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Sustainable Yield in New South Wales Regional Forest Agreement regions

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Executive Summary

The purpose of this document is to meet the commitment in the New South Wales Regional Forest Agreements (RFAs) to publicly release estimates of sustainable yield for public forests in RFA regions where timber harvesting is permitted.

Under the 2018 variations to the NSW RFAs, NSW renewed the commitment to supplying wood from public native forests in RFA regions at or below sustainable yield, and removed volume commitments.

This approach is consistent with the NSW Government's ongoing commitment to ecologically sustainable forest management and with wood supply volumes and arrangements in NSW.

The original RFAs contained minimum wood supply volume commitments to industry. Although determined using the best available information at the time, the volumes became out-of-date and did not reflect refinements in modelled sustainable yields, reductions in the area available for timber harvesting, or reductions in wood supply volumes to industry to address lower sustainable yield estimates.

The amended RFA commitments provide a rigorous process for determining sustainable yield, requirements to update and publish sustainable yield calculations at least once every five years, and requirements for independent review of sustainable yield calculations.

The benefits in this approach include the recognition that sustainable yield and forest ecosystems are not static. The approach provides greater flexibility in managing the NSW public forest estate, increased longevity in the RFAs, and importantly greater transparency through improved and more regular communication of sustainable yield estimates with the public.

The current estimate of sustainable yield for each NSW RFA region is shown in **Table E1**.

Table E1: Sustainable yield of high quality logs and other wood products in NSW RFA regions for the five-year period 2019 to 2023

RFA region[1]		Annual sustainable yield	
		High quality logs (m^3)	Non-high quality logs (tonnes)
North East (including upper and lower North East regions)		230,000	660,000
Eden		26,000	195,000
Southern	South Coast sub region	50,000	160,000
Southern	Tumut sub-region	35,000	40,000

(1) The Southern RFA region is treated as two discrete resource areas for sustainable yield modelling, due to differences in the forest types and customer base.

NSW recognises that sustainable yield is not static and that regular updates, reconciliation with actual timber yields, independent reviews, and public release of findings are important. The forward work plan associated with sustainable yield includes:

- ongoing implementation of the continual improvement program for sustainable yield systems, processes and model inputs

- finalising the update of the Tumut sub-region model and its inputs in 2019 to provide and publicly release amended sustainable yield figures
- undertaking reconciliations of estimated yields with actual timber yields at least twice every five year period, noting the last reconciliation was published in 2016 and the next reconciliation is due to be released in 2019
- updating all sustainable yield figures ahead of the next five-yearly review under the RFAs, which is due to commence in 2024
- commissioning an independent review of sustainable yield calculations prior to the next five-yearly review under the RFAs, noting that the last independent review of sustainable yield systems and processes was undertaken in 2017.

1 Introduction

Sustainable yield is a measure of how much wood can be harvested from a forest over a long period of time, while maintaining wood supply levels and meeting sustainable use objectives for the forest.

Under the 2018 variations to the Regional Forest Agreements (RFAs), New South Wales has committed to supplying wood from public native forests and harwood plantations in RFA regions at or below the sustainable yield, and removed volume commitments. This approach is consistent with the NSW Government's ongoing commitment to ecologically sustainable forest management (ESFM) and with wood supply volumes and arrangements in NSW.

Forests in NSW are managed within a comprehensive framework of legislation, policies, and institutional and administrative arrangements to achieve ESFM. The framework[1] ensures that ESFM principles are applied to all aspects of forest management, across all forest tenures and all forest uses. Importantly this includes forestry operations where they are permitted in NSW public native and plantation forests. Forestry operations include the harvesting of timber.

Principles of Ecologically Sustainable Forest Management (ESFM)

- ✓ Maintain or increase the full suite of forest values for present and future generations across the NSW native forest estate
- ✓ Ensure public participation, access to information, accountability and transparency in the delivery of ESFM
- ✓ Ensure legislation, policies, institutional frameworks, codes, standards and practices related to forest management require and provide incentives for ecologically sustainable management of the native forest estate
- ✓ Apply precautionary principles for prevention of environmental degradation
- ✓ Apply best available knowledge and adaptive management processes

RFAs are long-term agreements between the Australian and four state governments for the sustainable management and conservation of Australia's native forests and to provide for the long-term stability of forests and forest industries.

[1] State of NSW (2018) *Overview of the New South Wales Forest Management Framework* https://www.dpi.nsw.gov.au/forestry

The NSW and Australian governments signed RFAs for the Eden, North East and Southern regions of NSW, on 26 August 1999, 31 March 2000 and 24 April 2001 respectively.

The original RFAs contained minimum wood supply volume commitments to industry. Although determined using the best available information at the time, the volumes included in the NSW RFAs became out-of-date and did not reflect refinements in modelled sustainable yields, reductions in the area available for timber harvesting, or reductions in actual wood supply volumes to industry to address lower sustainable yield estimates.

In the review and amendment of NSW RFAs undertaken in 2018, the NSW Government sought to address the discrepancy in wood supply commitment volumes in the RFAs and estimated sustainable yield by replacing the original commitments with new ones to supply wood to industry at or below the sustainable yield determined for the RFA region.

The amended RFA commitments do not include specific volumes, but provide a rigorous process for determining sustainable yield, requirements to update and publish sustainable yield calculations at least once every five years, and requirements for independent review of sustainable yield calculations.

The benefits in this approach include the recognition that sustainable yield and forest ecosystems are not static and are subject to change. The approach provides greater flexibility in managing the NSW public forest estate, increased longevity in the RFAs, and importantly greater transparency through improved and more regular communication of sustainable yield estimates with the public.

The purpose of this document is to meet the NSW RFA commitment to publicly release sustainable yield. It provides a brief overview of the processes and considerations in determining and managing sustainable yields in RFA regions within public forests where forestry operations are permitted, describes the forest resource in the three NSW RFA regions, and provides:

- the current forecast of sustainable yield of hardwood logs by RFA region
- certainty in the level of resource availability to facilitate long term supply agreements to industry.

2 Forests in NSW

There are over 20 million hectares of forest in NSW, including native and plantation forests, of which around half is on public land. More than 5 million hectares are permanently protected in national parks and reserves, and a further 2 million hectares is in State forests or other Crown-timber land.

The national park estate in NSW is managed for the conservation of nature, the conservation of objects, places and features of cultural value in the landscape (including places, objects or features of significance to Aboriginal people), and for the fostering of public appreciation of nature and cultural heritage.

Areas dedicated as State forests are managed for multiple uses including for the production of timber[2] and other forest products, and to allow for other uses such as grazing or bee keeping, for the conservation of flora and fauna, and for recreation and tourism where they are compatible with ESFM principles.

The Forestry Corporation of NSW (FCNSW) manages wood supply from State forests and other Crown-timber land on behalf of the NSW Government.

2.1 Regional Forest Agreements

Forest management including forestry operations in the coastal forests of NSW are managed under the RFA framework. RFAs are bilateral agreements between the Australian and state governments that provide a plan for the sustainable management and conservation of forests.

There are three RFAs in NSW covering the Eden, North East and Southern regions (**Figure 1**), which were signed on 26 August 1999, 31 March 2000 and 24 April 2001 respectively.

RFAs are plans that seek to balance economic, social and environmental values of forests. The RFA's key principles are to provide:

- for ecologically sustainable forest management and use of forests
- certainty for conservation of the environment and heritage values through the establishment and maintenance of a comprehensive, adequate and representative (CAR) reserve system
- certainty of resource access for the forestry industry.

[2] Timber in this context means wood within trees which can be harvested for logs and other wood products.

Figure 1: Regional Forest Agreement regions in New South Wales

The RFAs provide a streamlined approach to satisfying Commonwealth legislative requirements for environmental planning and assessment and for conducting forestry operations to meet ESFM objectives.

The RFAs require NSW to manage the harvesting of timber and forest products to meet ESFM principles and within long term sustainable limits.

3 Sustainable yield

To satisfy ESFM principles and requirements under the NSW RFAs, harvest volumes and wood supply from NSW public native forests must follow a long-term sustainable yield strategy.

Within the RFAs, sustainable yield is defined as the long-term estimated wood yield from forests that can be maintained from a given region in perpetuity under a given management strategy and suite of sustainable use objectives.

The RFAs set out how sustainable yield is to be determined, reviewed and periodically updated in NSW RFA regions. NSW has committed to manage the availability of timber resources for the State forest estate in each RFA region in accordance with ESFM principles and within sustainable yield limits, including to:

- take account of climate risks and adaptation responses
- ensure that the resource model used to determine sustainable yield is maintained and continually improved
- provide periodic reviews of wood product yields (comparing actual volumes harvested against predicted/modelled volumes)
- undertake and make publicly available independent reviews of sustainable yield estimates during each five-yearly review period under the RFAs.

A summary of the sustainable yield of high quality logs for the period 2019 to 2023 in the three NSW RFA regions is provided in **Table 1**, along with yields of non-high quality products. Further detailed information on sustainable yield and the forests in each RFA region is presented in **section 4**.

Table 1: Sustainable yield of high quality logs and other wood products in NSW RFA regions for the five-year period 2019 to 2023

RFA region[1]	Annual sustainable yield	
	High quality logs (m^3)	Non-high quality logs (tonnes)
North East (including upper and lower North East regions)	230,000	660,000
Eden	26,000	195,000
Southern South Coast sub region	50,000	160,000
Southern Tumut sub-region	35,000	40,000

(1) The North East and Eden RFA regions are each modelled as single resource areas within FRAMES, as the forests within these regions share geographic or regional groupings, including common forest types and customers. The Southern RFA region is treated differently within FRAMES because it has two discrete resource areas being the coastal and tablelands forests in the South Coast sub-region, and alpine forest types with a separate customer base in the Tumut sub-region.

The yields of non-high quality products arise from harvesting of high quality products and other forestry operations such as thinning. Although modelled over a 100-year time-horizon, sustainable yield is provided relative to a five-year period to allow for potential changes in modelling input data, new or altered regional prescriptions, catastrophic fire events, and the

requirement under the RFAs to review and update sustainable yield at least once each five-year period.

3.1 Determining sustainable yield

NSW uses the Forest Resource and Management Evaluation System (FRAMES) to determine sustainable yield from State forests in RFA regions.

FRAMES is a strategic wood supply model that simulates future timber harvesting, growth and regeneration in native forest and hardwood plantations. The Forestry Corporation of NSW maintains and operates FRAMES, including a continual improvement program.

Further information on FRAMES is provided in **section 5**.

3.2 Allocating sustainable yield

Forestry Corporation uses Wood Supply Agreements (WSAs) to allocate wood supply volumes to customers. WSAs are commercial contracts between Forestry Corporation and their customers to supply a set volume of specified wood product(s) over a certain period of time.

Under the NSW RFAs and Integrated Forestry Operations Approvals (IFOAs)[3], Forestry Corporation is not permitted to harvest wood products in excess of sustainable yields over a twenty year period. Variations above or below sustainable yields are permitted on an annual basis (see **section 3.4** for further details) but in the long-term, harvested volumes must not exceed the sustainable yield. The WSAs ensure that the total volume allocated to customers from an RFA region does not exceed the sustainable yield for that region. Forestry Corporation may also apply commercial constraints to the volume of wood allocated to customers, which means that the volume available to industry may be less than the sustainable yield determined for an RFA region.

3.3 Defining sustainable supply

Consistent with ESFM principles, sustainable wood supply encompasses social and environmental as well as economic factors. Maintaining landscape and forest condition

[3] IFOAs set the rules for how forestry operations can be carried out on State forests and Crown-timber lands in NSW. They include rules to protect native plants, animals, important habitat and ecosystems, soils and water in native forestry operations on public land. They also set requirements to achieve ESFM in NSW. Further information on IFOAs can be found on the NSW Environment Protection Authority web site. Accessed September 2018: https://www.epa.nsw.gov.au/your-environment/native-forestry/integrated-forestry-operations-approvals

values are important factors within FRAMES. FRAMES contains parameters that simulate the requirements and prescriptions established within the relevant IFOA. For NSW RFA regions this is the Coastal IFOA.

The harvest and supply of wood products within sustainable yield limits does not always equate to an even flow of all log products. Factors such as varying forest types, silviculture history and other logistical issues can lead to uneven flow outcomes within a broader sustainable yield context. In particular, the yield of low quality and pulpwood or residue logs fluctuates over time due to changes in stand age and structure, different silviculture regimes and management history. This effect can be particularly pronounced in areas where plantations and younger regrowth forests predominate, as thinning of these resources can often occur in 'phases' where large volumes of low quality products (e.g. residues) are produced for a short period of time due to bunched age-class distribution, where operations may ramp up to allow for thinning to be undertaken commercially. Another factor that influences the harvesting of different wood products is the market demand or availability over time. If there is little or no demand for certain tree species or types of wood products, they may not be harvested.

3.4 Annual supply variations

Log availability in each region can vary from year to year based on weather and logistical constraints both in the forest and log markets. Examples of logistical constraints include a market down-turn or an endangered species requiring a new management approach. As such, actual yields supplied to industry can fluctuate up to 25% in any given year. Although these annual fluctuations occur, Forestry Corporation manages the total amount supplied to industry over the long term to be consistent with the sustainable yield. This allows flexible management of wood supply within logistical and weather constraints while ensuring that the long-term sustainability of the resource is not compromised.

The IFOA relevant to each NSW RFA regions provides more information on permitted annual yield variations over one, five and twenty year periods, which include:

- Annual variation in one year: ±25% of sustainable yield
- Five-year annual average variation: ±10% of sustainable yield
- Twenty-year annual average variation: 0% of sustainable yield (i.e. over a twenty-year period, the annual average yield must not exceed the sustainable yield).

