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A rating model applied to private native forest on the NSW north coast

Valuing the suitability of native forests for timber production

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Contents

Introduction

The inherent timber values of native forests are often recognised but seldom are they classified and formally reported. Biophysical and market factors can be used to measure and quantify timber values. By systematically analysing the timber values of native forest it is possible to build a picture of their relative suitability and importance for timber production at a property, local and regional level.

This report details the methodology that was used to develop a spatial model for assessing and rating the timber value of native forests. The model was applied to individual private properties on the NSW north coast where relevant input data existed. In total 395,782 net hectares of private native forest was modelled and mapped on 4,573 properties.

Application of the model to native forests in other regions and on other tenures may readily occur where relevant data is available.

Method

A rating model was developed to assess the suitability of native forest for timber production and applied to private native forest on the NSW north coast. This section details the extent of the model and how it was developed and applied.

Modelling Extent

In total 395,782 ha of native forest distributed over 4,573 individual properties was modelled. The modelled forest area represented 16% of the area of private native forest that is nominally available for timber harvesting on the NSW north coast (Figure 1). The extent of the modelled private native forest was limited by the availability of tree canopy height data[1] and only included contiguous stands of native forest greater than 25 hectares.

[1] Sourced from a DPI Growth Status and productivity map of north coast private native forests

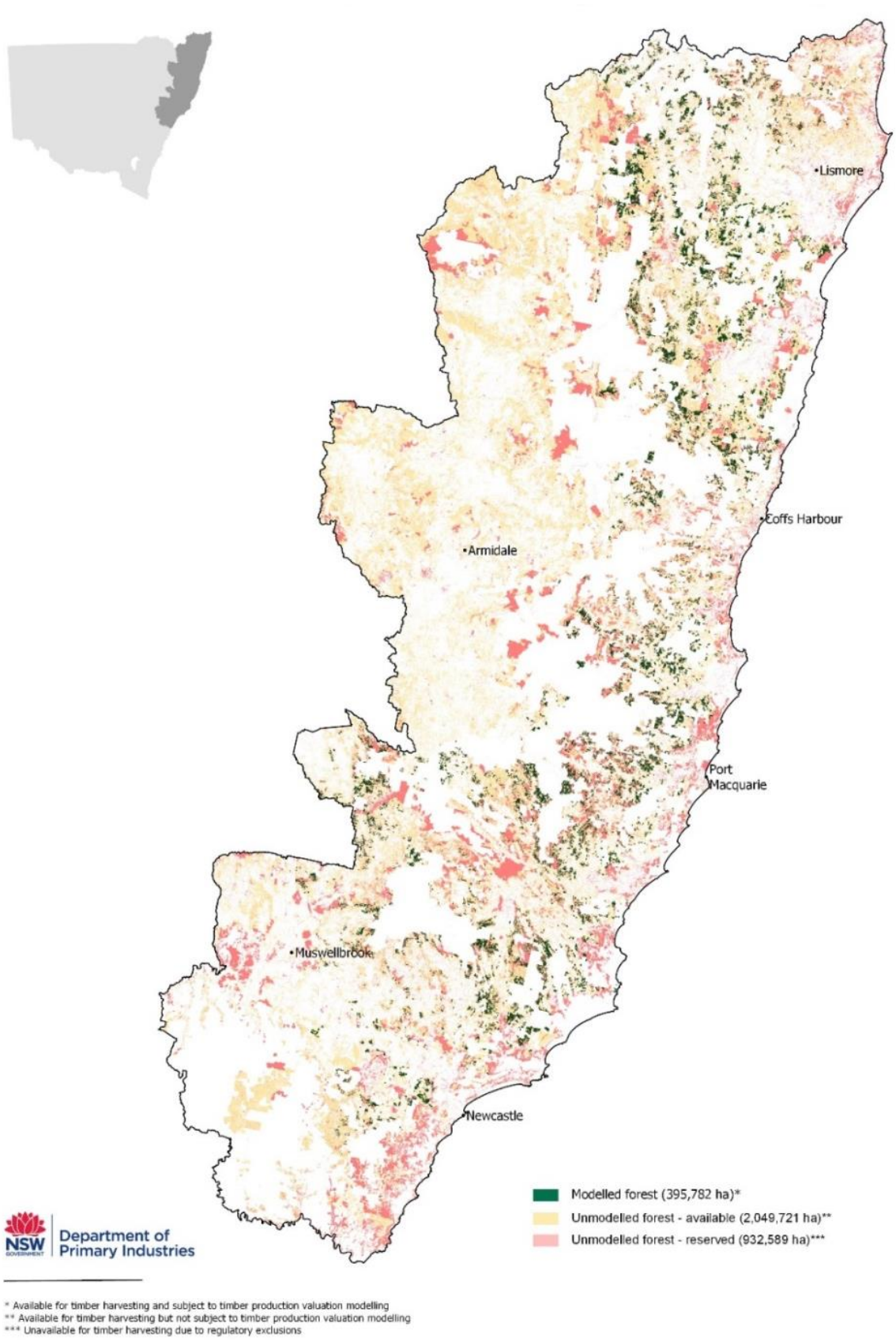

Figure 1 – Map showing extent and distribution of 'modelled' and 'unmodelled' private native forest on the NSW North Coast.

Analysis Software, Geoprocessing Tools and Spatial Layers

The model was developed and run using Arc Map 10.3 and ARC GIS Pro and used specialised geoprocessing tools including the Network Dataset function and Network Analysis extension in ArcCatalog. Seven spatial layers were used in the model, a description of each is provided below:

i. NSW Woody Vegetation Extent 2011 developed by the NSW Office of Environment & Heritage (OEH). This product broadly identifies isolated tree crowns as well as contiguous forest at a five metre resolution. The overall state accuracy of this layer is 90% when compared to LiDAR datasets and 88% and when compared to visually derived validation points (OEH 2018).

ii. Cadastral boundaries of private properties on the NSW north coast. 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.

iii. Growth status and productivity mapping of north coast private native forests. NSW DPI commissioned ForeSense Pty Ltd to develop this layer using digital airborne photo (DAP) imagery, acquired with ADS 40/80 sensors. Imagery between 2007 and 2014 vintage was sourced as mosaic tiles (n. =59) from Spatial Data Services within the NSW Department of Finance, Services & Innovation. NSW DPI supplied ForeSense Pty Ltd with a base map layer of approximately 1,000,000 hectares of private native forest. ForeSense Pty Ltd then used 3D digital aerial photography interpretation (API) software to map the growth status and productivity of areas of homogenous[2] private native forest areas 25 hectares or greater in size within the base map area. The mapping process captured mature canopy height (m) data with height values grouped into 10 categories: 15, 20, 25, 30, 35, 40, 45, 50, 55 and 65+. 'Un-productive' forest types[3] less than 15 metres in height were excluded. The final product was converted to a kmz file that may be viewed in Google Earth. The mapped canopy height data used in the model was a clipped layer 395,782 hectares in extent.

iv. A map of the Yield Association Groups of the NSW north coast developed by NSW DPI. This layer was used as an indicator of commercial species log mix. Detail on the methodology that was used to generate this map and its accuracy is provided in a separate report available on the NSW DPI private native forest webpage.

[2] Native forest with common biophysical attributes
[3] Dry forest with poor form, deemed by a qualified forester as incapable of supporting a commercial harvesting operation.

v. Availability of private native forest in the North East RFA Region for timber harvesting. This layer defined the area where private native forestry can legally operate. The 2,440,000 hectare layer was developed by NSW DPI based on environmental and cultural heritage data generated by the NSW Office of Environment & Heritage for the *Biodiversity Conservation Act 2016* and the *Local land Services Act 2013*. Information on the types and size of regulatory exclusions that apply to PNF are contained in a separate DPI report titled NSW planning and regulatory instruments that interact with private native forestry.

vi. NSW digital elevation model "DEM_GDA94_Lambert_mosMaxReject.tif" was sourced from Forestry Corporation of NSW. The raster layer had a pixel size of 25m*25m; projected coordinate system: GDA 1994 NSW Lambert.

vii. Forestry - NSW Wood Processing Facilities. This NSW DPI dataset contained the location coordinates of hardwood processing facilities in NSW, Australia and is available at: https://spatial.industry.nsw.gov.au/arcgis/rest/services/Bioenergy_Assessment/Forestry_NSW_Wood_Processing_Facilities/MapServer.

Modelling Parameters

Six attributes known to influence a native forest's timber production value were selected as modelling parameters:

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

The spatial layers that were used to inform each modelling parameter are reproduced in Annexure A.

Each modelling parameter was classified into four 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 with the general objective being to distribute the values evenly across the four categories based on their frequency. Once defined, the four categories acted as broad indicators of 'suitability for timber production'.

A summary description of the six parameters and the modelling category values is shown at Table 1. A more detailed description of how each parameter was modelled is provided in the sections below.

Table 1 – Modelled parameters, parameter descriptions and rating categories used to assess the relative suitability of native forest for timber production.

