Ethanol Technologies Pty Ltd

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Lignocellulosic Feedstock Availability and Accessibility

Undertaken by MBAC Consulting Group

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Ethtec Cellulosic Ethanol Pilot Plant

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Forest and Forest Industry Consultants

Lignocellulosic Feedstock Availability and Accessibility

A report prepared in satisfaction of the Ethtec-ARENA Funding Agreement Milestone 3, Part (viii) Deliverable - Provision of an Independently Prepared Report to include Cellulosic Feedstock Availability in Australian and Asian Markets

Prepared for
Ethanol Technologies Pty Ltd (Ethtec)

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MBAC CONSULTING GROUP PTY. LTD.
A.B.N. 36 126 232 746
1/3 HILL ST, TWEED HEAD, NSW
P.O. BOX 322, TUGUN QLD
AUSTRALIA

MOBILE +61 438 438 892
www.mbac.com.au

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It provides a very high-level description of the potential Availability and estimated relative-Accessibility of lignocellulosic feedstock in Australia. The report contains estimates, predictions and forward-looking statements. MBAC does not guarantee that these estimates, predictions or forward-looking statements will occur as stated. The variation here can be significant.

This is a desk study. Data for this work have been provided by Ethtec, ARENA and other government and commercial published sources. Our use of these data does not suggest we accept the data are reliable. Opinions in this report are based on these data.

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MBAC Consulting Group Pty. Ltd.

Rod Meynink

Director

1 August 2023

Achnowledgements – This project has been undertaken by Rod Meynink (MBAC), Dr. Glenn Dale (Verterra) and Andrew Yates (Verterra).

Cover – Radiata pine plantation mechnaical first-thinning (T1) generating substantial forest residues

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Abbreviations

ABS	Australian Bureau of Statistics
ARENA	Australian Renewable Energy Agency
ACCU	Australian Carbon Credit Unit
BDMT	Bone Dry Metric Tonnes
C&D	Construction and Demolition
C&I	Commercial and Industrial
CEFC	Clean Energy Finance Corporation
CERF	Carbon Emissions Reduction Fund
CGT	Cotton Gin Trash
ERF	Emissions Reduction Fund
GMT	Green Metric Tonnes
H	High
ha	hectare
HWD	Hardwood
L	Low
LGA	Local Government Area
LT	Long Term
M	Medium
m^3	cubic metre
MSW	Municipal Solid Waste
N	Nitrogen
NPI	National Plantation Inventory
pa	per annum
SWD	Softwood
T1	First thinning
T2	Second thinning
VH	Very High
VL	Very Low

Key assumptions for this report

- 1 cubic metre (m^3) equals 1 Green Metric Tonne (GMT) which equals 0.5 Bone Dry Metric Tonnes (BDMT).
- 1 GMT of roundwood (pulpwood or sawlogs) produced from a plantation conservatively generates 0.2 GMTs[1] of waste or residues, from either softwood or hardwood plantations.
- The moisture content of forest waste/residues is 50% i.e. 1.0 GMT equals 0.5 BDMT.
- Costs or prices expressed in cubic metres is the same in GMTs but is double in BDMT's (as it takes 2 GMTs to 'produce' 1 BDMT).
- For pulpwood for conversion into woodchips, 5% of the volume chipped is lost as waste at the chipper and an additional 3% of the screened volume is lost as fines.
- 80% of softwood sawlog Availability is utilised in sawmills which generate 25% of this as waste which presents as either woodchips, sawdust or sawn timber offcuts.
- '*Production*' refers to actual consumption of available material.
- '*Availability*' refers to projected volumes and is always an estimate.
- '*Accessibility*' refers to what can or needs to be 'secured' as a percentage of Availability and is always an estimate.
- $ refers to Australian Dollars, unless otherwise stated.
- All the 'numbers' referred to above are variables in a 'simple' Accessibility model (Appendix 5) developed for this project.

What this report covers

This report focuses on potential lignocellulosic biomass furnish for the ethanol industry and estimates Accessibility for forest based furnish, based on very high-level assumptions. This is 'best thought of' as relative Accessibility rather than an absolute quantity or percentage.

What this report does not cover

This report does not cover biomass competition, collection, compaction, drying, storage, uniformity, moisture content, sustainability, conversion, distance to market, carbon accounting etc. These are 'next-step' type questions.

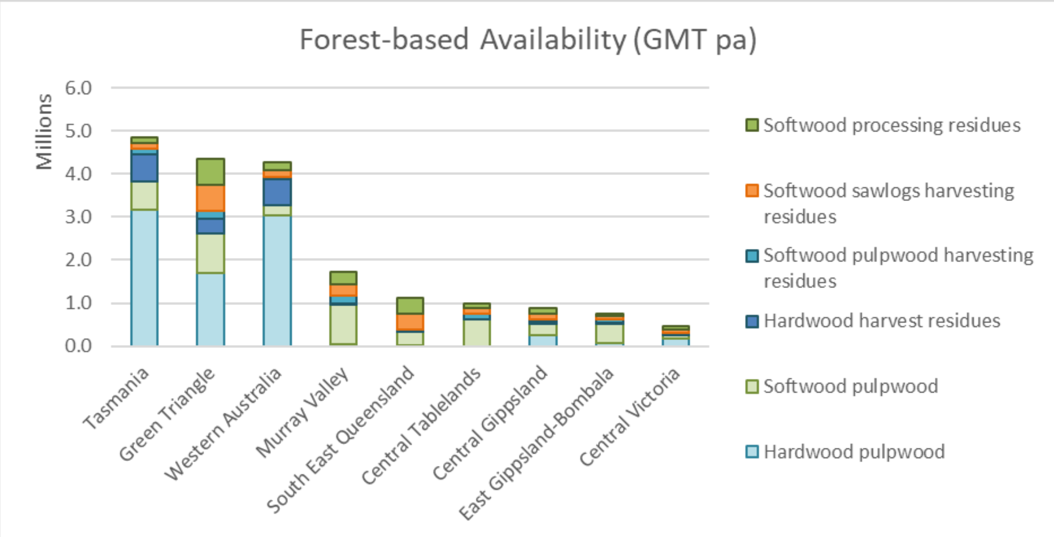
[1] This is a (necessary) gross simplification of the great variability that occurs here.

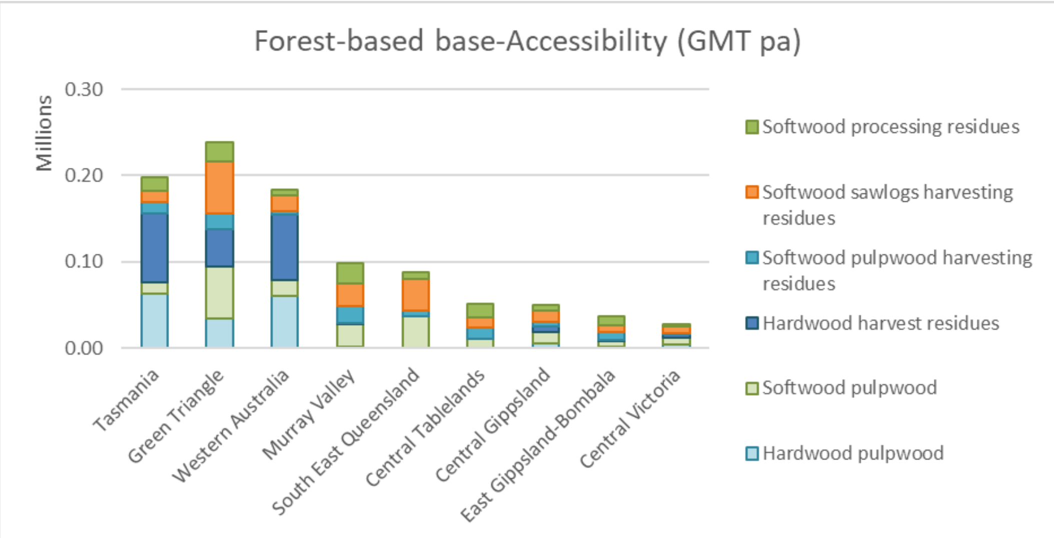
SUMMARY

There is a significant difference between lignocellulosic biomass feedstock 'Availability' and 'Accessibility'. At best, this desk-study can only provide high-level estimates of Availability and even higher-level estimates of Accessibility.

There are many forest-based lignocellulosic feedstock types, including commercial logs (pulpwood converted to woodchips), associated harvest residues and associated processing residues (woodchipping and sawmilling for example). There are also greenfield biomass plantations (i.e. mallee) and non-commercial forest waste/weeds (i.e. camphor laurel trees).

Australian pulpwood from plantations can be converted into woodchips and made available to domestic users prepared to pay the 'price' – which is mostly the export-parity price. The location of the plantations that produce forest products and publicly available estimates of Availability of pulpwood and estimates of residues over time is shown spatially in this report. This is summarised below by the major National Plantation Inventory (NPI) Regions with 'modelled' Accessibility estimates – best 'viewed' in relative rather than absolute terms. For example, there is likely around double the Accessible forest-based furnish in the Green Triangle, Tasmania and Western Australian NPI regions than in The Murray Valley and SE Queensland and even less in the Central Tablelands, Central Gippsland, East Gippsland-Bombala and Central Victorian NPI regions.



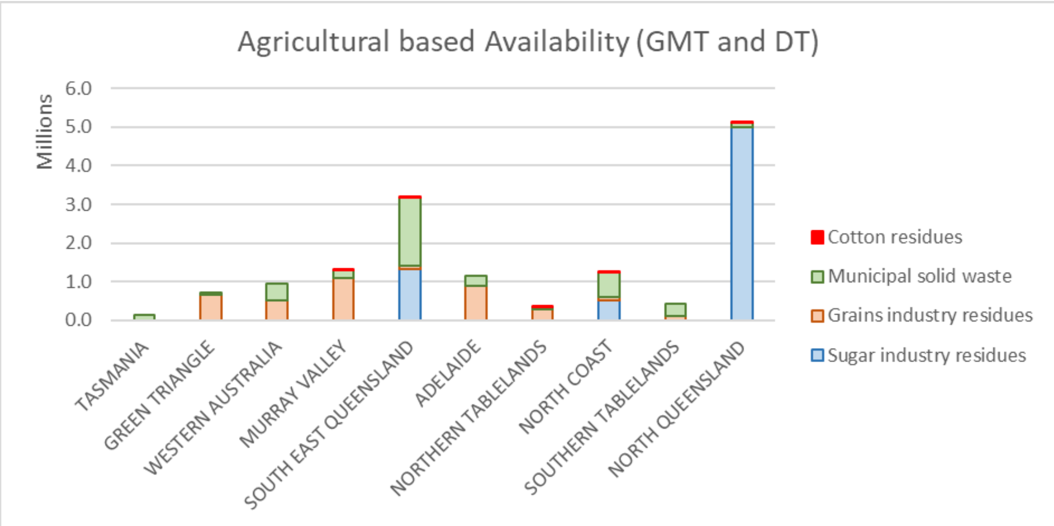


Australian plantation products are sold into both domestic and international markets. The Asia Pacific trade in hardwood woodchips is around 30 million Bone Dry Metric Tonnes (BDMT) per year. Of this, Australia supplied around 5 million BDMT and Vietnam supplied around 15 million BDMT. The supply-demand dynamics here are exceedingly complex and impacts Availability and price of Australian hardwood and, to a lesser extent, softwood woodchips. The forecast is for a significant Asia Pacific deficit of hardwood woodchips.

The report discusses the potential impact on forest-based furnish Availability of commercial carbon farming plantations that can be registered under the Australian Emissions Reduction Fund (ERF) Scheme. Once the pace of carbon farming greenfield plantings becomes measurable, then any impact on woodflows will become available. Regardless, the likely impact on potential furnish is a slight delay in the Availability described above, rather than any dramatic changes.

Carbon forestry may encourage greenfield plantation establishment/new silvo-pastoral plantings, which may expand the potential lignocellulose resource (but also the solid wood resource). However, new carbon plantings for solid wood applications are expected to be more financially attractive than plantings for biomass, so the latter may only be developed where forestry for timber products is not viable, or where environmental co-benefits (e.g. salinity/waterlogging management) provide an additional revenue stream. The scale of any new plantation development is speculation at this point in time, and the products will compete on the same basis as existing plantations.

A wide array of non-commercial forestry lignocellulosic residue sources and residues are generated by various industries, including purpose-grown oil mallee plantations, municipal solid waste, sugar industry residues, grains industry residues, cotton residues, vegetable processing residues, nut residues, fruit residues, orchard prunings, winery residues, and flower industry residues.



Oil mallee plantations, particularly in southwest Western Australia, offer potential lignocellulosic feedstock for bioenergy production, but challenges in harvesting, processing, and transportation may limit economic viability. Municipal solid waste stands out due to its consistent and reliable supply over time and existing infrastructure for aggregation, potentially converting waste into a valuable revenue-generating asset while mitigating greenhouse gas emissions. Sugar cane residues are abundant and conveniently concentrated, but competition arises with energy production from bagasse and soil carbon maintenance. Cereal straw, rice husks, and maize cobs have low moisture content but are not widely utilized in Australia for bioenergy due to their benefits for soil conservation and the energy-intensive process of gathering them. Rice hulls and non-cereal crop residues present opportunities for supplementing forest residues, while cotton residues have potential for bioenergy production, yet storing and converting them can be challenging. Vegetable processing residues, nut residues, and fruit residues offer rich potential sources of ethanol in various regions. Orchard pruning and winery residue quantities are relatively small, while flower industry residues are limited in availability in certain regions.

The apparent Attractiveness of the different furnishes by major NPI region is summarised below.

NPI Region	HWD pulpwood	HWD harvest residues	SWD pulpwood	SWD processing residues	SWD pulpwood harvesting	SWD sawlogs harvesting	Mallee	Non-commercial	Carbon forests	Municipal waste	Grain residues	Sugar residues	Cotton residues
Green Triangle	✓	✓	✓	✓	✓	✓			✓		✓		
Tasmania	✓	✓	✓		✓				✓				
Western Australia	✓	✓							✓		✓		
Murray Valley			✓		✓	✓	✓			✓	✓		✓
South East Queensland				✓		✓		✓		✓		✓	✓
North Coast (NSW)								✓		✓	✓	✓	✓
Northern Tablelands											✓		✓
Mount Lofty Ranges (Adelaide)										✓	✓		
North Queensland												✓	✓
Sub regions													
NE Tasmania – Bell Bay	✓	✓	✓		✓				✓				
Albany Region	✓	✓					✓		✓				
NW Tasmania - Burnie	✓	✓							✓				
Murray Valley (NSW) - Tumut					✓	✓	✓			✓	✓		✓

1 SCOPE

Lignocellulose can be broadly classified into virgin biomass, such as trees (forest-based feedstock in this report), bushes and grasses; waste biomass, such as agricultural waste (corn stover, sugarcane bagasse, straw etc.) and forestry waste (forest residues, sawmill residues and other processing residues).

1.1 AVAILABILITY VS ACCESSIBILITY

There is a significant difference between lignocellulosic biomass feedstock 'Availability' and that which is "… *technically, commercially and sustainably accessible* …"[2] – 'Accessibility' in this report. Conveniently, the Australian Renewable Energy Agency (ARENA)[3] points out that the difference between Availability and Accessibility …

- *"… stems from the practicalities of collection and transport of low energy density, distributed supplies, resource quality, competing uses of resources and other supply chain costs."*
- *"… while reasonably robust data is available to estimate the current theoretical resource potential, limited information is available to assess its current and future, technical, commercial and sustainable Accessibility*."
- "… *even when bioenergy is cost-competitive … the modelling … shows that resources cannot be accessed in sufficient quantities to meet all of the potential demand*."[4]

At best, this desk-study can only provide high-level estimates of Availability and even higher-level estimates of Accessibility – best viewed in relative rather than absolute terms.

1.2 APPROACH

In this report, Availability, quality, price and supply/demand variables are 'quantified' as shown in Table 1. By scaling Availability variables from 1 to 6 or classifying as Low, Medium and High the relative 'sum' by furnish and region 'points' to locations in Australia where Availability may warrant further investigations.

Table 1: Subjective approach to quantifying and qualifying furnish Accessibility

1. Attractiveness	2. Code	3. Availability (GMT pa)	4. Quality	5. Delivered price ($/GMT)	6. Accessibility (% of Availability)
Very High	VH	>10 million	VH	>$0	>20%
High	H	>1 million	H	>$50	10-20%
Medium	M	>100,000	M	>$75	5-10%
Low	L	>1,000	L	>$100	2.5%-5%
Very Low	VL	>=0	VL	>$150	0-2.5%

For (exaggerated) example, for a particular ethanol lignocellulosic furnish in a particular region if Availability attractiveness (column 2 above) is VH, Quality attractiveness is VH and Price attractiveness is VH, then we could assume Accessibility could be Very High i.e. >20,%. Conversely, VL, VL and VL, we could assume Accessibility could be Very Low i.e. 0-2.5%. So, 'middle-ground' M, M and M, we could assume Accessibility could be 5-10%[5].

[2] ARENA 2021. Australia's Bioenergy Roadmap P24

[3] ARENA 2021. P24 "*For the modelling in this* [ARENA] *Roadmap, the Business As Usual scenario assumed on average only 45 per cent of the theoretical potential could be accessed*."

[4] ARENA 2021. P24

[5] This can be changed in the model.

2 TYPES OF FOREST-BASED FEEDSTOCKS

There are several main types of forest-lignocellulosic feedstocks of relevance to this report. These are presented in Table 2 below.

Table 2: Types of forest-based furnish Availability

#	Potential forest based lignocellulosic feedstocks	Source	Predominate species group	Section #
1	Roundwood pulpwood from commercial forests converted to woodchips – thinnings and clearfell	Commercial Forests	Mix	2.1
2	Waste from commercial forest thinning harvesting operations (largely softwood)	Commercial Forests	Softwood	2.2
3	Waste from commercial forest clearfell harvesting operations (softwood and hardwood)	Commercial Forests	Mixed	2.3
4	Standing failed or failing plantations that will be cleared and converted to agriculture (mostly hardwood)	Commercial Forests	Hardwood	2.4
5	Waste from in-forest processing operations (i.e. woodchipping) mostly hardwood	Wood Processing Operations	Hardwood	2.5
6	Waste from centralised processing centres (i.e. woodchipping) mostly hardwood	Wood Processing Operations	Hardwood	2.6
7	Purpose-grown biomass plantations (i.e. mallee plantations) mostly hardwood	Commercial Forests	Hardwood	4.1
8	Non-commercial forests (ie camphor laurel stands) mostly hardwood	Non-Commercial Forests	Hardwood	4.3
9	Waste from processing industry (such as sawmills and wood-based panel mills), which is mostly softwood based	Wood Processing Operations	Softwood	2.7

The interest in this report is pulpwood and residues or waste. This is because pulpwood Availability is high and, for hardwood, is largely exported as woodchips and, to a lesser extent, as roundwood logs. It is these export volumes that 'point' to domestic demand being less than Availability. However, international demand has a significant impact on domestic pricing (as we shall see).

2.1 AUSTRALIAN SOFTWOOD AND HARDWOOD PULPWOOD AVAILABILITY

This Section focuses on potential lignocellulosic feedstock #1 (see Table 2 above). Around 13 million GMT of roundwood pulpwood[6] (i.e. logs as in Figure 1 and Figure 2) is produced each year from Australian commercial hardwood and softwood forests.

Note, Figure 1 shows wood that has been affected by fire. Even though this is debarked, any burnt wood is unsuitable for woodchip export for paper products, as buyers have zero tolerance for charcoal in woodchips.

[6] DAFF 2022. Australian forest and wood products statistics March and June quarters 2022

Figure 1: Softwood pulpwood (residual grade) stacked and drying at roadside

Some of these pulplogs are then:

- Converted to woodchips (Figure 2) and exported largely for the Japanese and Chinese pulp and paper industry (i.e. unburnt ones).
- Exported as 'pulpwood'[7], largely for offshore wood-based panel production in China, Korea and elsewhere.
- Sold to domestic processing industry for production of wood-based panels[8].
- Used for cogeneration power for processing facilities or 'feeding' into the grid.