3.5 Risks to maintaining wood supply

There are several factors that can change the sustainable yield determined for an area of forest, as they influence either:

- the area of forest available to harvest – e.g. transfer of land from State forest to the conservation estate, a catastrophic bush fire, or maturing of new hardwood plantations
- tree growth rates and wood quality – e.g. rainfall, temperature, pests and disease, or silvicultural and forest management practices.

Some of these factors create risks to maintaining wood supply to industry and need to be carefully managed and addressed through forest management practices and policies.

Since the RFAs were signed there have been significant changes in land tenure and industry configuration that have required re-adjustment of long-term sustainable yield, particularly in the North East region. Significant changes to long-term sustainable yields can also arise from a significant disturbance event, such as a major bushfire or other climatic event. Where such events occur a review of sustainable yield calculations may be warranted and a corresponding consideration given to adjustment in wood supply arrangements.

Climate change impacts may also affect future rates of forest growth and hence long-term predicted yields. Climate change projections for NSW (**Table 2**) include increasing frequency of extreme events such as drought and high temperatures, changing rainfall (increasing or decreasing at different times of the year), and rising atmospheric carbon dioxide (CO_2) concentrations. Also associated with climate change projections are an increased likelihood of forest health impacts from pests and disease, and an increased risk of forest fire. While forest growth rates are influenced by all of these factors, some will reduce growth rates and wood quality, and others may increase them[4].

Future tree growth, quality and wood yields will be the result of complex interactions between these factors and forest management practices, and are likely to vary based on forest types and species. Localised or regional variations in rainfall, water availability, temperature and climate events will cause differential impacts on tree growth across RFA regions; however, there is currently no definitive estimate available of the potential impact on long-term timber yield from forests under climate change projections.

Across the RFA regions, Forestry Corporation maintains permanent growth plots, which are areas of forest where various tree growth and quality parameters are routinely measured. These include tree species, diameter and height, product quality features, habitat features and accessibility. The permanent growth plot program (described in **section 5.2)** provides a key dataset for estimating tree growth rates in FRAMES. Regular plot re-measurement can help to determine the effects of climate change, drought, other large scale environmental change and silvicultural practices on tree growth rates. Forestry Corporation is also investigating the use of technological advancements and remote sensing technologies, such as light detecting and ranging (LiDAR), to improve growth estimates across the State forest estate.

Research on climate change risks and impacts on forests, is being undertaken by various organisations at a State and national level, and tools are available to help forest managers consider risk.

[4] Cowie *et al* (2007) *Climate Change Impacts and Research Priorities for the Forestry Sector*. Accessed August 2018: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/191521/Climate-change-and-forestry---a-background-paper.pdf

The NSW and ACT Regional Climate Modelling project (NARCliM) provided regional climate change projections for NSW[5]. By 2070, NARCliM indicates that all three NSW RFA regions are likely to experience increasing minimum and maximum temperatures; decreasing rainfall in winter and/or spring; increasing rainfall in summer and autumn; and an increase in forest fire risk in summer and spring (**Table 2)**.

Table 2: NARCliM climate change projections by 2070 for NSW RFA regions

RFA region	NARCliM region[1]	Temperatures[2]	Rainfall	Forest fire risk
North East	North Coast New England and North West Hunter Central Coast	Increasing by 1.4-2.7°C	Decrease in winter and/or spring. Increase in autumn, spring and/or summer.	Increase in summer and spring.
Eden	South East and Tablelands	Increasing by 1.4-2.5°C	Decrease in spring and winter. Increase in summer and autumn.	Increase in summer and spring.
Southern	South East and Tablelands Illawarra Murray Murrumbidgee	Increasing by 1.3-2.5°C	Decrease in winter and/or spring. Increase in summer and autumn.	Increase in summer and spring.

Table notes: (1) The whole or part of the NARCliM region may be within the RFA region's boundary; (2) Includes maximum and minimum temperatures.
Source: Office of Environment and Heritage (2014) regional climate change snapshots

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is undertaking research on climate change risks to forests and released the Forest Climate Risk Tool[6] in June 2018, an online tool that enables forest managers to quickly and readily assess risk. The tool is intended to increase industry awareness of climate change and to assist industry to manage risk and improve productivity. Forestry Corporation was a member of the project steering committee to develop the tool.

As research on climate change impacts, forest growth and health progresses, Forestry Corporation will incorporate key findings and address implications for sustainable yield estimates in RFA regions.

[5] Office of Environment and Heritage (2014) Regional climate change snapshots, accessed August 2018: https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW
[6] CSIRO (2018) Forest Climate Risk Tool webpage. Accessed August 2018: https://research.csiro.au/climatesmartagriculture/data-tools/forest-climate-risk-tool/

3.6 Product definitions in wood supply models

Wood products are typically sold under local WSA arrangements or specifications that relate to the type of processing facility that operates in an area. Wood supply modelling uses generic descriptions of logs so that models remain comparable over the long term regardless of local market conditions. As an example, poles used for electricity transmission and street lighting networks, are not specifically modelled as they are not described easily during forest inventory or models. Within FRAMES, poles are a sub-set of the high quality log category. Similarly, veneer, pile and girder logs are included as a sub-set of high quality logs, although they may have discrete, local specifications that are more stringent than the general high quality log specification modelled.

The product definitions used in FRAMES are:

- HQL: High quality (large) logs generally with little defect, including potential sawlogs, poles or peeler logs with a minimum centre diameter under bark (CDUB) greater than or equal to 40 cm.
- HQS: High quality (small) logs generally with little defect, including potential sawlogs, poles or peeler logs with an CDUB between 40 cm and 30 cm, and greater than 30 cm at the small end under bark (SEDUB).
- HQ25 (Eden Only): High quality logs general with little defect, including potential sawlogs or peeler logs with an SEDUB below 30 cm and above to 25 cm.
- Low quality logs: logs that do not meet required threshold for defects (including wood properties and log form) or logs that are too small to meet specifications for high quality logs, that can still be processed using traditional sawing methods.
- Pulpwood logs: logs of timber that do not meet the requirements for high quality logs of species with acceptable fibre yields.
- Residue logs or other wood products: eucalyptus and non-eucalypt logs and waste material unsuitable for high quality logs due to defects and size with low fibre yields also unsuitable for current pulpwood log specifications. This category can include logs sold for fencing as round or split posts, fibreboard or for other industrial uses. Heads and offcuts of logs are not specifically reported in FRAMES and volumes of heads or offcuts not sold in log form are additional to those reported here.

Firewood logs can be any surplus logs that do not meet specifications for high quality logs. Firewood logs are not specifically modelled in FRAMES.

3.7 Log quality assumptions

Within FRAMES, key assumptions are applied relating to the requirements for logs in terms of their length, size and other properities, such as level of internal defect, recovery performance in processing, or expected fibre properties. These assumptions are linked to current log grading specifications and processes. As wood processing technologies change and new or emerging technologies provide better information, the assumptions applied within FRAMES will be reviewed by Forestry Corporation to ensure they are still appropriate.

Log quality and grading system assumptions used in FRAMES have the potential to alter yield estimates if they change. The regular review and updating ofsustainable yield estimates

required under the RFAs will ensure that impacts on sustainable yield from assumption changes can be assessed. Forestry Corporation will document changes to assumptions and the impacts to sustaniable yield estimates through this process.

Due to the nature of log quality grading and estimation, the approach taken in determining sustained yield under the RFA will be based on two modelled factors:

- Total high quality logs produced per year
- Total non-high quality logs produced per year.

4 Regional sustainable yield estimates

4.1 Eden region

The Eden RFA region encompasses forests stretching from the New South Wales-Victorian border to areas inland of Bermagui, as well as forests along the edge of the southern tablelands around Bombala. The region's forests are dominated by silvertop ash (*Eucalyptus sieberi*) and stringybark/gum forest types (*E. muellerana* / *E. cypellocarpa* amongst others) in the coastal and foothills forests, with brown barrel (*E. fastigata*) dominating at higher altitude and on the Tablelands.

The area of forest and major public land tenures in the Eden RFA region are provided in **Table 3**.

Table 3 Forest areas in the Eden region

Area of forest and tenures in the Eden RFA region[1]	Area (hectares)
Total forested area – all tenures	601,600
National park	311,800
State forest	164,300
State forest - net harvestable area	114,300
State forest - areas excluded from harvesting	50,000

Source: National Forest Inventory (2013)
Table notes: (1) National park and State forest areas include forest and non-forest areas

4.1.1 Major forest types in production forests

Figure 2 shows the forest type groupings mapped in State forests in the Eden region, which are consistent with forest type mapping from *Forest Types in New South Wales, Research Note No. 17* (Forestry Commission of NSW 1989)[7].

[7] Forestry Commission of NSW (1965) *Forest Types in New South Wales, Research Note No. 17*. Accessed August 2018: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0014/390011/Forest-Types-in-NSW.pdf

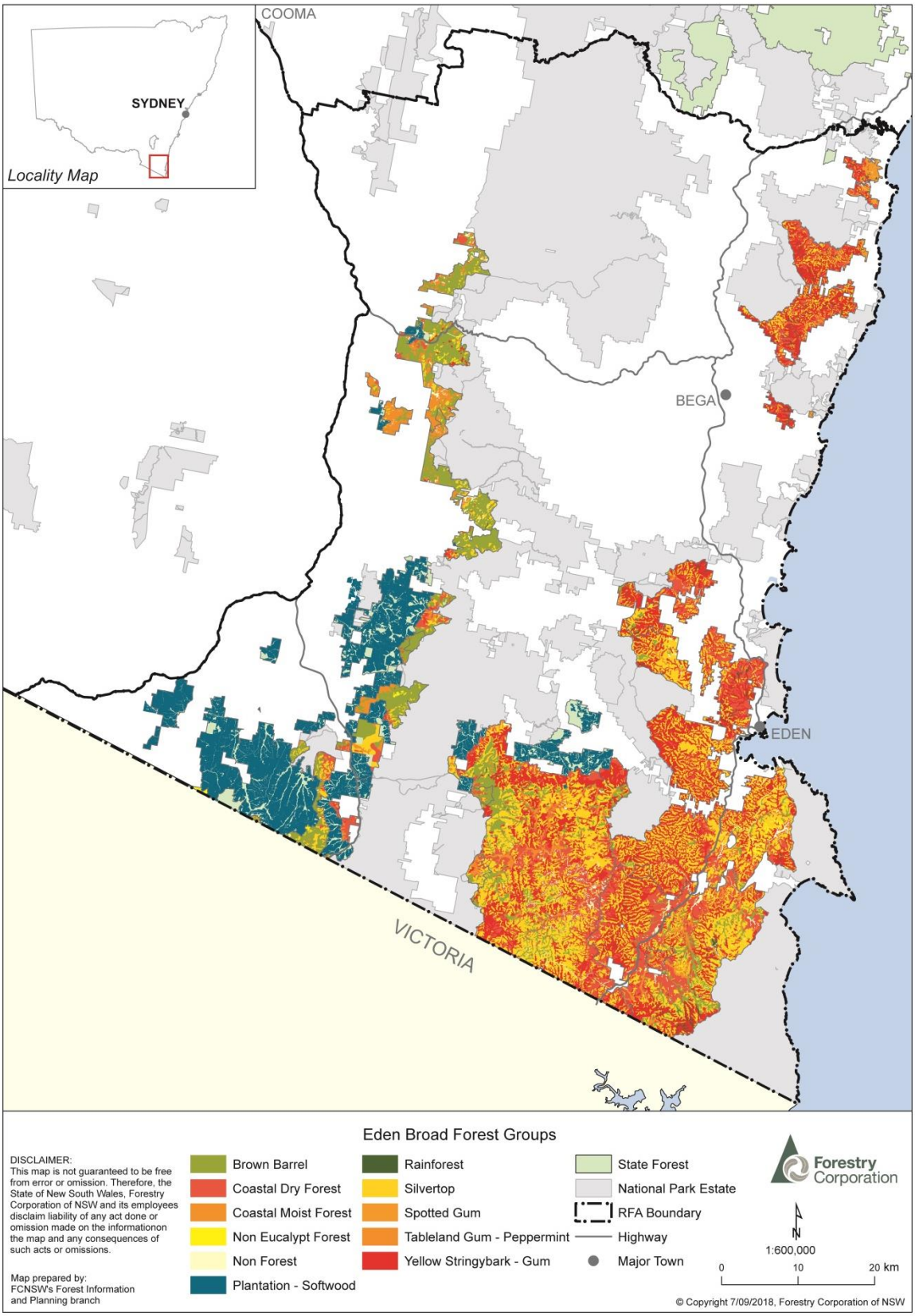

Figure 2: Broad Forest Groups of the Eden RFA region

4.1.2 Industry description

Over the past 20 years under the Eden RFA, the Eden region wood supply has been largely focused on two product groups and two major customers:

- high quality sawlogs, which have been processed at the hardwood sawmill in Eden
- pulpwood, which has been exported as woodchips via the port facility at Twofold Bay in Eden.

The forest resource is transitioning out of older forest and into a regrowth dominated resource, which has significantly changed the average size and quantity of all logs produced. Further information is provided in **section 4.1.4**.

4.1.3 Sustainable wood supply

Annual sustainable yield volumes calculated for the Eden region are shown in **Figure 3** and **Figure 4**[8]. The presented data for high quality product classifications in the figures are indicative yields only and actual supply of these grades of log will vary based on the annual harvesting program.

[8] Note on wood supply charts in this document: High quality log products are measured and sold on a volume (cubic metre) basis, where price often varies depending on the log's dimensions (length and diameter) and/or species. Charts for high quality logs are reported by volume in cubic metres. Low quality logs and pulpwood logs are sold by weight for each product grade and as a result charts describe sustainable yield for these products by weight (tonnes).