ID	Modelled Parameters	Parameter description	Relative suitability for timber production - Rating Category			
			Very High (4)	High (3)	Med (2)	Low (1)
P1	Net harvestable area (NHA)	Area of modelled NHA on an individual property (ha)	>= 200 ha	>= 100 to < 200 ha	>= 50 to < 100ha	>= 25 to < 50ha
P2	Distance by road to wood processing facility	Average distance by road to closest three wood processing facilities (km)	>= 0 to < 50km	>= 50 to < 100km	>= 100 to < 150km	>= 150km
P3	Slope premium	% of native forest within the NHA above 20 degrees (%)	< 25%	>= 25 to < 50%	>= 50 to < 75%	>= 75 to 100%
P4	Terrain roughness premium	Variability in elevation within the NHA (σ)	Low (> 104)	Med (3rd σ) (64 to 104)	High (2nd σ) (27 to 64)	Very High (1st σ) (0 to 27)
P5	Yield Association Group[1] (stumpage value)	Percentage coverage of each YAG within the NHA (%)	Very High BBT, SG	High MCE, SMTD	Med DSF	Low TE-M, TE-D, VS, SS
P6	Mature canopy height	Percentage coverage of each height category within the NHA (%)	>40 m	>30 and <= 40 m	>20 and <= 30 m	>15 and <= 20 m

1 Refer table 2 for a description of the YAG types used in P5

P1 - Net harvestable area

Net harvestable area (NHA) was used as an indicator of the commercial viability of harvesting timber on an individual property. For this study net harvestable area (NHA) was defined as the sum of all the contiguous areas of native forest on an individual property that were

greater than 25 hectares in size and legally available for harvesting. Data layer constraints meant that available forest areas < 25 hectares were unable to be included.

The following layers were used to derive the NHA:

- NSW Woody Vegetation Extent 2011
- Area nominally available for timber harvesting on NSW north coast private native forest (2.44 million hectares)
- The cadastral boundaries of individual private properties on the NSW north coast
- Growth status and productivity mapping of north coast private native forests (395,782 ha)
- Yield Association Groups of the NSW north coast

Analysis of 'fixed' and 'partially fixed' setup costs showed that, when they are dispersed over a small number of hectares, they can make a harvesting operation commercial unviable. In contrast when 'fixed' and 'partially fixed' setup costs are distributed over a 200 hectare area, or greater, the unit cost becomes immaterial.

For the purpose of modelling all the areas of assessed forest within a property were summed. The totals were then grouped into one of the following four NHA size classes:

- >= 200 hestares
- >= 100 to < 200 hectares
- >= 50 to < 100 hectares
- >= 25 to < 50 hectares

Standard 'Fixed' and 'partially fixed' setup costs were estimated for harvest planning, floating of harvesting machinery and road maintenance and upgrades. The ranked NHA categories were then used to determine the degree to which the 'fixed' and 'partially fixed' setup costs could be dispersed.

P2 - Distance by road to wood processing facility

To realise the timber values of a native forest the forest has to be harvested and the log products delivered by road to a wood processing facility. Determining the distance by road from individual properties to wood processing facilities enabled the average cost of log haulage to be estimated.

On the NSW north coast there are over 60 wood processing facilities that process hardwood logs (Figure 2). Each facility has discrete markets which gives rise to specific log mix preferences. To obtain the best market price (i.e. the highest value end use) log producers typically sell their logs to a range of local wood processors which have a preference for their timber. For the purpose of modelling we assumed the property owner would sell their hardwood logs to their nearest three wood processors facilities.

The following layers were required to calculate this parameter:

- The cadastral boundaries of individual private properties on the NSW north coast
- Centroid of each of the 4,573 properties identified in the cadastral boundary layer
- ARC GIS Shapefile of 'Forestry – NSW Wood Processing Facilities'
- Shapefile of all public roads.

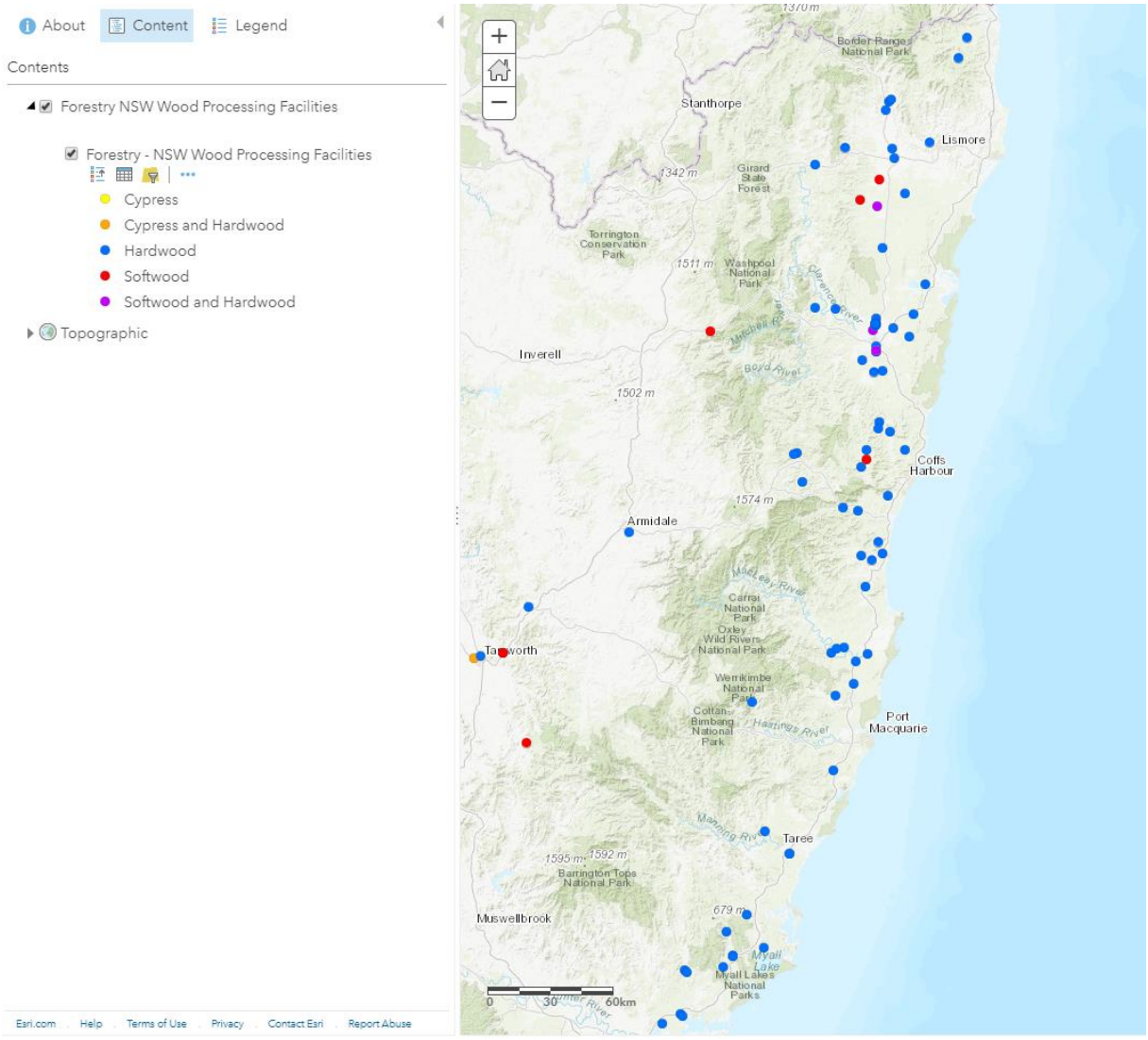

Figure 2 – Location of hardwood processing facilities (in blue) that were used in the model. Image taken from ArcGIS Online map viewer of NSW Wood Processing Facilities

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 3).
ii. Then, using the "Network Analyst" extension, the "New Closest Facility" tool was used to calculate the distance by road from each property to the three closest wood processors facilities.

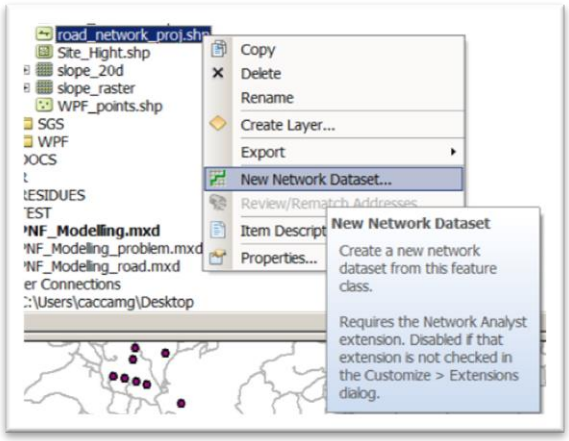

Figure 3 - Using ArcCatalog to create a new Network dataset

iii. In the "New Closest Facility" tool, wood processors facilities were assigned to "Facilities", whilst the centroids of the 4,573 properties were assigned to the "Incidents". For both "Facilities" and "Incidents", "Search Tolerance" and "Location Snap Options" were set to a suitable distance (~50 kilometres).

iv. In "Closest Facility Properties" (Figure 4), "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 (50 Km) and "Snap to" was set to "Closest".