Figure 2: Hardwood woodchips stockpiled and HWD 'pulpwood' logs stacked prior to export

Increasingly, Australian hardwood and softwood forest owners are seeking domestic markets for these products, in addition to exporting these to (say) China, which recently overturned a 2 year plus ban on import of Australian forest log products to Chinese markets. This reduced 'demand' and other COVID issues resulted in the decline in production, as shown in Figure 21 on page 17.

This pulpwood production/Availability is largely from either:

[7] Our pulpwood commonly becomes an importers' sawlogs, as they have different quality standards in producing their solid wood products.

[8] Particleboard, Medium Density Fibreboard (MDF), Oriented Strand Board (OSB), Laminated Veneer Lumber (LVL), High Density Fibreboard (HDF) and lesser products.

- Thinning operations from long-rotation softwood plantations, at around age 10-15 years[9] and again at age 20-25 years[10] with some from clearfell operations (around age 25-35 years).
- Clearfell operations of short-rotation (9-15 years) hardwood plantations.

These harvesting operations generate substantial forest waste which, in part, is an important nutrient source for the next crop or next rotation. The degree to which the waste material is retained for forest nutrient purposes is likely substantial and has been ignored in this report.

2.2 PULPWOOD AND RESIDUES FROM THINNING OPERATIONS

This Section focuses on potential lignocellulosic feedstock #2 (see Table 2 on page 2).

Thinnings are mostly produced from softwood plantations. However, increasingly, thinning pulpwood and associated residues will also be produced, as some short-rotation hardwood plantations transition to either long-rotation hardwood plantations or, after harvesting, to long-rotation softwood plantations, to capture carbon sequestration benefits (discussed in Section 3.10).

Figure 3 shows a thinned outrow in a softwood plantation (LHS) and a thinned outrow in a eucalypt plantation (RHS)[11]. The thinning allows the remaining trees between outrows, referred to as the bay, to increase in diameter and height at a faster rate than would otherwise have been possible[12]. Thinning is an important silvicultural treatment for long-rotation planted forests.

Figure 3: Examples of first-thinning (T1) in softwood (LHS) and hardwood (RHS) plantations

Thinning generates significant volumes of waste, in the form of snapped tops of trees, sizing off cuts from cutting logs to specific lengths and removing defects, bark, branches and leaves. In very general terms:

- Around 80-130 tonnes per hectare of almost all pulpwood (i.e. no sawlogs) are harvested from softwood first-thinnings (T1).
- More or less the same volume is harvested from second thinnings (T2), although here there is a mix of pulpwood and sawlogs (highly variable but may be 20-50% small sawlogs and the remainder is pulpwood).

[9] First thinning referred to as T1.

[10] Second thinning referred to as T2.

[11] This example hardwood plantation is transitioning to a carbon stand (see later).

[12] Less competition for light, water and nutrients.

In both cases, we have assumed waste is generated in an approximate 1.0:0.2 proportion[13] of roundwood (pulpwood and sawlogs) to residues. In other words, for every cubic metre or GMT of harvested roundwood, another 0.2 GMT[14] or 0.1 BDMT of residues are generated. This is a conservative estimate and is only required to determine relative Availability quantities in this report.

Importantly, the type and volume of wood products and, in particular, the type of residues, vary considerably by type of thinning machinery, age of thinning, silvicultural history, type of thinning[15], tree quality (straight, bendy), stocking (number of trees per unit area), market demand (especially lack of demand for some products) and many other variables. It is not simple.

Different thinning residues are shown in Figure 4 and Figure 5 for the same operation (T1), producing different residue types. In this case, very different market conditions applied resulting in very different residues volumes per hectare and types remaining in the forest.

Figure 4: A pine plantation T1 outrow with smaller residue

Figure 5: Typical pine plantation T1 outrow with larger residue

This variability in type of wood and residue is important to the ethanol industry, given the technical difficulties (recalcitrance[16]) of separating the lignin from the cellulose from the

[13] MBAC knowledge

[14] This can be changed in the Accessibility model developed for this project.

[15] Thinning from below is the most common (i.e. estimated at 90%+) form of thinning in Australia, involving removal of trees with smaller diameters and less-developed crowns and/or malformed trees. Thinning from below is usually done early in the life of a plantation to help establish the remaining trees and encourage them to grow bigger and taller. Virtually all the first thinning (T1) products here are pulpwood while the T2 operation generally generates a mix of sawlog and pulpwood.

[16] The term "recalcitrance" in the ethanol industry refers to the resistance of certain types of plant materials, particularly lignocellulosic biomass, to being broken down and converted into ethanol using existing technologies. Lignocellulosic biomass is a complex mixture of cellulose, hemicellulose, and lignin

hemicellulose. However, for a process that can accommodate a wide range of furnishes, this is an advantage as it improves Accessibility to furnishes, all other things being equal.

Figure 6: Pine T1 operation generating significant waste

2.3 PULPWOOD AND RESIDUES FROM CLEARFELL OPERATIONS

This Section focuses on potential lignocellulosic feedstock #3 (see Table 2 on page 2).

Clearfell operations in Australian short-rotation hardwood plantations produce around 8 million cubic metres per year of pulpwood with around 5-6 million cubic metres produced from softwood plantations (see later). The ratio of pulpwood to residues from these plantations is highly variable. Figure 7 shows a mechanical feller-buncher operating in a sub-tropical *Acacia* plantation in northern Australia. This machine cuts the tree, delimbs it, cuts the tree bole into pulpwood lengths (3m billets in this case) or just removes the tree top if log-length extraction ensues. Regardless, in the case below, substantial residues are produced due to a preponderance of poorly formed trees and many other issues in this plantation.

Figure 7: Clear felling generation of waste in an *Acacia* plantation

Often, the woody-waste accumulates inside the stand, as shown in Figure 8, if the tree is processed or partly processed in the forest. If the whole tree is extracted to roadside for processing, then the waste material is also transferred to the roadside.

that requires specialized enzymes to be broken down into simple sugars that can then be fermented into ethanol. However, the physical and chemical properties of lignocellulosic biomass, particularly the presence of lignin, can make it difficult for enzymes to access the cellulose and hemicellulose. This can result in low conversion rates and low yields of ethanol.

Figure 8: Accumulation of woody waste in the forest in an *Acacia* plantation

While there are many factors 'at play' here, market demand for certain product segments has a major influence on the volume of waste. For example, Figure 9 below shows substantial small pulpwood remaining in the forest due, in this case, to the uneconomic haulage distance to suitable processing sites (i.e. woodchip export at a port.)

Figure 9: High levels of residues remaining in a eucalypt plantation due to market constraints

Figure 10: Skidder extracting whole trees including waste from the forest to the roadside

2.4 WASTE FROM CLEAR FELLING FAILED OR FAILING STANDS

This Section focuses on potential lignocellulosic feedstock #4 (see Table 2 on page 2).

The forest owning industry annually reports forest values and identifies the Highest and Best Use (HBU) of each stand. In some instances, the HBU is no longer 'forestry'. In these circumstances, the commonest HBU is agriculture. If so, the plantation is commonly 'knocked over', the stumps pulled out, everything is windrowed, then burnt and what remains incorporated into the soil. This is an expensive exercise. However:

- The bulk of these HBU conversions have already occurred over the last decade.
- While there will be some future HBU transitions, this will be scattered throughout the plantation regions, mostly where too far from markets (i.e. ports or wood processing industry).
- To 'capture' the residues here requires more opportunistic utilisation (i.e. right person, right place, right time).

Figure 11: Failed eucalypt plantation (main) before and after reversion to agriculture (inset)

2.5 RESIDUES FROM IN-FOREST PROCESSING (WOOD CHIPPING)

This Section focuses on potential lignocellulosic feedstock #5 (see Table 2 on page 2).

Once trees and especially whole trees are at roadside for conversion to woodchips, there is fibre loss which accumulates at the chipper. For whole trees, this is largely from the chain-flail delimber (Figure 12), which removes the bark, leaves and small branches prior to the integrated chipper reducing the debarked and delimbed stem into woodchips. However, the mechanical nature of this process also dislodges some of the desired wood fibre which is also lost as waste.

Thus, there can be significantly varying types of residues, even from the same type of plantation. This is dependent on numerous variables, such as type of mechanised harvesting, mechanised processing, log/tree extraction, market requirements, tree quality, silvicultural status etc.

Figure 12: Infield (at roadside) chipping waste from chain-flail delimber

There are also additional fines-losses produced elsewhere at the chipper. MBAC estimates that the combined chain flail delimber and chipper waste is c. 5% of Total Recoverable Volume (TRV).

Figure 13: Infield (at roadside) chipper waste (undersized woodchips called fines)

Often, with whole tree processing, the combined harvest and chipping waste is returned to the forest using suitable machinery, as shown in Figure 14. This waste is subsequently spread across the site in the following site preparation operations prior to replanting. In any biomass recovery operation, a proportion would not be returned to the forest. Rather, it would accumulate along the roadside and allowed to partially dry, prior to collection for biomass purposes.

Figure 14: Harvest and chipping waste returned to the forest prior to spreading

If whole tree removal is not possible, then waste can be removed from the forest in a dedicated process. In the example below, a skidder drags trees and tree-length logs to the roadside, then returns to the forest and extracts residues. It can therefore work in combination with a harvester or a feller buncher.

Figure 15: Skidder extracting pine tree-tops waste from the forest

In other operations, trees are delimbed and the bark removed at the landing. Again, considerable waste is generated, as shown in Figure 16.

Figure 16: Eucalypt waste accumulating at the landing with whole tree processing

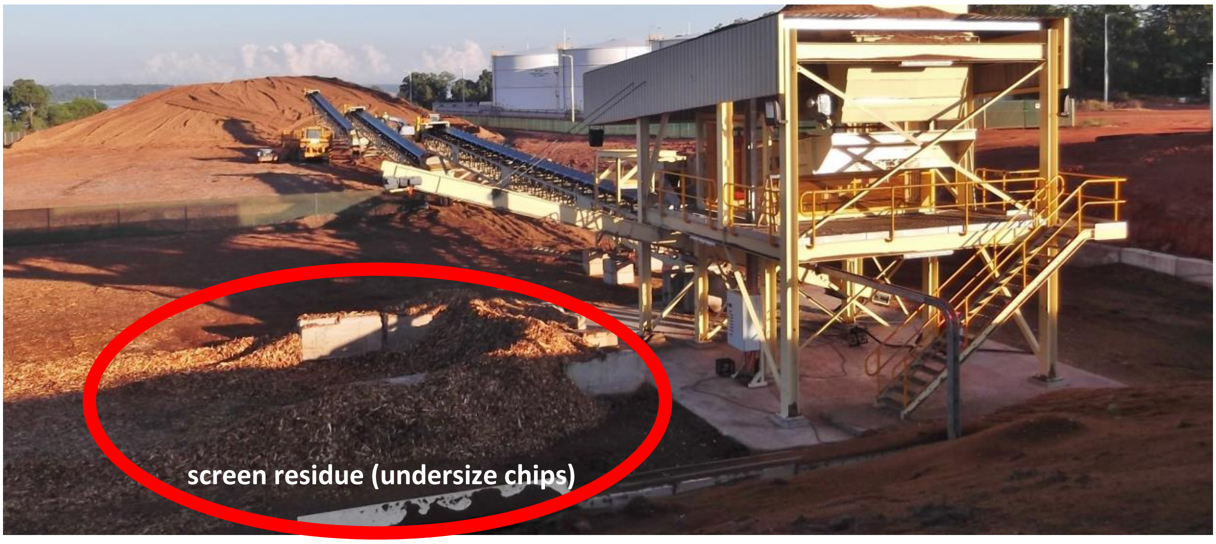
2.6 WOODCHIP SCREENING RESIDUES

This Section focuses on potential lignocellulosic feedstock #6 (see Table 2 on page 2).

There are also losses where woodchips are screened for size, invariably at a centralised processing site (commonly at the port), with over-size woodchips being re-chipped and undersize (fines) adding to waste. The fines produced here are commonly a 'problem' to sell and are often dumped into landfill type situations.

MBAC estimates around 3% of the woodchip mass is lost as waste at the screening process. In most instances, this is the more difficult waste stream to deal with, as there are limits at present to market options i.e. largely landscape supplies. This would be an idea furnish for the ethanol industry. There are some sites, such as North East Tasmania where there are multiple chipping plants with screens located within the same general region - Bell Bay north of Launceston in this case (discussed later).

Figure 17: Waste (undersize woodchips) generated at the chip screen prior to transfer to stockpile



2.7 WASTE FROM PROCESSING INDUSTRY

This Section focuses on potential lignocellulosic feedstock #9 (see Table 2 on page 2).

High-quality forest product processing residues are largely from sawmills and may consist of bark, sawdust, shavings, wood chips, and other wood residues.

Sawlog production from Australian plantations is around 10.5 million cubic metres of softwoods and 0.7 million cubic metres of hardwoods for a total of around 11.2 million cubic metres. Most residues generated are used to supply wood-based panel facilities with woodchips or used for co-firing for the sawmills own energy requirements (mostly the kilns used to dry green sawn timber) or for feeding into the electricity grid.

Assuming 25% useable[17] green waste based on the cubic metres or GMT log intake, there could be around 2.8 million GMT of waste produced in these facilities. That not used for co-fired energy production is either sold to wood-based panel manufactures, sold to landscape suppliers or (minimal) sold for export (most sawmills are not close to ports).

Regardless, the waste is potentially a feedstock (Availability) for the ethanol industry.

[17] The waste from sawmills may be greater than this.

Availability is High (i.e > 1 million GMT). However, as there is strong demand for this fibre, Accessibility is Low.

2.8 WOOD AND WOODY WASTE DRYING FOR BIOMASS

Invariably, wood or woody waste for bioenergy use needs to be dried prior to accumulation and transport to any biomass production centre. This introduces the beginnings of harvest changes, such as double handling, invariably required to facilitate biomass recovery from otherwise 'normal' forest operations (see later).

Figure 18: Plantation eucalypt pulpwood drying in field and at roadside

Export woodchip moisture contents tends to range from 40% to 53% with an average of around 47%. Moisture content is obviously highly dependent on species, seasonal factors and time between felling and processing into woodchip. However, biomass users likely require moisture contents around 40%[18], to reduce transport costs and speed up the conversion process from green wood to ethanol. Water loss can be achieved by killing standing trees prior to harvesting, seasonal harvesting, leaving wood or woody biomass on the ground or storing chipped material in storage sheds. There are limited examples of where this occurs in Australia.

Figure 19: Processed stems drying prior skidding

[18] MBAC knowledge of offshore biomass buyer

2.9 RELEVANCE OF THIS SECTION

The relevance of the previous section is to present, in pictorial format, the vast array of forest waste products than can be generated by commercial forest operations. Obviously, the mass of waste produced is highly variable as is the type and quality of waste.

Simply:

- In poor-formed forests, with less-than-ideal mechanisation, steep terrain, poor environmental conditions (i.e. rain), multiple product assortments and poor demand for some lower value products, the waste generated will be higher.
- In well-formed forests, with appropriate mechanisation, flatter terrain, ideal environmental conditions, fewer product assortments and high demand for all products, all other things being equal[19], the waste generated will be lower.

Thus, estimates residues Availability from forests are dependent on many variables and are highly imprecise. In this report, we have necessarily used generic ratios for estimating the volume or mass of residues relative to the volume of roundwood (pulpwood and sawlogs) produced.

[19] Which, in forestry, they never are.

3 AUSTRALIA'S PLANTED COMMERCIAL FORESTS AVAILABILITY

In Australia, our major commercial forests are located around the eastern and south eastern seaboard, in south west Western Australia and across northern Tasmania. In addition, domestic processing industry that utilises wood from these forests are generally located close to the forests.

3.1 AREAS BY NATIONAL PLANTATION INVENTORY REGIONS

There are several National Plantation Inventory (NPI) Regions[20] in Australia. These are areas of land where trees are grown for commercial purposes, such as timber production. The main NPI Regions are:

- **Green Triangle**: Located in the south-eastern part of South Australia and the western part of Victoria, this region is known for its softwood plantations.
- **Central Highlands**: Located in Victoria, this region is known for its hardwood plantations, particularly eucalyptus trees.
- **Murray Valley**: Located in Victoria and New South Wales, this region is known for its softwood plantations.
- **Western Australia**: This state has several National Plantation Regions, including the South West and Great Southern, which are known for their hardwood and softwood plantations.
- **Tasmania**: This island state is known for its softwood and hardwood plantations, particularly radiata pine and eucalyptus trees.

These regions are shown in Figure 20 below.

The NPI Regions are important for the Australian forestry industry, for two reasons:

- Firstly, they provide sustainable sources of timber and other wood products, with suitable regional data, such as wood Availability projections.
- The location of carbon-forests, under the Australian Emissions Reduction Fund (ERF)[21] scheme, overseen by the Clean Energy Regulator[22], specifies that any carbon forest must be within 100 kilometres of a National Plantation Inventory (NPI) region.

The current area by NPI Region and species group[23] is shown in Table 3 on page 16 and in Figure 20 on the next page.

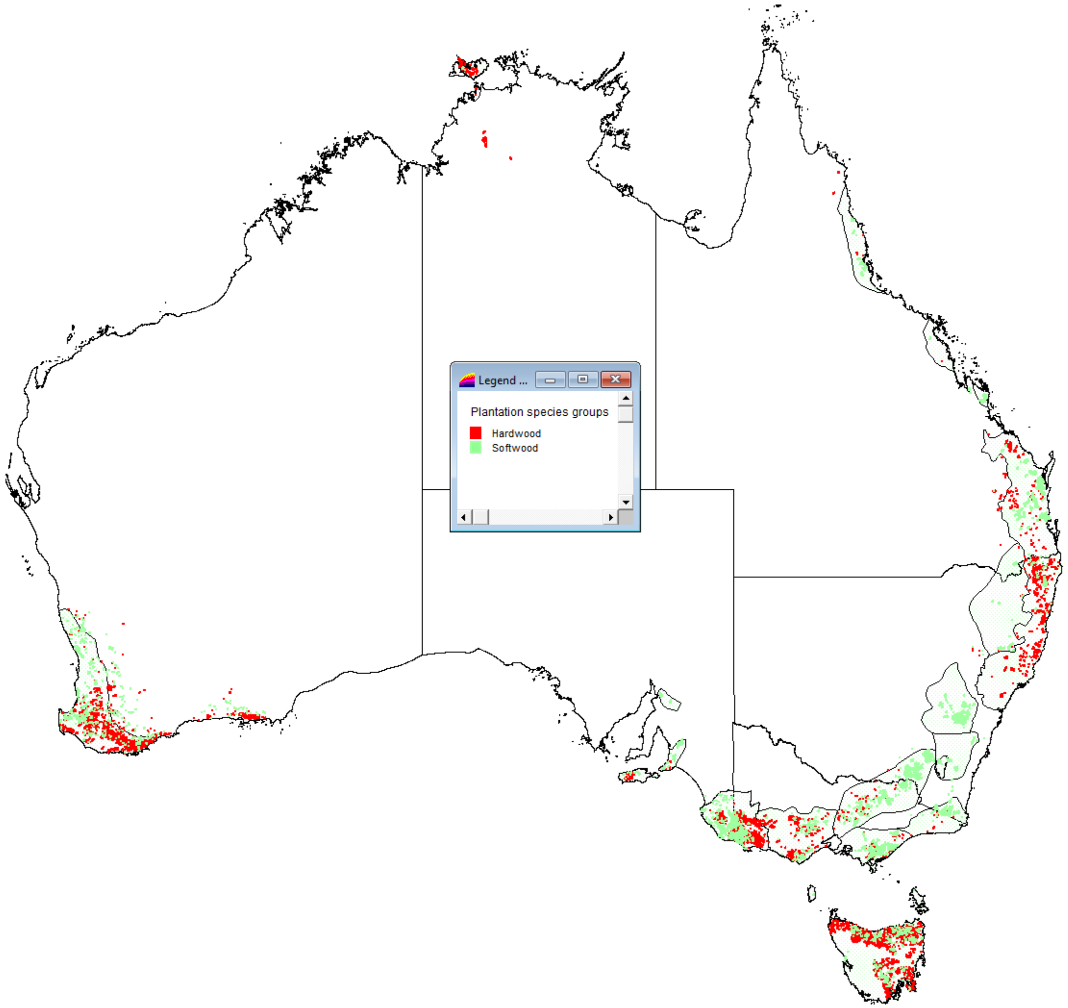
[20] https://www.agriculture.gov.au/abares/forestsaustralia/forest-data-maps-and-tools/spatial-data/australias-plantations