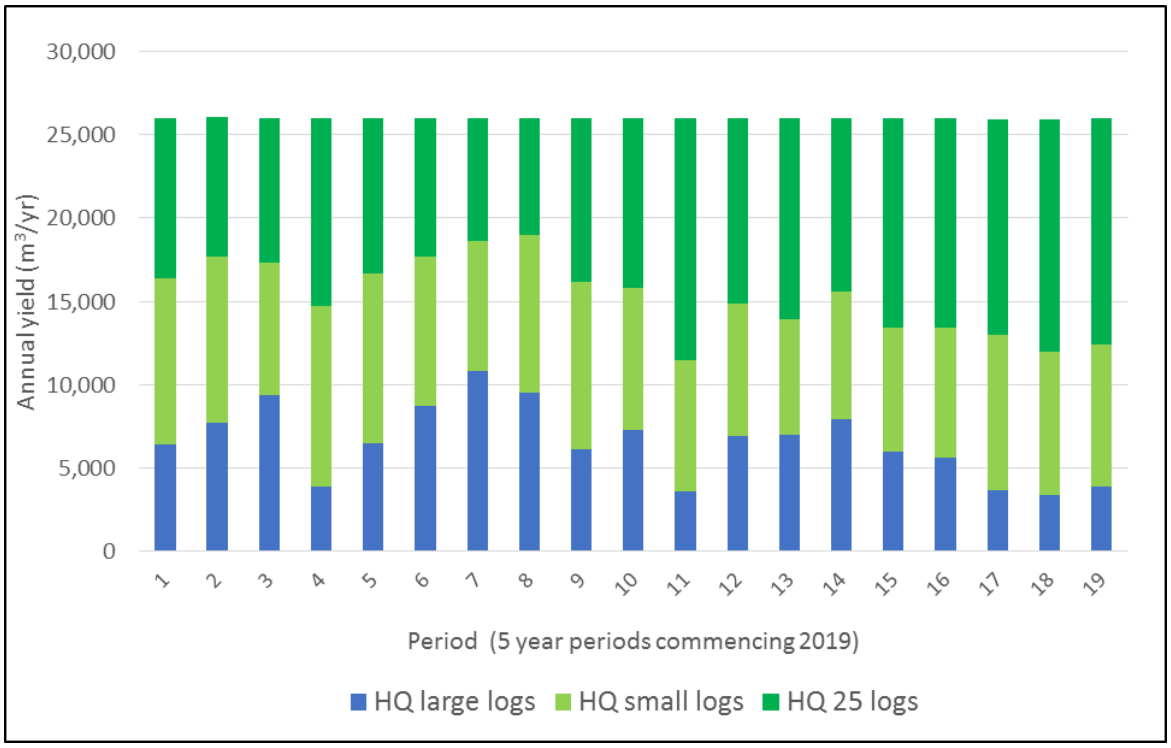

Figure 3: Sustainable wood flow for high quality logs for the Eden RFA

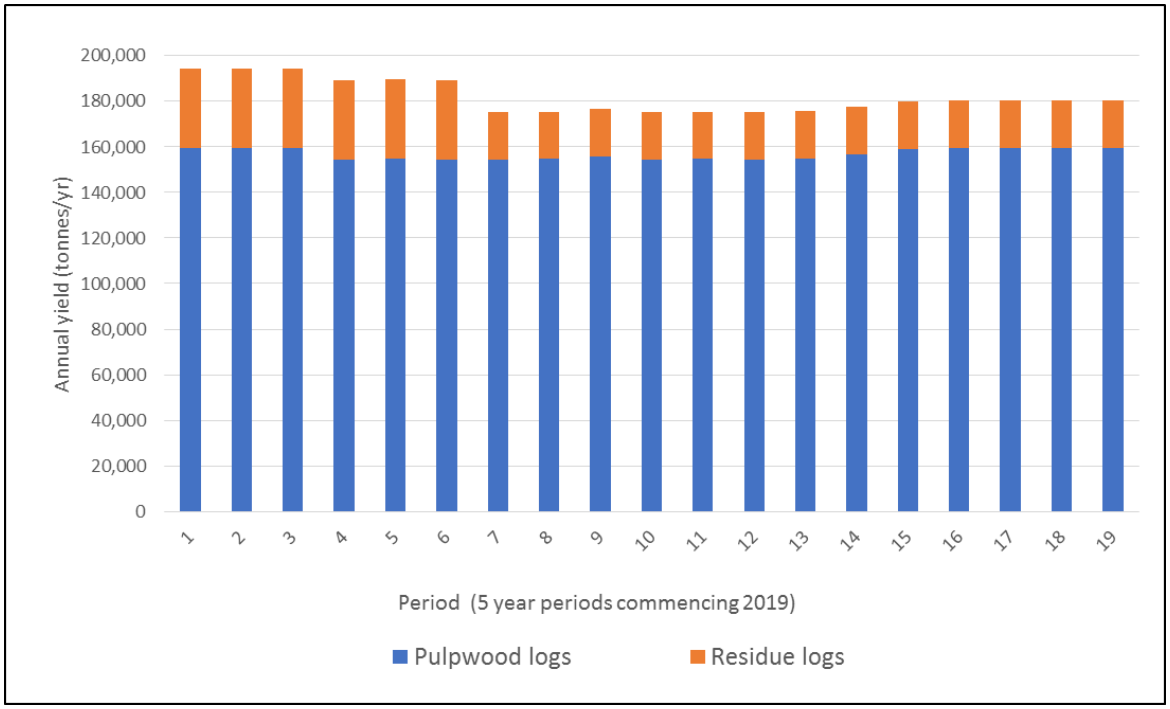

Figure 4: Sustainable wood flow for pulpwood logs and residue logs for the Eden RFA

4.1.4 High quality log supply

The Eden resource is transitioning from forest dominated by older and mixed age forest to one where wild fire regeneration and regrowth from intensive harvesting in the 1970s onwards is dominating the resource profile. This has resulted in a significant change in the nature of log yields and relative product proportions as the proportion of younger age forest

harvested increases. Issues relating to the transition from multi-age forest and older fire regrowth to younger regrowth were identified in the 2012 yield forecasts for the Eden region[9].

In 2016, the Murrah, Mumbulla, Tanja and part of Bermagui State Forests were declared a flora reserve covering 11,860 hectares. The dedication of the Murrah Flora Reserves was made in consideration of the habitat value of these forests for one of the few remaining koala populations in southern NSW. While providing an important conservation outcome, the rezoning of these forests reduced the net harvestable area in the Eden region by 9,700 hectares and resulted in a significant impact on the availability of timber. To address the shortfall in available timber and contracted volumes, the NSW Government committed to short-term supplementary arrangements to meet existing wood supply agreements until they expire.

Figure 5 shows harvesting exclusion zones in the Eden region, with the Murrah Flora Reserves highlighted (shown as 'Flora Reserve Dedicated 2016' on the map legend).

One of the key forest management responses for the Eden wood supply transition is for industry to adjust to processing smaller diameter high quality logs. The current minimum SED for high quality logs in Eden, sold as sawlogs, is 30 cm under bark. The new product class is HQ25 with a SEDUB less than 30 cm and above 25 cm. This transition into smaller high quality log supply will increase the potential long-term level of high quality log production and improve utilisation of the forest resource for local processing.

Since the Eden RFA was signed in 1999, high quality large logs have made up approximately 90% of the high quality log volume sold as sawlogs.

From 2019, the proportion of HQL in the total supply will reduce to around 25% of the total high quality log volume. There will be a reduction in annual HQL harvest volumes from approximately 20,000 m^3 to approximately 6,500 m^3. HQS and HQ25 will make up over two thirds of the total high quality log volume over the length of the modelling time-horizon.

The transition into supplying smaller high quality logs will impact both harvesting contractors and timber processors, as systems and equipment will need to change to efficiently handle the smaller logs and reduced average piece size. Success of the transition will be reliant on adaptation of the industry and the high quality log market to the smaller diameter product.

[9] Forests NSW (2012) *Yield forecasts – Eden Regional Forest Agreement*. Accessed August 2018: http://www.forestrycorporation.com.au/__data/assets/pdf_file/0010/439417/Yield-forecasts-eden-regional-forest-agreement.pdf

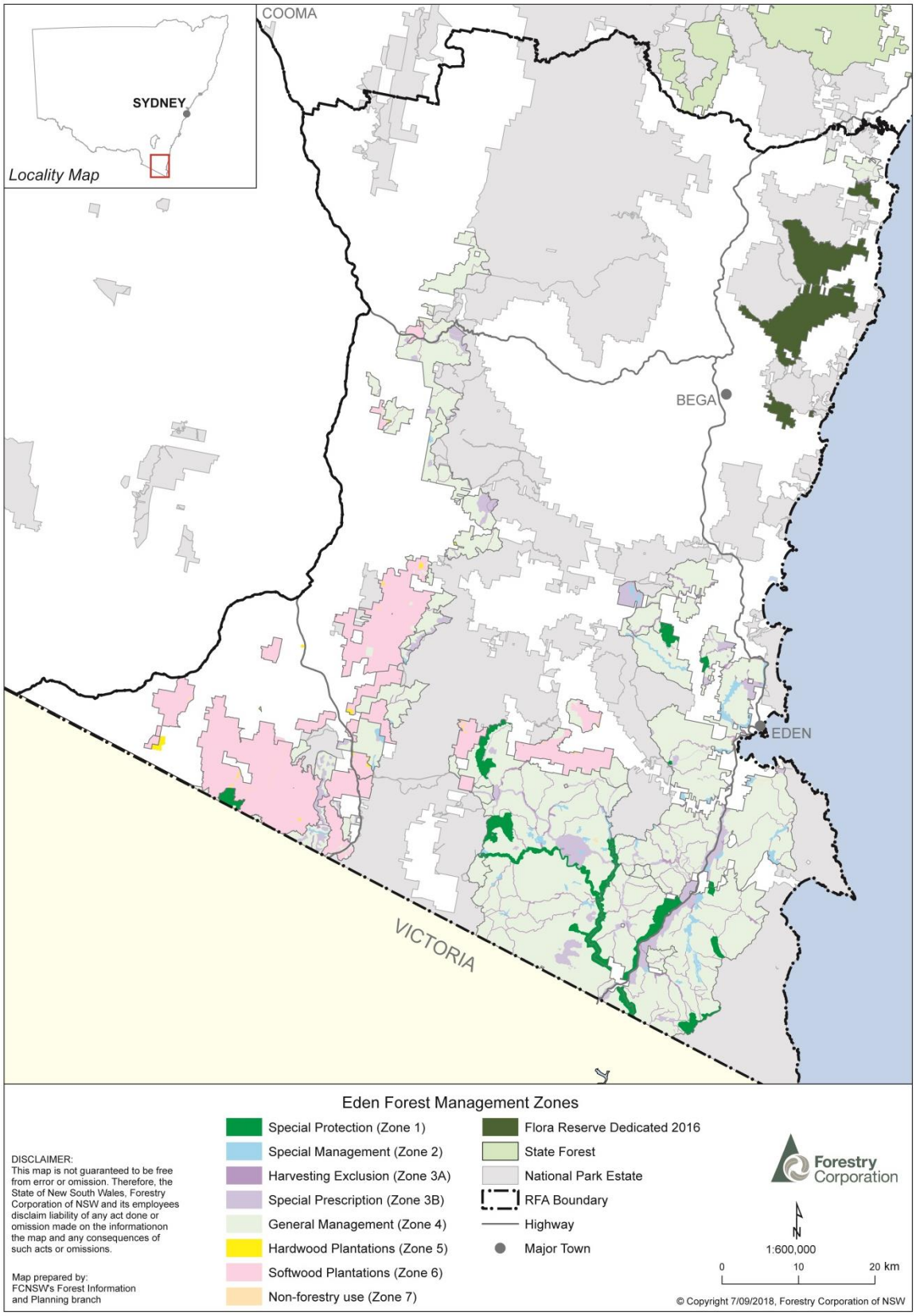

Figure 5: Forest Management Zones of the Eden RFA region

4.1.5 High quality log modelling assumptions

Recovery factors applied in the Eden model are lower than other regions, which means that trees that are visually assessesd as high quality have a lower likelihood of meeting log grading requirements when graded due to internal defects not visible in a standing tree. The recovery factors used are based on local studies using visual grading. As the Eden resource fully transitions to smaller regrowth forest, and new processing facilities are likely to be required to process the logs, there is a significant chance that the recovery factors will need to be monitored and reviewed in the initial years of operation as small sawlog harevsting is normalised and actual yield data is available for verification of the recovery factor.

In order to manage this issue Forestry Corporation will work co-operatively with the NSW Government to report any changes in log quality assumptions and log grading systems that could impact log quality assumptions in modelling and work towards adjusting the sustainable yield modelling if required.

4.1.6 Pulpwood and residue log supply

The modelling shows that pulpwood log supply can be sustained at around 160,000 tonnes per year for traditional pulp species. This pulpwood supply is predominantly made up of regrowth logs that are too small and otherwise out of specification due to defect to be sold as high quality logs, but does also include larger logs which contain significant defects that make them unsuitable for high quality logs.

Additional volumes of species with fibre and wood properties that are not suitable for current markets but could potentially be utilised for new residue products have also been captured in inventory measurements. Forestry Corporation estimates that an additional 35,000 tonnes per year of eucalypt and non-eucalypt non-high quality products could be made available to industry. Forestry Corporation will make further refinements to this estimate should a market opportunity for this wood product arise.