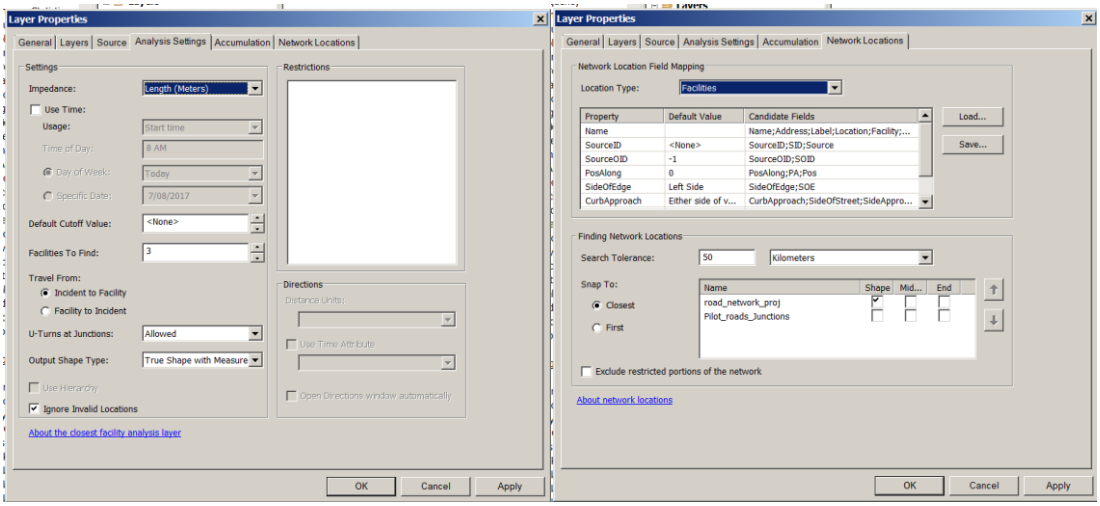

Figure 4 - Parameters setting in "Closest Facility Properties"

v. The distance by road from each property to the three closest wood processors facilities was calculated by clicking on "Solve" in the "Network Analyst" toolbar. The output (in table format) was accessed by right-clicking on "Routes" in the "Network Analyst Window". Using the "pivot-table" function in Excel, the average distance by road from each property to the three closest wood processors facilities was calculated (Figure 5).

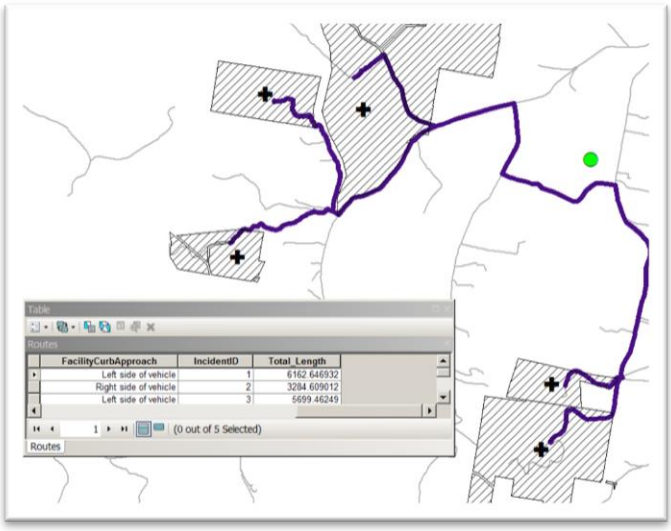

Figure 5 - Closest path by road (purple lines) from each property (black crosses) to wood processors facilities (green circle).

vi. Finally, the 4,353 properties were classified as Very High (i.e., >=0 to < 50 kilometres), High (i.e., >= 50 to < 100 kilometres), Med (i.e., >= 100 to < 150 kilometres) or Low (i.e., >= 150 kilometres) based on their average distance to the three closest WPF.

P3 - Slope premium

Harvesting machinery can legally operate on slopes up to 30 degrees, however, on slopes over 20 degrees harvesting difficulty (the time it takes to harvest a tree) increases and machinery uses more fuel. Increases in time and fuel use impact on harvesting cost which reduces the residual value of the timber.

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)
- The private property cadastral layer
- The NSW digital elevation model (DEM) layer

The DEM was applied to the NHA for each of the 4,573 properties. The area with slope >= 20° within the NHA was then calculated (Figure 6). The extent was expressed as a percentage by dividing its value by the total NHA. Finally, the 4,573 properties were classified as either Very High (<25% over 20°), High (>=25 to <50% over 20°), Med (>=50 to < 75% over 20°) or Low (>=75 to 100% over 20°) based on the % value.

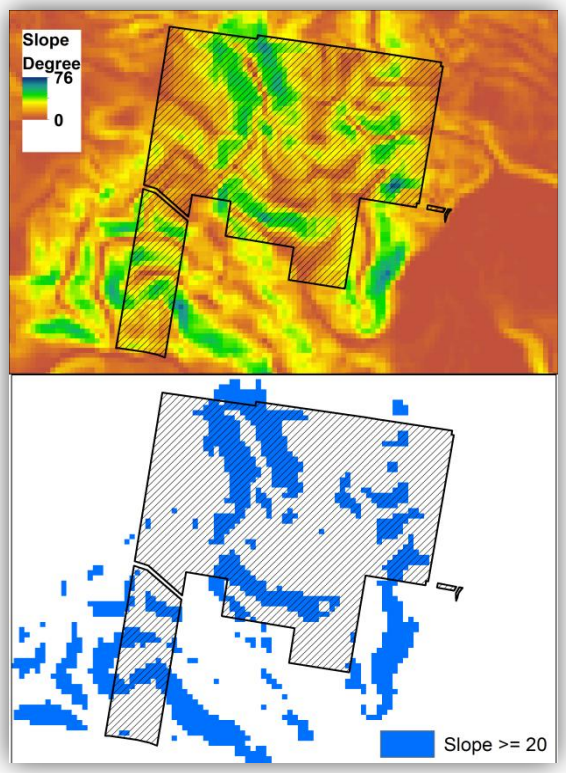

Figure 6 - Mapping the area with slope >= 20° within the NHA of each property.

P4 - Terrain roughness premium

Like slope, terrain roughness (variability in elevation) was used as an indicator of harvesting cost. Terrain roughness effects the density of roads and log dumps. In rough terrain roads are more expensive to construct so there tends to be fewer of them. Fewer roads and dumps equate to longer snig distances. Log snig distance has a direct influence on harvesting cost.

The same three layers used to map slopes over 20 degrees were used to calculate Terrain roughness, namely:

- Net Harvestable Area (NHA) layer
- The private property cadastral layer
- The NSW digital elevation model (DEM) layer (Figure 7)

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 4,573 properties, the standard deviation (σ) of the DEM within the NHA was calculated. Standard deviation values were grouped into four categories using break values at 27 (1^{st} σ), 66 (2^{nd} σ) and 104 (3^{rd} σ). Finally, the 4,573 properties were classified to Very High (0 to 27), High (27 to 66), Med (66 to 104) or Low (> 104) based on the σ values.

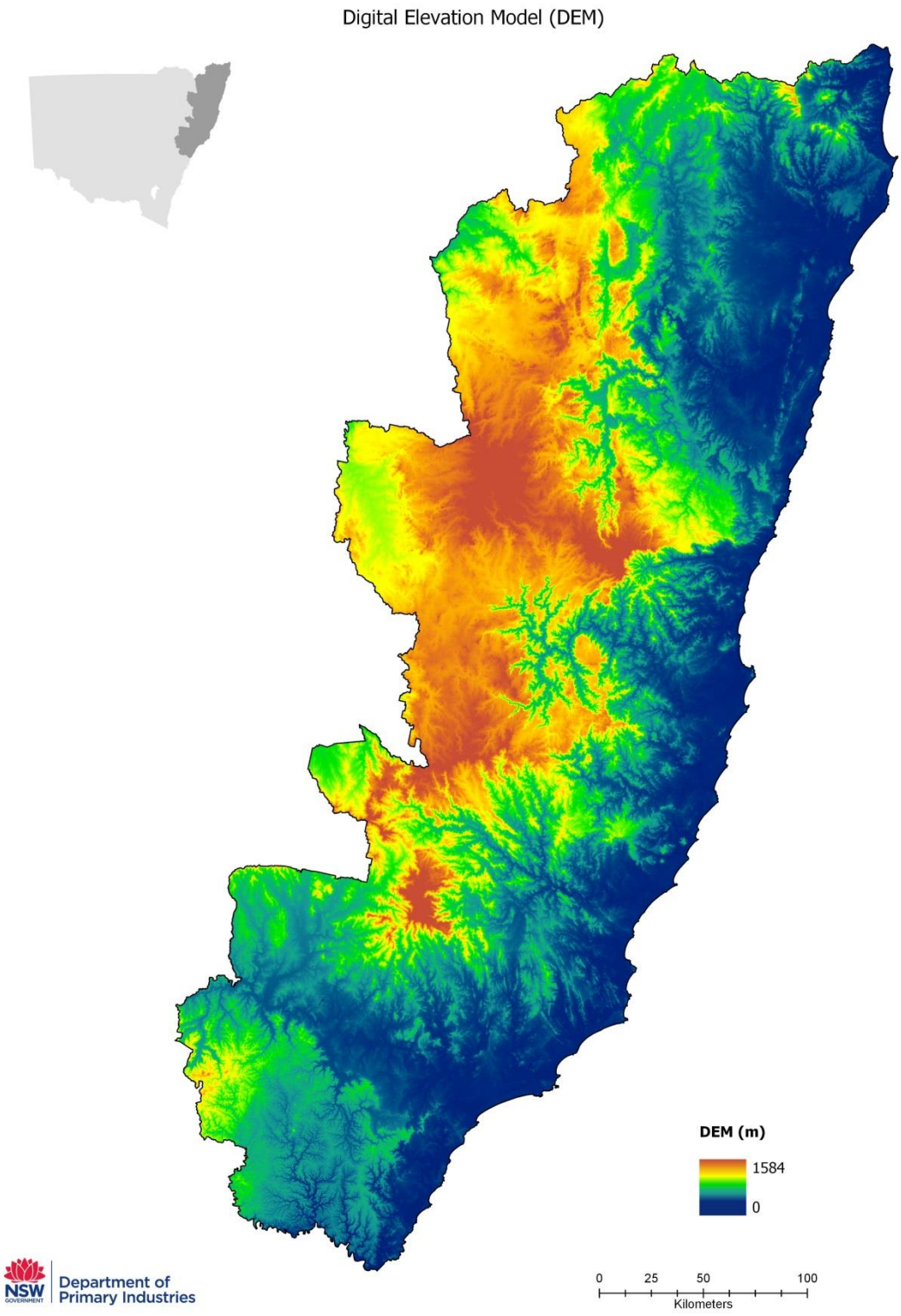

Figure 7 – Digital elevation model (DEM) of the NSW north coast.