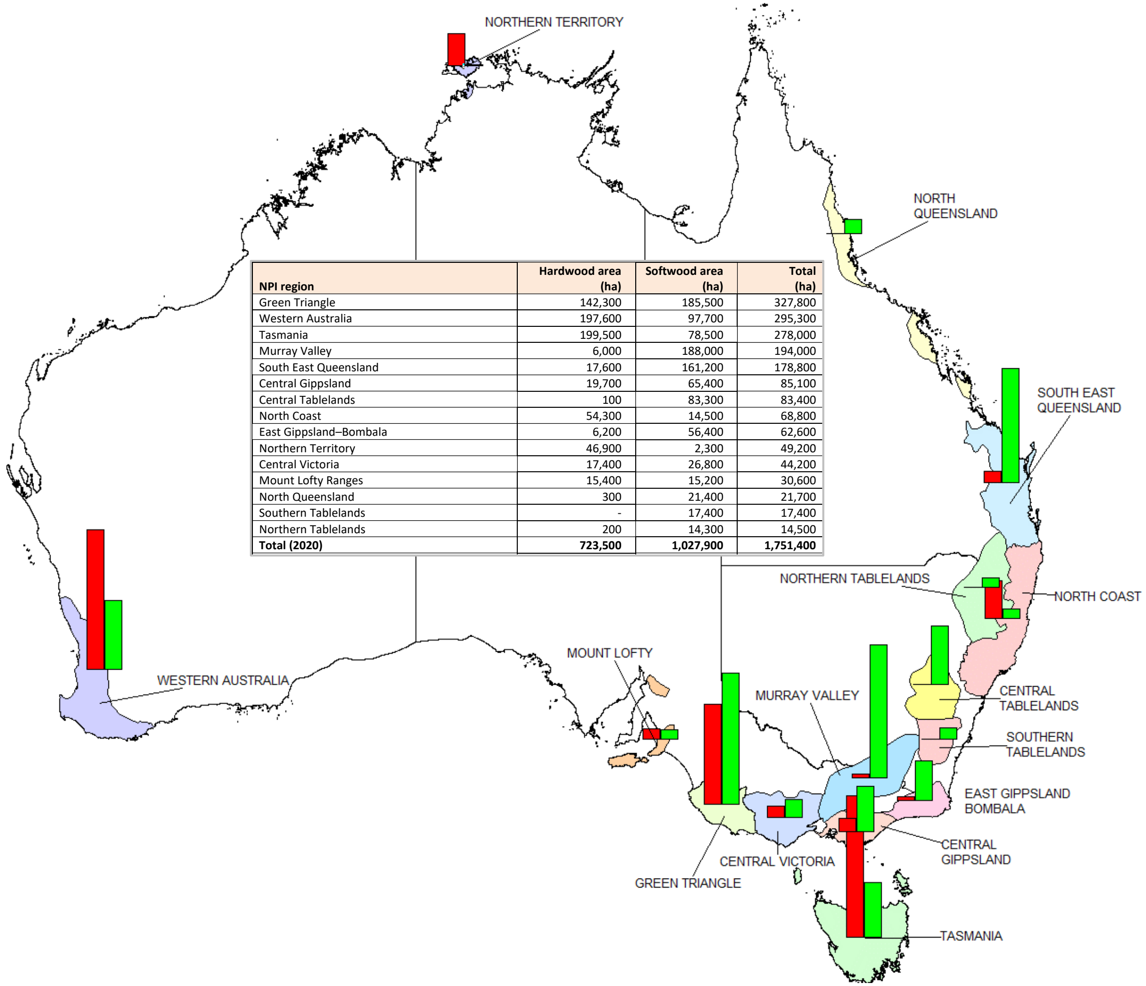
[21] About the Emissions Reduction Fund (cleanenergyregulator.gov.au)

[22] Clean Energy Regulator Clean Energy Regulator - Home

[23] ABARES 2021. Australian plantation area and log Availability – National Plantation Inventory regions and Regional Forestry Hubs

Figure 20: Australian National Plantation Inventory regions and area map





NPI region	Hardwood area (ha)	Softwood area (ha)	Total (ha)
Green Triangle	142,300	185,500	327,800
Western Australia	197,600	97,700	295,300
Tasmania	199,500	78,500	278,000
Murray Valley	6,000	188,000	194,000
South East Queensland	17,600	161,200	178,800
Central Gippsland	19,700	65,400	85,100
Central Tablelands	100	83,300	83,400
North Coast	54,300	14,500	68,800
East Gippsland–Bombala	6,200	56,400	62,600
Northern Territory	46,900	2,300	49,200
Central Victoria	17,400	26,800	44,200
Mount Lofty Ranges	15,400	15,200	30,600
North Queensland	300	21,400	21,700
Southern Tablelands	-	17,400	17,400
Northern Tablelands	200	14,300	14,500
Total (2020)	**723,500**	**1,027,900**	**1,751,400**

Table 3: Planted area by NPI Region and species group (2020)

NPI Region	Hardwood area (ha)	Softwood area (ha)	Total (ha)
Green Triangle	142,300	185,500	327,800
Western Australia	197,600	97,700	295,300
Tasmania	199,500	78,500	278,000
Murray Valley	6,000	188,000	194,000
South East Queensland	17,600	161,200	178,800
Central Gippsland	19,700	65,400	85,100
Central Tablelands	100	83,300	83,400
North Coast	54,300	14,500	68,800
East Gippsland–Bombala	6,200	56,400	62,600
Northern Territory	46,900	2,300	49,200
Central Victoria	17,400	26,800	44,200
Mount Lofty Ranges	15,400	15,200	30,600
North Queensland	300	21,400	21,700
Southern Tablelands	-	17,400	17,400
Northern Tablelands	200	14,300	14,500
Total (2020)	**723,500**	**1,027,900**	**1,751,400**
Total (2022)	**711,000**	**1,010,000**	**1,744,000**

In 2022, Australia had 1.744 million hectares of planted forests of which 0.711 million hectares[24] were hardwood (mostly *Eucalyptus*), 1.010 million hectares were softwood (mostly *Pinus radiata*) and the balance minor species.

The following sections are produced using ABARES[25] NPI data available.

3.2 POTENTIAL HARDWOOD PULPWOOD AVAILABILITY

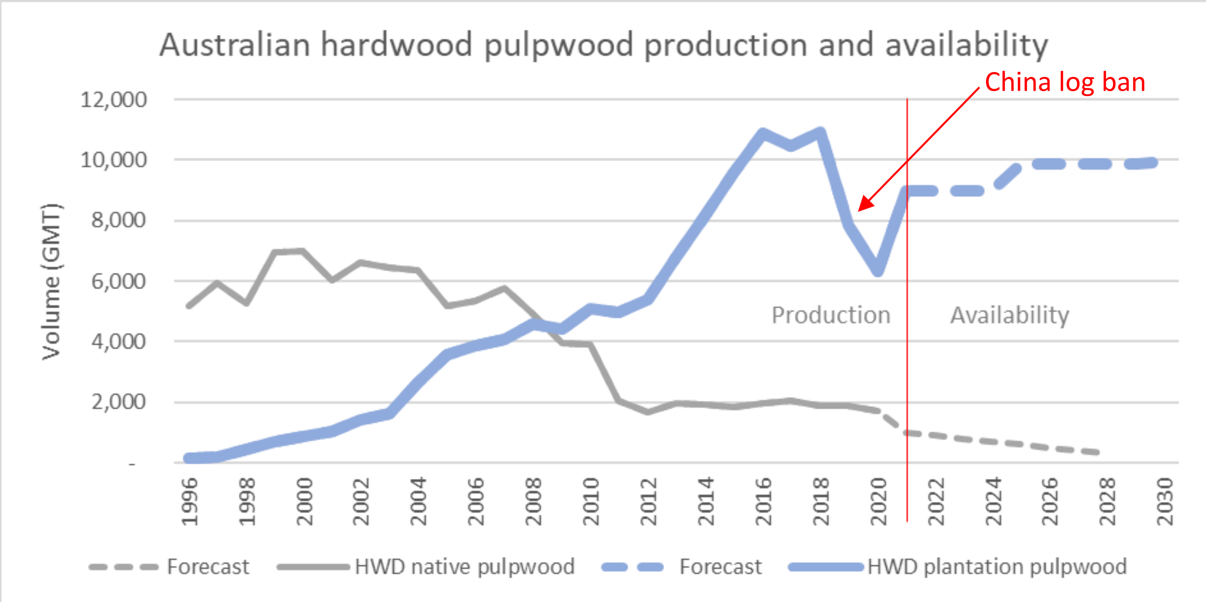
This small section covers native and plantation hardwood pulpwood Availability.

The plantation hardwood area has declined from a high of around 973,000 hectares in 2010 to the present of around 723,000 hectares in 2020 and closer to 711,000 hectares in 2022 (see later). This is largely due to over 200,000 hectares reverting from plantation hardwoods to agriculture (higher and best use) over the last decade, although this transition has likely slowed.

[24] DAFF 2022. Australian forest and wood products statistics March and June quarters 2022

[25] https://www.agriculture.gov.au/abares/forestsaustralia/plantation-inventory-and-statistics

Figure 21: Australian plantation and native hardwood pulpwood production and Availability



3.3 HWD PULPWOOD FROM COMMERCIAL PLANTED FORESTS

Total Australian plantation log harvest volume in 2020-21 was about 24 million cubic metres. Of this, around 6.4 million cubic metres[26] was hardwood pulpwood, as shown in Figure 21, rising to over 8 million cubic metres in recent times. This was a significant decline from earlier years, as China banned imports of Australian logs from 2020. This has now been lifted.

Most of this hardwood pulpwood production/Availability is destined for woodchip exports for pulp and paper manufacture. Given an anticipated increase in Chinese demand, MBAC suggests plantation hardwood woodchip Availability is likely to be around 4.0 million BDMT (approximately 8 million cubic metres[27]) through 2025-2026, increasing to around 5.0 million BDMT per annum[28] through to 2027-2029. This may decline slightly as some hardwood plantations revert to softwood plantations (see later).

3.4 HWD PULPWOOD FROM COMMERCIAL NATIVE FORESTS

Native hardwood pulpwood production was 1.7 million cubic metres[29] in 2020. We have assumed native hardwood pulpwood Availability will further decline to well less than 1.0 million cubic metres in the short- to medium-terms.

3.5 POTENTIAL SOFTWOOD PULPWOOD AVAILABILITY

Total Australian plantation softwood pulpwood production in 2020 was 6.2 million cubic metres[30] or approximately 3.8 million BDMT, as shown in Figure 22. This is largely used for domestic pulp and wood-based panel production with lesser volumes exported.

[26] DAFF 2022. Australian forest and wood products statistics March and June quarters 2022

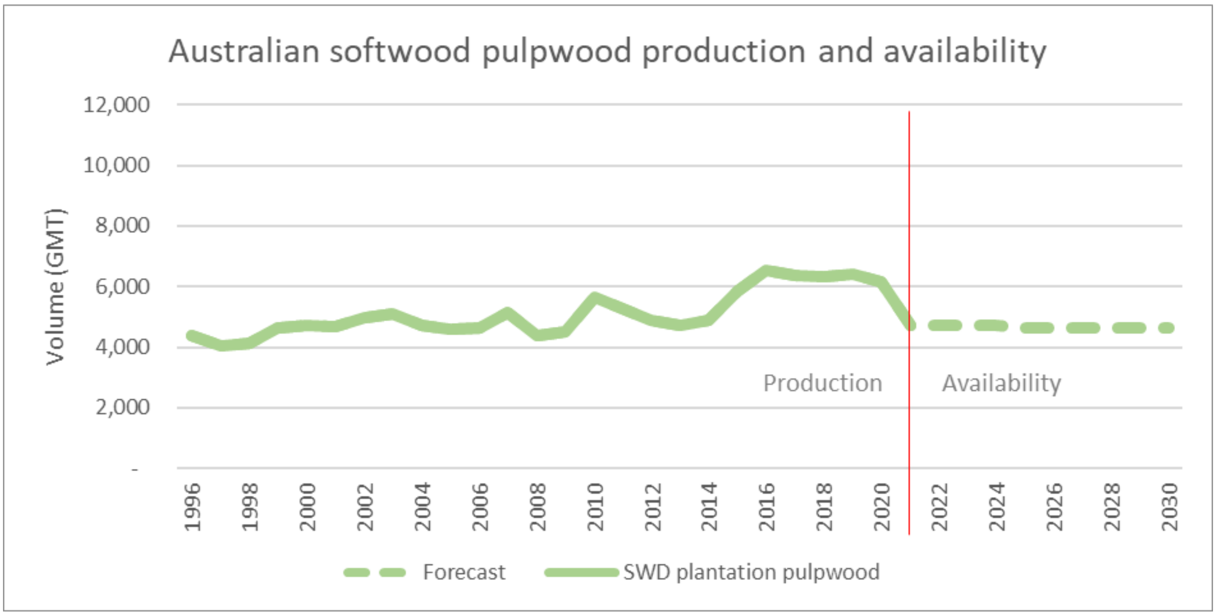
[27] ABARES 2020. Australian plantation area and log Availability – National Plantation Inventory regions and Regional Forestry Hubs datasets

[28] ABARES 2020. Australian plantation area and log Availability – National Plantation Inventory regions and Regional Forestry Hubs datasets

[29] DAFF 2022. Australian forest and wood products statistics March and June quarters 2022

[30] DAFF 2022. Australian forest and wood products statistics March and June quarters 2022

Figure 22: Australian plantation softwood pulpwood production and Availability



MBAC has assumed, for this report, that softwood pulpwood Availability will decrease slightly to 4.7 million cubic metres per year or 2.4 million BDMT, before increasing slowly after 2030 as areas of hardwood plantations are changed to softwood plantations and the volumes from huge 2020 fire replants begin producing volume. This is discussed later.

3.6 POTENTIAL PULPWOOD BY REGION AND TYPE

The most important regions for Availability of Australian hardwood and softwood pulpwood and residues are shown in Table 4.

For hardwood furnish Availability in 2024, these are:

- Tasmania
- Western Australia
- Green Triangle (SA/VIC)
- Central Gippsland (VIC)
- North Coast (NSW), although the ABARES data are highly optimistic for this NPI region as many of the hardwood plantations have failed here and reverted to agriculture or have been chipped and exported.

For softwood furnish Availability in 2024, these are:

- Murray Valley (NSW/VIC)
- Green Triangle (SA/VIC)
- Tasmania
- East Gippsland (VIC)/Bombala (NSW)
- SE Queensland

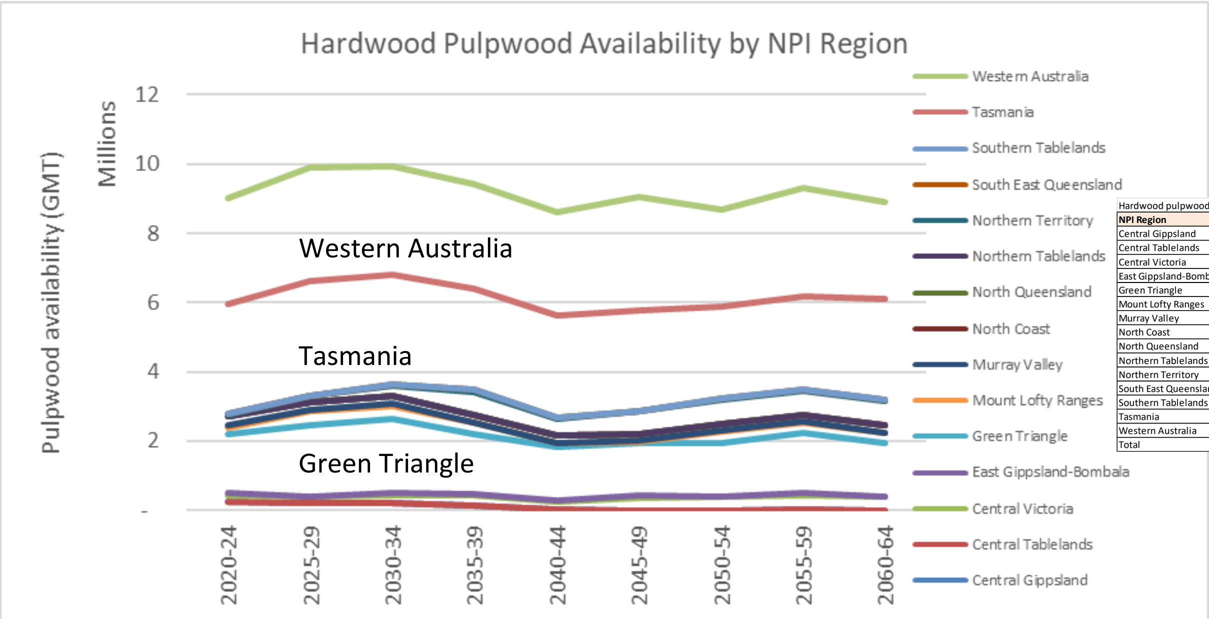
The major regions with over 1 million cubic metres of pulpwood Availability per year are Tasmania, Western Australia and the Green Triangle. Combined, these regions account for 72% of Australia's pulpwood production and, hence, the same general proportion of commercial plantation residue generation.

Table 4: Projected hardwood and softwood pulpwood volumes by NPI Region (2024)

NPI Region	Hardwood (GMT pa)	Softwood (GMT pa)	Total (GMT pa)
Tasmania	3,178,000	649,000	3,827,000
Western Australia	3,034,000	231,000	3,265,000
Green Triangle	1,709,000	907,000	2,616,000
Murray Valley	57,000	918,000	975,000
Central Tablelands	0	633,000	633,000
East Gippsland-Bombala	62,000	459,000	521,000
Central Gippsland	261,000	252,000	514,000
South East Queensland	15,000	313,000	328,000
North Coast	252,000	45,000	296,000
Mount Lofty Ranges	189,000	67,000	256,000
Central Victoria	179,000	66,000	245,000
Northern Tablelands	0	96,000	97,000
Southern Tablelands	0	88,000	88,000
Northern Territory	60,000	0	60,000
North Queensland	0	8,000	8,000
Total	**8,996,000**	**4,732,000**	**13,729,000**

These are all very high-level estimates. Regardless, the Availability of technically suitable lignocellulosic furnish for the ethanol industry far exceeds the industry requirements, before considering price and other constraints (see later). Over time, the pulpwood Availability is dynamic as shown in Figure 23. We will later separate Tasmania into North East, North West and South regions and Western Australia into Bunbury and Albany regions).

