uncertainty, which is another way of thinking about increasing certainty. Reducing uncertainty can come about through the transparent and rigorous use of data and information to deliver a common understanding of conditions and measures of the level of uncertainty. Once all parties can share data and agree on information, facts and conditions, then that can be the basis for negotiation and argument about desired outcomes and the best way to get there.
- Consistency can be promoted by developing processes, standards and protocols that are applicable for all applicants, where the expectations are understood, and there are tools and expert advice available for the landholder to meet the requirements of the PNF Codes and the principles of Ecologically Sustainable Forest Management (ESFM). Not all landholders have the same expertise, experience or motivations, so the more tools, guidance, information and data available to plan and manage risks up front, the more consistent will be the outcomes.
- To achieve this, consistency is needed by NSW agencies and landholders across:

  - **Agreement on facts** – Openness, transparency and aligned methods in measuring, modelling, reporting and data collection and handling so disagreement about the factual basis of decisions can be avoided. Agencies should not be arguing over the facts, but rather using the facts as a basis to negotiate policies and priorities.
  - **Agreement on metrics** – Transparency and common understanding between both portfolio agencies about what data, modelling, standards and thresholds will need to be considered and met for concurrence to be provided. And documenting for future generations, whether thresholds are based on science or other considerations. This includes a common understanding and agreed approaches to incorporate climate change into planning and management.

- Key consideration for LLS in working with landholders on codes is that not all locations and forests are the same, have the same structure or characteristics or vulnerabilities, or provide the same functions in the landscape. And not all landholders seek to achieve the same outcomes – some seek to maximise productivity and economic output, some seek to maximise biodiversity and ecological health, and some seek to maximise aesthetic beauty from land management efforts. To maximise the chances of consistently high-quality silviculture practice that delivers ESFM as well as other outcomes, appropriate training, decision making guidelines, regulatory and compliance measures, and incentives for good practice can be used.

Increased silviculture intensity and scale

- The intensity of silvicultural practice will increase for much of the forested area covered in the proposed PNF codes compared with that allowable in the current PNF Code. The regions of the greatest intensity-increase also being the area of the greatest population of koalas in NSW being the North Coast region of NSW, where there is alignment between the following: 1) location of with the biggest koala population and high number of Areas of Regional Koala Significance (ARKS); 2) location of most PNF approvals; 3) location of lowest basal area limit (proposed 10 m^2/ha); 4) location of dense/tall forests.
- The area covered by koala prescription triggers has been increased from the current PNF Codes to the proposed PNF Codes through the use of mapping, however this mapping covers only a fraction of the important habitat for koalas.
- The strength of prescriptions (10 primary koala food trees and 5 secondary koala food trees) or forest habitat set asides (rainforest, 70% riparian habitat, old growth forests, hollow bearing trees etc) are largely unchanged from the current PNF Codes, even though the intensity of silviculture allowable is increased particularly in important koala areas such as the ARKS which contain much habitat that is currently captured by the 16 or 18 m^2/ha basal area limit.
- When prescriptions are triggered, their mitigative impact is minor relative to the tree removal that would be allowable in koala habitat. Koala prescriptions trigger protection of 10 primary koala feed trees and 5 secondary feed trees of 30 cm (or more) DBH (equivalent to about 1.5 m^2/ha if 30cm), but this need not be additional to the trees kept as habitat or retained trees under the PNF Code.
- Koala habitat density in some locations is high 20s to high 30s m^2/ha prior to harvesting and would be reduced to an average minimum of 10 m^2/ha under the proposed PNF Code for Northern NSW if silviculture is undertaken to the limit allowed.

Forestry and koalas

- The work of Law et al indicates that low-level timber extraction and koala persistence need not be mutually exclusive, but this is dependent on how the forest developed in the years after harvest. Will the forestry be undertaken sustainably to maintain the features important to koalas and other components of the ecosystem, or will the long-term loss of values, tree cover and tree diversity result? The proposed PNF Codes have almost nothing to say about how this will be monitored and ensured, as regeneration requirements focus on number of seedlings and

saplings but not the level of diversity and it is not apparent that this process lasts beyond 24 months – will the forest suitability score be maintained?

- Work by Law *et al* on koala occupancy post forestry has shown that koalas either remain or come back to areas that have been forested if there is healthy habitat remaining. Much of this work of Law et al (pre-publication) has occurred in the context of state forests where silviculture is undertaken in a mosaic arrangement leading to a heterogeneity of forest structure and age.
- Important questions and decisions at the planning and implementation stage are required, to avoid negative or unintended impacts from forestry for koalas. What will be the plot's ability to support koalas immediately post-harvest versus the longer term? What species will be retained? Will their regeneration be favoured or not by altered light conditions post-harvest? Will there be invasion by species such as lantana and associated Bell Miner Associated Dieback (BMAD) with the opening up of North Coast tree canopies under increased silviculture. Lantana incursions have implications for koala movement through the landscape, for tree regeneration and for dieback of canopy species including important koala feed trees.

Risk management – mitigations

- Other comparable silviculture settings such as under IFOAs in state forests include a range of pre-harvest assessments that are required and undertaken by experts before harvesting. IFOA has a requirement to ensure sustainability over decades to 100 years; systemic approaches to monitoring plots to understand conditions of forest; modelling to plan out locations and sequence of harvesting; systematic approaches to early thinning, second thinning, Single Tree Selection (STS-release and STS-regen) sawlog phase; prescriptions about the locations of coups and mosaic harvesting etc. Nothing resembling this appears to be required for PNF, yet these PNF forests are just as important as those under IFOAs.
- The proposed increased allowable take (lowered minimum average basal area limit) proposed in the proposed PNF Codes is not coupled with proportionate enhancement of risk management or ecosystem protection efforts: retained or set aside habitat; regulatory oversight in the planning phase; or information gathering and forestry outcomes monitoring. Improvements in compliance will be enabled with the sharing of PNF Plan contact information with the EPA.
- Some of the triggers for the proposed prescriptions are better for koalas (foresters look for koalas in trees before cutting them down) but some are worse for koalas (scats under a tree no longer trigger the koala habitat prescription of retaining 10 Primary and 5 Secondary koala feed trees).
- No current single koala survey technique is able to identify all koalas that use an area, and each technique has applicability depending on the question that is being investigated, with trade-offs between scale and accuracy. For example, although faecal samples have been shown to degrade quickly in Northern NSW, scat surveys (either by ecologists and/or scat-detection dogs) still represent a good survey method for presence/absence that compliments other survey techniques. Other techniques include acoustic surveys, drone detection etc.
- Habitat suitability maps developed by DPI and EES are used in the proposed PNF Codes as a mechanism to trigger the koala prescriptions only in areas of categorised as highly suitable habitat (DPI) equivalent to very highly suitable (EES). Due to the trigger levels chosen (0.6 DPI and 0.8 EES), habitat categorised as high and moderate suitability (EES) is not captured by these maps. It is noted by the Review that koalas utilise a range of habitat types. In the North Coast habitat identified by the DPI and EES maps as moderately suitable habitat represents ~ 45-60% of koala records. Further, low densities or low survey rate could influence the categories. The two mapping techniques don't completely align in some areas.
- The maps that trigger prescriptions are impacted by inconsistency in survey effort, which is understood to be more likely to be lower on private land.

- Both maps provide an important tool for decision makers and landowners to help identify possible areas of koala habitat. They can be used to guide survey effort or in the case of the PNF Codes guide where precautions should be undertaken in relation to koalas. Neither map is perfect, each map has strengths and weaknesses. Both maps need to be updated regularly to ensure that they provide the best and most up to date information, including post fire, post-harvesting where suitability score has changed. Consideration could also be made to whether the maps could be combined to provide a single open mapping source for koalas in NSW.
- A landholder can dispute a map and seek a reassessment undertaken by an expert. There appears to be inconsistencies with the metrics required to assess koala habitat in these cases, with the metrics required to categorise koala trees in PNF planning – in particular the number of scats under trees to categorise it as a koala tree is 20 when remapping, and between 1 and 10 for the forestry plan itself.
- The tree species list being proposed for PNF has been developed to assist authorities to identify koala habitat for land categorisation. Using it to choose trees to remove or keep on a site-by-site basis is not in line with its purpose. Instead, the choice of trees to keep for the purpose of koala protection should be informed by an understanding of the most favourable koala trees in the area (for example, this is in part relative to the amount and digestibility of protein in the leaf, with further information available from the Natural Resource Commission from research undertaken under the NSW Koala Strategy). Further, there needs to be the consideration of the composition of retained trees, as feed tree retention also needs to be in conjunction with other retained trees with different habitat values (e.g., species and size of trees used for shelter).
- In some locations more intense forestry operations could be required. This outcome could still be achieved within the constraint of the minimum average stand basal area approach, where a percentage of stands can be cut to a basal area for regeneration (e.g., 25% stands below 7m^2/ha). EPA guidelines for current PNF require 50% of measurement sites for basal area to be above the average minimum basal area retained, however this has been removed for the proposed PNF Codes. The removal of this constraint can lead to a majority of the silviculture area being well below the average basal area limit.
- The Review understands that the Forest Stewardship Plan (FSP) is designed to deliver an outcomes-based approach, but this is not articulated within the documents provided. Further, there is a lack of certainty and potentially lack of rigour in how prescriptions would be triggered due to the Forest Operation Plan (FOP) and FSP development process:
    - there is no requirement for expert input (either silvicultural or environmental expertise) into the development of the FOP (noting that the FSP is developed by either LLS or an accredited expert in conjunction with the landholder),
    - lack of use of forestry growth plots, modelling, expertise in making decisions about where, when and how much to harvest on site and across the landscape
    - LLS doesn't approve FOPs (the onus is on the landholder to ensure that their FOP reflects the PNF Plan and complies with the PNF Code), nor see the FOP prior to or after forestry operations (unless requested)
    - FSPs and FOPs can be amended by the landholder, without notification, ensuring that they are still within the PNF footprint and meet Code prescriptions
    - PNF Plans, FOPs and FSPs do not go on public display, unlike development approvals.
- The Review was informed by stakeholders that there are legal questions about the FSP pathway that are outside the scope of this work and the Review has not made further comment.
- The commitment to a systematic approach for LLS informing EPA of where and when FOPs have been developed and forestry will and has been undertaken, is welcome.

- The wider landscape and function of koala habitat (for example, whether it is an important corridor linking larger habitat patches) is not considered in planning for PNF
- A monitoring program to measure the outcome of forestry would assist in measuring the impact on habitat, biodiversity and longer-term forest health.
- Current monitoring of forestry and forest condition appears to be not undertaken except in a narrow set of cases (koala occupancy), and not shared between agencies and the public. The Review notes that the NRC is leading work around the Forest Monitoring Improvement Program which aims to collect and disseminate cross-tenure data, but also notes that this is reliant on the data provided to NRC by other agencies such as LLS.

Future contexts

- Future issues of climate change, drought, bushfires and habitat loss will mean that remaining land and habitat will become more and more important.
- The new Koala Strategy being developed for NSW will utilise ARKS to focus population expansion efforts, these regions will be even more important to protect in terms of the habitat and carrying capacity, to achieve the NSW goal of doubling koala numbers by 2050. Much of the land identified as an ARKS is located within areas of Northern NSW where forestry activity is subject to the largest intensity increase under the plans.

Recommendations

Recommendation 1: LLS, EPA, EES and DPI work together, with an expert impartial convenor and group of experts to derive common agreement on fundamental information:

A. **Agreement on facts** – Openness, transparency and aligned methods in measuring, modelling, mapping, reporting and data collection and handling so disagreement about the factual basis of decisions can be avoided.

B. **Agreement on metrics** – Transparency and common understanding between both portfolio agencies about what data, modelling, standards and thresholds may be required for Ministers to be able to provide concurrence on PNF matters into the future. The relative prioritisation and other information should also be considered by portfolios as relevant, but a shared understanding and data collection approach will assist in decision making. This includes a common understanding and agreed approaches to incorporate climate change considerations into planning and management, which also will improve into the future.

Recommendation 2: To assist in delivering on Recommendation 1A, DPI Forestry Science, LLS, EPA and EES should collaborate on koala habitat maps to ensure consistency in mapping products that are available for regulators and landholders. DPI Forestry Science, LLS, EPA and EES should work together to find solutions for uncertainty and inconsistencies, and the consequences when it comes to developing maps.

Recommendation 3: Median and mean values for basal area are both important and can help avoid offset logging-like outcomes, where a small area of forest is kept at a very high density, and the remainder is cut well below the average minimum residual basal area level presents a risk for habitat. A level such as 50% of land should remain at a basal area above the average minimum basal area level.

Recommendation 4: There are no apparent cumulative or scale limits to the extent of private property that can be placed under PNF plans in a region, other than the onsite restrictions around the type of forest eligible for PNF. Once under a PNF Plan and FOP/FSP, there is also freedom for the landholder to harvest at any time during the 15 years approval. This means there is little opportunity to encourage approaches such as mosaic harvests, to try to maximise the availability of undisrupted habitat for native species.

A ceiling level of habitat that can be forested from each ARKS should be agreed to mitigate the possibility that a region could encounter wide-spread and contiguous, coincident, high-impact forestry.

PNF Plans, FOPs and FSPs should be informed by broader scale considerations and mapping including accounting for habitat beyond the landowner's property, including koala habitat (moderate, high and very high suitability), location of ARKS, presence of neighbouring cleared land on farms, PNF approvals on neighbouring land and neighbouring forests, and cumulative impacts.

The outcomes of PNF should be monitored, and the relevant maps kept up to date.

Recommendation 5: The process to designate land as being high value koala habitat through current mapping approach is insufficient and risks leaving high value koala habitat out of the prescriptions.

The following attributes should also be built into (or alongside) the current habitat suitability mapping approach:

- Identify flaws in mapping and address these – e.g., disagreement between EES and DPI maps in some cases for very high suitability.
- Include both high and moderate suitability koala habitat (very high suitability by EES metric is already mapped)
- Include important koala corridors or connectivity structures
- Map and include areas of drought and bushfire refugia for koalas (work being undertaken by EES)
- ARKS should include koala prescriptions as a matter of course
- Use Koala Likelihood mapping to assist interpretation of suitability maps, where the threshold suitability scores are not met and where there is no or limited or low confidence in koala data.

Recommendation 6: Scats are used to identify koala trees in the proposed PNF Codes; however, three amendments are required:

- the presence of koala scats should again trigger koala tree retention prescriptions
- the number of scats in Southern Coastal region that trigger a prescription should be one rather than 10
- in cases where the landholder disputes the koala habitat map, and an expert is commissioned to resurvey, the number of scats under the RGbSAT survey method should match trigger values for scat numbers for that PNF Code – for instance, the number of scats that trigger prescription in Southern Tablelands is one, whilst the RGbSAT survey method requires 20 scats to identify a koala tree.

Recommendation 7: At least two surveys methods should be employed for any form of monitoring and/or surveying at a site. The PNF Code should require two methods and to use the guidance in the Koala Monitoring Framework established by NSW Government.

Recommendation 8: Forest management activity should not be done in a way that reduces the habitat suitability and value for koalas in the landscape. An approach to deliver on this should be agreed, but it could include enhancing the proposed PNF Code clause 3.4 and Appendix C (Regeneration) so that not only should 65% (STS) or 55% (AGS) of plots be regenerating at 24 months, but ongoing surveys and tube-stock planting should result in the maintenance of the relative abundance of tree species in harvested areas by 7 years (one koala generation) after the harvesting the habitat should have the same (or higher) koala suitability score as before the forestry operation.

Recommendation 9: There is not sufficient evidence to demonstrate that the koala prescriptions as set out in the proposed PNF Codes will provide suitable protection for koalas given the increased intensity of harvesting allowed. Having an approach that uses an average stand basal

area assists in providing flexibility to forest managers to implement silvicultural approaches to improve outcomes at different locations, and provides consistency as required. The stand basal area average minimum values should be increased until proportionate protections and procedures for koalas are included, and their beneficial effect can be demonstrated, in particular in the Areas of Regional Koala Significance (ARKS).

Recommendation 10: A standard approach for policy setting should be incorporated for PNF and other forestry activities into the future, that if forestry limits and restrictions are being relaxed (such as increased harvest volumes or lower basal areas limits), this should be accompanied by increased protections or risk mitigations such as a combination of regulatory protections or planning rigour or increased environmental set asides/offsets or increased pre- and post-harvest monitoring requirements.

Recommendation 11: The information sharing protocol that is being developed between LLS and EPA should include (but is not limited to):

- Notification prior to commencement and completion of forestry operations.
- PNF Plan and the approval information (such as approval conditions)
- FOP and/or FSP and associated information (dates of activity, identity of contractor etc.) including any amendments as part of the pre-notification and the post-notification process
- Procedures to ensure adequacy of maps prior to PNF Plan development and prior to harvest, and to update maps and information following harvesting, including where the koala suitability level has been reduced
- Any monitoring activities and data, including data on forest condition, health and structure, and enable viewing of data in the broader regional context – including data for early identification and intervention actions.
- Data agreed on under recommendation 1A and 1B.

Recommendation 12: LLS and EPA guidance, regulatory and compliance roles for PNF should be enhanced, whether or not the intensity of harvesting increases under the proposed PNF Codes. Enhancing the role for ecologist and experts should occur. The proposed PNF Codes provide general limits to harvesting however to get a more outcomes-based approach strong guidance and input from LLS (informed by ecological experts) should be provided at the planning stage.

Recommendation 13: In moving forward on Recommendation 1B, a standardised Monitoring, Evaluation and Reporting framework should be established to understand the impact of forestry practice and to inform future efforts and impacts of climate change. This framework should link forest outcomes and trends with interventions and decision making across the region.

Contents

1 Introduction

In June 2021, the NSW Chief Scientist & Engineer (CSE) was requested by the Secretary, Regional NSW to provide advice on the proposed additional koala protections outlined in Appendix A of the proposed Private Native Forestry Codes of Practice (PNF Codes).

The advice is to consider if the proposed additional koala prescriptions provide "*robust protections for koalas in areas of high value koala habitat*" and "*certainty and consistency for primary producers*" as agreed by the Ministers in March 2021.

At the same time, it was requested that the advice consider the May 2020 CSE Review of the report by Professor Cris Brack (Australian National University) 'Native Forest Harvesting and Thinning on Private Managed Lands in NSW for Multiple Purposes' which informed the basal area for Single Tree Selection in the proposed PNF Codes. The CSE review included the peer review by Professor Jerry Vanclay (Southern Cross University).

The letters of request are at Appendix 1 and the proposed koala protections are at Appendix 2.

1.1 Process for the report

The Office of the Chief Scientist & Engineer (OCSE, the Review) provided a draft report to the Department of Planning, Industry and Environment (DPIE) and Regional NSW on 2 July 2021 seeking factual comments. Representatives from Local Land Services (LLS), DPIE (Environment, Energy and Science (EES) and the Environment Protection Authority (EPA)) met with the Review to discuss the comments.

The Review met with the EPA, EES, LLS and DPI Forest Science. The Review requested and received further information and mapping from LLS, and EPA.

Discussion and feedback on draft report content was provided by experts in the areas of koala ecology and silviculture, this included Associate Professor Mathew Crowther (the University of Sydney), Dr Ben Moore (Western Sydney University), Dr Martin Predavec (retired: former Principal Scientist in DPIE) and Professor Jerry Vanclay (Southern Cross University).

1.2 Context

There are several reports, policies and strategies that sit in the background to PNF and koala protection in NSW. These include, but are not limited to the following:

- The NSW Government committed to all 43 recommendations of the 2014 Independent Biodiversity Legislation Review Panel Report, including Recommendation 7 which related to a review of the *"regulatory arrangements for timber harvesting on private land as part of a separate process that:*
    - *a) does not regulate the harvesting of native timber on private land as a form of land use change*
    - *b) considers options for regulating sustainable forestry operations based on their scale and intensity rather than tenure, including options for permitting low-intensity operations on private land without the need for approval and a focus on outcomes rather than process*
    - *c) considers a range of options for improving the environmental performance of haulage and harvest contractors operating on private and public land, including licensing and minimum standards."*[1]
- In 2016, the NSW Government released the NSW Forestry Industry Roadmap. This set out guiding principles for the forestry industry including:

[1] Independent Biodiversity Legislation Review Panel (2014) A review of biodiversity legislation in NSW. Final Report.

- balancing long-term and reliable timber supply with the maintenance of environmental values
- management of planted and native forestry in line with the principles of Ecologically Sustainable Forest Management
- data supporting forest policy decisions should be timely, reliable and transparent
- regulation of the forestry industry should be efficient, effective, transparent and outcomes focused.

It was noted that the industry should be *"Operating within a fair and consistent framework, addressing the Independent Biodiversity Review Panel recommendations to no longer recognise private native forestry as a form of land clearing and consider regulating sustainable forestry operations based of their scale and intensity rather than tenure."*[2]

- In 2016, the NSW Chief Scientist & Engineer released the *Independent Review into the Decline of Koala Populations in Key Areas of NSW*.[3] This report described current status of koala populations in NSW and threats and provided a number of recommendations, including the development of a whole of government strategy.
- The NSW Koala Strategy was released in May 2018.[4] The objective of the Strategy is to stabilise and then increase koala numbers over the longer-term, ensuring genetically diverse and viable populations across NSW. The Strategy includes several actions to be undertaken over three years under four pillars: koala habitat conservation, conservation through community action, safety and health of koala populations and building our knowledge.
- The November 2018 Regional Forestry Agreement was varied between the NSW and Commonwealth Governments for North East Region of NSW. The RFAs include obligations for forestry operations on both private and public lands.
- In November 2018, the NSW Government commenced a review of the PNF Codes of Practice. The terms of reference for the review included the requirement that the PNF Codes be *"streamlined, clear and easier to use and enforce, support social, environmental and economic sustainability in line with ecological sustainable forest management".*[5] The NSW Government released draft PNF Codes for public consultation in March 2020 (for 8 weeks, ending 19 May 2020) as part of this process.
- In May 2020, the Office of the Chief Scientist and Engineer (OCSE) facilitated a peer review of the report '*Native Forest Harvesting and Thinning on Private Managed Lands in New South Wales for Multiple Purposes*' by Dr Cris Brack (Fenner School of Environment and Society, Australian National University).

  The report by Dr Brack examined the use of minimum basal area threshold values of 10m^2/ha for Northern NSW and 12m^2/ha for Southern NSW to reduce compliance risks and improve implementation for landholders. The report deals primarily with deliberate reduction in the density of trees as landholders seek to generate wood-based products; renew or regenerate the forests; or provide for associated improvements in productivity or other services.

  OCSE engaged Professor Jerry Vanclay (Sustainable Forestry, Southern Cross University) to undertake a peer review of Dr Brack's report.

  Key points from Professor Vanclay's review included:

[2] NSW Government (2016) NSW Forestry Industry Roadmap
[3] CSE (2016) Report of the Independent Review into the Decline of Koala Populations in Key Areas of NSW
[4] NSW Government (2018) NSW Koala Strategy
[5] NSW Government (2018) Private Native Forestry Review Terms of Reference

- Prof. Vanclay concurred with Dr Brack that '*Brack's conclusion that 10 m^2/ha and 12 m^2/ha basal area are workable limits, if basal area limits are instituted in place of other alternatives – such as incentives – for regulating timber harvests*'[6].
- Prof. Vanclay and Prof. Brack both recognised the importance of stand specific management:
  - Dr Brack states that "*small-scale variation in management in response to small scale changes in site quality or history are a good part of stand-specific silviculture and should be promoted*"
  - Prof. Vanclay states that he would "*prefer that any harvesting addressed the biodiversity, habitat and environmental services of each specific stand, rather than advocating for some theoretical size distribution*"
  - Dr Brack also indicates that *'there are situations when different levels of density reduction conflict with different management objectives, and so, it is important to consider the primary management objectives when determining desired post-harvest density*"
- 10 m^2/ha basal area across the board would have less complexity in terms of compliance compared with different basal areas for different plant communities and tree heights
- Basal area of 10m^2/ha can also promote regeneration of new trees where regeneration is required for shade intolerant species.
- However, in his general remarks on forest outcomes, Professor Vanclay comments on the limits of basal area-based planning and suggests alternate, more outcomes-based approaches may be preferable, provided that clear outcomes can be demonstrated in relation to plants, wildlife or environmental services.
- *"Forward-looking may lead to a realization that simply monitoring basal area is neither necessary nor sufficient to provide the habitat or services desired. This distinction is important, because a major limitation of using basal area to infer forest condition is that basal area reflects the 'crowdedness' of a forest, but not the health or the potential of a forest"*
- "*This evidence from the Pacific North West*[7] *offers a salutary warning about generic indicators applied as blanket rules, and a reminder that it is preferable to monitor desired outcomes rather than rely on generic proxies*."

- In June 2020, a Legislative Council inquiry into koala populations and habitat in New South Wales[8] report was released.:
  - Found that "*given the scale of loss to koala populations across New South Wales as a result of the 2019-2020 bushfires and without urgent government intervention to protect habitat and address all other threats, the koala will become extinct in New South Wales before 2050*".
  - The committee recognised that *"there are high numbers of koalas located on private land and private native forestry is a significant threat to them."*
  - Recommended that the NSW Government:
    - *"in the Native Forestry Review:*

[6] OCSE (2020) *Peer review of the report 'Native Forest Harvesting and Thinning on Private Managed Lands in New South Wales for Multiple Purposes' by Dr Cris Brack*
[7] See Section 3.4.2.1 for further commentary
[8] NSW Legislative Council, Portfolio Committee No. 7 – Planning and Environment (2020) Koala populations and habitat in New South Wales, Report 3

- *require consideration to be given to whether private native forestry plans are consistent with the objects of the Private Native Forestry Codes of Practice before such plans are approved; and*
- *require that the objects of Private Native Forestry Codes of Practice be amended to refer to the protection of biodiversity, water quality and soil quality."* (Recommendation 30)

This was supported in principle by the NSW Government.

- *"assess the interaction between legacy Private Native Forestry plans and koala plans of management to ensure core koala habitat is protected."* (Recommendation 31)

  This was supported in principle by the NSW Government, noting that as part of the PNF review how to balance koala habitat protection and the sustainable development of PNF in NSW would be considered.[9]
- *"provide additional funding to the NSW Environment Protection Authority to expand its compliance capabilities in the area of private native forestry" (Recommendation 32)*

  This was noted by the NSW Government stating that since December 2019, the EPA "*has been implementing a realignment of it structure along functional themes. This has allowed the EPA to increase regulatory presence on the group at all stages of logging operations*".[10]

- In July 2020, the Minister for Energy and Environment announced the goal of doubling the number of koalas in NSW by 2050.[11]
- On 8 March 2021, it was announced that State Environment Planning Policy (Koala Habitat Protection) 2019 (Koala SEPP 2019) would be remade across NSW as Koala SEPP 2021. This process included decoupling Koala SEPP 2021 from Private Native Forestry (PNF) Codes and Local Land Service Services (LLS) Codes and revising them to "*ensure robust protections for koalas in areas of high value koala habitat and certainty and consistency for primary producers*".[12]

  Koala SEPP 2021 commenced on 17 March, largely reinstating Koala SEPP 2019, and applies to all zones in 8 Sydney metropolitan councils as well as the Central Coast LGA. Koala SEPP 2020, which maintains provisions from SEPP 44, applies to RU1, RU2 and RU3 zones outside of the 9 LGAs where SEPP 2021 applies to all land.

1.3 Current policy settings and proposed changes

Koalas in NSW are managed under a range of legislation, regulations and policies depending on the type of activity being undertaken or the land type.

In NSW koalas are listed as vulnerable under the *Biodiversity Conservation Act (2016)* thus requiring them to be considered under the *NSW Environmental Planning and Assessment Act (1979)* (EP&A Act) when preparing environmental planning instruments and when undertaking development assessments. The EP&A Act is the legislative tool that sets out how planning occurs in NSW, including environmental planning instruments such as State Environmental Planning Policies (SEPPs).

1.3.1 State Environment Planning Policy for koalas

The Koala SEPP has two primary aims: to assist in the preparation of Comprehensive Koala Plans of Management (CKPoMs) and to standardize the process for preparing, assessing, and

[9] NSW Government (2020) NSW Government Response. Inquiry into koala populations and habitat in New South Wales
[10] NSW Government (2020) NSW Government Response. Inquiry into koala populations and habitat in New South Wales
[11] Hannam, P (2020, July 26) Matt Kean aims to double koala population by 2050, Sydney Morning Herald
[12] Media Release (8 March 2021) NSW Government delivers Koala SEPP 2021

implementing development applications on private lands for applicants and consenting authorities (i.e., councils, where they are the determining authority).

In 1995, State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44) was introduced. Then in 2019, SEPP 44 was replaced by Koala SEPP 2019. This change included a broader list of koala habitat trees.

In November 2020, Koala SEPP 2019 was replaced by koala SEPP 2020 (which largely reinstated SEPP 44) and was repealed. Then in March 2021, Koala SEPP 2021 commenced (this largely reinstates the policy framework of koala SEPP 2019). This SEPP currently applies across all zones in the 8 Sydney Metropolitan Councils and the Central Coast and to zones not considered Primary Production (RU1), Rural Landscape (RU2) and Forestry (RU3). In the areas RU1, RU2 and RU3 the SEPP 2020 continues to apply until new land management and PNF codes are developed. When those codes are developed SEPP 2020 will be repealed, SEPP 2021 will apply across the state. Further, Development Consent requirements for PNF will be removed and koala protections will be managed through the PNF Codes.

1.3.2 Regional Forest Agreements

Regional Forestry Agreements (RFAs) are bilateral agreements between the Australian Government and the NSW, Victorian, Tasmanian and Western Australian governments to provide for the "*sustainable management and conservation of Australia's native forests*".[13] They are given statutory effect under the *Commonwealth Regional Forest Agreements Act 2002* (RFA Act).

The RFAs "*seek to balance competing economic, social and environmental demands on forests by setting obligations and commitments for forest management that deliver:*

- *certainty of resource access and supply to industry—building investment confidence*
- *ecologically sustainable forest management—ensuring forests are appropriately managed and regenerated*
- *an expanded and permanent forest conservation estate—to provide for the protection of Australia's unique forest biodiversity."*[14]

The basis for the RFAs is the goals and objectives of the National Forest Policy Statement, which sets out a shared vision for managing Australia's forests and achieving ecologically sustainable forest management. Comprehensive Regional Assessments (CAR) were undertaken to determine the values and uses of the forests in each RFA region[15], examining timber harvesting, regional employment, biodiversity conservation, wilderness, water catchment protection, tourism, recreation and culture and heritage values.

The RFAs provide protections for threatened and rare species and ecological communities and include protecting forests in the CAR reserve system, developing recovery plans and threat abatement plans consistent with the Environment Protection and Biodiversity Conservation Act 1999 and state-based legislation and prescribing management requirements (i.e. preserving key features and habitats such as important nesting and foraging sites). The framework also provides continuous improvement and adaptive forest management when new information that impacts on forest management becomes available[16].

A legally binding clause for the RFA is the basis for the agreement – the National Forest Policy Statement in which:

> *"The Parties confirm their commitment to the goals, objectives and implementation of the National Forest Policy Statement (NFPS) by:*
>
> *(a) Implementing Ecologically Sustainable Forest Management (ESFM);*

[13] https://www.epa.nsw.gov.au/your-environment/native-forestry/about-public-native-forestry/regional-forest-agreements-assessments
[14] Department of Agriculture (2015) Regional Forest Agreements – an overview and history.
[15] In NSW these include Eden, Southern NW, Upper North East NSW and Lower North East NSW
[16] Commonwealth of Australia, Department of Agriculture (2015), Regional Forest Agreements, an overview and history

(b) Establishing and maintaining the Comprehensive, Adequate and Representative (CAR) Reserve System; Regional Forest Agreement for North East NSW

(c) Supporting an internationally competitive wood production and wood products industry through facilitating efficient and sustainable wood production, and wood products industries, based on maximising value-adding opportunities and efficient use of wood resources; and

(d) Promoting the conservation and management of the private Forest Estate".[17]

Further there are several clauses that are not legally binding but are relevant for PNF, including:

"26A New South Wales will use best endeavours to ensure that the Forest Management Framework provides for the protection of Matters of National Environmental Significance.

26B The Parties agree that research, monitoring, reporting, evaluation and the communication of findings are important to support decision making with regard to Matters of National Environmental Significance.

26C New South Wales will use best endeavours to continue to improve research, monitoring, reporting, evaluation and communication mechanisms as part of its Forest Management Framework in accordance with clause 46.

26D The Parties agree that the monitoring, audit, reporting and review processes set out in this Agreement provides an assurance that the Forest Management Framework takes into account the protection of Matters of National Environmental Significance."

"46 New South Wales confirms its commitment to the ongoing implementation and achievement of ESFM on both Public Land and Private Land through the continued implementation and improvements to its Forest Management Framework and adaptive management in accordance with the ESFM principles in Attachment 14."[18]

1.3.3 Forest Management Framework

The NSW Forest Management Framework is a comprehensive system for delivering ESFM across all public and private land tenures, including conservation reserves, state forests, PNF and plantations. A number of international policies, Australian Government legislation, policies and bilateral agreements influence forest management in NSW, shown in Table 1.

The Framework aligns with an adaptive management process by incorporating research finding and feedback processes associated with compliance and enforcement systems, stakeholder engagement and monitoring and review mechanisms. The Framework has, at its core, four primary elements:

- *A CAR reserve system that securely protects forest environment and heritage values on public and private land*
- *A system for managing and regulating native forestry on public and private land*
- *A system for authorising and regulating plantation operations on public and private land*
- *A system for managing forests outside reserves in a manner that contributes to sustainable environmental, social and economic outcomes*[19]*.*

The NSW Forest Management Framework is applied across the State's land tenures whereby state laws under which they are established may be specific to the type of land tenure. For private land, the primary legislation in the LLS Act, which provides the regulation of native vegetation management on private land and the authorisation and regulation of private native forest operations.

[17] Deed of variation in relation to the regional forestry agreement for the north east region (2018)
[18] Deed of variation in relation to the regional forestry agreement for the north east region (2018)
[19] Overview of the NSW Forest Management Framework

Table 1: International and national context for forest management in NSW

NSW Forest Management Framework	
Agreements	Comprehensive, Adequate and Representative (CAR) reserve system
	ESFM
	Industry stability
Legislation	Environment Projection and Biodiversity Conservation Act 1999
	Export Control Act 1982
	Regional Forest Agreement Act 2002
Policy	National Forest Policy Statement 1992
International	United Nations Conference on Environment and Development (UNCED) 1992
	United Nations Convention on Biological Diversity (CBD)
	Montreal Process Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests
	IUCN Aichi Biodiversity Targets

1.3.4 Private Native Forestry

PNF is the logging of native timbers on privately owned lands. Part 5B of the *Local Land Services Act 2013* (LLS Act) provides the legal framework for the regulation and objectives of legislation around PNF. The objectives include:

- carrying out PNF operations in accordance with the principles of ESFM
- protection of biodiversity and water quality
- enabling landholders to carry out forestry operations in a sustainable manner
- ensuring that the difference between PNF and native forestry in State Forests or other Crown-timber land are recognised (including in the application of protocols, codes, standards and other instruments).

Both the Minister for Agriculture and the Minister for Energy and Environment must have regard to these objectives being met.

In undertaking PNF, there is a need to ensure that the principles of ESFM are met, as defined in the *LLS Act 2013* as:

- maintaining forest values for future and present generations including:
  - forest biological diversity
  - the productive capacity and sustainability of forest ecosystems
  - the health and vitality of native forest ecosystems
  - soil and water quality
  - the contribution of native forests to global geochemical cycles
  - the long term social and economic benefits of native forests
  - natural heritage values
- ensure public participation, provision of information, accountability and transparency in relation to the carrying out of forestry operations
- provision of incentives for voluntary compliance, capacity building, and adoption of best practice

- delivering best practice forest management via the application of the best available knowledge and adaptive management processes
- applying the precautionary principle in preventing environmental harm[20]

The *LLS Act 2013* requires the development of PNF Codes of Practice. These codes require the concurrence of the Minister for Agriculture and the Minister for Energy and Environment (responsible for administering the *Biodiversity Conservation Act 2016* (BC Act 2016)). These codes should "*set minimum operating standards for harvesting private native forests in line with ecologically sustainable forest management*".[21] There are specific codes that apply to different regions and specific forest types (Northern NSW, Southern NSW, River Red Gum (RRG) forests, and Cypress and Western Hardwood forests).

PNF can occur in native forests on private land, however there are exclusions in areas of environmental significance or heritage value including "*mapped old growth forest, rainforest, riparian buffers, and Aboriginal heritage objects and places*".[22] Clearing of vegetation for agriculture or for development is managed under different regulatory instruments.

The LLS Act requires landholders that want to undertake forestry activities to obtain approval of a PNF Plan from the LLS, who are responsible for providing advice to land holders on PNF and approval of PNF plans. The Environment Protection Authority (EPA) is responsible for compliance and enforcement of PNF Plans and the PNF Codes. The approval process for undertaking PNF activities is set out in Figure 3.

Currently, the PNF Code prescriptions for koalas prohibit PNF occurring in areas of core koala habitat within the meaning of SEPP 44. If the koala prescriptions and codes, that are the subject of this report, are approved, it is proposed that PNF will be decoupled from the Koala SEPP.

1.3.4.1 PNF Codes of Practice

The PNF Codes "*are statutory documents that guide private native forestry operations in NSW. The Private Native Forestry Codes set minimum operating standards for harvesting in private native forests in line with ecologically sustainable forest management*."[23] There are PNF Codes which apply to: Northern NSW, Southern NSW, RRG forests, and Cypress and Western Hardwood forests.

This section provides a high-level summary of changes within the proposed Codes. A more detailed comparison between the current and proposed PNF Codes, and the Coastal Integrated Forestry Operations Approvals (IFOA), can be found in Appendix 3.

Areas subject to PNF

Information on the impact or extent or uptake or outcomes of the current PNF codes is not available. The current PNF Codes have higher requirements for retained basal area for STS silviculture compared with what is proposed for PNF (Appendix 3). However, there is no available information on the impact of the current PNF settings in different areas or locations of logging. LLS noted that currently PNF clearing is approximately 1,880 ha per year based on monitoring through the Statewide Landcover and Tree Study (SLATS) however this is unlikely to be accurate given the resolution of SLATS and that the data does not discriminate between trees removed through PNF, illegal logging, storms and other methods (See Section 2.3.5).

The LLS does have information on the amount of land (and location of properties) under PNF Plans. LLS informed the Review that there was currently:

- ~ 580,000 ha in NSW that have approved PNF plans (accounting for ~3% of the state's native forests) that could be subject to forestry operations now

[20] As referred to in Section 6(2)(a) of the *Protection of the Environment Administration Act 1991*
[21] https://www.lls.nsw.gov.au/help-and-advice/private-native-forestry/private-native-forestry-code-of-practice
[22] https://www.lls.nsw.gov.au/help-and-advice/private-native-forestry/getting-started-in-private-native-forestry
[23] https://www.lls.nsw.gov.au/help-and-advice/private-native-forestry/private-native-forestry-code-of-practice

- ~280 plans have been approved each year (2014/15 to 2020/21) (Table 2)
- Approved plans per year cover an average of 33,203 ha (2014/15 to 2019/20) (Table 3), with the net difference each year of approx. 3,500 ha (as land exceeded the 15-year lifetime of respective PNF Plans and as land was approved under new PNF Plans).
- ~1,880 ha per year of identified clearing based on monitoring through the SLATS. However, this is unlikely to be accurate given the resolution of SLATS and that the data does not discriminate between trees removed through PNF, illegal logging, storms and other methods

LLS was asked by the Review whether there was any prediction of what the uptake of PNF approvals would if the proposed PNF Codes were approved, and they thought there would be fewer applicants '*as the rules were tighter*'[24]. However, this could be counter to the intentions behind the proposed PNF Codes, which is to provide certainty and consistency to landholders (i.e., making the process clearer, consistent over time, etc.). The Review suggests that the assumptions behind this should also consider the impact that any potential increased harvest volume would have on uptake should the new proposed levels be approved. Figure 1 shows the current intensity of PNF by approvals in NSW.

Table 2: Number of PNF Plan approvals per year

Forest region	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Northern NSW	202	306	314	229	216	275	252
Southern NSW	7	13	11	2	12	9	18
River Red Gum	11	18	10	11	9	2	8
Cypress and Western Hardwood	2	2	3	11	11	9	10
TOTALS	**222**	**339**	**338**	**253**	**248**	**295**	**288**

Source: LLS pers comms

Table 3: Area (ha) of PNF Plan approvals per year

Forest region	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Northern NSW	24,671	41,464	33,177	24,584	24,458	30,728
Southern NSW	577	756	701	259	372	426
Riverina Red Gum	871	7,286	2,416	2,549	4,134	24
Cypress and Western Hardwood	1,837	2,155	1,892	4,261	4,555	3,248
Totals	**27,956**	**51,661**	**38,186**	**31,653**	**33,520**	**34,436**

Source: LLS pers comms

[24] LLS (2021) pers comms

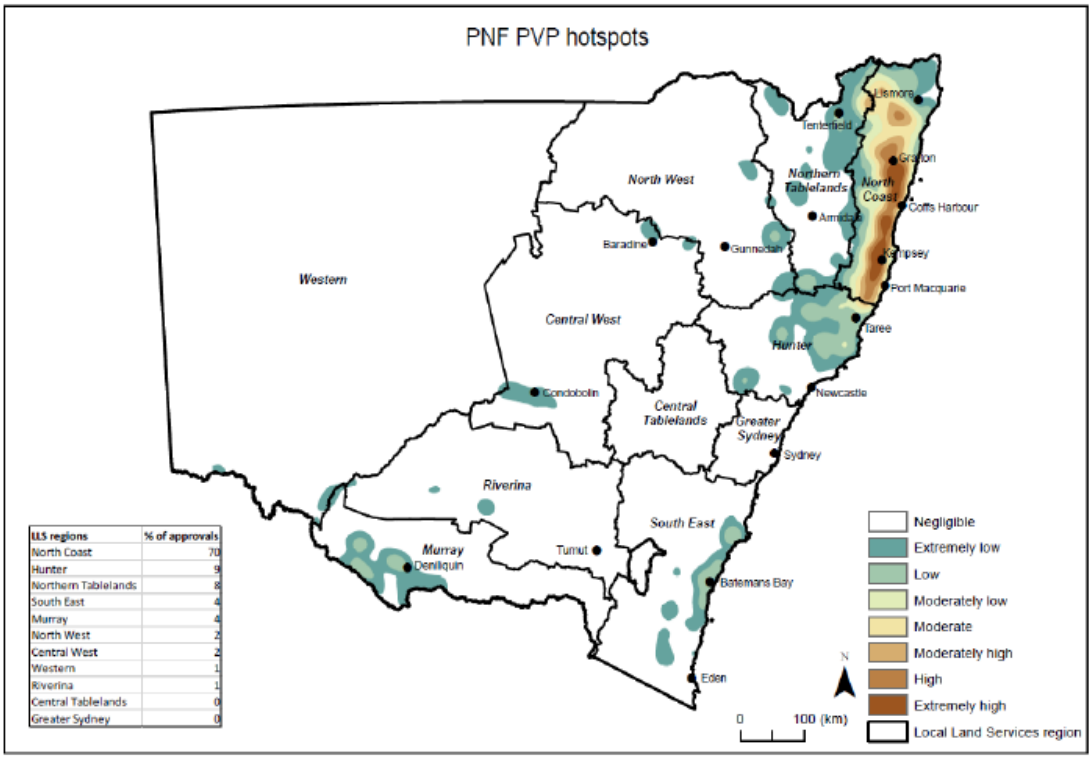


Figure 1: Intensity of PNF by location of approvals of PNF Property Vegetation Plans under the current PNF Codes
Source: NSW EPA (2021) pers comm (Appendix 5)

Koala prescriptions

Appendix A of the proposed PNF Codes provide koala prescriptions. The koala prescriptions apply to PNF where there are the following triggers:

- Known record – sighting or a record in NSW BioNet that is less than 20 years old that has a reliability level of 1 to 4[25] and a coordinate accuracy of 100 m or less
- Site evidence – signs that a koala has visited or regularly uses a site, and includes observations of faecal pellets or scats, chewed seed cones or a nest, or evidence that the site has been used as a latrine. It should be noted that this applies to other threatened species listed within the prescriptions, not just koalas
- Areas that have been identified as potential koala habitat – through maps of koala habitat suitability that have been developed by DPI Forestry Science and/or EES (DPIE) across regions of NSW (not all locations are covered by DPI maps). The Review understands that where DPI Forestry Science Maps are available, they are used, where they are not available the EES maps are used.

If the landholder believes the mapping of koala habitat to be inaccurate, they can engage a suitability qualified expert to conduct an on-ground field survey either Regularised Grid-based Spot Assessment Techniques (RGbSAT) or acoustic monitoring survey (song meters), survey methods are discussed in Section 2.3.2). The requirements for the surveys and expertise required to undertake them are set out in the prescriptions.

Where the koala prescriptions apply there are requirements for tree retention. This includes (depending on the trigger):

[25] The reliability level refers to the Source Code for the koala record including the sighting ID. Source Code 1 to 3 refer to specimens such as in public museums and collections. Source Code 4 refers to sightings by experts and the public.

- A minimum of 10 trees from the primary tree lists and 5 from the secondary tree list per hectare
- Trees should be spread evenly across the net harvestable area, have leafy broad crowns and be in a range of size classes with a minimum 30 cm diameter at breast height over bark
- minimising tree damage from felling and post-harvest burns
- requirements for visual assessment of trees for koala presence before felling. Trees that contain a koala or have evidence of a koala (10 or more scats or scratches) require the implementation of an exclusion zone (the size of which depends on the Koala Management Area (KMA)).
- The provisions also set out a list of primary and secondary koala use trees for each of the KMAs.

Prescriptions in the current and proposed PNF Codes are set out in Appendix 3 and 4. A major change to the proposed PNF Codes approach was to remove the exclusion from forestry for habitat mapped in CKPoMS in six local government areas under the SEPP 44, totalling approximately 6,000 ha (the Review notes that this number does not reflect the inclusion of the core koala habitat identified in the approved Tweed and Byron CKPoMS).

There are a few issues with the terminology used that require consistency:

- Reliability level - It is also noted that the prescription requires a sighting or record in BioNet that has a "*reliability level of 1 to 4".* The terminology used in BioNet designates koala records and sightings by Source Code. Source Code 1 to 3 refer to specimens such as in public museums and collections. Source Code 4 refers to sightings by experts and the public. The terminology in the prescription should reflect the terminology in the BioNet database. It has been confirmed with LLS that the correct data is being used and they noted that the prescription would be updated to reflect the correct terminology.
- KMAs - It is noted by the Review that the nine KMAs in the proposed koala prescriptions equate to the nine KMRs as developed by EES as part of the Koala Habitat Information Base (KHIB). Previously, the 2008 NSW Koala Recovery Plan[26] identified seven KMAs. There needs to be consistent terminology across agencies and polices (Figure 2).

[26] https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/koala/koala-habitat

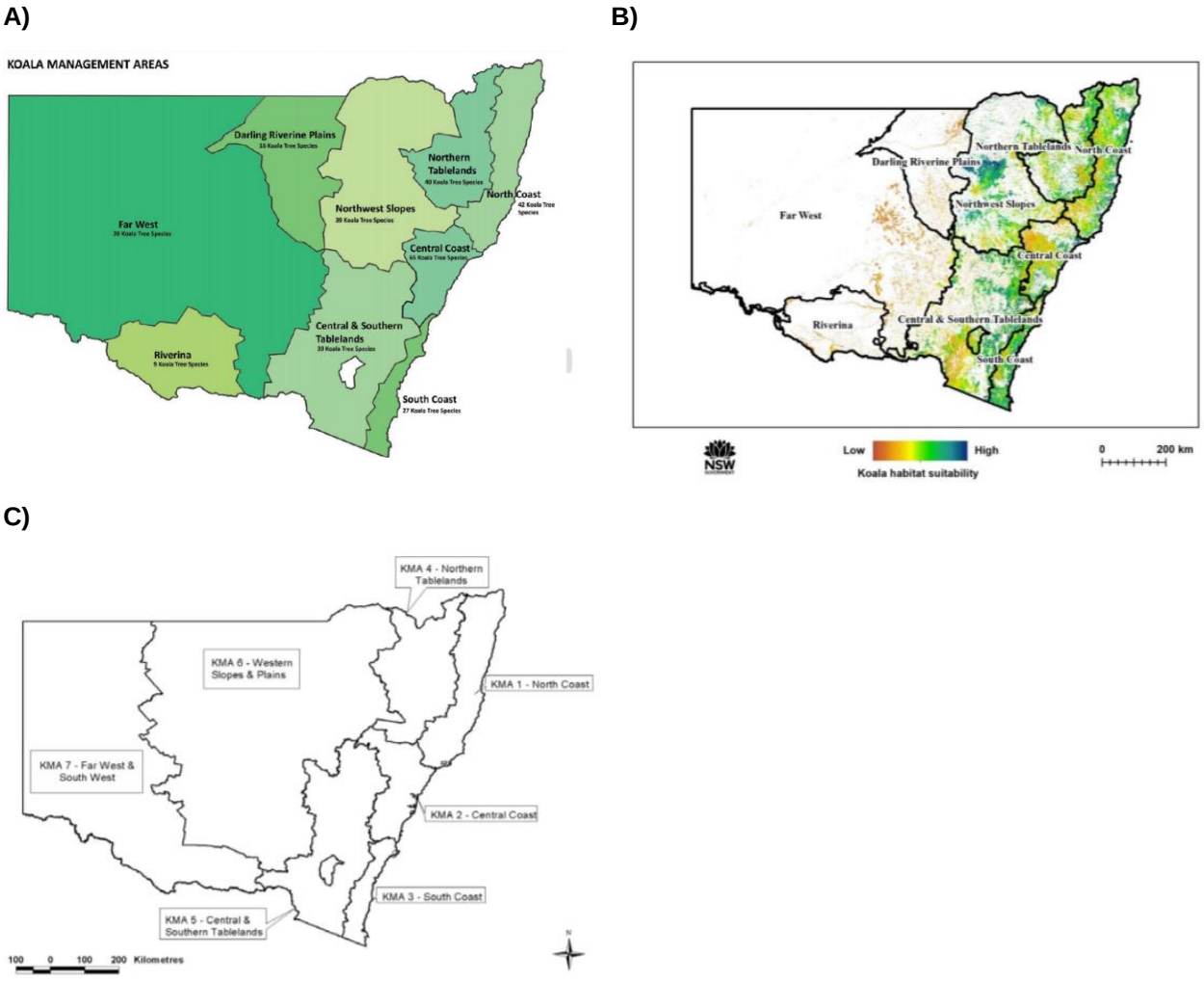


Figure 2: Comparison of the maps for managing and modelling koalas. A) KMAs as in the proposed PNF Codes, B) KMRs in the KHIB and C) KMAs in the Koala Recovery Plan
Sources: A) Appendix A proposed koala prescriptions, B) DECC (2008) Recovery plan for the koala C) DPIE (2019) Koala Habitat Information Base Technical Guide

Basal Areas

Studies including that of Jay (2017)[27] on the condition of the forests in the North Coast private forest indicated that there was a predominance of basal area and tree numbers in the smaller DBH classes (DBH < 40 cm). The study, which looked at patch size above 25 ha, reflected previous work of Jay and Dillon (2016)[28] and that the estate structure and condition appeared to reflect a long history of 'high grading' in PNF (i.e., selective harvesting of the highest grades of timber that, over time, leads to poor forest health).

