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Technical report for Local Land Services

Suitability of private property for native timber production in Northern NSW

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Suitability of private property for native timber production in Northern NSW

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Contents

Introduction

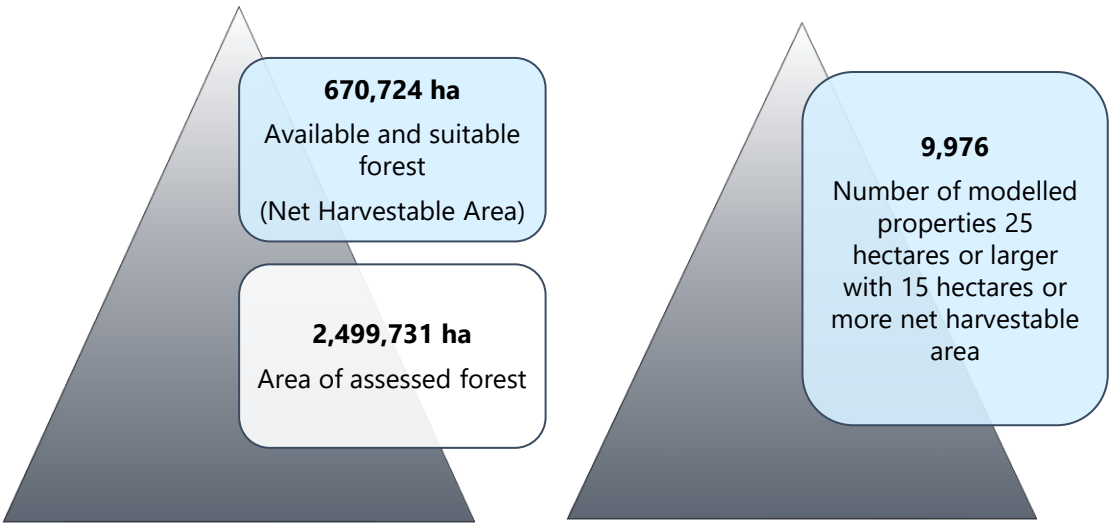
DPI Forest Science has developed a method for assessing the availability and suitability of native forest for private native forestry. The method was applied to 2.5 million hectares of private native forests on the NSW north coast. Nearly ten thousand properties covering 670,724 hectares of native forest were identified as available and suitable for private native forestry. A modelling process using six parameters enabled each property to be individually assessed and classified into a private native forestry suitability class. This report details how the process was undertaken and the modelled results.

Aim

To develop a model for evaluating the suitability of private property for native timber production.

Key Findings

A summary of the key findings is presented in the figures below.



a) Private Native Forest Area b) No. of Properties

Figure 1 – a) Area of private native forest assessed and modelled as available and suitable. b) number of properties suitable for PNF that were modelled

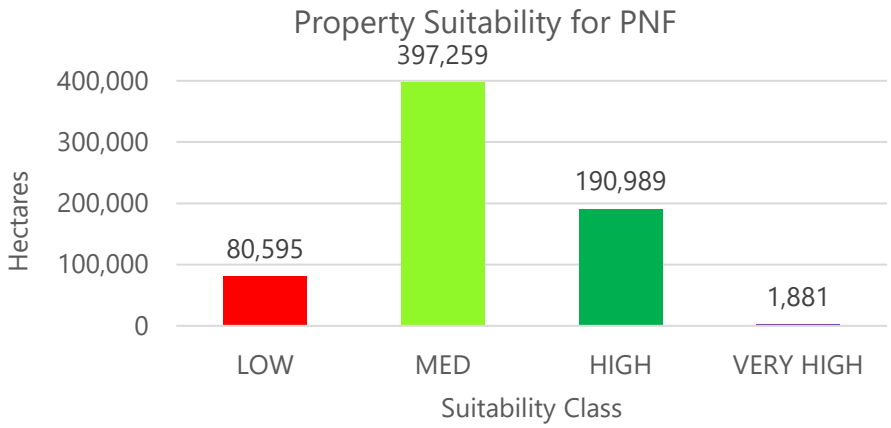


Figure 2 – 670,724 ha of forest available and suitable for PNF by suitability class

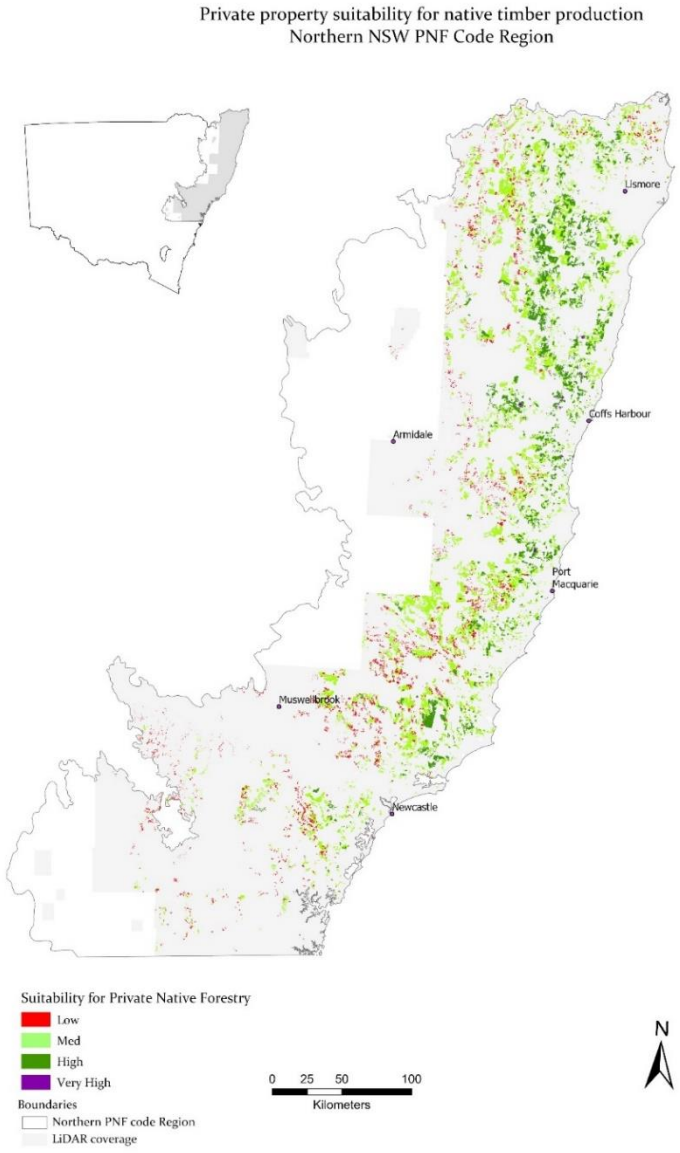


Figure 3 - Distribution of private native forest available and suitable for PNF by suitability class

Method

Analysis Software, Geoprocessing Tools and Spatial Layers

The model was developed and run using Arc Map 10.4 and ARC GIS Pro 2.7 and used specialised geoprocessing tools including the Network Dataset function and Network Analysis extension in ArcCatalog (ArcGIS® software by Esri). Ten spatial layers were used in the model, a description of each is provided below:

i. A **NSW native forest cover layer** was derived from a national woody vegetation layer developed by the National Greenhouse Gas Inventory (NGGI2018). This layer was downloaded from data.gov.au in 2019 and refined by DPI forest science (Alaibakhsh, 2019) to match the Australian definition of a forest (SOFR2018). The woody vegetation layer included 3 classes. Class 2, illustrating areas with greater than or equal to 20 percent canopy cover, was selected and used as the base woody vegetation layer. Then, using plantation layer (provided by DPI Plantation unit), EPI Land zoning (EES), Land use 2013 (SEED data portal), and horticultural land layers from QSpatial live data portal some exclusion classes were removed to create a 20 percent canopy cover forest layer for NSW (NSW forest extent interactive reports).

ii. A **Northern NSW PNF Code region** boundary layer was created by DPI Forest Science (Alaibakhsh, 2020) using the IBRA7 regions layer. The Sydney CBD latitude (33° 52' 2.71" S) was used to define the southern boundary.

iii. A **NSW Spatial Services Lidar** extent layer was sourced from Spatial Services. This layer was clipped to the Northern NSW PNF Code region. This layer does not cover the entire Northern region covers. There is full coverage of the North Coast but only limited coverage of the Northern Tablelands.

iv. **Cadastre NSW** layer detailing boundaries of private properties in Northern NSW. This layer was derived from 2017 land ownership records administered by the NSW Land Registry Services. Adjoining Lots with a common title holder were treated as an individual property. Details of individual owners were kept confidential.

v. Two **Public Roads** layers for NSW and QLD sourced from FCNSW and Queensland Government data portal (qldspatial.information.qld.gov). A shapefile of all public roads, NSW and QLD (within 100 km from NSW border) was created.

vi. A **NSW digital elevation model** layer was derived from Spatial Services LiDAR data (Hislop, 2021).

vii. A layer detailing the location coordinates of **NSW and QLD wood processing facilities** was sourced from ABBA (2020) 'NSW Wood Processing Facilities' spatial data, Australian Biomass for Bioenergy Assessment (ABBA) Project, available on National Map, https://www.dpi.nsw.gov.au/forestry/science/forest-carbon/abba. From

the layer the location coordinates of wood processing facilities that process hardwood were selected.

viii. A layer identifying **private native forest available and suitable for timber production** on the NSW north coast was used to refine the area of forest to be modelled. This layer was developed by DPI Forest Science (Alaibakhsh et al, 2021) for LLS. The layer was created by removing forest subject to regulatory operating exclusions (more than 40 spatial layers) as well as forest classified as non-commercial (Kathuria et al, 2021). Details of the methodology are contained in a report titled "*Private native forest available and suitable for timber production within PNF Plan areas*".

ix. A layer detailing the **forest yield association groups of the NSW north coast** was used to differentiate between preferred and non-preferred forest types that are non-commercial (e.g. rainforest). The layer was developed by DPI Forest Science (Kathuria et al, 2021a) for LLS. The methodology that was used to generate this layer and information on its accuracy is detailed in a report prepared for LLS titled "*Forest Yield Association Group Mapping of NSW North Coast Native Forests*".

x. A **forest site quality layer** was used to differentiate forest based on its productivity and timber yield potential. This layer was developed by DPI Forest Science (Kathuria et al, 2021b) for LLS. Details of the methodology that was used is contained in a DPI report titled "*Site Index Mapping for North Coast NSW using LiDAR Data"*.

Caveats and limitations

The modelling of property suitability for PNF considered the availability and suitability of a property's native forests over the longer term. The existing silvicultural condition and growth status of the forest was not considered. Silvicultural condition and growth status are a product of past management events and practices and as such vary over time and from one property to the next. For example, a property may be classified as highly suitable for PNF based on its size, location, terrain, species mix and site quality but may not currently contain merchantable timber due to having been recently harvested or impacted by wildfire.

The views or attitudes of the owners of the modelled properties were not considered. A separate study (DPI 2017) examined this issue and found that not all landholders are inclined towards PNF; so, classifying a property's forests as suitable for PNF does not necessarily mean that they will be managed for this purpose.

Technical caveats

- LiDAR data wasn't available for the entire Northern PNF Code Region. The project's area of interest was limited to the LiDAR data coverage area.
- Fire and harvesting effects were not considered.
- P2. Distance by road to wood processing facilities
    - 14 properties came with no distance from WPFs due to the roads layer not touching the property boundaries, so an average of distance from WPFs of the

neighbouring properties which share the roads together were calculated and used.

- P4. Terrain roughness
    - we evaluated DEM variation within the NHA of the properties not the region or whole property.
- P5. Forest Yield Association Group
    - The YAG layer (Kathuria et al, 2021a) was only available for zone 56 of the northern PNF Code Region. Therefore, we had to evaluate the YAG value differently for 83 properties. The elevation, geographical location, Site index and vegetation types of the properties were employed to evaluate P5 for the 83 properties.

Modelling Parameters

Six attributes known to influence timber production suitability were selected as modelling parameters:

- P1. Net harvestable area (NHA)
- P2. Distance by road to wood processing facilities
- P3. Slope
- P4. Terrain roughness
- P5. Forest Yield Association Group
- P6. Forest site quality

Each modelling parameter was assigned four suitability categories, namely, 'Very High (4)', 'High (3)', 'Med (2)' or 'Low (1)'. The stratification process was based on an analysis of the measured values for each parameter using knowledge of their influence on commerciality. A detailed explanation of the process for each parameter is provided later in the report.

P1 - Net harvestable area

P1 - Explanation

For a property to be eligible for modelling it had to be 25 hectares or greater in size and have 15 or more hectares of contiguous net harvestable area. For modelling purposes, all the areas of assessed forest within a property were summed.

Properties that didn't meet the size criteria were not considered viable for commercially forestry but may still support small scale timber harvesting operations, particularly if harvesting and processing is undertaken by the landholder.

All commercial harvesting operations incur 'fixed' and 'partially fixed' costs. These costs include forest assessment/inventory, preparation of a forest operations plan, floating of harvesting equipment to the site, road maintenance and upgrades. These costs are commonly in the order of $5000-$10,000. Depending on the contractual arrangement these costs may be borne by the landholder or the harvesting contractor. Regardless of who pays, for the operation to be commercially viable, the income from the sale of timber needs to exceed the costs.