4.2 Southern Region - South Coast sub-region

The South Coast sub-region resource is made up a mixture of coastal spotted gum and associated dry and moist eucalyptus forests, including small areas of blackbutt (*E. pilularis*), foothills forests (predominantly stringybarks (e.g. *E. agglomerata*), silvertop ash (*E. sieberi*) and gums (e.g. *E. cypellocarpa*)) and tablelands forests (brown barrel (*E. fastigata*) and associated types).

The area of forest and major public land tenures in the South Coast sub-region are provided in **Table 4**.

Table 4 Forest areas in the South Coast sub region

Area of forest and tenures in the South Coast sub-region[1]	Area (hectares)
Total forested area – all tenures	1,331,200
National park	848,700
State forest	200,400
State forest - net harvestable area	98,100
State forest - areas excluded from harvesting	102,200

Source: National Forest Inventory (2013)
Table notes: (1) National park and State forest areas include forest and non-forest areas

4.2.1 Major forest types in production forests

Figure 6 shows the major forest type groupings mapped in State forests in the South Coast sub-region, which are consistent with forest type mapping from *Forest Types in New South Wales, Research Note No. 17* (Forestry Commission of NSW 1989).

4.2.2 Industry description

The South Coast forest resource and associated wood supply has historically been dominated by spotted gum (*Corymbia maculata*) in the coastal forests and brown barrel (*E. fastigata*) in the tablelands forests. Blackbutt (*E. pilularis*), bluegum (*E. saligna*) and the ironbark and stringybark species groups have typically made up the remaining minor component of wood supply.

Since the commencement of the Southern RFA, the South Coast sub-region wood supply has largely focused on sawlog production, with firewood and pulpwood logs being produced as by-products of harvesting.

In recent years, the majority of the sawlog resource from the South-Coast sub-region has been processed at sawmills in Ulladulla, Eden, Nowra and Narooma. The balance of sawlogs from the region has gone to a range of smaller local sawmills scattered across south east NSW and eastern Victoria. Over the last 15 years the total sawlog supply including high quality and low quality logs from the South Coast sub-region has averaged approximately 68,000 m^3 per year.

Pulpwood logs from the South Coast sub-region have largely been exported as woodchips via the Eden export facility. Over the last 15 years the overall pulpwood log supply from the South Coast sub-region has averaged approximately 68,000 tonnes per year, with a peak of 106,919 tonnes in 2010 and a low of 34,237 tonnes in 2014.

In recent years, pulpwood markets have become more restricted, and firewood has become a significant component of the South Coast sub-region wood supply with firewood log sales reaching almost 40,000 tonnes in 2017.

4.2.3 Sustainable wood supply

Figure 7 shows the non-declining yield modelled for high quality logs in the South Coast sub-region. The presented data for high quality product classifications are indicative only and actual supply of these grades of log will vary based on the annual harvesting program. **Figure 8** provides the estimated yields for non-high quality products.

4.2.3.1 High and low quality log supply

Sustainable yield modelling shows that high and low quality logs can continue to be supplied at levels comparable with recent supply from the South Coast sub-region; however, maintaining this supply level would require a significant change in the typical log species mix supplied and the historical areas of supply. Historically, a greater proportion of high quality log production has been spotted gum from coastal forests.

To meet the long term yield as modelled, high quality logs would need to be increasingly supplied from foothill and tablelands forests. Historically yields from these forests have been difficult to obtain due to issues with the terrain, accessibility of harvest areas and high proportions of low quality and residue logs. While these areas remain a potential source of high quality logs in the region, the increased costs to harvest and the reduced quality within the yield may make these areas economically unviable to harvest.

4.2.3.2 Pulpwood and residue log supply

The modelled potential yield of pulpwood and residue logs is predicted to remain at levels well above current demand. These products will continue to be made available to the market as they arise from timber harvesting.

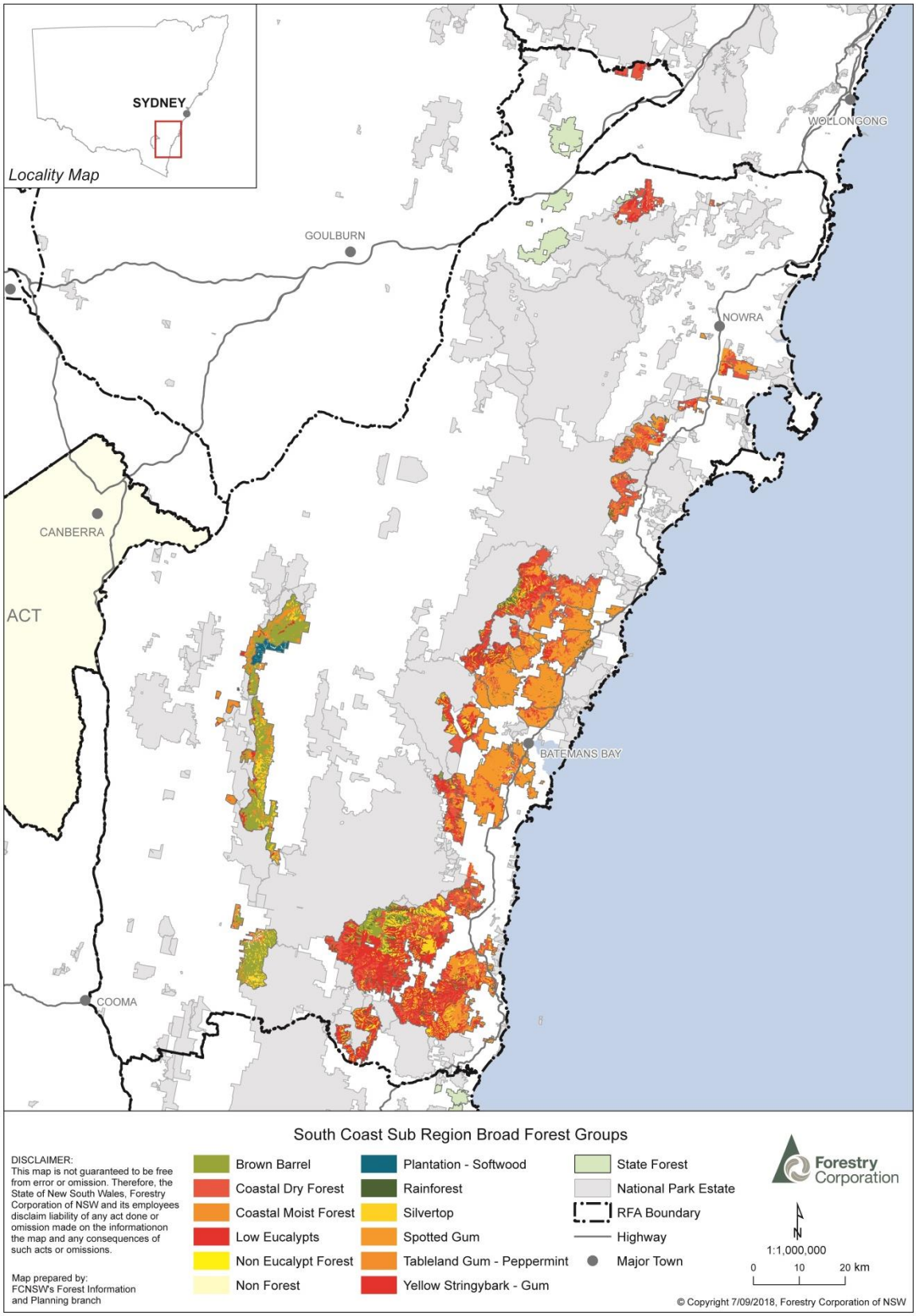

Figure 6: Forest types across the South Coast sub-region

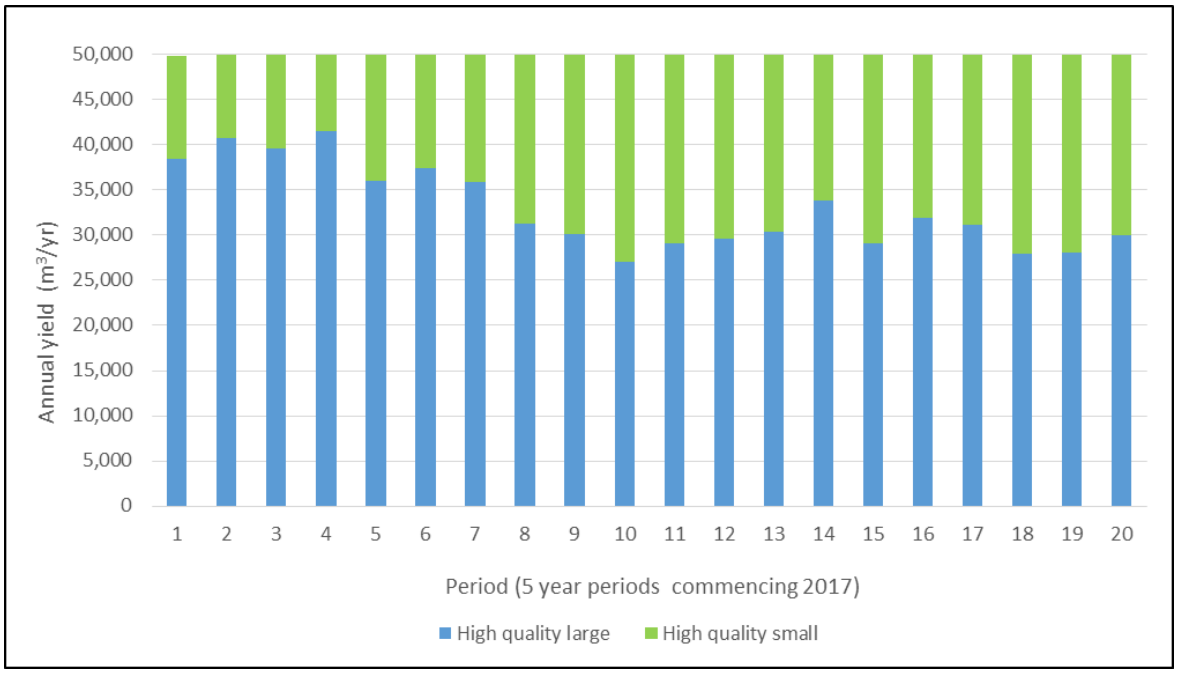

Figure 7: Sustainable wood flow for high quality large and small logs for the South Coast sub-region.

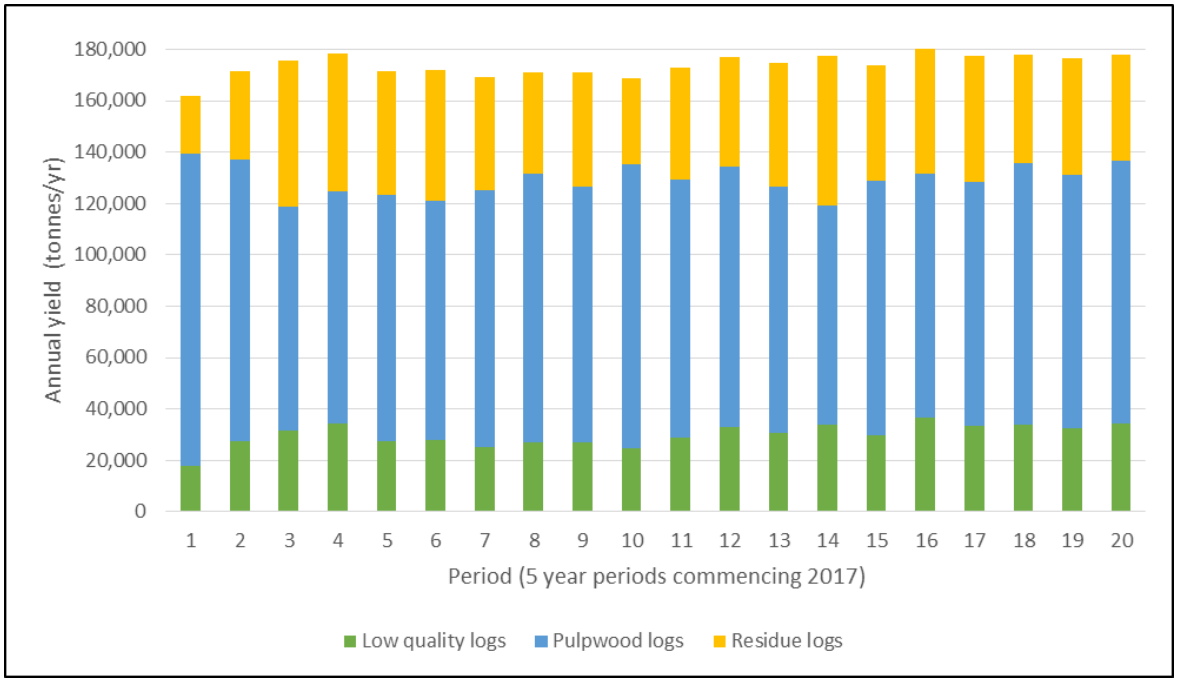

Figure 8: Sustainable wood flow for low quality, pulpwood and residue logs for the South Coast sub-region.

4.3 Southern region - Tumut sub-region

Native forests in the Tumut sub-region are dominated by highly productive alpine ash (*E. delegatensis*) forests with some areas of other medium to high altitude eucalypts such as mountain gum and peppermints (*E. dalrympleana, E. radiata, E. dives*) of lower commerciality.

The majority of the production forests in the region are located between the Victorian border and to the east of Tumut, mostly in areas above 500 m in altitude. Bago and Maragle State Forests are two of the larger production forests in the region.

The production forests of the Tumut sub-region have had a history of landscape scale forest regeneration events resulting from a combination of extensive bushfires and heavy harvesting in the early twentieth century. A mosaic of different silvicultural regimes has shaped the forests in the intervening years.

The area of forest and major public land tenures in the Tumut sub-region are provided in **Table 5**.