Jay (2017) found the median stand basal area (SBA) of the plots was between 20 and 25 m^2/ha, and more than 90% of the full plot list had a SBA over 10m^2/ha. Further, 60% of trees had a DBH above 30cm.

The study reflected 1/6 of the stems had a DBH of 25 - 40 cm (most common size class) with weak crowns and approximately a quarter of the total estate had DBH 10 - 25 cm with weak crowns. However, the majority of larger trees had strong crowns. About 32% of the forest basal area was in trees with strong crowns >40cm DBH. In respect of harvest log quality, Jay demonstrated that very

[27] Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI
[28] Jay and Dillon (2016) Modelling the outcomes of different silvicultural approaches in the private native forests of north-eastern New South Wales, Australian Forestry 29 (2) 85-95

few plots had a basal area above 10m^2/ha of large high-grade logs, with a proportion of those being non-commercial, and half of plots had less than 2m^2/ha basal area of high-quality large logs. Jay did not find an association between the stand structure (diameter distributions in six groupings) and whether a stand was classed as even aged or multi-aged, they did note that the estate structure and condition appeared to reflect a long history of PNF high grading.[29,30]

Under the current PNF Codes, there is a complicated approach to minimum basal area limits, that are different between Codes, and within a Code, are dependent on both the forest type and dominant tree height (Table 4). The complicated minimum retained basal area limits in each Code and evidence of overstocked forests, with a preponderance of small trees and low quantities of large high quality logs led the LLS to propose a different approach to basal area limits for STS and Thinning on PNF that is more in line with the approach in the Coastal Integrated Forestry Operations Approval (Coastal IFOA); an average basal area that is independent of the type of forest, and where there is no distinction between the basal area of tall stands ≥ 25 metres versus shorter stands < 25 metres.

The proposed PNF Codes include changes to the retained basal area (Table 4), including:

- for areas subject to STS and Thinning forestry operations, the operations must not reduce the average minimum basal area below 10 m^2/ha (Northern NSW), 12 m^2/ha (Southern NSW, which includes Riverina Red Gum) and 8 m^2/ha (Western Hardwood forests).
- removing the different classifications of stand height (i.e., greater than or less than 25 m stand height). This change reflects the conclusions of Dr Brack, that there "*seems to be no ecological support for the 25 m stand height threshold*" and that the "*removal of stand height classification therefore is an obvious opportunity to reduce compliance risk*".[31]

In the current PNF Code prescriptions, areas subject to forestry operations must not reduce average stand basal area below 12 m^2/ha to 14 m^2/ha (in stand heights less than 25 m in height across NSW), and between 16 m^2/ha to 18 m^2/ha (in stand heights greater than 25 m), across various forest types (further breakdown in Table 4). The proposed PNF Code changes remove the height differential and remove the variations for forest types. The greatest change would be for tall stands in the proposed new Northern NSW Code as this would be a reduction from 18 to 16 m^2/ha (current code), down to 10 m^2/ha as a minimum average.

Table 4: Minimum stand basal areas for single tree selection and thinning operations in current PNF Code for Northern NSW (stand basal areas are calculated as an average)

Broad forest type	Stand height (< 25 metres)	Stand height (≥ 25 metres)
Tablelands hardwood	12 m^2/ha	16 m^2/ha
Tablelands ash	12 m^2/ha	16 m^2/ha
Spotted gum	12 m^2/ha	16 m^2/ha
North coast dry mixed hardwood	12 m^2/ha	16 m^2/ha
North coast moist mixed hardwood	12 m^2/ha	16 m^2/ha
North coast flooded gum	12 m^2/ha	18 m^2/ha
North coast blackbutt	14 m^2/ha	18 m^2/ha

Source: EPA (2016) Private Native Forestry Code of Practice for Northern NSW

Under the proposed PNF Codes, all forestry operations must have an average basal area equal to or above these minimum average basal area limits, with no more than 25% of sampling points having a basal area below 7 m^2/ha in Northern NSW, 5 m^2/ha and 6 m^2/ha in Cypress and Western Hardwoods forests respectively, 8 m^2/ha in Southern NSW, and 8 m^2/ha in RRG. This is a change

[29] Jay and Dillon (2016) Modelling the outcomes of different silvicultural approaches in the private native forests of north-eastern New South Wales, Australian Forestry 29 (2) 85-95

[30] Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI

[31] Brack, C, Cabinet in Confidence document, provided to the OCSE in 2020.

from the current PNF Codes, as per PNF Code Guideline No. 5: Techniques for Measuring Stand Basal Area, '*while the stand basal area provisions of the Code are applied as an average, there are limits to this principle: … no more than half of the sampling points in the relevant operational area can be below the minimum limits*.'[32]

The Review was interested to understand whether there was any spatial alignment between the density of koala populations/importance, density of PNF activity and locations where the allowable intensity might change most. To assist with interpreting this, the Review requested both LLS and EPA to provide mapping information to demonstrate the extent of locations where the basal area limits would decrease the most (those areas with heights above 25m), along with information on the Areas of Regional Koala Significance (ARKS), and current PNF approvals. In response, LLS and EES both provided specific information noted in this report and mapping study information which is in included in Appendices 4 and 5.

Appendices 4 and 5 cover the different approaches by the agencies to understand forest (tree) height via remote sensing technologies (Airborne Laser Scanner, ALS, LiDAR, Landsat/GEDI). Whilst the LLS/DPI mapping looks across the forest estate on the north and south coast, the EES mapping provided focuses on tree height measurements in the koala habitats of North-East NSW, although the technique can be used across the state. It is also worth noting for the context of both of these studies, the current and proposed PNF Code defines stand height as '*mean height of the dominant trees in the stand*'. The EES notes that '*there is no accurate surrogate for analysing stand height as per this definition*' and therefore both of these studies could be underestimating the amount of vegetation taller than 25 m (Appendix 5).

Further, both studies have limitations. The LLS/DPI notes within their study that there is a coverage and LiDAR limitation. OCSE also notes that extrapolation of the multiple regression model from the south coast to the north coast was not tested. EES also notes limitations for the LLS/DPI mapping (Appendix 5).

The conclusion drawn from the above studies is that the areas where there are strong koala populations (i.e., ARKS) are also the areas with a greater proportion of tree heights above 25 m, and therefore could be subject to the greatest change under the proposed Codes, and are already have the highest concentrations (above 85%) of PNF Plans in NSW (See Figure 1).

Other proposed changes

It was noted by LLS that several additional changes have been made in the proposed PNF Codes, this includes:

- replacing annual reporting with a pre-harvest and post-harvest notification system (although noting that this in and of itself will not directly improve environmental outcomes, but rather compliance of those outcomes)
- introducing small-scale harvesting to encourage voluntary compliance and help deliver Recommendation 7 of the Independent Biodiversity Legislation Review Panel Report,
- improving protections for threatened fauna, by introducing 16 additional fauna species including the Greater Glider and the Black-chinned Honeyeater,
- modernising threatened flora protections by introducing 15 additional species including the Buttercup Double tail and Pale-Yellow Double tail orchids,
- requiring species records to be updated before forestry operations commence,
- ensuring threatened flora and fauna records are applied to relevant IBRA regions
- looking at an approach that would enable foresters to exceed statutory limits by introducing a FSP – there are questions about the legal status of this.

[32] NSW EPA (2013) Private Native Forestry Code of Practice Guideline no. 5. Techniques for Measuring Stand Basal Area

Process for PNF plans and forestry under proposed PNF Codes

A landholder seeking to undertake silviculture on their land, where applicable, would need to develop a PNF Plan, and subsequent to its approval, develop a FOP or request the development of a FSP that sets out the operational components that include aspects such as the operation type (thinning, STS or AGS) and the forest parameters. The FOP or FSP needs to be in place prior to the commencement of any forestry operation, noting that the proponent (or approved agency, in the case of the FSP) is required to develop this and the landholder must ensure that it is consistent with the PNF Codes. Figure 3 steps out the roles and responsibilities for the landholder, the responsible agency LLS under the proposed new PNF Codes.

Some of the key elements from this process are:

- PNF Plan is approved by the LLS
- The new pathway to develop a forestry plan, the FSP, is developed by LLS and requires the approval by agreement from the Secretaries of the Department of Planning, Industry and Environment and the Department of Regional NSW respectively (or, failing agreement at this level, agreement from the Minister administering Part 5B of the LLS Act and the Minister administering the *Biodiversity Conservation Act 2016*).
- Conversely, the FOP is developed by the landholder (or contracted forestry consultant) and is not required to be approved by LLS
- The FOP and FSP can be amended by the landholder from time to time, but this cannot alter any aspect of the PNF Plan (such as the forestry footprint)
    - For example, once forestry operations begin, it may not be feasible to remove identified trees due to obstacles in the landscape or changes that have occurred over time
- The PNF Plan is valid for 15 years, with forestry operations (under a FOP or FSP) occurring at any stage during this period. Once this 15-years lapses, a new PNF Plan approval must be sought

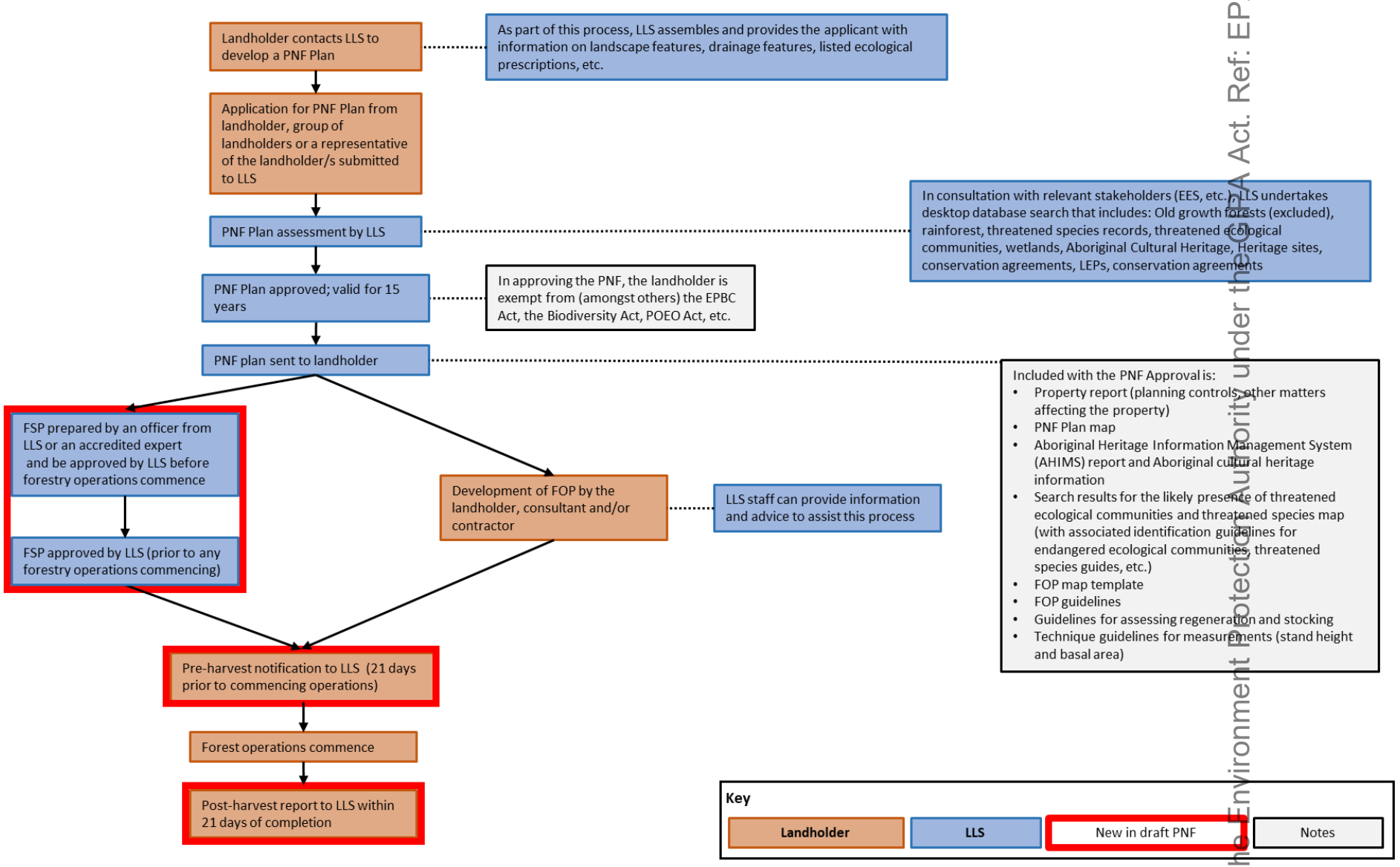


Figure 3: Private Native Forestry approval process

2 Forestry and koalas

This Chapter provides commentary on habitat requirements for koalas, silvicultural process, monitoring and mapping for both koala habitat and forestry.

2.1 Koala habitat

Historically in NSW, koalas were distributed throughout eucalypt woodlands and forests, although they are not typically found in rainforest habitats. Their distribution is widespread across the state, although the highest concentration of koalas appears to be in the north east of the state where there are suitable trees in fertile landscapes with higher nutritional content.

Most koala populations now survive in fragmented and isolated habitat and are threated across their range due to impacts such as habitat loss and fragmentation, vehicle strikes, dog attacks, drought, bushfires, disease (e.g., Chlamydiosis and koala retrovirus) and climate change.[33]

Koala habitat is more than just feed trees, it provides a range of trees for shelter, refuge, movement, and breeding. Whilst feed trees can meet some of these needs, shelter trees are important (e.g., turpentines). This subsection of the report considers koala habitat in terms of tree species, use and requirements for movement across the landscape. It aims to bring together understanding of what forest environments are particularly preferred by koalas and how these are categorised, where are particularly important location of koalas and habitat, what is the effect on koalas from disturbance to the forests.

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Koala habitat is defined as *"any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees. This can include remnant and non- remnant vegetation in natural, agricultural, urban and peri-urban environments. Koala habitat is defined by the vegetation community present and the vegetation structure; koalas do not necessarily have to be present."*[34]

The Review is examining whether the proposed PNF Codes provide robust protections for koalas in areas of high value habitat. The proposed PNF Codes use a number of triggers for koala prescriptions, one of which is utilisation of habitat suitability maps. Habitat value, suitability and other descriptors such as quality and importance are discussed below.

High value habitat refers to how well the habitat supports koalas and contributes to their ongoing viability. The components that contribute to the value includes: [35]

- Condition – the condition of the habitat in relation to koalas and considers factors such as vegetation condition and diversity, and the number of relevant habitat features.
- Context – The relative importance of the habitat based on its position in the landscape, which takes into account the connectivity needs of koalas. This includes factors such as koala movement patterns, proximity to other patches of suitable habitat, and the role of the habitat in relation to koala populations (e.g., allow for gene flow).
- Carrying capacity – The maximum population size that the habitat can sustain given factors such as food, habitat, water and other requirements. A low carrying capacity does not indicate poor value: habitat may have a high value for koalas despite having poor condition and/or context.

Determining the value of koala habitat is not always straightforward and often requires the expertise of trained ecologists and foresters.

[33] CSE (2016) Independent Review into the Decline of Koala Populations in Key Areas of NSW
[34] Commonwealth of Australia (2014) EPBC Act Referral Guidelines for the vulnerable koala (combined populations of Queensland, New South Wales and the Australian Capital Territory)
[35] Based on the Commonwealth Government, How to use the Offsets assessment guide

Habitat value differs from habitat suitability. In ecology it is established that habitat suitability ranges from 0 to 1 and this is determined by models that includes data such as koala records, vegetation, soil, climate, and topography. Habitat suitability indicates the suitability of the habitat to support the presence of a species, but it does not take into account the demographic performance of a population - this is determined by habitat value.

2.1.1 Koala habitat and preferences

Previous studies have shown that koalas have complex and extensive habitat requirements[36], and may use different eucalypt species for feeding and shelter. The nutritional quality of habitats across a landscape is a significant determinant for koala carrying capacity. A recent study undertaken as part of the NRC Koala Research program found that the nutritional quality of eucalypt leaves differed substantially amongst tree species, with tallowwood (*Eucalyptus microcorys*) and small-fruited grey gum (*E. propinqua*) exhibiting the highest nutritional value. Because there was no difference found in the nutritional quality of mature leaves from different sized trees of the same species, it was concluded that tree species composition, and not tree size, is the key determinant of habitat nutritional quality for koalas[37]. With this in mind, it is expected that koalas can therefore find food of adequate nutritional quality in a forest mosaic that includes a range of eucalypt species with heterogeneity in tree sizes and ages (including regrowth).

The literature shows that koalas are known to use a wide range of tree sizes, including small and young regenerating trees. The koalas in the North-coast of NSW were observed to be using trees above 8 cm DBH[38], north-east NSW koalas have been observed using trees 12 to 197 cm DBH[39] and koalas in the Pilliga forests have been found to use trees from 7 to 150 cm DBH[40].

Data from diurnal koala tree use shown they seek refuge from hot weather in larger trees[4142], where greater tree foliage would be considered an important habitat feature, particularly during heatwaves and droughts. These trees may not always be eucalypts. North-western NSW koalas have been found to use taller trees with denser foliage during the heat of the day compared to at night (when they are known to mostly feed). When considering the predicted increase of warmer and drier weather with a changing climate, a mosaic of larger trees with dense foliage spread throughout the landscape for koala refugia is just as essential to a habitat as is a range of tree species composition for feeding[43].

From this data, we can conclude that the landscape's capacity to support koalas is affected by changes to tree species composition, that might result from harvesting and regeneration, and this impact can be positive or negative, depending on which species are harvested, retained and regenerate[44].

2.1.1.1 Koala use of habitat – movement and density

Koalas can be highly transient and span across their landscape. A recent, unpublished study by Law *et al.*[45] found that male koalas were widespread at all harvested and unharvested sites in the North coast of NSW, and selective harvesting had no short-term (i.e., three to five months) effect

[36] Office of Environment and Heritage (2018) *A review of koala tree use across New South Wales*, Sydney, NSW, Australia
[37] NRC (2020) Draft report, Koala response to harvesting in north coast state forests, Research Program
[38] NRC (2020) Draft report, Koala response to harvesting in north coast state forests, Research Program
[39] Faulks (1990) cited in Melzer, A. and Houston, W. (2001). An overview of the understanding of koala ecology: how much more do we need to know? Pp. 6-45 in eds. K. Lyons, A. Melzer, F. Carrick and D. Lamb: *The Research and Management of Non-urban Koala Populations*. Koala Research Centre of Central Queensland Central Queensland University Rockhampton Qld
[40] Kavanagh, R. P., Stanton, M. A., and Brassil, T. E. (2007). Koalas continue to occupy their previous home-ranges after selective logging in Callitris–Eucalyptus forest. *Wildlife Research* 34: 94–107
[41] Marsh, K. J., Moore, B.D., Wallis, I.R., Foley, W. J. (2014) Feeding rates of a mammalian browser confirm the predictions of a 'foodscape' model of its habitat. *Oecologia* 174:873-882. doi: 10.1007/s00442-013-2808-3
[42] Moore, B.D., Lawler, I.R., Wallis, I.R., Beale, C.M., Foley, W.J. (2010). Palatability mapping: a koala's eye view of spatial variation in habitat quality. *Ecology* 91:3165-3176
[43] NRC (2020) Draft report, Koala response to harvesting in north coast state forests, Research Program
[44] Ford. J K., Youngentob. K N and Clark. G R (2021) Determining the effects of regeneration harvesting on habitat nutritional quality for koalas (unpublished)
[45] Law *et al.* Regulated timber harvesting does not reduce koala density in north-east forests of New South Wales. Unpublished

on koala occupancy or population density within this region. It was suggested that the slight decline in detection rate of koalas at some sites was due to drought and its impact on browse quality rather than in response to harvest, as the decline was seen at two particular drought impacted sites (paired control and treatment site).

This study indicates that koalas either remain or come back to areas that have been forested if there is healthy habitat remaining. It is important to note that this work is in the context of state forests, where silviculture is undertaken in a mosaic arrangement leading to a heterogeneity of forest structure and age. This recent work also focusses on looking at the impact on koala density/occupancy compared with the level of timber extraction, as opposed to the final basal area retained. The NSW Government has funded research under the NSW Koala Strategy to assess koala occupancy in PNF in north-east NSW.[46] Koala bellows were recorded across 130 sites using mini-acoustic sensors and preliminary findings suggest koalas are widespread in private forests under a range of land uses and disturbance histories. Further research to investigate koala response to harvesting under the proposed PNF codes is underway by DPI Forest Science.

However it is not clear to what extent this outcome is dependent on: the intensity of previous harvesting (the amount of forest taken and the amount remaining); time since previous harvesting (time frames of 1-4 years and 5-50 years were used in one study); the area and connectedness of adjacent pristine or healthy habitat and the extent of the forested vs non-forested area over a landscape; impacts that drought; the ratio of koala feed trees versus non-feed trees as remnants; whether the koalas are healthy and breeding, and whether koalas were still observed there because they had expanded their home ranges, or there was simply enough carrying capacity in the unlogged area to meet the needs of the resident koala population. The NRC concluded that research in North East NSW suggests that '*koala populations can be maintained in areas subject to low intensity harvesting but may be impacted by high intensity harvesting*'.[47]

The density of koalas in an area is dependent on profile of tree species composition[48] and food tree species available, in terms of primary and secondary trees[49]. The Koala Habitat Mapping Pilot: NSW State Forests (EPA 2016) indicated that where primary food tree species are absent or occur in low density, koalas will rely on secondary food tree species, but this will result in a decrease in carrying capacity of the habitat (i.e., number of animals per hectare). However, the same study noted that high numbers of koalas are still present throughout secondary habitat types, and these types have the greatest spatial cover at the landscape scale. At a landscape scale, koala densities are positively correlated with average concentration of digestible nitrogen[50]. Work by Au (2018) at the ANU modelled densities of koalas that might be supported in the NSW North Coast and modelled the impact that silvicultural changes to tree species composition could have on nutritional quality. The work predicted that sites in the North Coast of NSW could support a koala density of no more than 0.25 koalas per hectare over a given area. Although, there could be some places with a localised density higher than this given the mosaic nature of habitat across a landscape[51]. The modelling suggests that forestry practices that reduces the proportion of koala preferred browse trees or increase the proportion of non-preferred trees (e.g., blackbutt) lowered the average concentration of digestible nitrogen, reducing the carrying capacity for koalas.

Landscape connectivity facilitates the movement of koalas and facilitating gene flow. Loss of connectivity reduces the size and quality of available habitat, reduces or interrupts dispersal to new habitats and can lead to population declines and eventual loss of genetic variation.

[46] OEH (2019). *NSW Koala Research Plan 2019-28 – A 10-year plan under the NSW Koala Strategy*. Office of Environment and Heritage, Sydney.
[47] NRC (2016) Advice on Coastal Integrated Forestry Operations Approval Remake
[48] Moore BD, Lawler IR, Wallis IR, Beale CM, Foley WJ (2010) Palatability mapping: a koala's eye view of spatial variation in habitat quality. Ecology 91:3165-3176
[49] NSW EPA (2016), Koala Habitat Mapping pilot, NSW State Forests
[50] Au J (2018) Multi-scale effects of nutrition on an arboreal folivore. PhD thesis, The Australian National University
[51] NRC (2020) Draft report, Koala response to harvesting in north coast state forests, Research Program

Koalas require large areas of connected habitat. Koala home ranges vary greatly with the quality and connectedness of the habitat, from less than 2 hectares to several hundred hectares in size.[52] A study by Rus el at[53] found that reductions in connectivity led to longer koala movements and home ranges included more core patches. Keeping or improving connectivity reduces the cost to koalas associated with moving between isolated resources in fragmented landscapes. That is, when habitat is connected it is easier for koalas to find food, shelter and mates.

2.1.1.2 Koala tree species

In 2018 a review of koala tree uses was undertaken by OEH. The review[54]:

- identified evidence of koala use for 137 tree species in NSW, with 75% of species from the genus *Eucalyptus*
- found that tree use varied substantially across regions of the state and this variation reflected patterns of tree species distribution and abundance regionally.
- found that *"patterns of koala tree use across New South Wales and at regional (KMA) levels reflect the complex interplay between the requirements of individual koalas (for food, shelter and social needs) and access to trees of a necessary quality and diversity to satisfy those needs."* And that this variation of tree use patterns at local and regional scales was likely related to the "*need for koalas to balance and trade nutrient, moisture and toxins levels within available tree species and individual trees*."

Regional variation in koala tree use can be explained by patterns of tree species distribution, and the nutritional and chemical drivers will be similar across regions. Shelter trees are essential in some circumstances and may not always be eucalypts.

Factors that can influence tree use may include[55]:

- Tree foliar (leaf) chemistry
- Site quality and soil nutrients
- Tree genetic lineage
- Tree foliar moisture and free water
- Shelter needs
- Tree neighbourhoods
- Overall preference for larger trees
- Overall preference for habitats supporting structural diversity
- Landscape configuration (habitat loss, fragmentation and degradation leading to the loss of koalas, can mislead tree use patterns)
- Breeding status and other social influences
- The presence of threats

The OEH review was undertaken to provide an evidence base for the development of habitat suitability maps (Section 2.3.3).

The tree lists have been incorporated in the Koala SEPP 2021 and in the koala prescriptions in the proposed PNF Codes based on Koala Management Regions (KMRs). It is noted however that that the proposed PNF Codes and the Koala SEPP 2021 use koala tree lists for different purposes. The SEPP uses the expanded tree list to take a precautionary approach to habitat identification,

[52] https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10616
[53] Rus, A.I. et al (2021) Habitat fragmentation affects movement and space use of a specialist folivore, the koala. Animal Conservation
[54] Office of Environment and Heritage (2018) A review of koala tree use across New South Wales
[55] Office of Environment and Heritage (2018) A review of koala tree use across New South Wales

however this is not necessarily the same as the maps' use in the proposed PNF Codes aiding the selection of the feed and other habitat trees to preserve.

This issue is further understood through observations that within KMRs different trees on the Primary Species list and the Secondary Species list will be more or less preferred at different sites. Previous studies have noted that within a given area, individual koalas will preferentially feed on only a few of the available Eucalypt species: for example, in north-east NSW tallowwood (*E. microcorys*), grey gum (*E. propinqua*), forest red gum (*E. tereticornis*) and swamp mahogany (*E. robusta*) are identified as among the most preferred food tree species[56]. Other Eucalypts, and non-Eucalypt species, within the area may be used as supplementary browsing or for habitat purposes (shelter, etc.). Where primary food trees are at low density or are absent, koalas will rely on secondary food trees, but the habitat will have a lower carrying capacity[57].

2.1.2 Koala habitat and tenure

This section looks at tenure and how that relates to koala habitat across the state. The mapped koala prescriptions in the proposed PNF Codes covers 1.2M ha of koala habitat designated high suitability across NSW. This comes with the removal of the absolute exclusion of silviculture in core koala habitat (over 6,000 ha) as designated in the CKPoMs.

Freehold land represents a majority (57%) of the moderate to highly suitable habitat in NSW. Tables 5a and 5b shows the suitability of habitat across the various tenures.

As discussed in Sections 2.3.3 both the DPI and EES koala mapping using different suitability descriptors for koala habitat:

- DPI uses four descriptors: high, moderate, low and not habitat
- EES uses six descriptors: very high, high, moderate, low and very low, no class

In the proposed koala prescriptions, the DPI high and a threshold that is close to the EES very highly suitable habitat is used. The EES mapping has been conducted across the state and is used in this section of the report to look at tenure and koala habitat across NSW.

There are nine koala modelling regions (KMRs) in NSW. The KMRs are based on:

- landscape characteristics, particularly the geographic distribution of primary or secondary food tree species
- administrative boundaries including Local Government Areas (LGAs) and IBRA

Table 6a-c show the amount of freehold (private) land in the KMRs across the different habitat suitability classes as defined by the EES Koala Habitat Suitability Model (described in Section 2.3.3). Overall, there is ~6M ha (8%) of moderate to very highly suitable koala habitat on freehold land in NSW. There 1.3M hectares of moderate to very highly suitable habitat in the North Coast region of the state where most koalas are located and most PNF occurs.

Table 5a: Koala Habitat Suitability Class and Tenure in NSW

Habitat Suitability Class	National Park			Crown Land			Freehold		
	ha	% tenure	% total	ha	% tenure	% total	ha	% tenure	% total
Very High	371,156	5.0%	0.5%	113,955	3.2%	0.1%	764,945	2.1%	1.0%
High	1,717,473	23.0%	2.1%	374,586	10.4%	0.5%	4,177,827	11.4%	5.2%
Moderate	1,422,339	19.0%	1.8%	201,399	5.6%	0.3%	2,948,929	8.0%	3.7%
Low	1,245,680	16.7%	1.6%	105,358	2.9%	0.1%	1,481,409	4.0%	1.8%
Very Low	503,229	6.7%	0.6%	31,609	0.9%	0.0%	457,897	1.2%	0.6%

[56] NSW EPA (2016), Koala Habitat Mapping pilot, NSW State Forests
[57] NSW EPA (2016), Koala Habitat Mapping pilot, NSW State Forests

No Class	2,208,612	29.6%	2.8%	2,761,588	77.0%	3.4%	26,969,720	73.3%	33.6%
Total area	7,468,489	100%	9.3%	3,588,496	100%	4.5%	36,800,731	100%	45.9%

Table 5b: Koala Habitat Suitability Class and Tenure in NSW (continued)

Habitat Suitability Class	Lease Land			State Forest			Other		
	ha	% tenure	% total	ha	% tenure	% total	ha	% tenure	% total
Very High	6,773	0.0%	0.0%	299,161	14.0%	0.4%	42,470	2.6%	0.1%
High	40,496	0.1%	0.1%	678,440	31.7%	0.8%	185,785	11.6%	0.2%
Moderate	21,450	0.1%	0.0%	489,774	22.9%	0.6%	106,120	6.6%	0.1%
Low	14,996	0.1%	0.0%	180,651	8.4%	0.2%	49,881	3.1%	0.1%
Very Low	5,899	0.0%	0.0%	36,867	1.7%	0.0%	15,143	0.9%	0.0%
No Class	28,463,624	99.7%	35.5%	456,564	21.3%	0.6%	1,208,905	75.2%	1.5%
Total area	28,553,237	100%	35.6%	2,141,458	100%	2.7%	1,608,304	100%	2.0%

Source: EES (2020) pers comms

Table 6a: Koala Habitat Suitability Classes, Koala Management Regions (KMRs) and freehold land area

Habitat Class	Central & Southern Tablelands		Central Coast		North Coast		Northern Tablelands	
	ha	% region	ha	% region	ha	% region	ha	% region
Very High	69,033	1%	54,828	4%	194,446	8%	155,414	5%
High	1,403,349	22%	269,528	21%	417,573	17%	510,205	17%
Moderate	360,999	6%	177,555	14%	703,687	28%	664,224	22%
Low	424,960	7%	128,326	10%	247,415	10%	252,898	8%
Very Low	115,286	2%	36,056	3%	50,601	2%	60,370	2%
No Class	4,076,770	63%	624,639	48%	885,496	35%	1,434,374	47%
Total freehold	6,450,396		1,290,932		2,499,219		3,077,486	
Total area (*% of Freehold)*	9,119,957	*(71%)*	2,599,984	*(50%)*	4,211,845	(59%)	4,079,541	*(75%)*

Table 6b: Koala Habitat Suitability Classes, Koala Management Regions (KMRs) and freehold land area (continued)

Habitat Class	South Coast		Northwest Slopes		Far West		Darling Riverine Plains	
	ha	% region	ha	% region	ha	% region	ha	% region
Very High	26,326	6%	264,887	3%	2	0%	11	0%
High	96,665	22%	1,480,435	17%	40	0%	32	0%
Moderate	116,183	26%	926,263	11%	14	0%	4	0%
Low	35,153	8%	392,635	4%	19	0%	2	0%
Very Low	9,840	2%	185,717	2%	7	0%	20	0%
No Class	164,468	37%	5,488,844	63%	7,416,787	100%	2,973,803	100%
Total freehold	448,634		8,738,781		7,416,868		2,973,872	
Total area (*% of Freehold)*	1,460,729	*(31%)*	10,594,059	*(82%)*	37,313,557	*(20%)*	6,125,300	*(49%)*

Table 6c: Koala Habitat Suitability Classes, Koala Management Regions (KMRs) and freehold land area (continued)

Habitat Class	Riverina	
	ha	% region
Very High	0	0%
High	2	0%
Moderate	0	0%
Low	1	0%
Very Low	0	0%
No Class	3,904,428	100%
Total freehold	3,904,431	
Total area (*% of Freehold)*	4,648,309	*(84%)*

In 2020, Saving our Species (SoS) developed a framework for the prioritisation of koala conservation actions in NSW.[58] This study identified 48 areas in NSW that are considered ARKS (Figure 4). The "*smallest being South West Rocks, at around 400 hectares, and the largest being Bungonia (Illawarra) at 353,000 hectares (made up of five sub-areas). Altogether, 4,195,549 hectares (~42,000 square kilometres), or around 5% of New South Wales is mapped as being of significance for koalas."*[59]

A key proposed plank of the new Koala Strategy will be to identify a number of ARKS across the state that can be coordinated to contribute to koala population growth. These will be areas of good, connected habitat with large populations where efforts can contribute to increased births and longer life expectancy. These will be important areas and may need to be particularly considered in terms of risk appetite and increased protections when it comes to land clearing, fragmentation and habitat removal.

[58] EES (2020) Saving our Species – Iconic Koala Project. Framework for the spatial prioritisation of koala conservation actions in NSW.
[59] EES (2020) Saving our Species – Iconic Koala Project. Framework for the spatial prioritisation of koala conservation actions in NSW.

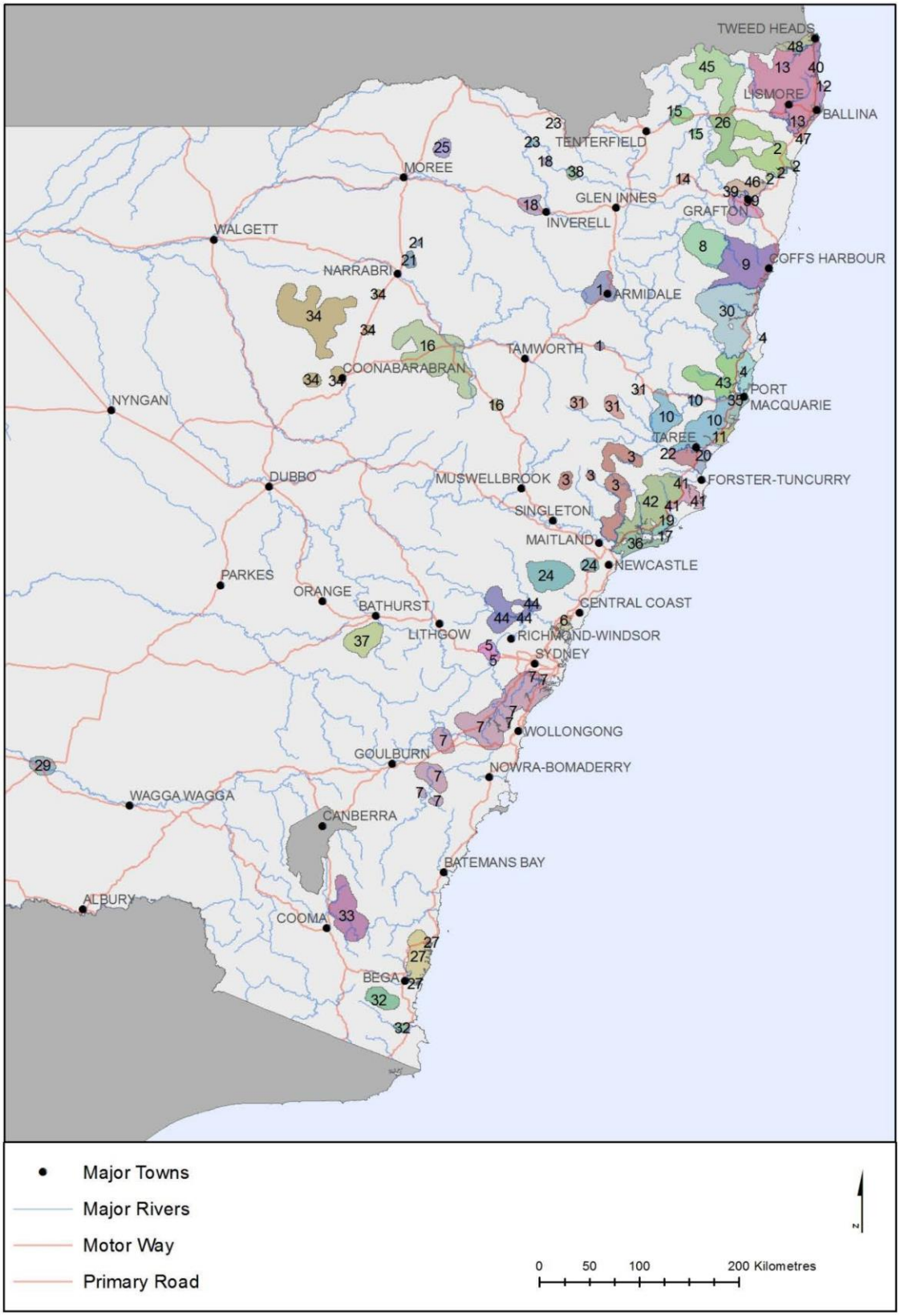


Figure 4: Areas of Regional Koala Significance in NSW
Source: EES (2020)[60]

[60] EES (2020) Saving our Species – Iconic Koala Project. Framework for the spatial prioritisation of koala conservation actions in NSW.

2.1.3 Koalas and habitat disturbance

The EPA Habitat Mapping Pilot[61] found variable habitat utilisation across the landscape, but that higher koala activity was correlated with greater abundance of diversity of local koala feed trees, trees and forest structure mature size classes and areas of least disturbance. However, it is known that koalas can tolerate and adapt to minor levels of disturbance, especially if their main food trees are protected.

2.1.3.1 Forestry and koalas

This section provides an overview of studies and information on the interface of koala and habitat disturbance through forestry in NSW, and what data is available on the impact on koalas.

A study by Law *et al.* in 2018 deployed acoustic recorders at 171 sites for use in occupancy modelling and koala response to timber harvesting.[62] The study found neither occupancy nor bellow rate were influenced by timber harvesting intensity, time since harvesting or local landscape extent of harvesting or growth. Occupancy modelling concluded that the hinterland forests of north-east NSW support a widespread, though low-density koala population, larger than what was previously understood. Further to this study, Law *et al.* undertook further research in 2021 to determine the effects of timber harvesting on koala density in public native forests of north-east NSW. This research was funded through the Natural Resources Commission (NRC) under the NSW Koala Strategy and is not yet published or publicly available.

This study was focused on NE NSW (Wauchope, Kempsey and Coffs Harbour), assessing male koala density (via acoustic arrays) over multiple (nine) 400 ha study areas. Law *et al.* has previously noted that the use of acoustic arrays and spatial count modelling have produced reliable estimates of koala density in NSW.[63]

The methodology was based on a before-after-control-impact-paired-series (BACIPS), with paired treatment (State Forest) and control sites (National Parks). The selective harvesting treatments at the three BACIPS sites resulted in a range of intensity in forestry operations (17-51 m^3 per ha). Additional sites were also sampled in previously (5-10 years) heavily harvested areas. The Review is anticipating the availability of the data on the operations intensities in terms of basal area changes at sites before and after harvesting, this has been requested by the NRC.

Observations and results from this study include:

- No overall difference in koala densities between pre- and post-harvest periods
    - Lower Bucca recorded the highest harvest intensity (51 m^3/ha, equivalent to a basal area reduction from 33 m^2/ha to 19 m^2/ha) and the largest decrease in male koalas per hectare (-0.007 per ha)
    - Koala occupancy and density were similar to comparable unharvested sites – however, it was noted that the baselines for these sites were unknown
    - Canopy cover was significantly reduced relative to comparable unharvested sites, however, canopy species composition was similar
    - Both treatment and control sites included areas with ‘average’ koala density (0.03-0.07 males per hectare) for the array, as well areas with densities above (for example 0.3 males per hectare) and below (less than 0.01 males per hectare) this average density
    - GPS collared koalas were using the full range of available landscape, including the regenerating forest.

[61] NSW EPA (2016), Koala Habitat Mapping pilot, NSW State Forests
[62] Law, B.S., Brassil, T., Gonsalves, L., Roe, P., Truskinger, A. and 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), p.e0205075
[63] Dr Brad Law, DPI Forestry Science, pers comms

- Spatial variation in density at each site was overlaid on the mosaic of forest harvesting, exclusions and forest regrowth. Density in areas that were selectively harvested was generally comparable to the density in harvest exclusions, areas of regrowth and areas of old growth, it was therefore suggested that tree retention and harvest exclusion zones are important measures to provide refuge for koalas when harvesting operations occurs.
- Other research noted, includes:
    - A radio-tracking study in the Pilliga forests that found koalas tolerate selective harvesting of shelter trees, at least in the short term (i.e., six months after harvesting). This study also showed evidence that koalas continued to occupy their home ranges immediately after the harvesting of shelter trees[64]
    - Koala scats are positively correlated with the number of harvesting events, suggesting resilience in koala populations to previous low-intensity harvesting. However, scats are also associated with mixed-age and structurally complex forests that are dominated by preferred browse species[65]
    - Koalas have been shown to move into adjacent habitat during intensive harvesting in blue gum plantations in Victoria[66]
- One of the suggested management recommendations is '*dispersing harvesting in space and time to ensure its effects on koalas continue to be minimised*'.
    - Law *et al.* also noted that '*triggered retention of browse species can be achieved through use of habitat suitability maps (Law et al. 2017)*[67] *as per the newly established practice in NSW*'.

The work of Law looked at koala occupancy and density in locations subject forestry, where the harvest volume or change in basal area was being compared. The work does not provide information on the final forest density yet. The Review has sought this information from the NRC (which commissioned the work), and it is understood that relevant agencies are in the process of compiling that information. This issue is of relevance as the Review would like to better understand the effect of both the change in habitat density and final minimum average basal area achieved.

2.1.3.2 Habitat loss and fragmentation

Koala population structure should be recognised in our understanding of koalas in the landscape and this includes facilitating the movements of koalas between smaller areas. Logging has resulted in the loss of koala habitat, but the effect on local koala numbers is a function of the management regime of the logging operation, so the level of threat is specific to the situation and is determined by the management regime and the adherence to prescriptions.[68]

Koalas can maintain home ranges in areas that have been affected by logging, particularly where the range overlays areas that are unlogged/remnant/old growth, and also in areas that have had regeneration adjacent to unlogged stands including plantations.[69]

Maintenance of subpopulations, through maintaining movement corridors, is important for maintaining genetic variability and long-term adaptability to environmental change. Therefore, it is

[64] Kavanagh RP, Stanton MA, Brassil TE. 2007. Koalas continue to occupy their previous home-ranges after selective logging in *Callitris-Eucalyptus* forest. Wildlife Research **34**:94-107.
[65] Law, B.S., Brassil, T., Gonsalves, L., Roe, P., Truskinger, A. and 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), p.e0205075.
[66] Australian Koala Foundation. 2008. Use of blue gum plantations by koalas (a report to stakeholders in the plantation industry by the Australian Koala Foundation). Australian Koala Foundation, Brisbane.
[67] Law et al (2017) Development and field validation of a regional, management-scale habitat model: A koala *Phascolarctos cinereus* case study. Ecology and Evolution 7:18, p7475-7489
[68] Commonwealth of Australia (2011) The Senate. Environment and Communications References Committee. The koala-saving our national icon. Chapter 3
[69] Dr Brad Law, DPI Forestry Science, unpublished

important that on-the-ground review occurs and mapping that depicts functional habitat such as corridors is used. Mapping and site validation should be used to identify these features.

Work by MacAlpine et al[70] concludes that for a given area of habitat, a landscape of more numerous smaller habitat patches is less likely to be occupied than one of fewer larger patches. They also found that extinction processes for local koala populations may occur on habitat patches that are too isolated or small to support viable populations. It is noted that there can be potential negatives from connectivity such as disease transmission and fire spread.

Figure 5 depicts the Clarence and Richmond lowland areas, with ARKS identified with blue borders and blue hash, and current approved PNF Plans in black. The figure shows the considerable areas of habitat that are already under approval, particularly in the ARKS and before the proposed PNF Codes come into place. It is possible that with new PNF Codes, more properties within this area will enter into PNF Plans and have increased forestry activity.

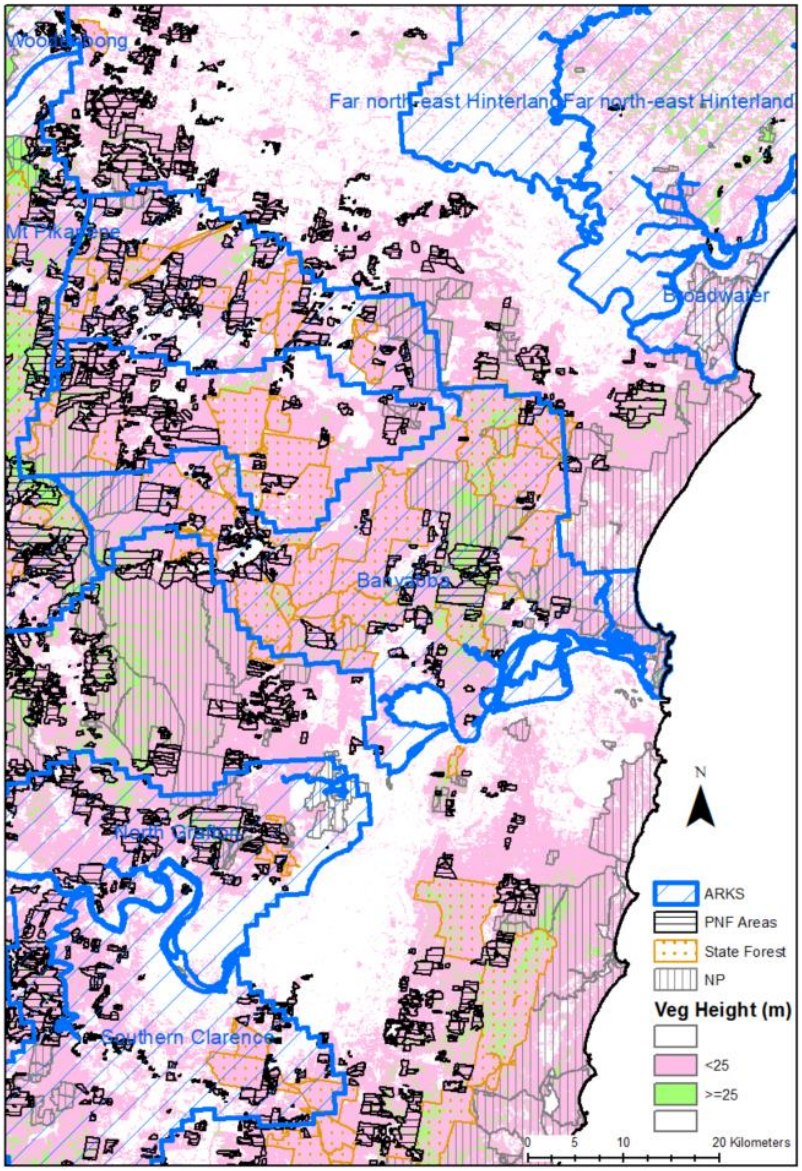


Figure 5: Tree heights in the Clarence and Richmond Lowlands Area
Source: NSW EPA pers comms

[70] McAlpine, C.A. et al., (2006b). The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation*. 132:153-165.
McAlpine, C.A., M.E. et al., (2006a). Testing alternative models for the conservation of koalas in fragmented rural-urban landscapes. *Austral Ecology*. 31:529-544

2.1.3.3 Climate change impacts and koala resilience

Climate change is expected to lead to an increased frequency of high temperatures and presents a risk to the long-term survival of koalas across tenures. There may be increased frequency of wildfire, prolonged periods of heat exposure and heat stress and loss of leaf moisture. Wildfires may also impact on plant composition and therefore nutrients available to koalas.

The effects of environmental stressors on koalas and the changes of these due to a changing climate regime are not well understood. However, under stressful conditions such as low rainfall, koalas have been shown to have elevated faecal cortisol metabolite levels[71]. Increased stress levels may increase koala susceptibility to disease (such as chlamydiosis).

The changing concentration of CO_2 in the atmosphere may also impact the leaf chemistry of koala feed trees, due to a change in concentration and digestibility of protein.[72]

Considerable long-term planning efforts are underway in the NSW Government that are relevant to the forestry across tenures, these include:

- A Climate Change (modelling and utilisation) Community of Practice has been launched for NSW Government agency staff to build competency and capacity[73]
- the NSW and ACT Regional Climate Model (NARCliM) is being updated as NARCliM 1.5 with further improvement planned in NARCliM 2.0. Regional Water Strategies (RWS) are being developed across the state (13 regions), that brings together NARCliM data with rainfall variability information to better predict water availability.
- The NSW Sharing and Enabling Environmental Data (SEED) is growing in scale and reach and enabling sophisticated data visualisation opportunities for the public and government.
- The NSW Government is finalising the next iteration of the state's koala strategy which has been developed to reach the goal of doubling koala numbers in the state over the next thirty years. The research capacity in relation to bushfires and understanding impacts is also receiving a boost through national and state-based initiatives.