When costs are dispersed over a small number of hectares, harvesting becomes less viable. In contrast when setup costs are distributed over a large forest (200 hectares or greater) the unit cost becomes immaterial.

Table 1 details the classification of the NHA into forestry suitability classes based on the cost per net harvestable hectare.

Table 1 – P1. Net harvestable area (NHA) forestry suitability classes

Suitability Class	Very High (4)	High (3)	Med (2)	Low (1)
Net harvestable area (ha)	≥ 200	≥ 100 to < 200	≥ 50 to < 100	≥ 15 to < 50
Harvest planning, setup and maintenance costs ($/ NHA)	Low	Med	High	Very High

P1 - Modelling process

The following spatial layers were used to derive the NHA:

- Northern NSW PNF Code Region boundary (Alaibakhsh, 2020)
- Cadastre NSW property boundaries
- NSW forest cover (Alaibakhsh, 2019)
- NSW Spatial Services Lidar coverage
- Private native forest available and suitable for timber production layer (Alaibakhsh et al, 2021)

To generate the NHA layer the following steps were followed:

1. Properties in the Cadastre NSW layer less than 25 hectares were removed.
2. The NSW Forest Cover layer was intersected with the Northern NSW PNF Code Region NSW boundary, the Spatial Services Lidar extent layer, and the clipped Cadastre NSW property layer.
3. The private native forest available and suitable for timber production layer was overlayed and removed from the clipped Forest Cover layer.
4. Remaining properties with less than 15 hectares of net harvestable forest were removed.
5. What remained was classified as the Net Harvestable Area (NHA) layer.

The modelling process revealed that 3.45 million hectares of privately-owned land in the Northern NSW PNF Code region has native forest cover. 2.5 million hectares (72%) of this

forest had Spatial Services LiDAR coverage. Of the 950,000 hectares of native forest that did not have Lidar coverage most was located on the Northern Tablelands[1].

Of the 2.5 million hectares of assessable forest, 1.9 million hectares was available after applying regulatory exclusions. This reduced to 670,724 hectares after removing non-commercial forests[2] and properties with less than 15 net harvestable hectares. The net harvestable area (Figure 5b) was distributed across 9,976 properties.

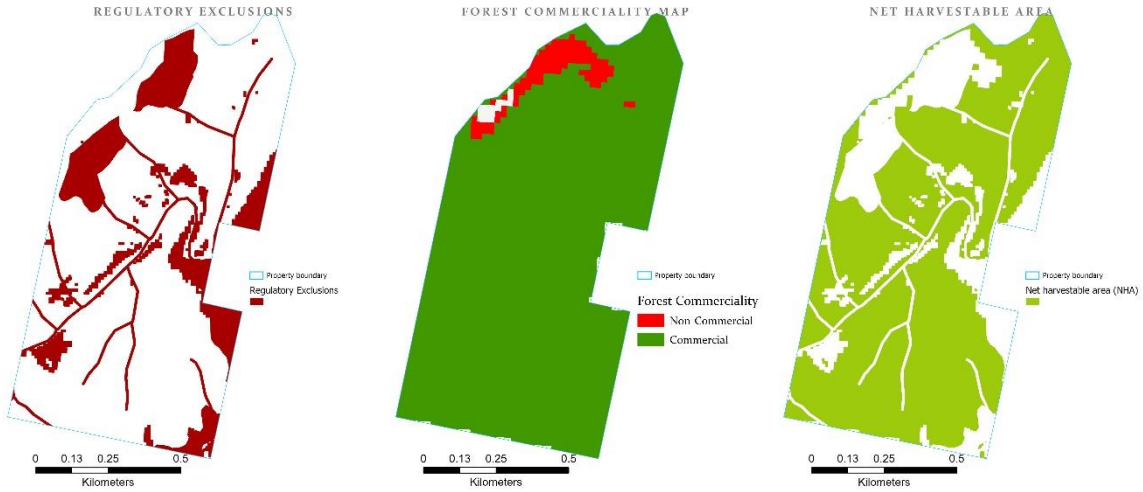
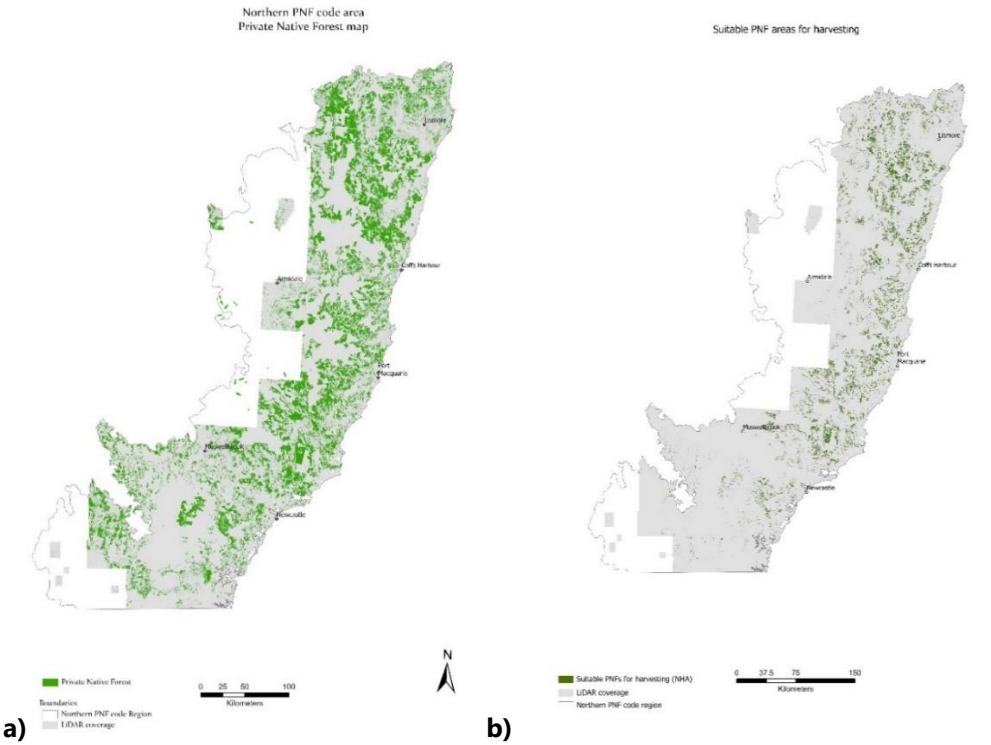


Figure 4 – Example of the process followed to derive the net harvestable area on a forested property (Alaibakhsh et al, 2021).

[1] It may be assumed that most of the Tableland forests have low suitability for PNF due to non-preferred species and low site quality.

[2] Non-commercial forest is defined as native forest that is incapable of producing high-quality logs based on its height and form.

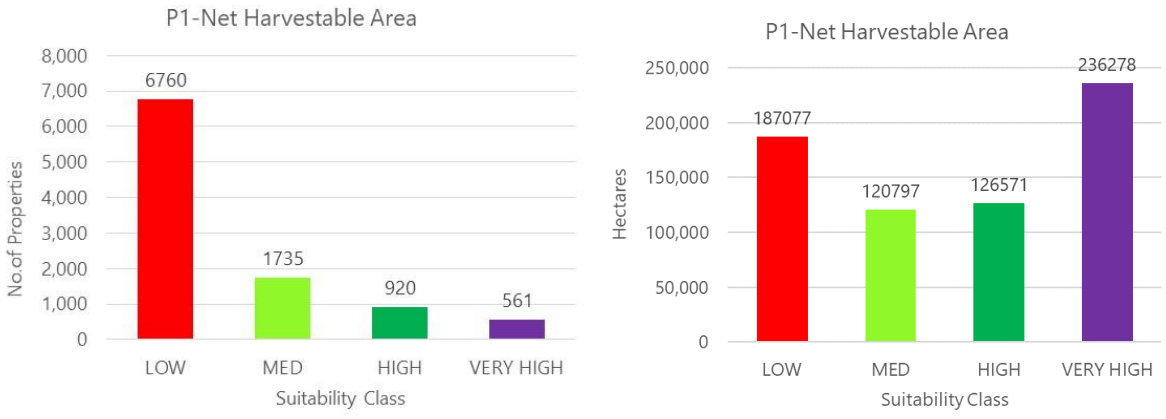


a) b)

Figure 5 – Map a) The gross area of private native forest area (2.5 million hectares) with LiDAR coverage (Alaibakhsh, 2019). Map b) The net harvestable area (670,724 hectares) of private native forest that was modelled and rated (Alaibakhsh et al, 2021).

P1 – Modelled result

Over two thirds of the assessed properties (n=6,760) had less than 50 hectares of net harvestable area, putting them in the 'low' suitability class (Figure 6). Together these properties accounted for 187,077 hectares or 28% of the total net harvestable area (670,724 hectares). In contrast only 8% properties were classified as very high suitability (200 or more hectares of net harvestable area) accounting for 35% of the net harvestable area.



a) b)

Figure 6 – a) Property count by net harvestable area suitability class b) NHA by NHA suitability class

In most parts of the Northern Region, the size of the harvestable area (NHA) on a property was quite variable. One discernible trend was that properties with a large NHA (200 ha or greater coloured purple) were mainly located in the hinterland between 50 and 100 kms from the coast (Figure 7).

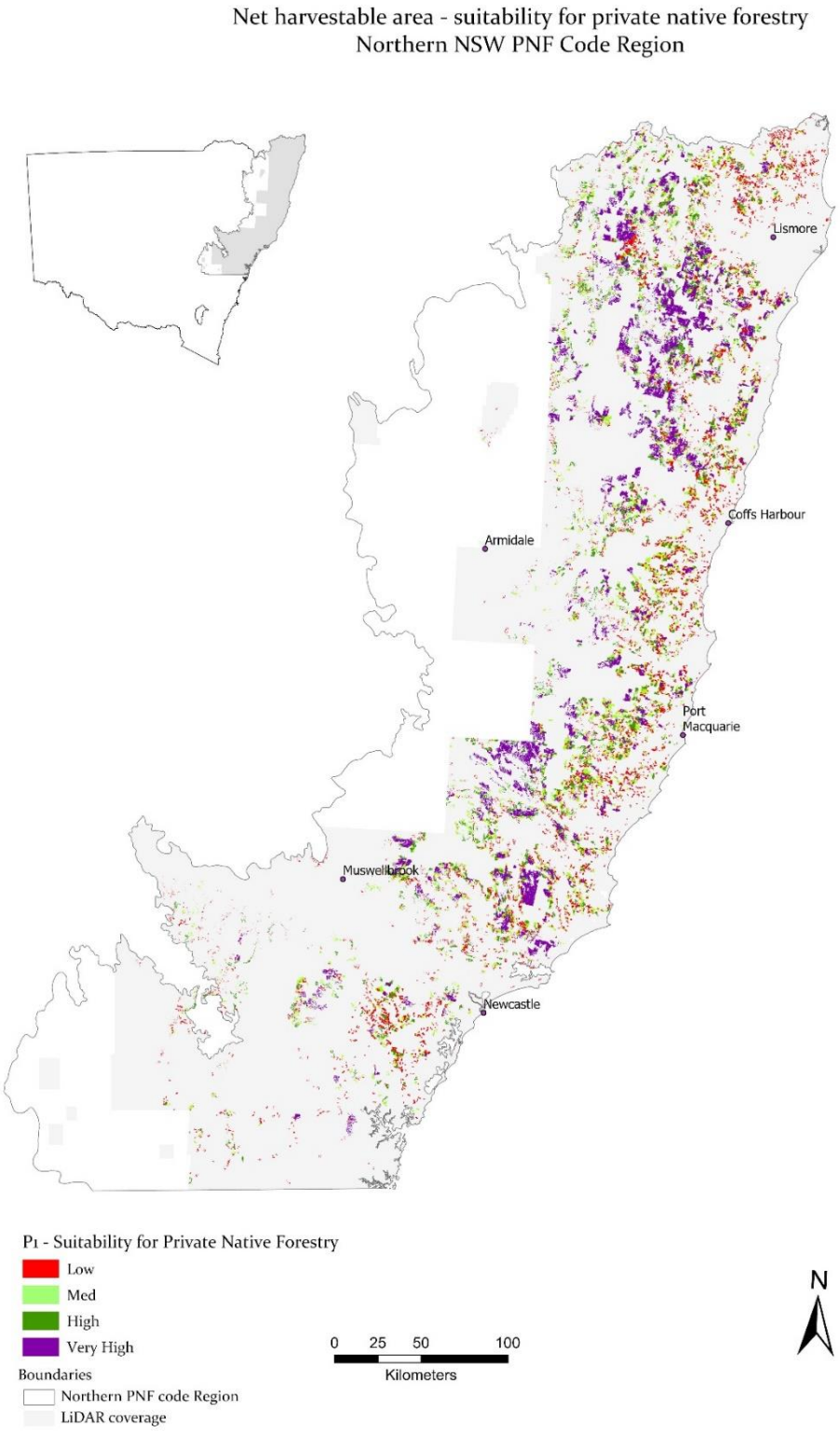


Figure 7 – Suitability for PNF based on the size of the net harvestable area

P2 – Log Haulage distance

P2 - Explanation

To realise the timber values from a native forest, trees must be harvested, and their log products delivered by road to wood processing facilities[3] (WPF). Determining the distance by road from a property to its nearest wood processing facilities enables the cost of log haulage to be estimated. Properties located close to wood processing facilities will have low log haulage costs while those situated in remote localities will have high costs.