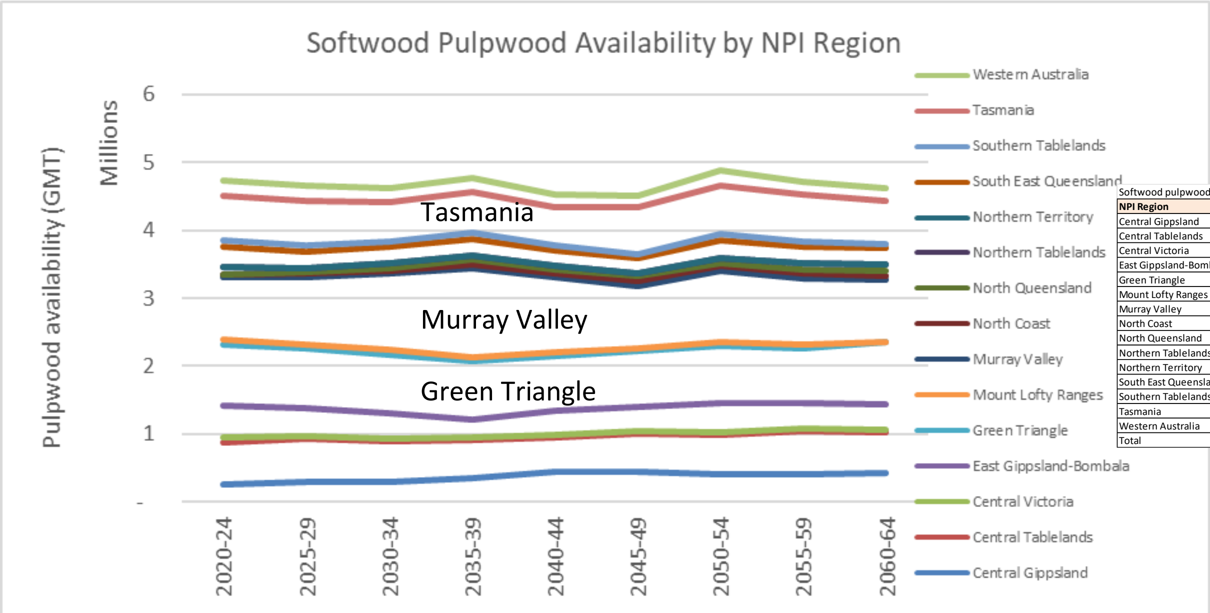
Figure 23: Hardwood pulpwood Availability by NPI Region



Hardwood pulpwood

NPI Region	2020-24
Central Gippsland	261,000
Central Tablelands	-
Central Victoria	179,000
East Gippsland-Bombala	62,000
Green Triangle	1,709,000
Mount Lofty Ranges	189,000
Murray Valley	57,000
North Coast	252,000
North Queensland	-
Northern Tablelands	-
Northern Territory	60,000
South East Queensland	15,000
Southern Tablelands	-
Tasmania	3,178,000
Western Australia	3,034,000
Total	8,996,000

Figure 24: Softwood pulpwood Availability by NPI Region



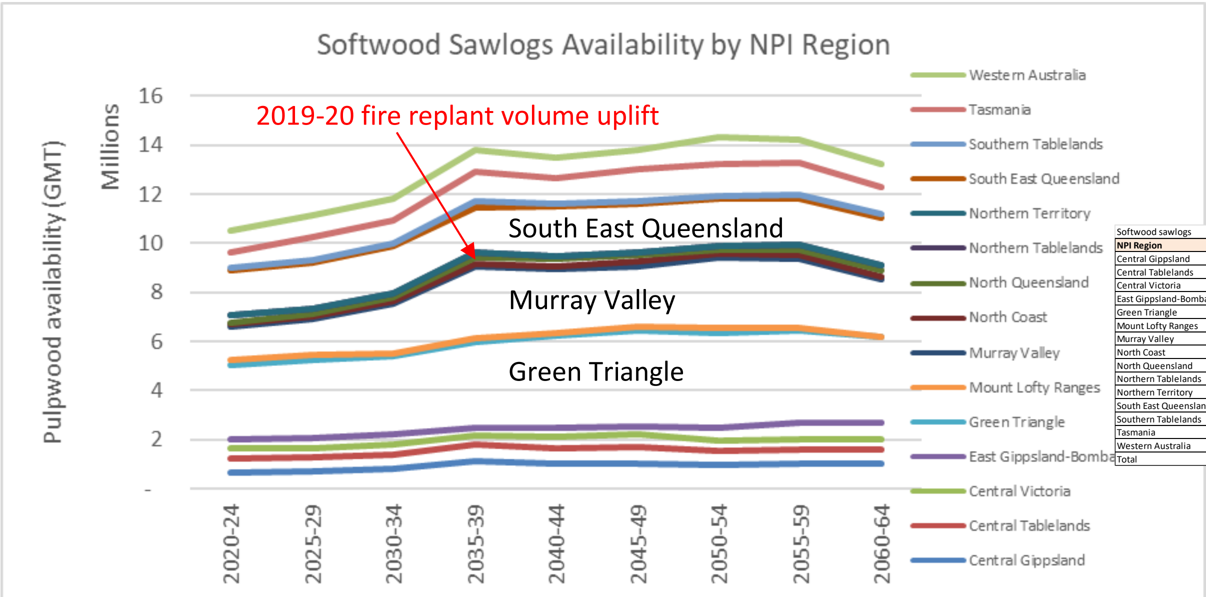
Softwood pulpwood	
NPI Region	**2020-24**
Central Gippsland	252,000
Central Tablelands	633,000
Central Victoria	66,000
East Gippsland-Bombala	459,000
Green Triangle	907,000
Mount Lofty Ranges	67,000
Murray Valley	918,000
North Coast	45,000
North Queensland	8,000
Northern Tablelands	96,000
Northern Territory	-
South East Queensland	313,000
Southern Tablelands	88,000
Tasmania	649,000
Western Australia	231,000
Total	4,732,000

The apparent Availability here is more evenly distributed with the same more important regions.

3.7 POTENTIAL SOFTWOOD SAWLOGS FROM THESE FORESTS

We need to 'understand' sawlog production to estimate associated forest residue Availability and sawmill residues Availability. From Figure 25 on the next page, we can see the major softwood sawlog producing regions are Green Triangle, South East Queensland and the Murray Valley. Not surprisingly, this is where most of the large softwood sawmills are located. Essentially all softwood sawlog production will be consumed domestically for the foreseeable future as wood required for housing exceeds wood supply in Australia.

Figure 25: Softwood sawlog Availability by NPI Region



Softwood sawlogs	
NPI Region	**2020-24**
Central Gippsland	677,000
Central Tablelands	557,000
Central Victoria	403,000
East Gippsland-Bombala	348,000
Green Triangle	3,033,000
Mount Lofty Ranges	250,000
Murray Valley	1,355,000
North Coast	81,000
North Queensland	57,000
Northern Tablelands	300,000
Northern Territory	-
South East Queensland	1,839,000
Southern Tablelands	77,000
Tasmania	652,000
Western Australia	900,000
Total	10,529,000

3.8 POTENTIAL RESIDUES AVAILABLE FROM THESE FORESTS

Harvesting residues

Assuming a ratio of 1.0:0.2 log to residues, then the very high-level apparent Availability of residues may be around 1.8 million GMT[31] from hardwood plantations and 3.1 million GMT[32] from softwood plantations, for a total of 4.9 million GMT as shown in Table 5. This rises to 5.6 million GMT by 2050.

Of interest, assuming 20% in forest residues, the total softwood forest residues for Victoria, Tasmania, Queensland and New South Wales is 2.4 million GMT, which is similar to the ABARES figure of 2.245 million GMT.

The 20% residue to log percentage is sufficient for this high-level report.

Table 5: Projected hardwood and softwood harvesting residue volumes by NPI Region (2024)

NPI Region	Hardwood (GMT pa)	Softwood (GMT pa)	Total (GMT pa)	Availability
Green Triangle*	341,800	788,000	1,129,800	H
Tasmania*	635,600	260,200	895,800	M
Western Australia	606,800	226,200	833,000	M
Murray Valley*	11,400	454,600	466,000	M
South East Queensland*	3,000	430,400	433,400	M
Central Tablelands*	0	238,000	238,000	M
Central Gippsland*	52,200	185,800	238,000	M
East Gippsland-Bombala*	12,400	161,400	173,800	M
Central Victoria*	35,800	93,800	129,600	M
Mount Lofty Ranges	37,800	63,400	101,200	M
Northern Tablelands*	0	79,200	79,200	L
North Coast*	50,400	25,200	75,600	L
Southern Tablelands*	0	33,000	33,000	L
North Queensland*	0	13,000	13,000	L
Northern Territory	12,000	0	12,000	L
Total	**1,799,200**	**3,052,200**	**4,851,400**	H
SWD QLD, NSW, VIC, TAS*		**2,355,600**		

The apparent High Availability (> 1 million GMT pa) of softwood plus hardwood harvesting residue are only in the Green Triangle and is mostly softwood.

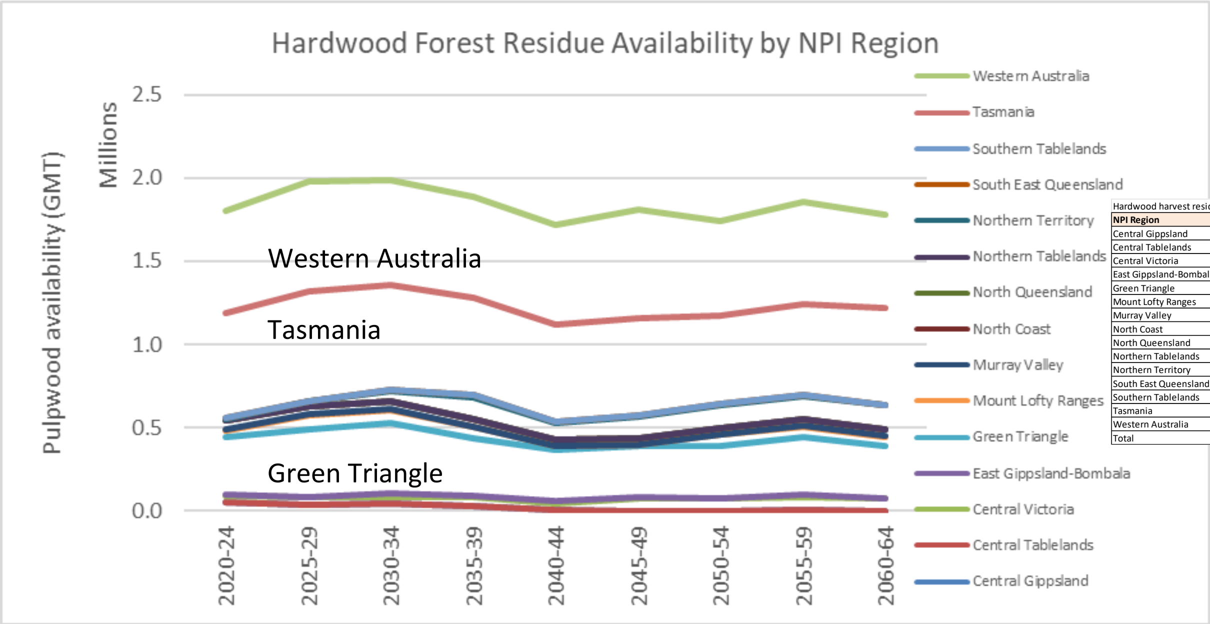
The major apparent Medium softwood plus hardwood residue Availability regions are in Tasmania (mostly hardwood), Western Australia (mostly hardwood), Murray Valley (essentially all softwood) and South East Queensland (all softwood).

The apparent hardwood forest residue Availability over time is shown in Figure 26, with Tasmania, Western Australia and the Green Triangle being the major regions.

[31] 9.0 million GMT HWD pulpwood x 0.2 = 1.8 million GMT residues

[32] 4.7 million GMT SWD pulpwood x 0.2 = 0.94 million GMT residues

Figure 26: Apparent hardwood harvesting residues by NPI Region

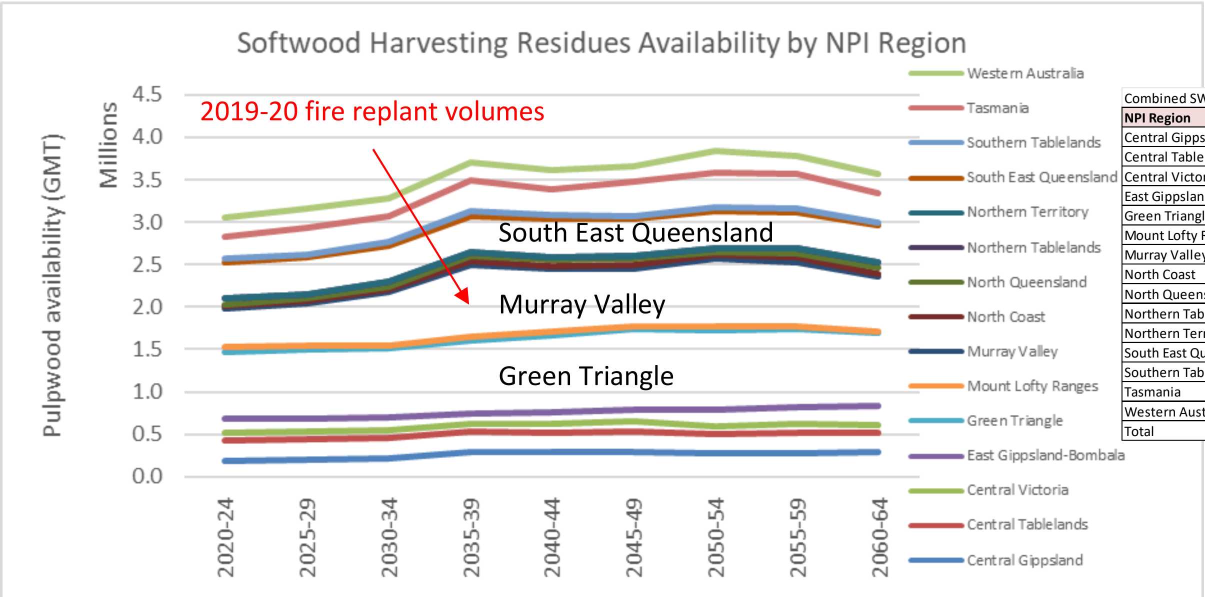


Hardwood harvest residues

NPI Region	2020-24
Central Gippsland	52,200
Central Tablelands	-
Central Victoria	35,800
East Gippsland-Bombala	12,400
Green Triangle	341,800
Mount Lofty Ranges	37,800
Murray Valley	11,400
North Coast	50,400
North Queensland	-
Northern Tablelands	-
Northern Territory	12,000
South East Queensland	3,000
Southern Tablelands	-
Tasmania	635,600
Western Australia	606,800
Total	1,799,200

The apparent softwood harvesting residues (Figure 27) are more 'evenly' spread, although most is in the Green Triangle, SE Queensland, and The Murray Valley (NSW/VIC) – all 'homes' to Australia's major softwood sawmills who consume the major proportions of the sawlogs.

Figure 27: Apparent softwood harvesting residues by NPI Region



Combined SWD pulp res + sawlog re

NPI Region	2020-24
Central Gippsland	185,800
Central Tablelands	238,000
Central Victoria	93,800
East Gippsland-Bombala	161,400
Green Triangle	788,000
Mount Lofty Ranges	63,400
Murray Valley	454,600
North Coast	25,200
North Queensland	13,000
Northern Tablelands	79,200
Northern Territory	-
South East Queensland	430,400
Southern Tablelands	33,000
Tasmania	260,200
Western Australia	226,200
Total	3,052,200

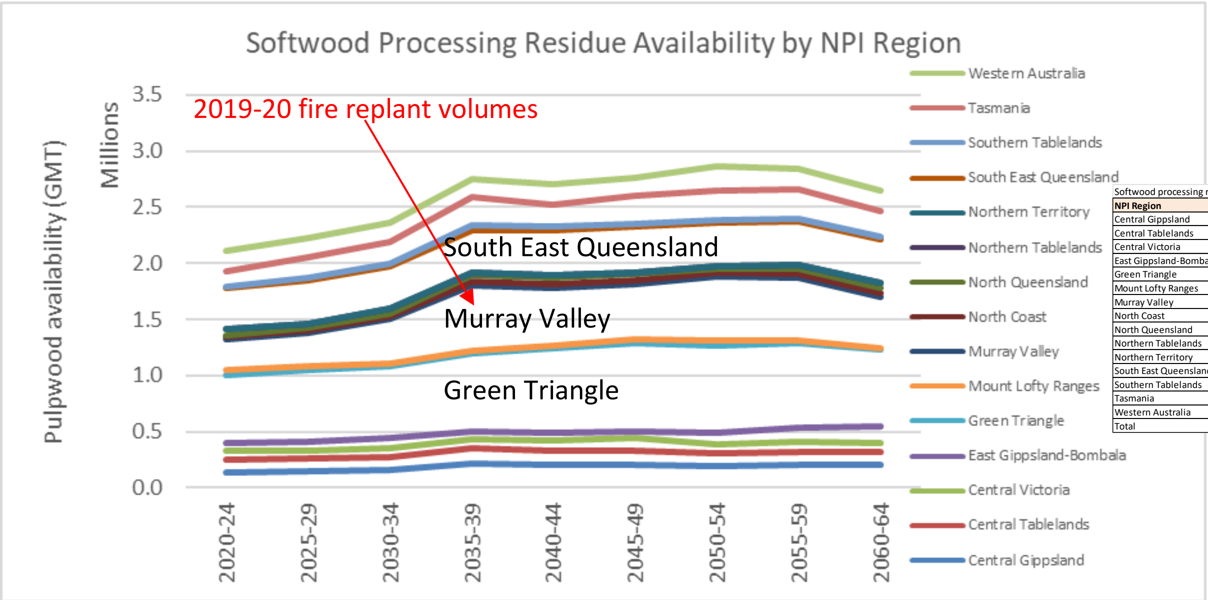
Sawmilling residues

The residues associated with these sawlogs are relevant here. Again, there is little actual data on such residues. ABARES reports that published estimate suggest Victoria and Queensland produced 1.687 million GMT of sawmill residues in a year. ABARES also estimated 4.1 million GMT are estimated to be produced by softwood sawmills[33].

Assuming 80% of the volume is processed in sawmills (as opposed to elsewhere) and that 25% of the net volume is generated as waste, we estimate the sawmill residue Availability is around 2.1 million GMT per year and rising. Thus, the Availability is High, from the same three regions as the sawlog Availability.

MBAC's model suggests 2.105 million GMT may be the Availability, of which 0.933 million GMT is produced in Queensland and Victoria. This is around 50% of the ABARES figures. If so, then the analysis here may be conservative. Importantly, it is the relative nature of the volumes that are most relevant in this report.

Figure 28: Apparent softwood sawmilling residues/waste



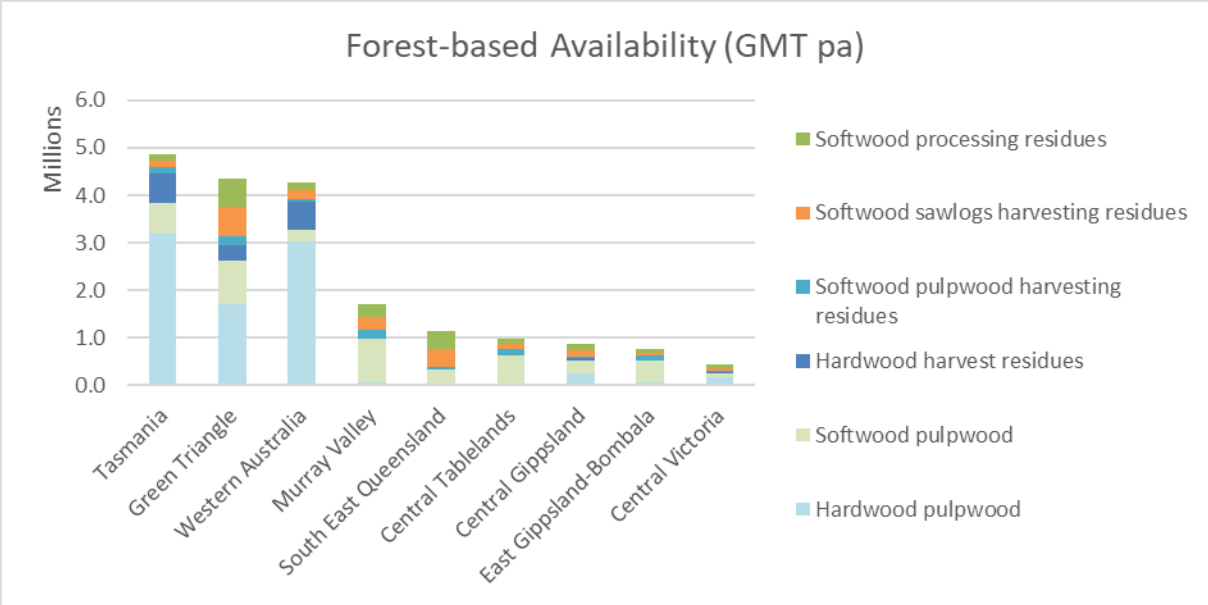
Softwood processing residues	
NPI Region	**2020-24**
Central Gippsland	135,400
Central Tablelands	111,400
Central Victoria	80,600
East Gippsland-Bombala	69,600
Green Triangle	606,600
Mount Lofty Ranges	50,000
Murray Valley	271,000
North Coast	16,200
North Queensland	11,400
Northern Tablelands	60,000
Northern Territory	-
South East Queensland	367,800
Southern Tablelands	15,400
Tasmania	130,400
Western Australia	180,000
Total	2,105,800

3.9 FOREST BASED AVAILABILITY

Combining these data, the apparent Availability totals by region are shown in Figure 29. The 'big' Regions, all with over 1 million GMT Availability, are Tasmania, Green Triangle, Western Australia, Murray Valley and South East Queensland.