These new information sources and programs will be relevant to planning and management for PNF and inform consideration of risk management, risk appetite and tolerance. The NSW Auditor General's Report *Managing climate risks to assets and services* Performance audit of DPIE and NSW Treasury September 2021 has found more work is needed in NSW government to embed climate change planning into services and assets, and notes

> "For agencies to manage the physical risks of climate change to their assets and services, leading practice identified by the Department means that they need to:
> • use robust climate projection information to understand the potential climate impacts
> • undertake sound climate risk assessments, within an enterprise risk management framework
> • implement adaptation plans that reduce these risks, and harness opportunities."[74]

The Regional Water Strategies[75], SEED and NARCliM platforms as well as the Climate Change modelling community of practice will be useful tools for LLS in planning, modelling and analysing FOP to ensure longevity and health of the forests.

[71] Metabolites are amino acids, fatty acids, lipids etc found in cellular regulatory processes, and it is the change in their levels that are an indicator of disease or environmental stimuli. Soured https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/metabolite

[72] Robinson EA, Ryan GD, Newman JA. A meta-analytical review of the effects of elevated CO2 on plant-arthropod interactions highlights the importance of interacting environmental and biological variables. New Phytol. 2012 Apr;194(2):321-336

[73] The Climate Change (Modelling and Application) Community of Practice was formed to promote collaboration and provide a forum to discuss best approaches for communicating the complexities of climate modelling and application, uncertainty and related issues. It also promotes collaboration between hydrological, hydrogeological and climate modellers and climate scientists more broadly and would help ensure mutual understanding develops.

[74] Audit Office of New South Wales (2021) Managing climate risks to assets and services, NSW Auditor-General's Report

[75] https://www.industry.nsw.gov.au/water/plans-programs/regional-water-strategies

2.2 Forestry operations

Forestry operations are undertaken for a number of reasons: primarily, they are undertaken to produce high quality sawlogs (that is used, for example, in decorative veneers, etc.), low quality sawlogs (e.g., used for structural timber in buildings) and residue (lower quality timber that can be used for firewood, pulp wood).

Almost all native timbers harvested in NSW are from hardwood species (*Eucalyptus* genus) which grow in tall native forests along the coast and tableland. The most common commercial species are Coastal Blackbutt, Spotted Gum, Sydney Blue Gum, Stringybark, Silver top Ash and Ironbark

Different forestry products draw on different types and characteristics of logs that would typically be drawn from hardwood forestry associated with koala habitat. On the NSW North Coast, species such as Coast Blackbutt, Spotted Gum, Flooded Gum, Dunn's White Gum and Gympie Messmate are in hardwood plantations. Hardwood forests provide timber that is visually attractive, dense, strong and durable, used for flooring, decks and structural purposes. Timber unsuitable for use in solid wood products is sold as pulpwood for woodchip export or as firewood for domestic heating. In plantations, Southern Pine is suited to a subtropical climate and is growth on the far north coast.

NSW produces one third of Australia's softwood timber, however most of it is via plantations using exotic species such as Radiata Pine. Cypress Pine is a common native softwood species that is harvested from dry native forests located west of the dividing range, including south-west slopes around Tumut, on the southern tablelands around Bombala and on the central west slopes around Bathurst-Oberon.

Riverina red gums that run along the Murry River are hard and durable and provide foundations for buildings, and timber for railway sleepers, wharves and fences. Offcuts are also commonly used as firewood[76].

2.2.1 Silviculture practices

Silviculture, in a commercial forestry operation, is undertaken with an aim to ensure the maintenance of natural species patterns, forest health and biodiversity values. Native eucalypt forests are complex systems and therefore require varied management principles when undertaking forestry operations.

The type of silvicultural system underpins the future productivity of the forest by contributing to effective regeneration and allowing existing trees to continue growing. The PNF code adopts three silvicultural systems which may suit a range of circumstances.

Single tree selection (STS) involves selecting and harvesting individual or small clumps of trees that are selected on the basis of diameter and forest condition. Dominant and co-dominant trees are often retained with supressed trees (which might be younger and/or smaller) targeted for harvest. STS is regulated by the PNF Code through the application of retained basal area limits[77],

Thinning is generally applied to even-aged stands where the retained trees have a strong ability to keep growing larger, once the competing trees have been removed, thereby increasing access to, water and soil nutrients. The primary purpose of thinning is not necessarily to open the canopy nor encourage regeneration, rather to ensure the growing trees have maximum opportunity to grow to a commercial size. Thinning is also regulated through retained basal area limits.

Australian Group Selection (AGS) is designed to encourage regeneration by creating canopy openings in the forest canopy which allows maximum light onto the forest floor. AGS aims to create smaller patches of even aged regrowth through the harvest zone. AGS is regulated through the retention of large trees of a specific DBHOB.

Generally, PNF forests have been reported to be more complex, with different tree types compared to state forests under IFOAs. The way in which FCNSW undertakes forestry in state forests

[76] NSW Government, Private Native Forestry Field Guide for the River Red Gum Forests (2016)
[77] NSW Government, Private Native Forestry Field Guide for the River Red Gum Forests (2016)

according to the prescriptions set out in the IFOAs is designed to promote sustainable forestry outcomes over (typically) a 100-year timeframe: i.e., at the end of the 100-year period, the forest will still be in a sustainable state that forestry practices could occur over the next 100 years. In order to achieve this, typical forest operations go through a cycle that can include thinning (to reduce competition and promote those trees that could be harvested in future for high quality logs [HQL]), a second stage thinning (to remove further competition), STS release (selective logging for HQL) and STS regeneration (designed to promote regeneration and/or stand renewal). Appendix 3 shows a comparison of current PNF Codes (and guidelines) with the current Coastal IFOA.

2.2.2 Forestry exclusions in PNF Codes

There are several areas and forest types that are excluded and/or protected as specified in the PNF Codes, these include:

- Threatened ecological communities
- Areas of outstanding biodiversity value
- Rainforests
- Old growth forests
- Wetlands
- Healthland
- Rocky outcrops
- Steep slopes
- Cultural and heritage sites
- Dispersible and highly erodible soils
- Riparian zones (70% retained[78])

There are a number of requirements related to retention of habitat and biodiversity including the protections a specific habitat trees such as hollow bearing trees, recruitment trees, food resource trees, roost trees and nest trees

2.2.3 Forestry and forest health

Silviculture practices can contribute to ESFM as well as the health and productivity of the forest. A healthy forest is one that it resilient and persistent. Forest health could be represented by productivity over time (e.g., high quality logs, volumes) and/or its biodiversity and ecology.

Silvicultural thinning is a well-established practice of selectively removing trees in woody ecosystems to promote and control the structure and growth of retained trees for the purposes of timber production (yield) and to meet associated specifications. Thinning does not typically aim to promote regeneration (although it is classified in the Codes as a regeneration activity); it reduces the density of individuals competing for resources available within a site, so that there are more resources available for those individual trees that are retained. When used commercially, thinning can provide flexibility to support the timing, quantity and quality of wood.

Ecological thinning refers to thinning undertaken to achieve specific ecological benefits, including increasing resilience to environmental stress and disturbances. It is emerging as a tool for improving ecological health and enhancing opportunities for natural regeneration of the ground flora, increasing biodiversity and improving habitat for native fauna.

As defined in the proposed PNF Codes, primary outcomes for PNF is to '*support the long-term sustainable management of native forests on private land and Crown land (other than Crown timber land) for timber production and ecologically sustainable forest management*'.

[78] According to the current and proposed PNF Code, for riparian zones '30% of the pre-harvest basal area can be removed in any ten-year period and the minimum basal area must be maintained within the riparian buffer zone'

Further, there is a need for forestry operations to ensure adequate regeneration and/or stand stocking. Regeneration determines the long-term productivity, growth, dynamics and composition of the forest.[79]

Under the proposed PNF Codes, a 'regeneration event' is defined as "*a harvesting or thinning operation*" in relation to small scale harvesting, STS and thinning, and AGS. Regeneration outcomes must be achieved within a 24-month period, with Appendix C of the proposed Codes setting out the method of calculating forest regeneration in STS/thinning and AGS. Whilst the method of being considered 'stocked' is similar irrespective of the forestry operation type undertaken:

- STS/thinning: plots (circular, minimum 1.8 m radius, and approx. 10 m plot size) 20 m apart in a square formation 200 m x 200 m – 65% of plots stocked by 24 months
- AGS: plots (circular, minimum 1.8 m radius, and approx. 10 m plot size) that are located systematically across the canopy openings with a minimum inter-point distance of 20 m
    - In this context, a canopy opening is defined as '*an area greater than 0.1 hectares in size, measured between canopy perimeters, where any vegetation remaining within the opening is less than one-half of the stand height*'
    - 55% of plots in canopy openings stocked by 24 months
- The number of sample points required and other considerations for both STS/thinning and AGS is outlined further in Appendix C of the proposed PNF Codes.

A plot is considered 'stocked' if any part of the plot is under the canopy of an existing tree, contains at least one viable seedling or contains 'advanced growth' of an upper canopy species that has the capability to form part of the canopy.

2.3 Monitoring and mapping techniques

Robust monitoring programs are essential to understand the impact of interventions and activities at a landscape scale and at specific sites and how vegetation and koala populations respond over time. Targeted monitoring is important in remote areas that may not be regularly visited by the public or researchers.

The monitoring should have clear objectives to assess and report on actions or activities and should include trigger points that specify the implementation of actions when thresholds are exceeded in line with an adaptive management approach.

It is noted that there are no perfect methods for monitoring koalas and vegetation, in many cases there are trade-offs between accuracy/sensitivity and extent/footprint. This Section of the report looks at the monitoring frameworks and techniques that are used to monitor koalas and vegetation in NSW.

To enable open data the NSW Government supports several repositories that contain data on threatened species and the environment. The data are used by landowners and regulatory agencies to support decision making. This includes data on animal locations/sightings, vegetation and habitat maps, etc. Much of these data are available through the NSW Government's SEED portal.[80]

The discussions in the previous two subsections – on categorisation of koala habitat, and representations of intensity and scale, are both relevant to discussion of data collection, monitoring and mapping.

[79] Australian Government (2018) Australia's State of the Forests Report
[80] https://www.seed.nsw.gov.au/

2.3.1 Koala monitoring framework

In July 2021, the NSW Koala Monitoring Framework[81] was released by EES, which was developed as part of the NSW Koala Strategy to determine the effectiveness of actions and provide overall structure for long-term koala monitoring in NSW.

The framework includes key metrics to understand various aspects of koala conservation management at a range of scales. This includes:

- Population dynamics (Statewide/regional/local)
- Koala habitat (Statewide/regional)
- Genetic diversity and functional genetic diversity (Statewide/regional)
- Disease and reproduction (Statewide/regional/local)
- Threats (Statewide/regional/local)
- Effectiveness of local projects/actions targeting threats (including research projects and management actions)

2.3.2 Koala surveys and records

The Koala Monitoring Framework describes the range of monitoring techniques that will be used, and include:

- **Community wildlife surveys:** This makes use of the citizen science allowing the collection of data, in this case koala sightings, over a range of locations and tenures.
- **Scat surveys**: Occupancy method that used Regularised Grid-based Spot Assessment Techniques (RGbSAT). There are well documented limitations associated with scat detectability such as rate of decay, exposure to rain and surface water and invertebrates. This method is prescribed to survey koalas in the proposed PNF Codes (in the case of the habitat mapping being questioned by a landholder).
- **Visual surveys (diurnal and nocturnal):** replicated diurnal and spotlighting transects that are used to determining the relative density of koalas. The technique is limited by topography, accessibility, and canopy density.
- **Passive acoustic monitoring:** *"Song meters have been used to monitor koalas over time, using estimates of detectability and the likelihood of occupancy"*[82] [83]*. Current algorithms are only effective at detecting male koalas. Passive acoustics are less effective outside the breeding season when bellows are less frequent".*[84] *"Passive acoustic monitoring is suited to regional/landscape rather than local-scale monitoring, but research is in progress to assess the capabilities of using local arrays of song meters for determining male koala density at site scales."*. This is the other survey method specified in the koala prescriptions.
- **Scat detection dog surveys:** This uses dogs to detect koala scats and is more effective than human scat sighting. It is limited by the cost of training the dogs as well as issues around topography and accessibility and well as the issues around scats described above.
- **Drone surveys:** Remotely piloted aircraft systems or drones are a method for detecting and surveying koalas. Thermal imaging is used to detect koalas. The method is limited by the temperature differential between the koala and ambient temperatures and at the

[81] DPIE (2021) NSW Koala Monitoring Framework: A statewide cross-tenure framework to monitor koalas
[82] Law, B., Caccamo, G., Roe, P., Truskinger, A., Brassil, T., et al. (2017). Development and field validation of a regional, management-scale habitat model: A koala Phascolarctos cinereus case study. *Ecology and Evolution*, 7, 7475-7489. 10.1002/ece3.3300
[83] Law, B.S., Brassil, T., Gonsalves, L., Roe, P., Truskinger, A. and 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), p.e0205075.
[84] Law, B.S., Brassil, T., Gonsalves, L., Roe, P., Truskinger, A. and 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), p.e0205075.

moment is limited to cooler times of the day/year, which tend to be Winter months between midnight and dawn.

Koalas are cryptic animals and are notoriously difficult to find and count. Each method has its benefits and deficits, and, in many cases, multiple methods are utilised and chosen depending on the objective of the monitoring. The methods are limited by a range of factors including, but not limited to, expense, resource-intensity, requirements for specific weather conditions and scale.

Further, surveys of koalas are often biased towards areas that are more heavily populated or frequented by humans. Generally, there are more koala sightings along roads and close to urban centres (i.e. close to where there are people to easily observe them). There are places in NSW that likely contain koalas but have never been surveyed due to issues around location/terrain.

The OCSE, in collaboration with EES, through the NSW Small Business Innovation and Research (SBIR) program, are supporting the development of innovative technologies to enable the rapid and effective quantification of the number and geographical extent of koalas in NSW.[85] Technologies and methods developed by this program have the potential to be procured by government to improve the monitoring and understanding of koalas in NSW.

Koala records from surveys are entered in NSW BioNet. The NSW BioNet is the repository for biodiversity data managed by DPIE. The aim of BioNet is to "*improve biodiversity outcomes by enabling the community and government to proactively manage and enhance biodiversity in NSW through comprehensive and robust information.*"[86]

Koala records in BioNet come from survey data (government, ecological consultants, research scientists and others (as part of the scientific licence procedure)), data from other agencies (e.g. FCNSW and Australian Museum), historical reports and the general public. All records entered into BioNet go through an automatic validation process where the record is validated against the accepted geographic distribution of the species. For threatened species such as the koala that accepted geographic distribution is based on IBRA subregions. Koala sightings in the BioNet repository are limited and are therefore unreliable as a single source of evidence for the presence of koalas. Issues with survey methods have been described above.

2.3.3 Koala habitat modelling and maps

Modelling can be undertaken to classify areas of suitable koala habitat and make maps that can be used in decision making. Different groups in the NSW Government have developed maps, these include:

- A map of North East NSW developed by the Forestry Science group within the NSW Department of Primary Industries (DPI, Regional NSW) ('DPI map')
- A set of seven regional maps across NSW developed by Environment, Energy and Science (EES) in DPIE as part of the state-wide Koala Habitat Information Base using regionally specific inputs. ('EES map')

Both models used to develop the maps use maximum entropy (MaxEnt) species distribution methods that rest on ecological niche theory.

2.3.3.1 DPI North East NSW koala habitat predictive map (DPI map)

Forestry Science within DPI have developed a regional scale koala suitability map for NE NSW.[87] This map was developed using koala occurrence records (from 1990-2015 from BioNet) and environmental variables (vegetation, browse trees, topography, fire, climate and primary productivity) at a 250 m spatial distribution. The browse trees information derived from the Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) from NSW NPWS (published in 2001).

[85] https://www.chiefscientist.nsw.gov.au/funding/research-and-development/small-business-innovation-research-program
[86] http://www.bionet.nsw.gov.au/
[87] Law et al (2017) Development and field validation of a regional, management-scale habitat model: A koala *Phascolarctos cinereus* case study. Ecology and Evolution 7:18, p7475-7489

The model was validated using independently collected field data – koala occupancy (acoustic sampling) and browse tree availability. The field validation demonstrated a linear increase in koala occupancy with higher modelled habitat suitability at ground-truthed sites. A site habitat quality index at ground-truthed sites was correlated positively with modelled habitat suitability.

Methodology to develop and validate the map are available in Law et al (2017).[88]

2.3.3.2 Koala habitat information base

Under the NSW Koala Strategy, DPIE developed a statewide Koala Habitat Information Base (KHIB). The KHIB provides spatial data on koala distribution, koala preferred trees and koala sightings for NSW. It provides information to assist government agencies, local councils and private land holders to make informed decisions about koala conservation. The data is publicly available on the SEED Portal.

The KHIB includes several layers of spatial information including:

- Koala Habitat Suitability Model (KHSM) – the probability of finding koala habitat at any location (EES map)
- Koala Tree Suitability Index (KTSI) – the probability of finding a tree species that koalas are known to use for food or shelter
- Koala Likelihood Map (KLM) including a confidence layer – predicts the likelihood of finding a koala at a location
- Areas of Regional Koala Significance (ARKS) – identifies key koala populations and management areas with potential for long-term viability as well as priority threats to key koala populations.
- Native vegetation of NSW – this is a high-resolution model of native tree cover and water bodies
- All koala sightings recorded in NSW BioNet[89]

The KHSM predicts the spatial distribution of potential koala habitat across NSW. It provides a measure of koala habitat suitability at any location. The model predicts the likelihood of finding habitat that is ecologically similar to where koalas have been observed over the past 40 years. Due to the variability in tree species use across the state each region has its own map/tailored model.

Full details on the development of the koala habitat suitability map is available in the Koala Habitat Model Technical Guide.[90]

[88] Law et al (2017) Development and field validation of a regional, management-scale habitat model: A koala *Phascolarctos cinereus* case study. Ecology and Evolution 7:18, p7475-7489
[89] http://www.bionet.nsw.gov.au/
[90] DPIE (2019) Koala Habitat Information Base Technical Guide

2.3.3.3 Habitat suitability map comparisons and limitations

The DPI and EES maps have been developed using similar methodologies to provide predictions of likely koala habitat. Both maps provide guidance to government and landholders on the likely location of koala habitat. A comparison of the features of the maps is in Table 7.

Table 7: Comparison of DPI and EES koala habitat suitability maps
Source: Remote Sensing & Landscape Science, EES, DPIE (pers comms)

Factor	DPI map	EES map
Scale	Covers NE NSW	Covers North Coast, Central Coast, South Coast, Northern Tablelands, North West Slopes, Central and Southern Tablelands and Western Regions
Suitability descriptors	High, Moderate, Low and not habitat	Very High, High, Moderate, Low, Very Low, no class
Resolution	250 m	5 m (30 m model), picking up individual scattered trees and fragmentated areas
Koala Occupancy/Presence	Wildlife Atlas (incorporated into NSW BioNet)	NSW BioNet
Tenure	All tenure	All tenure
Vegetation	CRAFTI (2001)[91] mapping	Koala Tree Index
Field validation	Yes	No
Released	2016	2019
Review	Published in peer reviewed journal (Ecology and Evolution)	Local expert review, academic peer review panel

There are several limitations and differences between the maps that is relevant for PNF, this includes:

- **Bias:** Both the models are based on koala records so there is an inherent bias to the spatial distribution of koala records. The models reflect the distribution of koala records, but don't necessarily reflect the distribution of koalas. This is important for PNF as it is less likely to have koala records on private land due to limited or no access by the public.
- **Habitat suitability classes and thresholds:** The DPI and EES models classify habitat differently with 4 and 5 suitability classes respectively (Table 7). Figure 6 compares the habitat suitability classes for both the DPI and EES models on the North coast on how habitat suitability relates to koala records in BioNet. For both maps the habitat suitability classes 0.4 to 1 cover ~90% of the koala records.

  The proposed triggers for koala protections in the proposed new PNF codes use the thresholds of >0.6 on the DPI model and >0.8 on the EES model. In the North Coast these thresholds represent:
  - For the DPI map, ~47% of koala records and ~278,000 ha (~10%)
  - For the EES map, ~38% of koala records and ~267,000 ha (~8%)

  The EES model is made up of a set of 7 regional maps using regionally specific inputs. The suitability value of 0.8 is not equivalent across these regions, because the value is a sliding scale within each region. For example, the 0.8 threshold on the EES North Coast map would only capture some of the 'very high' suitability areas and not capture any of the 'high' and 'moderate' suitability areas. It was noted by EES that it would be more appropriate to consider what suitability class is used as opposed to a single threshold.

[91] NSW National Parks and Wildlife Service (2001). Completion of GIS Products for the upper north east CRAFTI floristic layer: Lower north east RFA region. Unpubl. report, Coffs Harbour.

It was noted by the NSW EPA that "*the threshold used is set at a level that is excessively high for protecting koala habitat in PNF, where under the IFOAs, the threshold is set much lower to include moderate habitat (in combination with another map that further captures areas with moderate to high probability of koalas occurring). The IFOA also acknowledges the data deficiencies in the DPI map, and requires any cells missing data assume the value of the highest value koala's habitat. This appears to be lacking in the prescription proposed."*

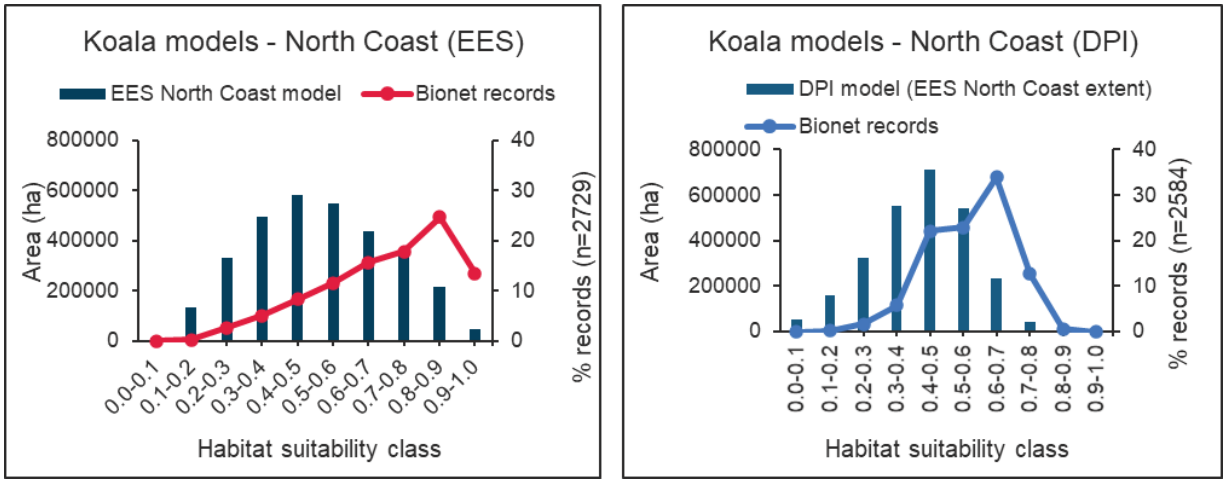


Figure 6: Comparison of distribution of habitat suitability class and koala records in EES koala habitat mapping and DPI habitat suitability model
Source: LLS pers comms

- **Resolution and coverage:** The resolution of the maps differs with 250 m for the DPI map and 5 m (30 m model) for the EES map. The difference in the resolution by both maps at equivalent thresholds is shown in Figure 7. The comparison of the maps demonstrates that they identify different patches of vegetation. The Figure shows that there are areas where the maps do not align and identify different habitat. In the Figure the EES map picks up the riparian vegetation on the right and not much of the patch of vegetation on the right edge, the pattern is different on the DPI map.

  Map coverage in ARKS is a key issue to ensure protection of key koala populations across NSW. Analysis by the NSW EPA found that the use of the DPI map and the 0.6 threshold "*would result in no prescription being triggered in many areas"* as identified as ARKS. For example, the Banyabba ARKS have been extensively studied by the NSW EPA and Dr Steve Phillips and Figure 8 shows that there are areas of the ARKS not covered by the DPI map.

  Further the NSW EPA (Appendix 5) found that ~175 PNF approvals where "*entirely outside of the North Coast outside of the DPI models footprint and a much larger number that have only partial coverage. A particularly concerning example of this is the area south of Kempsey around Kundabung within the Wilson River ARKS*" shown in Figure 9. *"In this instance neighbouring areas within the coverage under the DPI model have very high values triggering the prescription and the EES Koala Habitat Suitability Model, which does have model coverage across the areas concerned shows high and very high values*".

Table 8 shows the difference in the sites retained between the DPI and EES maps with them covering 51.2% and 61.8% respectively. Table 9 shows that the EES map covers a greater area of the PNF tenure than the DPI map.

An analysis by NSW EPA compared the DPI map and the EES map coverage in the North Coast KMR. The moderate to very highly suitable habitat is separated by the EES thresholds. Table 10 shows the percentage of the habitat in and out of the prescription areas as defined by the DPI map (>0.6 threshold) within all the North Coast KMR ARKS. Table 11 provides the same information but broken down by the ARKS. Overall, 83.1% of moderate to very highly suitable habitat is outside the prescription area.

- **Vegetation:** The underlying vegetation mapping used in the models for the DPI and EES maps differs.
    - DPI map: Uses a broad scale vegetation map for the North Coast – CRAFTI mapping that was developed in ~2001.
    - EES map: a continuous index of koala trees as the vegetation predictor. Developed at 30 m it predicts the likelihood of finding a tree species at any location that a koala is known to prefer. The tree species that contributed to the tree species index was tailored to each koala modelling region through expert consultation and literature review.

Both maps provide an important tool for decision makers and landowners to help identify possible areas of koala habitat. They can be used to guide survey effort or in the case of the PNF Codes guide where precautions should be undertaken in relation to koalas. Neither map is perfect, each map has strengths and weaknesses. Both maps need to be updated regularly to ensure that they provide the best and most up to date information, including post fire, post-harvesting where suitability score has changed. Consideration could also be made to whether the maps could be combined to provide a single open mapping source for koalas in NSW.

Neither of the maps currently considers habitat fragmentation or important koala corridors, which are particularly important in the context of fragmented habitat on the PNF estate. As koalas live on fragmented habitat on private land, corridors are particularly important. EES have proposed the development of a Koala Priority Survey Map to identify important koala habitat for survey investigation.[92] The current available maps do not consider habitat fragmentation and the Priority Survey Map aims to identify potentially important koala corridors for investigation. The identification of koala corridors is important as they are critical habitat for the movement of koalas across the landscape.

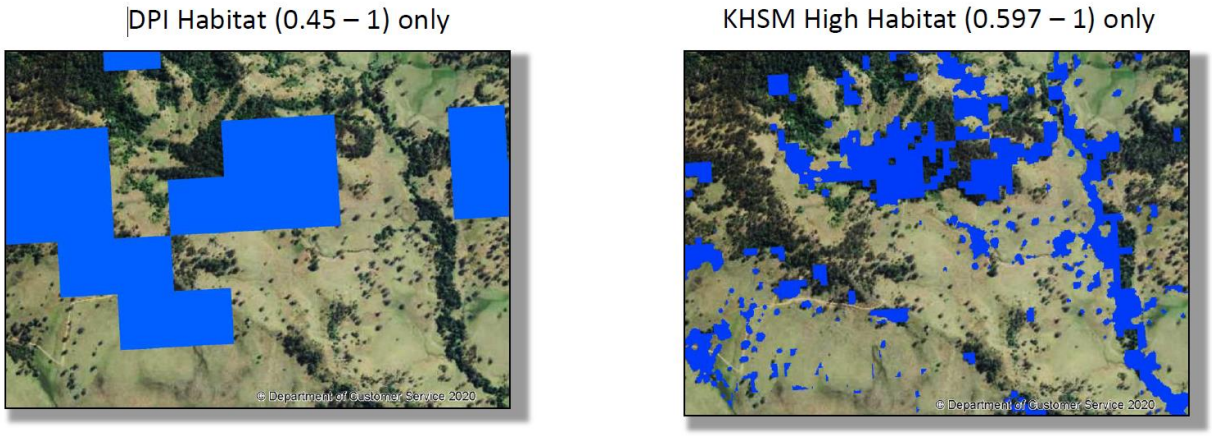


Figure 7: Comparison of the DPI and EES maps
Source: EES pers comms

[92] Remote Sensing & Landscape Science, EES, DPIE (pers comms)

Table 8: Comparison of koala sites retained in the North Coast KMR

	Number	% sites
Total koala sites	25,478	100%
DPI map	13,040	51.2%
EES map	17,345	68.1%

Source: EES pers comms

Table 9: Comparison of total area of PNF retained (June 2020) in the North Coast KMR

	Area (ha)	% PNF tenure
PNF Tenure	380,953	100%
DPI map	339,135	89.02%
EES map	366,610	96.23%

Source: EES pers comms

Table 10: Total Moderate to Very Highly Suitable Habitat (based on EES mapping) in relation to current prescriptions and the ARKS in the North Coast KMR

Habitat Suitability	Outside Prescription Area	Prescription Area
Very High	67.8%	32.2%
High	81.2%	18.8%
Moderate	89.8%	10.2%
Low	92.6%	7.4%
Very Low	94.2%	5.8%

Source: NSW EPA pers comms

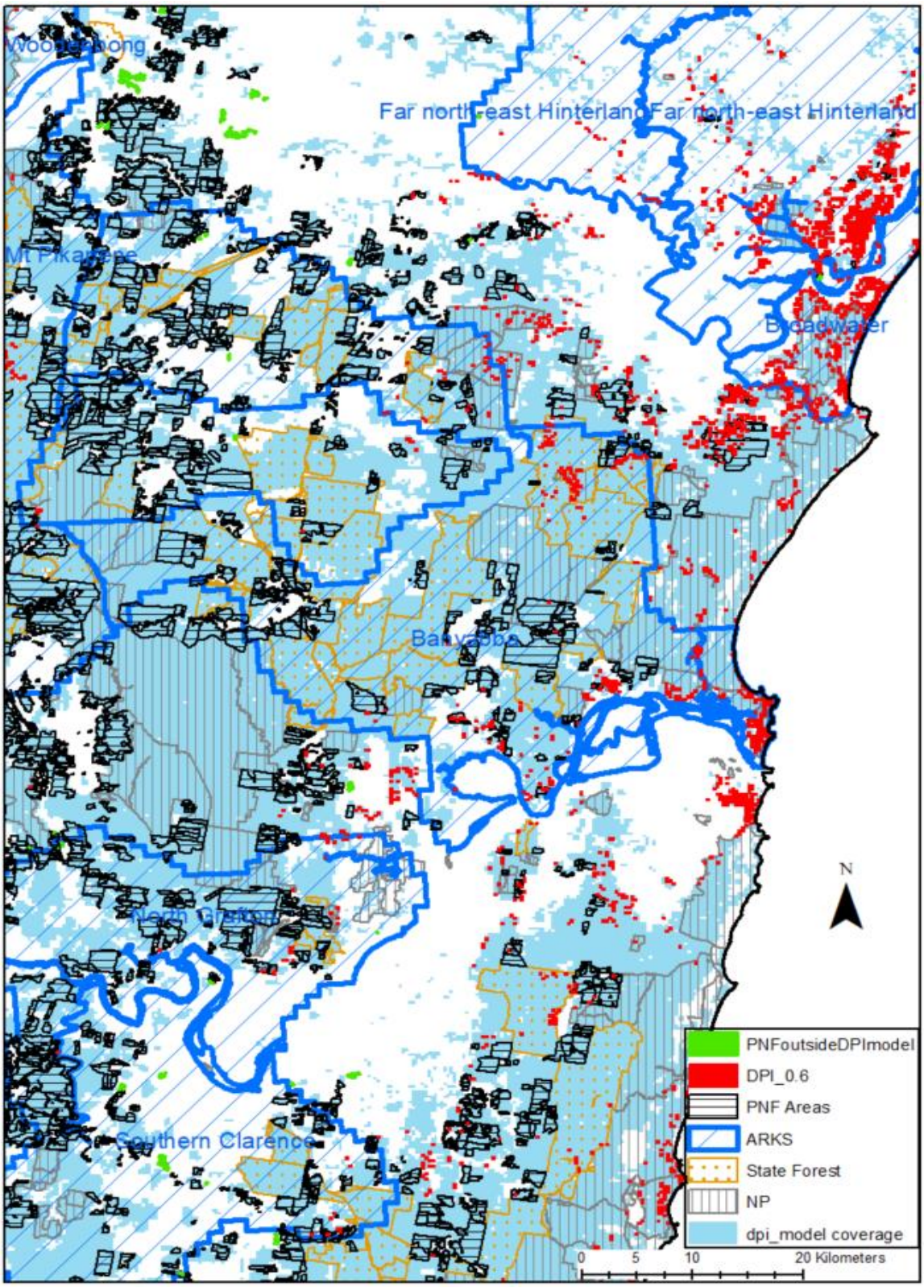


Figure 8: DPI Model coverage of the Banyabba ARKS
Source: NSW EPA pers comms (Appendix 5)

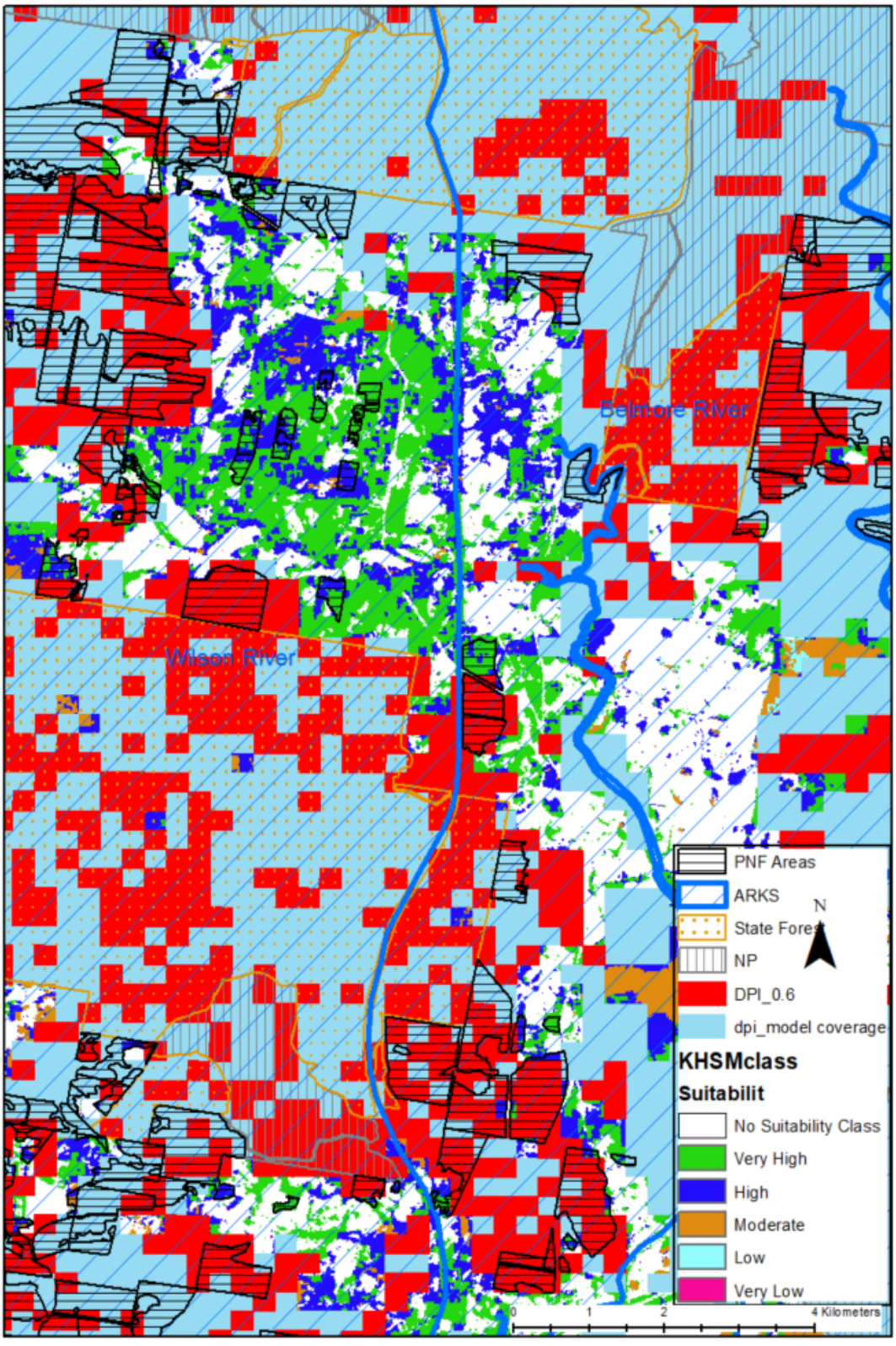


Figure 9: Coverage limitations of the DPI model for PNF properties - Kundabung are of Wilsons River ARKS

Source: NSW EPA pers comms (Appendix 5)

Table 11: Percentage of Moderate to Very Highly Suitable Habitat in relation to the proposed prescriptions in each of the ARKS within the North Coast KMR

ARKS	Outside Prescription Area	Prescription Area
Banyabba	98.3%	1.7%
Barrington	88.1%	11.9%
Belmore River	73.6%	26.4%
Broadwater	71.2%	28.8%
Clouds Creek	75.3%	24.7%
Coffs Harbour - North Bellingen	69.5%	30.5%
Comboyne	67.9%	32.1%
Crowdy Bay	64.4%	35.6%
Far north-east	54.8%	45.2%
Far north-east Hinterland	89.2%	10.8%
Gibraltar Range	100.0%	0.0%
Girard - Ewingar	96.8%	3.2%
Hawks Nest	81.5%	18.5%
Karuah - Myall Lakes	85.1%	14.9%
Khappinghat	64.7%	35.3%
Kiwarrak	89.5%	10.5%
Mt Pikapene	99.8%	0.2%
North Grafton	99.5%	0.5%
North Macleay - Nambucca	84.6%	15.4%
Nowendoc	88.6%	11.4%
Port Macquarie	50.6%	49.4%
Southern Clarence	99.9%	0.1%
Tweed Coast	47.6%	52.4%
Tweed Ranges	85.6%	14.4%
Wallingat NP	85.0%	15.0%
Wang Wauk SF	91.5%	8.5%
Wilson River	75.9%	24.1%
Woodenbong	92.8%	7.2%

Source: NSW EPA pers comms

2.3.3.4 Likelihood map

The KHIB includes the KLM which provides a likelihood estimate of finding koalas based on arboreal mammal records (e.g., gliders and possums). As described in the KHIB Technical Guide the "*use of records for other arboreal species provide a measure of survey effort independent of koalas and allow identification of areas where other arboreal mammals have been recorded, but not koalas*".[93] As seen Figure 10 grids across the state are assessed and a likelihood of koalas being recorded is determined. In addition, there is a confidence layer that represents the relative confidence in the likelihood estimates (Figure 11). "*The level of confidence is as important as the likelihood estimate because it indicates how confident we are in the likelihood of koala occurrence and whether more data should be obtained to increase our confidence*." That is where survey effort can be directed.

[93] DPIE (2019) Koala Habitat Information Base Technical Guide

The KLM was originally developed in 2014 for PNF regulation for the EPA.[94] This map could be used by regulators to see where further information is needed for areas slated for forestry and development.

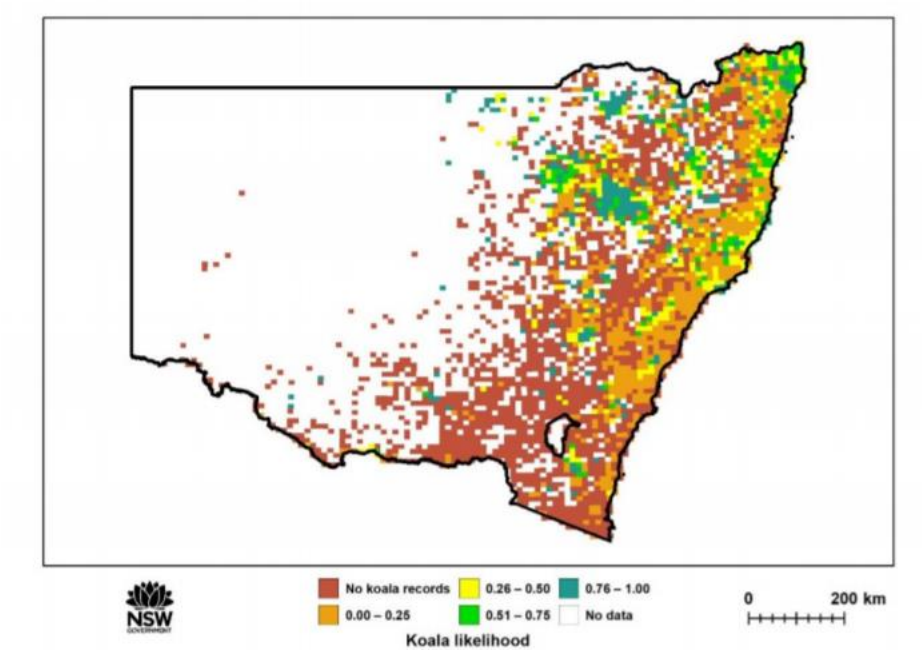


Figure 10: Illustration of the Koala Likelihood Map (KLM) v 2.0 (August 2019) likelihood layer
Source: DPIE (2019) Koala Habitat Information Base Technical Guide

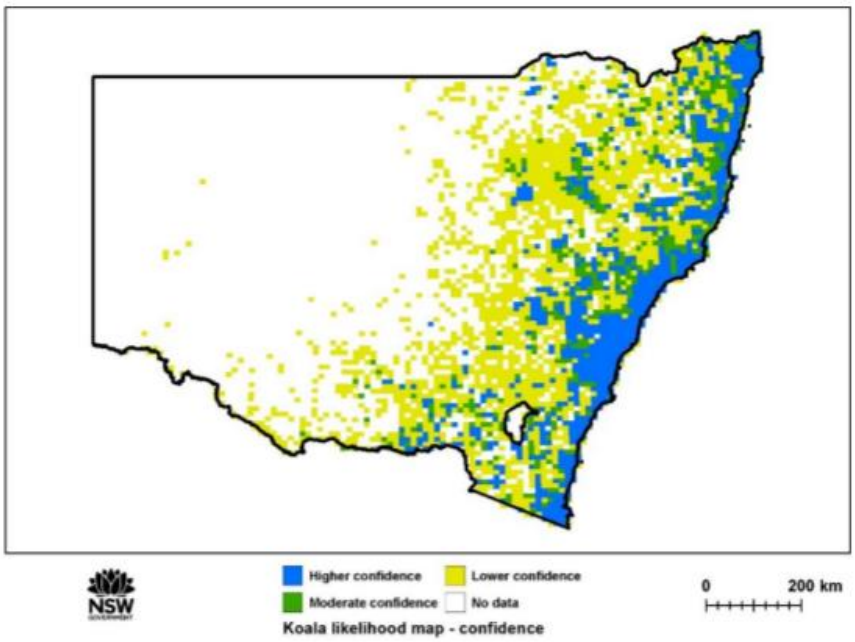


Figure 11: Illustration of the Koala Likelihood Map (KLM) v 2.0 (August 2019) confidence layer
Source: DPIE (2019) Koala Habitat Information Base Technical Guide

[94] https://datasets.seed.nsw.gov.au/dataset/koala-likelihood-map-v2-0-august-2019

2.3.4 Forest monitoring

The NSW government is committed to ESFM across all tenures under the *NSW Forest Management Framework*. Koala occupancy is captured by ESFM along with a suite of forest values, including environmental, social, economic and cultural values. Tracking the status and trend of these forest values is essential for ongoing forest management and to understand whether NSW is on track in achieving its ESFM commitments.

Continued forest monitoring will now occur under the NSW Forest Monitoring and Improvement Program (FMIP), which is part of the NSW Koala Research Plan as part of the NSW Koala Strategy.[95] The FMIP aims to deliver information and evidence to support the strategic management of forests and forest practices in NSW across tenures (including state forests, national parks, private native forests, private conservation forests and crown forested land). The FMIP will be targeted towards improving the adaptive management of forests and provide independent advice to forest managers in NSW on how policies and on-ground management can be improved, through the evaluation of forest monitoring data and research[96].

The FMIP will be overseen by the NRC and supported by a funding commitment of $9.2 million over four years to support the design and establishment of monitoring and evaluation program.

2.3.5 Vegetation change

Landcover in NSW is monitored and reported on an annual basis by the NSW Government through the SLATS program.[97] Satellite imagery and subsequent analysis is used to detect vegetation changes including due to agriculture, infrastructure, and forestry. This SLATS data is used by LLS as a proxy estimate for the extent of PNF harvesting occurring in NSW.

Analysis of SLATS data by EES has shown that 2,037 ha (466 ha Very high and 1,571 ha of Highly suitable habitat) was removed between January 2019 to 2020. It is noted that this is likely an underestimation of what has been harvested through PNF due to limitations in the resolution of the satellite imagery. It was noted to the Review that the pixel size is ~10x10 m which may not pick up selective logging as undertaken by PNF. The satellite will likely pick up areas cleared for log dumps or more intensive operations.

The Koala Monitoring Framework monitors the changes in koala habitat over time this uses the SLATS in conjunction with the Koala Habitat Suitability Model (EES Map), the Koala Likelihood map, the ARKS, core koala habitat mapped in CKPoMs and koala refugia.[98] Disturbances due to fire is also accounted for using fire extent and severity maps. Gains in habitat will be determined through the creation and protection of habitat through revegetation and purchases.

[95] OEH (2019). *NSW Koala Research Plan 2019-28 – A 10-year plan under the NSW Koala Strategy*
[96] NRC, NSW Forest Monitoring and Improvement Program (2019). Program Strategy Draft for Consultation
[97] https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/landcover-monitoring-and-reporting/woody-vegetation-change-statewide-landcover-tree-study/more-about-slats
[98] DPIE (2019) Koala Habitat Information Base Technical Guide

Recommendation 1: LLS, EPA, EES and DPI work together, with an expert impartial convenor and group of experts to derive common agreement on fundamental information:

A. **Agreement on facts** – Openness, transparency and aligned methods in measuring, modelling, mapping, reporting and data collection and handling so disagreement about the factual basis of decisions can be avoided.

B. **Agreement on metrics** – Transparency and common understanding between both portfolio agencies about what data, modelling, standards and thresholds may be required for Ministers to be able to provide concurrence on PNF matters into the future. The relative prioritisation and other information should also be considered by portfolios as relevant, but a shared understanding and data collection approach will assist in decision making. This includes a common understanding and agreed approaches to incorporate climate change considerations into planning and management, which also will improve into the future.

Recommendation 2: To assist in delivering on Recommendation 1A, DPI Forestry Science, LLS, EPA and EES should collaborate on koala habitat maps to ensure consistency in mapping products that are available for regulators and landholders. DPI Forestry Science, LLS, EPA and EES should work together to find solutions for uncertainty and inconsistencies, and the consequences when it comes to developing maps.

3 Proposed PNF Codes and koala protections

The proposed PNF Codes of Practice (new PNF Codes) have been revised to change the reach and triggers of prescriptions for koalas and when finalised will decouple them from the koala SEPP. It is noted that the proposed new PNF Codes have not been finalised and are still subject to negotiation.

The proposed PNF Codes include prescriptions on how koala habitat is identified and surveyed, tree retention and how these are triggered, koala exclusion zones, list of primary and secondary trees in each region, and koala management processes.

The major changes between the current and proposed PNF Codes are (Appendix 3):

- increase in intensity of allowable silviculture moving to average stand basal area remaining values of between an average of 8 m^2/ha in Western Hardwood forests, 10 m^2/ha in Northern NSW and 12 m^2/ha in Southern NSW and River Red Gum forests, and removal of the requirement that half measurement sites for the average minimum basal area should be greater than the average value
- removal of the approximately 6,000 ha of habitat that was previously not able to be harvested as they were approved core koala habitat under koala SEPP 44
- prescriptions on approximately 1.2 million ha of highly suitable koala habitat, that include:
    - locations mapped using either the DPI or EES mapping methodologies, depending on region
    - the requirement for visual assessment of trees for koala occupancy immediately prior to being felled
    - the expanded tree species list for primary and secondary koala use, from which 10 primary and 5 secondary trees should be retained per hectare
- noting that whilst it does not directly impact koalas, the pre- and post-notification of forestry operations within the proposed PNF Codes could have an impact on koala prescriptions.

As a high-level comment, while the Review was asked to provide advice on robustness of protections for koalas in the proposed PNF Codes in areas of high value koala habitat, the Review was not provided with modelling or information on the possible impact of the changes in the PNF Code for koalas, nor analysis of robustness of koala protections with the current PNF Codes. The Review did receive copies of the four draft PNF Codes, to assess the measures, the changes and processes proposed in regard to koala prescriptions.

The Review has been asked to give advice on whether the protections for koalas in areas of high value koala habitat are robust under the proposed PNF Codes. This aligns with a risk assessment approach, with a view on the level of risk or hazard to koalas (silviculture intensity and scale), the risk tolerance of this threat (level of importance of the koala habitat), and the risk mitigation tools being deployed (prevention, planning, regulations and monitoring).

The Review has mentioned in the previous chapter the benefit that would accrue for reaching a common understanding between agencies on a number of definitional and factual elements, and these are further described in the findings and Recommendation 3. Developing a process to achieve:

- an agreed set of definitions of important and high value koala habitat as well as low intensity and high intensity forestry,
- a shared understanding of the factual data and mapping techniques, and
- a shared understanding of what information each portfolio would depend upon to make a decision on concurrence

would provide a common platform from which to debate, and negotiate positions and outcomes, and to discuss the scope and structure of regulatory protections.

In finalising the report, the Review does not have the benefit of having LLS and EPA land on agreed positions for intensity and data etc, and so provides comment on the balance of the information before it, with advice from independent experts and information from the literature. As described in Section 2.1.1.2, the Review has set out key attributes that describe high value and important habitat and uses this to assess the adequacy of prescriptions and protections. In some situations, there are very clear improvements that can be made, in other cases, the situation is not as clear.