On the NSW north coast and QLD (within 100 km from NSW border) there are over 100 wood processing facilities that process hardwood logs (Figure 8). Each facility has discrete markets which gives rise to specific log mix preferences.

To be able to sell a range of different log types and obtain the best market price log producers often sell their logs to multiple wood processors. To capture this trend the average distance by road to a property's nearest three wood processing facilities was calculated and modelled (Table 2).

Table 2 – P2 – Distance by road to wood processing facilities - suitability classes

Suitability Class	Very High (4)	High (3)	Med (2)	Low (1)
Average distance by road to closest three wood processing facilities (km)	≥ 0 to < 15km	≥15 to < 25km	≥25 to < 50km	≥ 50km
Log haulage cost ($/m3)	Low	Med	High	Very High

[3] Note some landholders undertake onsite milling using portable milling equipment. This scenario was not modelled

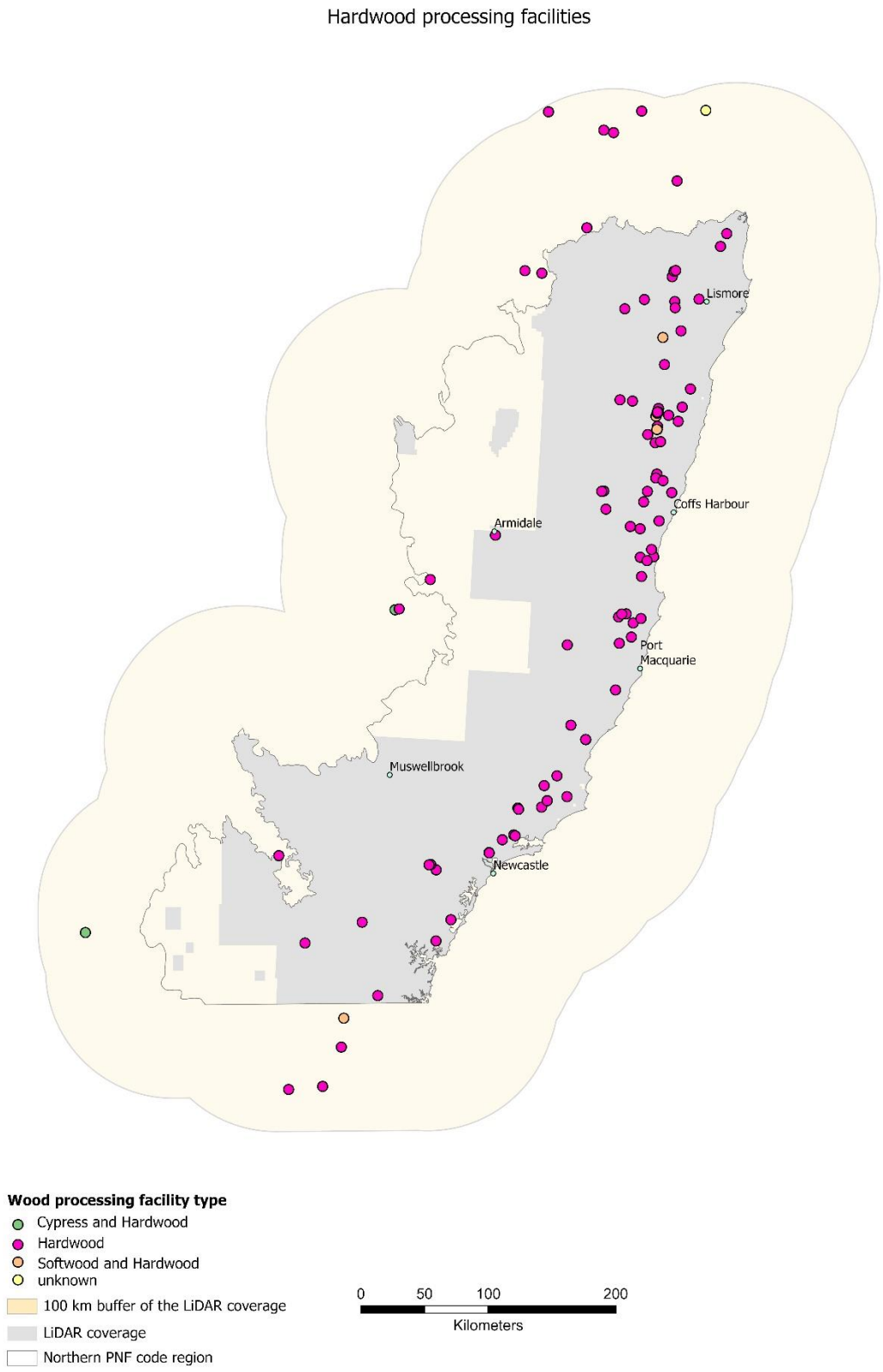


Figure 8 – Location of hardwood processing facilities that were used in the model (source: ABBA (2020), 'NSW Wood Processing Facilities' spatial data).

P2 - Modelling Process

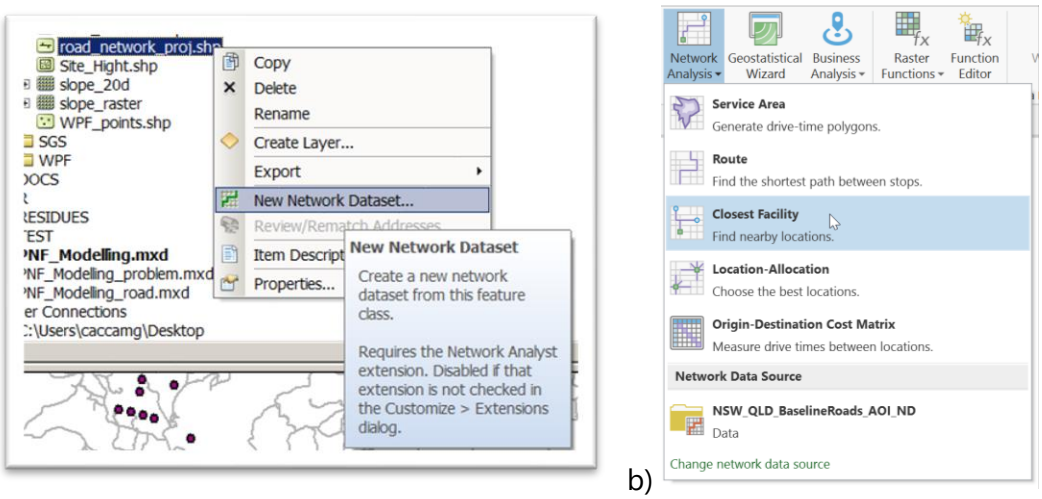
For modelling purposes, we assumed the landowner would sell their hardwood logs to the three wood processing facilities located nearest to their property. The following spatial layers were required to calculate this distance:

- Cadastre NSW
- Centroid of each of the 9,976 properties identified in the cadastral boundary layer
- NSW and QLD Wood Processing Facilities (ABBA (2020), 'NSW Wood Processing Facilities' spatial data)
- Public Roads (NSW & QLD)

The procedure to model log haulage distance was as follows:

i. First, in ArcCatalog, the "New Network Dataset" function was used to convert the road shapefile into a network dataset (Figure 8a).

ii. Then, using the "Network Analysis" toolset in ArcGIS Pro, the "New Closest Facility" tool was used to calculate the distance by road from each property to the three closest wood processors facilities (Figure 9b).



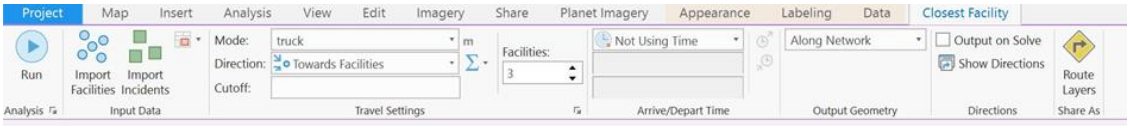
a) b)

Figure 9 – a) Using ArcCatalog to create a new Network dataset, and b) ArcGIS Pro Closest Facility tool to calculate closest paths to WPFs.

iii. In the "New Closest Facility" tool, wood processors facilities were assigned to "Facilities", whilst the centroids of the 9,976 properties were assigned to the "Incidents". For both "Facilities" and "Incidents", "Search Tolerance" and "Location Snap Options" were set to a suitable distance (~500 km).

iv. In "Closest Facility Properties" (Figure 9a), "Impedance" was set to "Length (Meters)" and "Facilities to Find" was set to 3. In the "Network Locations" tab, "Search Tolerance" was set to a suitable distance (500 Km) and "Snap to" was set to "Closest".

a)



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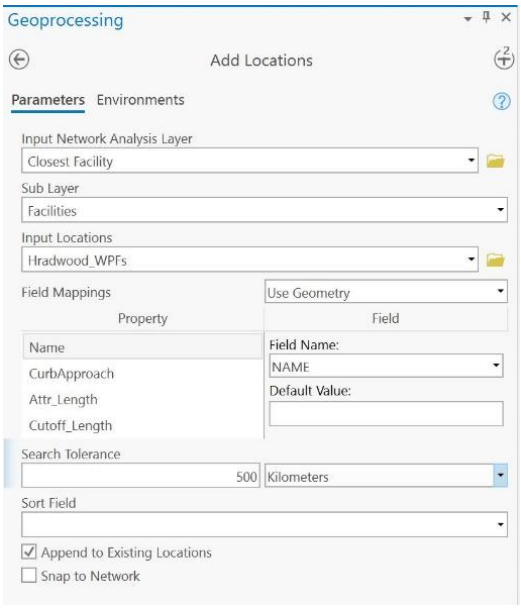


c)

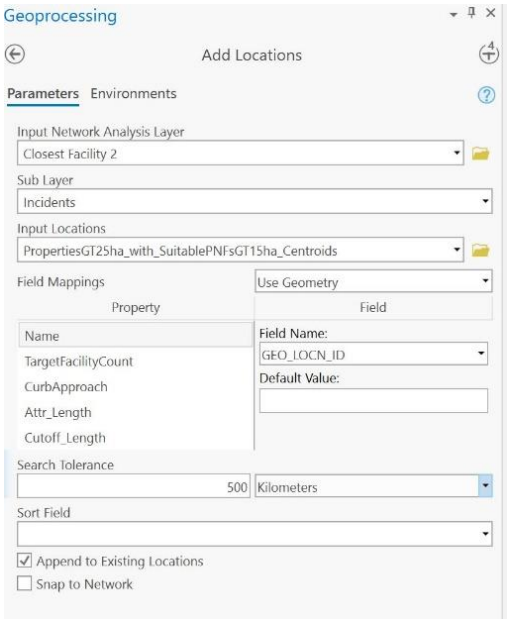


Figure 10 - Parameters setting in "Closest Facility Properties" using ArcGIS Pro. a) Closest facility toolbar, b) assigning 'Facilities' parameters, and c) assigning 'Incident' parameters.

v. The distance by road from each property to the three closest wood processors facilities was calculated by clicking on "Run" in the "Closest facility" toolbar (Figure 10a). The output (in table format) was accessed by right-clicking on "Routes" in the "Closest facility" dataset. Using the "pivot-table" function in Excel, the average distance by road from each property to the three closest wood processors facilities was calculated.

vi. Finally, the 9,976 properties were classified as Very High (i.e., ≥0 to < 15 km), High (i.e., ≥ 15 to < 25 Km), Med (i.e., ≥ 25 to < 50 Km) or Low (i.e., ≥ 50 Km) based on their average distance to the three closest WPFs.