Table 5 Forest areas in the Tumut sub region

Area of forest and tenures in the Tumut sub-region[1]	Area (hectares)
Total forested area – all tenures	1,393,700
National park	736,600
State forest	65,100
State forest - net harvestable area	37,400
State forest - areas excluded from harvesting	27,700

Source: National Forest Inventory (2013)
Table notes: (1) National park and State forest areas include forest and non-forest areas

4.3.1 Major forest types in production forests

Figure 9 shows the forest type groupings mapped in State forests in the Tumut sub-region, which are consistent with forest type mapping from *Forest Types in New South Wales, Research Note No. 17* (Forestry Commission of NSW 1989).

4.3.2 Yellow bellied glider management

In 2010, the NSW Government listed the Bago Plateau yellow bellied glider population as an endangered population. Consequently, harvesting operations ceased in the habitat of the endangered population and log production was significantly reduced in the Tumut sub-region from around 21,000 m^3 per year to between 3-5,000 m^3 per year. The NSW Environment Protection Authority and Forestry Corporation worked on a population

management plan for the endangered population and in 2013 the plan was released[10]. Harvesting operations then resumed with new prescriptions. Log sales were re-established, increasing to approximately the same level of supply prior to 2010. Forestry Corporation undertakes regular monitoring of the Bago Plateau yellow bellied glider population under this plan.

4.3.3 Industry description

For the past 18 years under the Southern RFA the Tumut sub-region wood supply has focussed on high quality log production from alpine ash (*Eucalyptus delegatensis*) dominated forest types. Low quality logs and intermittent sales of pulpwood logs have also occurred and are produced as a by-product of harvesting from alpine ash and mixed eucalypt forests.

High quality logs from the Tumut sub-region are largely processed into sawn timber by a sawmill in Benalla, Victoria. Over the RFA period, the overall high quality log supply from the Tumut sub-region has averaged approximately 15,000 m^3 per year.

The majority of low quality logs from the Tumut sub-region are processed into sawn timber, by facilities located in Tumut and Corryong. Over the RFA period the low quality log supply from the Tumut sub-region has averaged approximately 9,000 m^3 per year.

Between 2004 and 2008, there was also a strong demand for pulpwood, which led to an average of approximately 24,000 tonnes per year of pulpwood logs being produced in the Tumut sub-region over the period. The pulpwood logs were typically transported to an export facility in Geelong, Victoria.

4.3.4 Sustainable wood supply

Annual sustainable yield volumes calculated for the Tumut sub-region are shown in **Figure 10** and **Figure 11**. The presented data for high quality product classifications are indicative only and actual supply of these grades of log will vary based on the annual harvesting program.

These sustainable yield estimates for the Tumut sub-region are based on older inventory and modelling undertaken in 2008. Actual volumes harvested since 2008 are well below the 2008 sustainable yield estimates and Forestry Corporation are in the process of revising the yield model with new inventory and LiDAR data and udpated sustainable yield estimates are due to be released in 2019.

[10] Forestry Corporation of NSW (2013) *Population management plan for the Bago Plateau yellow bellied glider population*. Accessed August 2018: http://www.forestrycorporation.com.au/__data/assets/pdf_file/0008/476396/Population-management-plan-Bago-Plateau-Yellow-Bellied-Glider.pdf

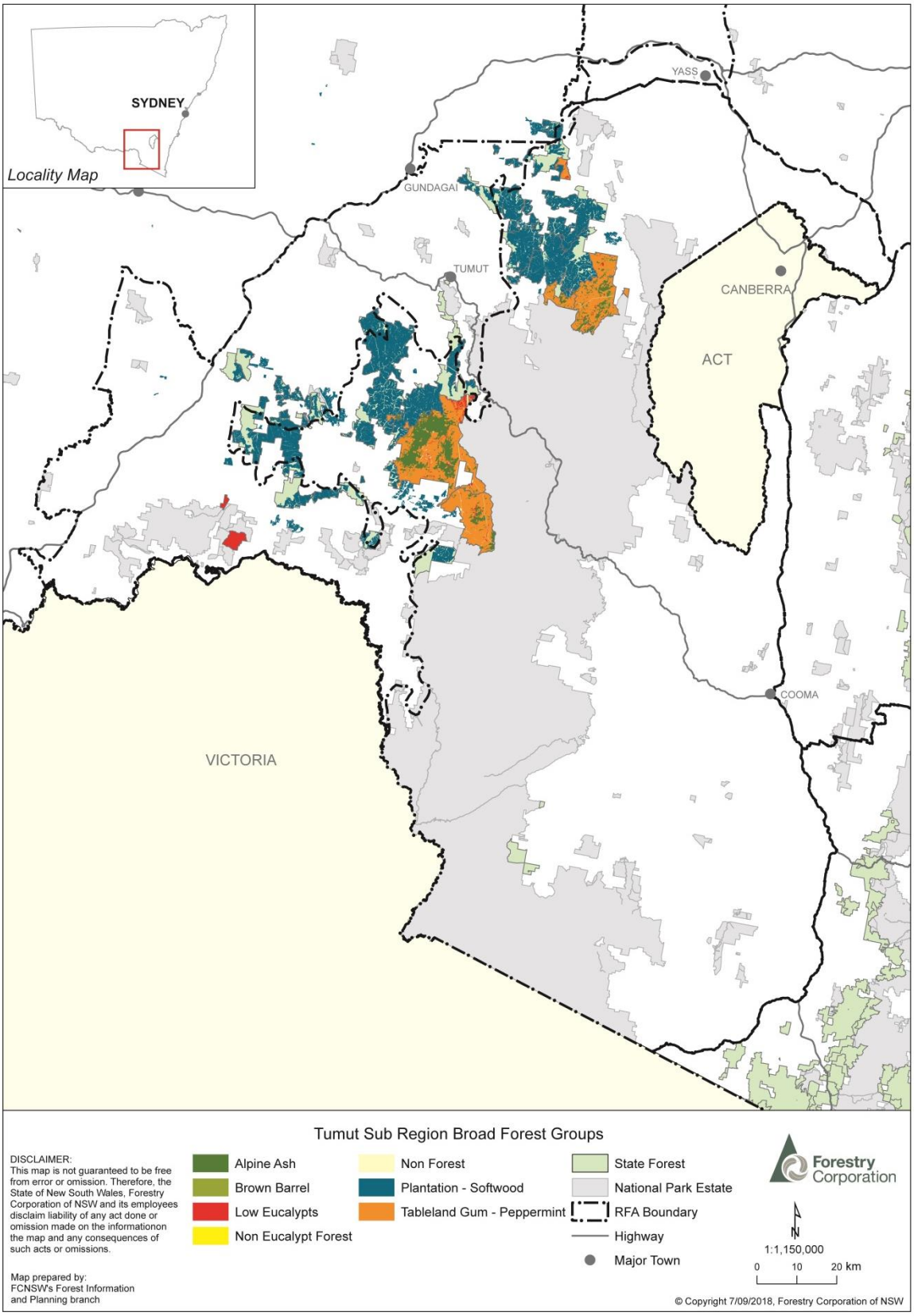

Figure 9: Forest types across the Tumut sub-region

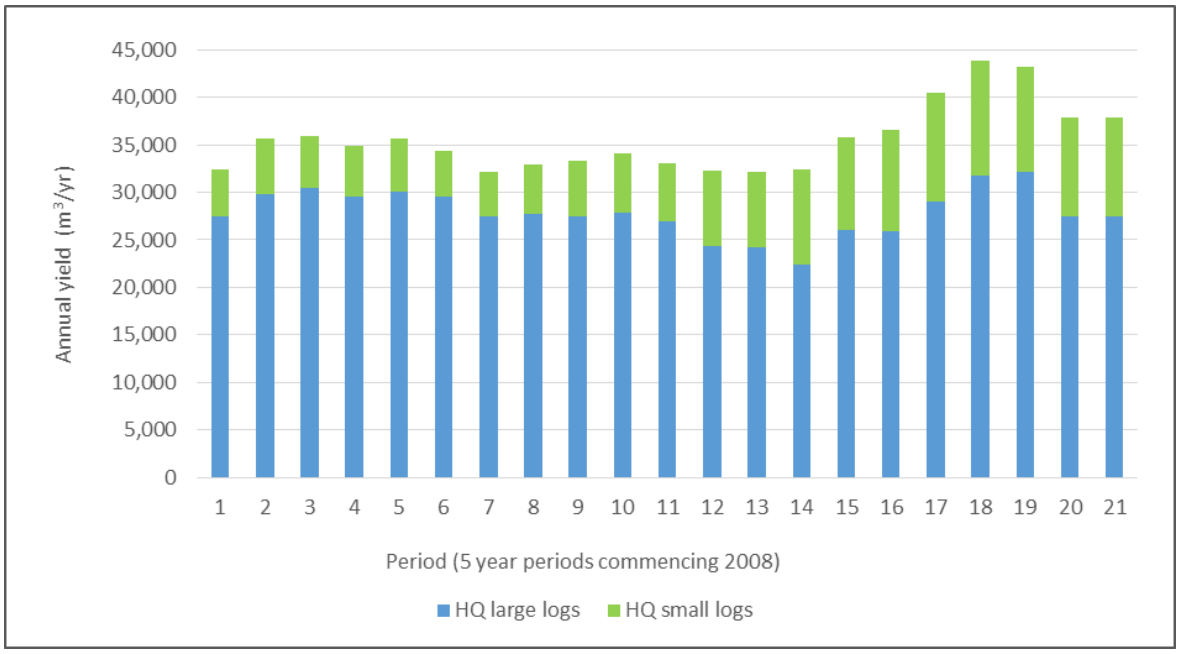

Figure 10: Sustainable woodflow for high quality logs for the Tumut sub-region.

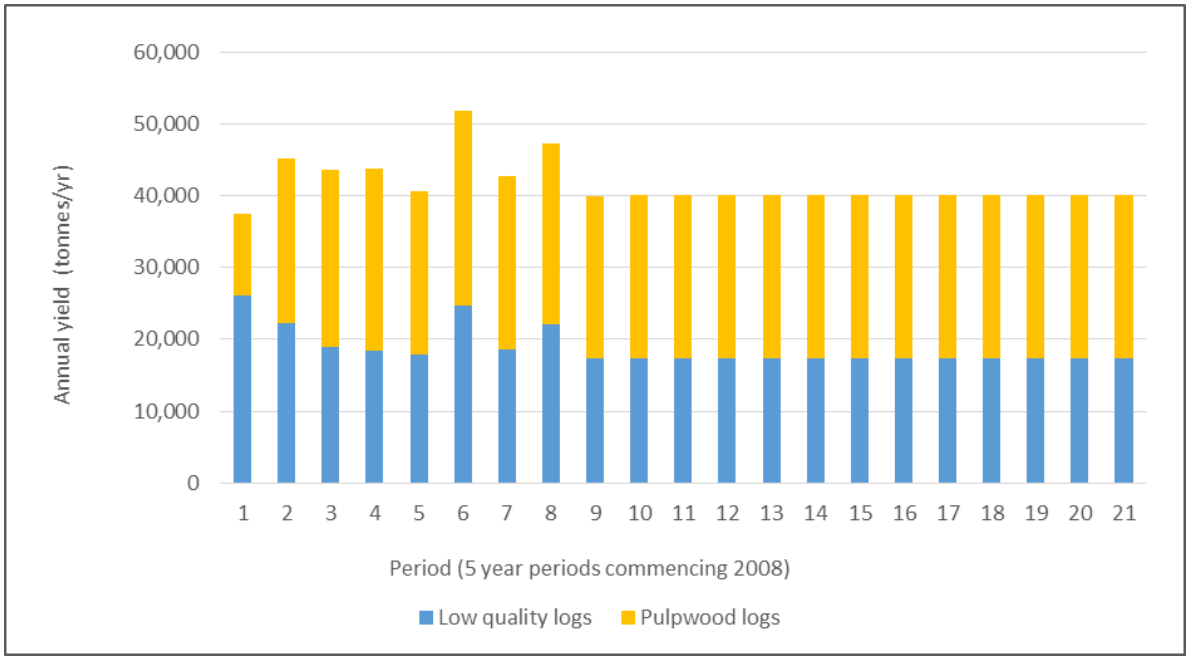

Figure 11: Sustainable woodflow for low quality and pulpwood for the Tumut sub-region.

4.3.5 Future log supply

Forestry Corporation are currently revising growth and yield models within FRAMES for the Tumut sub-region, based on recently acquired LiDAR data and inventory.

Alpine ash high quality logs make up 60 to 80% of the total modelled supply of high quality logs and the majority of the high quality logs harvested are alpine ash. The sustainable yield of pulpwood, residue and firewood logs remains at levels well above current demand. These products will continue to be made available to the market as they arise from timber harvesting operations.

Initial indications from the revised inventory work indicate that sustainable volumes of alpine ash will remain at or above current supply levels. A revised sustainable yield model for all products and species groups is expected to be available to update this report in 2019.

4.4 North East region

The North East RFA region covers a very wide latitudinal range, from the Queensland border, south to Sydney, as well as a large altitudinal range. Consequently, the forests present within the region are complicated and variable throughout.

Important forest types of the coastal regions and foothills include blackbutt (*E. pilularis*), found mostly in higher rainfall areas, spotted gums (*Corymbia variegata, C. henryii, C. maculata*) often with grey gums (*E. propinqua, E. biturbinata)* and ironbarks (*E. fibrosa, E. crebra)* on drier sites or on poorer soils, mixed moist forest (tallowood – *E. microcorys*, Sydney blue gum - *E. saligna*, brush box – *Lophostemon confertus* and grey ironbarks - *E. siderophloia* and others), and mixed dry forests (grey gums - *E. propinqua, E. biturbinata*, ironbarks - *E. fibrosa, E. crebra*).