A key setting for this review is the certainty and consistency requirement for primary producers, these attributes are described by the Review in the context of systems and processes that can improve these and stochastic events that can work against these. There is a potential tension between the stated need to provide certainty and consistency approach for primary producers balanced against the protection of environmental values which vary spatially and temporally. Habitat differs greatly in different locations, in some places dry and low fertility, in others wetter with high fertility, soil fertility, altitudes vary. Some locations in some parts of the state have less fertile and lower suitability forests than others, yet these locations still support important koala populations. A one-size-fits-all approach is therefore not ideal.

PNF approval conditions that are reflective of the environment and ecosystem they are being applied to could come through the PNF Code settings and limits however the proposed new PNF Code is aiming for a simple general rule set across all private forests in each PNF Code area to be applied no matter what the conditions because it makes compliance easier. So in that case, to avoid a one-size-fits-all approach, the onus rests on LLS to provide the expert directions and guidance, including when approving PNF Plans to have a stronger eye to the specific conditions settings and intensity.

3.1 Basal area limits and the draft proposed PNF Codes

The proposed new PNF Codes include changes to the retained basal area:

- for areas subject to STS and thinning forestry operations, the operations must not reduce the average minimum basal area below 10 m^2/ha (Northern NSW), 12 m^2/ha (Southern NSW, which includes RRG) and 8 m^2/ha (Western Hardwood forests) compared to the current PNF Codes (Table 4)
- removing the different classifications of stand height i.e., greater than or less than 25 m stand height. This change reflects the conclusions of Dr Brack, that there "*seems to be no ecological support for the 25 m stand height threshold*" and that the "*removal of stand height classification therefore is an obvious opportunity to reduce compliance risk*".[99]
- that all forestry operations must have no more than 25% of sampling points having a basal area below 7 m^2/ha (Northern NSW) – and an addition change that removes the requirements from the current Codes where 50% of the sampling points must be above the average minimum basal area.

The greatest change would be for tall stands in the proposed Northern NSW PNF Code, as this would be a reduction from 18 to 16 m^2/ha (current PNF Code), down to 10 m^2/ha under the proposed PNF Code.

Basal area changes are of interest to the Review as they are a surrogate for changes in the koala habitat: a reduction in the basal area (both amount and the proportion of the total basal area) could lead to differences in the habitat for koalas. Basal area also correlates well with other factors that could impact koalas preferred trees, such as tree competition and water use within a forest.

[99] Brack, C, Cabinet in Confidence document, provided to the OCSE in 2020.

LLS commented that a 10m^2/ha or lower basal area may be required in places where there is 'high grading' within PNF where inappropriate forest management has been undertaken and only the best trees were taken, and so in these cases sometimes the best option is to remove a maximum amount of stems and initiate vigorous regeneration.

Reflecting on this, the Review notes that this highlights the need for properly planned and implemented and managed forestry systems to avoid poor outcomes from practices such as high grading – if the forestry management is undertaken in a manner that leads to a condition where the best or only way forward is to remove as much basal area as possible, then the management has arguably failed.

There are silvicultural choices available to get a range of outcomes whilst also protecting the environmental values, and these can be used to promote outcomes such as straight poles, large habitat trees, complex habitat, these are all possible with outcomes-focussed planning.

Work by Jay (2017)[100] and Jay and Dillon (2016)[101], agree that there has been high grading with PNF in the North Coast. While the proportion of commercial species was relatively high, the proportion of high-quality timber was low and not evenly distributed. Jay (2017) surveyed trees and plots on private property in North Coast and provides histograms of the distribution of tree sizes and of plot densities by median stand basal area, see Figure 12. Reflecting on these data (in the 2017 report from forest stands measured in up to 2013), the percentage of forests in the KMR with a basal area less than 10 m^2/ha is approximately 8% of the full list of stands. For multi-aged forests, 80% of their stands are above 20 m^2/ha stand basal area.

The locations which might experience some of the greatest change under the proposed PNF Codes revision of forestry basal areas limits, are those where there is a large proportion of stands with dominant species above 25 m stand height (Figure 13). As modelled by DPI, those sites in the Northern NSW PNF Code region that have an index value of 25 m or greater in height represent approx. 31% of the private estate (Figure 14).

However, the distribution of heights varies considerably location to location. For example, within the ARKS in the North Coast KMR, with the North Bellingen – Coffs Harbour ARKS that are 76.3% above 25 m high vegetation, nearly 85% above 20 m (as measured by Landsat/GEDI[102],[103]) (see

[100] Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI
[101] Jay, A and Dillon, A., Modelling the outcomes of different silvicultural approaches in the private native forests of north-eastern New South Wales, Australian Forestry, 79(2), 85-95
[102] Appendix 5
[103] Potapov et al., (2021) Mapping global forestry canopy height through integration of GEDI and Landsat data, 253

Table 12 and Figure 13). Therefore, the North Coast ARKS would be subject to a greater change in basal areas limits under the proposed PNF Codes.

These locations of high koala importance would be faced with extraction levels under an FOP arrangement, down to an average minimum basal area of 10 m^2/ha, which as demonstrated by Jay (2017)[104] is rarely seen across the area; 8% of all stands had a basal area this low. A FSP could be even lower as it would permit forestry to occur at lower than the minimum average limit if approved.

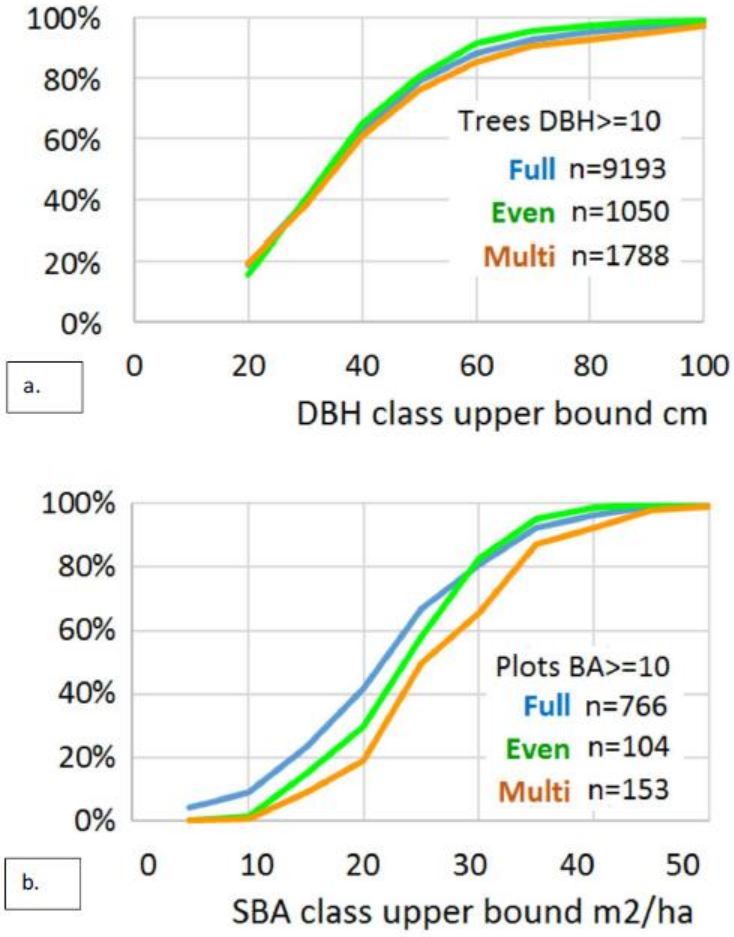


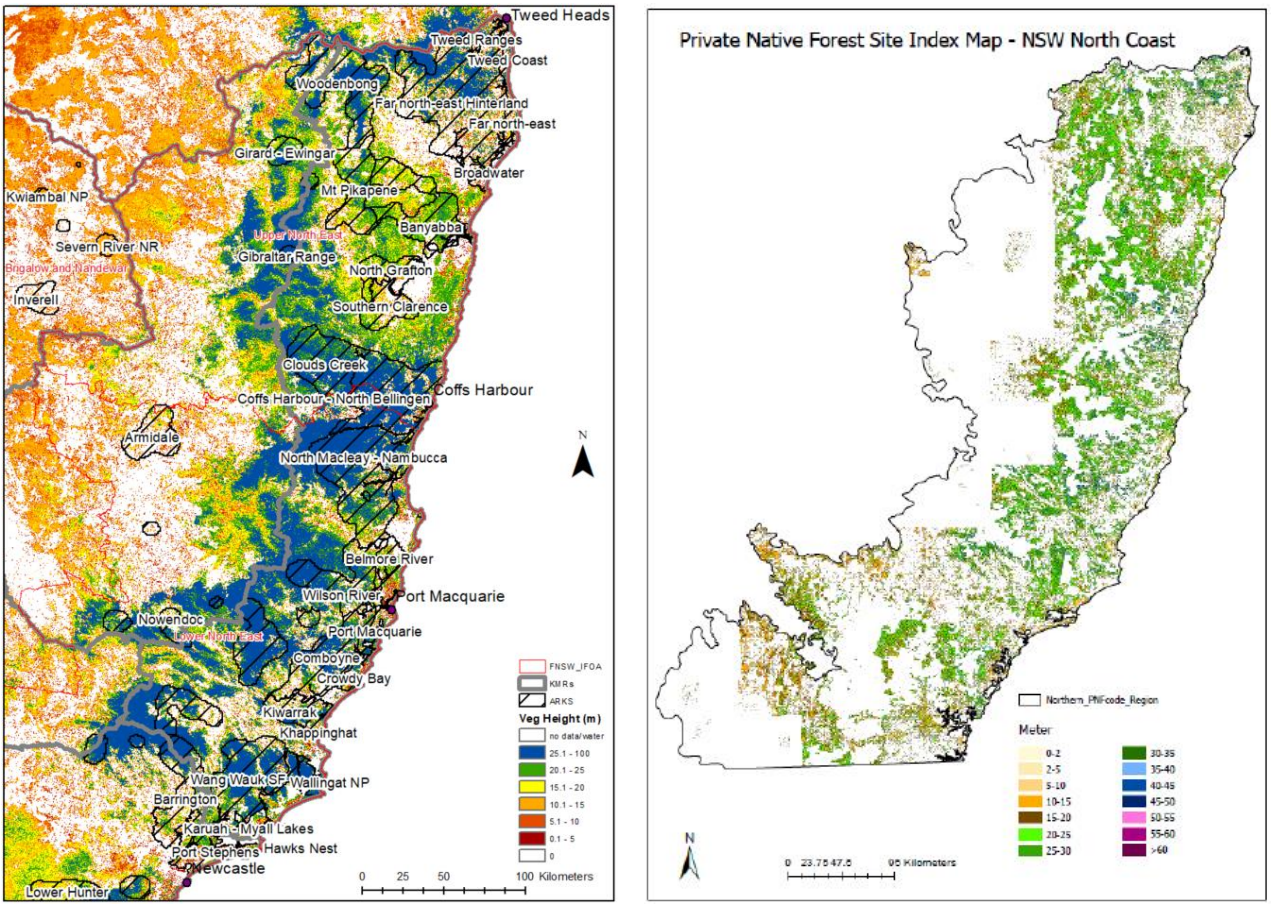
Figure 12: Distribution of tree sizes and plot densities in the data

a) Cumulative frequency of sampled tree sizes in 10 cm DBH intervals and
b) cumulative frequency of plot SBA in 5m2/ha intervals.

Cumulative frequency is plotted against the maximum of the class interval. Hence the lines show the percentage of sample trees or points which are less that the value read on the horizontal axis.

Source: Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI

[104] Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI



A) B)

Figure 13: A) NSW North Coast regions showing KMRs (grey border), and ARKS (Black lined sections) and illustration of vegetation high measured using Landsat/GEDI. Blue areas have been measured at >25 m tall and green areas at between 20 and 25 m tall (noting that the measurement technique underestimates height), developed by EES and EPA. B) Site index map of forest for private properties within the Northern NSW PNF Code region, developed by DPI. (Note: the higher the value, the higher the site index)

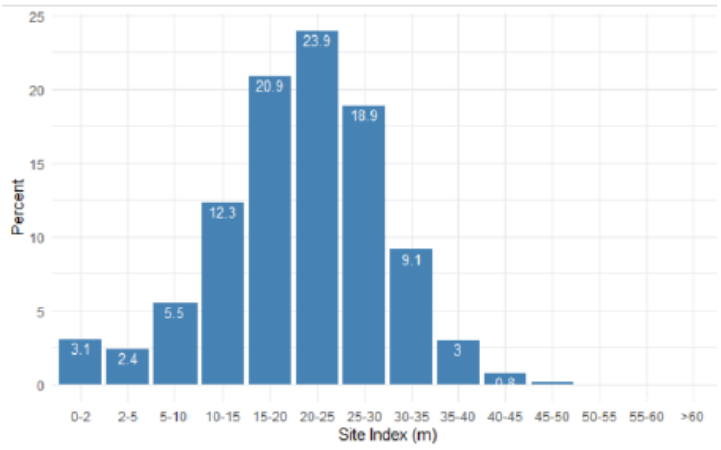


Figure 14: Percentage of private property by site index class in Northern NSW PNF Code region (DPI data) (Refer to Figure 13 for extent of mapping)

Table 12: Tree heights (20 m and 25 m) in the North Coast KMR

Height	NE NSW	NC KMR	PNF areas ARKS NE NSW	PNF areas ARKS NC KMR	North Bellingen - Coffs Harbour ARKS	Banyabba ARKS
Median	21m	24m	23m	23m	31m	21m
<25m	66.2%	53%	58%	56%	23.7%	92.9%
>=25m	32.8%	47%	42%	44%	76.3%	7.1%
<20m	43.8%	28.5%	21.4%	20.8%	15.3%	35.4%
>=20m	56.2%	71.5%	78.6%	79.2%	84.7%	64.6%

Source: NSW EPA pers comms (Appendix 5)

3.1.1 Requirements in minimum average basal area

The EPA guidance[105] document for the current PNF iterates that when calculating stand average basal area limit, no more than half of the sampling points in the relevant operational area can be below the minimum limits in the current PNF.

However, in the proposed new PNF Codes, there is no requirement that 50% of basal area measurements need to be above 10 m^2/ha, meaning that a contiguous stand could be harvested with stand basal area measurements, for example 6m^2/ha (25%), 8m^2/ha (62%), 30 m^2/ha (13%)[106] and still be within the PNF Code requirements. This is illustrated in Figure 15.

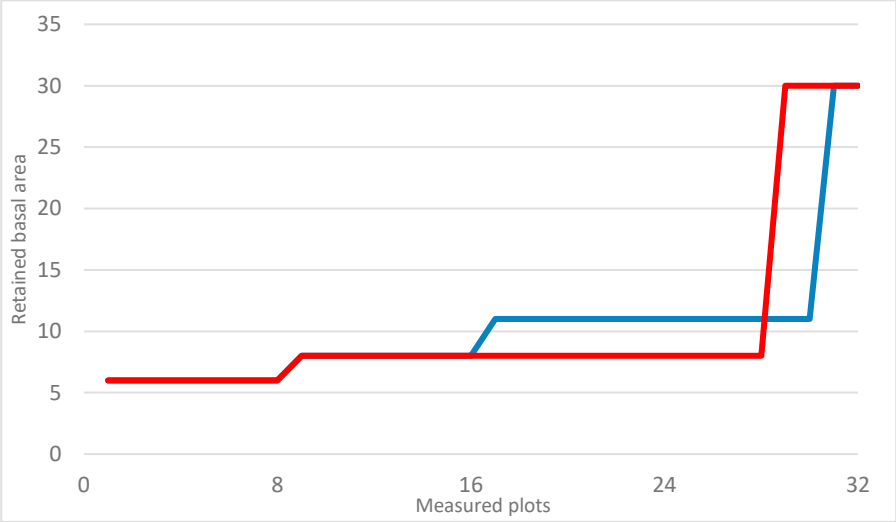


Figure 15: Hypothetical forestry operations scenarios of what basal areas could remain under the proposed PNF Codes (red) compared to the current PNF Codes (blue).
It is noted that the requirement for no more than 25% of plots are below 7 m^2 basal area (y-axis) and the current PNF Code requirement that 50% of the measured plots (x-axis) must have a basal area above the minimum average basal area (10m^2)[107]

The above hypothetical situation in Figure 15 has been illustrated to demonstrate potential consequences of not having the 50% above mean attribute of the basal area in the proposed PNF Codes. The Figure shows the difference between the proposed new PNF Codes (with the proposed prescription of no more that 25% of plots below a basal area of 7 m^2/ha, with (blue) and without (red) the 50% basal area prescription. Note, the values chosen include 6 m^2/ha (i.e., below 7 m^2/ha for both scenarios) and the upper limit of 30 m^2/ha was chosen based on literature

[105] EPA (2013) Private Native Forestry Code of Practice Guideline No.5, Techniques for Measuring Stand Basal Area
[106] The Review have used the upper bound of 30 m^2 per ha, as work by Jay (2017) shows that approx. 79% of measured plots in the upper north-east NSW private native forests had a stand basal area of less than 29.9 m^2 per ha
[107] Note, this is a hypothetical example that uses 32 data points, thus allowing 8 data points to be within the lowest quartile (as per the proposed prescriptions, no more than 25% below 7 m^2/ha)

(evidence from Jay (2017) indicates that '*more than 70% of the full list of plots had stand basal area between 10 and 29.9 m^2 ha^{-1}*').[108]

The Review notes that advice provided to LLS indicated that removing the requirement of 50% of measurement sites being above the average minimum basal area is due to the distribution of basal areas within an area (the assumption of a normal distribution versus realistic skewed distributions), and the difference between the mean and median. It was stated that this could result in the minimum stand basal area threshold (for example, 10 m^2/ha in Northern NSW under the proposed PNF Codes) becoming a limiting factor on the lesser of these statistical measures, whilst the other measure would still require a higher basal area: i.e., although the mean may be 10 m^2/ha, the median may have to be higher than that. Conversely, in the removal of this prescription, it could lead to a perverse outcome of a greater number of measurement points with removal below the average basal limit, whilst still achieving the minimum average basal area stand requirement via 'offsets' from measurement points that have a very high basal areas (for example, the points at the right of the Figure). The hypothetical example illustrated above leads to an effective basal area of 8m^2/ha or less over 87% of the stand.

Recommendation 3: Median and mean values for basal area are both important and can help avoid offset logging-like outcomes, where a small area of forest is kept at a very high density, and the remainder is cut well below the average minimum residual basal area level presents a risk for habitat. A level such as 50% of land should remain at a basal area above the average minimum basal area level.

Basal area limits under FSP

The proposed approach of allowing FSPs to be developed with the approval of both LLS and EPA is also relevant to discussions of the minimum average basal area. In this case, FSPs would potentially allow landholders to extract to levels below the minimum average basal area. LLS has explained that this would allow flexibility to ameliorate previous PNF issues.

LLS commented that a 10m^2/ha or lower basal area may be required in places where there is 'high grading' within PNF where inappropriate forest management has been undertaken and only the best trees were taken, and so in these cases sometimes the best option is to remove all stems and initiate vigorous regeneration.

Reflecting on this, the Review notes that this highlights the need for properly planned and implemented and managed forestry systems to avoid poor outcomes such as high grading – if the forestry management is undertaken in a manner that leads to a condition where the best or only way forward is remove as much basal area as possible, then the management has arguably failed.

There are silvicultural choices available to get the outcomes wanted, and these can be used to promote outcomes such as straight poles, large habitat trees, complex habitat, these are all possible with outcomes-focussed planning. The approach of the proposed PNF Codes sets an average basal area, with a maximum percentage (25%) allowed to be below a value (7 m^2/ha in proposed PNF codes).

3.1.2 Outcomes based approach

In both the report by Brack and Vanclay's review for the CSE the authors discussed their preference for an outcomes approach to PNF. In terms of habitat and biodiversity, there are some species that benefit from dense vegetation. While the two reports of Brack and Vanclay did discuss the benefits of more timber extraction to promote regeneration, and a 10 m^2/ha basal area assists that, they both discussed an approach that was more nuanced (Appendix 3).

In the PNF report by Brack, he states:

[108] Jay, A (2017) Condition of NSW North Coast Private Forest, report to the NSW DPI

> *"However, there are situations when different levels of density reduction conflict with different management objectives, and so, it is important to consider the primary management objectives when determining desired post-harvest density."*

Vanclay in his peer review commented:

> *"Forward-looking leads to questions about any endangered fauna and flora* (sic)*, the key environmental services, and what habitat supports these animals, plants and services. Forward-looking may lead to a realization that simply monitoring basal area is neither necessary nor sufficient to provide the habitat or services desired. This distinction is important, because a major limitation of using basal area to infer forest condition is that basal area reflects the 'crowdedness' of a forest, but not the health or the potential of a forest."*

Vanclay also stated:

> *"I would prefer that any harvesting addressed the biodiversity, habitat and environmental services of each specific stand, rather than advocating for some theoretical size distribution."*

There is a lack of certainty and potentially lack of rigour in how prescriptions would be triggered due to the FOP and FSP map development process:

- there is no requirement for expert input (either silvicultural or environmental expertise) into the development of the FOP (noting that the FSP is developed by either LLS or an accredited expert in conjunction with the landholder),
- LLS doesn't approve FOPs (the onus is on the landholder to ensure that their FOP reflects the PNF Plan and complies with the PNF Code), nor see the FOP prior to or after forestry operations (unless requested)
- FOPs can be amended by the landholder, without notification, within the PNF footprint and within the code limits and may change between thinning, STS and AGS methods
- PNF Plans, FOPs and FSPs do not go on public display, unlike development approvals.

It should also be noted that the Review was informed by stakeholders that the FSP pathway is still subject to ongoing legalities that are outside the scope of this work. The Review has not made further comment on this matter.

The Basal Area limits under the proposed PNF Codes set a lower limit (although not a fixed limit as explained in 3.1.1) for the intensity of forestry that can occur on a landholding. The prescriptions for the silviculture include the mitigating measures that a landholder must take to reduce the harm to certain features on the land if the prescriptions are triggered, including to koala habitat amongst other things. Forestry and koala prescriptions are discussed in the following sections, followed by a discussion of the regulatory and compliance approach to ensure alignment of activities with the PNF Codes, and finally discussion of certainty and consistency.

3.2 Prescriptions in forestry operations

3.2.1 PNF Plan stage

The PNF Plan establishes the boundaries of the area of forest on the landholding that is subject to silviculture, over a 15-year period. Over that time period, when the landholder is ready to move forward, a FOP is developed by the landholder (or their forestry consultant). This sets out the spatial harvesting regime for the forestry operation. This FOP may be amended from time to time by the landholder, with increased or decreased extraction across the area under the PNF Plan. However, it cannot extend outside of the approved footprint, and must stay within regulatory limits (as set out by the PNF Codes). Further, PNF cannot be undertaken on certain tenures and forest types (e.g., PNF can't occur in old growth forests or rainforest etc).

In terms of the regulatory approach to scale beyond the landholder's property, as may be exercised by LLS or EPA, there are no apparent scale restrictions to the extent of PNF operations that can be approved on private land by LLS – between neighbours or across contiguous properties in valleys, etc. The proponent and LLS don't need to consider the wider regional scale impacts, if multiple landowners in a locality all apply for forestry approvals, or whether the properties surrounding the applicant are already cleared as farmland etc. However, LLS will inform the proponent if a koala has been reported within 500 m of the property and will update threatened flora and fauna records at the preharvest notification stage. The intensity of neighbouring and sometimes contiguous PNF Plan approvals is illustrated in Figure 16, showing locations near Broadwater, Royal Camp and Banyabba.

At the application phase of the PNF planning under the proposed PNF Codes, the proponent develops a PNF Plan, with input information and data from LLS, with the landholder being the responsible party. Input information includes location of koala records and koala habitat mapping within the property, although the landholder wouldn't be provided with equivalent information or mapping of habitat outside of and adjacent to the property (See Figure 3).

In considering the landholder's forestry footprint vis-à-vis neighbouring land there are no apparent process steps or restrictions to the extent of PNF operations over a region. The question of approved plans already in place with neighbours or across contiguous properties is not considered, thus the cumulative impacts for a landscape are not measured or planned for.

Understanding the wider habitat, and the role that the proponent's land plays in the wider region in terms of regionally important functions is important and should be part of the decision making and advisory role of LLS. As the approver of the PNF Plan, and having carriage of this process, it would seem natural that LLS should consider the potential cumulative impacts when assessing a PNF Plan.

This PNF Plan establishes the footprint of the area of forest on the landholding that is subject to silviculture, that is valid over a 15-year period. Over that time period, when the landholder is ready to move forward, a FOP is developed by the landholder. This sets out the spatial harvesting plan. This FOP may be amended from time to time by the landholder, with increased or decreased intensity extraction, and appears to be able move from a STS approach to an AGS approach or the other way, however it cannot go outside of the approved footprint, and must stay within regulatory limits. The only components of a FOP that the landholder can't amend are

> *Clause 2.1(5)(b)(iii) - a contemporary description of the pre-harvest forest condition (including overstorey species type and composition, known disturbance and harvest history, pre-harvest basal area, stand height [where required] and any presence of pests and/or weeds)*

The Review notes that some of the components in this clause may well change (in reality if not in FOP) over a potentially 15-year period, such as stand height and basal area and pests and weeds and disturbance in the case of bushfires.

PNF can't be undertaken on certain forest types (e.g., old growth forests or rainforest etc) or on lands already subject to private land conservation (according to the Biodiversity Conservation Trust, approx. 338,000 ha are subject to offset or Private Land Conservation agreements in NSW)[109].

[109] https://www.bct.nsw.gov.au/private-land-conservation-nsw

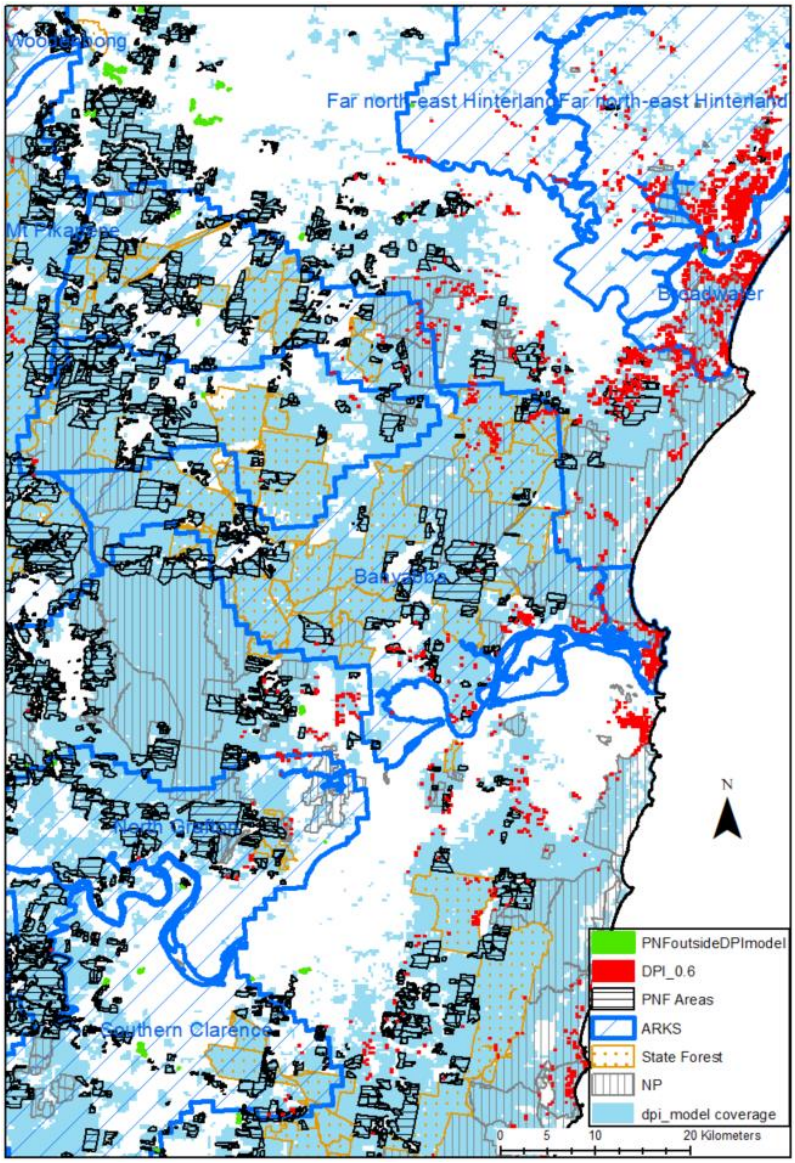


Figure 16: Clarence and Richmond lowland areas comparing the ARKS, PNF areas and DPI map coverage

Shows the extent of currently approved PNF Plans in the vicinity of Royal Camp, Broadwater and Banyabba, particularly highlighting the density of neighbouring properties with plans. White areas are not picked up by the DPI model, yet include sites of important koala habitat, within ARKS and potentially subject to logging.
Source:

LLS are not required to consider the wider impact that the on-site forest activity will have on the wider region in terms of regionally important functions that could be impacted – such as if the habitat is an important koala corridor.

The FOP requires the landholder to map locations of threatened populations or threatened ecological communities and species listed in Appendix A of the PNF Code, however ecologists or other subject experts are not required to undertake this work and more broadly to provide advice or guidance to the development of forestry and preferred outcomes through the PNF Plan or the FOP. The Review notes that suitably qualified experts are to be used to undertake a survey for koala presence if the landowner disputes the koala habitat suitability map.

The initial conditions of the property and its habitat is informed by: a) the landholder (who may not be expert or equipped or have the incentive or luck to identify vulnerable or important attributes such as koalas or koala trees, scats or scratches), noting that forestry contractors and/or consultant are often engaged to undertake forestry operations and prepare the FOP and b) habitat

mapping including a koala habitat suitability map determined by the distribution of koala use trees, topography, soil type and climate variables which may not have the accuracy or resolution (DPI suitability map has a resolution of 250m) to capture relevant plant communities or assemblages or habitat structures of importance to koalas, or c) koalas sighting records which are not consistent in quality and potentially underrepresent private property due to survey effort issues.

The FOP requirements specify that a map and written section is required, but does not seek images, to be provided (contemporary or historical) that would provide some information on forest condition and health. LLS is not required to approve the FOP, and the landholder can change the FOP as long as they don't exceed limits or prescriptions within the PNF Code.

Recommendation 4: There are no apparent cumulative or scale limits to the extent of private property that can be placed under PNF plans in a region, other than the onsite restrictions around the type of forest eligible for PNF. Once under a PNF Plan and FOP/FSP, there is also freedom for the landholder to harvest at any time during the 15 years approval. This means there is little opportunity to encourage approaches such as mosaic harvests, to try to maximise the availability of undisrupted habitat for native species.

A ceiling level of habitat that can be forested from each ARKS should be agreed to mitigate the possibility that a region could encounter wide-spread and contiguous, coincident, high-impact forestry.

PNF Plans, FOPs and FSPs should be informed by broader scale considerations and mapping including accounting for habitat beyond the landowner's property, including koala habitat (moderate, high and very high suitability), location of ARKS, presence of neighbouring cleared land on farms, PNF approvals on neighbouring land and neighbouring forests, and cumulative impacts.

The outcomes of PNF should be monitored, and the relevant maps kept up to date.

3.3 Koala prescriptions in the proposed PNF Codes

The threatened species prescriptions in PNF Codes assist in protecting species of interest, the koala for the purposes of this report. The koala prescriptions included in the proposed PNF Codes are largely reflective of the current PNF Code, protecting 10 primary koala trees and 5 secondary koala trees per hectare, and putting in place exclusion zones for trees with koalas or koala records (Appendix 2).

There are some differences to aspects of the prescriptions that are better for koalas and some are worse for koalas compared with the current codes, these are set out in Table 13 and as follows. Prescriptions under the proposed PNF Codes may be triggered under a range of different scenarios – e.g., by a koala being spotted (Situation 3), or koala scats found on the property (Situation 4). On the other hand, a landholder may have good quality and arguably high value koala habitat on their land, but it may not be captured under the proposed PNF Codes (e.g., Situation 6 - it is not mapped as high suitability in the Codes as it may be classed as medium suitability (yet may be high value) or missed on the map due to resolution or stand size). The following draws from Table 13 and describes the changes in prescription triggers that are better and worse for koalas compared with the current codes (Appendix 3 and 6 provide more information on comparisons).

Changes to triggers that are <u>better</u> for koalas compared with current codes:

a. Each tree is assessed for the presence of a koala before cutting it down
b. Evidence of koala scratches on a tree can trigger an exclusion around the tree
c. Some koala management areas had a requirement to find 20 scats under a tree before it would have mitigations in current PNF Codes, this has been decreased to 10 scats in those sites in the proposed PNF Codes

d. Koala suitability mapping has been undertaken and will trigger some mitigations, over an area which covers 1.2 million ha (equivalent to area ~110 km x 110 km)

It is worth noting that whilst a. b. and c. are improvements, they rely on the landholders or the contracted forestry operator to undertake these assessments.

Changes to triggers worse for koalas:

a. Scats found under trees no longer trigger the 10 primary and 5 secondary retention prescription

b. The South Coast region, under the current PNF Codes, had a 1 scat threshold, but that has now been increased to 10 scats under a tree in the new Southern NSW Code, the same number as the North Coast. (From discussion with LLS, the Review understands that this change is inadvertent and LLS indicates it would be fixed in a future version.)

c. For koalas on previously exempt habitat under the current Code (approx. 6,000 ha of approved core koala habitat could not be harvested). Under the proposed PNF Codes, this land is no longer exempt but also able to be harvested subject to the PNF Plan approvals at the time.

d. The list from which the choice of primary and secondary koala trees that can be maintained is now a lot longer meaning that the less preferred trees (within each of the primary and secondary tree lists) on a site can be kept, at the expense of more preferred but commercially valuable trees being taken.

3.3.1 Mapping thresholds as triggers for prescriptions

The protections for koalas are to apply "*in areas of high value koala habitat*". Chapter 2 discusses the concept of high value habitat, and the inadequacy of habitat suitability maps to reflect this at the local scale and landscape scale, due in part to important habitat potentially including very high, high and moderate habitat, and that other functional attributes are relevant, and that the role of habitat for high value koala populations, such as in the ARKS, is also relevant. Table 13 sets out the triggers and prescriptions that would be applicable to land under PNF Codes under a range of situations and compares the prescriptions with those currently in place. An example situation could be where scats have been found, or there is koala record, or the property appears on a Koala suitability map.

3.3.1.1 Habitat suitability maps

The koala habitat suitability maps developed by DPI and EES are used in the proposed PNF Code as a mechanism to trigger the koala prescriptions. However, it is noted that two different mapping approaches are being used in different parts of the state and these have different strengths and weaknesses (Section 2.3.3).

As discussed in Section 2.3.3 the threshold of 0.8 (EES map) to define areas under koala prescriptions is not equivalent in each of the KMRs. It would be more appropriate to consider what categories of suitability are to be used for example very high or very high to moderately suitable habitat.

Having a single consistent mapping approach would provide more consistency across the state and could be explored in collaboration between DPI Forestry Science and EES. Further, these maps are a snapshot in time and require continual updating based on new koala and vegetation data – including status and trends in forest condition such as where habitat suitability has declined post-harvest.

The Koala Likelihood Map (KLM) developed by EES (available on the SEED portal) provides a prediction of the likelihood of finding a koala across NSW relative to other arboreal mammals. The map also provides a measure of the confidence in the koala likelihood estimate and therefore indicates regions where more ground surveys should be undertaken. This map was originally

developed in 2014 for use in PNF regulation for the EPA and has been used to inform the Coastal IFOA.

More fundamentally, the process for the PNF Codes needs to consider more than only a very high (EES) or high (DPI) habitat suitability score when dealing land in and out of a mapped prescription regime. As discussed in Section 2.3.3, high value habitat is not only dependent on the habitat suitability scores in a place being very high (EES map) or high suitability (DPI map), but high and moderate suitability habitat are also important for koalas and high value for the koalas living there. Also, other attributes are important including the function of the habitat in the broader landscape (as refugia in drought or fire), quality of the habitat, the importance and significance of the koala population that depends on the habitat.

The issue that high value habitat may not be captured with the thresholds of 0.8 for the EES map and 0.6 for the DPI map could be addressed through measures such as: 1) reducing the threshold value, in particular in areas such as ARKS, or 2) using the KLM in concert with the habitat suitability map (where habitat that is mapped at values below the thresholds) and where KLM indicates limited or no survey effort, then this could prompt survey activity to fill the gap.

Recommendation 5: The process to designate land as being high value koala habitat through current mapping approach is insufficient and risks leaving high value koala habitat out of the prescriptions.

The following attributes should also be built into (or alongside) the current habitat suitability mapping approach:

- Identify flaws in mapping and address these – e.g., disagreement between EES and DPI maps in some cases for very high suitability.
- Include both high and moderate suitability koala habitat (very high suitability by EES metric is already mapped)
- Include important koala corridors or connectivity structures
- Map and include areas of drought and bushfire refugia for koalas (work being undertaken by EES)
- ARKS should include koala prescriptions as a matter of course
- Use Koala Likelihood mapping to assist interpretation of suitability maps, where the threshold suitability scores are not met and where there is no or limited or low confidence in koala data.

3.3.2 BioNet records and koala spotting as triggers

Habitat may also not be captured in the prescriptions because of issues of spotting koalas, which triggers prescriptions and is an underpinning data source for mapping tools. Koalas are described as cryptic and are difficult to see and find in the wild. Furthermore, there is a lower level of survey effort on private land with members of the public not able to access private property in general, and there are some potential disincentives for some landholders to find koalas on their property or scats and scratches associated with trees[110].

Given that a number of triggers for prescriptions rely on these factors, via either mapping tools (BioNet records) or evidence that a site is used by a listed species in the proposed PNF Codes ('*site evidence is a sign a species has visited or regularly uses a site, and includes observations of, for example, faecal pellets or scats, chewed seed cones or a nest, or evidence that the site has been used as a latrine*'), this could lead to under-activation of the prescriptions during forest planning and forestry operations.

[110] Finding breeding females, which is possibly an even clearer indication of important koala habitat (used in previous planning instruments), is even harder to differentiate than just spotting koalas and requires expertise.

3.3.3 Scat triggers

In the current PNF Code the presence of a koala scat under and primary or secondary feed triggers the prescription to retain 10 primary and 5 secondary feed trees per hectare. This triggered prescription is removed in the proposed code (Table 13). This should be reversed – the identification of a scat under a koala feed tree on a property is clearly a sign that koalas are using the feed trees on the property, particularly when it is considered how challenging it will be for non-expert (potentially disincentivised) landowners or contractors from finding very obscure scats over a potentially very large property. A similar issue arises for koala scratches in trees – the challenge for non-expert landholders to identify koala marks across their property – although these have been included as a trigger in the proposed PNF codes for exclusion zones (Table 13).which is an improvement (Table 14).

Justification under the current PNF Codes as to why there is a threshold for one scat in certain regions notes that

> *Koala populations are generally sparse or of low density in the South Coast, Central and Southern Tablelands and Western Koala Management Areas (Koala Management Areas 3, 5, 6 and 7; see Figure 4) and, as a result, scats are rarely encountered. Therefore, recording of any scat or a sighting of a koala in these areas should be considered significant*

Whilst the proposed PNF Codes do retain the one scat trigger for the Far West, Riverina, Darling Riverine Plains and Central and Southern Tablelands KMAs[111], they do not include the South Coast as per the current PNF Codes (Table 13). From discussion with LLS, the Review understands that this inconsistency is inadvertent and LLS indicates it would be fixed in a future version so that the South Coast trigger will become one scat.

It is also worth noting in this context that there is an inconsistency between the triggers for scats (as discussed above), and the number of scats that need to be counted should the proponent (landholder) decide to challenge the mapping and engage an expert to undertake a RGbSAT Survey (proposed PNF Codes, Appendix D: Protocol for re-evaluating koala habitat on private property). The RGbSAT survey states that, as part of the surveying method, once 20 or more scats are identified beneath a tree the search may cease, and a record must be made of the koala faecal pellets. There is a need to ensure that this trigger for survey effort matches the initial trigger in each of the respective regions.

Recommendation 6: Scats are used to identify koala trees in the proposed PNF Codes; however, three amendments are required:

- the presence of koala scats should again trigger koala tree retention prescriptions
- the number of scats in Southern Coastal region that trigger a prescription should be one rather than 10
- in cases where the landholder disputes the koala habitat map, and an expert is commissioned to resurvey, the number of scats under the RGbSAT survey method should match trigger values for scat numbers for that PNF Code – for instance, the number of scats that trigger prescription in Southern Tablelands is one, whilst the RGbSAT survey method requires 20 scats to identify a koala tree.

Koalas are difficult to spot in the landscape, and while there are several established methodologies (and new ones on the near horizon), none are perfect, they each have their strengths and weaknesses, many are expensive, and some lend themselves to higher accuracy over a smaller area, while others have a significant spatial reach but low resolution. Therefore, good practice is to use more than one method in monitoring and survey protocols.

[111] See Section 1.3.4.1 regarding KMA vs KMR terminology in the koala prescription

For example, scat surveys are a useful method for observing current and past presence/absence in cryptic species such as koalas. However, koala scats can degrade quicker or slower depending on the climatic conditions or can be detected at varying levels of confidence based on the ground cover (leaf litter and/or vegetation amounts). Using dogs to identify the presence of scats is becoming more common approach, although this can be expensive. The use of drones is also a method being developed, ground-truthed and standardised, with new directions such as the use of artificial intelligence to improve accuracy in detection by remote sensing. Currently however, drones can only be deployed during winter and at night as they depend on differential temperature signals.

As a further example, acoustic monitoring arrays are limited in their application by the time of year, as they are reliant on detecting male bellows during mating season. A recent study by DPI Forest Science installed an array of acoustic sensors to detect koalas and record koala calls over two-weeks in spring, as spring is the breeding season for koalas and when they are most vocal. This method therefore relies on the presence of young, breeding males within the landscape, as females rarely bellow. In this study, DNA was extracted from a sample of fresh scats which confirmed the 1:1 sex ratio of koalas that has previously been reported in the literature.

The DPI Forest Science study then used spatial count modelling to estimate male koala density within the study region, using data collected from the acoustic sensors and the expected koala home ranges (one male koala would be expected to occupy the area monitored by each sensor, approximately 30 ha per koala; Law, unpublished data). This gave an estimate to the number and location of koala activity centres, modelling koala density from such estimates. Because koala density is typically low, which results in a low probability of detection using other methods mentioned above, acoustic arrays, along with spatial count modelling is considered by the authors to produce the most reliable estimates of koala density in NSW[112].

The spatial count methods estimate density based on unmarked animals. An acoustic array grid must therefore be closely spaced so that you can obtain correlated detections between adjacent sensors, to estimate the number of males. This method does not provide information on whether the males are transient, and being detected in multiple sensors, or that there are more males in a location (Brad Law, pers. comm). However, as it is adult males that primarily bellow, and therefore tend not to be transient (as opposed to younger males), it can be assumed that detected koalas are most likely to be resident individuals, which has been confirmed by recent GPS tracking of collared koalas (Law *et al*, unpublished). Further developments in technology, such as automated detection of individual koalas based on their bellow would allow us to determine if a region with a high spatial count has more koalas, or just more transient ones.

GPS collaring of individual koalas, although a more involved survey method, can generate a number of GPS spatial points to help understand koala movements and tree use throughout a landscape. A recent DPI GPS study (with full results anticipated late 2021) tracked 11 individual koalas[113] (including three breeding females) at the three harvested sites that were characterised by variable harvest intensity. The koalas were tracked over two years generating 12,000 GPS spatial points. Preliminary analysis of this tracking data suggests that five to ten years after harvesting had occurred, the koalas used the full range of the available landscape – including varied topographic positions as well as young and older forest and the full range of tree sizes above 8 cm DBH.

Recommendation 7: At least two surveys methods should be employed for any form of monitoring and/or surveying at a site. The PNF Code should require two methods and to use the guidance in the Koala Monitoring Framework established by NSW Government.

[112] Law, B., et al., (2021). *Validation of Spatial Count Models to Estimate Koala Phascolarctos cinereus Density from Acoustic Arrays.* NSW Primary Industries, Unpubl. Report. Paper submitted to *Wildlife Research* for peer review.

[113] See https://www.dpi.nsw.gov.au/forestry/science/koala-research. A research collaboration between DPI Forest Science Unit, Port Macquarie Koala Hospital and FCNSW.

Table 13:Hypothetical situations for landholdings of different instances of koala presence or signs, or koala habitat mapping status, to compare prescription triggers ('10P + 5S' refers to the prescription to retain ten primary and five secondary koala feed trees from the list in the proposed PNF Code)

Protections for koalas – can silviculture be undertaken and what triggers prescriptions? What are the situations?	Current PNF			Proposed new PNF		
	Basal Area (BA) retained (m^2/ha)	**Exclusion zones (trigger)**	**10P+5S trees retained (trigger)**	**Basal area (BA) retained (m^2/ha)**	**Exclusion zones (trigger)**	**10P+5S trees retained (trigger)**
Situation 1 – forestry prohibited Old growth forests[114] OR Where permanent clearing is desired	**PNF operations prohibited**			**PNF operations prohibited**		
Situation 2 - previous SEPP 44 In areas of approved core koala habitat as defined in SEPP 44. Total area approx. 6000 ha	**PNF operations prohibited**			**Av, BA 10 or 12** More intensive than current[115]	See situations below	See situations below
Situation 3 – koala sighting Highly suitable koala habitat: • koala spotted or BioNet record	BA 12, 14, 16, 18	Tree with koala	Record or within 500 m of record	**Av, BA 6, 8, 10, 12** More intensive than current Each tree assessed for koalas immediately before felling	**Tree with koala or marks**	**Record or within 500 m of record** Same as current
Situation 4 – koala scats found Highly suitable koala habitat: • scats identified • no koala spotted • no BioNet record • not mapped	BA 12, 14, 16, 18	**20 or 1 scats**	**1 scat** (under a primary (P) or secondary (S) food tree)	**Av. BA 6, 8, 10, 12** More intensive than current	**10 or 1 scats** Slightly stronger than current (10 not 20) except: South Coast 10 scats up from 1 in current - weaker	**No scat trigger** Weaker than current
Situation 5 – habitat mapped Highly suitable koala habitat: • Koala habitat mapped • no koala spotted nor BioNet record • no scats found	BA 12, 14, 16, 18	**No prescription**	**No prescription**	**Av. BA 6, 8, 10, 12** More intensive than current. Each tree assessed for koalas immediately before felling	**No protection** Same as current **Can seek reassessment**	**Mapped area** Better than current **Can seek reassessment by a suitably qualified expert**
Situation 6 – habitat not mapped Highly suitable or good koala habitat that is: • unmapped Koala habitat • without koala observations or BioNet record • without scats found	BA 12, 14, 16, 18	**No prescription**	**No prescription**	**Av. BA 6, 8, 10, 12** More intensive than current	**No protection** Same as current	**No prescription** Same as current

[114] As an example of an area excluded from harvest
[115] This is more intensive than current PNF Codes for Northern NSW, and for all regions due to the removal of the requirement that 50% of measured plots must have a BA above the minimum average basal area

3.3.4 Effectiveness of prescriptions

So even if habitat or mapping or other measures do trigger prescriptions, what does it mean for the koalas' habitat? As mentioned previously, there is no available analysis provided by the LLS on the extent of PNF Forest extraction under current PNF Codes with lower intensity settings, nor the effect the PNF Codes, their Basal Area limits or prescriptions have on koalas nor koala habitat.

Law *et al.* (unpublished) have undertaken work to understand the impact on koala occupancy (and more recently density) from forestry under IFOA, and work on PNF is underway. Recent density work was undertaken for the NRC looking at impacts on koala density of different extraction levels expressed as harvest intensity measured as m^3/ha, ranging from 17 m^3/ha to 122 m^3/ha[116]. The NRC has requested additional information from the research team that would allow the extraction volumes to be interpreted in terms of remaining basal area, which is how the PNF Codes are structured, however this information hasn't been provided to date.

The following provides some qualitative analysis of the prescriptions in the PNF Code.

3.3.4.1 Tree retention

The tree retention rules have stayed the same between the current PNF Codes and the proposed PNF Codes, with a few slight adjustments (Table 13):

- There is the added requirement, as part of the forestry operation process, for the visual inspection of trees prior to felling (note, this would trigger the retention of that tree and exclusion zone)
- Recruitment trees and hollow bearing trees are now qualified as trees with a DBHOB of 30 cm or greater (previously no DBHOB requirement)
- Expanded primary and secondary tree species list.

When prescriptions are triggered, their mitigative impact is minor relative to the tree removal that would be allowable in koala habitat. Koala prescriptions trigger protection of 10 primary koala feed trees and 5 secondary feed trees of 30 cm (or more) DBH (which is equivalent to about 1.5 m^2/ha if the 15 trees are 30cm), but this need not be additional to the trees kept as habitat or retained trees under the Code, these 15 trees may already be retained in the basal area limit or habitat tree retention requirements.

The NRC notes that a potential threat to koalas is '*timber harvesting and clearing practices that lead to permanent changes in forest structure (at a landscape level) and reduce preferred koala feed trees due to changes in forest composition*'. In noting this, there are no prescriptions in the current or proposed PNF Codes that address or reduce the impact on forest structure or to maintain similar tree species compositions in forestry operations: for example, a minimum per cent change of dominant species.

Further, as previously mentioned, an expanded tree list to align with the SEPP 2021 can have benefits, but also perverse outcomes. This could arise from the different aims of the SEPP 2021 and the proposed PNF Codes.

This issue is further understood through observations that within KMRs different trees on the Primary Species list and the Secondary Species list will be more or less preferred at different sites. Previous studies have noted that within a given area, individual koalas will preferentially feed on only a few of the available Eucalypt species: for example, in north-east NSW tallowwood (*E. microcorys*), grey gum (*E. propinqua*), forest red gum (*E. tereticornis*) and swamp mahogany (*E. robusta*) are identified as among the most preferred food tree species[117]. Other Eucalypts, and non-Eucalypt species, within the area may be used as supplementary browsing or for habitat purposes (shelter, etc.).