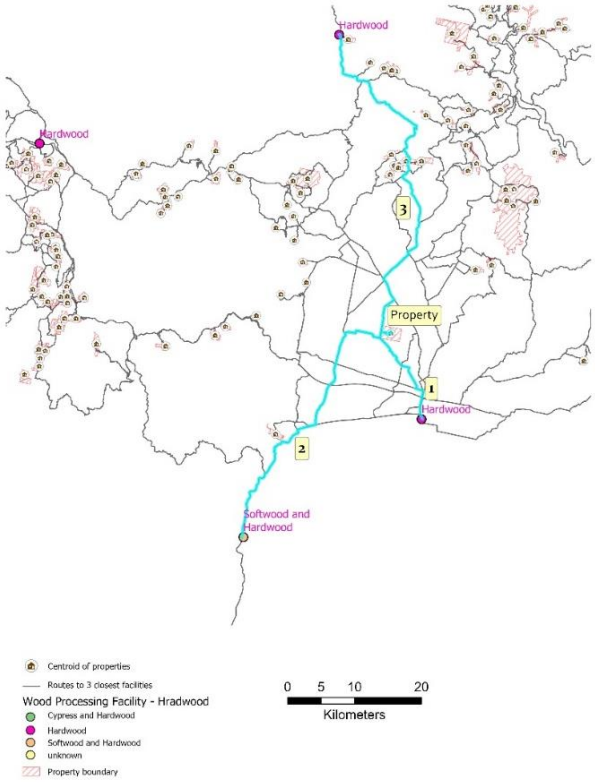
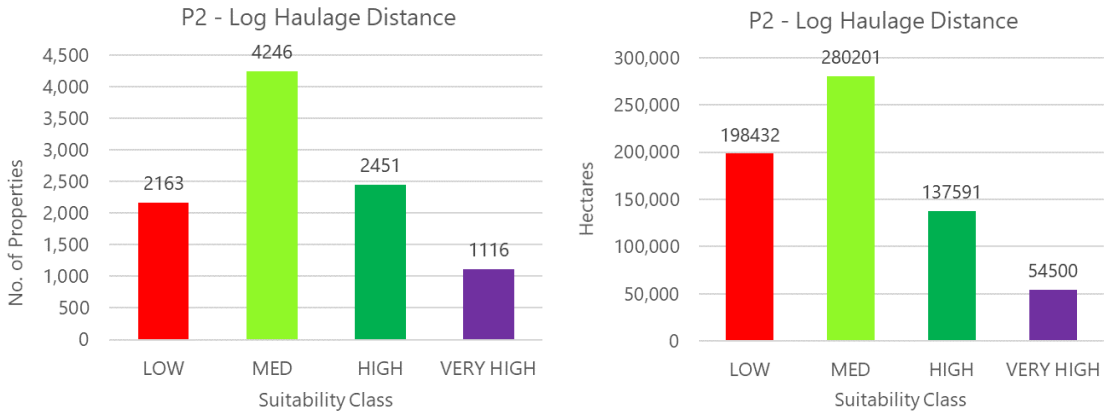


Figure 11 – Example property showing closest route by road to nearest three wood processors facilities.

P2 – Modelled Result

Average log haulage distances between a property and its nearest three wood processing facilities were found to be closely aligned with the property's proximity to the Pacific Highway and with clusters of wood processing facilities (Figure 13). Properties located near these features were classified as high or very high. The Pacific highway runs right through the region roughly following the coast (typically ~10 kms inland). Clusters of wood processing facilities are located around Bulahdelah, Kempsey, Coffs Harbour and Grafton.



a) b)

Figure 12 – a) Property count by log haulage distance suitability class b) NHA by log haulage distance suitability class

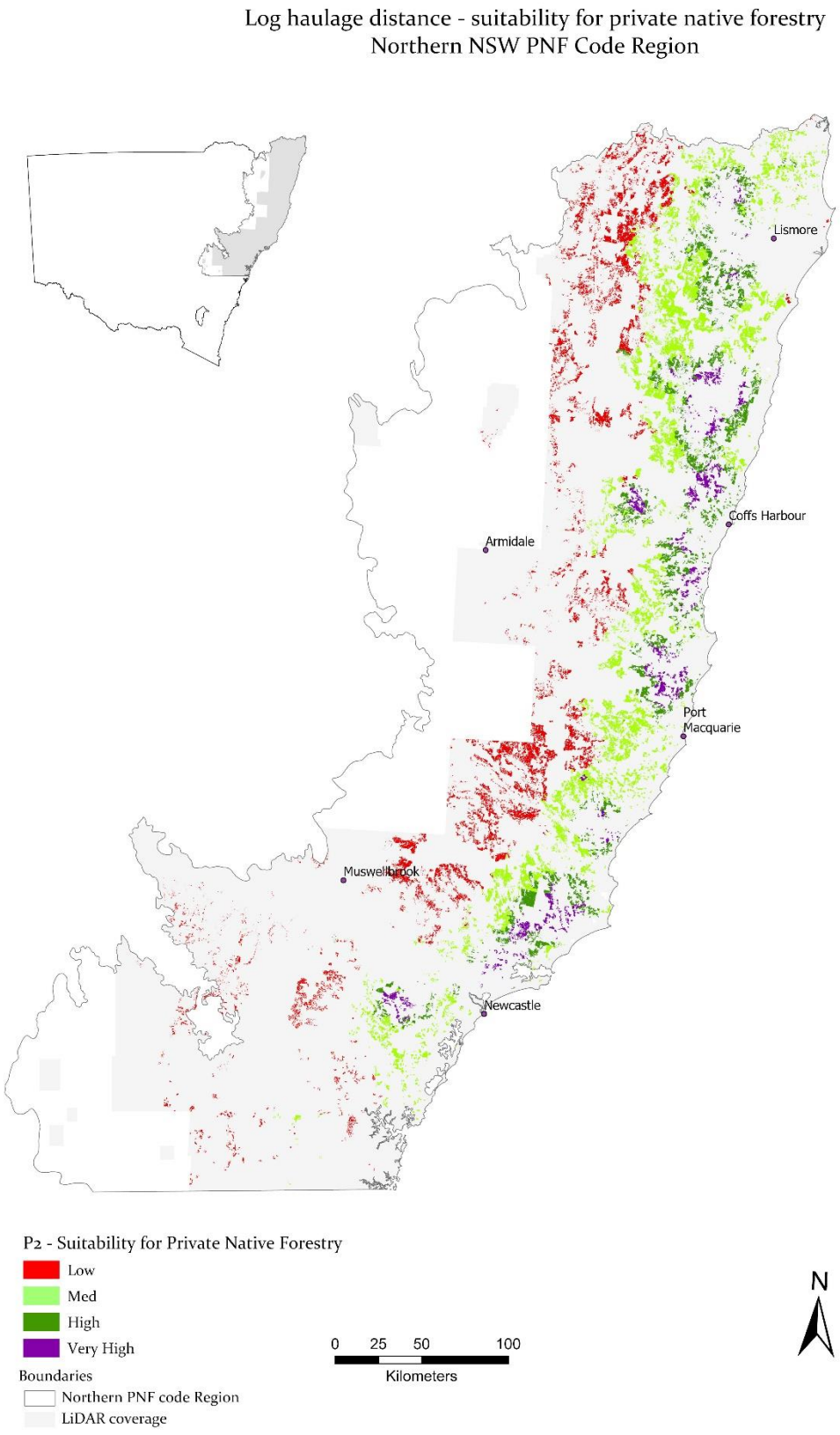


Figure 13 – Suitability for PNF based on the distance to the nearest wood processing facilities (Alaibakhsh et al, 2021).

P3 - Slope premium

P3 - Explanation

Harvesting machinery can operate on slopes up to 30 degrees, however, on slopes over 20 degrees harvesting difficulty increases (the time it takes to harvest a tree), as does fuel use. These increases affect the overall cost of harvesting which in turn reduces the value of the timber being harvested. The proportion of a harvestable areas that exceeds 20 degrees is therefore an important component of assessing a property's suitability for forestry (Table 3).

Table 3 – P2 – Slope premium - suitability classes

Suitability Class	Very High (4)	High (3)	Med (2)	Low (1)
Proportion of net harvestable area with slopes over 20 degrees (%)	< 10%	≥ 10% to < 25%	≥ 25% to < 50%	≥ 50 to 100%
Harvesting cost ($/m3)	Low	Med	High	Very High

P3 – Modelling Process

Three different layers were used to calculate this parameter:

- Net Harvestable Area (NHA) layer (this layer that was derived from the process detailed in P1)
- NSW Cadastre
- The NSW digital elevation model (DEM)

The DEM was employed to create slope layer within the NHA for each of the 9,976 properties. The area with slope ≥20° within the NHA was then calculated (Figure 14). The extent was expressed as a percentage by dividing its value by the total NHA. Finally, the 9,976 properties were classified as either Very High (<10% over 20°), High (≥10 to <25% over 20°), Med (≥25 to < 50% over 20°) or Low (≥50 to 100% over 20°) based on the % value.

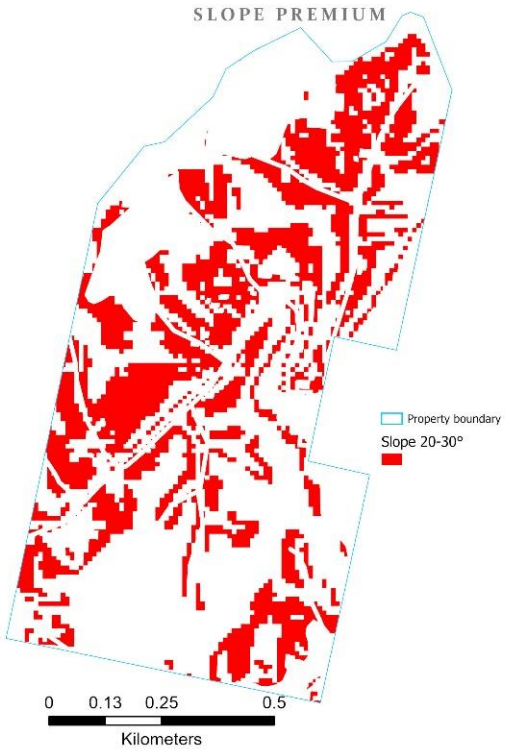
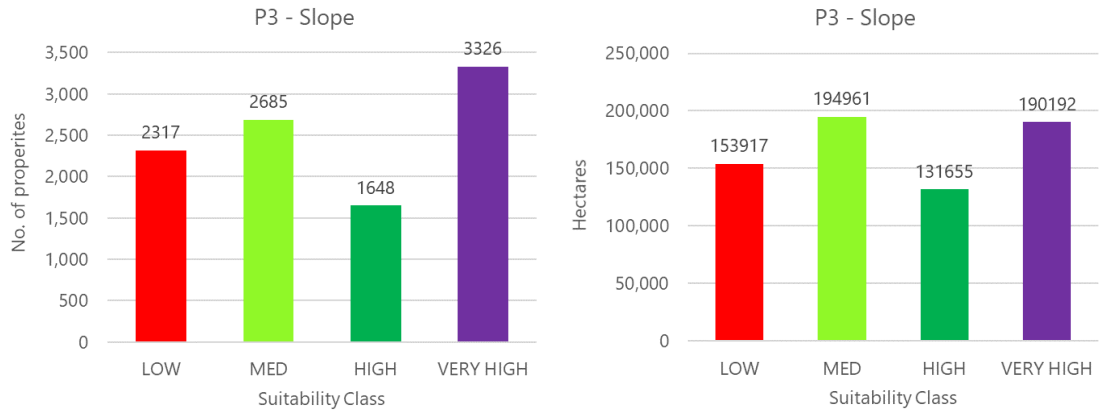


Figure 14 – Mapping the area with slope ≥ 20° within the NHA of each property.

P3 – Modelled Result

When ranked according to slope, properties were relatively evenly spread across the four suitability classes. The greatest number of properties (one third) were found to have less than 10% of their net harvestable with slopes over 20 degrees putting them into the very high suitability class (Figure 15).



a) b)

Figure 15 – a) Property count by slope suitability class b) NHA by slope suitability class

Properties with a very high suitability class rating (gently sloping) were mostly found within 25 kms of the coast and in the area around Grafton and Casino (Figure 16).

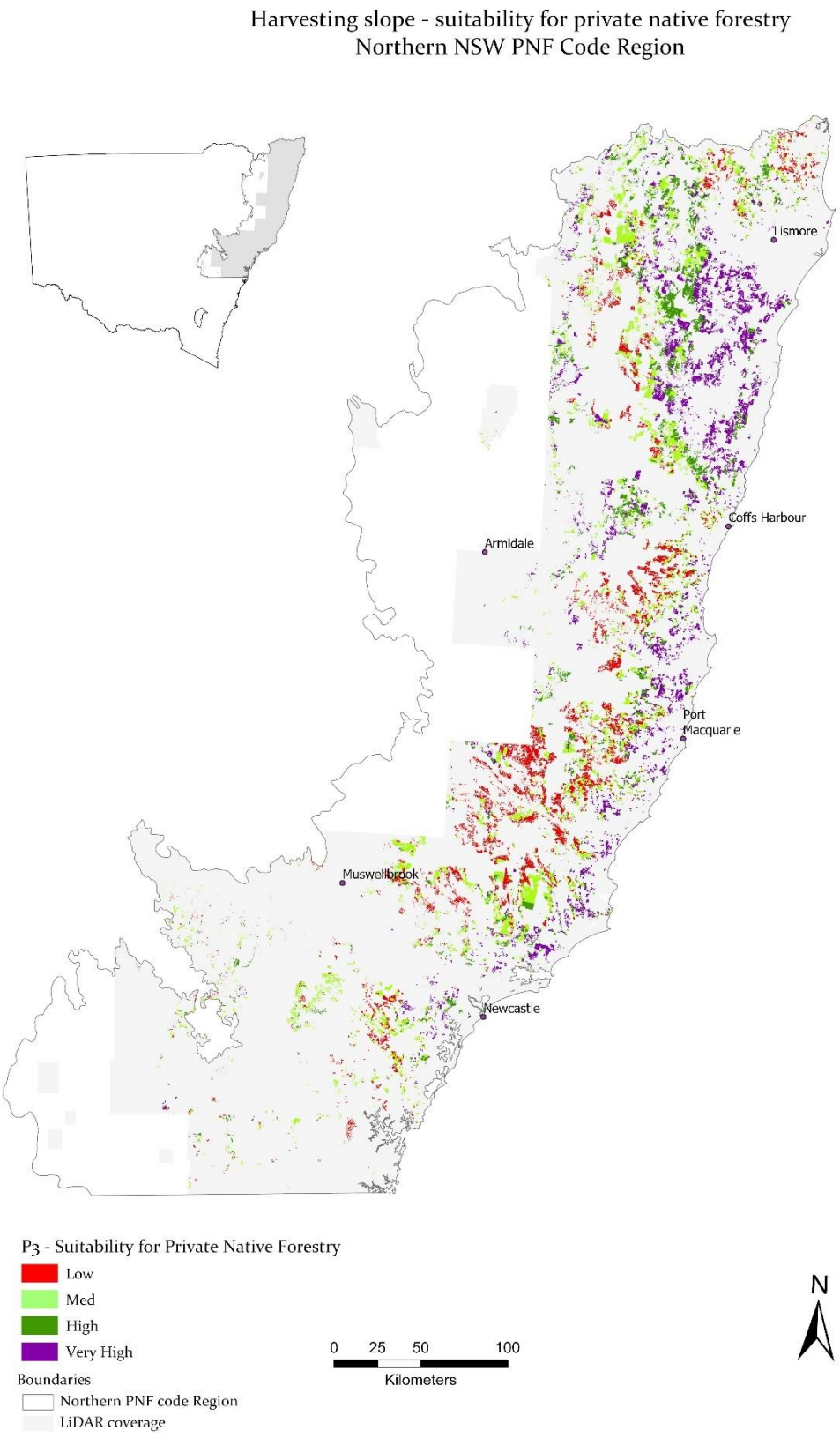


Figure 16 - Suitability for PNF based on the proportion of the NHA that has steep slopes