These forest types are frequently found in a complex mosaic where the mix of species can quickly change based on local landscape characteristics and fire and management history.

Tablelands forests are dominated by messmate (*E. obliqua*), New England blackbutt (*E. campanulata*), ribbon gum (*E. nobilis*) and various stringybark species (e.g. *E. laveopinea, E. cameronii*).

The areas of forest and major public land tenures in the North East RFA region are provided in **Table 6**.

Table 6 Forest areas in the North East RFA region

Area of forest and tenures in the North East region[1]	Area (hectares)
Total forested area – all tenures	6,238,800
National park	2,038,140
State forest	847,400
State forest - net harvestable area	336,900
State forest - areas excluded from harvesting	510,500

Source: National Forest Inventory (2013)
Table notes: (1) National park and State forest areas include forest and non-forest areas

4.4.1 Major forest types in production forests

Figure 12 and **Figure 13** show the forest type groupings mapped in State forests in the Lower North East and Upper North East regions respectively, which are consistent with forest type mapping from *Forest Types in New South Wales, Research Note No. 17* (Forestry Commission of NSW 1989).

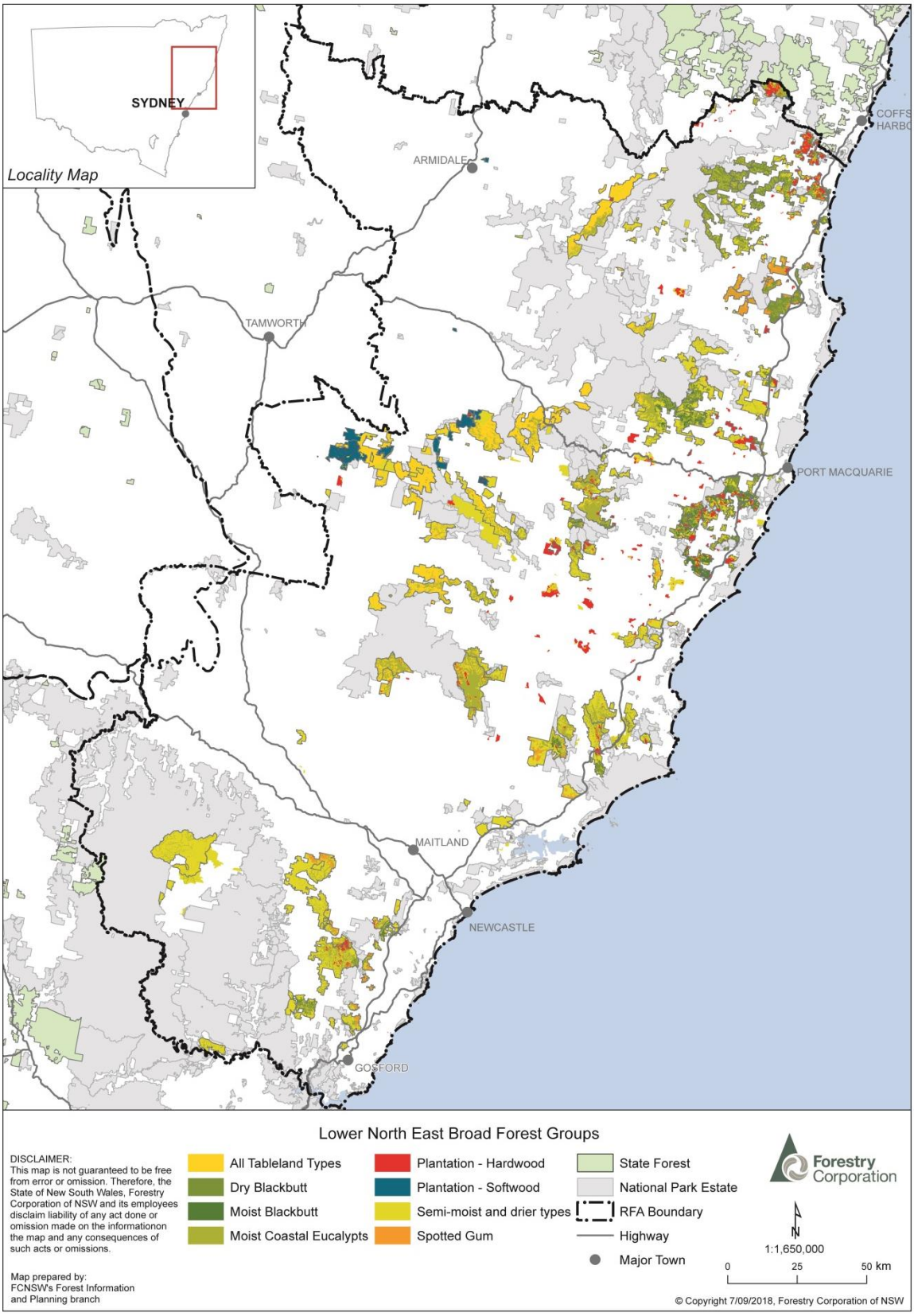

Figure 12: Broad forest groups of the Lower North East region

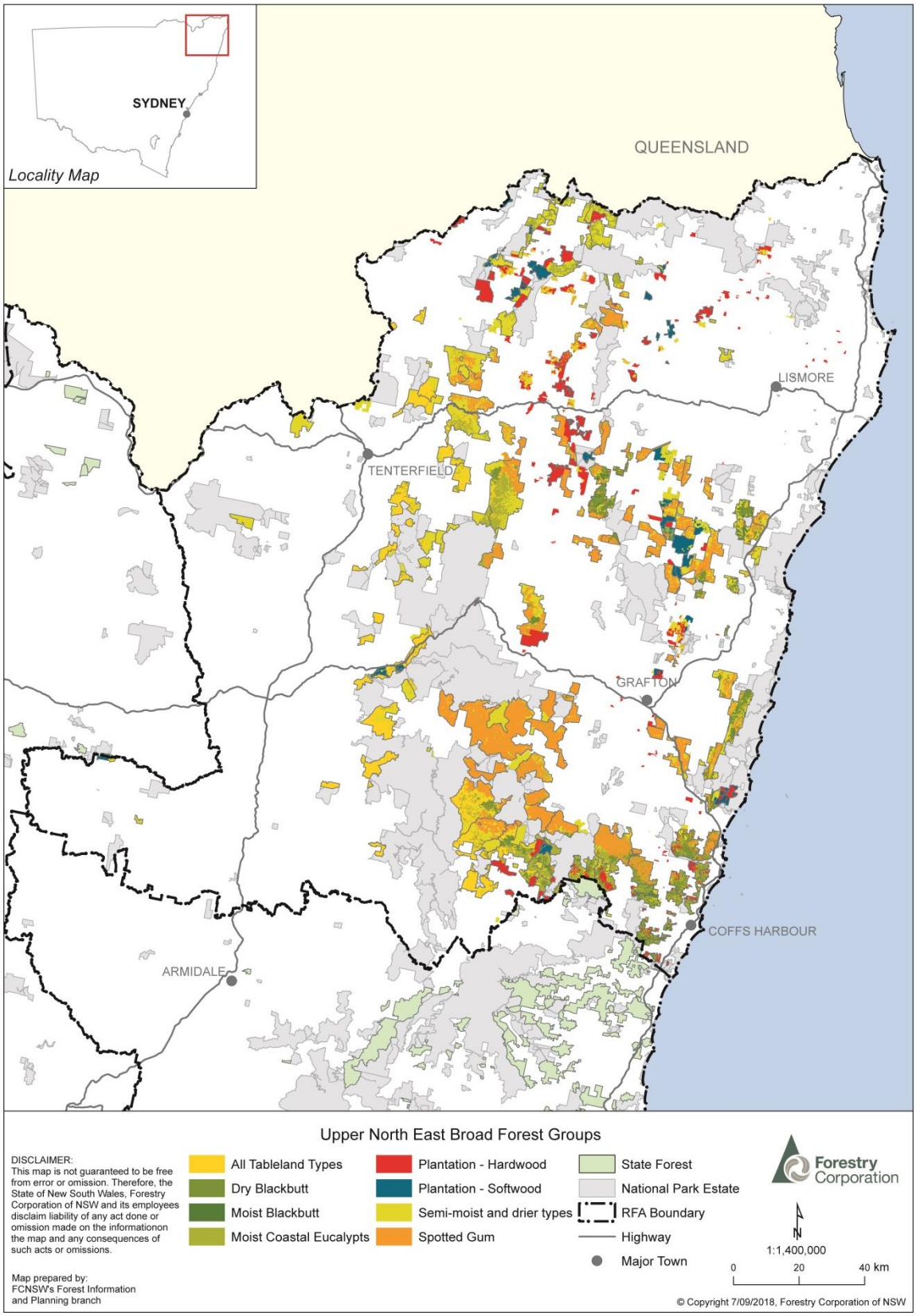

Figure 13: Broad forest groups of the Upper North East region

4.4.2 Hardwood plantation resource

In addition to native forests, the North East region has around 38,000 hectares of native hardwood plantations that are managed largely to provide high quality logs to supplement wood supply from native forests.

The predominant high quality log species planted is blackbutt (*E. pilularis*), but there are also large areas of spotted gum (*E. maculata, E. variegata*) and stringybarks (*E. agglomerata, E. laevopinea*), which contribute significantly to overall wood supply. Substantial areas of flooded gum (*E. grandis*), Dunns white gum (*E. dunnii*), are also planted, but are not expected to produce significant yield of high quality logs due to generally poor wood properties. These species are more often associated with non-high quality product uses, such as pulpwood, due to their inherent wood properties.

4.4.2.1 Historic and current planting program

1960 - 1984

Early hardwood plantations were established by the then Forestry Commission of NSW and Australian Paper Manufacturers Ltd (APM) between 1960 and 1984. These plantings were primarily for pulpwood production and essentially left to grow without any deliberate silvicultural intervention (e.g. thinning). The APM plantations were acquired by the Forestry Commission of NSW in 1983 and a late thinning program was introduced to the resource in 1995 and final harvest with a subsequent replanting program in 2002. The second rotation operations are currently harvesting and replanting at rates of between 300 to 500 hectares per year, and this rate is expected to continue until 2023.

1985 - 1993

Minor areas of plantation were established during the period 1985 – 1994. These plantations are of variable size and quality, and are often in small patches.

1994 - 2003

The balance of Forestry Corporation's hardwood plantation estate was established by State Forests of NSW in part under the North East RFA Hardwood Sawlog Supply Supplementation Strategy (1999 to 2004). This plantation expansion program included the first large scale plantings of Dunn's white gum and spotted gum and also included a range of other species planted in small sections. As well as in State forests, plantings were established on non-State forest land, including private land joint ventures and annuity agreements, though many of these agreements and contracts have since been terminated and any timber expectation associated with them has been removed from FRAMES.

2004-present

New hardwood plantation establishment effectively ceased in 2004 and the plantation program slowed to primarily second rotation establishment. The program to harvest and re-plant timber plantations on the older age class plantations has been ongoing. These new plantings are largely replacing older age class flooded gum and mixed species plantations with blackbutt, which Forestry Corporation anticipate will perform far better on these sites in terms of both growth and yield of high quality log products. Blackbutt is currently a highly sought-after timber for high quality uses such as flooring.

4.4.3 Industry description

The North East RFA region supports a large and diverse timber industry that has largely been focused on higher value, appearance grade solid timber products.

Large sawmilling centres include Kyogle, Casino, Grafton, Bellingen, Kempsey and Heron's Creek. The larger sawmilling enterprises that process high quality logs on the north coast produce a range of value added products including high grade flooring, decking, decorative and structural timber products.

The largest pole processor in Australia is based in Grafton, and other timber pole suppliers are also based within the region. A rotary veneer plant in Grafton produces high quality structural and decorative veneer and plywood products. Low quality logs from plantations supply processors of pallet timbers and roof battens.

In the Hunter region there are several small to medium sawmills processing both high and low quality logs for a range of end uses. There is also a wood fibre panel manufacturer that utilises pulpwood grade logs.

Export facilities at either end of the region, in Brisbane and Newcastle, are capable of exporting wood products that cannot be processed by local industry.

Since 2016, smaller quantities of pulpwood have been exported from Brisbane sourcing logs from hardwood plantation harvesting.

4.4.4 Sustainable Wood Supply

Annual sustainable yield volumes calculated for the North East region, including both the Upper North East and Lower North East regions, are shown in **Figure 14** and **Figure 15**. **Figure 16** and **Figure 17** illustrate sustainable yield by source and species respectively. The presented data for product classifications in these figures are indicative only and actual supply of these grades of log will vary based on the annual harvesting program.

4.4.5 Species groupings

The North East FRAMES wood supply model focuses on species groupings to a greater extent than other models due to ongoing contractual requirements and reliance from the industry. Due to their importance, blackbutt and spotted gum are included individually in the analysis and have their own sustainable yield objectives. Three further species groupings are also used in the model:

- Big 3 Hardwoods: blue gum, tallowwood and brush box.
- New England Hardwoods: high quality log species that occur in association in tablelands forests across northern NSW, including New England blackbutt, mountain gum, messmate and brown barrel, peppermint and stringybark species.
- Other Hardwoods: all other species not covered in the previous two groups.