[33] Lock, P & Whittle, L 2018. Future opportunities for using forest and sawmill residues in Australia, ABARES, Canberra, November. P17

Figure 29: Forest based Availability totals by Region



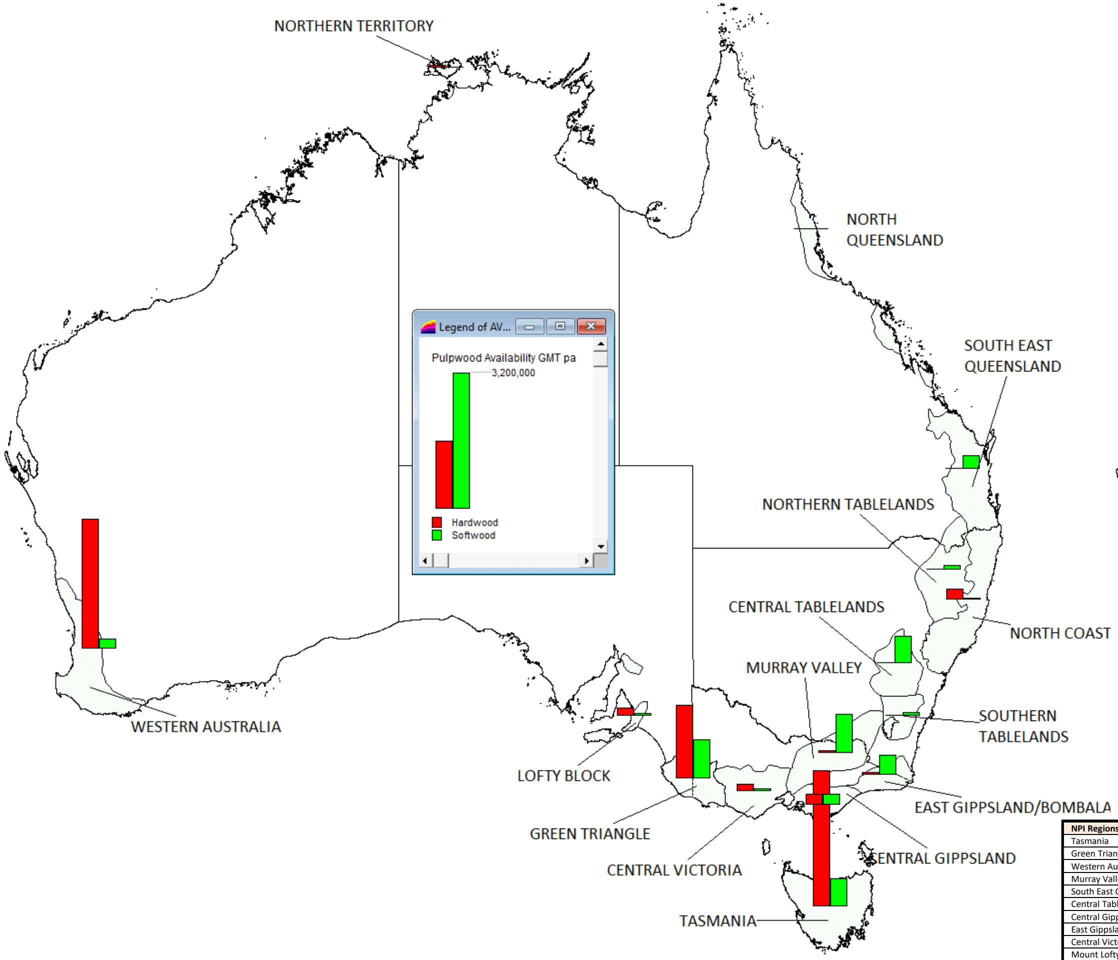
The location and scale of SWD and HWD pulpwood and harvesting residues apparent Availability is shown in Figure 30. A map and scale of pulpwood and residues (harvesting & processing) apparent Availability is shown in Figure 31.

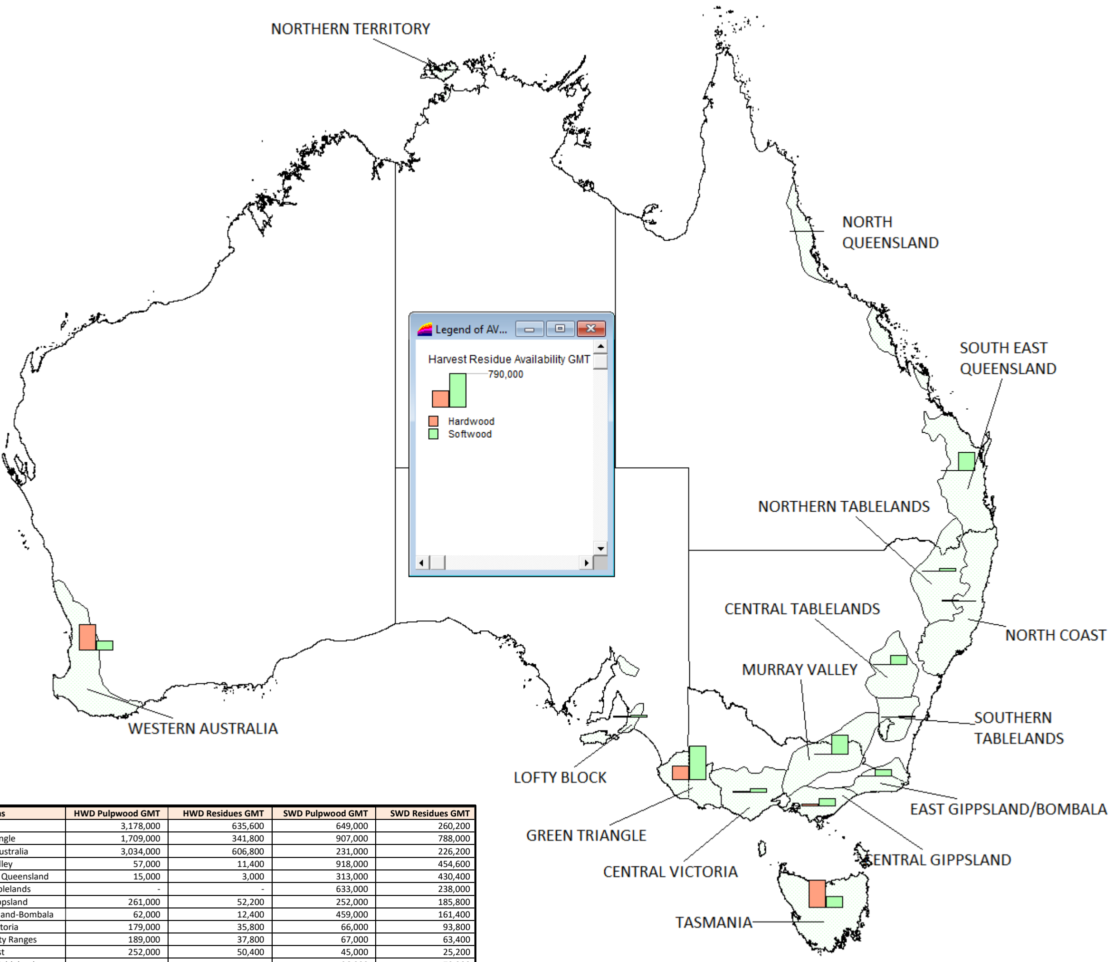
Figure 30: Location and scale of SWD and HWD pulpwood and harvesting residues apparent Availability

SWD and HWD pulpwood

Availability GMT pa

SWD and HWD harvesting residues





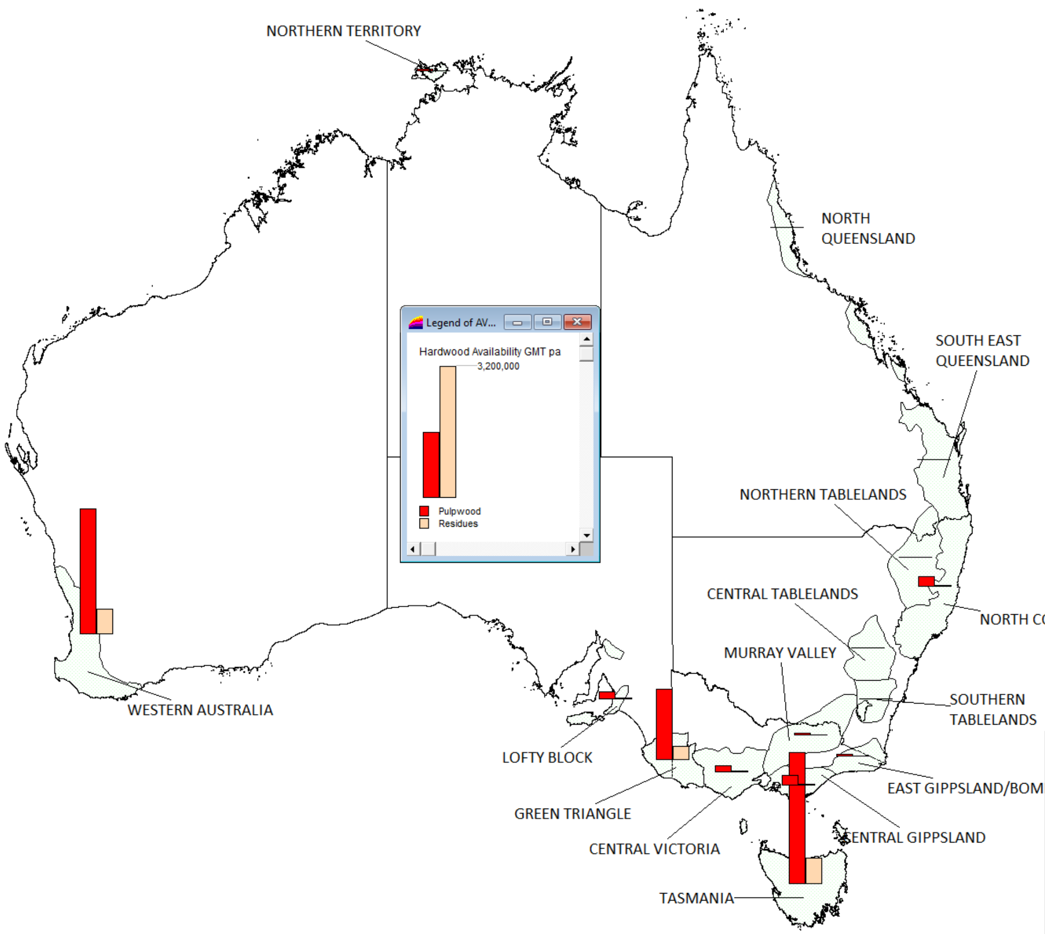
NPI Regions	HWD Pulpwood GMT	HWD Residues GMT	SWD Pulpwood GMT	SWD Residues GMT
Tasmania	3,178,000	635,600	649,000	260,200
Green Triangle	1,709,000	341,800	907,000	788,000
Western Australia	3,034,000	606,800	231,000	226,200
Murray Valley	57,000	11,400	918,000	454,600
South East Queensland	15,000	3,000	313,000	430,400
Central Tablelands	-	-	633,000	238,000
Central Gippsland	261,000	52,200	252,000	185,800
East Gippsland-Bombala	62,000	12,400	459,000	161,400
Central Victoria	179,000	35,800	66,000	93,800
Mount Lofty Ranges	189,000	37,800	67,000	63,400
North Coast	252,000	50,400	45,000	25,200
Northern Tablelands	-	-	96,000	79,200
Southern Tablelands	-	-	88,000	33,000
Northern Territory	60,000	12,000	-	-
North Queensland	-	-	8,000	13,000
	8,996,000	1,799,200	4,732,000	3,052,200

Figure 31: Map and scale of pulpwood and residues (harvesting & processing) apparent Availability

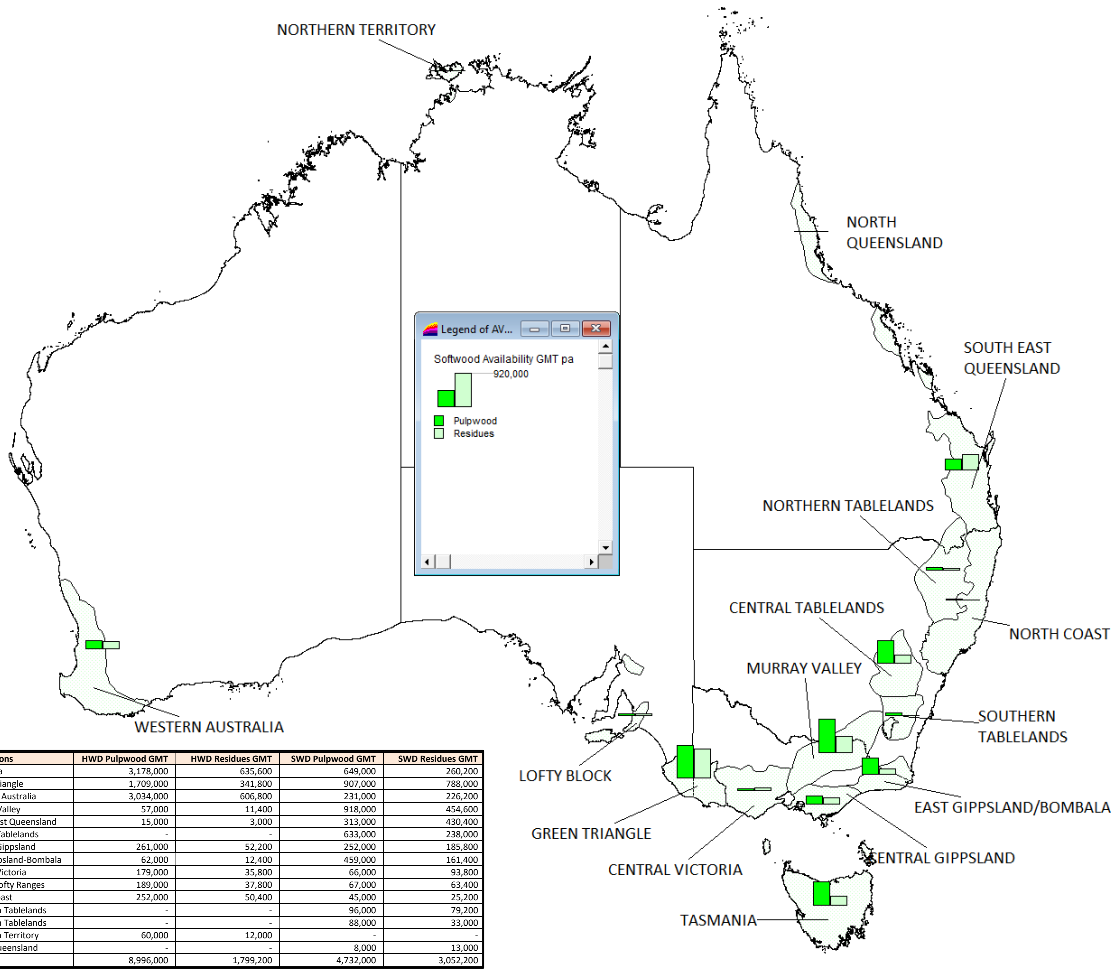
HWD pulpwood and residues

Availability GMT pa

SWD pulpwood and residues



NPI Regions	HWD Pulpwood GMT	HWD Residues GMT	SWD Pulpwood GMT	SWD Residues GMT
Tasmania	3,178,000	635,600	649,000	260,200
Green Triangle	1,709,000	341,800	907,000	788,000
Western Australia	3,034,000	606,800	231,000	226,200
Murray Valley	57,000	11,400	918,000	454,600
South East Queensland	15,000	3,000	313,000	430,400
Central Tablelands	-	-	633,000	238,000
Central Gippsland	261,000	52,200	252,000	185,800
East Gippsland-Bombala	62,000	12,400	459,000	161,400
Central Victoria	179,000	35,800	66,000	93,800
Mount Lofty Ranges	189,000	37,800	67,000	63,400
North Coast	252,000	50,400	45,000	25,200
Northern Tablelands	-	-	96,000	79,200
Southern Tablelands	-	-	88,000	33,000
Northern Territory	60,000	12,000	-	-
North Queensland	-	-	8,000	13,000
	8,996,000	1,799,200	4,732,000	3,052,200



3.10 FOREST BASED FURNISHES - LITERATURE REVIEW AVAILABILITY

Our assessments above generally or closely agree with 'literature review' material.

Lock and Whittle (2018)[34] estimate 5.6 million tonnes of log harvest residues could be available for further use in 2050, based on a total log harvest of 28.6 million cubic metres. We determined Availability may be 5.58 million GMT (see Section 3.2).

- Of this, 1.2 million tonnes of harvest residues are assumed to be high quality, or suitable for producing export grade woodchips, and the remaining 4.4 million tonnes are assumed to be low quality.
- 0.9 million tonnes, or 78 per cent of the available high-quality residues in 2050, could be exported as woodchips or used in wood-based panel production.

However, Lock and Whittle go on to say that practical availability may vary significantly from their estimates due to a range of reasons including economics of harvesting/recovery, and competition with other products and markets.

Plantation harvest residues - Availability

The National Map datasets[35], managed by Geoscience Australia in collaboration with CSIRO, provides alternative estimates of the Availability of a wide range of products, including pulpwood and harvest residues, for example. Complicating factors are that precision is unknown the dataset may not be complete, some data are in dry tonnes while other data are in GMT and some data includes native forest values as well as plantation values. In the text below, we have converted relevant 'volumes' to GMT where possible.

The base data are provided in Appendix 4. The following sections comments on those with High apparent Availability estimates or where a location has been 'flagged' as important in the previous sections (i.e. Green Triangle, Murray Valley, Albany regions etc):

Hardwood forests harvest residues - Availability

- Tasmania - This dataset suggests hardwood (native and plantation) harvesting residues may be 2.96 million GMT pa (High category). The plantation component for all of Tasmania is likely c. 1 million GMT. The highest concentration is in the North East region of Tasmania, which is largely plantation based (500,000 to 750,000 GMT pa). This is consistent with our figures for Tasmania (636,000 GMT pa see Table 5).
- Western Australia – The highest concentration of hardwood residues is in the Albany region of Western Australia, with over 400,000 GMT of Availability per year (High category). This is essentially all plantation based. This agrees with our figure of c. 607,000 GMT pa see Table 5).

Our assessment of quality and price for hardwood residues from the literature/public sources is that both are High classifications (i.e. for this report).

Softwood forests harvest residues - Availability

The database suggests there is Medium Availability of softwood harvest residues in NSW, Qld, Tas and WA.

[34] Lock, P. & Whittle, L. (2018). Future opportunities for using forest and sawmill residues in Australia, ABARES, Canberra, November. CC BY 4.0. https:/doi.org/10.25814/5bdfaee303b64

[35] https://nationalmap.gov.au

- NSW – Availability is 250,000 to 500,000 GMT pa in the Murray Valley (NSW side) and Central Tablelands NPI Regions (High Availability). This agrees with our estimate of 455,000 GMT pa, which is largely from the NSW side of this NPI Region (see Table 5).
- Qld – It is not possible to directly quantify forestry residues in Queensland. There is no regular or comprehensive assessment or monitoring of the generation or utilization of native forest or plantation residues. Regardless, the estimate here is 156,000 GMT pa. Our previous estimate is significantly higher at 430,000 GMT pa. Both estimates are in the Medium Availability range.
- SA – The estimate here is 54,000 GMT pa, which is in our Low category. This is just the South Australian side of the Green Triangle so is likely not comparable to our Green Triangle assessment of 788,000 GMT pa. There is a substantial pine plantation resource and harvesting business in the Green Triangle.
- Tas – The estimate here is 802,000 GMT pa. Our previous estimate is 260,000 GMT pa. There is some disparity here, although both estimates are in the Medium range.

Sawmill residues - Availability

This dataset estimates the biomass (dry tonnes) of sawmill residues from native hardwood/cypress forests, from plantation hardwood forests and from plantation softwood forests in NSW for the purposes of determining availability of biomass for bioenergy.