P4 - Terrain roughness

P4 - Explanation

Terrain roughness (variability in elevation) was used as an indicator of roading and harvesting cost. Terrain roughness affects the contiguity of the net harvest area and the density of roads and log dumps. In rough terrain the net harvest area tends to be more fragmented, roads and tracks are more expensive to construct as they involve more cut and fill, and a greater number of drainage feature crossings are required. In rough terrain there tends to be fewer roads. Fewer roads and dumps equate to longer snig distances which has a direct effect on harvesting cost.

Table 4 – P2 – Terrain roughness - suitability classes

Suitability Class	Very High (4)	High (3)	Med (2)	Low (1)
Variability in elevation within the NHA (σ)	(1st σ)	(2nd σ)	(3rd σ)	(>3rd σ)
Roading and harvesting cost ($/m3)	Low	Med	High	Very High

P4 – Modelling Process

Two of the three layers used to map slopes over 20 degrees were used to calculate Terrain roughness, namely:

- The private property cadastral layer
- The NSW digital elevation model (DEM) layer (Hislop, 2020) (Figure 17)

Rather than use the net harvest area the terrain model was based on the gross forest area. By doing so it gave a more holistic account of the terrain roughness across the forested parts of the property.

The standard deviation (σ) of a Digital Elevation Model (DEM) is a common measure of terrain roughness (Grohmann et al., 2011). For each of the 9,976 properties, the standard deviation (σ) of the DEM within the NHA was calculated using Arc GIS Pro Zonal statistics tool. Standard deviation values were grouped into 4 categories using 1st σ, 2nd σ and 3rd σ and >3rd σ. Finally, the 9,976 properties were classified to Very High (1σ), High (2σ), Med (3σ) or Low (> 3σ) based on the σ values of the layer (Figure 19).

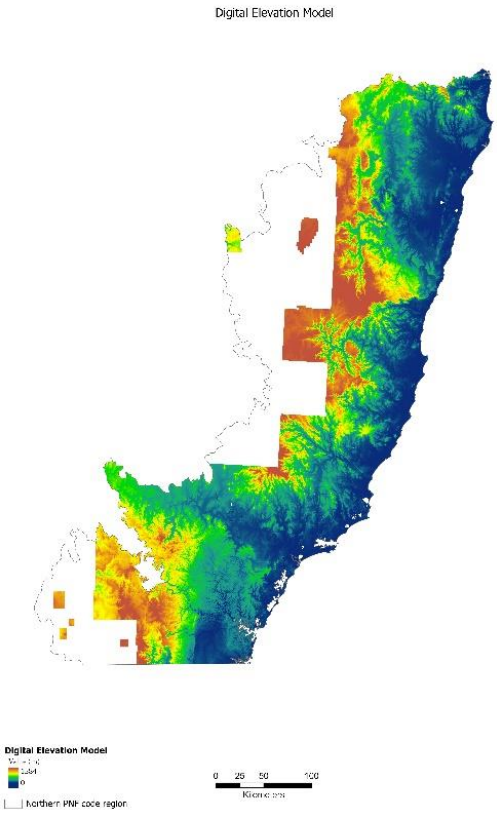


Figure 17 – Digital elevation model covering the study area (Hislop, 2020)

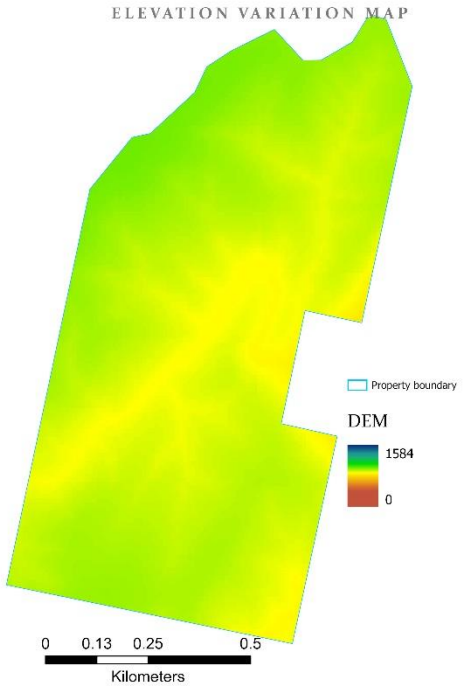
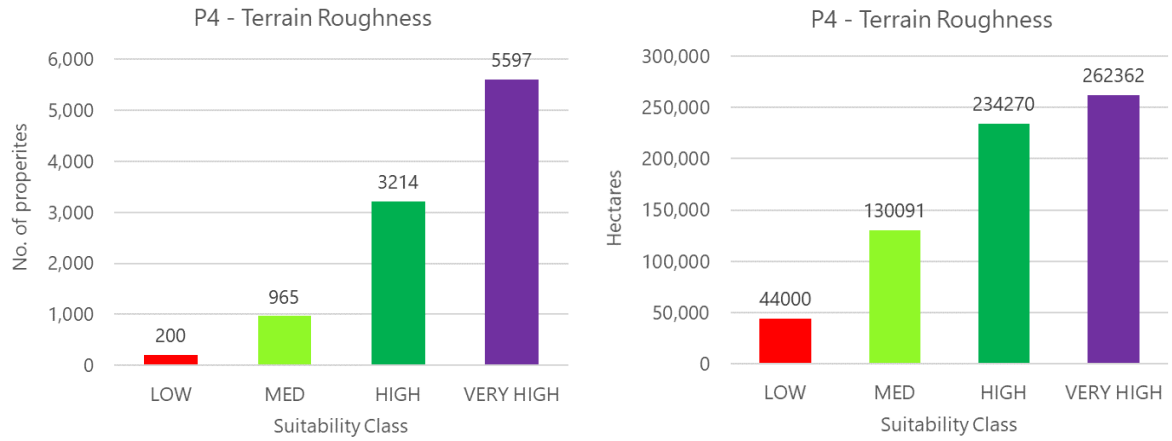


Figure 18 – Example of variation in elevation of an individual property

P4 – Modelled Result

Close to 90% of properties and 50% of the net harvestable area was classified as having high or very high suitability for forestry based on terrain roughness.



a) b)

Figure 19 – a) Property count by terrain suitability class b) NHA by terrain suitability class

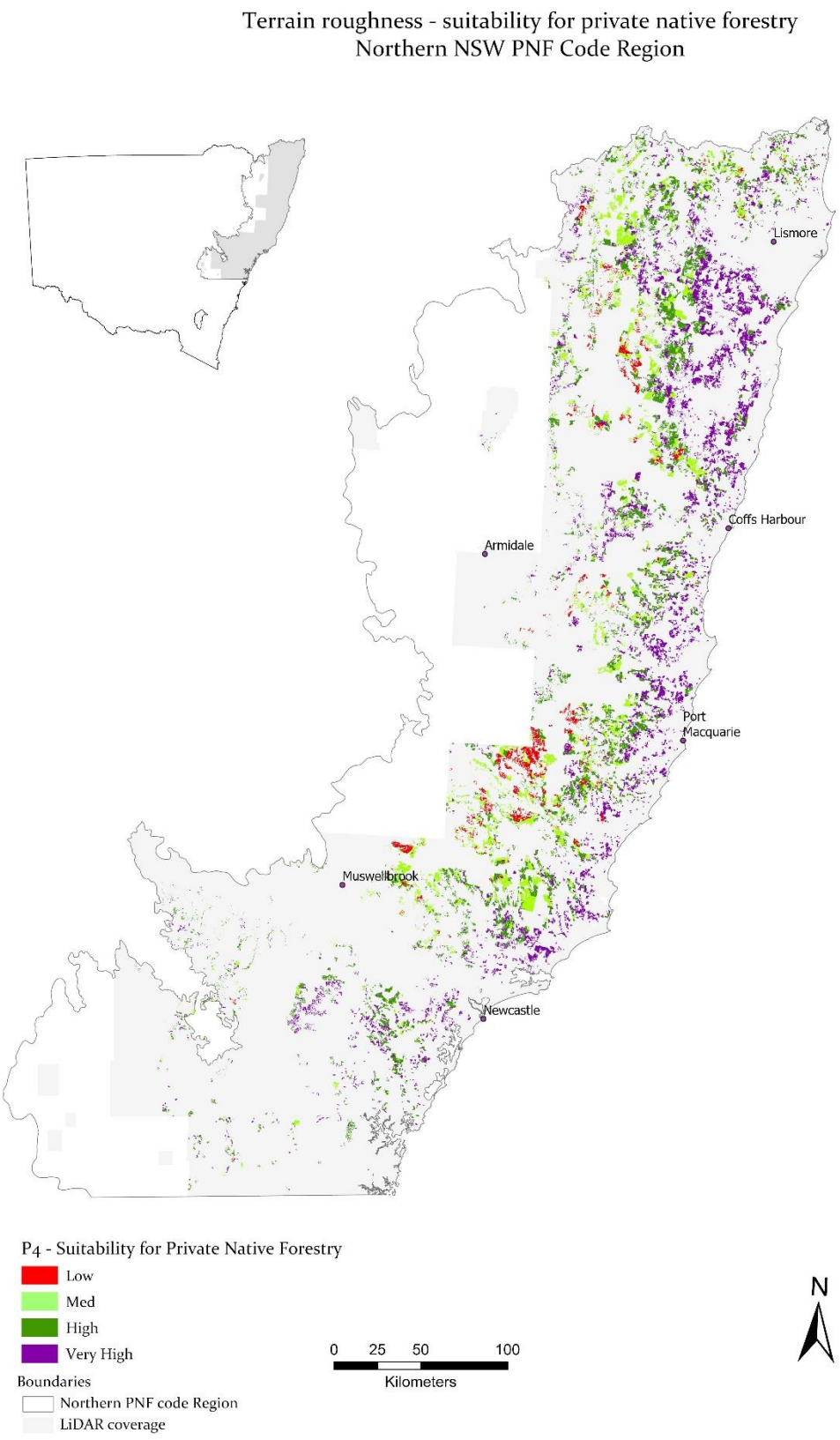


Figure 20 - Suitability for PNF based on the roughness of the terrain within the NHA

P5 – Yield Association Group (timber value)

P5 - Explanation

There are around fifty commercial tree species which grow naturally in the Northern NSW PNF Region. The market value of the timber generated by these species ranges from low (non-preferred) to very high (preferred).

To guide the assignment of tree species to a timber value class we were guided by the Forestry Corporation of NSW's Hardwood Log Value Pricing System (LVPS). The LVPS, which applies to high value hardwood logs produced on public land, differentiates log values based on their species, size, quality, and geographic location.

Most timber species grow naturally in association with other species. It is therefore not practicable to map the location of every species. The mapping of forest into more generic yield association groups (YAGs), however, provides a useful guide to the commercial species mix. In the case of common preferred species, namely, Blackbutt and Spotted Gum, the YAG map can identify the locations where these species are dominant in the mix.

Consideration was also given to log value based on size and log quality. For a given quality of log, the timber in large diameter logs (60 to 80cms) is more valuable than the timber in small diameter logs (30 and 40cms). Similarly, for a given log size, logs which are sound and free of large branch knots are valued more highly than logs which contain a higher proportion of internal defect.

The YAG map was used as an indicator of log size as follows. The YAG map classifies forests based on the height of the mature trees, namely, dry sclerophyll forest (up to 25 metres), semi-moist and taller dry forest (25 metres up to 35 metres) and tall most forest (35 metres and higher). Taller mature trees generally have thicker and longer boles (trunks) than shorter trees so tree height can consequently be used as a proxy for log size.