P5 – Yield Association Group (stumpage value)

Stumpage value is the timber value of a log before harvesting and transport costs are incurred. Factors (other than market factors) that influence timber stumpage prices include log size, log quality and species. To predict timber stumpage value we used the NSW DPI Forest Yield Association Group (YAG) Map of the NSW North Coast. This map classifies the forest into ten broad forest types as detailed in Table 2. The YAG classification distinguishes forests based on their moisture, where they occur in the landscape and their species mix. 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 1)

To guide the assignment of each YAG to a class we used 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 stumpage prices based on their size, defect %, species and geographic location.

Table 2 – Rating system applied to the forest YAGs used in the model

Yield Association Group	Acronym	Ave log Size	Ave log quality	Species mix stumpage value	Weighted Ave Timber Stumpage Value Class
Rainforest	RF	N/a	N/a	N/a	N/a
Viney scrub	VS	Very High	Very Low	Med	Low
Moist Coastal Eucalypts	MCE	Very High	High	High	High
Blackbutt	BBT	High	High	Very High	Very High
Semi-moist and Taller Dry Eucalypts	SMTD	High	High	High	High
Spotted Gum	SG	High	High	Very High	Very High
Dry Sclerophyll Forest	DSF	Med	Med	Med	Med
Swamp Sclerophyll	SS	Med	Med	Low	Low
Tableland Eucalypts - Moist	TE-M	Very High	Low	Low	Low
Tableland Eucalypts - Dry	TE-D	Low	Very Low	Low	Low

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

- Log size[4] - Moist YAGs (excluding swamp sclerophyll) were assigned the highest value followed by Semi-moist YAGs and then Dry YAGs.

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

- 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 20 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 *Eucalyptus pyrocarpa*) and Spotted Gum (*Corymbia maculata* and *Corymbia citriodora*) 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 2, the % coverage of each YAG within the NHA of the 4,573 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 4,573 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.

P6 – Mature Canopy Height

The height to which a forest grows (its mature canopy height) is an indicator of its overall site productivity (Geyer et al. 1987) and capacity to yield timber. We used NSW DPI's Growth Status and Productivity layer (refer method detailed on page 5) to obtain mature canopy height data for blocks of private native forest that were greater than or equal to 25 hectares (Figure 8). Height values in metres were grouped into 10 categories - 15, 20, 25, 30, 35, 40, 45, 50, 55 and 65. For each of the 4,573 properties, the percentage coverage of each height category was calculated (i.e. "Tabulate Intersection" tool in ArcGIS Pro). The % coverage was calculated within the NHA of the 4,573 properties. Then, for each of the 4,573 properties, weighted average height was calculated using the % coverage of each height category as weight. Finally, the 4,573 properties were classified as Very High (> 40m), High (>30 and <=40), Med (>20 and <= 30) or Low (>=15 and <=20) based on their weighted average values.

Of the six parameters used in the model mature canopy height was given the highest weighting (39%).

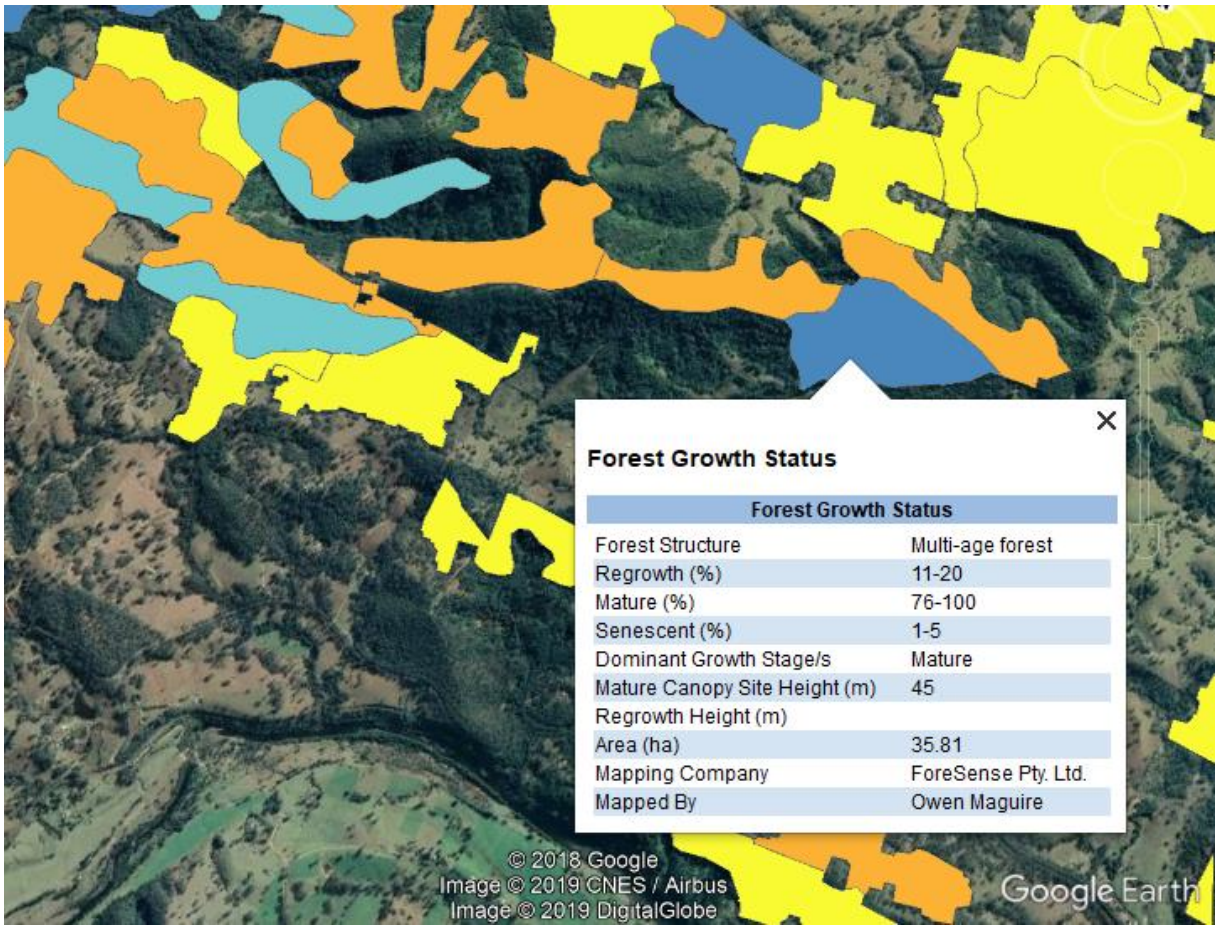

Figure 8 – DPI Growth Status and Productivity layer with mature canopy site height and other attributes highlighted for a selected forest area

Weighting of modelling parameters

Commercial measures were identified for each parameter to quantify the magnitude of the effect of each parameter on native forest timber value (i.e. its weighting). The standardised unit of measurement was $/net hectare (Table 3). For some parameters, generation of the standard unit of measure involved conversion from $/m^3 and m^3/net hectare.

Measured values were based on commercial operating costs, hardwood log yields, harvesting rates, haulage rates and stumpage rates used by the Forestry Corporation of NSW (FCNSW). Note: Details of actual rates are 'commercial in confidence' so cannot be divulged.

The values calculated for the 'Very High (4)' category were treated as optimal or benchmark values. These values were set at $0/net hectare. The value of the other categories ('High', 'Medium' and 'Low') were then calculated, being the difference from the original 'Very High (4)' benchmark value. The value differences between each category were treated as either a cost 'premium' or a revenue 'discount'.

To determine the relative weighting of each parameter all of the category values were summed (as absolute values) to generate a total value for all parameters. The weighting of the individual parameter was then calculated by dividing the total of the category's value (in absolute terms) by the total value for all parameters (in absolute terms).