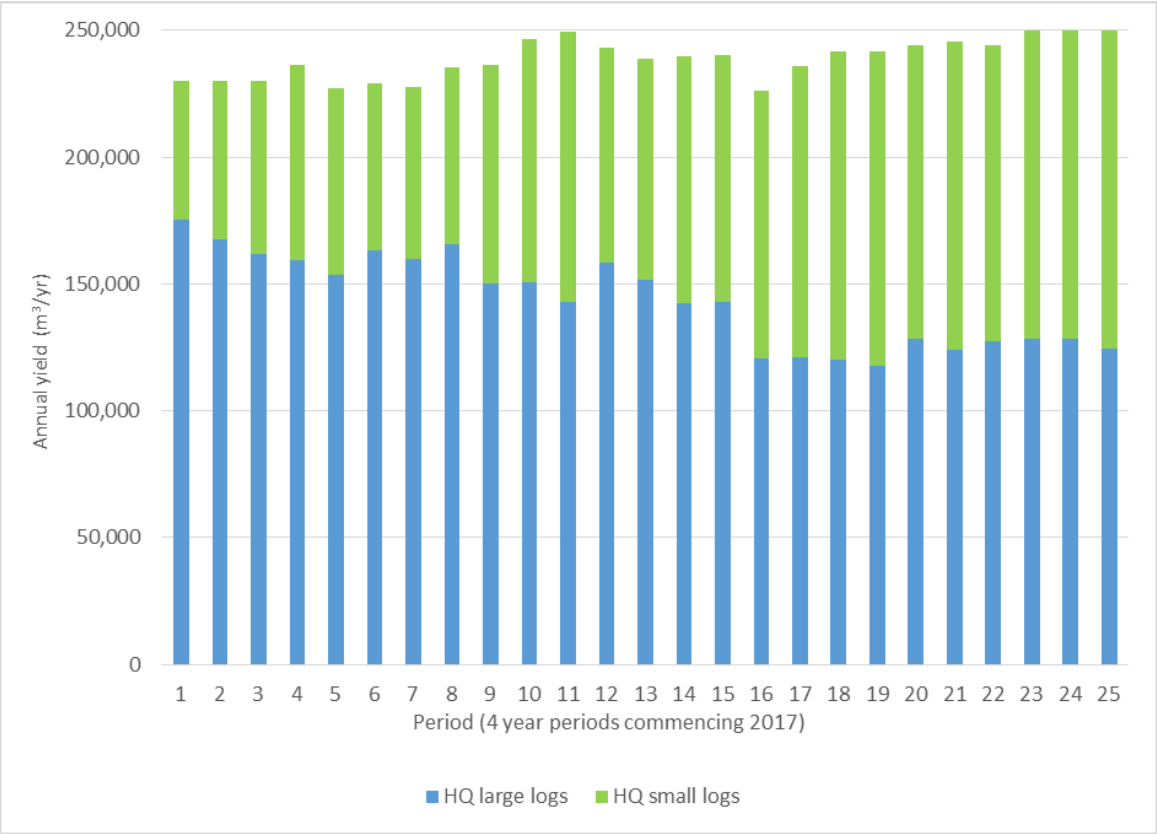

Figure 14: Sustainable woodflow for high quality logs for the North East region.

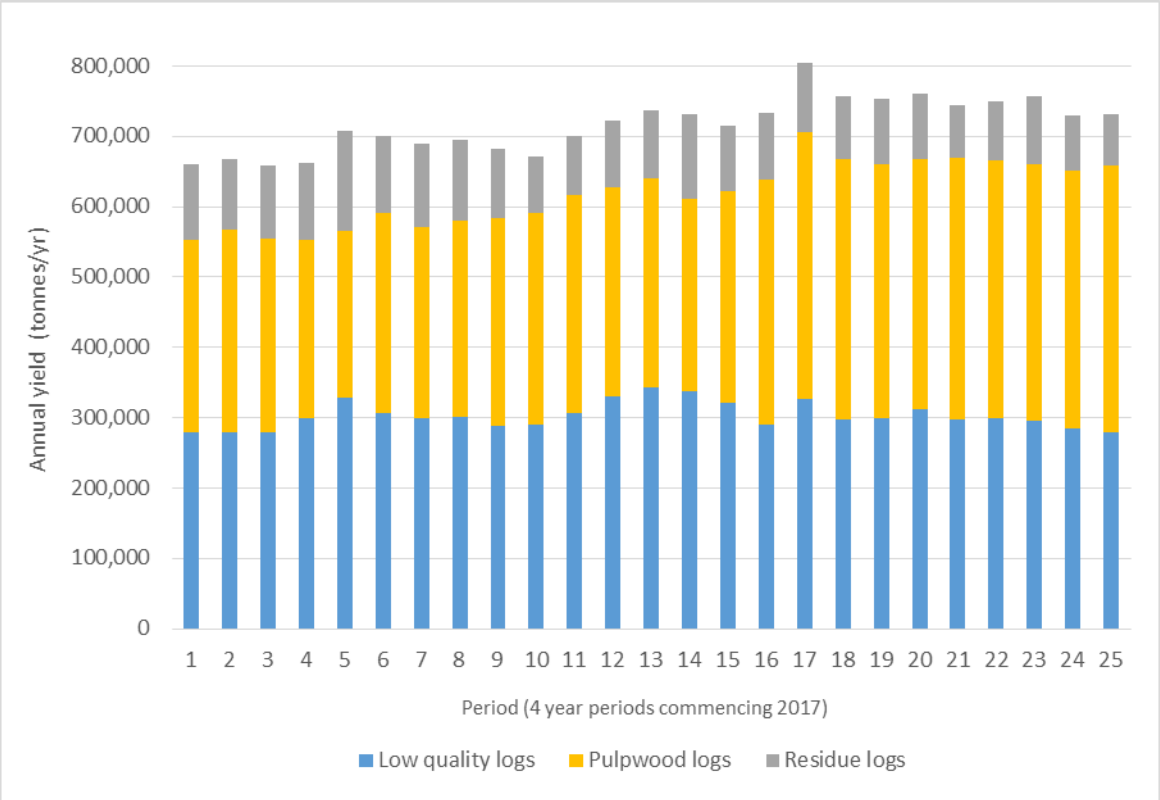

Figure 15: Sustainable woodflow for low quality, pulpwood and residue logs for the North East region.

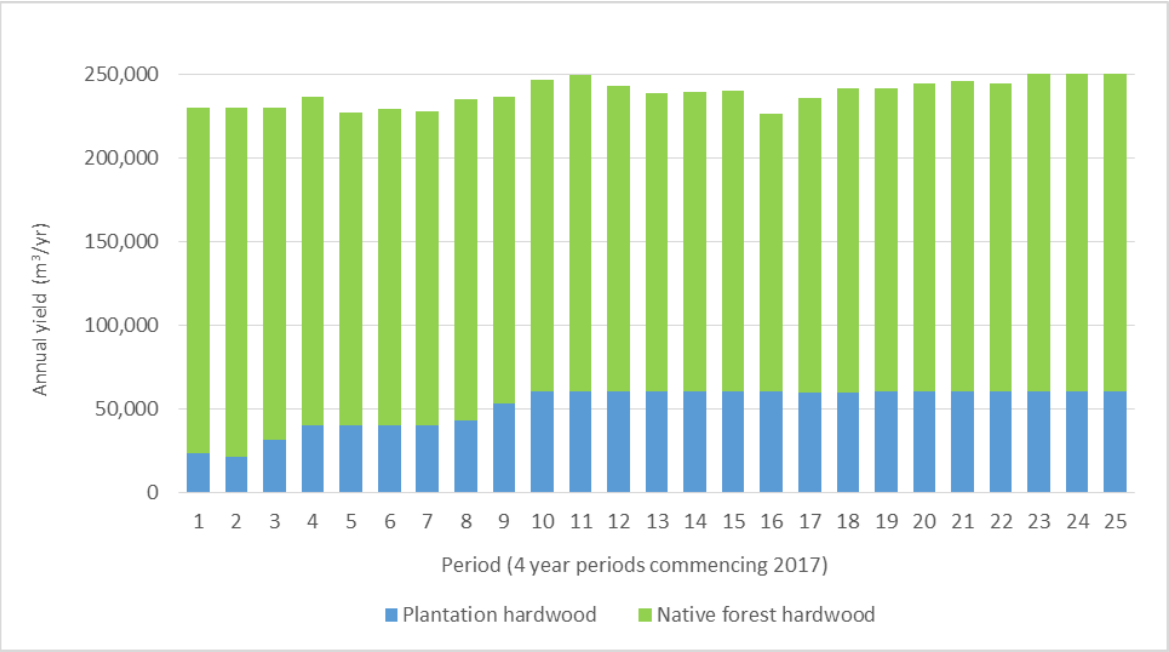

Figure 16: Sustainable wood flow for high quality logs by source for the North East region.

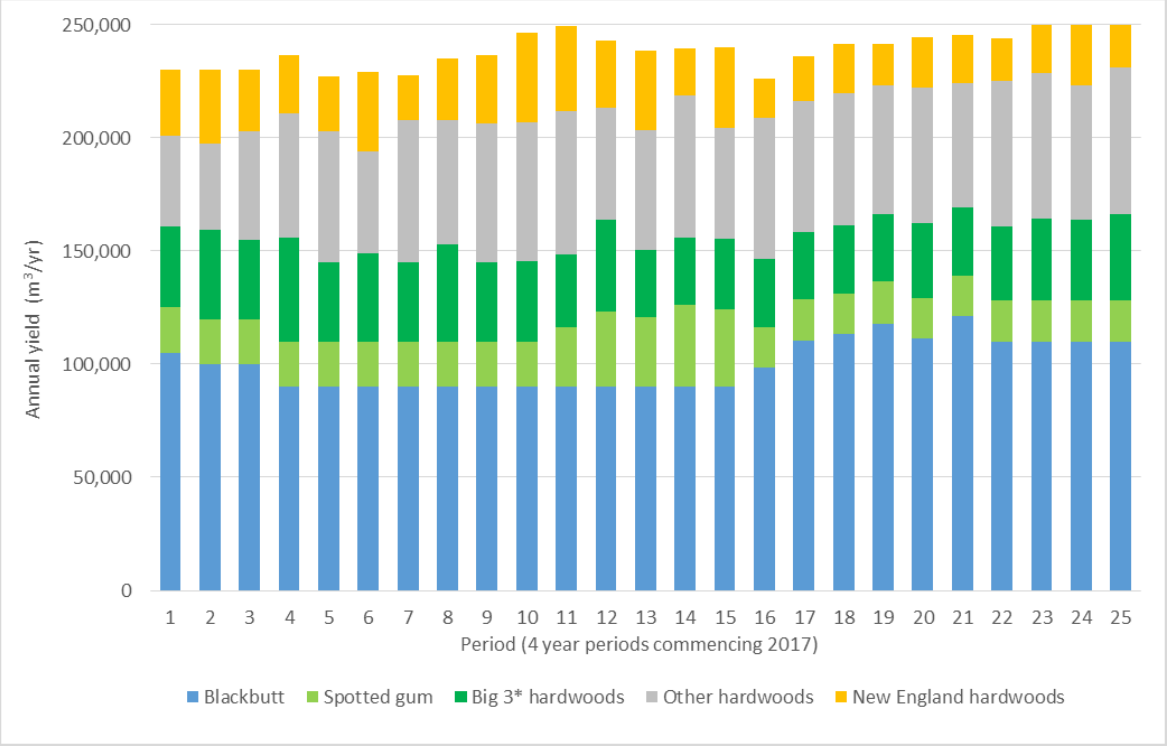

Figure 17: Sustainable wood flow for high quality by species for the North East Region.

4.4.6 High quality log supply

In 2012, the NSW Government commenced Project 2023 – North Coast Resources Review[11], which was a project to investigate issues associated with wood supply on the north coast of NSW. This included sustainability of supply to the end of the term of current wood supply agreements in 2023 and also over the long term. The project was finalised in 2014 with a buy-back of some wood supply, and since then the North East region high quality log supply has been operating on a long term sustainable yield basis for high quality log volumes sourced from native forests and hardwood plantations. This includes a long term even-flow of major species groupings.

Sustainable yield modelling completed for this report, indicates that total high quality log yield is approximately 230,000 m^3 per year and this level is expected to rise to around 250,000 m^3 per year once plantations have reached full production capacity from around 2050. Over the 100 year modelling horizon, the FRAMES projection is for an increasing proportion of the total wood supply of high quality logs is expected to be from high quality small logs, with a long-term trend from current levels at 25% of supply towards 50%. This trend is significantly impacted by the increased supply expected from hardwood plantations, which are modelled to be harvested on a shorter rotation than native forest logs have traditionally been grown.

High quality logs produced in the North East region are committed under wood supply agreements at or close to the modelled long term sustainable level. Forestry Corporation anticipates that these supply levels can continue indefinitely, unless risks to maintaining wood supply arise (**section 3.5**). The profile of logs produced will depend on the specific arrangements made under future wood supply agreements.

4.4.7 Low quality log supply

Low quality yields vary substantially across the different forest types and across the different supply zones, though generally these run at equivalent levels for high quality logs across the combined North East region native forest and plantation hardwood resource.

Low quality log supply is expected to continue to fluctuate due to these factors, as well as local market arrangements and harvesting crew configuration and capacity. These products will continue to be made available to market as they arise from timber harvesting.

[11] State of NSW (2014) *Project 2023 – North Coast Resources Review*. Accessed August 2018: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0013/520042/north-coast-timber-supply-summary-north-coast-forestry-resources-review.pdf

4.4.8 Pulpwood and residue log supply

The modelled potential yield of pulpwood, residue and firewood logs remains at levels well above current demand. These products will continue to be made available to the market as they arise from timber harvesting.

A major source of pulpwood logs and residue logs will be thinning operations in hardwood plantations, which are expected to ramp up in early years of the current model, due to the large age class bunching of timber plantations that are now due for thinning. Removal of these logs from plantation harvesting operations also allows for simpler, lower cost establishment operations as they will no longer remain on the forest floor and will not require treatment as waste such as heaping and burning on site. In the event that a plantation thinning program is able to scale up to meet demand in markets for small low quality and pulpwood logs, the level of pulpwood and low quality log sales may exceed the level forecast in the models presented here. Forestry Corporation will continue to review the level of supply to ensure that it does not compromise long term sustainable high quality log supply.