For log quality certain species are less defective than others. For example, preferred tree species like Blackbutt typically produce a higher proportion of high-quality log (low in defect) than non-preferred tableland tree species like Mountain Gum and Ribbon Gum. Taller trees are also more likely to produce a log of high-quality. This is because a tall tree is less likely to have had its growth or health impacted[4]. An exception to this rule is Viney Scrub. This YAG often contains tall remnant overmature trees which are typically in poor health and have poor log quality.

[4] When this occurs, trees incur stress which makes them more prone to insect and fungal attack which gives rise to log defect

P5 – Modelling Process

To predict timber stumpage value, we used the NSW DPI Forest Yield Association Group (YAG) Map of the NSW North Coast, Kathuria et al (2021a). This map classifies the forest into seven broad groups and fifteen classes as detailed in Table 5. Each YAG type (excluding rainforest) was assigned to a timber stumpage value class, namely - Very High (4), High (3), Med (2) and Low (1) (Table 5).

Table 5 – Rating system applied to the forest YAGs used in the model

Yield Association Group	Code	Ave log Size	Ave log quality	Species mix value	Weighted Ave Timber Value
Rainforest	RF	N/a	N/a	N/a	**Low**[5]
Viney Scrub	VS	High	Very Low	Med	**Low**
Coastal Eucalypts – tall moist	CEm	Very high	High	Very High	**Very High**
Coastal Eucalypts – semi-moist and taller dry	CEsm	Med	Med	Med	**Med**
Coastal Eucalypts – dry	CEd	Low	Low	Med	**Low**
Blackbutt – tall moist	BBTm	Very high	Very High	Very High	**Very High**
Blackbutt – semi-moist and taller dry	BBTsm	Med	Very High	Very High	**High**
Blackbutt – dry	BBTd	Low	High	Med	**Med**
Spotted Gum – tall moist	SGm	Very high	Very High	Very High	**Very High**
Spotted Gum – semi-moist and taller dry	SGsm	Med	High	High	**High**
Spotted Gum – dry	SGd	Low	Med	Med	**Med**
Tableland Eucalypts – tall moist	TEm	Very high	High	High	**High**
Tableland Eucalypts – semi-moist and taller dry	TEsm	Med	Med	Med	**Med**
Tableland Eucalypts – dry	TEd	Low	Low	Low	**Low**
Swamp Sclerophyll	SS	Med	Low	Low	**Low**

[5] Most rainforest was not assessed because it was mapped as a regulatory exclusion. Where small areas of rainforest occurred with the net harvest area they were given a 'low' rating to permit the model to run.

The YAG map used for this analysis (Kathuria et al, 2021a) did not include properties located in map zone 55. For these properties (n=83 the forest types were manually assessed using aerial photographic interpretation.

The way the assessment criteria were used to assign a YAG to a class was as follows:'

- Log size[6] - Moist YAGs (excluding swamp sclerophyll) were assigned the highest value followed by Semi-moist YAGs and then Dry YAGs.
- Log quality - Logs produced in Coastal YAGs were rated more highly than logs produced in Tableland YAGs. This is because Tableland species are less durable and on average have a much higher % of internal defect.
- Species - On the north coast there are over 50 commercial eucalypt species. Eucalypts which are preferred and available in quantity to the market (due to their more desirable wood properties - colour, feature, strength and durability) were valued more highly than those that didn't have these properties. Of all the YAGs, Coastal Blackbutt (*Eucalyptus pilularis*) and Spotted Gum (*Eucalyptus maculata*) were assigned to the highest stumpage value category due to their preferred wood properties and ready availability. In contrast, species from the Tableland YAG are least preferred by the market and, consistent with the Forestry Corporation of NSW's LVPS, were assigned the lowest stumpage value.
- Of the three assessment criteria, log quality and species mix were given an equal weighting and log size was given a lower weighting.

Using the weighted average stumpage value classes detailed in Table 5, the % coverage of each YAG within the NHA of the 9,976 properties was calculated. The % coverage was calculated using the "Tabulate Intersection" tool in ArcGIS Pro. Finally, the weighted average was calculated using the % coverage of the four groups within the NHA as weight.

Finally, the 9,976 properties were classified as Very High (i.e., ≥ 3.5), High (i.e., ≥2.5 and <3.5), Med (i.e., ≥1.5 and < 2.5) or Low (i.e., <1.5) based on their weighted average values (Figure 20).

[6] Large logs (60cm and 80 cm cdub) attract higher stumpage prices than smaller logs (30-40 cm cdub).

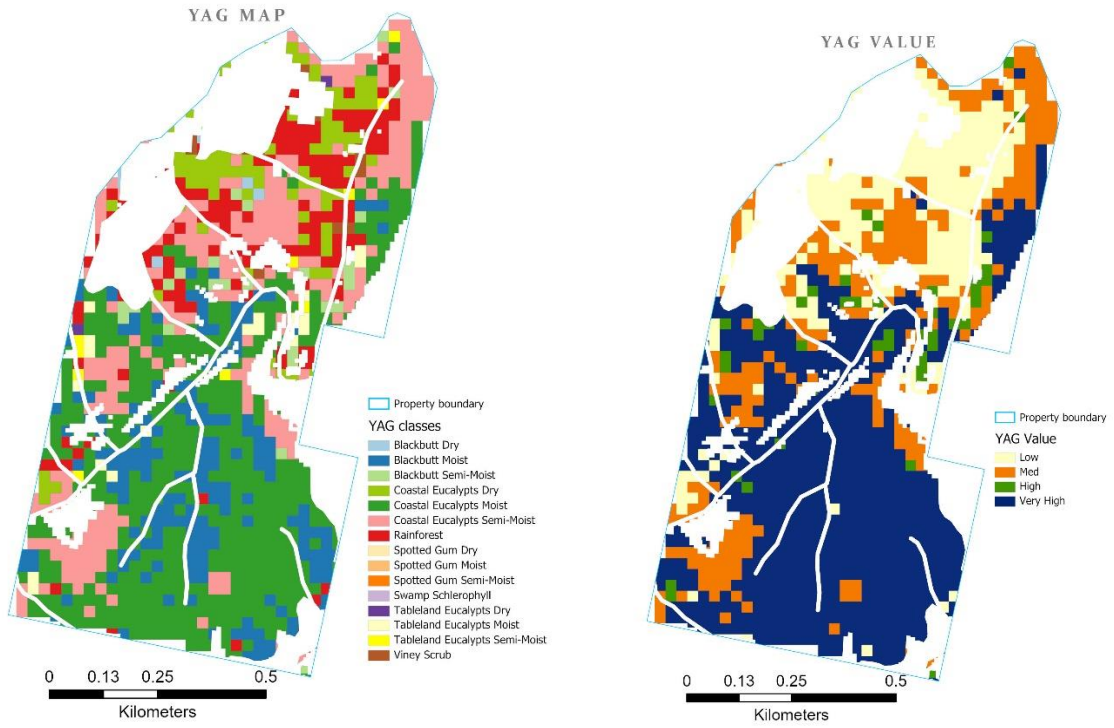
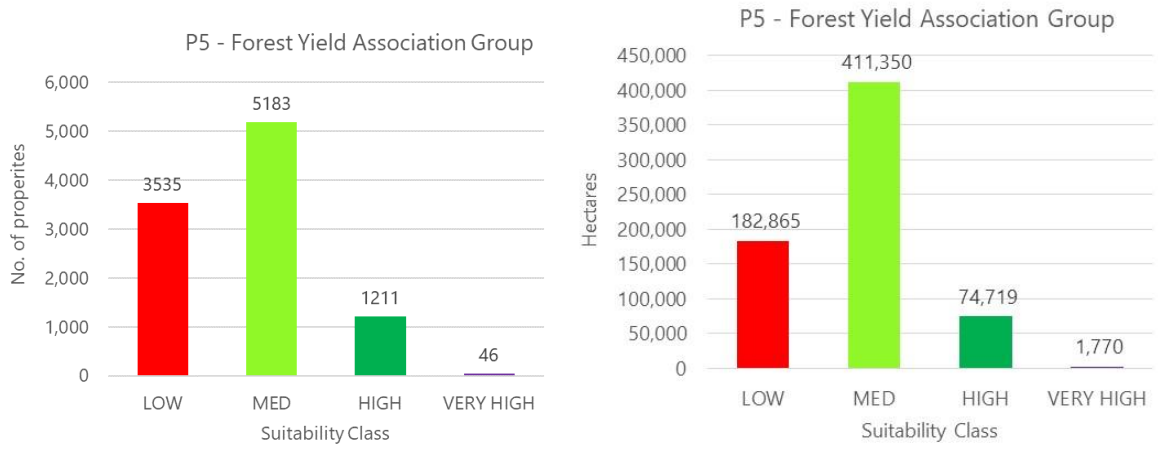


Figure 21 – Classification of an individual property into YAG suitability classes

P5 – Modelled Result

Only 11% of properties and 13% of the net harvestable area received a high or very high suitability rating for its forest yield association group mix. Most properties and most of the net harvestable area fell into the medium suitability class (Figure 22).



a) b)

Figure 22 - a) Property count by YAG suitability class b) NHA by YAG suitability class

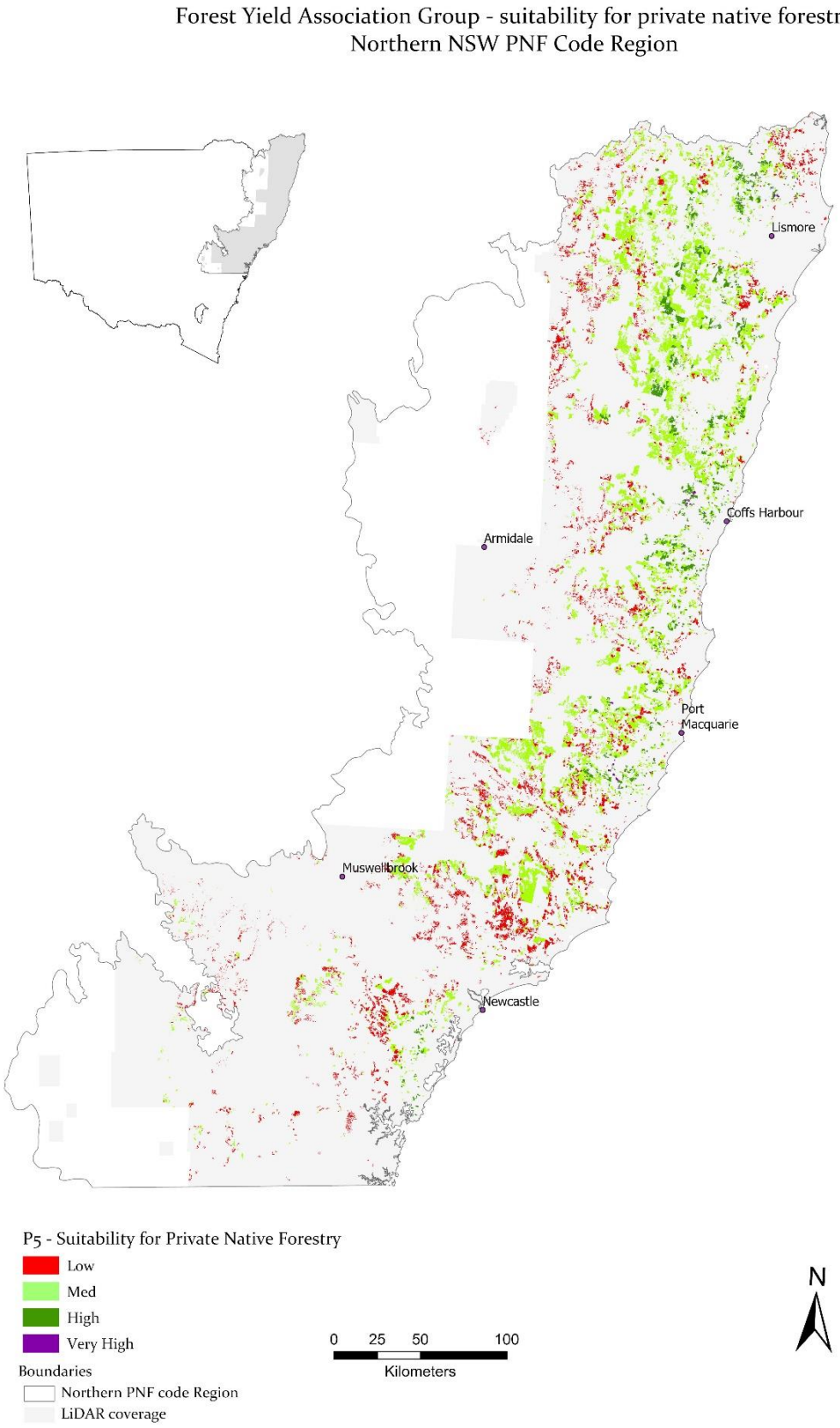


Figure 23 - Suitability for PNF based on the Yield Association Group mix

P6 – Mature Canopy Height

P6 - Explanation

The height to which a forest grows naturally (its mature canopy height) is a good indicator of its overall site productivity (Geyer et al. 1987) and its capacity to yield commercial timber.