Table 3 – Modelling parameter weightings showing the measured values ($/net ha) used to calculate them

ID	Modelling Parameter	Measure	Rating Category				Parameter Weighting
			Very High (4)	High (3)	Med (2)	Low (1)	
P1	Net harvestable area (NHA)	Property planning and harvest setup cost premium ($/ net ha)	$0	-$48	-$142	-$512	10%
P2	Distance by road to wood processing facility	Log haulage cost premium ($/net ha)	$0	-$222	-$426	-$583	17%
P3	Slope premium	Harvest cost premium($/net ha)	$0	-$82	-$164	-$246	7%
P4	Terrain roughness premium	Harvest cost premium ($/net ha)	$0	-$174	-$348	-$522	14%
P5	Yield Association Group[1] (Stumpage value)	Log stumpage discount ($/net ha)	$0	-$133	-$269	-$557	13%
P6	Mature canopy height (Site productivity)	Log yield discount and log harvest cost premium($/net ha)	$0	-$346	-$1,125	-$1,341	39%

1 Refer table 2 for a description of the YAG types used in P4

Results

Presented below are the modelled results for each of the six parameters. The result for all parameters combined is presented at the end using the weightings detailed in Table 3.

P1 - Net harvestable area

Of all the modelled parameters, NHA was shown to be the most variable. The only general trend was that properties with a very large NHA tended to be located further from the coast (> 50km) in terrain that is steeper and rougher than elsewhere in the region (Figure 9).

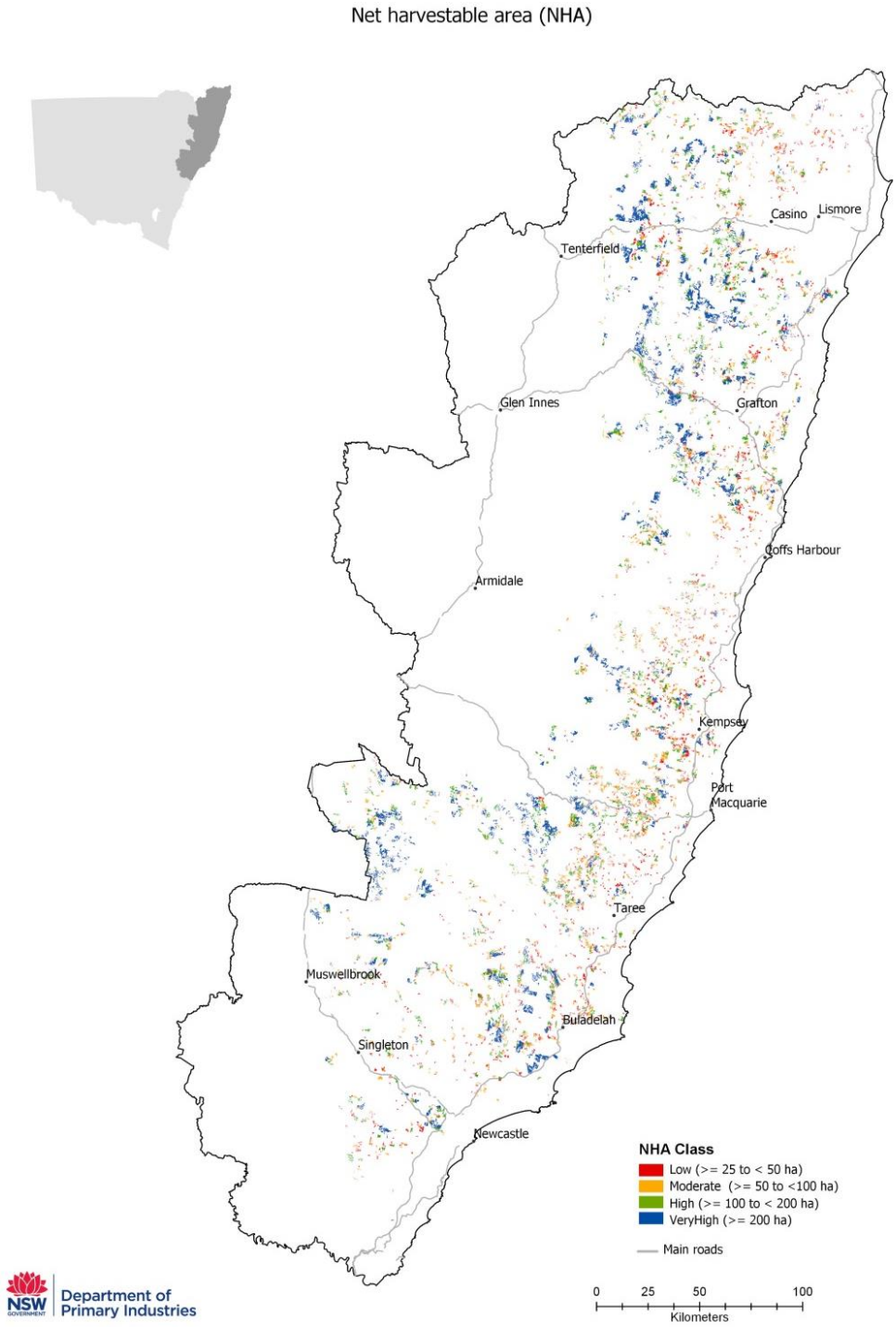

Figure 9 – Native forest timber production value of individual properties based on their net harvestable area (NHA)

P2 - Distance by road to wood processing facilities

The value of native forest timber is higher in forests that are located close to wood processing facilities (all other factors being equal). The modelled results showed that of the properties assessed, the majority were located within 50 kilometres (on average) of three wood processing facilities. This placed them into the 'very high' suitability class (Figure 10).

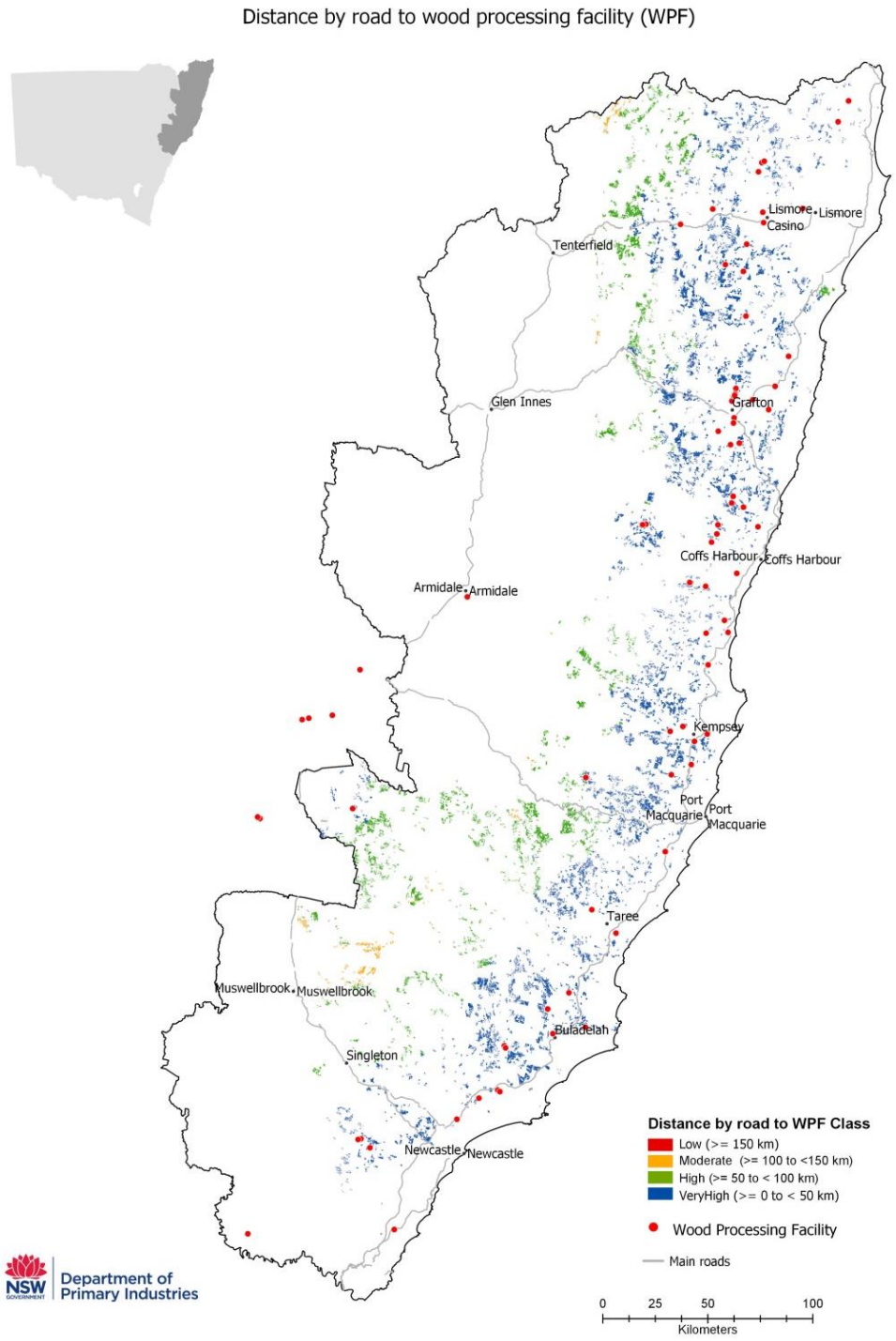

Figure 10 – Native forest timber production value of individual properties based on the distance by road to their three nearest wood processing facilities

P3 - Slope premium

83% (328,501 hectares) of the assessed forest area was found to be on land with slopes less than 20 degrees. At the property scale 71% of properties (n = 3,248) had forests in the 'Very high' timber production suitability class (i.e. less than 25% of their NHA was >20 degrees). A further 23% of the properties (n = 1,040) had forests in the 'High' suitability slope class (i.e. 25% to <50% of the NHA >20 degrees).