5 Sustainable yield systems and processes

As discussed in **section 3**, NSW uses FRAMES to determine sustainable yield in RFA regions.

FRAMES was developed in the late 1990s to support the establishment of the RFAs.

The key role of FRAMES is to inform land use decision making processes by modelling the availability of large high quality logs at a strategic level, and to provide an on-going capability for growth and yield modelling in native forests.

FRAMES provides a strategic planning system and is made up of a number of models and input datasets **(Figure 18**).

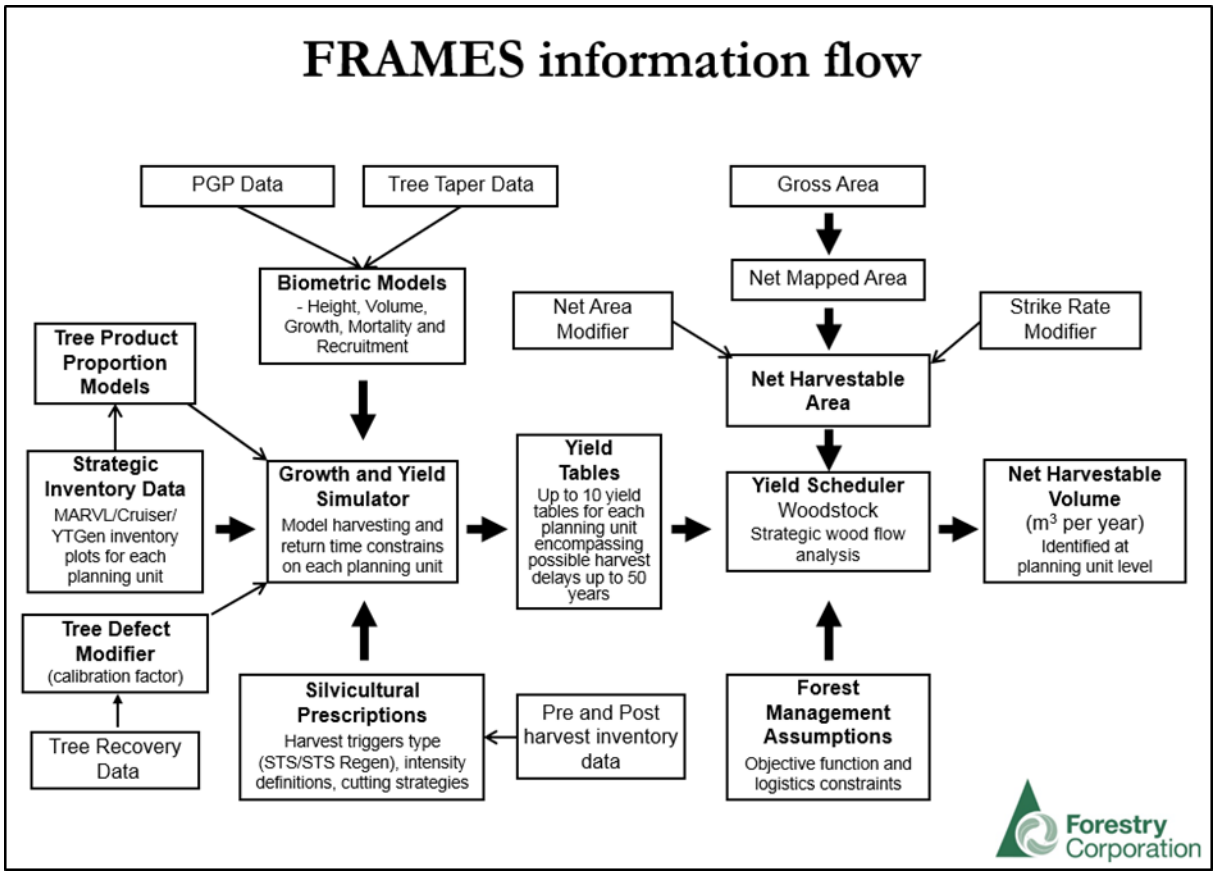

Figure 18: FRAMES models and inputs

Using FRAMES, Forestry Corporation models strategic wood supply projections to meet sustainable yield commitments under the RFAs. The modelling is based on producing a sustainable wood supply across a minimum period of 100 years (i.e. the modelling time-horizon), encompassing multiple harvesting cycles. This approach ensures that the modelled

harvest levels (or yields) and practices do not compromise ecological, environmental or social values across the entire modelled period.

The system has been further developed, refined and adapted to inform strategic planning for native forests and hardwood plantations. Under the continual improvement program, FRAMES has been periodically updated and internally reviewed since its inception, and has also been the subject of several independent reviews, the most recent of which was in 2017[12].

Forestry Corporation continues to evolve FRAMES to take advantage of the best available information such as new mapping or modelling software technologies. The component models are also updated as necessary to capture changes in the forest through maintenance of a strategic inventory plot measurement program, where sections of forest are routinely measured and remeasured throughout the landscape to provide ongoing information on the level of standing timber and growth of the forest.

The models underpinning the sustainable yield calculations are set up such that wood supply is sourced from the public native forest estate and supplemented, where available, by plantation-sourced hardwood logs from within the Forestry Corporation hardwood plantation estate.

In determining sustainable yield, FRAMES has been used to predict the sustainable supply of high quality logs. The yields of all other wood products determined by FRAMES (i.e. that are not high quality), only arise from operations to produce high quality logs. These operations could include harvesting or thinning operations. This means that the production of non-high quality products, such as pulpwood, residue, or low quality logs, does not drive on-ground forestry operations. The availability of these products to industry is expected to fluctuate over time based on what will be generated by high quality product operations.

Wood supply from private land and other Crown-timber land are not included in long-term sustainable yield estimates. Although Forestry Corporation can enter into commercial arrangements with private land holders from time to time, the irregularity and uncertainty in supply levels from these sources means they are not included in the model. Any forestry operations undertaken in native forest on private land must comply with the Private Native Forestry Code of Practice and meet the ESFM objectives under this code.

The following sections provide information on key systems and processes within FRAMES. A detailed history of development and implementation, and the latest independent review of FRAMES, can be found on the Forestry Corporation website[13&14].

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[12] Brack C (2017) *FRAMES Review*. Accessed August 2018: www.forestrycorporation.com.au/__data/assets/pdf_file/0011/701849/frames-review.pdf

[13] Forestry Corporation of NSW (2016) *Forest Resource and Management Evaluation System (FRAMES): A Report on its Development and Implementation to 30 June 2016*. Accessed August 2018: www.forestrycorporation.com.au/__data/assets/pdf_file/0016/702007/frames-development-and-implementation.pdf

5.1 Strategic inventory plots

The FRAMES system is underpinned by a network of 3,700 strategic inventory plots, which are established at approximate rates of one plot per 250 hectares (or at higher rates in areas where better data resolution are required). Strategic inventory plots provide a snapshot of forest condition.

These plots are randomly located within the productive forest estate, and periodically measured for:

- tree size (diameter and height)
- tree quality (products).

Plots are nominally measured on a 10-year cycle, and are also remeasured after a harvest event to maintain currency. The aim is not to remeasure the same trees located on the plot, although this may occur, but rather to provide a snapshot of what's there.

Strategic inventory plots provide Forestry Corporation with data on forest condition at a point in time, providing the input to the model in FRAMES where forest harvesting and growth are simulated.

5.2 Permanent growth plots

Complementary to the strategic inventory plots are a suite of permanent growth plots (PGPs), which are permanently marked in the field and more intensively measured. The plot size of PGPs is bigger than strategic inventory plots, they are remeasured at shorter, five-yearly intervals or after harvesting operations, and importantly individual trees are repeatedly measured over time. Re-measurement of PGPs captures regeneration information and any changes in growth rates of remaining trees after harvesting.

The data collected from PGPs are used to generate and update growth, mortality and recruitment models within FRAMES (collectively known as Biometric Models), which in turn are used to project the volume growth of the strategic inventory plots through time.

There are 830 PGPs in RFA regions that cover most forest types and conditions; however, due to tenure changes over time, some forest types are better represented in the PGP program than others.

The recent independent review (Brack 2017) of the PGP program recommended a review of the existing network to better reflect the current distribution of forest types within managed public forests.

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[14] Brack C (2017) *FRAMES Review*. Accessed August 2018: www.forestrycorporation.com.au/__data/assets/pdf_file/0011/701849/frames-review.pdf

5.3 Growth and yield simulator

The growth of trees in strategic inventory plots is projected through time using the Growth and Yield Simulator, which applies the growth models and harvest models to simulate harvesting under differing harvest intensities. A key component of the simulator is the silvicultural models that predict the trees that will be removed from the stand in a harvest event under a variety of harvesting types, examples of which are:

- Selective harvesting, where trees are removed selectively from within a stand, leaving retained trees within the harvest area to grow on to a final crop or where thinning is used to remove less dominant and poor form trees to promote growth on dominant and better form trees.
- Intensive harvesting, where enough trees are removed to provide growth conditions that optimise regeneration of the forest. Habitat and seed trees are retained, but overall removal levels are higher than in selective harvesting. This form of harvesting aims to open up the forest canopy and provide conditions that are conducive to the growth of eucalyptus seedlings.
- Plantation thinning, where intensive thinning is applied to reduce competition on retained stems, providing optimal conditions for growth and log quality.
- Plantation clear fell and reestablishment, which harvests and re-starts a plantation cycle assuming full restocking of the plantation with the most appropriate species for the site.

It is important that silvicultural models reflect the likely harvest methods employed within a region, and Forestry Corporation reviews these models periodically to keep them consistent with current practice, including regional variations.

Predicted timber volumes have a recovery factor applied to account for differences in the predicted and realised volume (often leading to a downgrade of logs). These arise most often through the presence of hidden internal defects in apparently high quality trees, but can also result from visually defective trees providing a higher quality product than anticipated. These factors are applied to species groups and/or geographic regions and are embedded within the Growth and Yield Simulator. The result of simulating growth and harvesting on a strategic inventory plot is a yield table, which integrates all of the sub-models and provides a prediction of timber volume at any future point in time.

5.4 Area estimates

Accurate estimates of the available land base are critical to the model. This is estimated by removing known harvest exclusion areas from the gross land base, with the remainder being the Base Net Area (BNA). BNA is updated regularly to ensure that each model references the best current available area estimate. The accuracy of the BNA estimate is dictated by the quality of the underlying map layers, but Forestry Corporation use the best available estimate at the time of modelling.

Further modifiers are applied to BNA to allow for unmapped or inaccurately mapped areas that will potentially require exclusion or protection during harvesting (e.g. habitat areas for identified fauna or flora, unmapped drainage, unmapped steep areas, inaccessible areas, etc.). These unmapped exclusions occur at a predictable frequency, and are applied to the BNA to

determine a final harvestable area estimate. Collectively these modifiers are termed the Net Harvest Area (NHA) modifier.

Area estimates have been dramatically improved by the acquisition of new technologies that have emerged in recent years, such as LiDAR and GIS mapping, which have improved spatial resolution of terrain mapping beneath the forest canopy. This is a quantum change in mapping quality and precision over traditional air photo based mapping processes.

Nearly all State forests in RFA regions are now covered by LiDAR images of various ages, which have been used to generate high precision terrain models, providing accurate prediction of the presence of exclusion zones associated with steep terrain and drainage features.

5.5 Optimisation

Yield and area estimates are brought together and simulated in a process called optimisation. Linear programming software is used to determine the maximum sustainable yield of target timber products given a range of pre-defined constraints. The models underpinning long-term sustainable yield are designed to maximise the production of high quality logs from State forests and balance environmental and social benefits as per ESFM principles.

Further constraints can be used to limit or maximise the production of particular species and products to reflect realistic economic or logistical constraints on supply across or within a geographic region.

5.6 Allowance for unpredictable events and model error

'Headroom' is an approach commonly used in modelling and planning processes to address uncertainty in balancing supply and demand, or model inputs and outputs. It is used in wood supply projections to allow for unpredictable events or model error and provides a buffer between modelled and harvested yields. All FRAMES models have a headroom factor applied to allow for unforeseeable external events such as fire, major changes to input data, as well as undetected errors within the model parameters. All FRAMES models presented in this report have a 10% headroom factor applied to native forest and older age-class plantations. Younger age-class plantations have a 15% headroom factor applied, as less data are available to predict long term yields, which results in less certainty in the modelled outputs.

5.7 Performance monitoring

The FRAMES system is reviewed and updated periodically for a variety of reasons:

- Regular reconciliation and review of predicted versus actual harvest volumes to review the silvicultural and growth models at least twice in each 5 year period
- Uploading newly collected inventory or area data, or revised growth models
- Independent review of the system framework to ensure continued 'best practice' and to meet requirements under the RFAs.

The most recent reconciliation of actual versus predicted harvest volumes was published in 2016 and covered the period 2010-11 to 2014-15[15]. Forestry Corporation will be undertaking the next reconciliation of actual and predicted harvest volumes in the next twelve months with a public release of the findings in 2019.

The most recent independent review of the FRAMES systems and processes was undertaken in 2017 and the next independent review is due ahead of the next five-yearly review of the RFAs due to commence in 2024.

[15]. FNCSW (2016) *FRAMES Actual vs Predicted Harvest Reconciliation – F2010/11 to F2014/15*. Accessed September 2018: http://www.forestrycorporation.com.au/__data/assets/pdf_file/0005/701852/frames-reconciliation-report-2010-11-2014-15.pdf