[116] Law *et al.* Regulated timber harvesting does not reduce koala density in north-east forests of New South Wales. Unpublished
[117] NSW EPA (2016), Koala Habitat Mapping pilot, NSW State Forests

To benefit koalas, the composition of the forest (ratio and variety of tree species present) shouldn't change substantially as a result of harvesting, or if it does change, should have more preferred koala feed and use trees, and have a heterogeneity in the age and size classes represented. Given the importance of habitat suitability and value to koalas, the act of undertaking PNF should not result in a downgrading of the koala suitability score or a reduction in the value over time.

Recommendation 8: Forest management activity should not be done in a way that reduces the habitat suitability and value for koalas in the landscape. An approach to deliver on this should be agreed, but it could include enhancing the proposed PNF Code clause 3.4 and Appendix C (Regeneration) so that not only should 65% (STS) or 55% (AGS) of plots be regenerating at 24 months, but ongoing surveys and tube-stock planting should result in the maintenance of the relative abundance of tree species in harvested areas by 7 years (one koala generation) after the harvesting the habitat should have the same (or higher) koala suitability score as before the forestry operation.

3.3.4.2 Site impacts and landscape/ cumulative impacts

Impacts of PNF harvesting on a property's ecosystem will be a function of a number of variables, including the amount of habitat that is to be removed overall and per hectare; the species, diversity and amount of habitat to be left intact and the basal area per hectare remaining of the harvested land and revegetation outcomes; distance of the harvested property to nearby intact habitat (is it adjacent or remote from national park or forest?) or whether contiguous neighbouring lands are also being harvested coincidently. The impact on the property will also depend on the contribution of the prescriptions.

Important questions and decisions at the planning and implementation stage are required, to avoid negative or unintended impacts. What will be the plot's ability to support koalas immediately post-harvest versus the longer term – what species will be retained, will their regeneration be favoured or not by altered light conditions post-harvest, will there be invasion by species such as lantana and associated bell miner associated dieback with the opening up of North Coast tree canopies under increased silviculture. Lantana incursions have implications for koala movement through the landscape, for tree regeneration and for dieback of canopy species including important koala feed trees.

How well the 10 primary and 5 secondary retention prescription will protect koalas given data on outcomes of the 8, 10 or 12 m^2/ha average basal area limit proposed in the proposed PNF Codes is not known. There is no data provided to the Review to demonstrate how well this prescription reduced forestry impacts to protect koalas under the current PNF Codes when the prescriptions were between 12 and 18 m^2/ha (for the Northern NSW current PNF Code depending on the type of vegetation and height of stand), and there is no analysis to indicate whether or how well the same prescription would protect koalas with a more intensive harvest of 10 m^2/ha (in the Northern NSW PNF Code).

The 2020 report of Brack and peer review of Vanclay both agreed that 10 m^2/ha provided better opportunities for shade intolerant tree species to regenerate. However not every tree is shade intolerant for example, species such as Tallowwood, *E. microcorys*; H, and Silvertop Ash, *E. sieberi*, that are preferred koala trees are relatively shade tolerant.

Work by Law *et al*[118] on-koala occupancy post forestry has shown that koalas either remain or come back to areas that have been forested if there is healthy habitat remaining. Much of this work of Law *et al.* (pre-publication) has occurred in the context of state forests where silviculture is undertaken in a mosaic arrangement leading to a heterogeneity of forest structure and age. Information on this recent work also focusses on the looking at the impact on koala density / occupancy compared with the level of timber extraction, as opposed to the final basal area retained. However, recent work on PNF is emerging and was discussed with the Review, and the

[118] Law *et al.* Regulated timber harvesting does not reduce koala density in north-east forests of New South Wales. Unpublished

Review also welcomed seeing a draft report on this exciting work. Some of this work appears to be showing that the occupancy and density of koalas in these areas appears to be greater than previously thought, which is encouraging.

However, it is not clear to what extent this outcome is dependent on:

- the intensity of previous harvesting (the amount taken and the amount remaining)
- the area and connectedness of adjacent pristine or healthy habitat and the extent of the extraction area over a landscape
- cumulative impacts that drought and forestry combined may have in the future
- the ratio of koala feed trees versus non-feed trees as remnants
- whether the koalas are healthy and breeding, and whether koalas were still observed there because they had expanded their home ranges, or there was simply enough carrying capacity in the unlogged area to meet the needs of the resident koala population.

Draft work of Law *et al* on koala density in state forests (under Coastal IFOA) was also viewed, that also demonstrated koalas in habitat (particularly unlogged) adjacent to logged stands after harvest as well as a low density of koalas in trees in spots that had been logged.

Chapters 1 and 2, show there is a clear convergence of issues in the North Coast KMR, and it is worth considering whether these lead to layering of impacts or increased risk. The area has the largest and most productive forests, with tall and dense trees (see Section 3.1). This arguably has led to both: a) the area having the largest and most significant populations of koalas, which will be critical to meeting the government's goal of doubling koala numbers by 2050; and b) the greatest concentration of forestry and PNF Plan approvals, 87.5% of approvals in 2020/21 equivalent 89% of the new land approved under PNF Plans. As well as having the largest forests, most koalas and most logging, it is also the location that will have the most intense harvesting permitted in terms of minimum average basal area limits.

This multitude of factors will require particular focus in terms of risk management, regulation outcomes monitoring and adaptive management so that if things start to go wrong then issues can be addressed. The strength of prescriptions (10 primary koala food trees and 5 secondary koala food trees) or forest habitat set asides (rainforest, 70% riparian habitat, old growth forests, hollow bearing trees etc) are largely unchanged from the current codes, even though the intensity of silviculture allowable is increased particularly in important koala areas such as the ARKS, which contain much habitat that is currently captured by the 16 or 18 m^2/ha basal area limit that would drop to 10 m^2/ha under the proposed PNF Codes. Further, whilst basal area is a useful tool for forest management and a proximate measure for habitat taken or protected, as noted within this report koalas do not rely on basal area triggers, but rather vegetation characteristics such as palatable foliage, shelter and as refuge (i.e., perch to which they have easy access to escape dangers).

Overall, the reach of prescriptions has increased based on hectares of habitat covered by maps, however the strength of prescriptions and protections has not changed, even though the intensity of forestry allowed is increased. This is out of step with good practice risk management.

Given the importance of the habitat, and koalas, and the sparse or absent evidence of the impact of prescriptions to mitigate the higher-level harvesting, and lack of procedures for LLS to limit the spatial spread of contiguous forestry operations through the regions, a lower intensity of activity should be achieved.

Recommendation 9: There is not sufficient evidence to demonstrate that the koala prescriptions as set out in the proposed PNF Codes will provide suitable protection for koalas given the increased intensity of harvesting allowed. Having an approach that uses an average stand basal area assists in providing flexibility to forest managers to implement silvicultural approaches to improve outcomes at different locations, and provides consistency as required. The stand basal area average minimum values should be increased until proportionate protections and procedures for koalas are included, and their beneficial effect can be demonstrated, in particular in the Areas of Regional Koala Significance (ARKS).

3.4 Regulation and compliance

Other than PNF Code limits and prescriptions, another set of risk management tools available is in the planning, regulatory and compliance regime established to guide forestry efforts and prevent extreme interpretations, encourage best practice on achieving beneficial outcomes.

As it stands, moving to a single basal area limit across a region, with increased incentives for landowners that maximise economic outcomes, there is a real risk that a one size fits all approach to harvesting will emerge meaning the previously diverse, complex habitat may be harvested to the regulatory limits and lead to homogenous stretches of thinly forested land. This could have considerable implications for both the biodiversity and aesthetic values of the land. To ameliorate this, there is a need for measures to inform, monitor, and advise landholders on the range of outcomes and how best to realise them through forestry practice and planning.

3.4.1 Risk based approach

On face value, there has been a proposed increase to the forestry operations within koala habitat that is not matched by increased prescriptions to protect koalas. Further, the new prescriptions reduce the protections on core koala habitat (from previous SEPP 44 protections) and risk increasing some of the threats to koala conservation – habitat reduction, tree species diversity, carrying capacity, role as refugia – not to mention other environmental values associated with other species. As described in the previous chapter, areas that are the location of the majority of forestry activity under PNF are also the location of the highest populations of koalas, including in ARKS, and also a new intensified framework for forestry planned for these sites given the reduced basal area limits. Within the context of the newly prepared NSW koala strategy, the role of the ARKS in being focal areas for increased koala populations, means that there is a decreased risk tolerance for the koala populations and habitat associated with the ARKS, which are particularly concentrated in the North Coast (Table 14).

Table 14: Risk between the current and proposed PNF Codes

Current code	Change from current to new
The level of risk or hazard to koalas (silviculture intensity and scale)	INCREASED RISK
The risk tolerance of this threat (level of importance of the koala habitat)	DECREASED RISK TOLERANCE
The risk mitigation tools (planning, regulations and monitoring).	SAME PROTECTIONS

Typically, in risk management practice, when risk intensity or likelihood increases, then the mitigation or management actions are enhanced to reduce the inherent risk. Similarly, if risk appetite or tolerance decreases, then again greater mitigations or management would typically be put in place. This approach has not been followed in this case moving from the current to the proposed PNF Codes.

Recommendation 10: A standard approach for policy setting should be incorporated for PNF and other forestry activities into the future, that if forestry limits and restrictions are being relaxed (such as increased harvest volumes or lower basal areas limits), this should be accompanied by increased protections or risk mitigations such as a combination of regulatory protections or planning rigour or increased environmental set asides/offsets or increased pre- and post-harvest monitoring requirements.

3.4.2 Data sharing, information, planning and compliance

An objective of the LLS Act is to ensure the difference between PNF and native forestry in State Forests is recognised, however the move to increase the allowed harvest intensity of forests under PNFs to be more intense than STS in IFOAs (with 10 m^2/ha regrowth, 12 m^2/ha non-regrowth, greater than 50% of sampling points above the average minimum limit and a mosaic forestry operation across the NHA), and on the basis of remaining basal area (in Northern NSW compared with the Coastal IFOA) appears to be running counter to this objective (Appendix 8). That this intensification up to the level of the IFOA would occur without the concomitant increase in environmental set asides and increased risk management, monitoring, and regulation causes concern.

The discussion above in Section 2.1.3.3 on Climate Change highlights to the Review that relevant information should be considered by the LLS in assessing PNF Plans. The assessment of plans should also be informed by the Regional Water Strategies (RWS) being developed by DPIE Water to assist planning in relation to future water availability and climate change.

Currently it is the view of the Review that there is a lot more planning and analysis and rigour that goes into IFOA planning than is required under the proposed new PNF Codes, even though the intensity of forestry appears to be greater in the proposed PNF Codes, and the protections lower. As the value of the forest as koala habitat is no lesser than that of the IFOA forests, and potentially greater, this is counter to typical risk management approaches where if the risk is increased, the protections would be increased[119].

LLS, sitting over the process would have the opportunity to review and amend and make decisions and improve on PNF Plans, FSPs and FOPs with a perspective on the wider terrain, including neighbouring properties and habitat. However, it is not required to under the proposed PNF Codes. The Review notes that the landholder develops the FOP, however the landholder is not required to provide the FOP to LLS or EPA (unless requested), the landholder is relatively free to change the FOP within the limits of the code and footprint of the PNF Plan.

The FSP, developed by LLS staff or an accredited expert, allows for variations from the provisions within the Code, which could impact some of the protections on koalas and their habitat. However, the process requires agreement of the Secretaries of DRNSW and DPIE, or if they cannot reach an agreement, the responsible Ministers. Furthermore, once the FSP is made and approved, it to can be amended by the landowner on the same terms as the FOP.

The Review also notes that landholders may amend the FOP/FSP but are not required to submit them to LLS or EPA; only record them within the FOP/FSP and provide upon request. Whilst the landholder must still comply with the PNF Codes, this could lead to repercussions that could have been prevented upon submission. Therefore, the Review has made the recommendation that as part of the new pre-notification and post-notification process under the proposed PNF Codes, the landholder should submit the FOP/FSP to LLS (who will in turn provide it to the EPA) as part of the pre-notification stage, and then again as part pf the post-notification stage (thereby allowing EPA to know where the property is, who are the landholders, what their contact details are, what the silviculture is planned, and what changes occurred as part of the forestry operations). It should also

[119] Crowther, M. S., McAlpine, C. A., Lunney, D., Shannon, I., and Bryant, J. V. (2009). Using broad-scale, community survey data to compare species conservation strategies across regions: A case study of the Koala in a set of adjacent 'catchments'. Ecological Management & Restoration 10, S88-S96. doi: 10.1111/j.1442-8903.2009.00465.x.

be clear that submitting the FOP/FSP does not constitute any form of approval, and the onus should still be on the landholder to complete the FOP in line with regulations and undertake forestry operations under the FOP/FSP that comply with the PNF Code.

Having clearer obligations for LLS in ensuring that FOPs are structured in a manner that ensures habitat does not too small or degraded to sustain koalas would be required, this would include maintaining data on where forestry has occurred and the outcomes from it. This would include incursions of weeds and threats (e. lantana or dogs). In developing internal guidelines and procedure documents to aid reviewing applications and plans, obtaining advice and insights from both DPIE EES and the EPA will be valuable to improve outcomes.

Monitoring and reporting, checking and compliance are methods available to government to increase protections and safeguards for koalas. Both EPA and LLS should have distinct roles in this and may require a degree of arm's length separation from each other on certain data sets, nevertheless there are opportunities to work together and share information and develop an agreed or comparable information platform – including mapping approaches that align, are hybridised and use the most up-to-date standardised and fit for purpose information.

Under current PNF arrangements, landholders obtain a PNF approval that lasts for 15 years, and must develop a FOP, but can undertake forestry activities at any time through that timeframe once the FOP is approved. Some operations may proceed and some may not end up going forward – depending on the decisions of the landholder/s and/or forestry contractors. This uncertainty about location, identity, contact details of landholders, and lack of information timing and initiation of silviculture preventing appropriate compliance by the EPA. EPA informed the Review that these challenges in obtaining information on approved PNF will mean there is limited information to identify compliance trends, proportion of PNF occurring (to what's approved), and general level of compliance. This observation was reinforced by LLS in terms of the level of information collected on approvals and timber volume. LLS indicated it is planning an information sharing protocol with EPA to make sure information is provided proactively. LLS also indicated that the introduction of pre-harvest and post-harvest notification system in the proposed PNF Codes will help address this issue and help improve extension and regulation. Information that EPA should receive from LLS includes: Information on each PNF Plan (in appropriate digital formats) including PNF boundary, exclusion zones attached to the plan, rainforest layers; addresses and contact details of landholders.

Over recent years, compliance efforts have focussed on where there has been a community complaint, where possible breaches have been detected it was likely determined from SLATS data, or where EPA operations staff opportunistically found it occurring, or via information from contractors.

Contractor training as well as investment in managing private forests (especially by industry contractors) has been reported to the Review by the EPA as a means to better ensure compliance with codes and regulations. The biggest issues tend to be taking the best trees within a habitat patch (ones worth the most commercially), irrespective of exclusion zones and tree retention rules.

The Review understands that there is a new program that is in the pilot stage, called ForestFIT. This is being developed DRNSW, in conjunction with the Australian Forest Contractors Association as the manager for the project and with a cross-agency project board supporting the process. The syllabus, which is due to be finalised June 2022, leverages existing VET-approved courses, industry recognised courses and, where the former two do not currently exist, will develop modules. The three training areas are Work Health and Safety, Environmental Practices, and Business Sustainability. This is still being developed, but the Review notes that NSW Government has considerable expertise in DRNSW and other clusters.

Other subordinate documents and guidance should be made public and transparent, such as:

- guidelines for landholders that establishes the standards that LLS decisions will be based on, and how these align with ESFM – the thresholds for decision making or advice by LLS – how do they decide and advise a landholder if an area is too large, or there has been too

much habitat clearing in neighbouring properties from farming, or forestry activity reducing quality, if intensity is too high, if habitat function too important and at risk.

- how to support koala management within the PNF – forest management guidelines, koala technical guides, instructional videos on koala management during forestry operations, how would the decision be made that property is not suited to a proposed silviculture approach. This material could also consider how landowners could get funding to manage forests on their property such as through the Biodiversity Conservation Trust.

Recommendation 11: The information sharing protocol that is being developed between LLS and EPA should include (but is not limited to):

- Notification prior to commencement and completion of forestry operations.
- PNF Plan and the approval information (such as approval conditions)
- FOP and/or FSP and associated information (dates of activity, identity of contractor etc.) including any amendments as part of the pre-notification and the post-notification process
- Procedures to ensure adequacy of maps prior to PNF Plan development and prior to harvest, and to update maps and information following harvesting, including where the koala suitability level has been reduced
- Any monitoring activities and data, including data on forest condition, health and structure, and enable viewing of data in the broader regional context – including data for early identification and intervention actions.
- Data agreed under recommendation 1A and 1B.

Recommendation 12: LLS and EPA guidance, regulatory and compliance roles for PNF should be enhanced, whether or not the intensity of harvesting increases under the proposed PNF Codes. Enhancing the role for ecologist and experts should occur. The proposed PNF Codes provide general limits to harvesting however to get a more outcomes-based approach strong guidance and input from LLS (informed by ecological experts) should be provided at the planning stage.

3.4.2.1 Monitoring the impact of the Codes

As previously summarised, Vanclay in his peer review reflects on the outcomes in Pacific Northwest and sees it as *"a reminder that it is preferable to monitor desired outcomes rather than rely on generic proxies."* These outcomes could include those on plants, wildlife or environmental services, and would need to be clearly identified.

To expand further on Prof. Vanclay's reflections, the forest management agencies in the Pacific Northwest of the USA in the 1950s held the view that unobstructed waterways were desirable, so there was a requirement to remove all fallen stems (either natural tree fall or from forestry operations) from the waterways. However, ~20 years later the importance of 'snags' (i.e. dead or dying tree) within waterways for fish was recognised and this legislation was reversed. This suggests that the appropriate response should have been to monitor the conditions prior to and post forestry operations.

The work of Dr Law indicates that low-level timber extraction and koala persistence need not be mutually exclusive, but this is dependent on how the forest developed in the years after harvest. Will the forestry be undertaken sustainably to maintain the features important to koalas and other components of the ecosystem, or will the long-term loss of values, tree cover and tree diversity result? The proposed PNF Codes have almost nothing to say about how this will be monitored and ensured. Although regeneration requirements set an approach to measure the presence of

seedlings, existing tree cover or advanced growth of saplings of canopy species by 24 months, it is not apparent that this activity occurs beyond 24 months; where the information goes (does it update mapping?); or that it provides longer term information on viability or tree diversity.

The Review argues that monitoring the outcomes of forestry operations should be undertaken and shared between relevant agencies, LLS and the EPA as regulators and compliance agencies, much of this data should be made public unless there is a strong argument not too. The data collected and shared with agencies should also feed back into informing and improving management and decision making. Improved outcomes would be derived from agencies having access to common functional information (site, location, spatial extent, intensity, silviculture method, timing of operations and operators), contextual information (structural attributes of habitat, mapped area harvested and not harvested, wider regional landscape information), compliance information (breaches of conditions, illegal activities), outcomes from the activity (change in basal area, new basal area post-harvest, regeneration activities and success, outcomes for species, weeds and pests). Importantly, the data and information produced by this approach should then be fed back into the system, to inform decisions being made by government, such as whether impacts are at an extent that forestry needs to reduce intensity or other protections put in place.

A monitoring and data protocol could also assist meeting objectives of ESFM as set out in Part 5B of the *Local Land Services Act 2013* (LLS Act) of maintaining forest biological diversity, productive capacity and sustainability of ecosystems, health and vitality of native forest ecosystems, and soil and water quality (see Section 1.3.4 for ESFM). LLS has informed the Review that occupancy monitoring will be undertaken by LLS, however this will not be provided to any other organisation and not be made public and does not on the face of it address these ESFM objectives.

Decisions made under a single PNF Plan and FOP/FSP could have wider implications, and this report has already discussed cumulative impacts of multiple approvals over a region, therefore monitoring efforts should be aimed at two levels: measuring the impacts of prescriptions at a local scale (i.e., at the level of the PNF Plan) and at a landscape scale (i.e., across a region). Having a monitoring approach that draws together individual spatially enabled data points and also uses remote data (such as acoustic monitors for koalas, satellites and LiDAR for vegetation), with it made available to community and land managers will enable more informed planning and decision making and an assessment of the effectiveness of koala prescriptions, and it will also allow LLS and EPA to understand the impact of approving a PNF Plan in the context of the region, and cumulative impacts on landscape-scale habitat values (see discussion at Section 3.2.1).

Therefore, the Review makes the case that additional monitoring is required for PNF, whether or not the prescriptions and PNF Code limits change, as there is currently almost no data available.

Section 2.3 discussed the need for the EPA and LLS to develop a common understanding of data and information and mapping requirements, agreeing on the facts, and sources of knowledge for decisions. This work should cover these expanded monitoring needs.

In the context of forest monitoring for outcomes, the NRC set out a monitoring program for the Coastal IFOA that aims to ensure the ongoing effectiveness of the approval in achieving outcomes in the Coastal IFOA at multiple landscape scales. This incorporates aspects of risk prioritisation (i.e., understanding the risk of a desired outcome not occurring, thereby prioritising actions) and forms part of the wider FMIP[120]. The Coastal IFOA monitoring program is designed to answer four key questions that are related to effectiveness monitoring (i.e. are the conditions meeting the objectives and outcomes), trend monitoring (the impact on landscape-scale environmental values or wood supply), compliance monitoring (both the ability to monitor the effectiveness of the conditions or if non-compliance is compromising the outcomes) and adaptive management (can the conditions within the Coastal IFOA, the forestry operations / management / monitoring be improved to better meet objectives and outcomes).

The Review was informed by LLS and NRC that there is a cross-agency working group on aspects of the FMIP process. However, there appears to be a need to expand this thinking into the PNF

[120] https://www.nrc.nsw.gov.au/ifoa-mer

estate, that ensures that the ruleset is having the desired outcome: i.e., the protection of threatened species and the environment whilst also providing landholders with certainty, and that agencies and decision makers have the necessary information available (to the required standards) for decision making.

Recommendation 13: In moving forward on Recommendation 1B, a standardised Monitoring, Evaluation and Reporting framework should be established to understand the impact of forestry practice and to inform future efforts and impacts of climate change. This framework should link forest outcomes and trends with interventions and decision making across the region.

3.5 Certainty and Consistency

The Review has been asked to provide advice on whether the elements as drafted ensure robust protection for koalas in areas of high value koala habitat, and certainty and consistency for primary producers. In terms of forestry, the Australian Taxation Office[121] defines primary producers as

> *A primary producer is an individual, partnership, trust or company operating a primary production business if they undertake tree farming or felling. Tree farming and felling includes*:
>
> - *planting or tending trees in a plantation or forest that are intended to be felled*
> - *felling trees in a plantation or forest*
> - *transporting trees or parts of trees that you felled in a plantation or forest to the place*
>   - *where they are first to be milled or processed*
>   - *from which they are to be transported to the place where they are first to be milled or processed.*

The increase in timber that would be available by decreasing basal area limits will likely maintain (or increase) certainty and consistency for primary producers. The Review hasn't seen modelling on either the amount of timber that could be taken (increased intensity per hectare and possible increased participation of landholders), the capacity of the mills, or the impact on regeneration of new trees and biomass over time (30 – 70 years for commercial maturity) from the decreased basal area.

The proposed PNF Codes as drafted are likely to increase the amount of wood removed from forests, without providing a substantial increase in koala protections – triggers are wider through the mapping, but don't cover all high value habitat, and the efficacy of the prescriptions are small compared with the increased intensity. Overall, the risk level from the proposed PNF Codes has not been balanced with a proportionate increase in protections for koalas.

For primary industry the opposite appears to be the case. The proposed PNF Codes have the potential to open up availability to more wood that can be felled, transported, milled and processed. This would seem to reduce their risks and maintain or increase their certainty and consistency.

However, improving the PNF Codes for koalas can still be done in a manner that provides certainty, reduces uncertainty and is consistent.

3.5.1 Certainty

Certainty for landholders and primary producers will come about through making processes for the PNF Plan, FOP/FSP development clear, and with transparent outcomes, as well as clarifying the roles and standards of land holders, forest managers, contractors, regulators and compliance authorities. Certainty can be enhanced through proper PNF planning and management – certainty

[121] https://www.ato.gov.au/business/primary-producers/primary-production-activities/

of forestry sustainability and supply in the long term, and certainty for the quality of the habitat and biodiversity on the land and its resilience to environmental and climatic stressors.

Certainty for landholders and primary producers will also be enhanced by maximising the likelihood that their PNF Plans, as approved, will be stable over their 15-year lifetime. Certainty will be improved through the establishment of strong and reliable regulations that are reflective of the real-world future conditions and risks, so including adaptability should conditions change or stochastic events occur, such as unfavourable climate conditions which may impact the forest. Once a PNF Plan, with either FOP or FSP (depending on the situation) is in place, and if events don't change the situation (e.g., bushfire), then the landholder has certainty. An important caveat to this is that there needs to be more emphasis on increasing the availability of information to landholders and primary producers on climate change, this includes avenues, direction and support on how to include this forward thinking in FOP and FSP preparation and land management.

Allowing producers to change their FOP and FSP without input, guidance or approval from the regulators (LLS and EPA) can lead to inconsistency and uncertainty for neighbouring landholders as more of the habitat functions need to be carried by their land holdings, while they as neighbours may be unaware of the changes on other properties.

The National Forests Policy Statement and Regional Forestry Agreements were designed to provide certainty for forest-based industries, forest dependent communities and achieve conservation outcomes.

Science, risk management, planning are typically directed toward reducing uncertainty, which is another way of thinking about increasing certainty. Reducing uncertainty can come about through the transparent and rigorous use of data, using robust statistical and analytical methods, and making information available to deliver a common understanding of conditions. Ongoing building of the knowledge base where all parties can share data and agree on information, facts and conditions, then that fact base can be the basis for negotiation and argument about desired outcomes and the best way to get there.

3.5.2 Consistency

Consistency can be promoted by developing processes, standards and protocols that are the clear and transparent for all applicants, where the expectations are understood, and there are tools and expert advice available for the landholder to meet the requirements of the PNF Codes and the principles of ESFM. Not all landholders have the same expertise, experience or motivations, so the more tools, guidance, information and data available to plan and manage risks up front, the more consistent will be the outcomes.

To achieve this, consistency is needed by NSW agencies and landholders across two paradigms:

- **Agreement on facts** – Openness, transparency and aligned methods in measuring, modelling, reporting and data collection and handling so disagreement about the factual basis of decisions can be avoided. Agencies should not be arguing over the facts, but rather using the facts as a basis to negotiate policies and priorities.
- **Agreement on metrics** – Transparency and common understanding between both portfolio agencies about what data, modelling, standards and thresholds will need to be considered and met for concurrence to be provided. And documenting for future generations, whether thresholds are based on science or other considerations. This includes a common understanding and agreed approaches to incorporate climate change into planning and management.

Key consideration for LLS in working with landholders on codes, is that not all locations and forests are the same, have the same structure or characteristics or vulnerabilities, or provide the same functions in the landscape. And not all landholders seek to achieve the same outcomes – some seek to maximise productivity and economic output, some seek to maximise biodiversity and ecological health, and some seek to maximise aesthetic beauty from land management efforts. To maximise the chances of consistently high-quality silviculture practice that delivers ESFM as well

as other outcomes, appropriate training, decision making guidelines, regulatory and compliance measures, and incentives for good practice can be used. Consistency means that one legal provision should not directly contradict another. Consistency can be provided to landholders and primary producers by:

- Having a clear and transparent process to applying Codes and monitoring their application
- Making clear the roles of the agencies (regulation, compliance, enforcement), expectations for landholders and contractors, overarching requirements such as ESFM principles
- Publishing clear guidance and supporting material
- As much as possible, making information and data publicly available

3.6 Conclusion

The proposed new PNF Codes do appear to provide certainty and consistency for primary producers as they would increase the amount of timber that could be taken from properties, particularly in the North Coast, and could also increase the incentives for landholders to participate. However, it will be important to understand the impacts on the environment from these changes to ensure they are in line with EFSM principles.

There is a lack of certainty about where PNF forestry has happened to date, there is not an approach of measuring local impacts and cumulative impacts from PNF, and a lack of assessment about what would be the increased impact from lowering the limits in PNF.

For koalas, there is an alignment of factors that is noteworthy – the largest concentration of koalas in the North Coast is also the location where the forests are particularly dense and fertile, and where currently the most PNF occurs (more than 85% of approvals), and where the forestry intensity limits (basal area) will decrease the most.

The lack of information on current impacts and projected future impacts of PNF; uncertainty around the new FSP and FOP guidelines; and deficiencies in the coverage of maps that trigger prescriptions mean that it is difficult to see whether forestry intensity will be increased in a way that provides protections for koalas. While the reach of prescriptions is greater, their strength is not changed even though the intensity of forestry allowed is increased.

Appendices

Appendix 1 – Request for review

NSW GOVERNMENT | Regional NSW

11 June 2021

Professor Hugh Durrant-Whyte
NSW Chief Scientist and Engineer
Level 6, 52 Martin Place
Sydney NSW 2000

Dear Professor Durrant-Whyte,

I write requesting your advice on the proposed final Private Native Forestry Codes of Practice.

A number of amendments have been made to the Listed Species Ecological Prescriptions for the koala (*Phascolarctos cinereus*) (Attachments A-D).

Previously, you have provided advice on the basal area for private native forestry. For convenience, this report is attached (Attachment E).

When considered in tandem, we seek your advice on whether the elements as drafted ensure robust protections for koalas in areas of high value koala habitat; and certainty and consistency for primary producers.

I request that the NSW Chief Scientist and Engineer provide advice to me with an initial report by 17 June 2021 and a final report by 24 June 2021.

Should you require additional information or wish to discuss further please contact Dr Jacqueline Tracey, Executive Director Policy and Strategic Reform, Local Land Services at
or [redacted]

Yours sincerely

[redacted]

Gary Barnes
Secretary

Encl.

Attachment A – Proposed Final Private Native Forestry Code of Practice for Northern NSW
Attachment B – Proposed Final Private Native Forestry Code of Practice for Southern NSW
Attachment C – Proposed Final Private Native Forestry Code of Practice for Cypress and Western Hardwood Forests
Attachment D – Proposed Final Private Native Forestry Code of Practice for River Red Gum Forests
Attachment E – Office of the Chief Scientist and Engineer review of Private Native Forestry Codes of Practice

Regional NSW

17 June 2021

Professor Hugh Durrant-Whyte
NSW Chief Scientist and Engineer
Level 6, 52 Martin Place
Sydney NSW 2000

Sensitive NSW Cabinet

Dear Professor Durrant-Whyte,

Further to your letter dated 16 June 2021, I write to provide clarity on the scope of the advice requested on koala protections within the proposed final Private Native Forestry Codes of Practice.

The Code was considered by Cabinet on 9 December 2019. The deliberations of Cabinet are confidential and care is required so as to not breach Cabinet confidentiality. In early March 2021 the Deputy Premier and Minister Stokes wrote to the Premier advising that they had agreed that the "Private Native Forestry (PNF) Codes of Practice … will be revised to ensure robust protections for koalas in areas of high value koala habitat and certainty and consistency for primary producers."

It is not intended to revisit previous decisions made by Cabinet or Ministers on the proposed Code. Our request is limited to whether the proposed additional koala prescriptions outlined in Appendix A of the proposed final Private Native Forestry Codes of Practice provide "robust protections for koalas in areas of high value koala habitat", **and** "certainty and consistency for primary producers" as agreed by the Ministers. In providing this advice please also consider your review of the report prepared by Professor Cris Brack of ANU on *Native Forest Harvesting and Thinning on Private Managed Lands in NSW for Multiple Purposes* which informed the basal area for Single Tree Selection in the proposed Codes.

The Codes give effect to the prescriptions in Appendix A through the Private Native Forestry Plan approval and the forest operations plan and we are happy to discuss these mechanisms in more detail with your team.

I appreciate your confirmation that you will provide us with a final report on 24 June. To meet this timeframe please provide me with preliminary report by 21 June 2021.

I trust this provides further clarity on the advice. Should you require additional information, please contact Dr Jacqueline Tracey, Executive Director Policy and Strategic Reform, Local Land Services at [redacted] or [redacted]

Yours sincerely,

[redacted]

Gary Barnes
Secretary

Regional NSW

Professor Hugh Durrant-Whyte
NSW Chief Scientist and Engineer
Level 6, 52 Martin Place
Sydney NSW 2000

Sensitive NSW Cabinet

Dear Professor Durrant-Whyte,

I write following my request for advice on the koala protections within the proposed final Private Native Forestry (PNF) Codes of Practice. I note a draft report was due on 21 June 2021 and final report due 24 June 2021.

I am now seeking the draft report by 5pm on 2 July 2021 so that I may meet with the Secretary of the Department of Planning, Industry and Environment to enable the progression of Government commitments.

As previously advised, my request is limited to whether the proposed koala prescriptions outlined in Appendix A of the proposed final PNF Codes of Practice provide "robust protections for koalas in areas of high value koala habitat", **and** "certainty and consistency for primary producers".

I am not seeking advice from the Office of the Chief Scientist on the PNF framework or the proposed Codes as a whole, noting that other elements of the PNF Codes may be discussed between agencies as required.

I look forward to receiving your draft report on 2 July.

Yours sincerely,

[redacted]

Gary Barnes
Secretary

1 July 2021

Appendix 2 – Proposed koala prescriptions

Prescriptions for different species are set out in each of the four proposed. Those for koalas are as follows – reproduced for the Northern NSW draft PNF Code.

Introduction

These prescriptions must be applied within the forestry operations area where there is a **known record, site evidence** or in relation to koalas potential habitat (see Figures 6-7) of a threatened species.

(a) A known record is a sighting or record of the species in the NSW BioNet that is less than 20 years old with a reliability level of 1 to 4 and a coordinate accuracy of 100 metres or less,

(b) Site evidence is a sign a species has visited or regularly uses a site, and includes observations of, for example, faecal pellets or scats, chewed seed cones or a nest, or evidence that the site has been used as a latrine.

A list of threatened species under the *Biodiversity Conservation Act 2016* and species profiles for each species can be viewed on the Department of Planning, Industry and Environment (DPIE) website at https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species

The prescriptions set out below assist in the protection of threatened species, and include:

(1) additional widths to stream exclusion zones

(2) exclusion zones and/or buffer zones around locations of threatened species records

(3) additional tree retention requirements around locations of threatened species records.

Exclusion zones and buffer zones requiring additional tree retention requirements must be applied within the PNF Plan area subject to the area of the forestry operation described in the Forest Operation Plan or Forest Stewardship Plan.

Some species prescriptions vary according to the Bioregion in which they occur. Unless otherwise stated, the regions referred to in the prescriptions are based on the Interim Biogeographic Regionalisation of Australia (IBRA) shown in Figure 4.

General conditions

For all threatened species prescriptions, the following applies:

- where a retained eucalypt tree (as required by these prescriptions) also meets the requirements of a habitat tree, the eucalypt tree may be counted as a habitat tree
- where other exclusion zones form part of the habitat area required for threatened species prescriptions, the exclusion zones may count towards the area of habitat required to be retained
- where public conservation/reserved land (for example National Parks) falls within buffer or exclusion zone areas requiring additional tree retention requirements as part of threatened species prescriptions, then the area of public conservation/reserved land may contribute towards the area of habitat required to be retained.
- buffer and exclusion zones are to be marked in the field where they adjoin the area, subject to forestry operations. This marking has to be visible while forestry operations are occurring.

Koala (*Phascolarctos cinereus*)

Prescription

(a) Where there is a record of a koala within the area of forest operations, or within 500 metres of an area of forest operations, or within areas identified as highly suitable koala habitat as shown in Figures 6-7, the following must apply:

- (i) A minimum of 10 primary koala use trees and 5 secondary koala use trees must be retained per hectare in the harvestable area (not including other exclusion or buffer zones), where available.
- (ii) These trees should be spread evenly across the net harvestable area, have leafy, broad crowns and be in a range of size classes with a minimum of 30 centimetres diameter at breast height over bark.
- (iii) Damage to retained trees must be minimised by directional felling techniques.
- (iv) Post-harvest burns must minimise damage to the trunks and foliage of retained trees.
- (v) Each tree must be visually assessed for koalas immediately prior to it being felled.

b) Any tree containing a koala, or any tree beneath which 10 or more koala scats are found (or one or more koala scats in Central and Southern Tablelands Koala Management Area), or where the presence of a koala is clearly identifiable by recent scratches must be retained, and an exclusion zone of 20 metres (50 metres in Central and Southern Tablelands Koala Management Area) must be implemented around each retained tree.

Note: Where landholders consider the mapping of koala habitat is inaccurate, the landholder may engage a suitably qualified expert to conduct an on-ground survey for koala presence. Survey methods must be consistent with Appendix D.

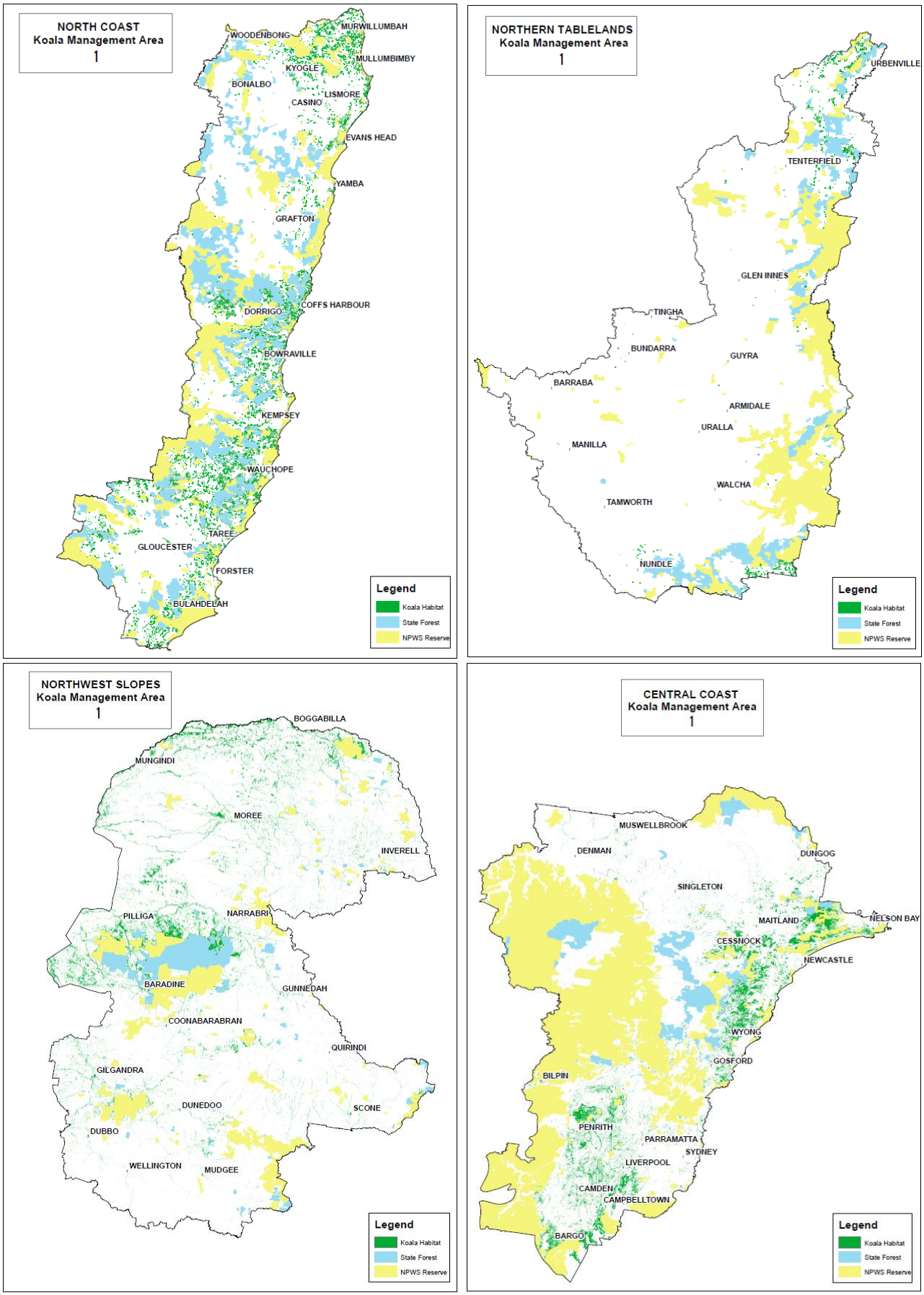


Figure 6: Highly suitable koala habitat (green) in North Coast (top left), Northern Tablelands (top right), Northwest Slopes (bottom left) and Central Coast (bottom right) Koala Management Areas.

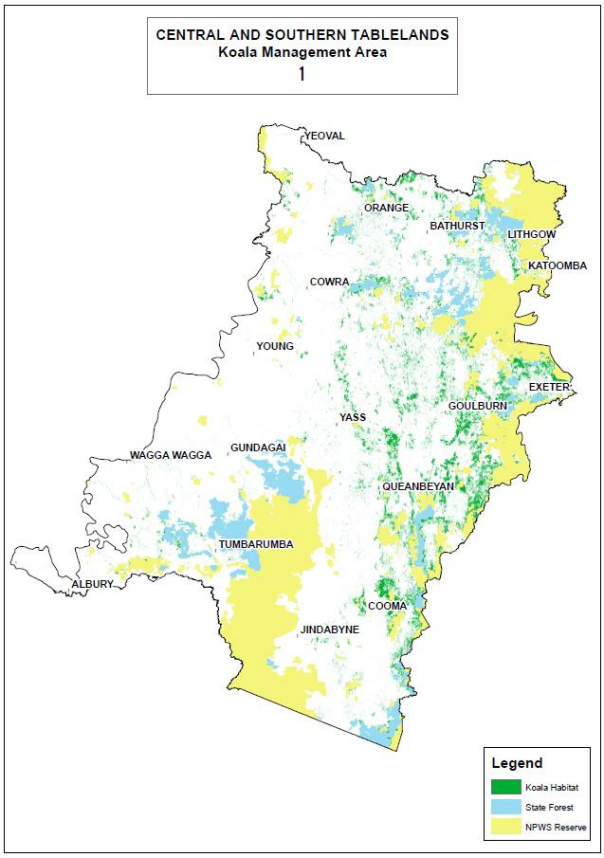


Figure 7: Highly suitable koala habitat (green) in Central and Southern Tablelands Koala Management Area.

Additional information

Generally, koala habitat comprises eucalypt forest and woodland containing primary and secondary food trees (see Table H). Koala droppings (scats) are relatively distinctive, being cylindrical and pit-shaped. Colour varies between green–yellow to yellow–brown. Scats can remain under trees on or within the leaf litter for periods of several weeks to months. For further information on the identification of koala scats, contact DPIE or refer to the DPIE website – https://www.environment.nsw.gov.au/

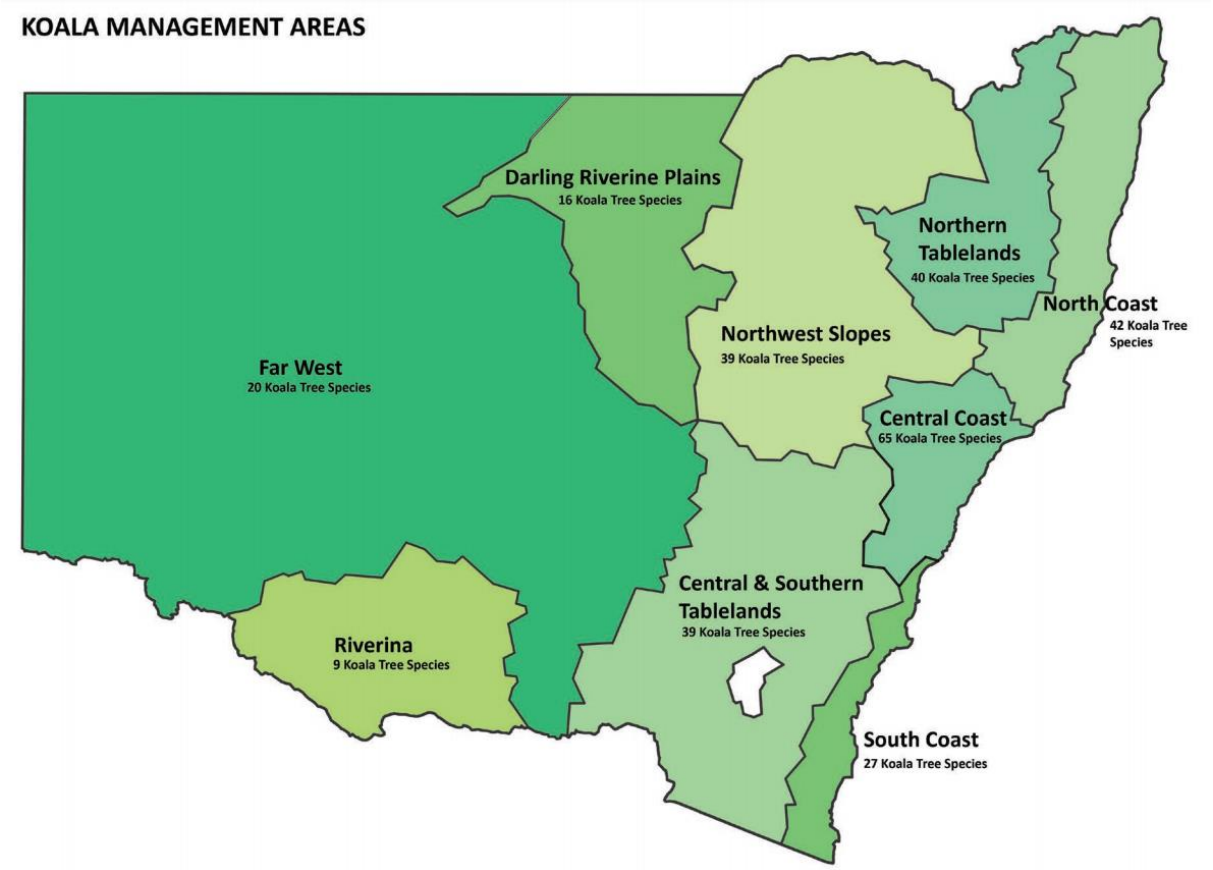


Figure 8: Koala Management Areas in NSW

Table H: Primary and secondary koala use trees for Koala Management Areas in the Northern PNF Code areas

Koala food tree species		Koala Management Area					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Primary tree species							
Apple box	*Eucalyptus bridgesiana*				x		
Beyer's ironbark	*Eucalyptus beyeriana*		x				
Bimble box/poplar box	*Eucalyptus populnea*					x	
Black box	*Eucalyptus largiflorens*					x	
Black Sally	*Eucalyptus stellulata*				x		
Blakely's red gum	*Eucalyptus blakelyi*		x		x	x	x

Brittle gum	*Eucalyptus mannifera*						x
Broad-leaved stringybark	*Eucalyptus caliginosa*				x		
Cabbage gum	*Eucalyptus amplifolia*	X					
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Primary tree species							
Coast grey box	*Eucalyptus bosistoana*		x	x			
Coolibah	*Eucalyptus coolabah*					x	
Craven grey box	*Eucalyptus largeana*	X	x				
Dirty gum	*Eucalyptus chloroclada*					x	
Dwyer's red gum	*Eucalyptus dwyeri*					x	
Flooded gum	*Eucalyptus grandis*	X	x				
Forest red gum	*Eucalyptus tereticornis*	X	x	x	x		x
Forest ribbon gum	*Eucalyptus nobilis*				x		
Fuzzy box	*Eucalyptus conica*					x	
Grey box	*Eucalyptus moluccana*	X	x		x	x	
Grey gum	*Eucalyptus punctata*	X	x	x		x	x
Grey gum	*Eucalyptus biturbinata*	X			x		
Grey ironbark	*Eucalyptus paniculata*		x				
Hard-leaved scribbly gum	*Eucalyptus sclerophylla*						x
Inland scribbly gum	*Eucalyptus rossii*						x
Large-fruited grey gum	*Eucalyptus canaliculata*	X	x			x	

Maiden's blue gum	*Eucalyptus maidenii*			x			
Monkey gum	*Eucalyptus cypellocarpa*		x	x			x
Mountain blue gum	*Eucalyptus brunnea*				x		
Mountain blue gum	*Eucalyptus deanei*		x				
Mountain gum	*Eucalyptus dalrympleana*				x		
Mugga (red) ironbark	*Eucalyptus tricarpa*			x			
Narrow leaved peppermint	*Eucalyptus radiata*				x		
Narrow-leaved black peppermint	*Eucalyptus nicholii*				x		
Narrow-leaved grey box	*Eucalyptus pilligaensis*					x	
Narrow-leaved ironbark	*Eucalyptus crebra*					x	
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Primary tree species							
Narrow-leaved stringybark	*Eucalyptus eugenioides*			x			
Orange gum	*Eucalyptus bancroftii*	X					
Orange gum	*Eucalyptus prava*					x	
Parramatta red gum	*Eucalyptus parramattensis*		x			x	
Peppermint	*Eucalyptus exserta*					x	
Red mahogany	*Eucalyptus resinifera*	X					
Ribbon gum	*Eucalyptus viminalis*				x		x
River red gum	*Eucalyptus camaldulensis*		x		x	x	x
Silver-leaved Ironbark	*Eucalyptus melanophloia*					x	

Silver-top stringybark	*Eucalyptus laevopinea*				x		
Slaty red gum	*Eucalyptus glaucina*	X					
Small-fruited grey gum	*Eucalyptus propinqua*	X	x				
Swamp mahogany	*Eucalyptus robusta*	X	x				
Sydney blue gum	*Eucalyptus saligna*	X					
Tallowwood	*Eucalyptus microcorys*	x	x		x		
Tumbledown red gum	*Eucalyptus dealbata*				x	x	
Wattle-leaved peppermint	*Eucalyptus acaciiformis*				x		
Western grey box	*Eucalyptus microcarpa*					x	
White box	*Eucalyptus albens*		x		x	x	x
White Sally, snow gum	*Eucalyptus pauciflora*				x	x	
White stringybark	*Eucalyptus globoidea*		x	x			x
White-topped box	*Eucalyptus quadrangulata*		x				
Woollybutt	*Eucalyptus longifolia*		x	x			
Yellow box	*Eucalyptus melliodora*		x		x	x	
Yertchuk	*Eucalyptus consideniana*			x			
Youman's stringybark	*Eucalyptus youmanii*				x		
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Secondary tree species							
Apple box	*Eucalyptus bridgesiana*					x	x

Bangalay	*Eucalyptus botryoides*		x				
Bastard tallowwood	*Eucalyptus planchoniana*	x					
Bastard white mahogany	*Eucalyptus umbra*	x	x				
Bastard white mahogany	*Eucalyptus psammitica*	x					
Belah	*Casuarina cristata*					x	
Black she-oak	*Allocasuarina littoralis*		x	x	x		
Blackbutt	*Eucalyptus pilularis*	x	x	x			
Blue box	*Eucalyptus baueriana*			x			
Blue-leaved stringybark	*Eucalyptus agglomerata*		x	x			x
Brittle gum	*Eucalyptus mannifera*					x	
Brittle gum	*Eucalyptus michaeliana*		x		x		
Broad-leaved apple	*Angophora subvelutina*				x		
Broad-leaved paperbark	*Malaleuca quinquenervia*	x	x				
Broad-leaved peppermint	*Eucalyptus dives*						x
Broad-leaved red ironbark	*Eucalyptus fibrosa*	x	x			x	x
Broad-leaved scribbly gum	*Eucalyptus haemastoma*		x				
Broad-leaved stringybark	*Eucalyptus caliginosa*					x	
Brown barrel	*Eucalyptus fastigata*			x			
Brown stringybark	*Eucalyptus capitellata*		x				
Bundy	*Eucalyptus goniocalyx*					x	x
Cabbage gum	*Eucalyptus amplifolia*		x		x		x

Camfield's stringybark	*Eucalyptus camfieldii*		x				
Candlebark	*Eucalyptus rubida*						x
Coast grey box	*Eucalyptus bosistoana*						x
Drooping ironbark	*Eucalyptus caleyi*				x	x	
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Secondary tree species							
Eucalyptus imitans	*Eucalyptus imitans*		x				
Eucalyptus williamsiana	*Eucalyptus williamsiana*				x		
Forest oak	*Allocasuarina torulosa*	x	x				
Forest ribbon gum	*Eucalyptus nobilis*	x				x	
Fuzzy box	*Eucalyptus conica*						x
Grey ironbark	*Eucalyptus siderophloia*	x	x				
Grey ironbark	*Eucalyptus placita*	x					
Grey ironbark	*Eucalyptus paniculata*			x			x
Hard-leaved scribbly gum	*Eucalyptus sclerophylla*		x	x			
Large-flowered bundy	*Eucalyptus nortonii*						x
Large-fruited red mahogany	*Eucalyptus scias*	x	x				
Large-leaved spotted gum	*Corymbia henryi*	x					
Maiden's blue gum	*Eucalyptus maidenii*						x
Messmate	*Eucalyptus obliqua*			x	x		x
Mountain gum	*Eucalyptus dalrympleana*					x	x

Mugga ironbark	*Eucalyptus sideroxylon*		x		x	x	x
Narrow leaved peppermint	*Eucalyptus radiata*						x
Narrow-leaved apple	*Angophora bakeri*		x				
Narrow-leaved ironbark	*Eucalyptus crebra*	x	x		x		
Narrow-leaved red gum	*Eucalyptus seeana*	x					
Narrow-leaved scribbly gum	*Eucalyptus racemosa*		x				
Narrow-leaved stringybark	*Eucalyptus eugenioides*	x	x		x		x
Narrow-leaved stringybark	*Eucalyptus sparsifolia*		x				
New England blackbutt	*Eucalyptus campanulata*	x			x		
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Secondary tree species							
New England peppermint	*Eucalyptus nova-anglica*				x		
Orange gum	*Eucalyptus prava*				x		
Pink bloodwood	*Corymbia intermedia*	x					
Red bloodwood	*Corymbia gummifera*	x	x	x			
Red box	*Eucalyptus polyanthemos*					x	x
Red mahogany	*Eucalyptus resinifera*		x				
Red stringybark	*Eucalyptus macrorhyncha*		x		x	x	x
Ribbon gum	*Eucalyptus viminalis*		x	x		x	
River peppermint	*Eucalyptus elata*			x			x

Rough-barked apple	*Angophora floribunda*	x	x	x	x	x	
Scaly bark	*Eucalyptus squamosa*		x				
Scribbly gum/narrow-leaved scribbly gum	*E. signata/E. racemosa*	x	x				
Silver-leaved Ironbark	*Eucalyptus melanophloia*				x		
Silvertop ash	*Eucalyptus sieberi*		x	x			x
Silver-top stringybark	*Eucalyptus laevopinea*	x				x	
Slaty red gum	*Eucalyptus glaucina*		x				
Smooth-barked apple	*Angophora costata*		x				
Spotted gum	*Corymbia maculata*	x	x	x			
Steel Box	*Eucalyptus rummeryi*	x					
Stringybark	*Eucalyptus tindaliae*	x					
Stringybark	*Eucalyptus oblonga*		x				x
Swamp oak	*Casuarina glauca*		x				
Sydney blue gum	*Eucalyptus saligna*		x	x	x		
Sydney peppermint	*Eucalyptus piperita*		x	x			x
Thick-leaved mahogany	*Eucalyptus carnea*	x	x				
Koala food tree species		**Koala Management Area**					
Common name	**Scientific name**	**North Coast**	**Central Coast**	**South Coast**	**Northern Tablelands**	**North West Slopes**	**Central and Southern tablelands**
Secondary tree species							
Tumbledown red gum	*Eucalyptus dealbata*						x
Turpentine	*Syncarpia glomulifera*		x				

Western grey box	*Eucalyptus microcarpa*						x
White cypress pine	*Callitris glaucophylla*				x	x	
White mahogany	*Eucalyptus acmenoides*	x	x				
White Sally, snow gum	*Eucalyptus pauciflora*						x
White stringybark	*Eucalyptus globoidea*	x					
White-topped box	*Eucalyptus quadrangulata*					x	x
Yellow bloodwood	*Corymbia eximia*		x				
Yellow box	*Eucalyptus melliodora*						x
Yellow stringybark	*Eucalyptus muelleriana*			x			
Yertchuk	*Eucalyptus consideniana*		x				

Appendix 3 – Comparison of proposed PNF Codes against current PNF Codes and Coastal IFOA, with comment

This Appendix brings together information that could impact have an impact on the protection of koalas, drawn from the current PNF Codes (and guidelines, where relevant), the current Coastal IFOA, and compared to the proposed new PNF Codes. Note: Unless otherwise stated, this information is a comparison of the Coastal IFOA and the Northern NSW PNF Codes of Practice (current and proposed), as the Review understands that this is where the majority of PNF occurs.