The small proportion of properties in the 'Moderate' suitability slope class were typically located more than 50 kilometres inland with a concentration occurring in the area north of Muswellbrook and in the hilly hinterland between Taree and Port Macquarie (Figure 11). There were only four (n = 4) properties in the 'Low' suitability slope class.

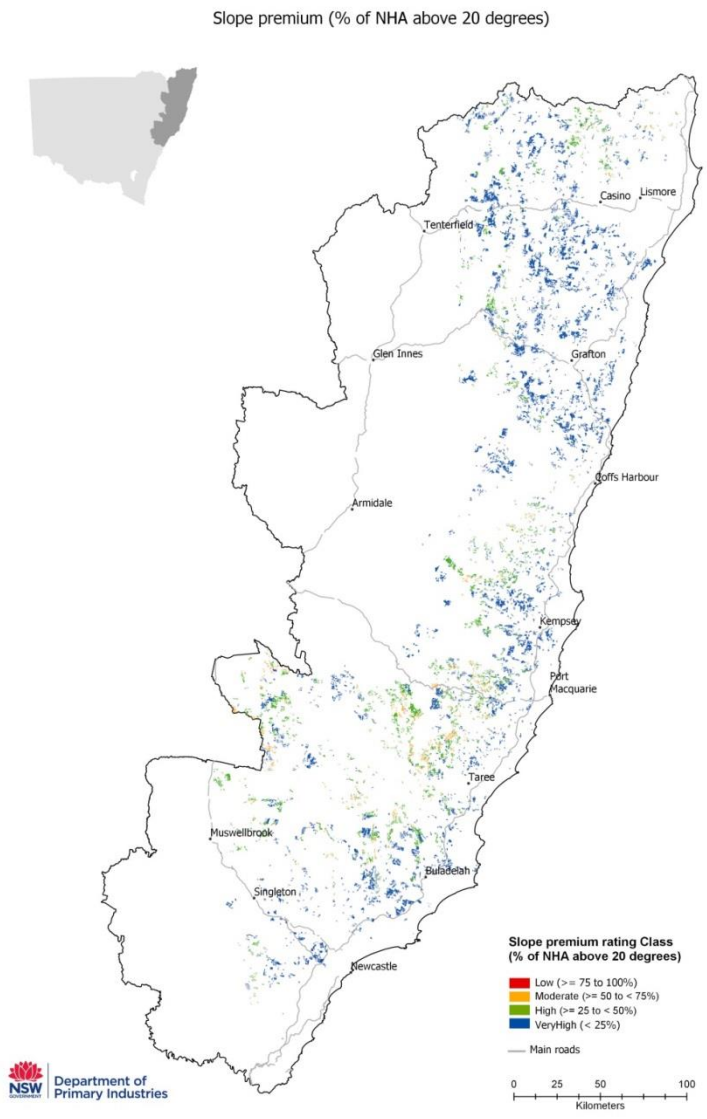

Figure 11 - Native forest timber production value based on the percentage of forest with slopes >20 degrees

P4 - Terrain roughness premium

Results for terrain roughness were more variable than for slope. Figure 12 shows the % of the property NHAs by terrain roughness class.

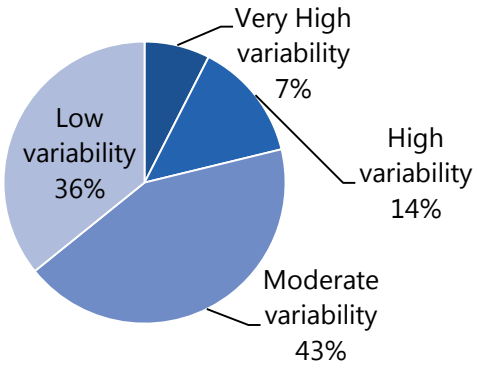

Figure 12 - Variability in elevation (terrain roughness) by property of NHA assessed forest.

Properties with 'high' or 'very high' terrain roughness were typically located more than 50 kilometres inland with the roughest terrain located to the north of Muswellbrook and to the northwest of Taree (Figure 13).

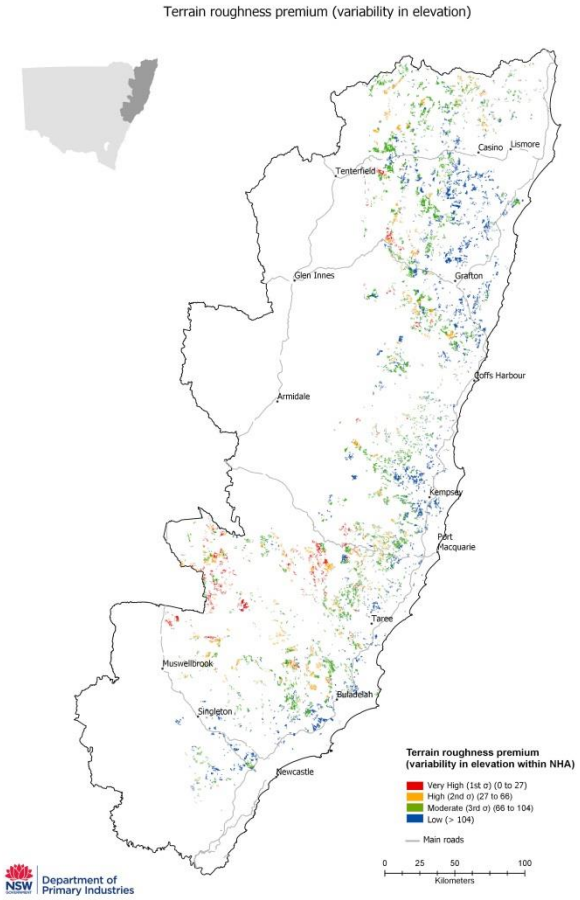

Figure 13 - Native forest timber production value based on terrain roughness

P5 – Yield Association Group (stumpage value)

Properties with native forests that generated 'very high' stumpage values (based on their yield association) were mainly located between Coffs Harbour and Casino. Properties with native forests with 'high' stumpage values were far more widespread extending in a broad band (50-100 kilometres wide) along the full length of the north coast. Properties that have native forests with 'moderate' stumpage values were less numerous but still widely distributed in discrete localities. Lastly, properties with 'low' stumpage values were nearly all located on the Northern Tablelands (Figure 14).

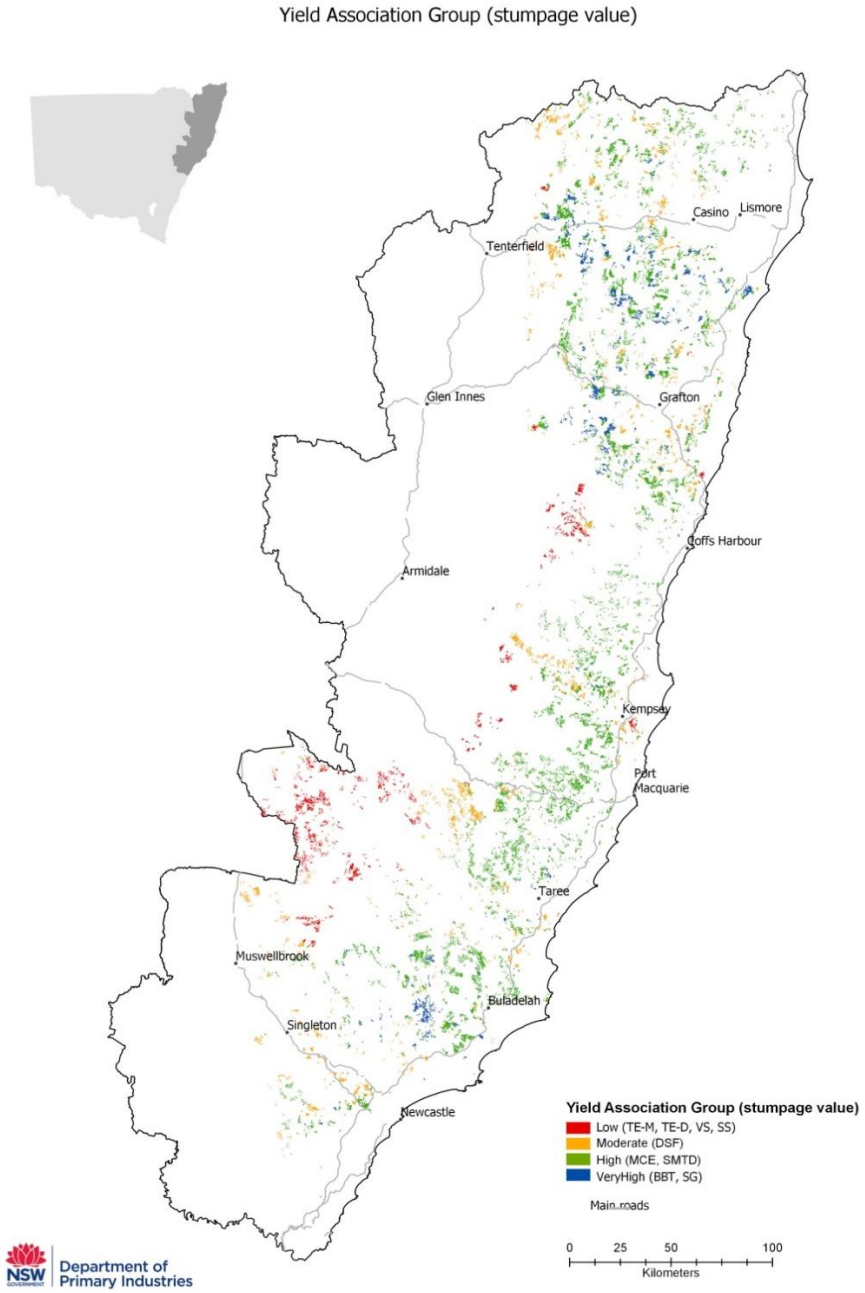

Figure 14 - Native forest timber production value based on Yield Association Group (stumpage value)

P6 - Mature canopy height

Very tall native forest (>40 metres), which was rated as 'Very high', was mostly confined to the coast between Taree and Coffs Harbour. The vast majority of assessed native forest was rated as 'High' with a mature canopy height of between 30 and 40 metres. 'Moderate' height native forest in the 20-30 metres category was limited, with more notable patches to the south of Grafton and in an area south of Bulahdelah (Figure 15).