Each region shows the average annual total of sawmill residues for the period January 2011 to December 2015 (average of 5 years) and the combined residue total of native and plantation residues which are made up of hardwood, softwood and cypress pine residues depending on the region.

- NSW – the highest concentration is in the Murray Valley (NSW side) and Central Tablelands NPI Regions. This is largely from softwood sawmills and is 300-500,000 GMT pa in both regions.
- The previous section estimated 271,000 GMT and 111,000 GMT from the Murray Valley and central Tablelands respectively.
- Both our determinations and the literature review determinations are in the Medium category and there is reasonable agreement here.

Table 6: Literature review of forest based furnish Availability by State

Furnish	NSW	QLD	SA	Tas	WA	Quality	Price	Issues
Plantation hardwood harvest residues	L			H	H	H	H	Economics of extraction
Plantation softwood harvest residues	M	M	L	M	M	H	H	Economics of extraction
Sawmill residues	M		VL	M		VH	M	Competition for landscaping products

The information for the above section is provided in Appendix 4.

4 PURPOSE GROWN ENERGY FORESTS

4.1 MALLEE EXAMPLE

This Section focuses on potential lignocellulosic feedstock #7 (see Table 2 on page 2).

Planted mallee stands are essentially grown in New South Wales and Western Australia in the 400-600 mm long term rainfall region[36]. Of importance to this report, this region is the closest to the commercial softwood and hardwood plantation regions, which, simplistically, occupies the 800mm + regions.

However, the price of land is now so high as for-harvest plantations, such as mallee, will likely shrink towards the major processing centres rather than expand away from these. The permanence obligations that will attach to these if carbon plantations suggest nothing will be available for at least 25 years.

These two regions are shown in Figure 32, along with the National Plantation Inventory (NPI) Regions, for which we have ‘reliable’ forest product supply and forecast Availability data[37] detailed in Section 3.1 on page 14.

Figure 32: The likely greenfield mallee short rotation furnish areas – 400-600 mm rain pa

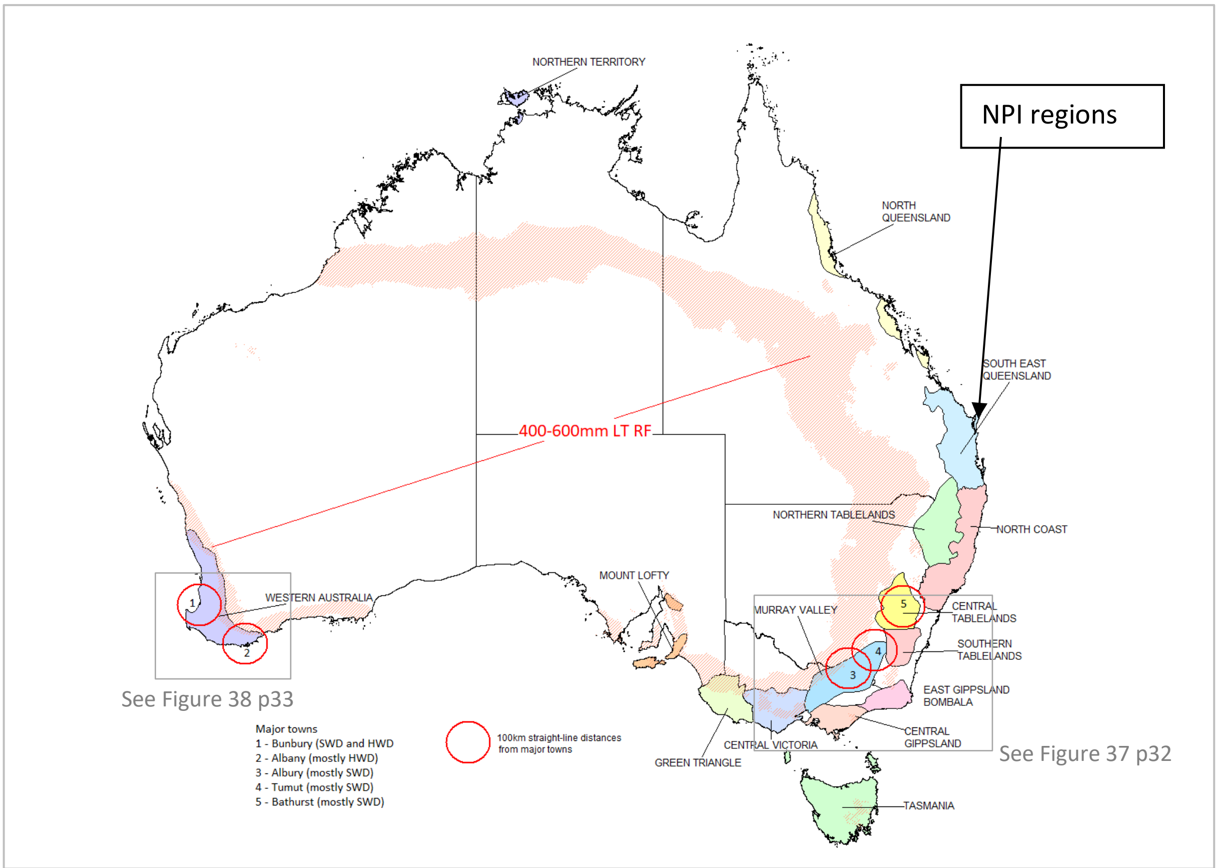


Figure 33 shows a greenfield mallee plantation in the 400-600 mm rainfall zone near Forbes in NSW.

[36] FullCAM rainfall map (raster)

[37] ABARES (see later references)

Figure 33: Mallee (eucalypt) being grown for biomass production (400-600 mm pa)

An example of a mature mallee plantation (shelterbelt) is shown in Figure 34.

Figure 34: Mature mallee plantation in Western Australia (400-600 mm pa)

In biomass-feasibility work undertaken by MBAC, we identified there was a great range of reported yields of mallee biomass at harvest, ranging from 40-70 GMT/ha[38] and around 60 GMT/ha[39]. After substantial work, MBAC determined that a greenfields mallee plantation could yield 50 GMT of above-ground biomass at age 4 to 5 years. If so, then a 150,000 GMT furnish would require a plantation estate of about 3,000 hectares[40].

Many attempts at producing greenfield biomass tree crops have had 'variable' outcomes. Figure 35 shows an 'heroic' trial in northern NSW to grow two species – one for biomass and the other for higher-value solid wood (sawlogs) uses.

[38] Amir A., Bartle J., and Giles R. (2009)

[39] Wu et al (2005)

[40] 150,000 / 50 = 3,000

Figure 35: Casuarina for biomass interplanted with silky oak for solid wood outcomes

One advantage of mallee plantations is their coppicing ability. Coppicing is simply an alternative option to replanting for second and less frequently subsequent rotations. In our experience, coppicing can be variable, sometimes achieving higher, and other times lower productivity than the original rotation due to variable survival.

4.2 MALLEE EXTENT

Oil mallees have been extensively established in Western Australia and, to a lesser extent, in NSW, as a potential woody biomass fuel (URS, 2008)[41] with numerous co-benefits including:

- Diversification of farm income
- Salinity and seasonal waterlogging control
- Stock shelter belts
- Biodiversity
- Carbon sequestration
- Capacity for integration into traditional farming and grazing operations.

Oil mallee biomass has been calculated using the Oil Mallee Association planting database, Google Earth and in-house GIS standing oil mallee plantings. Estimated area, dominant species and year of planting was then mapped and collated up to an Local Government Area (LGA) level. For Western Australia, this is shown in Figure 36[42]. MBAC notes that not all mallee plantings are exhibited here[43].

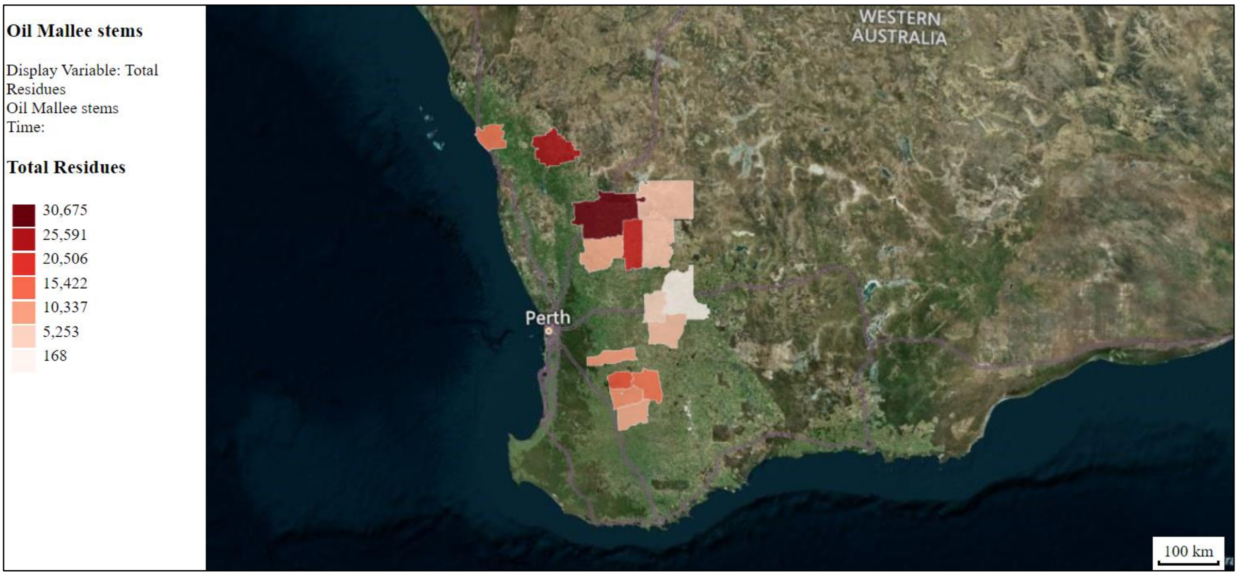
Note, we have not attempted to assess Availability of the purpose grown energy forests, as there is insufficient information available to undertake this.

[41] URS (2008). Oil mallee industry development plan for Western Australia. 106pp. https://www.wheatbeltnrm.org.au/sites/default/files/knowledge_hub/documents/oil_mallee_industry-development-plan_0_0.pdf

[42] https://nationalmap.gov.au/#share=s-nYN6ioRlRjpWb3nUxP3H26AYkya

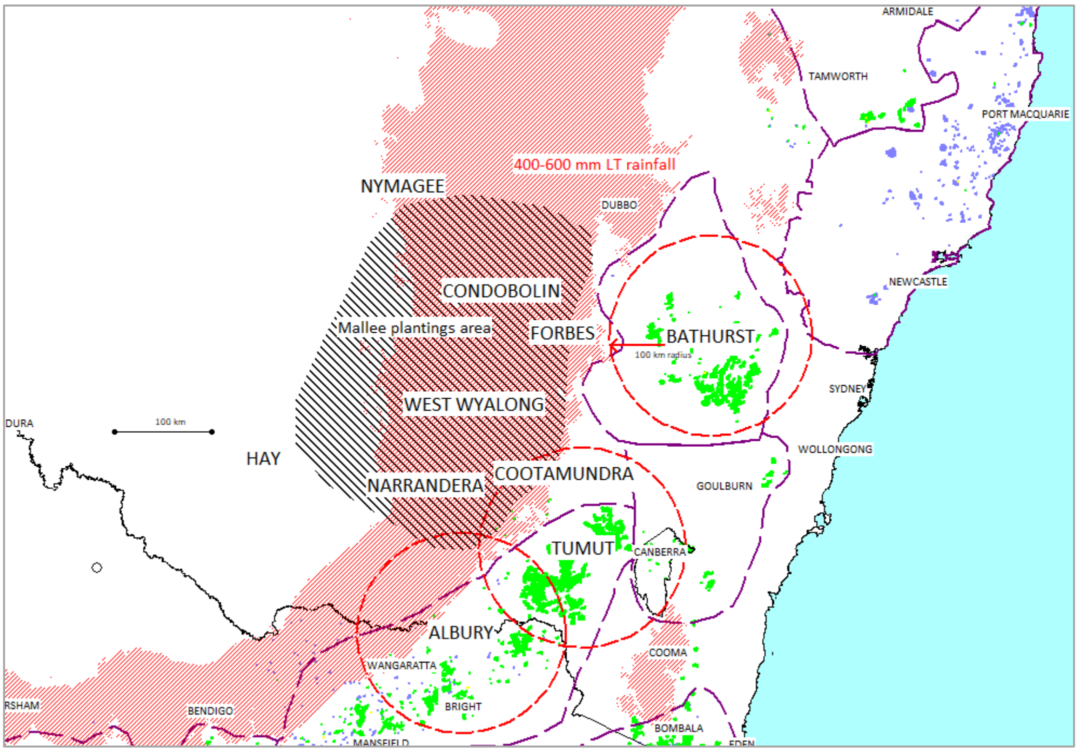
[43] MBAC knowledge.

Figure 36: Oil mallee locations WA



However, the 'actual' area of planted mallee … let alone planted commercial mallee … in Australia is not readily determinable. Regardless, based on MBAC's experience, the general locations that are also in some proximity to our major commercial plantations[44], are shown in Figure 37 below (for NSW) and Figure 38 (for WA).

Figure 37: General location of planted mallee species in NSW



[44] Actual mallee plantings are far more widespread than just the regions shown. These extend from the 350mm long term rainfall regions to the 600mm long term rainfall regions – a considerable area in NSW, Vic, SA and WA. Those closer to the commercial plantations are in the 500-600mm long term rainfall region.

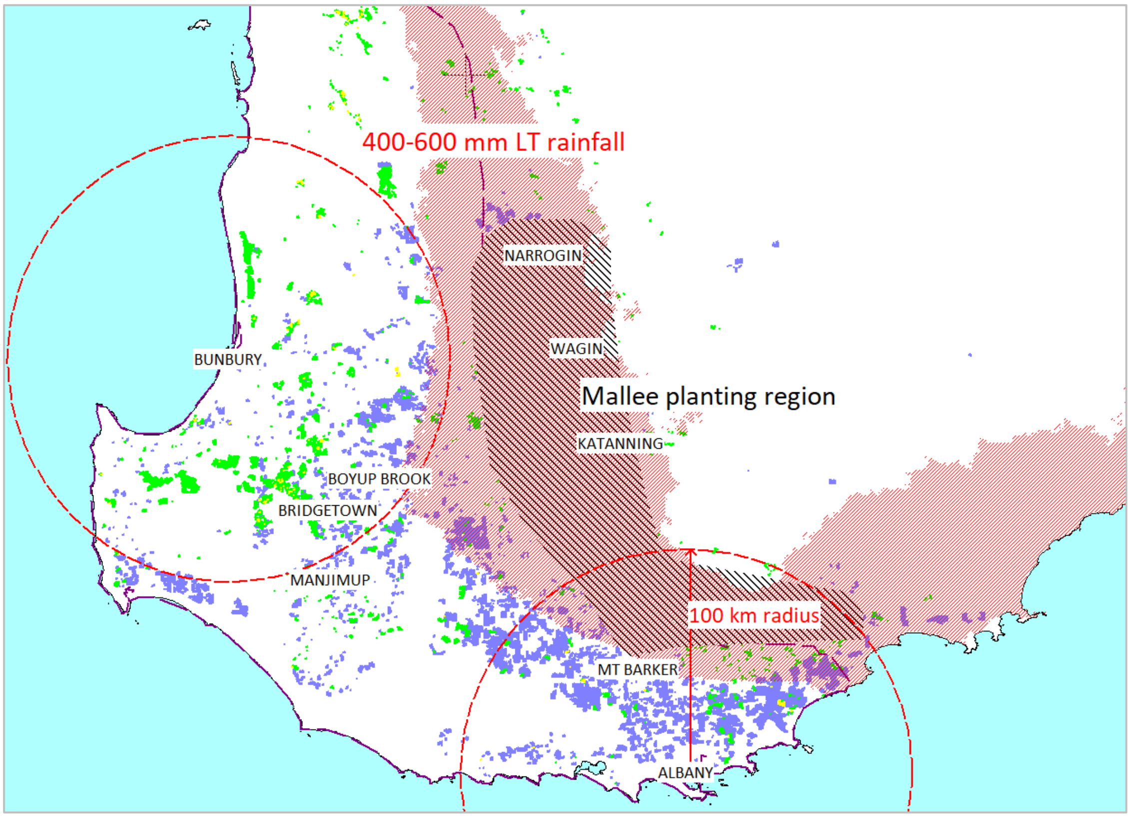
Planted mallee forests have been established in the wheatbelt region of NSW, which includes areas like the Central West and the Riverina. Towns such as Dubbo, Parkes, Forbes, Griffith, Wagga Wagga, and Deniliquin are the closest to these plantings.

The Murrumbidgee catchment area in southern NSW has also seen reforestation efforts involving planted mallee forests. Towns such as Albury, Griffith, Wagga Wagga, and Deniliquin are located within or near this catchment area.

Planted mallee forests in Western Australia have primarily focused on the state's wheatbelt region, including areas around York, Merredin, Narrogin, and Moora townships and towards Mt Barker in the Albany region.

There may be over 12,000 hectares of planted mallee in Western Australia[45] of which an unknown proportion is located within 100 km of Albany as shown in Figure 38.

Figure 38: Estimated relevant location of planted mallee species in Western Australia



The Albany region contains both commercial hardwood plantations and existing mallee plantations, the latter mostly in the 400-600 mm long term rainfall region although extending into the 600-700mm region with the likely closest around Mt. Barker. There is a reasonable but unknown area within 100-150 km of Albany.

Of note here, is that the 400-600 mm pa rainfall isohyet area is closest to the Murray Valley, Central Tablelands and the Western Australia plantation Regions. If short rotation dedicated biomass plantations are to be considered along with furnish from (say) forest residues, then it is these regions which will be more attractive for a facility using a combination of virgin mallee type biomass and forest fibre.

45 Spencer B, Abadi A, Bartle J, et al. 2020. Determinants of the economic viability of mallee eucalypts as a short rotation coppice crop integrated into farming systems of Western Australia. GCB Bioenergy.

Given the limited knowledge of mallee Availability, we cannot determine mallee Accessibility. However, MBAC suggests the ethanol industry should consider utilising the full offtake from a dedicated mallee estate (i.e. several locations) with those plantations located as close to the northern part of the Murray Valley or the Albany region of Western Australia.

Other eucalypts (in Western Australia Albany region)

There are significant areas of other than traditional commercial eucalypt species (blue gum) in the Albany region of WA. These are largely towards the northern side of the blue gum plantings and in slightly drier regions. However, these are poorly described.

MBAC has sighted (2023) numerous such plantations which are presently unaligned with the woodchip export industry. While many of these areas may be multi-purposes (environmental, protection etc) plantings, they appear to have been established using traditional commercial techniques, with around 1000 stems per hectare and other than shelter-belt designs.

The area and volumes available from these is unknown. However, these non-traditional species are less suitable (i.e. not favoured) for woodchip exports.[46]

The issue here becomes what to do with these different species, once harvested? The landowners' problem becomes whether to replant a forest or return the land to agriculture. Both require considerable expenditure ($2-3000 per hectare). These lands may become a basis for sustainable yields for the ethanol industry, by planting non-woodchip suitable species that are more suited to ethanol production. However, once harvested, these lands would be 'targeted' by the existing industrial plantation-based woodchip industry, as demand for their products exceeds supply and will likely do so for some decades hence.

4.3 NON-COMMERCIAL FORESTS AVAILABILITY

This Section focuses on potential lignocellulosic feedstock #8 (see Table 2 on page 2).

Estimates of biomass from non-commercial sources (e.g. camphor laurel 'forests') are focused in South East Queensland and northern NSW, which MBAC estimates aligns with (say) sugar cane residue regions but is less aligned with forest pulpwood production and forest residues. Accordingly, this potential furnish is likely Medium Availability and low Accessibility (costly). This is discussed later in this report.

Camphor laurel trees have been used for biomass production for energy in Australia. Camphor laurel is an invasive species in many parts of Australia, and its removal is often necessary to protect native ecosystems. The tree produces a large amount of biomass, which can be used as a feedstock for bioenergy production.

It is generally located in the north of the North Coast (NSW) NPI Region and in the south of the SE Queensland NPI Region[47]. The latter is between Brisbane and the Gold Coast as well as in the Sunshine Coast hinterland around Nambour.