	Actions and constraints	Current PNF Codes of Practice (Northern NSW)	Coastal IFOA	Proposed PNF Codes of Practice (Northern NSW)
Forestry take	Operations plan	The FOP contains: • map(s) with the location and boundaries of the area in which harvesting and/or other forestry operations are occurring; recorded locations an any populations or endangered ecological communities listed under the Threatened Species Conservation Act 1995 or in the Appendix to the PNF Codes; the location of specific landscape features (e.g. drainage features); indicative locations of existing / proposed roads, log landings, portable mill sites, etc; forest type classification • details of ownership of the land • description of broad forest types (includes overstory species composition, disturbance history and current condition) • estimated stand height and basal area for each broad forest type • details of forest access (construction, upgrades, maintenance, etc.) • details of harvesting and/or other proposed forest operations • flora / fauna management actions • details of tree marking activities • details on the activities that promote regeneration • details of relevant silviculture treatments that may be carried out within the FOP The PNF Code notes that the landowner may amend the FOP any time (except in regard to the contemporary description of the pre-harvest forest condition), with any amendments to be noted on the FOP. The FOP, plus any amendments, must be provided to an authorised officer from the EPA upon request.	Operational plans (forestry operations) must include: • Description of the operational area • Event ID • Type of forestry proposed • State Forest name and compartment numbers; for Crown-timber land, ID such as Lot and DP and/or lease number • Local landscape area identifier • If within the known habitat or potential habitat of a relevant species, must include flora/species management plan • Targeted flora and fauna surveys; broad area habitat search Operational plans (harvesting operations) must include: • Base net area (ha) • Planned intensity (selective, intensive, mixed intensity, alternate coupe) • Site-specific harvesting limits • Targeted tree species for removal • Estimated quantities of timber products • Total area (ha) of tree retention clumps Operational plans must show map scale, grid coordinates, contour lines, State Forest name (or tenure ID), operational areas (including boundaries), retained tree or habitat features, locations of new roads to be constructed, locations and names of roads to be used, seasonality restrictions on compartments, etc.	The FOP pathway is the same. In the proposed PNF Codes, an alternative pathway is available: the FSP. The FSP allows the landholder to undertake forestry operations, similar to the FOP. However, it FSP process allows for the variation of provisions within the PNF Codes of Practice, upon joint approval by the Secretary of DRNSW and the Secretary of DPIE (or, if they cannot reach agreement, the Minister administering Part 5B of the *Local Land Services Act 2013* and the Minister administering the *Biodiversity Conservation Act 2016* may make a determination on the proposed minor variation).

	Wood extraction volumes or weights	No wood extraction limits stated	Estimated total volume to be removed from each compartment (per ha): • High: > 80 m^3/ha • Medium: 30 – 80 m^3/ha • Low: < 30 m3 / ha Volume information (produced and sold): • High quality large sawlogs (m^3) • Large veneer logs (m^3) • High quality small sawlogs (m^3) • Small veneer logs (m^3) • Poles, piles and girder logs (m^3) • Low quality logs (tonnes) • Pulpwood logs (tonnes) • Timber products (include firewood, fencing, and woodchop blocks, in tonnes) • Heads and offcuts (tonnes) • Native forest biomaterial (for electricity generation; tonnes) Timber product quantities are limited within each 5-year period and are limited spatially.	No wood extraction limits stated
	Sampling points	No method stated within explicitly within the Code, rather the sampling method is as set out in the EPAs Silvicultural Guidelines to sample and apply basal area: the methods are angle count sampling or fixed area plot measurement. • Angle count sampling: unbiased, quick estimates of basal area that involves a sweep (i.e. 360 degree sighting) of an area of the forest from a sampling point using specific instruments that measure basal area factor (for example, a relascope, dendrometer or wedge prisms). • Fixed area plot measurement: involves the measurement of the diameter of all trees within a set area (1/10 ha plots are the standard practice), thereby calculating the basal area of each tree within the plot towards a total basal area.	A minimum number of sampling points are require based on the harvest area size: • 0 – 30 ha: 20 sample points • 31 – 50 ha: 30 sample points • 51 – 100 ha: 40 sample points • 101 – 200 ha: 50 sample points • 201 ha+: 60 sample points	Calculating minimum stand basal area • Systematically across the harvested area with a minimum inter-point distance of 60 m • Must be taken using angle count sampling or fixed area plot measurements • Where fixed area plots are used, plots must be 50 m x 20 m • Total number of samples are as follows: ○ 0 – 30 ha: 20 sample points ○ 31 – 50 ha: 30 sample points ○ 51 – 100 ha: 40 sample points ○ 101 – 200: 50 sample points ○ 201 ha+: 60 sample points Regeneration (STS and Thinning operations): minimum number of sample points required for harvested areas (with squares 200 x 200 m): • 0 – 10 ha: 80 (2 squares) • 11 – 50 ha: 120 (3 squares) • 51 – 100 ha: 200 (5 squares) • 101 – 200 ha: 280 (7 squares) • 201 ha+: 360 (9 squares) Regeneration (AGS): for compliance, calculating forest regeneration in areas subject to AGS must: • have all sample points within canopy openings created by the AGS operation • systematic sampling points across canopy opening, with inter-point distance of 20 m and circular plots size of ~10 m2 (minimum radius of 1.8 m) sampling intensity of 50 plots per ha or equivalent of 5%) • each plot is considered stocked if: ○ it is under the canopy of an existing tree ○ contains at least one viable seedling ○ contains advanced growth of an upper canopy spp. • Minimum number of openings that must be sampled are: ○ 0 -10 canopy openings: 2 canopy openings sampled ○ 11 - 50 canopy openings: 5 canopy openings sampled ○ 51 - 100 canopy openings: 10 canopy openings sampled ○ 101 - 200 canopy openings: 20 canopy openings sampled ○

	Silviculture practice	• STS and thinning
		• AGS, which must conform with the following requirements:
		  ○ Sum of canopy openings must at no time exceed 20% of the NHA
		  ○ Maximum width of canopy openings must not exceed twice the stand height
		  ○ Minimum distance between canopy openings must not be less than twice the stand height
		• Note: a canopy opening is an area greater than 0.1 ha in size, where any remaining vegetation is less than 50% of the stand height
			• Intensive harvesting: high level of tree removal and ground disturbance in specific zones ('intensive harvesting zones') in blackbutt-dominated forests; effects no more than 33.3% of the NHA in a local area zone in any cycle; 10 years between the use of intensive harvesting between adjacent coupes, does not exceed 2,200 ha of State forest each financial year
			• Selective harvesting: selectively removes trees from the harvest area
			• Alternate coupe logging (intensive harvesting type that only occurs in the Eden region)
			• Mixed intensity harvesting: where both intensive and selective harvesting occurs
				• Small scale harvesting (up to 5 trees per ha, and 5 ha, or volume is 50 m^3 per year) (requires PNF Plan)
				• STS and thinning (requires PNF Plan, and FOP or FSP) (STS may not result in canopy openings)
				• AGS (requires PNF Plan, and FOP or FSP):
				  ○ Sum of canopy openings must at no time exceed 20% of the NHA
				  ○ Minimum distance between canopy openings must not be less than twice the stand height
				  ○ Maximum width of canopy openings must not exceed twice the stand height or must not exceed 3000 m^2
				Note: a canopy opening is an area greater than 0.1 hectares in size, measured between canopy perimeters, where any vegetation remaining within the opening is less than one-half of the stand height.

	Minimum average basal area limit	STS and thinning operations must not reduce the stand basal area below the following limits:
		• For stand height < 25 m
		  ○ Tablelands hardwood: 12 m^2/ha
		  ○ Tablelands ash: 12 m^2/ha
		  ○ Spotted gum: 12 m^2/ha
		  ○ North coast dry mixed hardwood: 12 m^2/ha
		  ○ North coast flooded gum: 12 m^2 / ha
		  ○ North coast blackbutt: 14 m^2 / ha
		• For stand height > 25 m
		  ○ Tablelands hardwood: 16 m^2 / ha
		  ○ Tablelands ash: 16 m^2 / ha
		  ○ Spotted gum: 16 m^2 / ha
		  ○ North coast dry mixed hardwood: 16 m^2 / ha
		  ○ North coast flooded gum: 18 m^2 / ha
		  ○ North coast blackbutt: 18 m^2 / ha
		
		As per the PNF Code Guideline No. 5: Techniques for Measuring Stand Basal Area, '*while the stand basal area provisions of the Code are applied as an average, there are limits to this principle: … no more than half of the sampling points in the relevant operational area can be below the minimum limits.*'
			Selective harvesting limits
			• 10m^2 / ha (regrowth zone)
			• 12m^2 / ha (non-regrowth)
			All forestry operations must have an average basal area equal to or above these minimum basal area limits, with:
			• > 50% of sampling points having equal or above the average minimum limit
			• No more than 25% of sampling points having below 6 m^2/ha (regrowth) or 8 m^2 ha (non-regrowth)
				Av. 10 m^2 / ha in Northern NSW (STS and thinning)
				Av. 12 m^2 / ha in Southern NSW (STS and thinning)
				Av. 8 m^2 / ha in Western Hardwood forests (STS and thinning)
				
				All forestry operations must have an average basal area equal to or above these minimum average basal area limits, with no more than 25% of sampling points having a basal area below 7 m^2 / ha
				
				STS and thinning operations
				• RRG: must not reduce the stand basal area below 12 m^2 per ha across the harvested area of the FOP. Ideally, single tree selection and thinning should aim to space trees according to the formula: ¼ DBHOB (cm)*100
				• Northern Single: must not reduce the stand basal area below 10m^2/ per ha across the harvested area of the FOP
				• Southern: - must not reduce stand basal area below 12m^2/hectare across the harvested area of the FOP
				• Cypress and Western Hardwood: must not reduce the stand basal area below 6 m^2 per ha (Cypress) and 8 m2 per ha (Western Hardwood) across the harvested area of the FOP

Forestry protections	Application of the protections	Forestry operations prohibited in areas of approved core koala habitat as defined in SEPP 44 Total area approx. 6000 ha	Approval applies within State Forests and other Crown-timber land within the Coastal IFOA Region (subject to other conditions). Restrictions placed on activities that would result in: • harm to any animal or plant that is (or is part of) a threatened species, extinct species, species extinct in the wild or threatened ecological community listed in the BC Act. • Damage to a declared area of outstanding biodiversity value • harm to a threatened species, population or ecological community (meaning within the FM Act) • damage to critical habitat, or the threatened species, population or ecological community (meaning within the FM Act)	No prohibitions for core koala habitat set out in SEPP 44 mapped lands (SEPP 44 now switched off). Rather, prescriptions apply to highly suitable koala habitat and any area with a koala record Total area approx. under prescription: 1.2 m+ ha
	Exclusions from forestry operations	Forestry operations prohibited in areas of approved core koala habitat as defined in SEPP 44 Total area approx. 6000 ha	Approx. 38% of the State forest areas is permanently excluded from harvesting[122]	No exclusions

[122] NRC (2016) Advice on Coastal Integrated Forestry Operations Approval remake

	Tree retention rates (including in koala use areas)	Where there is a record of a koala within an area of forest operations or within 500 metres of an area of forest operations or a koala faecal pellet (scat) is found beneath the canopy of any primary or secondary koala food tree (see Table I below), the following must apply: (i) A minimum of 10 primary koala food trees and 5 secondary koala food trees must be retained per hectare of net harvesting area (not including other exclusion or buffer zones), where available. (ii) These trees should preferably be spread evenly across the net harvesting area, have leafy, broad crowns and be in a range of size classes with a minimum of 30 centimetres diameter at breast height over bark. (iii) Damage to retained trees must be minimised by directional felling techniques. Private Native Forestry Code of Practice for Northern NSW 30 (iv) Post-harvest burns must minimise damage to the trunks and foliage of retained trees. Tree retention • 10 hollow bearing trees per 2 ha ○ Where the total number of hollow bearing tress is less than this, additional recruitment trees must be retained to bring this number up to 20 trees per 2 ha • One recruitment tree from the next cohort, that is representative of the range of species on the forest prior to operations • Up to 50% of the required recruitment tree can be in the riparian buffer, if the 2 ha area is within 200 m (or partly includes) the buffer • A minimum of 6 feed trees per 2 ha should be retained where available • All feed trees with marks or 'V' notches from sap-feeding mammals must be retained • All roost, nest or food resource trees must be retained Retained habitat trees must also represent the range of species in mature and late mature growth stages	Koala browse tree retention • A minimum of 10 koala browse trees per ha of the NHA where koala prescription 1 applies • A minimum of 5 koala per ha of the NHA where koala prescription 2 applies and where a contemporary koala record exists (previous 10 years) • All koala browse trees in areas where the minimum coverage of koala browse trees (as iterated above) does not exists within the NHA prior to forestry FCNSW must record the location and identification of retained trees If any retained tree is damaged, it must be replaced with a comparable tree. If not available, a mature tree with a healthy, undamaged crown must be retained. Tree retention clumps must include as least one (and as many as possible) existing hollow-bearing trees, potential future hollow-bearing trees, nectar trees, Glider sap feed trees, koala browse trees, Glossy Black Cockatoo feed trees and giant trees, and dead standing trees. Tree retention clumps must be identified and permanently retained at least 100 m in advance of the forestry operation at a rate of at least 5% (regrowth zone) and 8% (non-regrowth zone) of the base net area. The tree retention clump must be at least 0.1 ha and up to 2 ha in size, and are in addition to Wildlife Clumps (see below). Wildlife Clumps • At least 5% of the base net are of each local landscape area must be identified prior to the commencement and permanently retained • Wildlife clumps must be greater than one hectare in size (unless it is a carry-over exclusion zone or previously unmapped rocky outcrops, cliffs, heath and scrub, wetlands and their associated exclusion zone)	As current Codes, with the addition of: • Added requirement of visually inspecting trees for koalas prior to felling, in addition to the provisions in the current PNF Code. Recruitment trees and hollow bearing tree definitions have been updated to note that trees must have a DBHOB of 30 cm or greater.
	Tree species list	7 primary koala use trees 50 secondary koala use trees	5 primary koala browse trees (excludes potential hybrids) 16 secondary koala browse trees	61 primary koala use trees 96 secondary koala use trees
	Tree scats	Any tree containing a koala, or any tree beneath which 20 or more koala faecal pellets (scats) are found (or one or more koala faecal pellets in Koala Management Area 5) must be retained, and an exclusion zone of 20 metres (50 metres in Koala Management Area 5) must be implemented around each retained tree	No provisions for the trigger value based on the number of scats	Any tree containing a koala, or any tree beneath which 10 or more koala scats are found (or one or more koala scats in Central and Southern Tablelands Koala Management Area), or where the presence of a koala is clearly identifiable by recent scratches must be retained, and an exclusion zone of 20 metres (50 metres in Central and Southern Tablelands Koala Management Area) must be implemented around each retained tree.

	Suitably qualified person	No definition of 'suitably qualified person' (or similar) is provided in regards to TEC or koalas	Threatened Ecological Communities '*For the purpose of identification of TEC (indicative), a suitably qualified person is a person who has extensive and bioregionally-specific experience in the field identification of TECs, as well as similar ecological communities that may be confused with TECs*' Assessment of Koala presence during harvesting '*A person tasked with undertaking assessments of the presence of Koala in trees in the course of harvesting operations (for the purpose of condition 75 of the approval) must:* *a) be properly trained and proficient, to the EPA's satisfaction, in:* *(i) the identification of Koalas;* *(ii) referred Koala browse tree identification; and* *(iii) Koala habitat use and habits; and* b) *undergo periodic refresher training on any new or updated information on the subject matter listed in condition 6.7(1)(a) of this protocol via semi-formal or formal delivery methods on the matters in (a) above and when new information on Koala habitat use or survey methods become available*'	'*For the purpose of Appendix D Clause 2(b)a suitably qualified expert means a person with a minimum undergraduate qualification in natural sciences, ecology, environmental management, forestry or similar from a university and with a minimum 3 years' experience in environmental assessment, including field identification of plant and animal species and habitat. The person must have as a minimum the following experience in conducting koala surveys:* • *Greater than 10 surveys* • *Experience in using the koala presence survey methods* • *Can accurately identify preferred koala use trees* • *Can distinguish between koala faecal pellets and those from other species that may present similar characteristics*'
	Seasonality restrictions	Seasonality restrictions apply within the former Northern Rivers Catchment Management Authority Area for the periods of December – March, or the rainfall erosivity is equal to or greater than 6,000 and the ground slopes are greater than 20 degrees	The Coastal IFOA protocols set out a methodology for determining the applicable seasonality restrictions (in regard to the inherent soil erosion and water pollution hazard assessment protocols). This includes time period restrictions within different rainfall zones on activities such as forestry operations on ground slopes that are greater than 20 or 25 degrees, or road construction on sloped greater than 30 degrees	As previous codes
	Regeneration	Minimum stand stocking must be achieved within 24 months of a regeneration event (i.e. harvesting or thinning operation). Harvesting operations cannot occur until stocking reaches the minimum stocked plot requirements, as follows: • Tablelands hardwood ○ Within canopy openings: 50% ○ Elsewhere in forest: 60% • Tablelands ash ○ Within canopy openings: 55% ○ Elsewhere in forest: 65% • Spotted gum ○ Within canopy openings: 60% ○ Elsewhere in forest: 70% • North coast dry mixed hardwood ○ Within canopy openings: 50% ○ Elsewhere in forest: 60% • North coast moist mixed hardwood ○ Within canopy openings: 55% ○ Elsewhere in forest: 65% • North coast flooded gum ○ Within canopy openings: 55% ○ Elsewhere in forest: 65% • North coast blackbutt ○ Within canopy openings: 60% ○ Elsewhere in forest: 70%	Regeneration to achieve the standards in this protocol is only required for harvested areas where the natural floristic composition exists at a basal area of less than 14 m^2 per ha The regeneration and stocking standard for harvested areas to which this protocol applies is met if at least 65% of a harvested area is stocked with natural floristic composition within 2 – 3 years (Dry Blackbutt, Dry Sclerophyll and Silvertop Ash) or 2 – 5 years (other). If 40 – 65% is achieved by these the previous time points, then FCNSW must determine whether the implementation of regeneration remedial action or a site-specific regeneration rehabilitation plan is required. If less than 40% of a harvested area is stocked with natural floristic composition within the previous time points, FCNSW must implement a regeneration remedial plan or a site-specific rehabilitation plan.	Minimum stand stocking must be achieved within 24 months of a regeneration event (i.e. harvesting or thinning operation). Harvesting operations cannot occur until stocking reaches the minimum stocked plot requirements, which is ≥ 55% (within canopy openings) or ≥ 65~~5~~% (elsewhere in forest). Method for calculating forest regen for STS and thinning harvested areas is above (sampling points).

Information	Reporting and forestry operations	Landholder submits report by 31 March each year	Annual plan submitted to the NSW EPA on or before June 20 (for each year that the approval has effect) An annual return every 12 months from the date of the approval issue Within the annual plan, FCNSW must include the following information for the coming year: • Harvesting operations • Road construction • Pre-harvest burns • Post-harvest burns • Regeneration activities FCNSW must also specify the type of each proposed forestry operations and the intended locations (State Forest and compartment number; management zone and harvesting zone; or, any other identifying particulars)	Must notify LLS 21 days prior to the commencement of forestry activities and within 21 of the completion of forestry operations At the commencement of activities, the following information must be provided to LLS: • PNF Plan approval number • proposed commencement date and estimated time for forestry operations completion • a map showing the location of the proposed forestry operations • name and contact details of the landholder. At the completion of activities, the following information must be provided to LLS: • PNF Plan approval number • map showing the location of the forestry operations • approximate volume of forest products harvested • approximate number of hectares on which the forestry operations have occurred • date that the forestry operations were completed
	Compliance	The landowner must provide the Forest Operation Plan, including any amendments, to an authorised officer from the Environment Protection Authority if requested to do so	FCNSW must record the date and details of any non-compliance with a condition of the approval whilst carrying out forestry operations	As current PNF Code
	Mapping, modelling, analysis and intel that goes into the planning		FCNSW must record a GIS spatial dataset record that outlines the boundaries of any forest operations, the type, and the date of commencement and completion	LLS provides updated information to the landholder on the locations of plants, animals and ecological communities listed in the schedules of the *Biodiversity Conservation Act 2016* at this time to ensure that the relevant Code requirements are applied to the forestry operation.
	Additional landholder consideration			Where landholders consider the mapping of koala habitat is inaccurate, the landholder may engage a suitably qualified expert to conduct an on-ground survey for koala presence. Survey methods must be consistent with Appendix D.

Appendix 4 – LLS Lidar Study

Department of Primary Industries

Technical Report for Local Land Services

Site Index Mapping for North and South Coast NSW using LiDAR Data

www.dpi.nsw.gov.au

Published by the NSW Department of Primary Industries

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Contents

Executive Summary

This study modelled the site productivity of forest on the NSW north coast using airborne laser scanner (ALS) data. Site productivity is a quantitative estimate of the potential of a site to produce plant biomass. It is often quantified as an index, typically site class or site index. Most commonly used site indices are based on or derived from estimates of stand height at a given age. As forest height is captured really well using ALS data accurate site index can be estimated using ALS metrics. The model may be readily applied to other regions where LiDAR data is available.

The aims of this study were to:

a) Analyse the relationship between dominant height of forest and ALS metrics

b) Develop a spatially-explicit model (20m resolution) of dominant height using ALS data

c) Produce a site Index map of North Coast NSW forest

d) Produce a site Index map of South Coast NSW forest

Key findings of the study were:

- Dominant height was highly correlated with a number of ALS metrics, such as average height, 99th height percentile, 95th height percentile and 90th height percentile of first returns.
- A spatially explicit model for site index forest was developed at 20m resolution for North Coast NSW.
- The model showed a good agreement with the reference data, the estimated bias was low (-0.17 m) and low root mean square error (RMSE) of 3.5 m and relative RMSE: 12.7%
- The model was applied to the ALS data from spatial services and 20 m resolution site index map for North Coast NSW forest was created.
- The model was applied to the ALS data from spatial services and 20 m resolution site index map for South Coast NSW forest was created.

Introduction

Reliable estimates of site productivity are crucial for the sustainable management of forest resources. Site refers to a geographic location that is considered homogeneous in terms of its physical and biological environment, and Site productivity is a quantitative estimate of the potential of a site to produce plant biomass (Pretzsch, 2009). A narrow definition is generally used in forestry that refer to part of the site potential that is or is expected to be realized by the trees for wood production. In that sense, forest site productivity may be defined as the potential of a particular forest stand to produce aboveground wood volume, referring to the production unit formed by the site and the stand of trees in concert. Within this narrower context, site productivity is often quantified as an index, typically site class or site index. Most of the indices are derived from estimates of stand height at a given age. Top and dominant height, are least affected by thinning and are the most stable height-based indicators of site productivity (Næsset, 1997, Skovsgaard, 2008).

The aims of this study were to:

a) Analyse the relationship between dominant height of forest and ALS metrics

b) Develop a spatially-explicit model (20m resolution) of dominant height using ALS data

c) Produce a site Index map of North Coast NSW forest

d) Produce a site Index map of South Coast NSW forest

Data

Study Area

The study area is private native forest on the NSW North Coast that has NSW Spatial Services LiDAR coverage (as shown at Figure 1).

Data for Model development: Eden Data (FCNSW)

The data from Eden Native forest was used. The Eden CRA Region totals about 800 000 hectares and extends, in broad terms, from Bermagui and Nimmitabel in the north to Delegate and Cape Howe in the south. About two thirds of the area is forested and most of the forest is on Crown lands – either as State forest (25% of the total area) or national park (32%). Other Crown-timber lands are a minor proportion of the total area (about 2%) (Towards an Eden Regional Forest Agreement, 1998).

The data file contains 350 forest plots with mean top height (MTH) as the response variable (figure 2). Mean Dominant Height is the mean height of the tallest 40 trees per hectare or 4 trees for a 0.1 ha plot. ALS metrics were calculated for the plots and used as predictor variables.

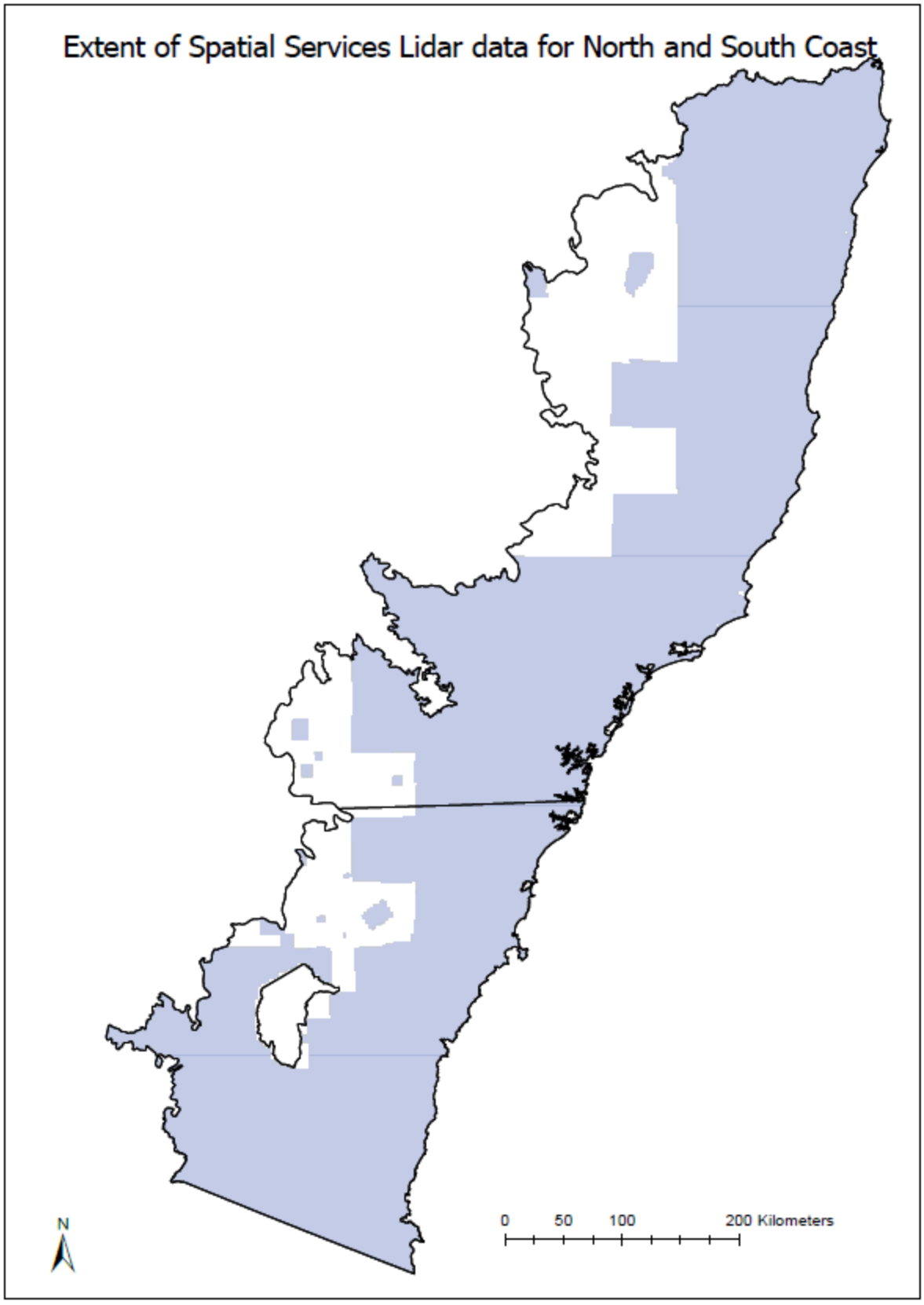

Figure 1: Spatial services LiDAR data showing the extent of the LiDAR data for North and South Coast PNF areas.

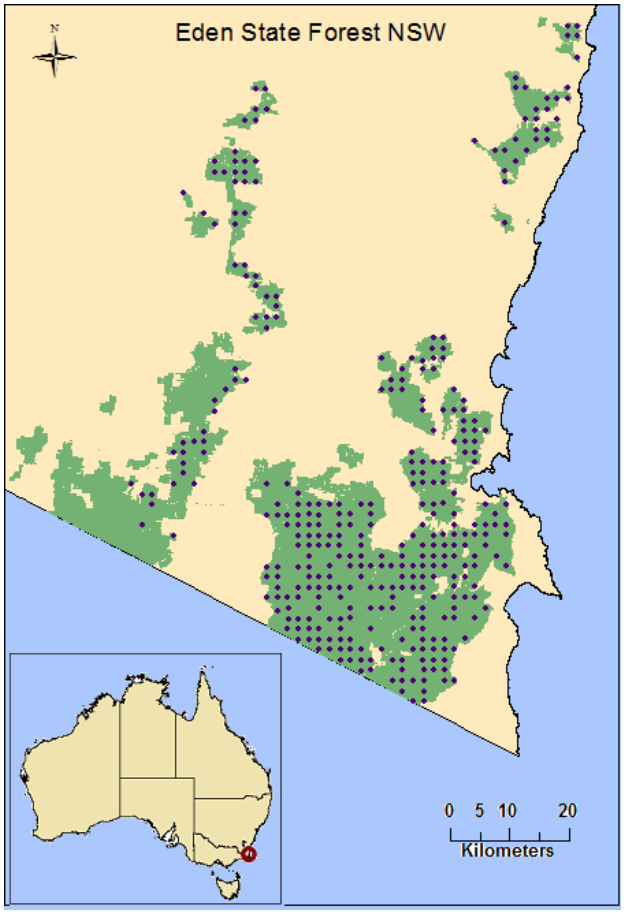

Figure 2: Location of 350 Eden study plots.

Validation data: Forest monitoring feasibility data

Data from 58 plots were collected for forest monitoring pilot study. Plot level data was collected from three regions: NSW North Coast (NNC), Brigalow Belt South (BBS) and South Eastern Highlands (SEH). There were 20 plots from NNC, 24 from BBS and 14 from SEH. The plots were spread across three tenures; National Parks (23), State forest (20) and Private property (15). The distribution of the plots by Region and by Tenure is presented in Table 1. Lidar data was available for 57 (Figure 3) plots and height information was not collected in 4 plots. So data from 52 plots was used for validation.

Table 1: IBRA and tenure of the Forest Monitoring feasibility study plot data.

	Region			
Tenure	**BBS**	**NNC**	**SEH**	**Total**
National Park	11	7	5	23
Private Property	3	8	4	15
State Forest	10	5	5	20
Total	**24**	**20**	**14**	**58**

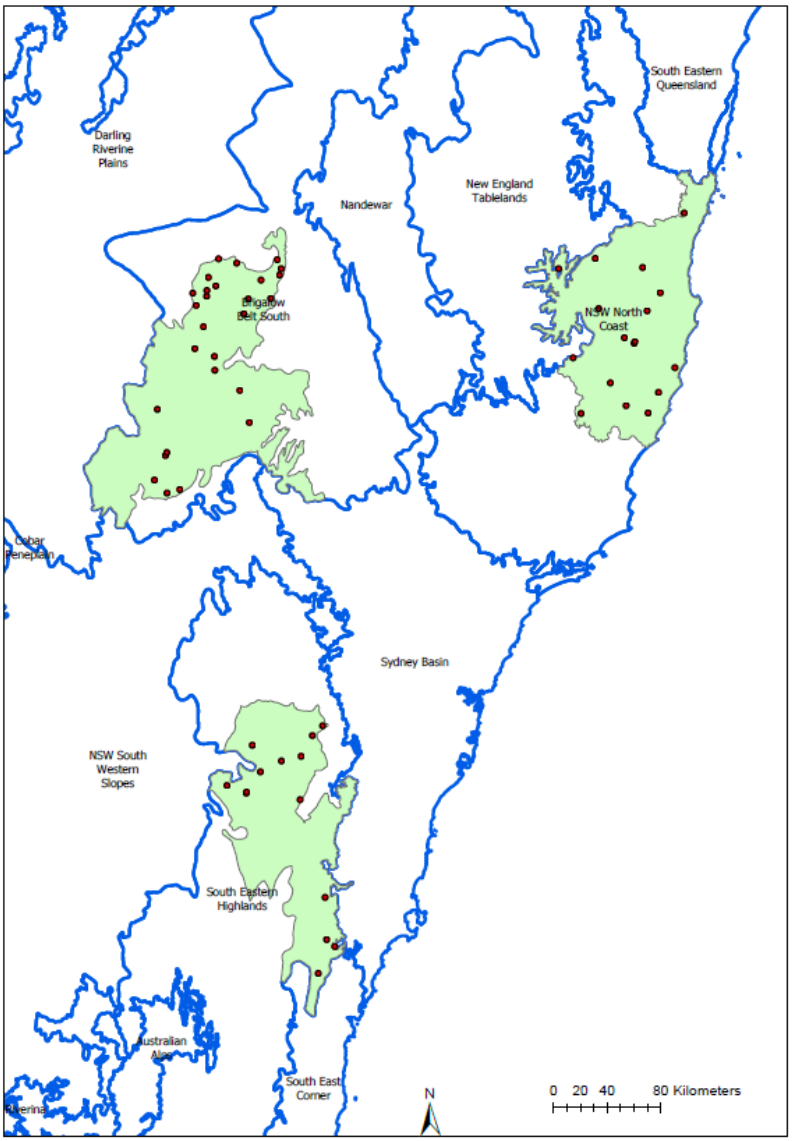

Figure 3: Location of the Forest Monitoring feasibility study plots.

Methods

LiDAR Processing

The point density for the ALS point cloud data for FCNSW was 1 to 2 points per square meter. LAStools (rapidlasso GmbH) software were used to process the ALS point cloud data. The noise points were identified using lasnoise, the data was then classified ground and non-ground. Digital terrain models were created and normalised point cloud data was created. Once the ALS data were normalized, the point data were processed to extract ALS metrics at the plot level.

A total of 50 ALS variables were initially selected. The final variables for model were selected after looking at a number of publications and identifying the variables strongly correlated with MTH.

Multiple Regression

As is often the case with ALS data analysis, there is a large number of predictor variables in the model. A number of the predictor variables were highly correlated, so a number of variable selection methods were examined to select the final set of predictor variables. Initially, a Spearman's correlation matrix was used to reduce the number of predictor variables and remove the potential for multi-collinearity in the models (Chatterjee et al. 2000). When two or more variables were found to have a correlation greater than 0.9, we selected one variable and removed all others. This was done on the basis of selecting the variable from the group of highly correlated variables that made the most biological sense and were easy to interpret in terms of their effect on tree identification.

A number of techniques have been developed to reduce the number of variables such as; forward, backward and best subset selection. There are techniques which use p values, R2 values, Akaike information criterion (AIC), Bayesian information criterion (BIC) values as the selection criteria (James et al. 2014,P. Bruce and Bruce (2017)). None of these methods are fool proof and care has to be taken in their application. We used the best subset selection method with AIC to select for the predictor variables (Harrell 2014).

Model evaluation

The precision of models were compared using the root mean square error (RMSE)

$$\mathrm{RMSE}(y_i) = \sqrt{\frac{\sum_1^{\mathrm{n}}(y_{obs} - y_{imp})\text{^}2}{\mathrm{n}}} \quad (1)$$

and bias

$$\mathrm{bias}(y_i) = \frac{\sum_1^{\mathrm{n}}(y_{obs} - y_{imp})}{\mathrm{n}} \quad (2)$$

where n is the number of plots, y_{obs} is the observed value of the stand variable y, and y_{imp}, is the imputed value. RMSE and bias were calculated in relative terms (%RMSE and %bias), i.e. the RMSE and bias values for the stand variable y were divided by their observed mean values and multiplied by 100.

Model Assessment and Validation

Model assessment and model validation is an important step in the development of a model. Model validation, in its simplest form, is a comparison between predicted and observed values. All models were validated using apparent validation (same data used for development and testing). Apparent performance is attractive because it is easy to perform, it results however in optimistic estimates of performance. Internal validation methods were used to evaluate model performance on an underlying population (also labelled 'reproducibility'). Internal validation methods aim to provide a more accurate estimate of model performance for new data that is not used in model building. This was done by dividing the reference data into training and test data and the validation was done using the test data. Eden data was used for model development and Forest Monitoring data was used as external validation. The model was developed using Eden data and was applied to Forest Monitoring data and errors were calculated.

Map Creation

Using the results of the model assessment, site index map for North and South Coast NSW was created at 20m resolution.

Results

Variable of Interest

Dominant height of mature forest is a good indicator of site quality. For Eden data there were 350 plots but only 54 of them were mature forest plots. A number of ALS height metrics are extracted for the plots and some of them have been shown to be highly correlated with MTH. The plot of MTH vs ALS metrics; average height, P90, p95, and p99 for Eden data is presented in figure 4. The ALS height metrics are highly correlated with MTH. Avg is under estimating MTH and p99 over estimates the MTH. If only one variable is to be used then p90 is the closest to MTH. A plot of the distribution of the MTH and ALS metrics is presented in figure 5. Again similar trends are observed. The plot at the top are the ALS metrics calculated using the first returns and the one at the bottom is for all returns. Again, p90 with first returns with returns >2m, is the closest in distribution to MTH.

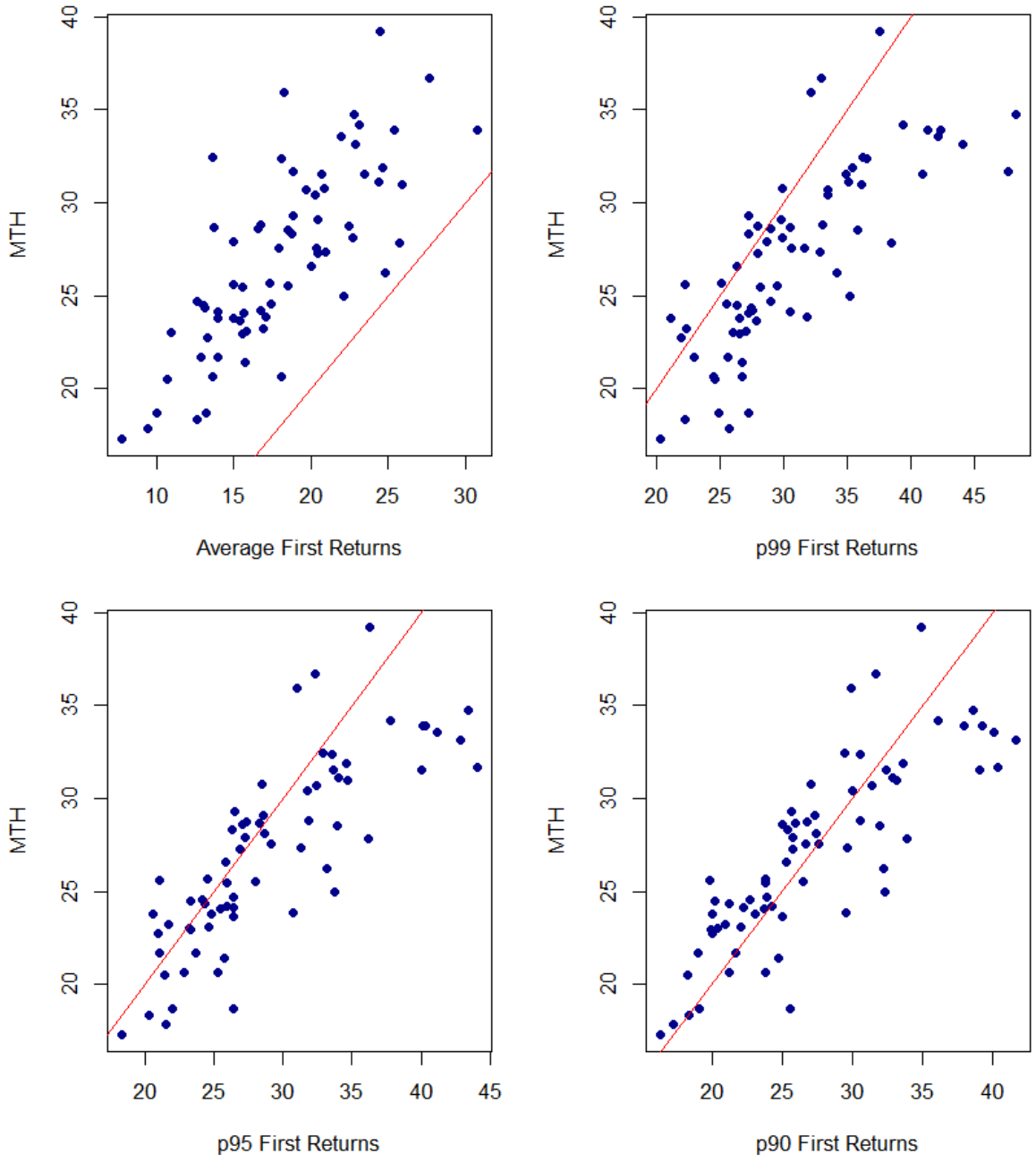

Figure 4: Plot of Mean top Height (MTH) with the height ALS metrics for mature forest plots of Eden Study area.

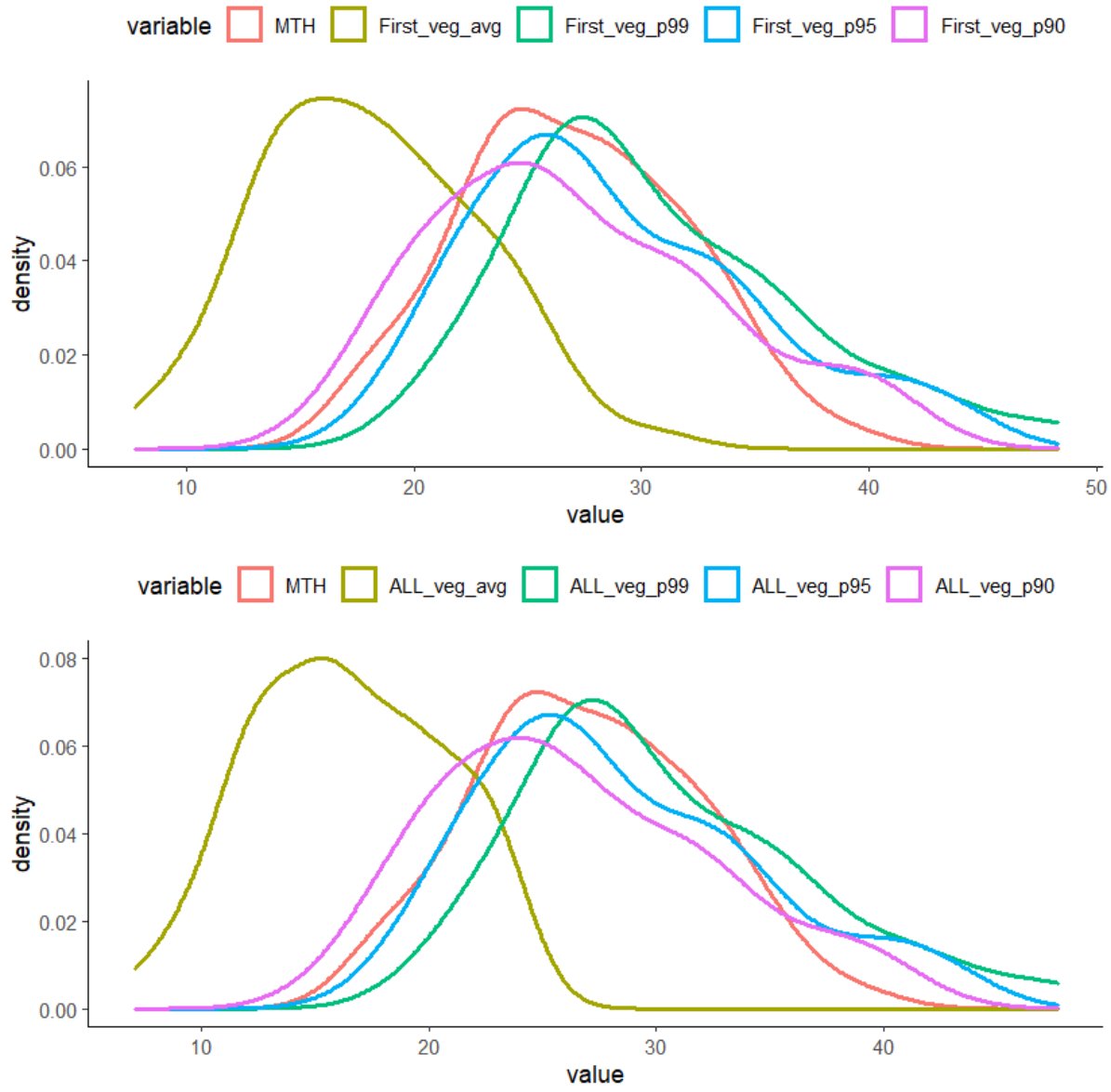

Figure 5: Density plot of Mean top Height (MTH) with the height ALS metrics for mature forest plots of Eden Study area.