P6 – Modelling Process

We used NSW DPI's Site Index layer (Kathuria et al, 2021b) (Figure 24) to obtain canopy height data of private native forest that were greater than or equal to 25 hectares. Height values in metres were grouped into 4 categories:

- 1. Low ≤25m,
- 2. Medium >25 and ≤ 30m,
- 3. High >30 and ≤35m
- 4. Very High >35.

For each of the 9,976 properties, the percentage coverage of each height category was calculated (i.e., "Tabulate Intersection" tool in ArcGIS Pro) within the NHA of the properties. Then, for each of the properties, weighted average height was calculated using the % coverage of each height category as weight. Finally, the 9,976 properties were classified as Very High (i.e., ≥ 3.5), High (i.e., ≥2.5 and <3.5), Med (i.e., ≥1.5 and < 2.5) or Low (i.e., <1.5) based on their weighted average values.

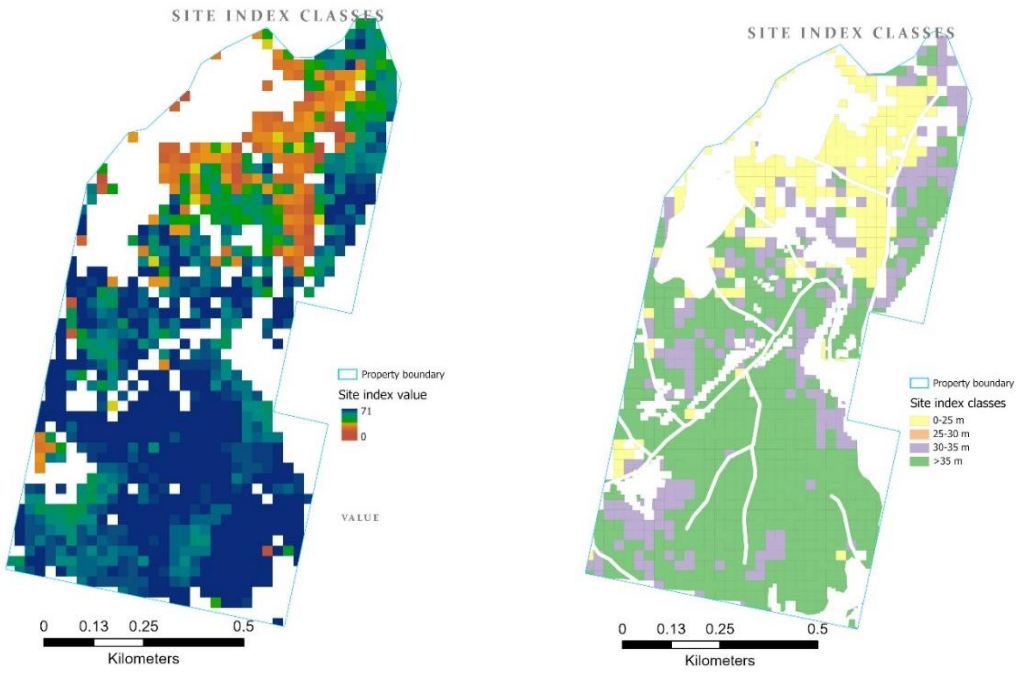
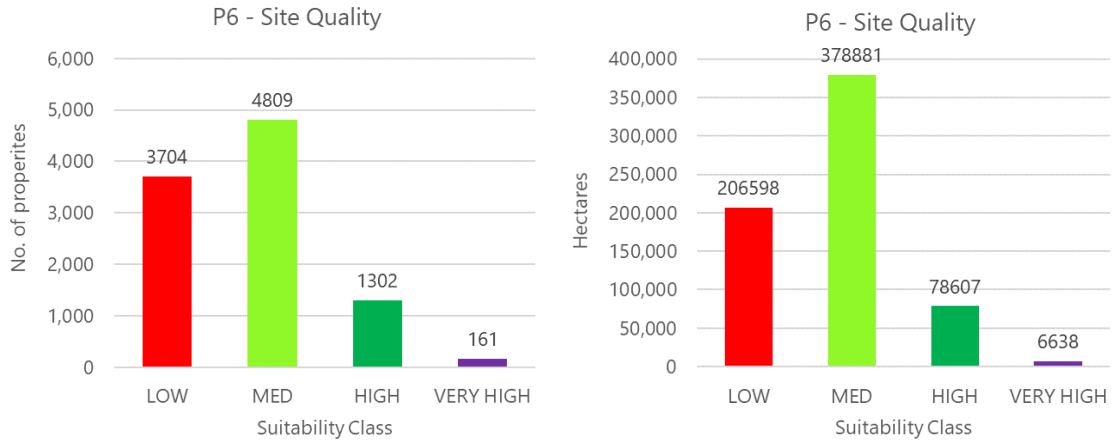


Figure 24 – Site quality index (Kathuria et al, 2021b) and site index classes for a selected forest area

P6 – Modelled Result

Like the modelled result for YAGs, only 15% of properties and 13% of the net harvestable area was assessed as having a high or very high suitability based on canopy height. Just under half of all properties and 56% of the net harvestable had medium suitability (Figure 25).



a) b)

Figure 25 - Suitability for PNF based on Site Quality

The properties that were classified as having high or very high suitability were mostly located between 25 and 50km from the coast with concentrations around Middle Brother, Bellingen, Dorrigo and Nimbin.

In contrast properties classed as having low suitably for canopy height were principally located around Grafton and Casino and in the lower Hunter Valley (Figure 23).

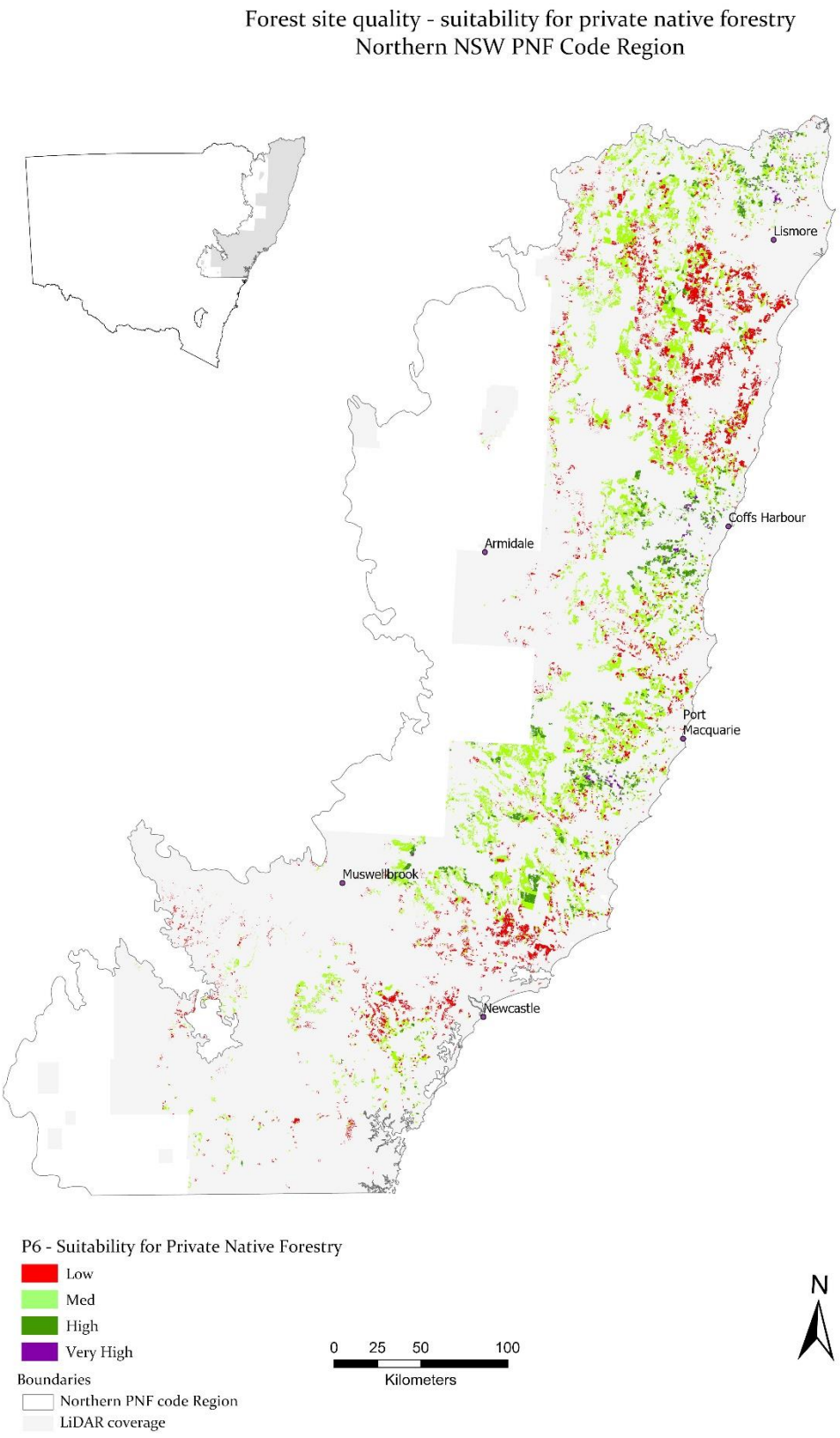


Figure 26 - Suitability for PNF based on site index model (canopy height)

Weighting of modelling parameters

The use of six discrete modelling parameters provided a comprehensive picture of the physical and biophysical attributes of 9,976 individual properties on the NSW North Coast.

To determine the overall suitability of each property for private native forestry it was necessary to assign a weighting to each modelling parameter.

In assigning a weighting consideration was given to the relative effect of each parameter on commerciality. Consideration, based on expert knowledge, was given to the effect on operational expenditure, timber yield, timber price and timber revenue.

Four of the six parameters, namely P1, P2, P5, and P6 were assigned a weighting of 20%. P3 had some commonality and overlap in its effect on commerciality with P4 so both parameters were assigned a lesser weighting of 10%. When combined, the weightings total 100% (Table 6).

Table 6 – Modelling parameter weightings showing the factors used to calculate them

ID	Modelling Parameter	Parameter Weighting
P1	Net harvestable area (NHA)	20%
P2	Distance by road to wood processing facility	20%
P3	Slope premium	10%
P4	Terrain roughness premium	10%
P5	Yield Association Group	20%
P6	Site Index model (Canopy height)	20%
	Total	**100%**

Combined Results

The results of the suitability of properties for PNF when all modelling parameters were combined and weighted are presented in Figure 27, Figure 28, and Figure 29.

Most properties (59%) and most of the net harvestable area within them (61%) was found to have a 'medium' suitability for private native forestry.

17% of properties and 28% of the net harvestable area was found to have a 'high' suitability for private native forestry. This confirms that bigger properties are on average more suitable for forestry than smaller properties.

Very few properties (0.1%) and very little net harvestable area was found to have a 'very high' suitability for private native forestry.

Properties that had 'low' overall suitability accounted for 22% of properties by number but only 11% by area.

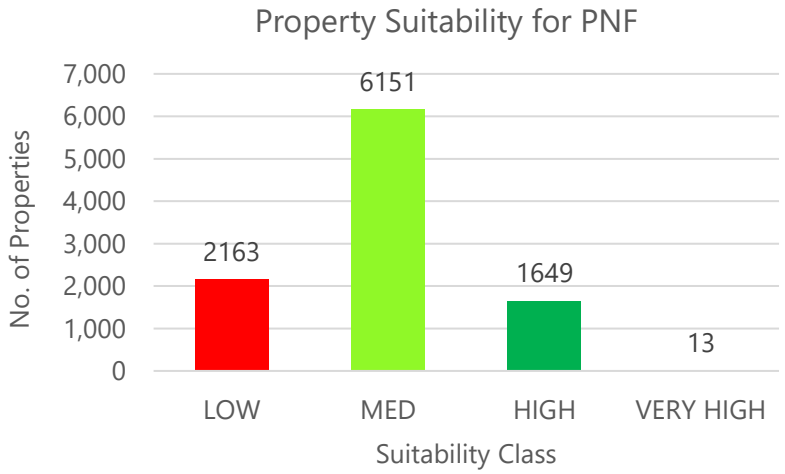


Figure 27 - Property count by suitability class using all modelling parameters

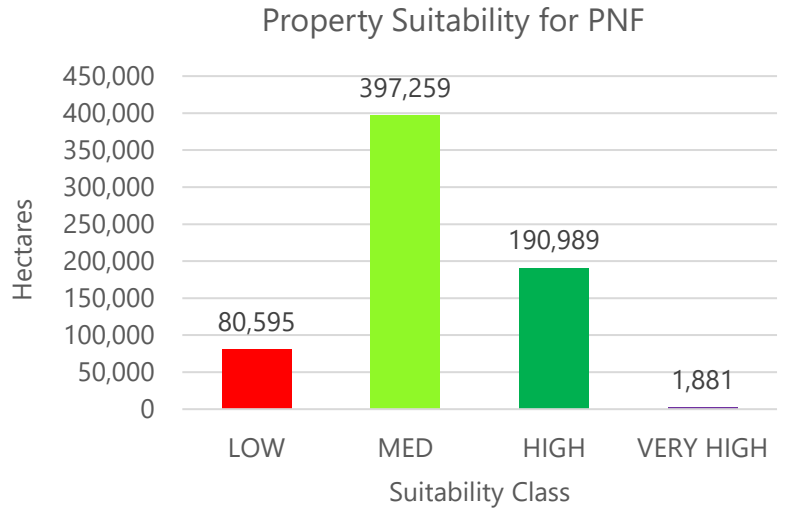


Figure 28 – Net harvestable area by suitability class using all modelling parameters

The properties that had 'high' or 'very high' suitability were located mainly between 10km and 50km from the coast between Bulahdelah and Coffs Harbour and between 10km and 100km from the coast between Coffs Harbour and the Queensland Border.