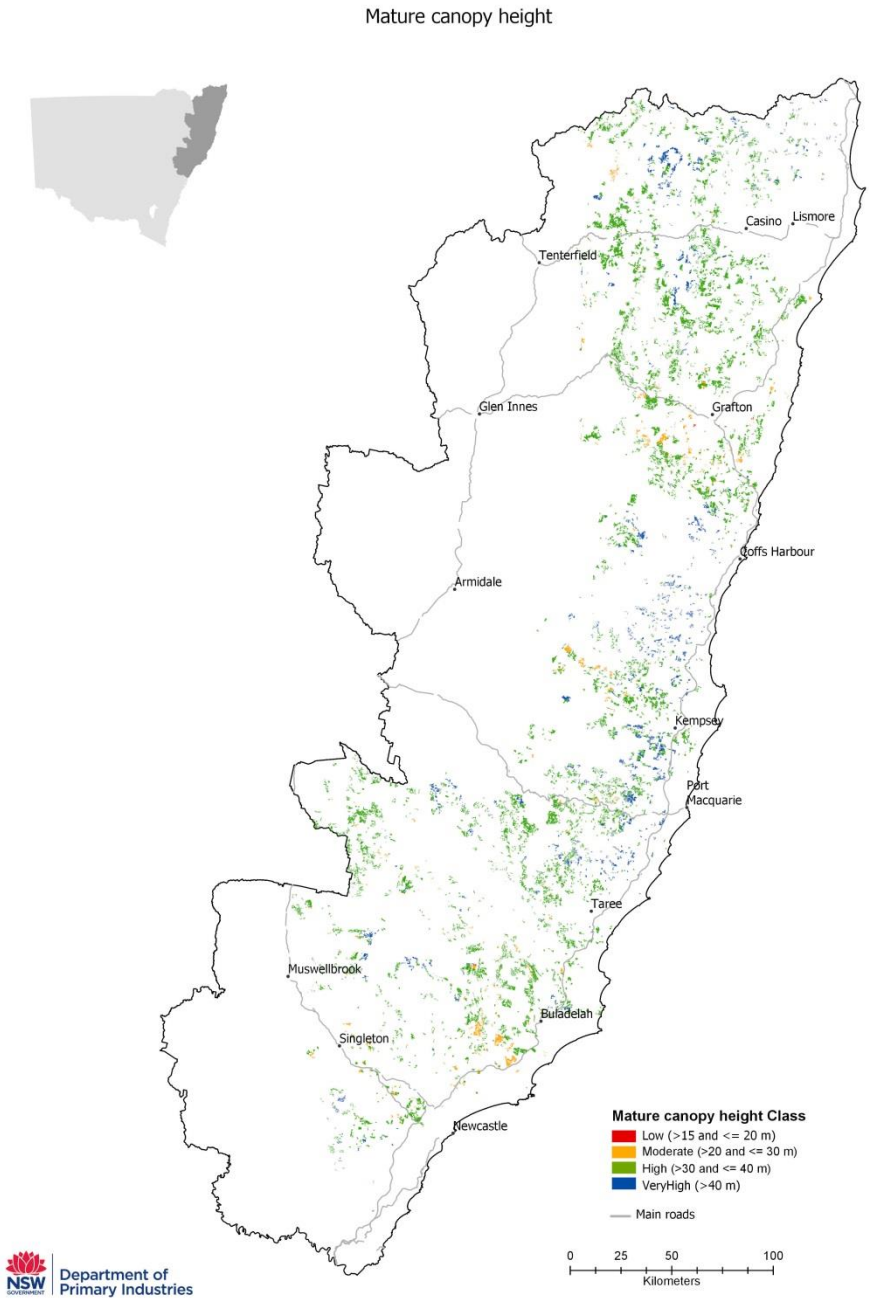

Figure 15 – Native forest timber production value based on mature canopy height

Modelled Timber Production Value (all parameters combined)

Modelled timber production values were generated by combining the results of the six weighted parameters (refer Table 3). We found that properties which have a 'Very high' suitability for timber production are located between 10 kilometres and 50 kilometres from the coast between Taree and Coffs Harbour and between 50km and 100km from the coast between Grafton and the Queensland Border. These properties account for 10% of the forests that were assessed.

Properties classified as having 'High' suitability for timber production were found to be very widespread accounting for 60% of the total native forest area that was assessed (Figure 16). On the lower north coast 'High' suitability properties were mostly found within a 50 km wide band extending from Newcastle[5] in the south to Kempsey in the north with the Pacific Highway forming their eastern boundary. On the far north coast 'High' suitability properties were more widespread occupying a broader band that extended from Coffs Harbour in the South to the Queensland border in the north. At its widest point, west of Casino, this band extends 130 kilometres inland.

Properties with 'Moderate' suitability for timber production accounted for 27% of the modelled forest. 'Moderate' value properties were mostly located at higher elevation along the western boundary of the modelled area. Only 2% of modelled properties were found to have a 'Low' suitability for timber production. These properties were located well inland in terrain that is remote and rugged. Figure 17 shows the distribution of all the assessed native forest by timber production suitability category.

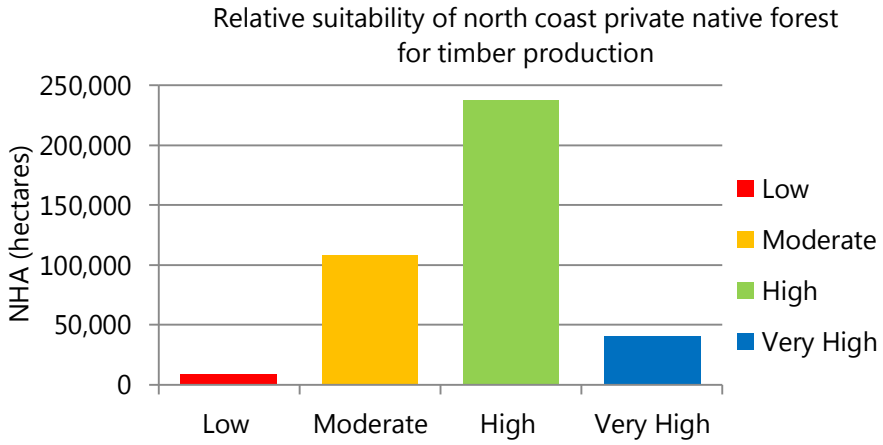

Figure 16 – Relative suitability of select private native forest areas for timber production (395,782 ha) on 4,573 individual properties