A multiple regression model was fitted to Eden data using a best subset selection method. Average of first returns and p99 of first returns were the two variables that were significant after best subset selection. The modelled values had a 0 bias and RMSE of 2.6 m, relative RMSE 9.7%. This is smaller than the bias when only p90 was used as predictor, bias was low (-0.17 m) and the RMSE of 3.5 m and relative RMSE, 12.7%. Two maps were created one with the multiple regression model and the other with p90 as the variable. A focal smoothing is applied using a 3 by 3 cell window. A focal operation applies an aggregation function to all cells within the specified neighbourhood, uses the corresponding output as the new value for the central cell, and moves on to the next central cell. A mean value was used an aggregation method. A visual inspection of the map produced using both the multiple regression and the p90 approaches with the canopy height model (CHM) suggest that p90 is closer when the top height is >40m. The range of MTH for the Eden study data is 17.3m to 39.2m. So in absence of data covering the full range of MTH values p90 was selected for the final map. Figure 6 is

the map of the CHM and the final map produced for three PNF properties. There appears to be a very good match of the top heights and the dominant height produced using ALS data (figure 6).

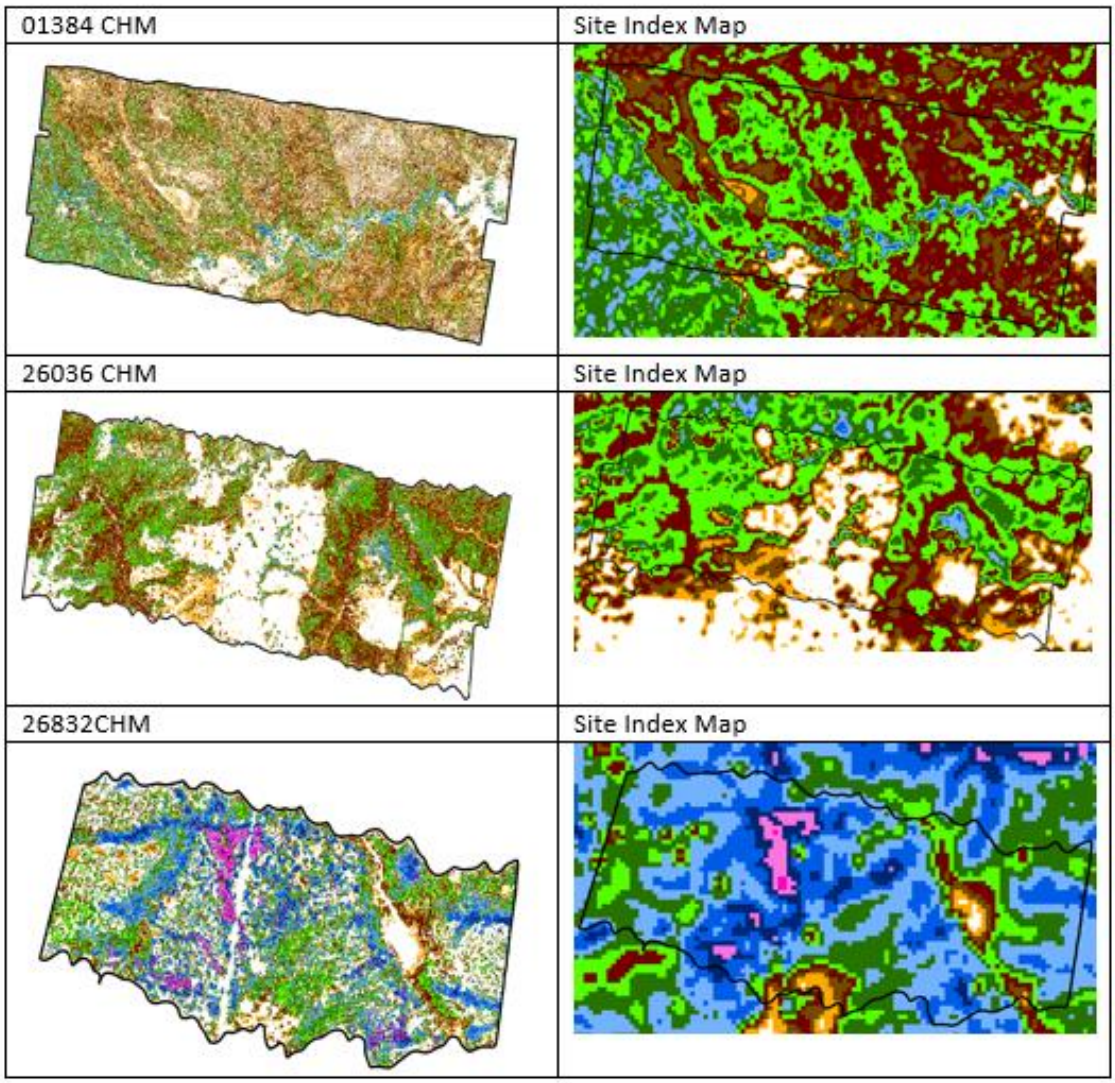

Figure 6: Canopy height model and the corresponding site index map for three PNF properties.

The model was applied to the data from Spatial Services for north and South coast and a site index map for North Coast forest is produced and is presented in Figure7 and Figure 8. Figure 9 presents the combined map for the PNF area in the north and south coast of NSW. Histogram plots of site index is presented in figures 10 and 11 and the table 2 has the area and percentages in the various size classes.

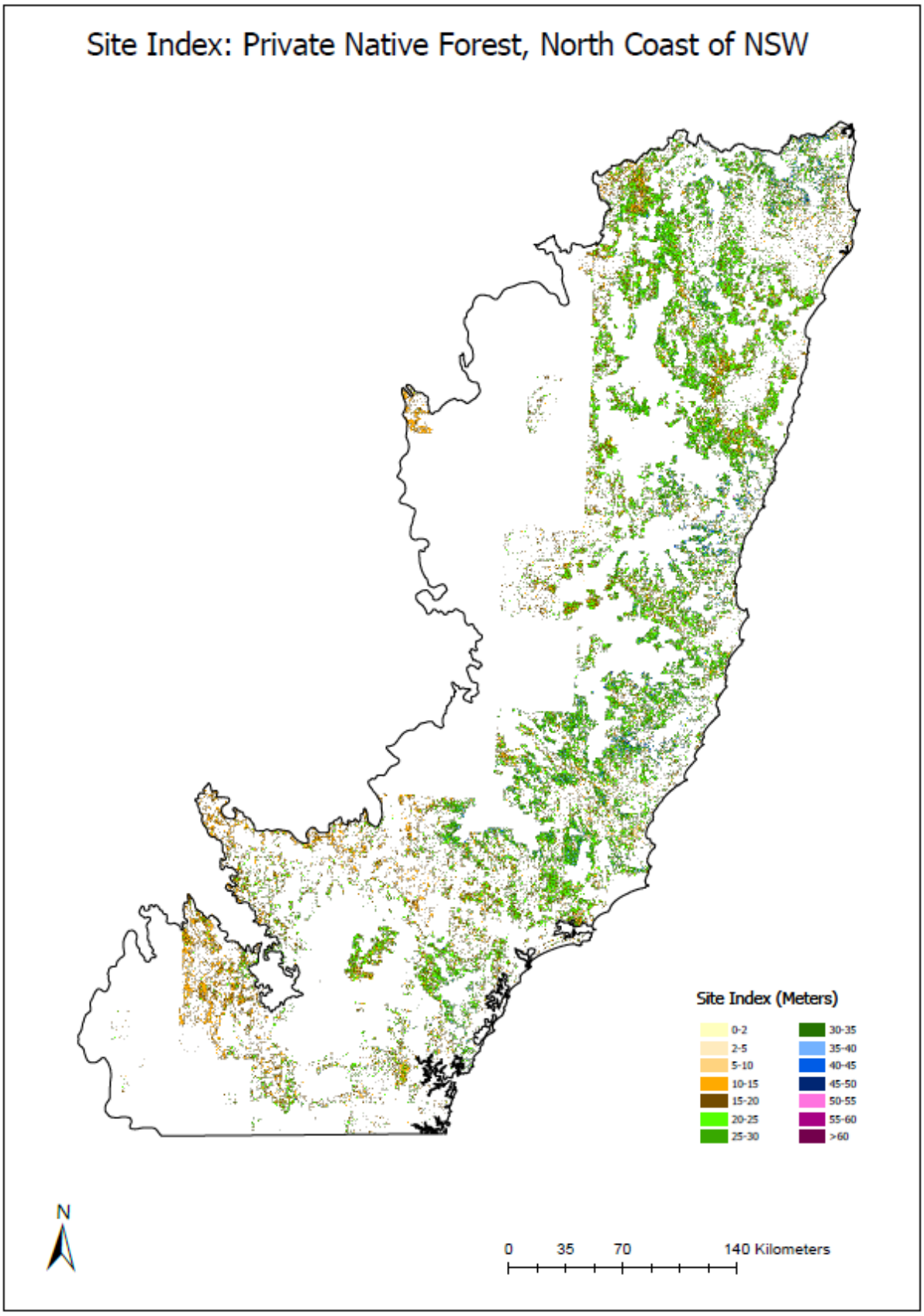

Figure 7: Site Index map of forest for North Coast NSW within the Northern NSW PNF Code region.

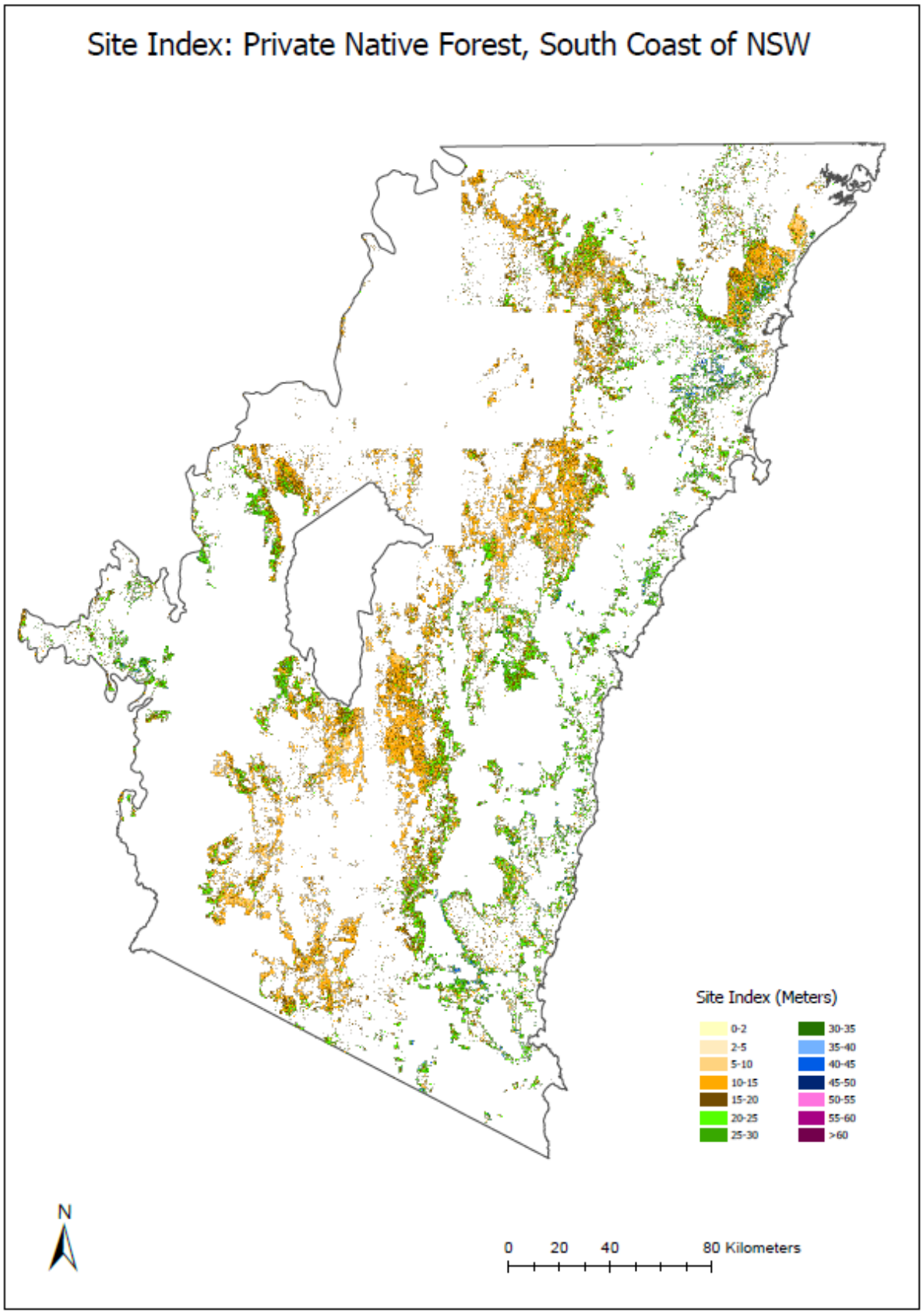

Figure 8: Site Index map of forest for South Coast NSW within the Southern NSW PNF Code region.

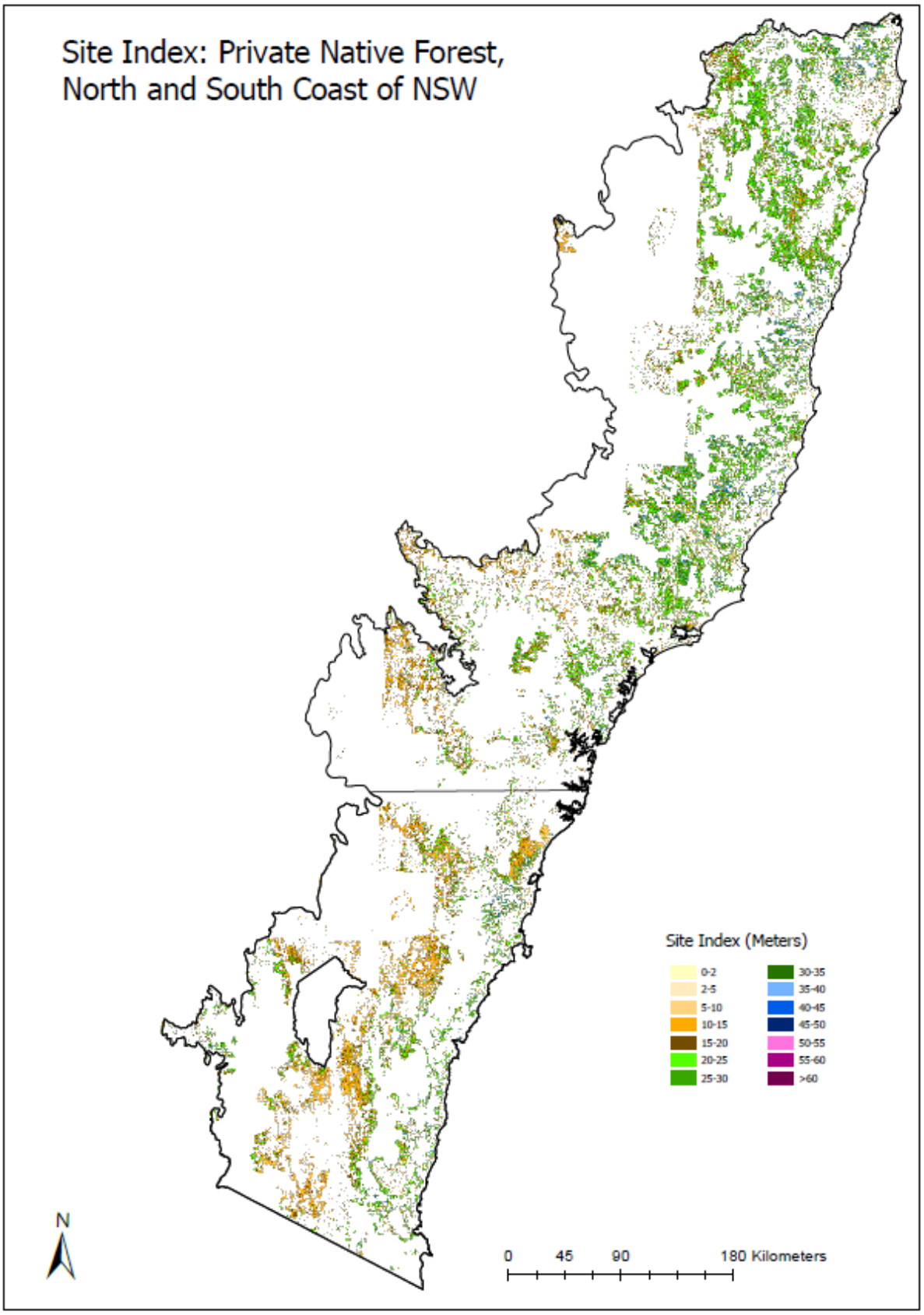

Figure 9: Site Index map of forest for North and South Coast NSW within the Northern and Southern NSW PNF Code region.

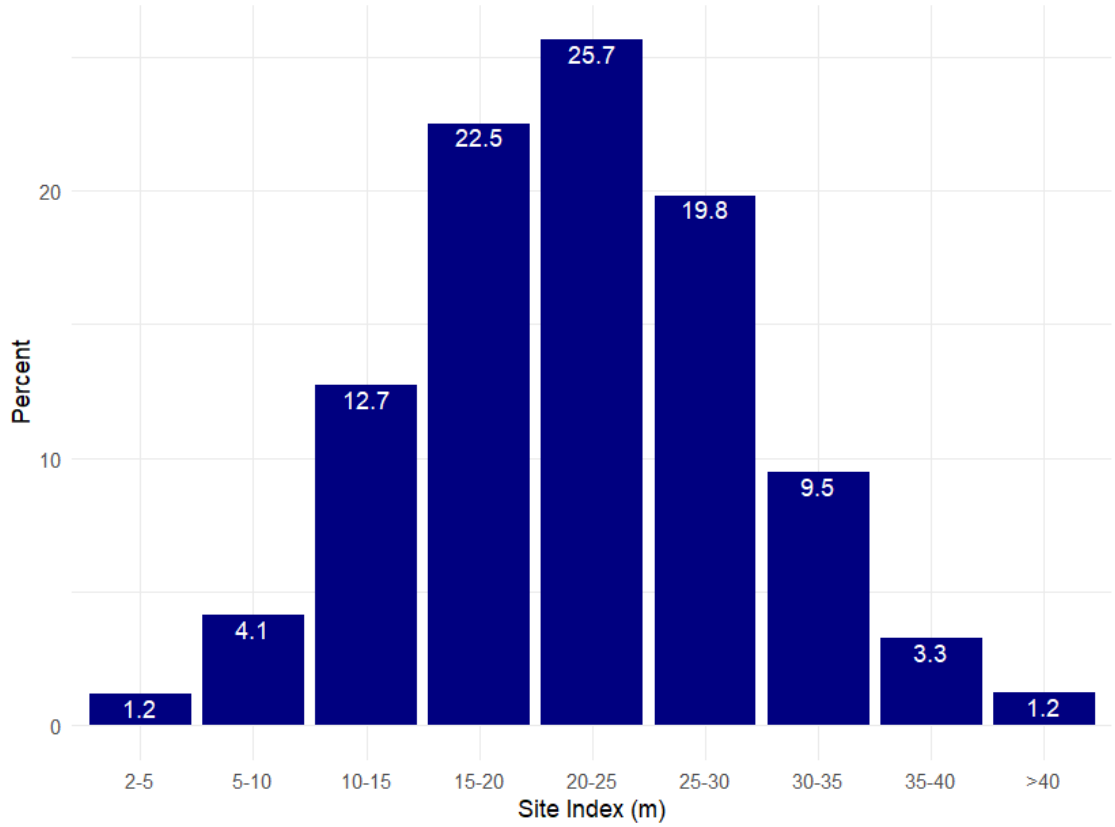

Figure 10: Percentage of Private property by site index class for Northern PNF region.

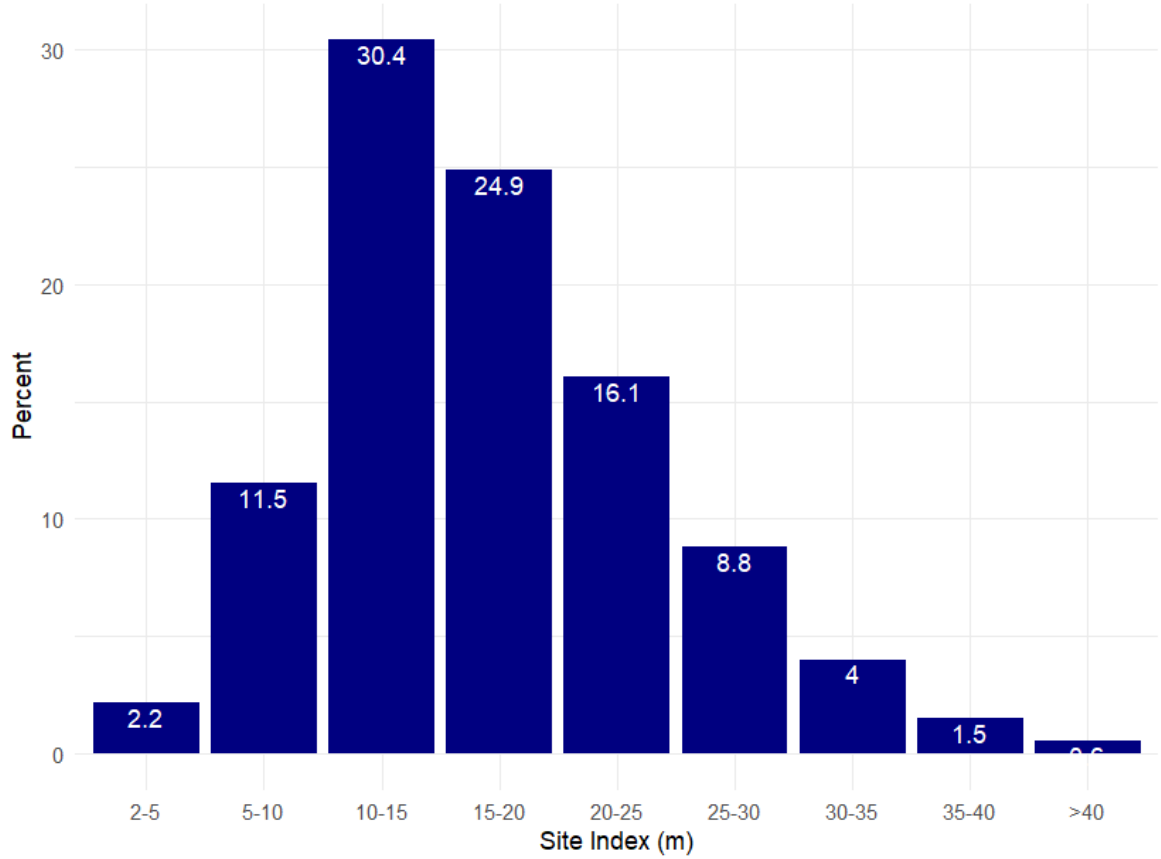

Figure 11: Percentage of Private property by site index class for Southern PNF region.

Table 2: Area and percentage of private property by site index class for forest area.

Site Index Class (m)	Northern PNF		Southern PNF	
	Percentage Area	Area (ha)	Percentage Area	Area (ha)
2-5	1.2%	28820	2.2%	22660
5-10	4.1%	100288	11.5%	119704
10-15	12.7%	308161	30.4%	315205
15-20	22.5%	545951	24.9%	257734
20-25	25.7%	622219	16.1%	166388
25-30	19.8%	480588	8.8%	91498
30-35	9.5%	229487	4.0%	41767
35-40	3.3%	79288	1.5%	15729
>40	1.2%	30286	0.6%	5789

Limitations of the Study

Coverage

Spatial Services ALS layer does not cover all of the PNF Plans in the Northern and Southern NSW PNF (Figure1), so for some PNF properties site index map is not available. But the number of such properties is small.

LiDAR

The LiDAR data used to produce the map is Spatial Services data, the point density for this data is much less than data collected in 2020 for LLS project but it has been shown that the height metrics for the two point densities are not very different (Kathuria, A. 2020). The data was collected over a long period of time, mostly from year 2001 to 2015. Also, Spatial services data does not cover the whole of the North and South Coast.

Future Work

The Eden data and the FM data did not have MTH values greater than 45m. So, look for other data sources so that the multiple regression model could cover the whole range of MTH values for the north coast. Also, an attempt was made to classify regrowth, more work needs to be done on that. The reference data from six largest properties indicates that there was 1.57% regrowth.

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Appendix 5 – Tree Heights in Koala Habitats of North East NSW

Report by the EPA and EES for the Office of the Chief Scientist and Engineers review of Private Native Forestry.

Context of consideration

The Private Native Forestry Code of Practice sets various requirements relating to timber harvesting on private land. One of the more overarching and fundamental requirements is the retention of a minimum stand basal area (BA), being a measure of tree density in terms of stems cross-sectional area at breast height expressed in m^2 per hectare. The existing code sets these BA minimums with reference to both broad forest type and stand height, with lower BA area requirements specified where the stand height is less than 25 metres.

There is no ecological basis for this threshold (it was a negotiated outcome) but is intended to differentiate the more open woodland forests in the tablelands and slopes, to that of the more productive densely stocked forests of the coast. This threshold effectively provides variation in retention somewhat proportionate to the pre harvest stand density. For example, a well-stocked tall blackbutt forest in a highly productive area typically has a pre harvest BA of $36m^2$/ha or more. Mixed species forests on lower productivity land are generally shorter and a lower BA, for example $24m^2$/ha, may be typical. The BA retention of at $18m^2$/ha and $12m^2$/ha respectively specified in the code retain approximately half of the stems in these examples. As discussed in the silvicultural guidelines for the Code, the BA limits currently identified aim to strike a balance between optimal timber yield and maintenance of non-timber values, particularly conservation of biodiversity.

While the Code provides prescriptions for particular threatened species, many of these are reliant on existing records and the Code does not require an ecological survey suitable to detect such records. Consequently, prescriptions for particular species have limited capacity to mitigate potential impacts and other requirements of the Code such as basal area retention are valuable in minimising risks to threatened species.

This report focuses on the characteristics of stand height in koala habitats of north east NSW. It is understood that a koala browse tree retention prescription is proposed to be applied in areas of modelled habitat indicated by a map layer. However, it is known that important koala habitats extend beyond those areas indicated by the prescription layer proposed by LLS. In those habitats, protection of habitat values will rely on adequate precautions being included in the broader provisions of the Code. Retention of a sufficient BA is the simplest approach to achieve this.

Tree heights in North East NSW

The PNF Code defines stand height as the mean height of the dominant trees in the stand. Which is measured on the ground in accordance with approved guidelines issued by the EPA. There is no accurate surrogate for analysing stand height as per this definition.

Tree height has been instead been depicted using Landsat/GEDI derived imagery which has a 30 metre pixel size (described in the article https://www.sciencedirect.com/science/article/pii/S0034425720305381). This is considered to align well with the concept of stand height used in the current PNF Code, but will still underrepresent the area of PNF in areas over 25m, particularly in areas of the state dominated by taller forests. Because of this potential underrepresentation, the report provides a equivalent figure of forest over 20m. Maps also are provided with forest heights broken up into 5m increments below the 25m threshold.

In the tables that follow this tree height data has been considered in the context of known Areas of Regional Koala Significance (ARKS) (https://datasets.seed.nsw.gov.au/dataset/areas-of-regional-koala-significance-arks), Koala Modelling Regions (KMRs)

(https://datasets.seed.nsw.gov.au/dataset/koala-modelling-regions) and PNF approval areas as of 30 September 2020.

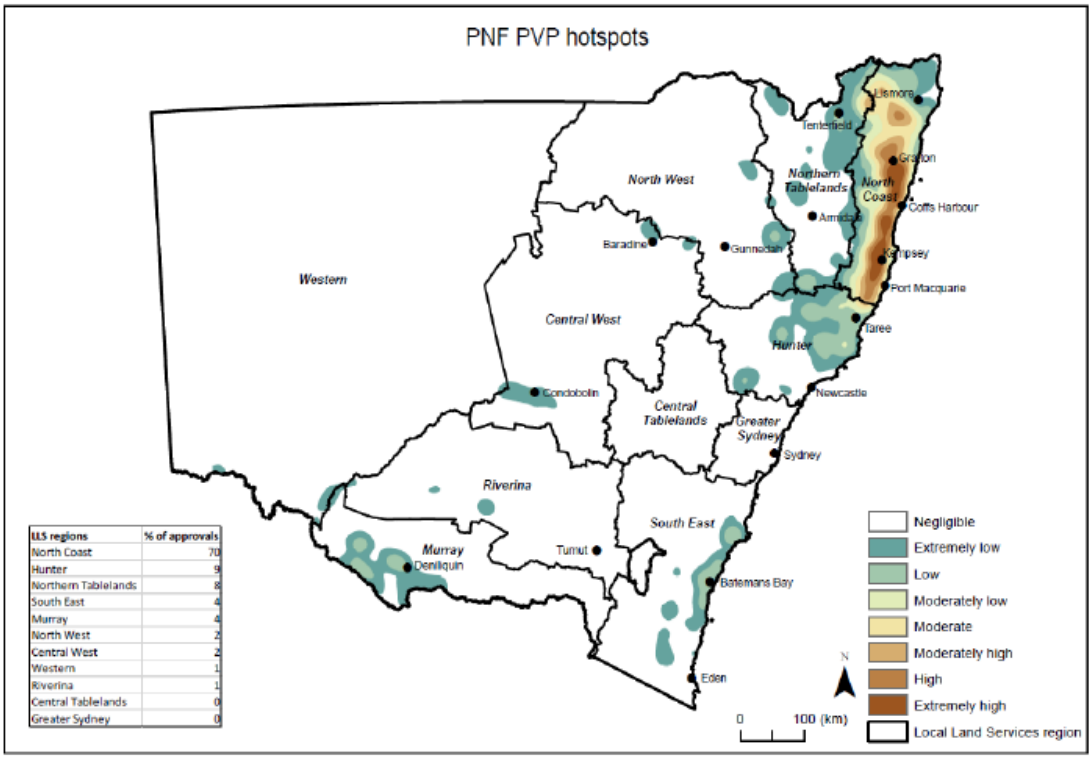
% of Mod-Very High Suitable Habitat Forest with Trees <25m or Trees <20m in various areas

Region	% Trees < 25m	% Trees <20m
All Eastern NSW	79.8%	62.2%
ARKS in All Eastern NSW	62.5%	41.6%
North Coast KMR	53.3%	26.5%
ARKS in North Coast KMR	46.1%	22.9%
North Coast KMR PNF Only	64.3%	24.3%
North Coast KMR PNF in ARKS	55.9%	20.1%

% of Mod-Very High Suitable Habitat Forest with Trees <25m or Trees <20m by Eastern KMRs

KMR	% Trees < 25m	% Trees <20m
North Coast	53.3%	26.5%
Central Coast	85.1%	59.9%
Northern Tablelands	74.7%	56.3%
Northwest Slopes	98.6%	95.8%
South Coast	57.1%	23.8%
Central and Southern Tablelands	91.4%	75.3%

A high degree of variation in stand height is apparent within eastern NSW. Where site quality is high, influenced by factors including soil fertility and rainfall, tall forests predominate. This is strongly correlated with the more productive forestry areas of NSW, and where 80 per cent of where PNF occurs (see hotspot map below). However, other areas are characterised by poorer site quality which stand out as having lower tree height.



Tree height data in areas of north east is presented in the maps that follow using either:

a) a 25 metre threshold, or
b) 5 metre intervals up to 25 metres

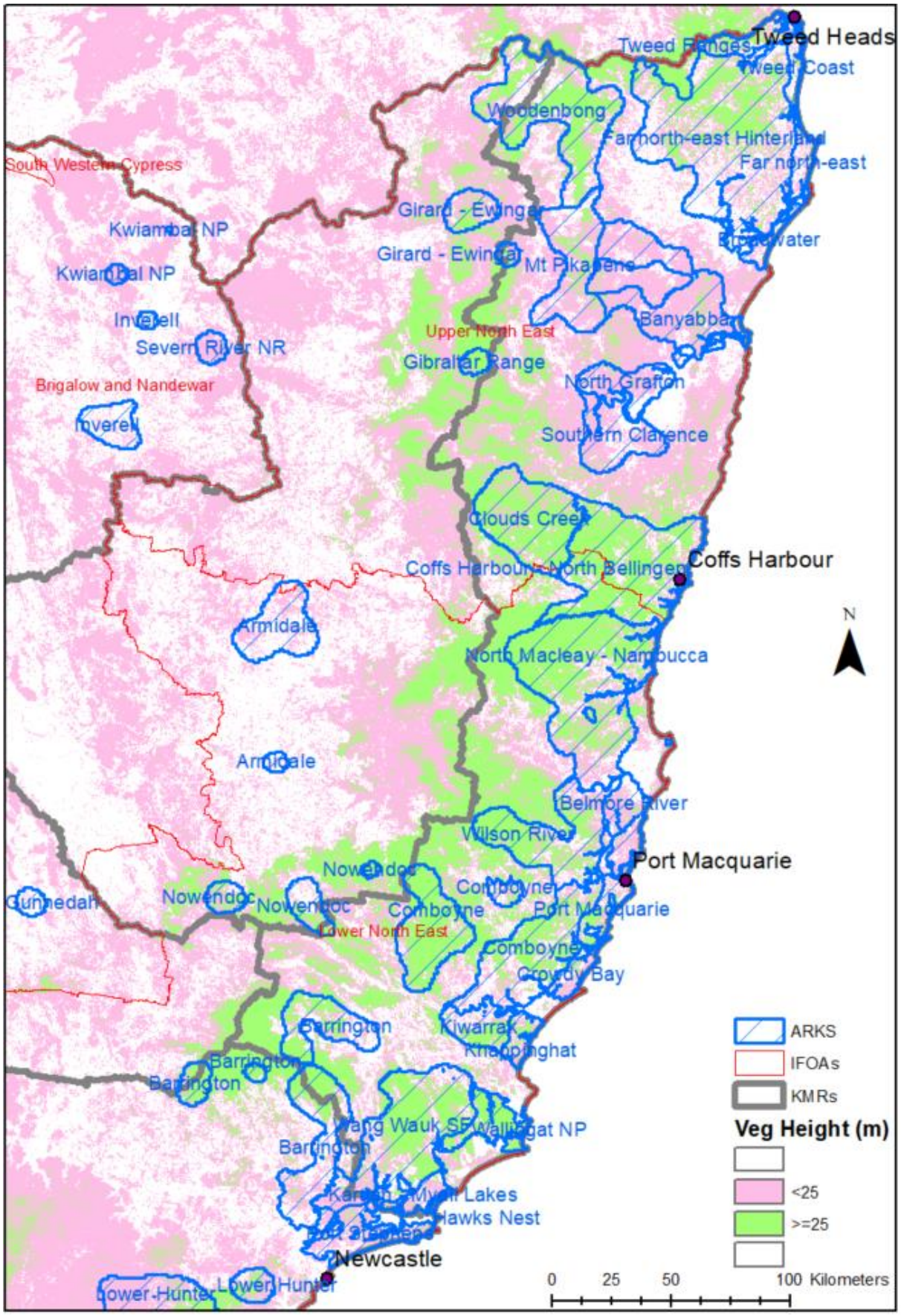
In Maps 1(a) and 1(b) these are overlaid with boundaries of:

- ARKS
- KMRs and
- Integrated Forestry Operations Approval areas.

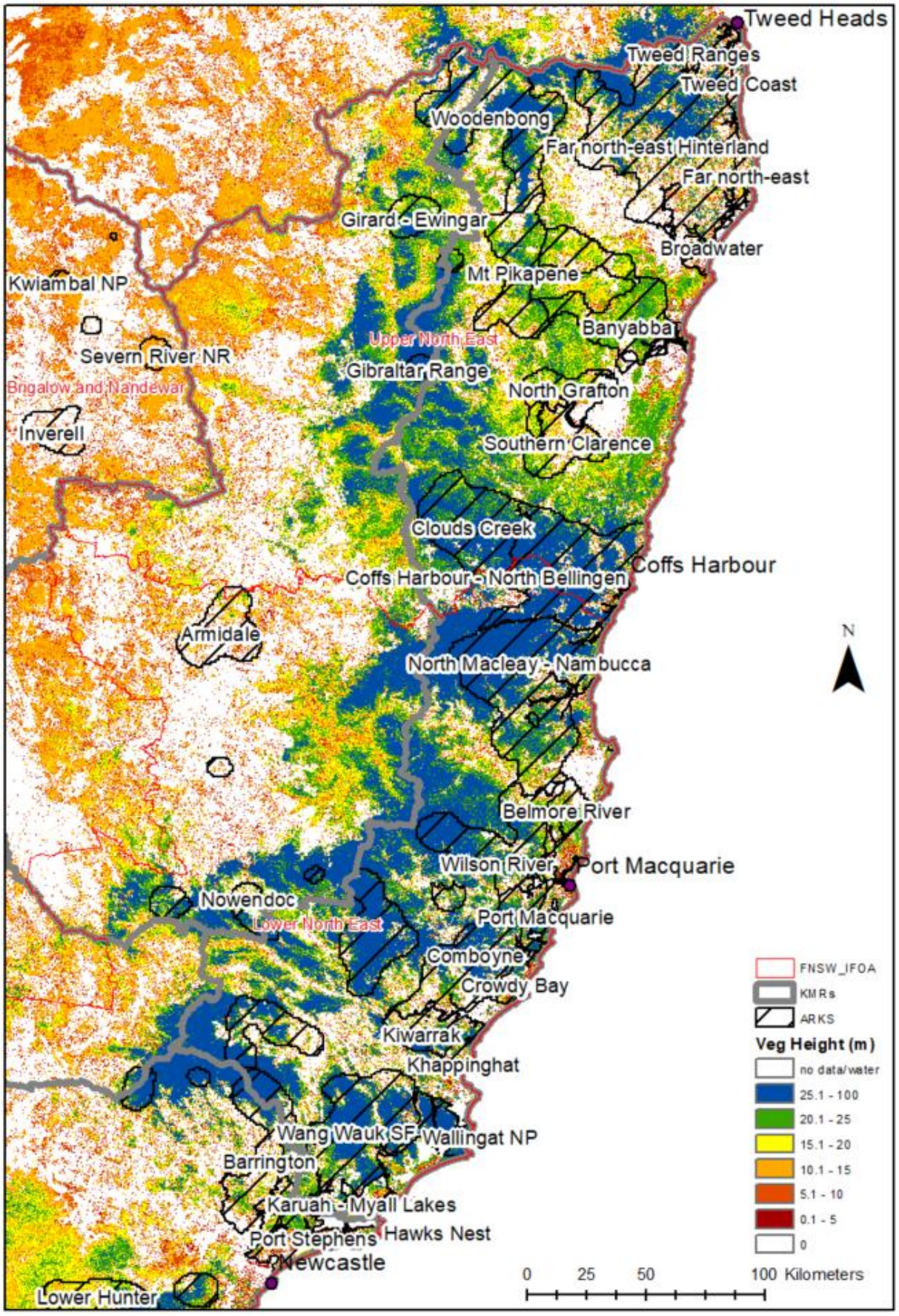
In Maps 2(a), 2(b), 3(a), 3(b), 4(a) and 4(b) the heights are overlayed with boundaries of:

- ARKS
- State Forest
- National Park and
- PNF approval areas as of September 2020.

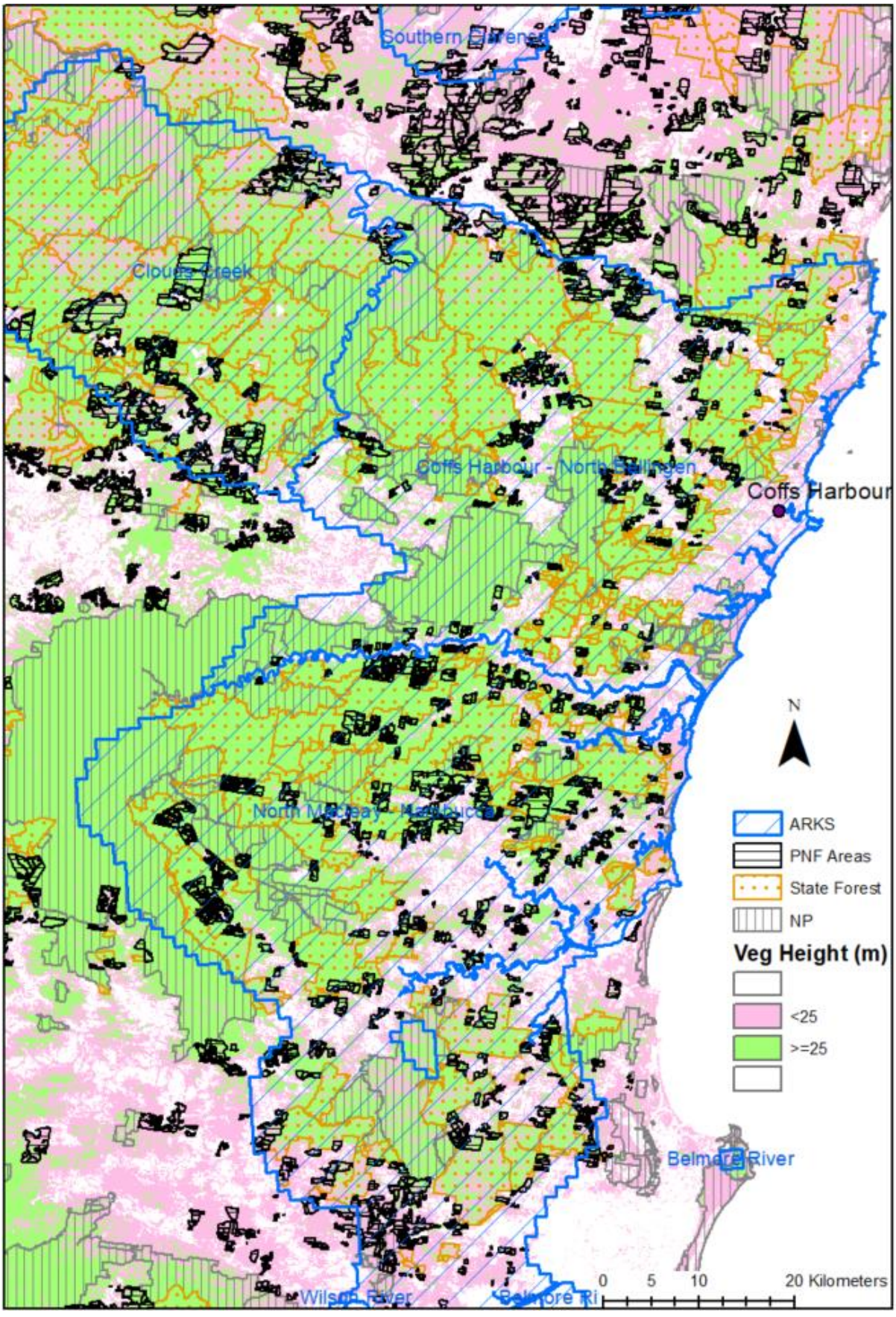
Map 1(a) - Tree Heights in North East NSW – 25m threshold



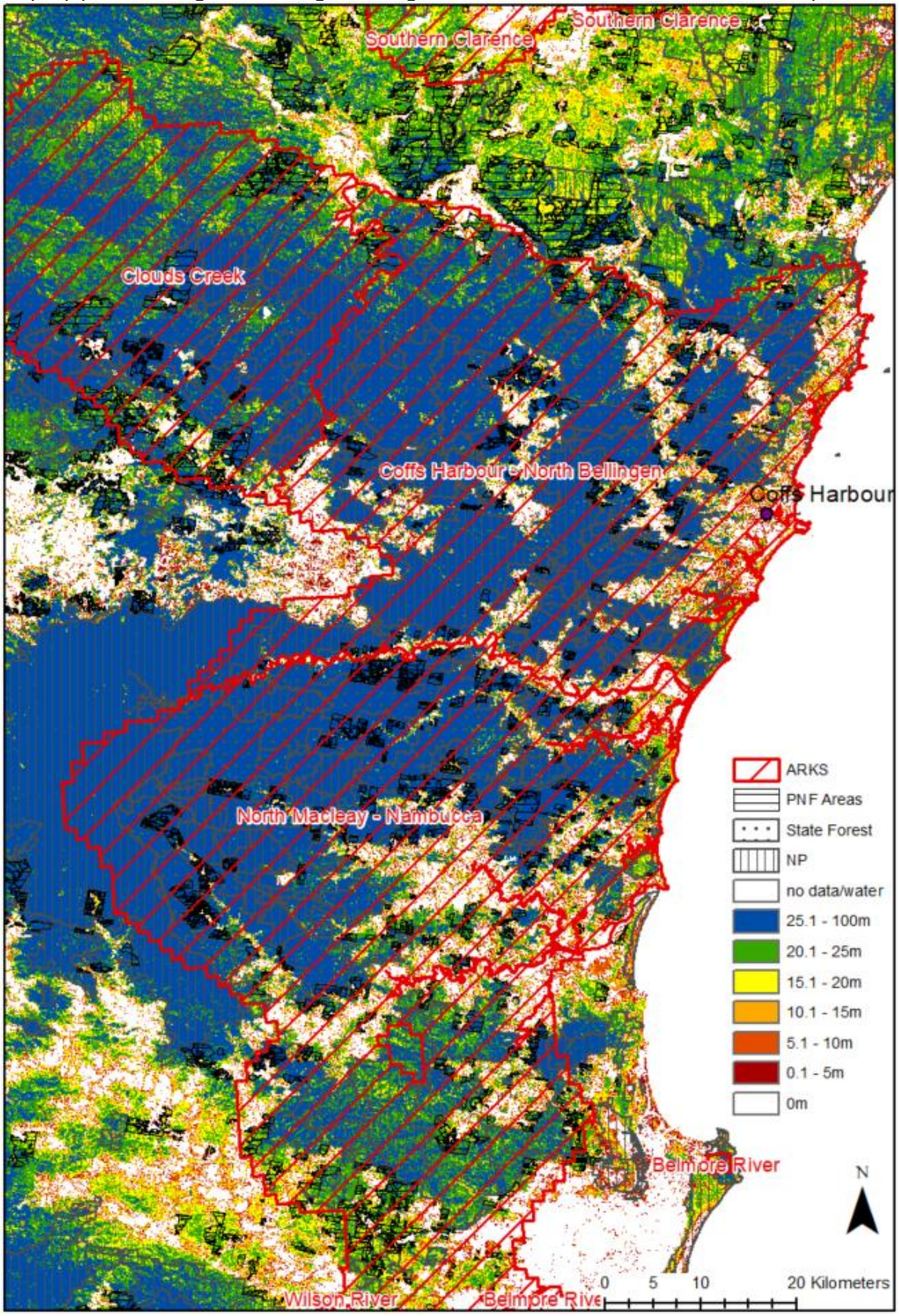
Map 1(b) - Tree Heights in North East NSW – 5m intervals up to 25m



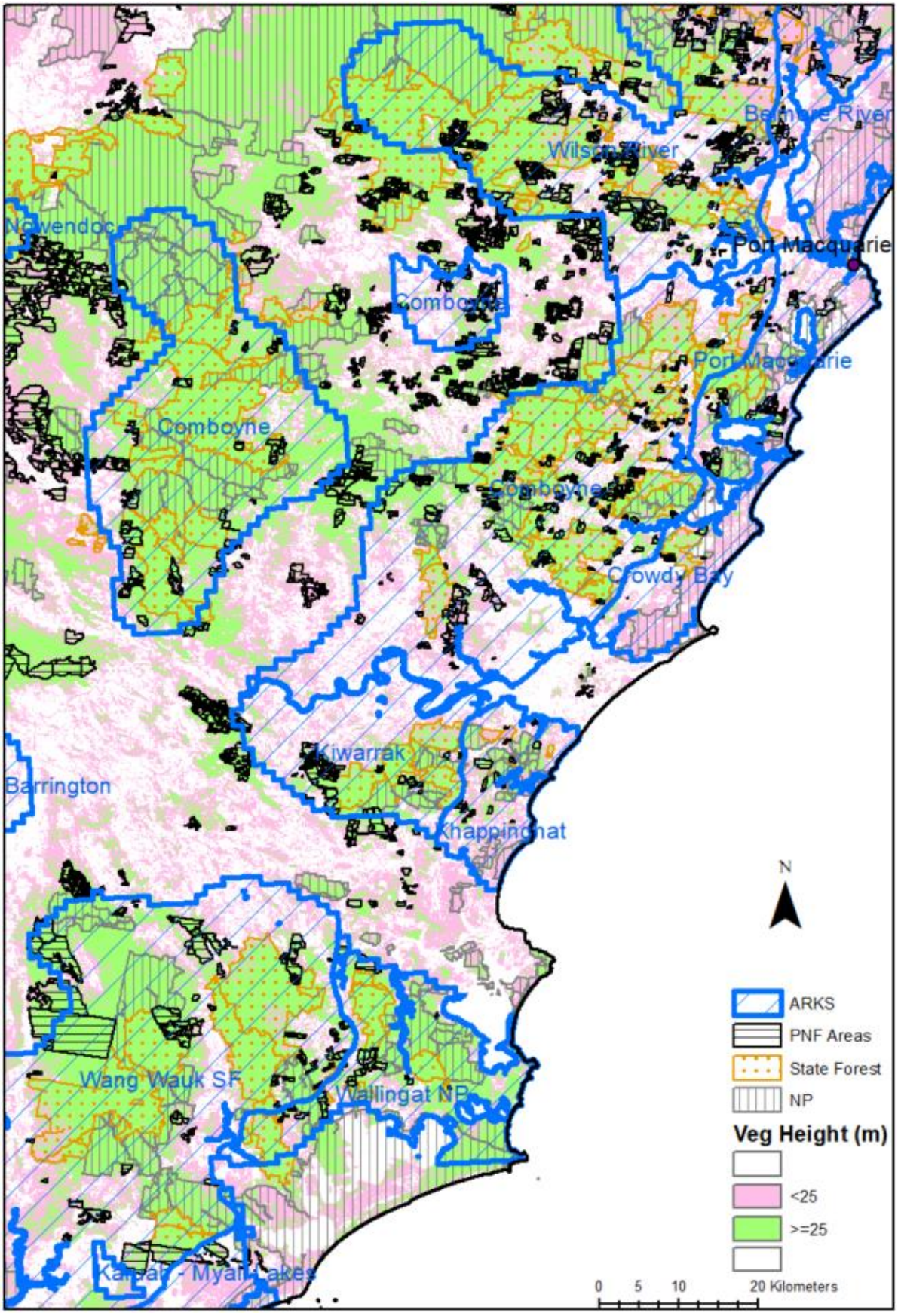
Map 2(a) - Tree Heights in Dorrigo, Bellingen, Coffs Harbour Area – 25m threshold