One example of the use of camphor laurel for biomass production is the "Farm Forests for Future" project in the Northern Rivers region of New South Wales[48]. This project aims to establish mixed-species agroforestry systems on farms, including the cultivation of camphor laurel as a biomass crop for use in a local bioenergy plant. The project aims to provide a sustainable source of bioenergy while also creating new income streams for farmers and improving soil health.

[46] To include them would reduce the existing high quality of a single species export (i.e. mostly *E. globulus* (blue gums) with some *E. nitens* (shining gum).

[47] https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/304594/Camphor-laurel.pdf

[48] Reference

Another example is the use of camphor laurel biomass as a fuel source for small-scale heating systems. In some areas of Australia, camphor laurel is chipped and used as a fuel for wood-fired boilers or stoves, providing a renewable source of heat for homes and businesses.

Overall, the use of camphor laurel biomass for energy production in Australia is still relatively limited, but there is potential for it to be used more widely as a sustainable source of renewable energy.

Its Availability would likely be Low (L) to Medium (M) with >1,000 to > 100,00 GMT available.

4.4 ROTATION AGE TO OPTIMISE SEQUESTRATION AND ETHANOL YIELD

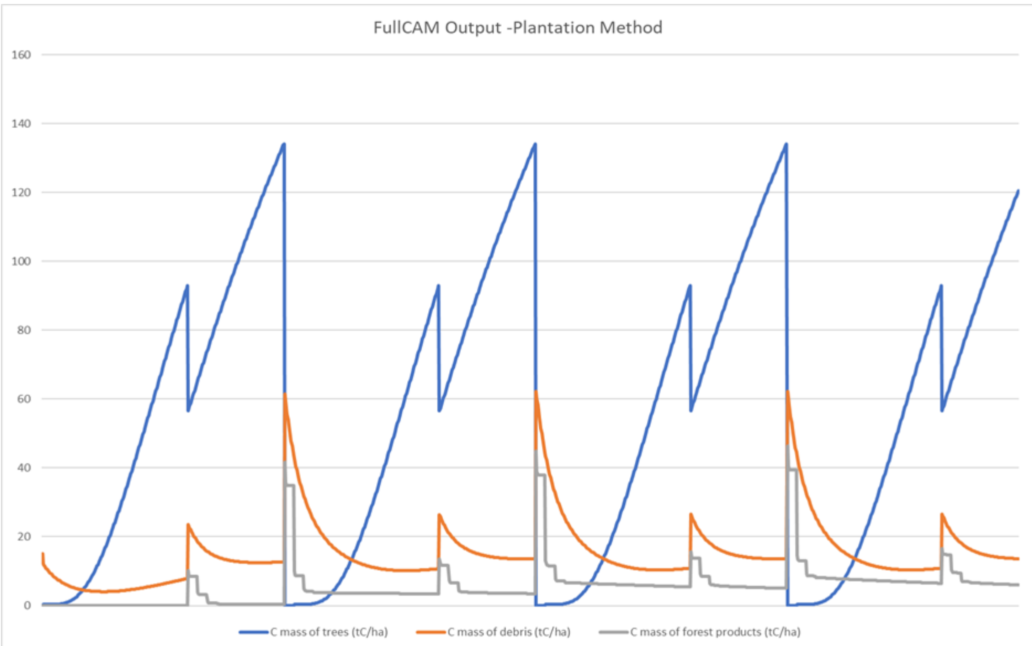
The rotation age for plantation crops to optimise both carbon sequestration and ethanol yield can vary depending on several factors, including species, environmental conditions, management practices, and the goals of the plantation. However, in general optimising for both aligns with traditional silviculture practices for both hardwoods and softwood.

Typically in our experience, stem-volume growth of softwood plantations may range between 10 and 25m³/ha/yr. Based on an average productivity of 17m³/ha/yr and wood density of 450kg/m³, this equates to a stem biomass productivity of 7.6t/ha/yr, or 230t/ha over a 30 year rotation.

Similarly, stem-volume growth of hardwood plantations may range between 5 and 20m³/ha/yr. Based on an average productivity of 12.5m³/ha/yr and wood density of 550kg/m³, this equates to a stem biomass productivity of 6.9t/ha/yr, or 172t/ha over a 25 year rotation.

This includes planting to a set stocking, followed by a period of growth, before thinning to maximise the growth of high value products before clearfall and re-establishment. These higher value projects such as sawlogs lock carbon up of extended periods, and contributes to the carbon credited under the ERF, rather than pulp and residue that has a shorter life and not included in carbon calculations. A typical carbon cycle for a plantation under the ERF is shown in Figure 39 below.

Figure 39: A typical carbon cycle for a plantation under the ERF



The blue line represents the total carbon mass in trees, the orange total carbon mass in forest debris, and the grey total carbon mass in forest products. The carbon in trees and debris remains unchanged through plantation rotations, while the forest products have slight incremental increase through time. ACCUs are calculated as the long-term average of all three factors combined and paid over a 25-year period.

Thus, it would not be possible to remove residues from these forests if they have been included in the determination of ACCUs.

This 25-years is referred to as the crediting period. This means the carbon benefit is capped. Beyond 25-years no further crediting or payment through ACCUs is received. To optimise plantations for both carbon sequestration and ethanol yield, project proponents would be advised to plan for the latter given the longer-term future payments of ethanol over carbon. Additionally, the ERF modelling is conservative in the volume of carbon stored in timber products.

4.5 INDICATIVE SEQUESTRATION POTENTIAL BY REGION

The indicative 25-year carbon sequestration potential in t C/ha (FullCAM) under the Environment Plantings method by State and LGA Region is illustrated in Figure 40.

As carbon sequestration potential is a function of rainfall and site productivity, the variation for environmental plantings can be considered to be correlated to the carbon sequestration potential for plantations. Variation in carbon sequestration potential is closely aligned with rainfall. In turn rainfall is also indicative of NPI regions (see Figure 41), which generally occupy regions above the 600mm annual rainfall isohyet as shown in Figure 2.

Carbon sequestration potential by Environment Plantings is very high (225 to 325 tons CO_2-e/ha at age 25) in the western and central region of Tasmania. For the majority of NPI regions throughout the balance of Australia, carbon sequestration potential by Environment Plantings is in the order of 125 to 225 tons CO_2-e/ha at age 25.

These results are based on FullCAM modelling in accordance with protocols specified in the Emissions Reduction Fund method and are averages for each LGA region. Local carbon sequestration potential may vary for specific sites. The absolute carbon sequestration potential under a plantation forest regime will vary from that shown in Figure 40 based on species, silvicultural regime and local site conditions, but can be expected to move proportionally to the variation for Environment Plantings.

The close alignment between carbon sequestration potential and rainfall is shown in Figure 41.

Figure 40: Carbon sequestration potential – Environmental plantings by State and LGA region

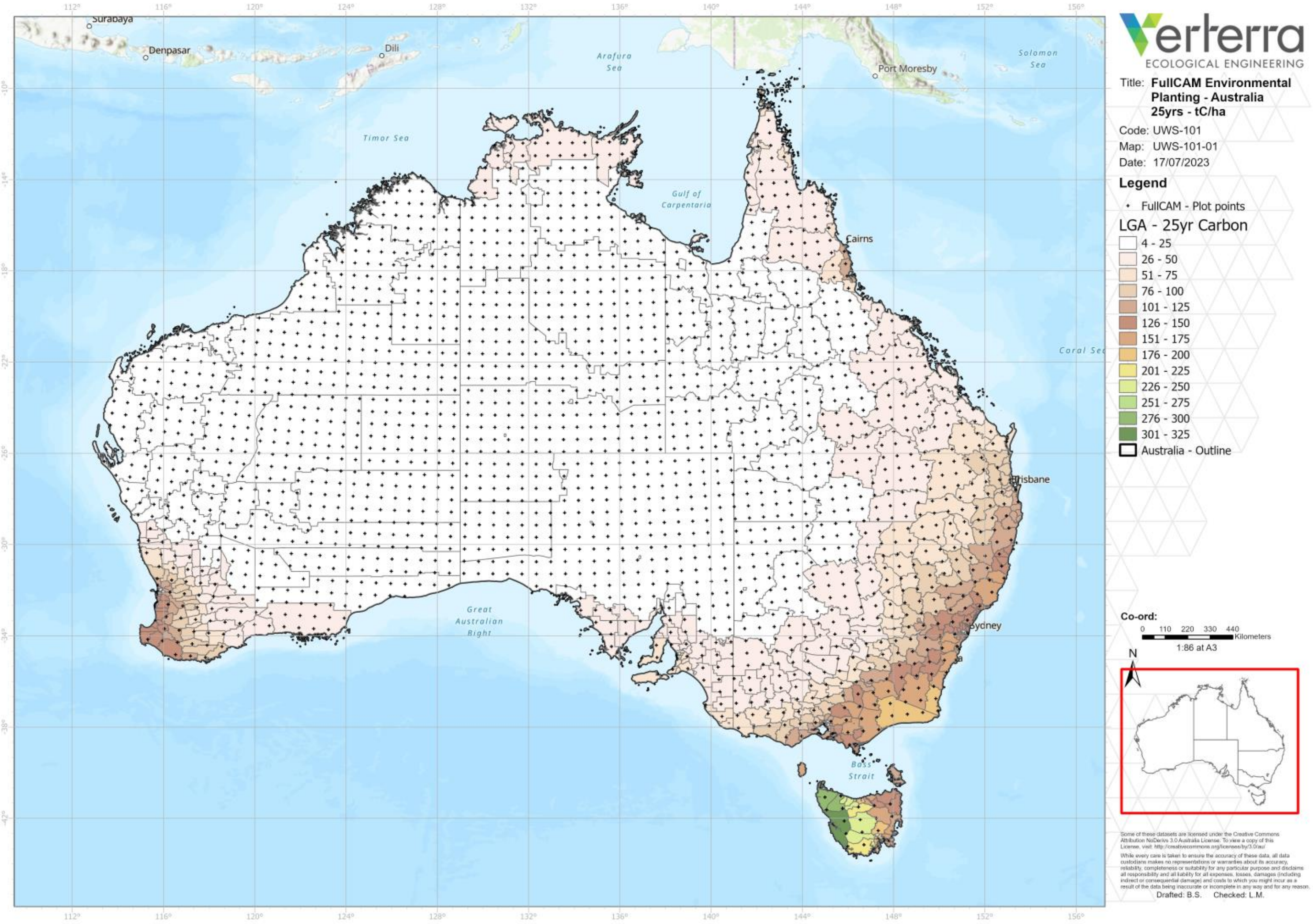
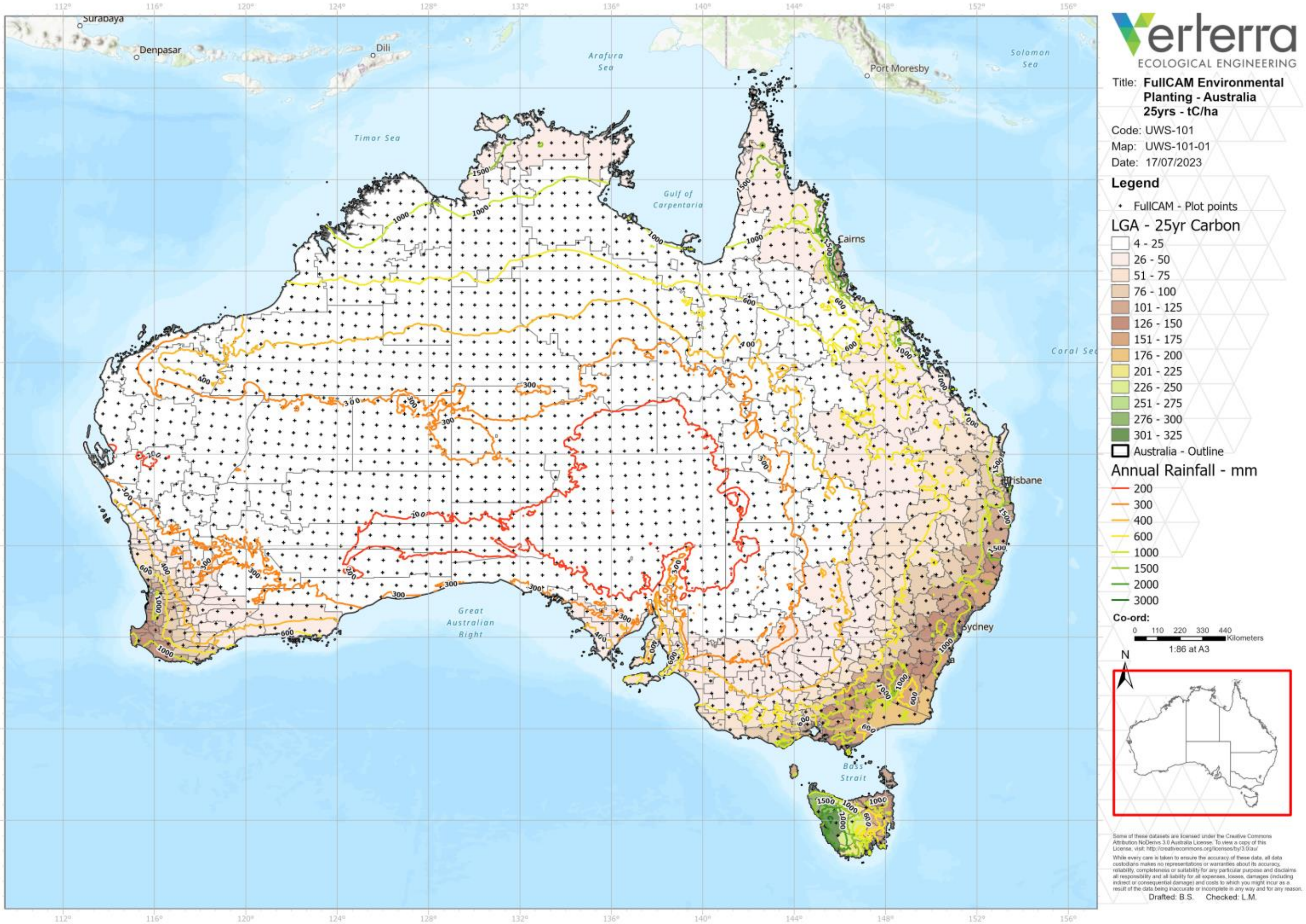


Figure 41: Carbon sequestration potential – Environmental plantings (showing rainfall isohyets)



5 ASSOCIATED CARBON OFFSET IMPLICATIONS

This section describes commercial carbon farming plantations that can be registered under the Emissions Reduction Fund (ERF) to generate Australian Carbon Credit Units (ACCUs).

5.1 AUSTRALIAN EMISSION REDUCTION FUND (ERF) OVERVIEW

Plantation forests and reforestation forms an important part of Australia's Long-Term Emissions Reduction Plan. Part of this transition to a low carbon economy will be from the sequestration of carbon in productive forests plus the associated forest products.

The ERF, overseen by the Clean Energy Regulator, provides incentives for participants to adopt practices to reduce their carbon emissions, or sequester carbon for sale or offsets. While the ERF focuses on a diversity of sectors including energy, facilities, mining, oil and gas, waste, and wastewater, 70% of the projects to date relate to vegetation management.

Additional to ERF administration, the Clean Energy Regulator undertakes methodology determination (or method) development. Methods adhere to offsets integrity standards that requires abatement to be additional, measurable, and verifiable. The methods set the rules for estimating emissions reductions from different activities. The principal ERF vegetation methodology that enables timber production is plantation forestry (4 Schedules):

- Schedule 1 – Establishing a new plantation.
- Schedule 2 – Converting an existing plantation from a short to long rotation.
- Schedule 3 – Continuing plantation forestry activities (sometimes referred to as avoided deforestation Schedule).
- Schedule 4 – Transition to a permanent (not-for-harvest) forest.

Methods 1, 2 and 3 accounts for the carbon sequestered through the growth of trees, plus the benefit of carbon stored in post-harvest timber products. There are currently 30 registered plantation projects within Australia, 7 in NSW, 7 in Tasmania, 5 in Victoria, and 11 in Western Australia. Combined, only 1,686 ACCU have been issued.

5.2 ADDITIONALITY AND NEWNESS

To be eligible to apply for ERF project registration, regulatory additionality and newness tests take place. The additionality requirements support the Government's policy that the ERF will only credit abatement that is genuine and additional to business-as-usual land management. The ERF will not fund projects required under Commonwealth, State, or Territory laws, or likely to be carried out in the absence of the ERF. To determine additionality, two tests are undertaken:

- **Project test:** Tests if activities covered by the method would occur in the absence of the incentive provided by the ERF.
- **Baseline test:** Tests what emissions or sequestration would occur if the project were not implemented (sets the baseline for crediting abatement).

Under newness requirements, an ERF project must not have started before registering with the Clean Energy Regulator, unless the method specifies otherwise (i.e. Schedules 2 and 3).

Importantly, additionality and newness ensure carbon credits are not 'double' counted. Project proponents cannot sell ACCU's to a third party and claim carbon neutrality themselves.

5.3 PERMANENCE OBLIGATION

The risk for all projects is failure to deliver ACCUs. This may occur through overestimation of carbon, a change in land title, or through natural events such as fire. To manage this risk the Government applies a risk of reversal buffer of 5% to all sequestration projects. This means the Government issues 95 ACCUs for every 100 tonnes of carbon stored.

Additionally, a permanence obligation applies. A permanence obligation means landholders agree to either 100 or 25 years of project maintenance. A further reduction of 20% occurs for projects that elect 25-year permanence obligation, with additional reductions for some plantation Schedules as shown in the table below.

Table 7: ACCU Discounts for the plantation method

Permanence Period	Relevant Schedule	Permanence discount	Total discounts including 5% risk of reversal buffer
25 years	All Schedules	20%	25%
25 years	Short rotation plantations under Schedule 1 Short or long rotation plantations under Schedule 3	25%	30%
25 years	Permanent non-environmental plantings under Schedule 4	20% + additional discount of 25% for certain CEAs	25% + additional discount of 25% for certain CEAs
100 years	All Schedules	Nil	5%

5.4 CREDITING

For each tonne of carbon dioxide equivalent (tCO_2-e) stored or avoided by a project, an ACCU is earnt. ACCUs can be used as security, traded, or ultimately cancelled to offset emissions (your own emissions or someone else's).

A 25-year crediting period exists for all sequestration projects. This means the carbon benefit is capped. Beyond 25-years no further crediting or payment through ACCUs is received, even if a 100-year permanence period in applied.

5.5 EXCLUDED OFFSET PROJECTS

The following projects are excluded carbon offset projects:

- A project that is mandatory under a Commonwealth, State or Territory law.
- The planting of any known weed species.
- The establishment of a forest under a forestry managed investment scheme (MIS). This does not restrict ex-MIS plantations from participating if they are no longer an MIS scheme.
- The establishment of vegetation on land that has been subject to illegal clearing of a native forest, or illegal draining of a wetland.
- For new plantations, the Minister for Agriculture determines the project may lead to an undesirable impact on agricultural production in the region.
- Specified tree planting, that is the planting of trees in an area that according to the CFI rainfall map receives more the 600 mm of long-term average rainfall. Often referred to as the 'water rule.'

5.6 THE WATER RULE

The water rule restricts forestry plantations projects from occurring where rainfall exceeds 600mm of annual rainfall. No other carbon farming vegetation method is subject to the same restrictions. Currently there is bipartisan agreement from the major political parties to remove the water rule. It is assumed the water rule will be lifted soon.

5.7 OVERVIEW OF THE PLANTATION FORESTRY METHOD

The method available under the ERF for the plantation forestry sector is known as the Carbon Credits (Carbon Farming Initiative – Plantation Forestry Methodology Determination 2022). Using the generally accepted 'shortened name', the Plantation Forestry Method relies on the FullCAM model to predict and account for carbon sequestration. Importantly, there is no requirement for field measurement and associated verification of yield.

To this time, four activities can be conducted under the Plantation Forestry Method, each with different eligibility requirements, as summarised in Table 2 below.