[5] Note, Newcastle was the southern extent of the modelled forest

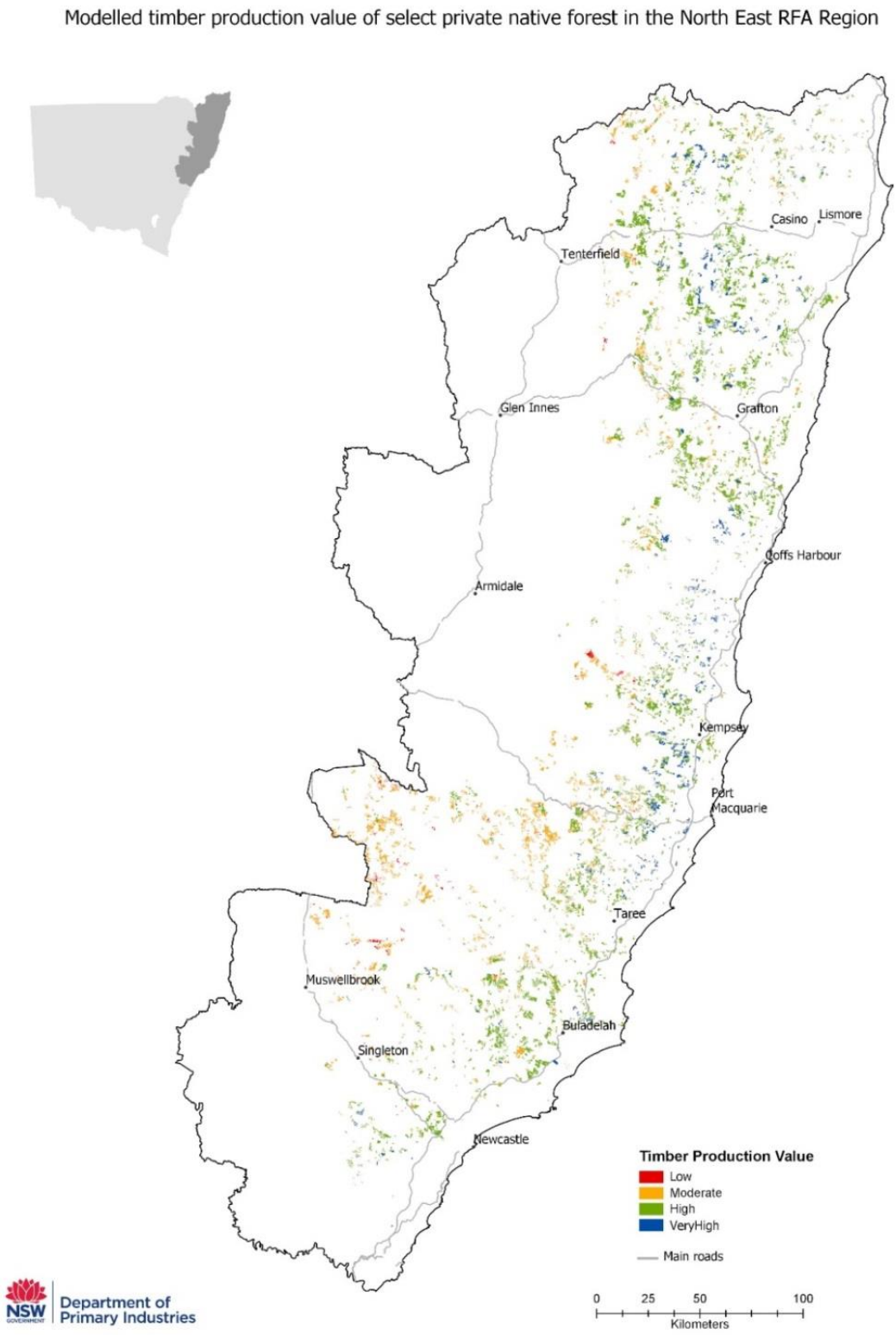

Figure 17 – Suitability of private native forest for timber production based on all modelled parameters

Discussion

Modelling of private native forest timber production values has not been previously attempted in NSW. This study was able to develop a model that has provided new insight and understanding into the way different factors influence a forest's suitability for timber production.

Modelling has identified the location and extent of properties on the NSW north coast with stands of native forest > 25 hectares and generated estimates of their relative suitability for timber production (Figure 17). This information is considered useful to government and industry as a land-use and business planning guide. The modelled results will also be of interest to individual landholders considering the potential commercial value of the timber on their property.

The development of the model involved the testing of a range of assumptions and new techniques. This process identified a number of opportunities for refinement and improvement. Over time it is envisaged that there will be opportunity to improve the reliability, accuracy and coverage of the model.

Potential improvements to the method

- Stratifying the input data (into four classes) before it was modelled made the process of modelling easier however this was a potential source of bias - due to over simplification. In particular some of the modelling parameter data had skewed distributions which didn't readily fit into the four equal classes. The assignment of the class divisions also introduced a possible source of bias. In future versions of the model it is proposed that, as far as practicable, the input data be left un-stratified.

- The reliability of the model was not tested in the field. The practical constraints of accessing private lands meant that only a limited amount of ground-truthing sites would have been possible. However, if ground-truthing had occurred the data could have been used to better inform the development of the model. Ground-truth sites could have also been set aside to test the model's accuracy.

Potential improvements to the input data

P1- Net Harvestable Area

The effect of not being able to model forest areas < 25hectares raised concern in terms of its effect on the modelled results. An evaluation of these concerns is detailed in Table 4. The key findings from this evaluation were:

- the exclusion of forest areas <25 hectares greatly constrained the extent of the forest that was modelled and wholly excluded many properties with small areas of native forest;
- for the properties that were modelled, the representativeness of forest areas =>25 hectares was not tested, however, there was no obvious evidence of bias;

- from an operationally perspective >= 25 hectares is a logical threshold to apply;
- The low weighting assigned to the NHA parameter (7%) meant if there was some bias it would not have a major impact on the final modelled result.

Data permitting, it is recommended that the NHA be remodelled without the 25 hectares restriction.

Table 4 Pros and Cons of excluding forest areas <25ha

Pros	Cons
• Contiguous areas of commercial forest >=25 ha are viable harvesting areas in their own right. In contrast areas of forest < 25 ha are dependent on their proximity and similarity to adjoining forestry areas >=25 ha and their site quality. • API mapping north coast private native forest has revealed that the growth status and site productivity of forest on an individual property is often highly variable. This variability means that only a subset of the forest on a property (that is nominally available for timber harvesting) will be suitable for harvesting at any given time. • If all the forest on a property nominally available for timber harvesting had been used to define the NHA this would have over-estimated the area that would typically be subject to a harvesting operation. • A comparison of NHA related costs with costs assigned to other modelling parameters resulting in a P1 weighting of 7%. This weighting was the equal lowest of all the modelled parameters. • For the properties that were assessed there was no evidence of any obvious bias.	• Only 16% of the area nominally available for harvesting was actually modelled. This equated to 4,573 individual properties. Had a different threshold been used the modelled area for each property would have been much larger as would the number of assessed properties. • Many properties with small areas of native forest were excluded altogether by the 25 ha rule. • The representativeness of the modelled forest, when compared to the total forest area nominally available for harvest within a property, was not tested.

P2 - Distance by road to wood processing facility

The road haulage distance model did not differentiate between the different road Classes (i.e. A, B and C). Road class effects haulage cost with a surcharge applying to Class B and Class C roads.

Having 3D point cloud data - obtained from Airborne Laser Scanners (ALS) - over private native forest would enable internal forest access roads to be mapped and included in the model. This would improve the accuracy of the haulage distance calculation. The Spatial

Services division of the NSW Department of Finance, Service and Innovation is currently implementing a broad scale data acquisition program using ALS.

In summary, taking account of road class and internal forest access roads would allow for fairer comparison of haulage routes.

P3 - Slope premium and P4 – Terrain Roughness

The resolution of the digital elevation model (DEM) is 25 metres. If a higher resolution DEM became available it should be adopted as 25 metre pixels result in some over-simplification.

As 3D point cloud data becomes more readily available from LiDAR it will enable development of higher accuracy terrain/slope model. 3D point cloud data may also enable internal forest access roads to be mapped. Knowledge of these features would improve understanding of forest accessibility (NHA) and may allow snig distances to be calculated.

P5- Yield Association Group (YAG) map

The accuracy of the Yield Association Group (YAG) map derived using multi-spectral satellite data can be improved. The map is accurate for some forest types (i.e. Blackbutt 82.5%) but unreliable for others (i.e. Moist Coastal Eucalypt 39.1%). The accuracy of the YAG map is important as it is relied upon for predicting stumpage value. Knowledge and expertise exists within the DPI Forest Science unit to improve the map's accuracy if time and resources permit.

Many of the YAGs are differentiated on the basis of their mature canopy height. The accuracy of these YAGs could be improved by using 3D point cloud data to generate a higher resolution canopy height layer.

Cross reference with the NSW Office of Environment & Heritage's recently produced Plant Community Type (PCT) layer may also help to validate the YAG map's accuracy.

P6 – Mature Canopy Height

At the time of mapping, the availability of high-resolution canopy height data on private land was very limited. It is anticipated that the current investment by Spatial Services in 3D point cloud data using ALS may facilitate the following improvements (in addition to those already been mentioned):

- provide a more reliable guide to the relative productivity and yield (based on mature canopy height) of the native forests.
- enable the mature canopy height of all native forests on private property to be modelled (not just those in stands greater than 25 hectares). Note, the limited availability of mature canopy height data was a major constraint on the extent of the private forest that could be modelled (i.e. 395,782 hectares or 16%).
- Enable all unproductive forest (non-commercial) to be identified which would allow the NHA to be refined.

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Annexure A

Spatial layers and analysis software and tools used to inform each modelling parameter

ID	Modelling Parameter	Spatial Layer	Analysis software and geoprocessing tools
P1	Net harvestable area (NHA)	• NSW Woody Vegetation Extent 2011 • Private property cadastral boundaries on the NSW north coast • Growth status and productivity mapping of north coast private native forests • Yield Association Groups of the NSW north coast • Availability of private native forest in the North East RFA Region for timber harvesting	• Arc GIS Pro
P2	Distance by road to wood processing facilities	• NHA derived layer • Location of NSW Wood Processing Facilities • Centroid of each of the private property • Road layer	• Arc GIS Pro / ArcMap 10.3 ArcCatalog New Network Dataset function and Network Analyst extension
P3	Slope premium	• NHA derived layer • Digital Elevation Model	• Arc GIS Pro
P4	Terrain roughness premium	• NHA derived layer • Digital Elevation Model	• Arc GIS Pro
P5	Forest Yield Association Group[1] (Stumpage value)	• NHA derived layer • Yield Association Groups of the NSW north coast	• Arc GIS Pro
P6	Mature canopy height	• NHA derived layer • Growth status and productivity mapping of north coast private native forests	• Arc GIS Pro