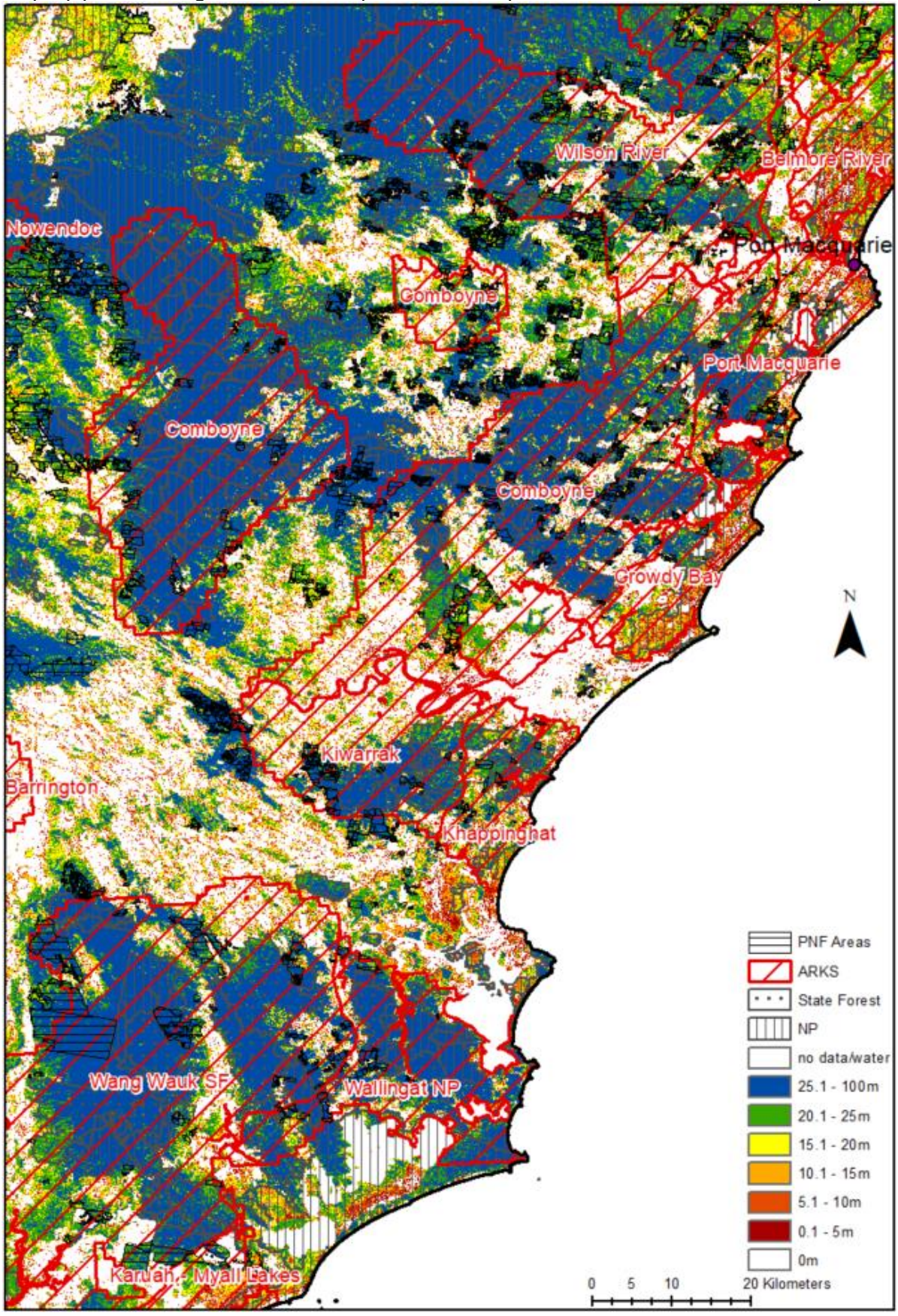
Map 2(b) - Tree Heights in Dorrigo, Bellingen, Coffs Harbour Area – 5m intervals up to 25m



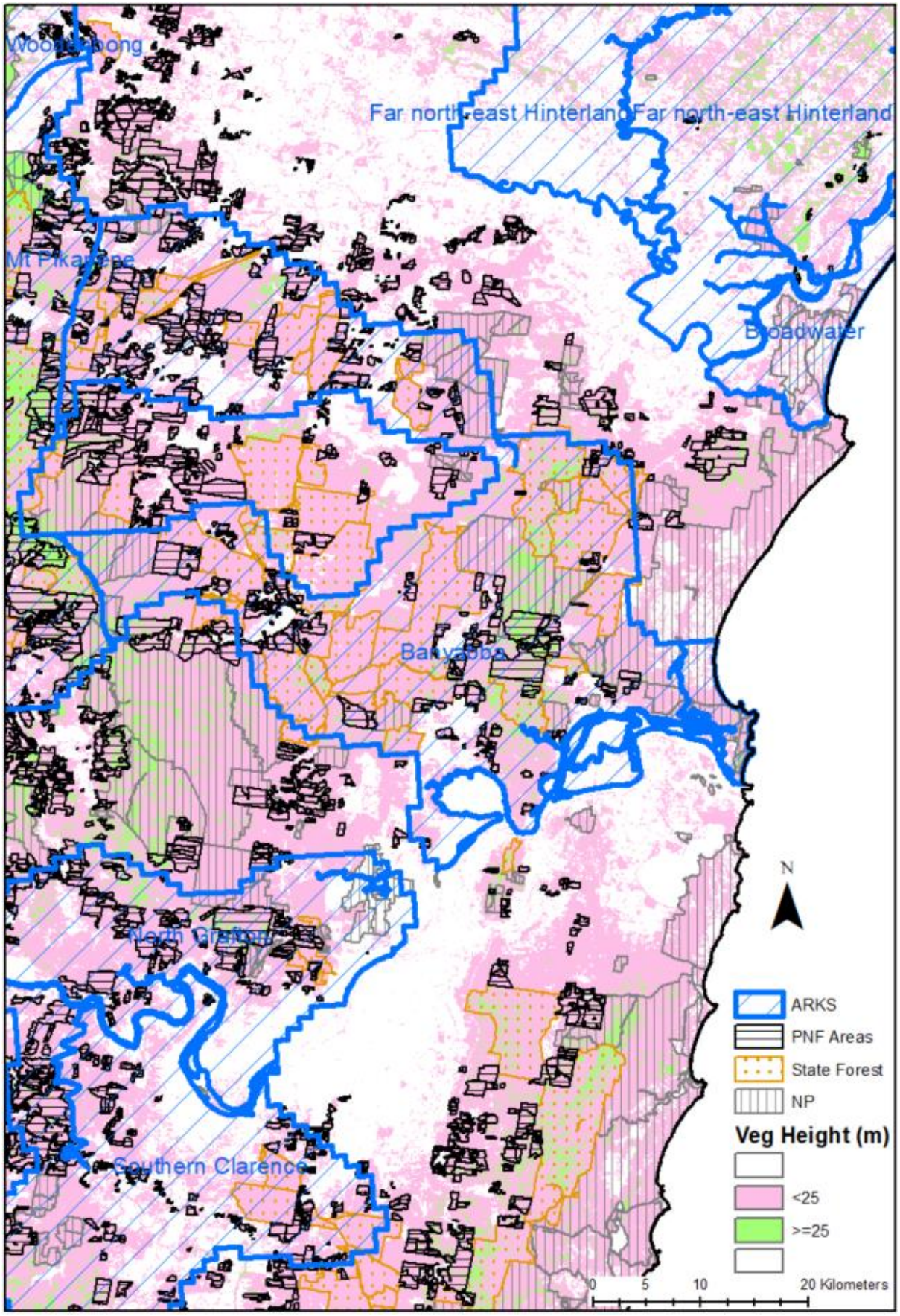
Map 3(a) - Tree Heights in Port Macquarie, Wauchope, Taree Area – 25m threshold



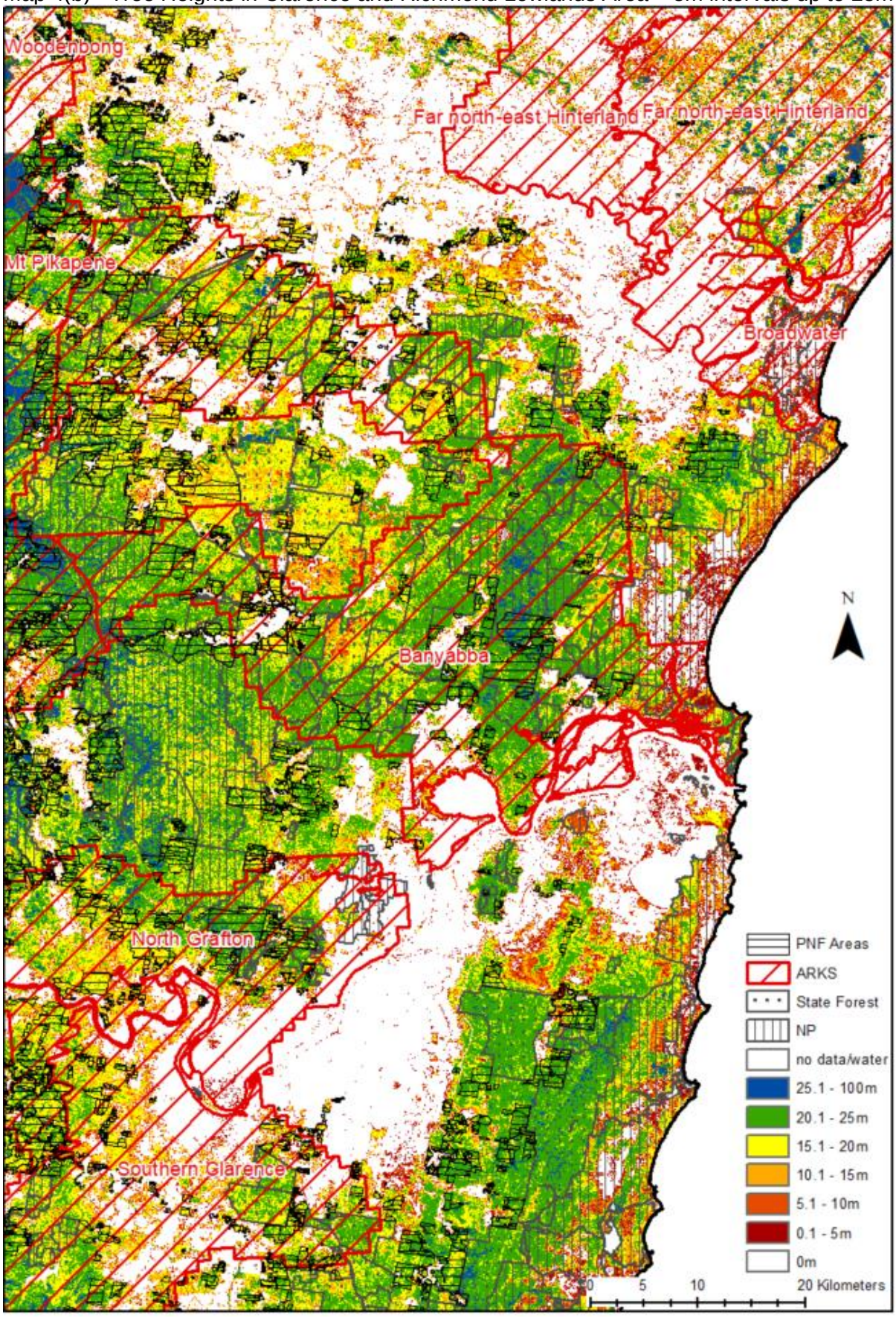
Map 3(b) - Tree Heights in Port Macquarie, Wauchope, Taree Area – 5m intervals up to 25m



Map 4(a) - Tree Heights in Clarence and Richmond Lowlands Area – 25m threshold



Map 4(b) - Tree Heights in Clarence and Richmond Lowlands Area – 5m intervals up to 25m



The taller, high productivity areas tend to also be the most biodiverse and typically support the most viable and important koala populations. Maps 2(a)/(b) and 3(a)/(b) show areas of the Coffs Coast and Mid North Coast which are dominated by these more productive, tall forests which include highly valued koala habitats. For example, in the North Bellingen – Coffs Harbour ARKS, 76.3% of forested areas have a stand height of 25 metres or greater with a median tree height of 31 metres.

While forests with lower stand heights typically are of relatively low productivity, some are important habitats for threatened species. In the area between Grafton and Casino, the Banyabba ARKS is recognised as a regionally significant koala population which includes State forest areas Royal Camp, Carwong and Braemar. This area has also had a very high uptake of private native forestry. In the Banyabba ARKS 92.9% of forest areas have a stand height less than 25 metres with a median height of 21 metres. The Banyabba ARKS and surrounding areas of the Clarence and Richmond valley lowlands are shown in map 4(a) and 4(b).

The table below provide a breakdown of tree height using both 25 and 20 metre thresholds in the North East FA/IFOA area, the North Coast Koala Modelling Region, PNF approval areas and Koala Areas of Regional Significance including the particularly contrasting examples of the North Bellingen – Coffs Harbour and Banyabba ARKS. Note that the NE IFOA region includes more tablelands areas which generally have lower site quality than the more coastal NC Koala Modelling Region.

Height[1]	NE NSW[2]	NC KMR[3]	PNF areas[4] ARKS[5] NE NSW[2]	PNF areas[4] ARKS[5] NC KMR[3]	North Bellingen - Coffs Harbour ARKS[5]	Banyabba ARKS[5]
Median	21m	24m	23m	23m	31m	21m
<25m	66.2%	53%	58%	56%	23.7%	92.9%
>=25m	32.8%	47%	42%	44%	76.3%	7.1%
<20m	43.8%	28.5%	21.4%	20.8%	15.3%	35.4%
>=20m	56.2%	71.5%	78.6%	79.2%	84.7%	64.6%

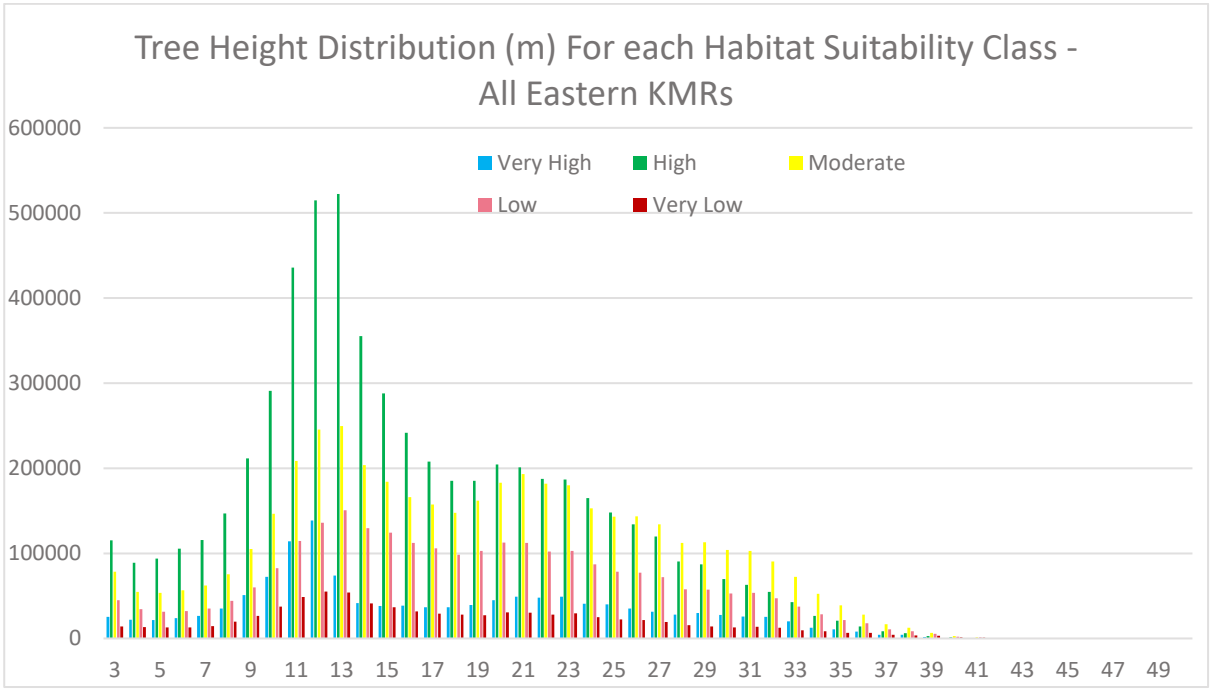
Tree Distributions across Koala Habitat Classes

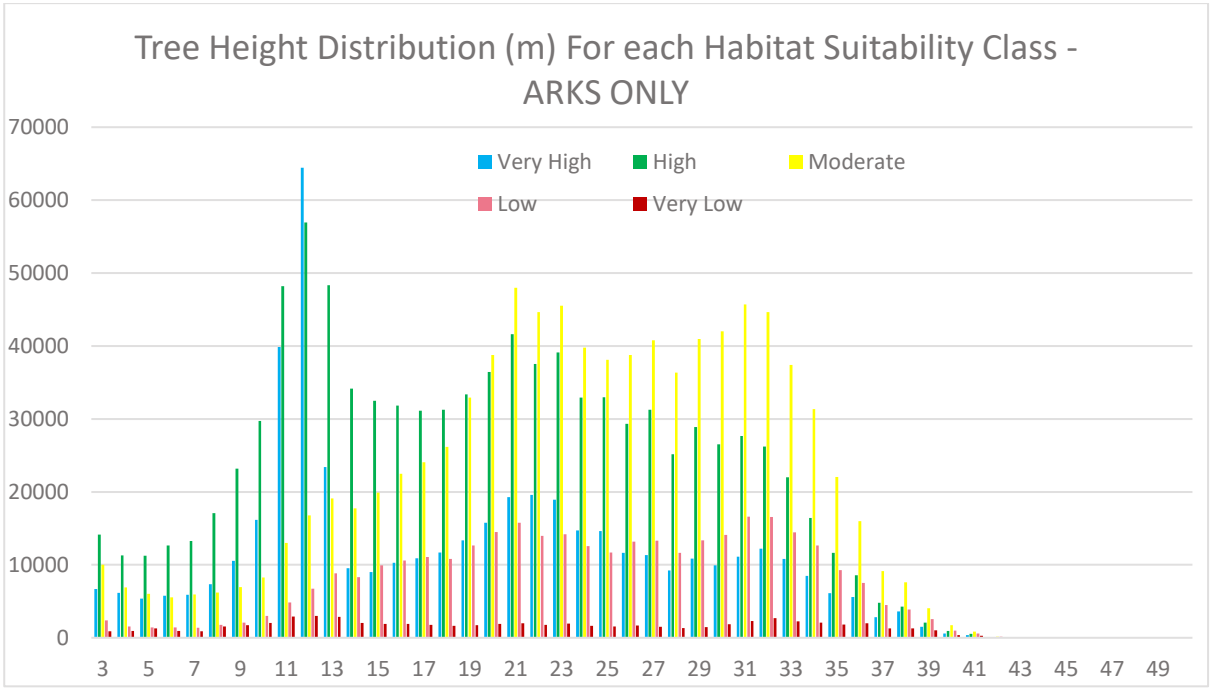
The graphs below illustrate variability in tree heigh distributions for each Habitat Suitability Class used by the Koala Habitat Suitability Model https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Threatened-species/koala-habitat-information-base-technical-guide-190534.pdf.

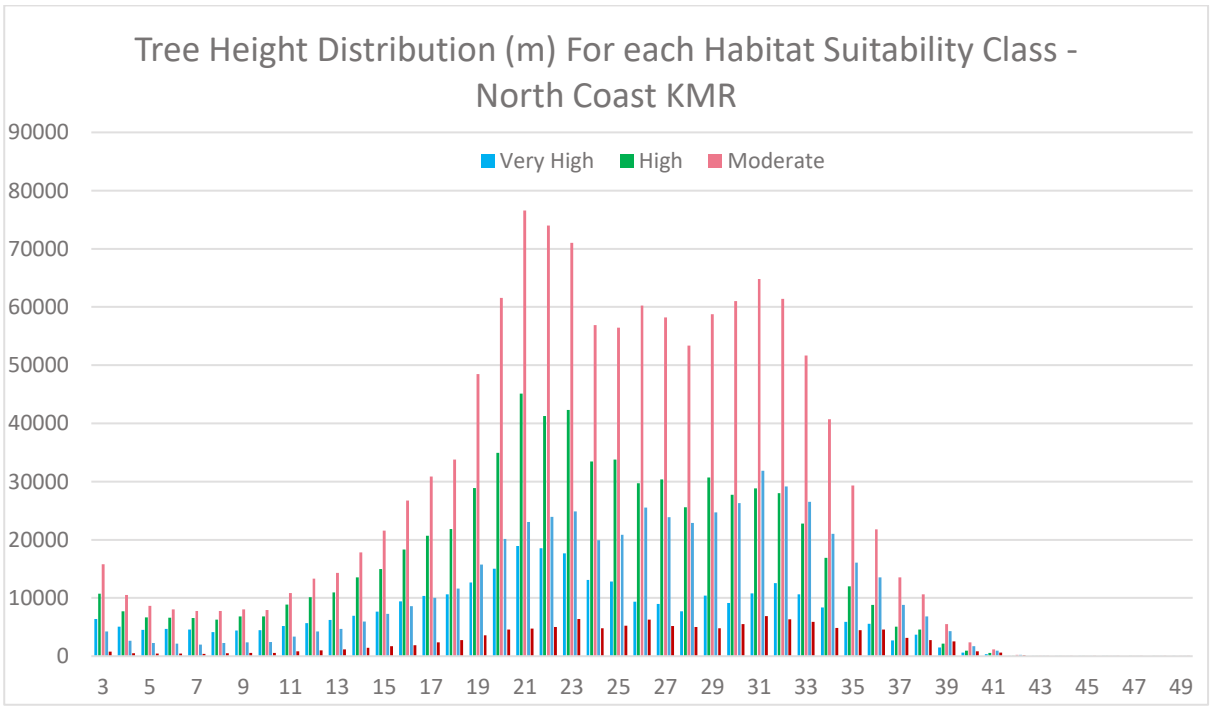
Graph are provided for each of the following regions:

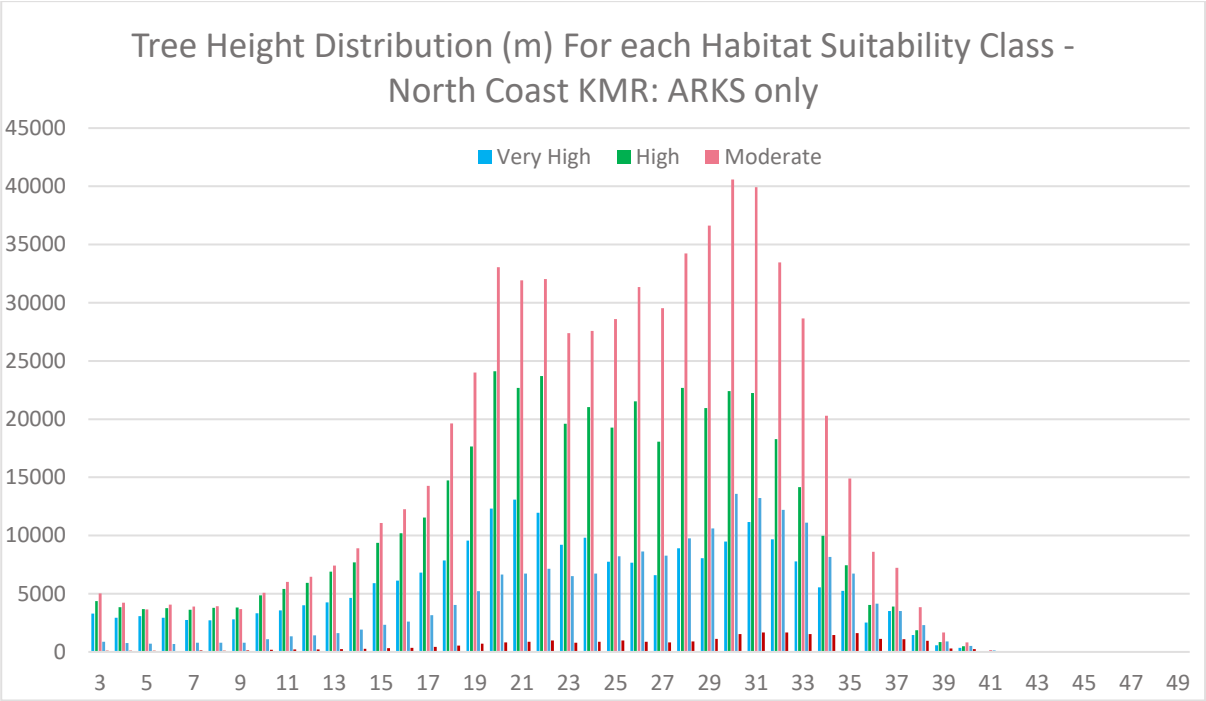
- All Eastern KMR's (Koala Modelling Regions)
- All ARKS
- The North Coast KMR only
- ARKS within the North Coast KMR only
- All PNF
- PNF within the North Coast KMR only

These charts show the variability in forest height across habitat suitability classes, and how the figures can be skewed if assessed at different scales. This indicates the importance of assessing the habitat values at appropriate scales. Further is show why the management of habitat may need to be more nuanced than a single approach across the north coast to ensure robust protections for koalas, and the protection on biodiversity more generally.









Koala model use and coverage in north east NSW

It is notable that use of the DPI model at a threshold of 0.6 as the basis for a koala specific prescription would result in no prescription being triggered in most PNF operations in many areas regionally significant koala populations as identified by ARKS, such as the Banyabba ARKS. This is shown as Map 5. The EPA has extensively studied koalas in this region, as well as Dr Steve Phillips (report can be supplied by EPA on request), and this outcome is a poor outcome for this high profile koala population.

One aspect of using the DPI model is that its extent is limited to that of its inputs, particularly the coverage of the CRAFTI floristics mapping, which doesn't exist in private land, or is inaccurate.

In addition, the threshold used is set at a level that is excessively high for protecting koala habitat in PNF, where under the IFOAs, the threshold is set much lower to include moderate habitat (in combination with another map that further captures areas with moderate to high probability of koalas occurring). The IFOA also acknowledges the data deficiencies in the DPI map, and requires any cells missing data assume the value of the highest value koala's habitat. This appears to be lacking in the prescription proposed.

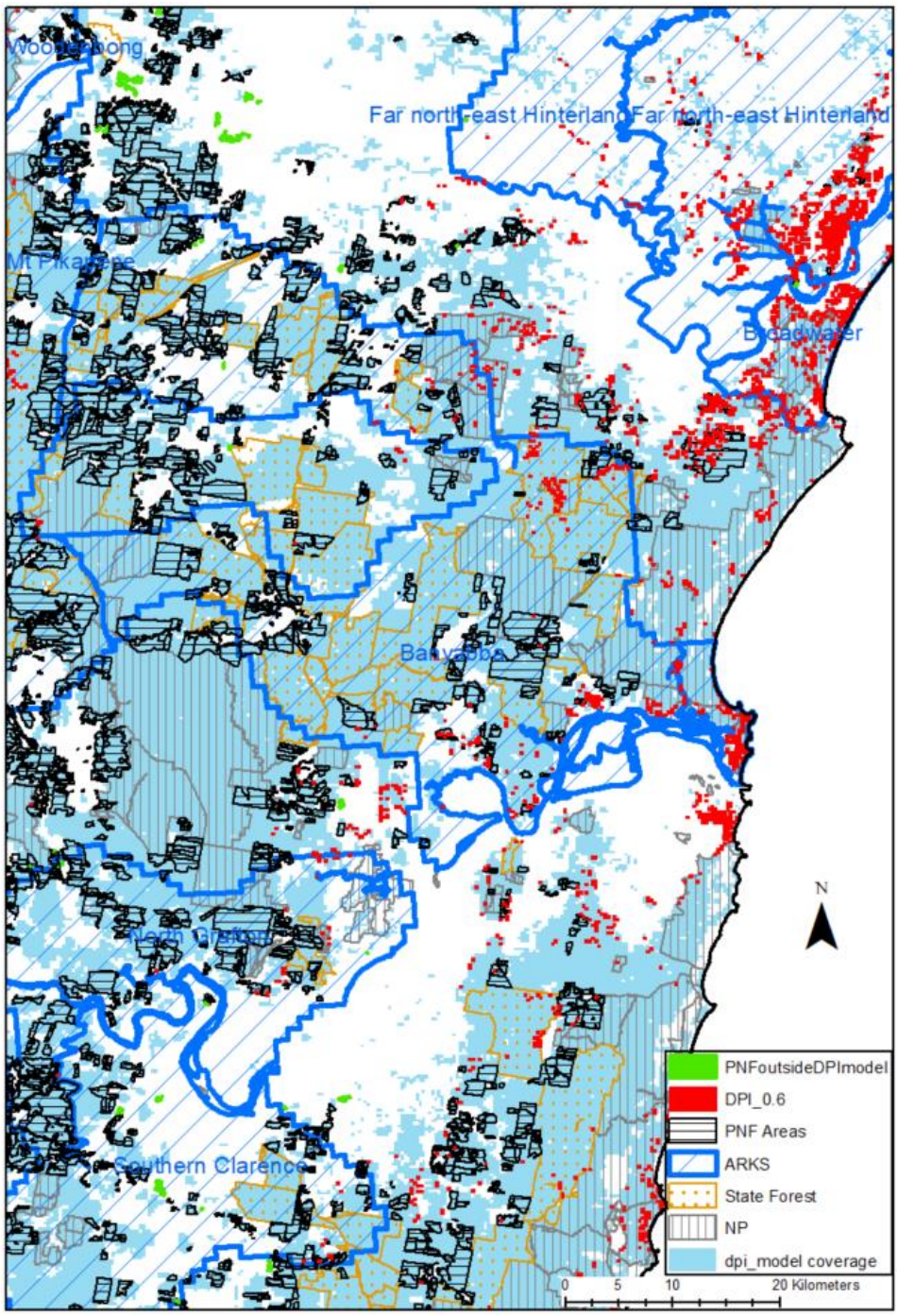
This leaves some areas, amounting to 175 PNF approvals, entirely outside of the North Coast outside of the DPI models footprint and a much larger number that have only partial coverage. A particularly concerning example of this is the area south of Kempsey around Kundabung within the Wilson River ARKS shown in Map 6. In this instance neighbouring areas within the coverage under the DPI model have very high values triggering the prescription and the EES Koala Habitat Suitability Model, which does have model coverage across the areas concerned shows high and very high values.

It should also be understood that the DPI model is actually two models, one of areas above 500m elevation and one for areas below. Using these models as a single layer with the same threshold results in an abrupt change in the outcome at the 500m elevation with much greater attribution of high values above 500m and much lesser below it. An example of this is shown in Map 7.

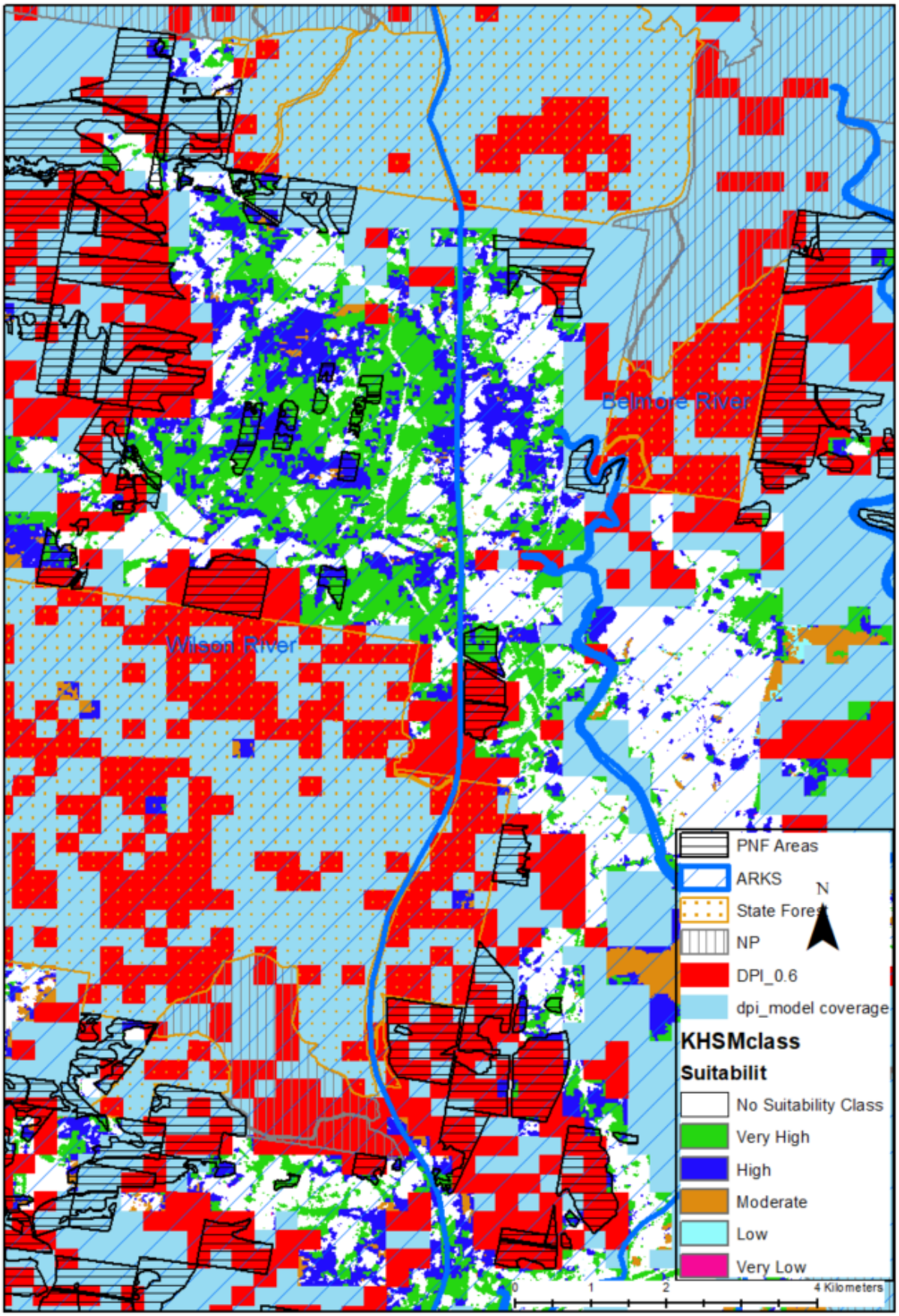
The basis for using the DPI map is unclear, especially given it was not designed for PNF and has severe limitations to it application to PNF. It has since been replaced by high resolution and more accurate state-wide habitat suitability model (DPIE map).

In addition, the DPIE koala suitability model is not designed to be used via a single threshold (as proposed by LLS at 0.8). Instead each region requires its own threshold be set to ensure areas of high and very high suitability are captured. It is understood that EES has already provided advice on this to the Office, and examples of the issues with the proposed approach of LLS. Further information on the issues can be provided, including examples where inappropriate use of the model will result in perverse outcomes.

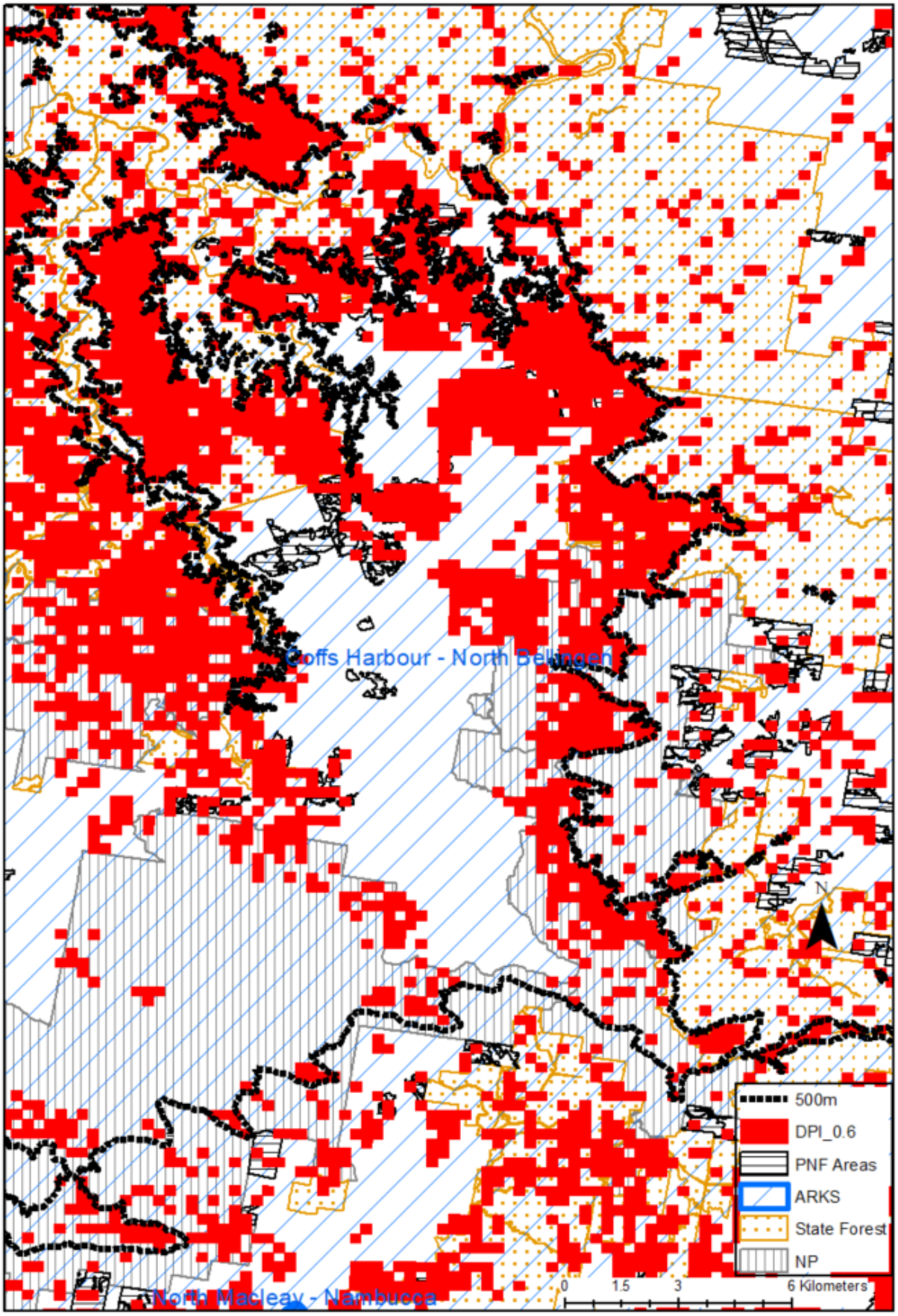
Map 5 – DPI Model coverage in the Banyabba ARKS



Map 6 – DPI model coverage limitations for PNF properties - Kundabung area of Wilsons River ARKS



Map 7 – DPI model coverage disparities at 500m elevation level



The breakdowns that follow provide % of Mod-Very High Suitable Habitat Outside the current prescription: ARKS within the North Coast KMR

Total Mod-Very High Habitat % Outside Prescription Area: 83.1%

Per Class:

Habitat Suitability	Outside Prescription Area	Prescription Area
Very High	67.8%	32.2%
High	81.2%	18.8%
Moderate	89.8%	10.2%
Low	92.6%	7.4%
Very Low	94.2%	5.8%

% of Mod-Very Highly Suitable Habitat outside the Current Prescription Per ARK within the North Coast KMR

ARK	Outside Prescription Area	Prescription Area
Banyabba	98.3%	1.7%
Barrington	88.1%	11.9%
Belmore River	73.6%	26.4%
Broadwater	71.2%	28.8%
Clouds Creek	75.3%	24.7%
Coffs Harbour - North Bellingen	69.5%	30.5%
Comboyne	67.9%	32.1%
Crowdy Bay	64.4%	35.6%
Far north-east	54.8%	45.2%
Far north-east Hinterland	89.2%	10.8%
Gibraltar Range	100.0%	0.0%
Girard - Ewingar	96.8%	3.2%
Hawks Nest	81.5%	18.5%
Karuah - Myall Lakes	85.1%	14.9%
Khappinghat	64.7%	35.3%
Kiwarrak	89.5%	10.5%
Mt Pikapene	99.8%	0.2%
North Grafton	99.5%	0.5%
North Macleay - Nambucca	84.6%	15.4%

Nowendoc	88.6%	11.4%
Port Macquarie	50.6%	49.4%
Southern Clarence	99.9%	0.1%
Tweed Coast	47.6%	52.4%
Tweed Ranges	85.6%	14.4%
Wallingat NP	85.0%	15.0%
Wang Wauk SF	91.5%	8.5%
Wilson River	75.9%	24.1%
Woodenbong	92.8%	7.2%

Appendix 6 - Triggers for prescriptions

It is evident that different plots of land (with koala habitat) held by landholders will have different status and categories of allowable activity and restrictions based on whether (Table 15):

- PNF is prohibited (Scenario 1)
- PNF is planned for land that is currently mapped as core koala habitat under SEPP44 (Scenario 2)
- Koalas have been seen on the land (Scenario 3)
- Koala scats have been found (Scenario 4)
- Koala habitat has been mapped as highly suitable (Scenario 5)
- Koala habitat on the land has been: not mapped, mapped as not highly suitable, mapped incorrectly, or mapped inaccurately (Scenario 6)

Table 15 makes a comparison between the different allowable basal areas in the current PNF and the proposed new PNF codes, as well as the thresholds by which the two main koala prescriptions are triggered – the implementation of exclusion zones around koala trees, and the requirement to retain 10 Primary Koala Trees and 5 Secondary Koala Trees.

The Table makes no commentary about whether the triggers, or prescriptions are firm enough to mitigate the increased risk from the increased wood take allowed under the lower stand basal areas, but simply indicates whether there is a relative improvement or otherwise between the current and the proposed new PNF settings.

Some observations:

- Scenario 3 – including koala scratches on trees as evidence of koala tree for an exclusion zone is positive for koalas
- Scenario 4 - Moving from 20 scats to 10 scats for a koala tree is positive for koalas in terms of triggering exclusion zones
- Scenario 4 - Having the South Coast Koala Management Area move from 1 Tree signalling a koala tree to 10 scats signalling a koala tree is negative for koalas, in particular given the low population density and extent of recent bushfires in that region
- Scenario 4 - Moving from 1 scat under a koala tree triggering 10 Primary and 5 Secondary tree retention to scats not triggering retention at all, is a negative outcome for koalas
- Scenario 5 - Having more of the state mapped for highly suitable koala habitat is positive for koalas

The use of triggers relies on standardised information capture and comparisons. Some observations of the review on trigger metrics quality and certainty:

- BioNet Records (Scenario 3)
    - Koala sighting records are limited and patchy, often old, and are therefore unreliable as a single source of evidence for the presence of koalas. Koalas are cryptic species and are notoriously difficult to find. Survey effort of koalas are often biased towards areas that are more heavily populated or frequented by humans. Generally, there are more koala sightings along roads, close to urban centres, generally close to where there are people to observe them.
- Koala sighting efforts (Scenario 3)
    - On private land, there may be fewer people who visit the land and land holders may be disincentivised from observing and reporting koalas in some cases

- Koalas are cryptic animals and difficult to spot, access by trained ecologists with experience in spotting koalas is less likely on private land. Identifying a breeding female is even more difficult

- Scat searching efforts (not dogs required) (Scenario 4)
  - Scats can be short lasting in duration, in particular in wetter climate
  - Scat dogs are a means of increasing observation success but there are not typically utilised (can be more expensive and time-consuming than other survey techniques) and not required under the codes
- Habitat mapping techniques (Scenario 5 and 6)
  - Habitat mapping techniques have different resolution, data inputs, ground truthed, accurate, applicable on private land. Some mapping approaches focus on vegetation communities (DPI) and others focus on tree species (EES)
  - The level of habitat considered for high value in these codes is high (0.6 for DPI and 0.8 for EES maps) and does not capture habitat suitability scores where most of the koala have been found (Appendix 5 Figure 2)
  - Habitat suitability maps are historically used as a trigger for more investigation to understand quality, setting, habitat function, landscape functions, however no requirement for onsite ground-truthing or further assessment
- Reassessment approach allowable under the new Proposed PNF (Scenario 5)
  - Every koala occupancy measurement technique has flaws – acoustic techniques pick up males of breeding age but not females, require deployment in grid-based patterns to provide accurate directional readings, do not measure absence; standard spotting (day observations or night spotlight) surveys are resource intensive, slow and miss a lot of koalas; drone survey techniques are growing in popularity and standards being gradually developed however need to be undertake at night and usually in winter; scat surveys by humans are slow and inaccurate with false negatives; scat surveys by dogs have increased accuracy but have higher expenses and time requirements
  - Given no one technique is definitive, on its own, at identifying koalas on habitat for FOP FSP planning and operations, lack of evidence of a koala should not be confused with a definitive 'absence' of koalas.

Table 15: Scenarios of different instances of koala presence or signs, or koala habitat mapping status, to compare prescription triggers

Scenarios of koala presence and habitat characteristics	Current PNF	Proposed new PNF
Scenario 1 - prohibited Old growth forests OR Where permanent clearing is desired	PNF operations prohibited	PNF operations prohibited
Scenario 2 - previous SEPP 44 In areas of approved core koala habitat as defined in SEPP 44. Total area approx. 6000 ha	PNF operations prohibited	Av Basal Area 10 or 12 m^2/ha Koala prescriptions (depending on koala and habitat mapping status as below)

Scenario 3 – koala sighting Locations where koalas have been identified Highly suitable or quality koala habitat: • koala spotted or BioNet record	Basal Area 12, 14. 16, 18 (depending on tree type and height) Koala prescriptions Tree containing a koala → exclusion zones of 20 or 50m around each tree Koala record in area or within 500m of operation → 10P + 5S koala trees retained rule	Av. Basal Area 10 Northern Code) or 12 m^2/ha (Southern Code and RRG Code), 6m^2/ha for Cypress and 8m^2/ha for Western Hardwood Koala prescriptions Tree containing a koala or recent scratch marks → exclusion zones of 20 or 50m around each tree Koala record in area or within 500m of operation → 10P + 5S koala trees retained rule Each tree must be visually assessed for koalas immediately prior to it being felled

Scenario 4 – koala scats found

Highly suitable or quality koala habitat:

- scats identified
- no koala spotted
- no BioNet record
- and not mapped

Basal Area 12, 14. 16, 18 (depending on tree type and height)	Av Basal Area 10 Northern Code) or 12 m^2/ha (Southern Code and RRG Code), 6m^2/ha for Cypress and 8m^2/ha for Western Hardwood
20 or 1 scats trigger → exclusion zones of 20 or 50m around each tree	10 or 1 scats or recent scratch marks → exclusion zones of 20 or 50m around each tree
1 scat under primary or secondary tree → 10P + 5S koala trees retained rule per ha	Scats **DO NOT** trigger the 10P + 5S koala trees retained rule
20 scats for Border Rivers-Gwydir, Central West, Hawkesbury-Nepean, Hunter-Central Rivers, Namoi, Northern Rivers and Sydney Metro. One or more scat for South Coast, Central and Southern Tablelands and Western Koala Management Areas (Koala Management Areas 3, 5, 6 and 7))	10 or more koala scats for: • Northern code in North Coast, Northern Table Lands, Northwest slopes and Central coast Koala Management Areas; • South coast (Southern code) One or more koala scats in: • Central and Southern Tablelands Koala Management Area for Northern and Southern Codes. • RRG Code in Far West, Riverina, Darling Riverine Plains and Central and Southern Tablelands Koala Management Areas; • Cypress Code - Far West, Riverina, Darling Riverine Plains and Central and Southern Tablelands Koala Management Areas.

Scenario 5 – habitat mapped Locations where koalas not spotted, no records, no scats Highly suitable or quality koala habitat: • Koala Habitat mapped • no koala spotted nor BioNet record • no scats	Basal Area 12, 14. 16, 18 (depending on tree type and height) No Koala prescriptions	Av Basal Area 10 Northern Code) or 12 m2/ha (Southern Code and RRG), 6m2/ha for cypress and 8m2/ha for Western Hardwood Koala prescriptions Mapped habitat → 10P + 5S koala trees retained rule per ha Each tree must be visually assessed for koalas immediately prior to it being felled
Scenario 6 – habitat not mapped Highly suitable or good koala habitat: • Koala Habitat NOT mapped • not koala spotted or BioNet record • no scats found	Basal Area 12, 14. 16, 18 (depending on tree type and height) No Koala prescriptions	Av Basal Area 10 Northern Code) or 12 m2/ha (Southern Code and RRG), 6m2/ha for cypress and 8m2/ha for Western Hardwood No Koala prescriptions