Properties with a 'medium' suitability were evenly distributed across the entire study area.

Properties classified as having 'Low' suitability for private native forestry were mainly located more than 50 kilometres from the coast between Sydney and Coffs Harbour and more than 100 kilometres from the coast between Coffs Harbour and the Queensland border.

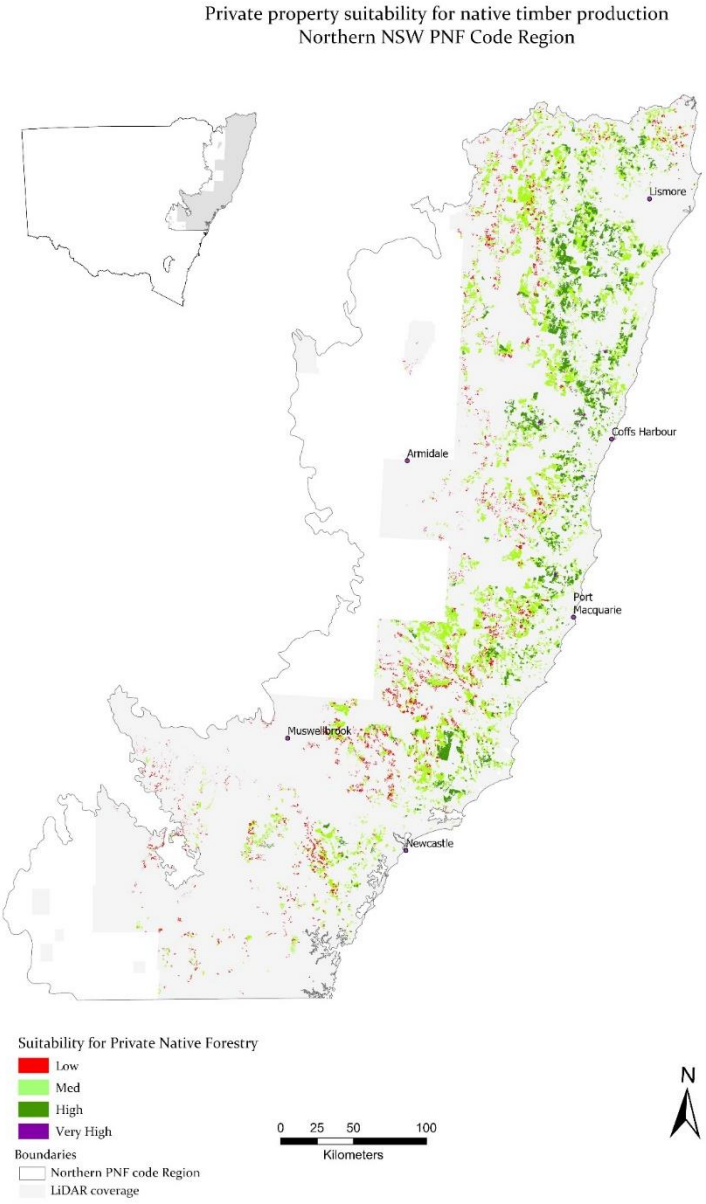
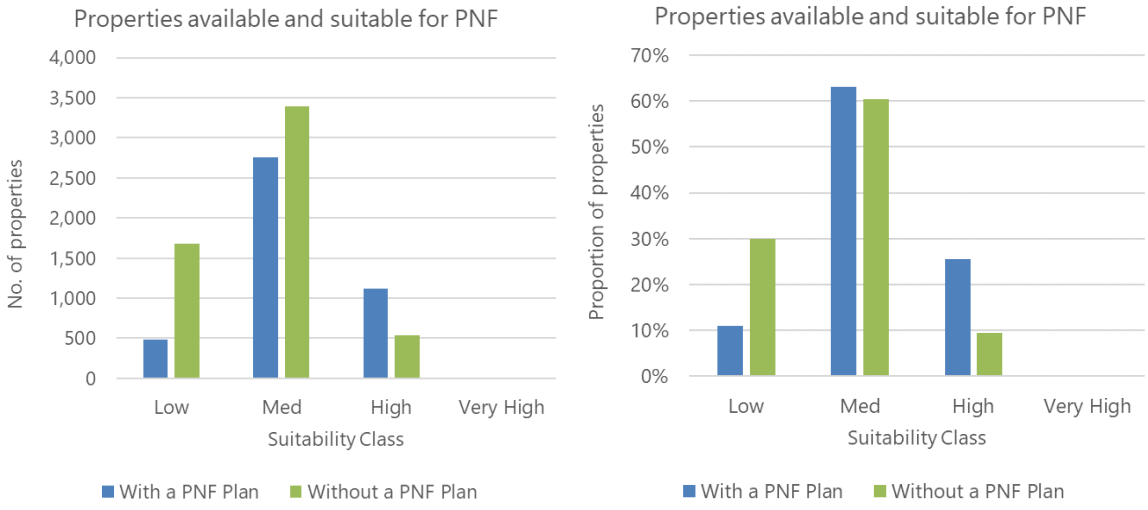


Figure 29 – Suitability of private property for private native forestry in Northern NSW using all modelling parameters

Properties with and without a PNF Plan

A comparison was made of the modelled results with the properties that have an existing PNF Plan approval. The findings are presented in Figure 30. They show that of the 9,976 properties that were modelled 4,365 (44%) already have an approved PNF Plan.

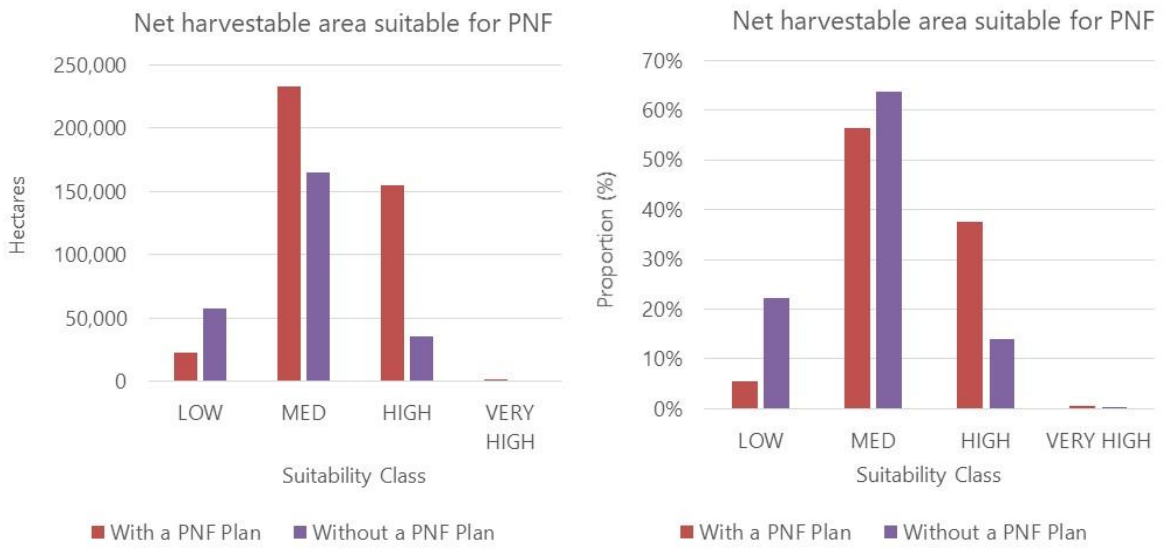
Of the 5,609 properties that didn't have an approved PNF Plan, 532 (9.5%) were classified as 'high' suitability, 3,391 (60.5%) as 'medium' suitability, and 1,684 (30%) as 'low' suitability. Interestingly, there were twice as many properties with a PNF Plan that were classified as 'high' suitability as there were properties without a PNF Plan. When it came to properties classified as having 'low' suitability there were four times as many properties without a PNF Plan than with a PNF Plan.



a) b)

Figure 30 – Comparison of the suitability of properties for PNF, with and without an approved PNF Plan. a) property count b) property percentage

Looking at the percentage of the net harvestable area with and without a PNF Plan (Figure 31) the results were quite different. 412,669 hectares of forest (68%) had an approved PNF Plan while only 258,055 hectares of forest (38%) didn't. Of the forest classified as 'high' suitability there was more than four times more net harvestable area with a PNF Plan (155,061 hectares) than there was without a PNF Plan (35,928 hectares). As a proportion, 38% of forest with a PNF Plan was modelled as having 'high' suitability compared to only 14% of forest without a PNF Plan. The trend was reversed for 'low' suitability. Of the forest with a PNF Plan only 6% was classified as 'low' suitability while 22% of forest without a PNF Plan had a 'low' suitability classification.



a) b)

Figure 31 – Comparison of the suitability of properties for PNF, with and without an approved PNF Plan. a) NHA b) NHA percentage

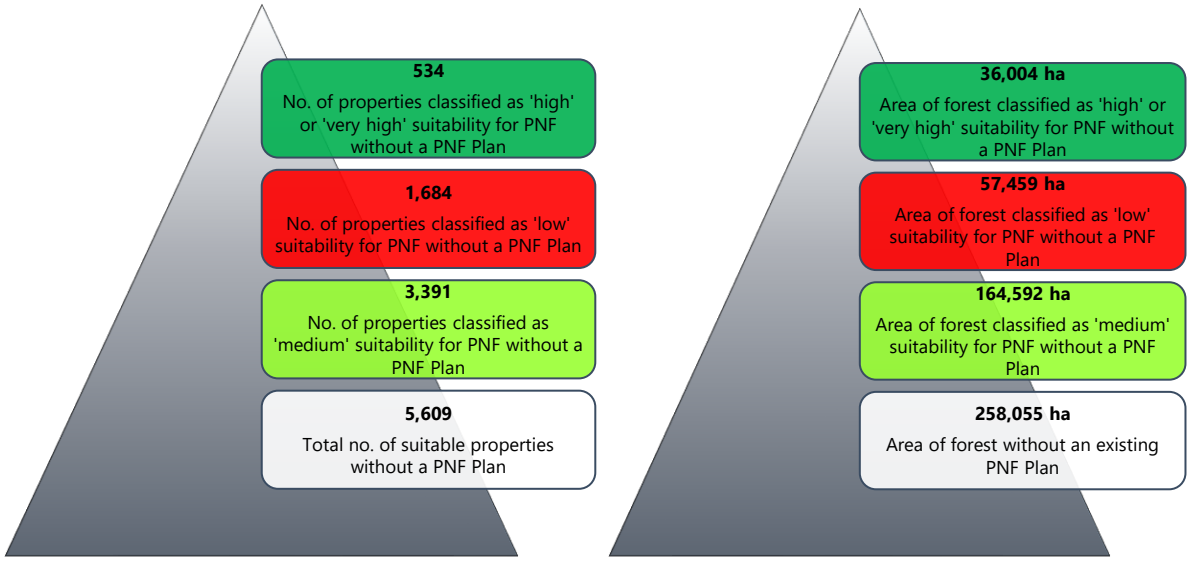
Discussion

The findings of this study shed new light on the availability and suitability of private native forests for timber production and the factors which influence this.

Modelling the suitability of north coast properties for private native forestry (PNF) was previously undertaken by DPI in 2018. This study built on the 2018 one using the same general approach but benefited from the use of better-quality data and more sophisticated modelling techniques. The scale and coverage of this study was also far more extensive, assessing 2.5 million hectares of private native forest from which 670,724 ha was modelled as being available and suitable (net harvestable area).

Modelled property suitability for PNF showed strong alignment with properties that had an existing PNF Plan with 68% of the net harvestable area covered by a PNF Plan increasing to ~80% of the net harvestable area for areas classified as 'high' or 'very high' suitability.

Analysis of the forest not covered by a PNF Plan reveals that much of it is uncommercial or has low suitability for PNF due to steep/rough terrain, low forest height, undesirable species mix or being remote from processing facilities. Approximately 200,000 hectares of net harvestable area that did not have an approved PNF Plan was classified as 'medium', 'high' or 'very high' suitability. This area was spread over 3,925 properties. Further detail is provided in Figure 32. Reasons why these properties are not engaged in PNF was not investigated but represents an opportunity for development of PNF in the future.



a) b)

Figure 32 – a) Property count by suitability class without an approved PNF Plan within the study area b) Net harvestable area by suitability class without an approved PNF Plan within the study area.

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