Table 8: Overview of the Plantation Forestry Method

Schedule #	Activities	Eligibility requirements
1	Establishing a new plantation forest	• There must not have been a plantation forest or native forest on the land in the previous 7 years
2	Converting a short-rotation plantation to a long-rotation plantation	• The plantation forest must be in or within 100 kilometres of a National Plantation Inventory (NPI) region. The conversion may occur either part-way through the short rotation plantation cycle or following harvest of a short-rotation plantation
3	Continuing rotational harvest cycles in a plantation forest	• The land must not have been, nor will need to be, cleared of native forest. • The land must be in, or within 50 kilometres of an NPI Region. • The plantation forest must be of an age (or was harvested at an age) that is within 2 years or older of the relevant default clear fell age in Schedule 6 under the method. • Evidence must be provided that the land would have otherwise been converted to a viable, non-forested land use within 24 months, or remain as fallow land
4	Transitioning a plantation forest to a permanent forest, in situations where that plantation is at risk of being converted to non-forested land (referred to as Avoidance by MBAC)	• The land must not have been, nor will need to be, cleared of native forest. • Evidence must be provided that the land would have otherwise been converted to a viable, non-forested land use within 24 months, or remain as fallow land

5.8 CARBON SEQUESTRATION PROFILE FOR EXAMPLE SOFTWOOD AND HARDWOOD PLANTATIONS

Carbon farming is seen by many as a possible pathway to increasing the size of Australia's planation estate. However, existing barriers to project participation, plus farming community perception suggests this will not occur in the short to medium term. Additionality and newness rules will likely apply when these Schedule plantations are finally clearfelled in years to come.

New plantations under Schedule 1, and re-establishment under Schedule 3 of the plantation forestry carbon farming method might increase the volume of pulp and residue from plantations. However, and fibre gains here may be offset by Schedule 2 and 4 plantations that either aim to increase the sawlog volumes over pulp or exclude forests from future harvesting.

5.9 SCHEDULE 1 ERF FORESTS – NEW PLANTATIONS

This section estimates the pulpwood and residues possibly available from Australian potential commercial greenfield planted forests that have been and may in the future be established under the ERF (ERF Schedule 1).

The barriers to carbon farming project participation, such as the 'water rule' under the methodology determination, limits project uptake and will not increase the size of Australian plantations in the short term.

Assuming these barriers are overcome, there is no forward projection on the area of greenfield plantation that might occur under carbon farming in Australia. In the past, various government initiatives have tried to encourage new plantings, with little to no success. Plantation based carbon farming is untested in Australia at an industry scale, so only time will tell if a material difference in the size of the plantation estate is observed.

Looking at New Zealand carbon farming that focuses on new softwood plantations as an example, although successful from a carbon sequestration perspective, rural committees are pushing back and making efforts to limit further investment. This is likely because of perceived over-planting, problems with plantation residues entering water courses in extreme weather events and limited actual emissions reductions in that country.

Australia might follow a similar trajectory, with acceptance of plantations from rural communities on a small scale only. Currently, any new carbon farming plantation in Australia requires Ministerial approval to ensure rural communities are not adversely affected.

Any new plantations under Schedule 1 will most likely be long rotation softwood plantings, aiming to produce high value sawlogs for the building and construction sector. These will need to occur within NPI Regions to capitalise on infrastructure for any meaningful increase in pulp and residue. It is highly unlikely carbon farming will generate more than 50,000 ha of greenfield establishment within 300 km of large mills, or generate a material increase in this feedstock.

5.10 SCHEDULE 2 ERF FORESTS – SHORT TO LONG TERM ROTATION

This section presents an estimation of the potential Availability of pulpwood and residues from Australian short rotation planted forests, which could be converted to long rotation planted forests under the ERF (ERF Schedule 2). This change is still in its early stages in Australia, and not all short rotation stands are eligible for this transition. For example, some short rotation hardwood forests have medium to long term wood supply agreements that prevent their conversion, while others have a HBU's as a short rotation forest.

Although there are no precise figures available, MBAC suggests that approximately one third of existing short rotation eucalypt forests may, at best, transition to long rotation hardwood plantations. If this occurs, hardwood pulpwood and associated residues from these plantations will be registered under the ERF and could attract industries other than the woodchip export industry. However, this change will result in delaying the Availability of pulpwood and associated residues, rather than causing any drastic changes.

Moreover, some short rotation hardwood forests can be converted to long rotation softwood forests after clear felling, and they also qualify as Schedule 2 carbon forests. If this trend gains momentum, there will be a delay in the production of pulpwood and associated residues, and the hardwood furnish will become softwood furnish instead.

Given the value of an ACCU is unrelated to distance to any market point (i.e. port, processing centre), these types of plantations will likely be spread across the entire plantation estates.

5.11 SCHEDULE 3 ERF FORESTS – RE-ESTABLISHMENT POST CLEAR FALL

This section presents an estimation of the potential Availability of pulpwood and residues from Australian continuing harvesting of forests, that means plantations will be re-established instead of converted to agriculture in the absence of a carbon farming project (ERF Schedule 2). These are referred to as avoided deforestation plantations.

To MBAC's knowledge, there are no plantations registered under the ERF for this Schedule. Large areas (c. 200-300,000 hectares) have already been converted to agriculture. Given the additionality clauses under the carbon farming rules, the areas already converted would not qualify.

Thus, only existing plantations where the financial returns from carbon farming that incentivise landholders to replant forests instead of converting to agriculture can participate. MBAC suggests at best maybe 50-100,000 hectares may qualify over the next 1-2 decades.

5.12 SCHEDULE 4 ERF FORESTS – TRANSITION TO A PERMANENT FOREST

Under this Schedule Availability of pulpwood and residue from forest plantations will be eliminated. This Schedule allows landholders to convert their hardwood plantations to environmental plantings that will remain in perpetuity for 100 years under the ERF permanence obligation.

This Schedule exists to allow 'failed' plantation areas is participate in the ERF, as plantations that will provide long term biodiversity benefits. In the absence of carbon farming, these areas would most likely have been cleared for wood and woodchip; however, under carbon farming no harvesting would be permitted.

To MBAC's knowledge, there are no plantations registered under the ERF for this Schedule. Only small areas will participate, with no material effect on current or future feedstocks.

5.13 IMPLICATIONS OF PLANTATION MANAGEMENT FOR DUAL PRODUCTION OF CARBON AND ETHANOL

No implications are identified by MBAC, either positive or negative in relation to plantation management for dual production of carbon and ethanol. Silviculture will remain unchanged when the aim of the plantation is to maximise the yield of sawlogs for carbon capture and storage while producing typical volumes of pulp and residue.

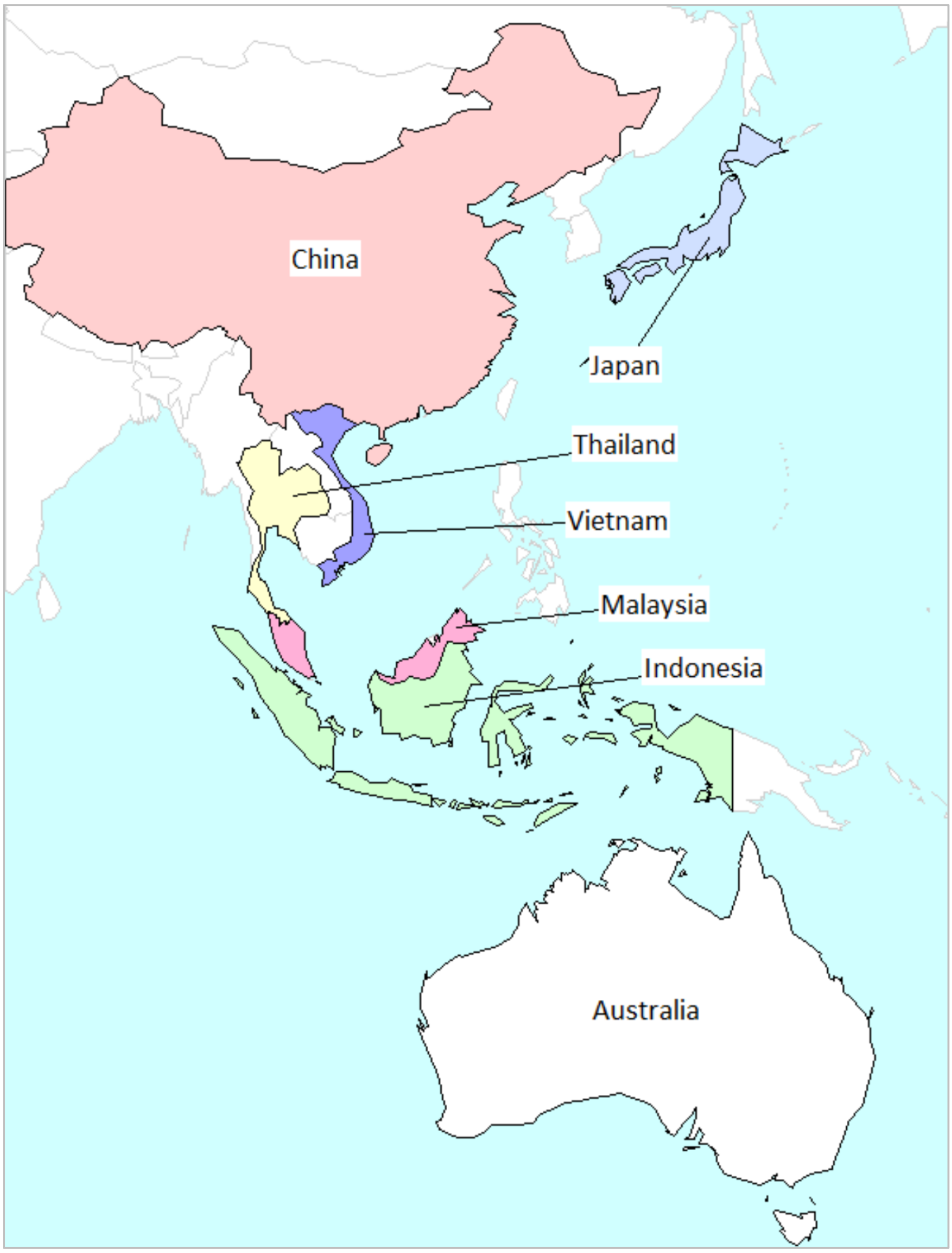
5.14 NEXT ROTATION ERF FOREST ISSUES

Rotation issues might occur where a 100-year permanence obligation is selected over 25-years. This will lock land parcels up for single use. However, this may not be considered an issue if long term pulp and forest residue is sought.

6 POTENTIAL ASIAN PULPWOOD AVAILABILITY

The Asian Pacific woodchip supply demand dynamics are primarily driven by the convenience and economic considerations of transport, especially shipping. Wood is largely converted into woodchips to facilitate transportation and this trade. The region of interest to this report[49], is overwhelmingly dominated by hardwood woodchip trade. The Asia Pacific trade in hardwood woodchips is around 30 million BDMT per year. Of this, Australia supplied around 5 million BDMT and Vietnam supplied around 15 million BDMT.

Figure 42: Region of interest in this report



The complex economics of the Asian Pacific woodchip supply demand are influenced by a range of factors. Woodchip Availability from different countries and Accessibility to different buyers is

[49] Excluding the huge trade in softwood logs from New Zealand to Asia, which is 'a different story'.

particularly significant for Australian suppliers and potential domestic users of this fibre[50]. Fibre Availability is influenced by factors such as forest resources, land availability, and government regulations. Accessibility is influenced by transportation costs, infrastructure, shipping routes, port capacities, stock levels, price and many other factors.

This trade is exceedingly complex and dynamic. In the context of the Australian market, understanding the complexities of the Asian Pacific woodchip supply demand necessitates considering the dominant role of hardwood woodchips and the key factors of Availability and Accessibility that impact Australian users.

- **Regional dynamics**: Different countries in the region have varying woodchip Availability levels, driven by factors such as forest resources, land availability, and government regulations. Some countries are very responsive to changes in demand, by increasing Availability (i.e. Vietnam), while others are not (i.e. Japan).
- **Supply sources**: The woodchip supply chain involves both domestic production and imports. Australia, with its large, planted forest resources, plays a significant role in supplying certified woodchips, which is mostly hardwoods. However, Accessibility to woodchips from buyers in other countries in the region also affects the overall supply in Australia.
- **Market demand**: Users of woodchips, such as the pulp, paper and wood-based panel industries, rely on a steady supply to meet their requirements. Factors influencing demand include population growth, economic development, changing consumer preferences and government regulations.
- **Trade and logistics**: Accessibility to woodchips involves considerations of transportation costs, infrastructure, shipping routes, and port capacities. Trade agreements and relationships between Australia and other Asian Pacific countries also influence the accessibility of woodchips.
- **Sustainability and environmental concerns**: The Availability and Accessibility of sustainable woodchips are increasingly important for Australian users and suppliers. Environmental factors such as responsible forest management, certification, and sustainable sourcing practices are critical considerations. There is a premium placed on such qualities.
- **Price volatility and market forces**: The Availability and Accessibility of woodchips from different sources can impact their prices in the Australian market. Market forces, competition, and currency exchange rates also play a role in price volatility.

Understanding the complexities of the Asian Pacific woodchip supply demand economics from an Australian perspective requires considering the Availability of woodchips, their Accessibility, and how these factors impact the local industry.

6.1 VIETNAM HARDWOOD AVAILABILITY

In 2021, Vietnam had 4.4 million hectares[51] of mostly *Acacia* and *Eucalyptus* plantations. These are mostly very short rotation (3-5 years), small-scale plantations with lesser quality (basic density) than longer rotations (still 'short' but more like 9-15 years) elsewhere, such as from Australia.

- Between 2017 and 2021, Vietnamese hardwood woodchip exports to other parts of Asia increased by 5.7 million Bone Dry Metric Tonnes (BDMT), a 72% increase. This reflects significant market changes where lower quality (lower priced) woodchips were favoured by

[50] 'Fibre' is the preferred term when referring to international trade in woodchips.

[51] JEC Assessment: Vietnam. 2022, P22

some buyers. Such changes were quickly recognised by Vietnamese farmers, responding with rapid increases in planted areas.

- In 2022, Vietnamese Free On Board (FOB) prices for hardwood woodchips increased from less than USD130/BDMT at the start of the year to a peak of over USD190/BDMT in October, before decreasing to about USD170/BDMT at the end of the year.
- Total exports increased by about 2.0 million BDMT in 2022 alone, to close to 15.6 million BDMT.

Hardwood woodchip Availability in Vietnam may, in theory, continue to expand, by several million more BDMT. However, MBAC suggests there are limiting factors to increasing woodchip exports from this country:

- Shipping constraints (insufficient ships).
- Wood quality[52] (lower than other suppliers).
- Small forest unit size (higher unit costs of production).
- Reliance on manual labour for harvesting and loading of pulpwood for woodchip production (a constraint on production).

Unlike many other plantation forest countries, with much larger stem sizes, straight *Eucalyptus* boles and much larger forest unit sizes, the Vietnamese industry has essentially no scope to reduce labour requirements through investment in mechanical processing. By late in this decade MBAC expects to see labour being the key factor that limits the total volume of hardwood woodchip exports from Vietnam.

For this report, MBAC estimates Vietnam's hardwood woodchip Availability will stabilise at around 15 million BDMT per year i.e. around 50% of the Asia Pacific total supply.

Of course, Vietnam also has substantial (c. 700,000 ha) commercial bamboo forests which grow rapidly and sell products into established industries in Vietnam (i.e. bamboo furniture and flooring). These could generate virgin and waste fibre for the lignocellulosic ethanol industry. Forest and bamboo industries are 'clumped' in Vietnam such that one industry utilises the virgin product and neighbouring industry utilises its waste wood and they are all close to the many ports in Vietnam to export their products. This close integration is widespread in Vietnam.

These hubs are strategically located within the wood supply zones of the major commercial forests in Vietnam. There are also many ports for export of woodchips (one or more in each of the Central Provinces).

Thus, Vietnam presents High Availability with probably Low Accessibility due to lower quality and lower price and high demand from domestic energy industry (wood pellets) and China, Taiwan and Japan for woodchips.

It is Vietnam's proximity to China (1-2 days sailing) and ability to respond rapidly to changes in demand that directly impact Australian Availability and Accessibility.

High Availability but Low to Medium Accessibility.

[52] Acacia tree shape and young age of stems being harvested

6.2 THAILAND HARDWOOD AVAILABILITY

Thailand, with 3.537 million hectares[53] of planted forests designated for production, has emerged as the third largest hardwood woodchip supplier in 2022, behind Australia and Vietnam.

- Thai exports peaked in 2013 at 2.6 million BDMT.
- In 2020, exports declined to a low of just over 1.0 million BDMT.
- Exports increased to 1.3 million BDMT in 2021.
- In 2022 exports nearly doubled and will likely total 2.5 million BDMT for the 2022-23 calendar year plus another 0.6 million BDMT from NE Thailand exported by road into Laos.

MBAC estimates Thailand's hardwood woodchip Availability will peak at around 3.5 million BDMT per year, with a maximum of 3.0 million BDMT exported. The longer-term outlook is more likely to be for roughly current volume levels or slightly higher to be continued.

There is High Availability and possibly some Accessibility.

6.3 MALAYSIA HARDWOOD AVAILABILITY

Malaysia has 1.697 million hectares[54] of planted forests designated for production. However, there has been minimal Availability for exports, as much of its available pulpwood has been diverted to pulp mills in Indonesia (Sumatra). There are little prospects for any increase in supply for export.

There is Very Low Availability and zero Accessibility.

6.4 INDONESIA HARDWOOD AVAILABILITY

Indonesia has 4.527 million hectares[55] of planted forests designated for production. They have significant domestic pulp and paper capacity which consumes significant volumes of plantation pulpwood. However, Indonesian exports to China (i.e. to Indonesian owned pulp and paper facilities) and elsewhere:

- Exports peaked at 1.8 million BDMT in 2014.
- Reduced to an average of 375,000 BDMT in 2018-2020.
- Exports increased in 2021 and 2022.
- A shortage of pulpwood in Indonesia means that this increase will not be repeated.

In 2022, MBAC believes about 300,000 BDMT of hardwood woodchips were imported to pulp mills in Sumatra from Vietnam, South Africa and Thailand, and local sources indicate that this import trade is likely to expand until Indonesia becomes a net woodchip importer in the next several years. Accordingly, there is no chance for larger volumes of woodchip exports.

Availability is Low and Accessibility is zero.

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[53] FAO 2020. "Global Forest Resources Assessment 2020. Main report. P155

[54] FAO 2020. "Global Forest Resources Assessment 2020. Main report. P153

[55] FAO 2020. "Global Forest Resources Assessment 2020. Main report. P152

6.5 JAPAN HARDWOOD AVAILABILITY

Japan has 10.184 million hectares[56] of planted forests. However, very little of this is used for domestic consumption as the cost of wood from these essentially very steep plantations is significantly greater than the cost of imported woodchips.

In Japan, 90% of hardwood woodchip consumption is imported, and both cost of harvesting and transport and environmental restrictions preclude any increase in domestic hardwood pulpwood production in Japan. Availability is zero.

6.6 CHINA HARDWOOD AVAILABILITY

China has 84.696 million hectares[57] of planted forests. For China, there is a considerable volume of *Eucalyptus* pulpwood produced in Guangxi Province and the bordering areas in Guangdong. However, the vast majority of this is utilised to produce wood-based panels, as prices paid by those mills are normally higher than that offered by local pulp mills.

Chinese panel production declined sharply due to COVID restrictions in the second half of 2022, but that was a short-term anomaly.

Chinese land is expensive and there is very little prospect for domestic hardwood woodchips to expand their share of the market. China is and will remain a major importer of hardwood woodchips. Availability is Low.

6.7 POTENTIAL AVAILABILITY FROM SOFTWOOD FORESTS

There are minimal areas of softwood plantations in these countries.

6.8 IMPACT OF RUSSIAN-UKRAINE WAR

The Russian-Ukraine war will have a number of impacts on demand for hardwood woodchip imports in Asia.

- In the short term (and lasting for likely many years after this conflict eventually ends), the lack of Russian hardwood woodchips flowing into Scandinavian pulp mills has diverted some volume away from Brazil, Uruguay and South Africa which might otherwise have gone to Asia.
- While Western sanctions on Russia will not impact the short-term flow of pulpwood into China, longer-term, sanctions may likely make it increasingly difficult for Russian pulp mills to maintain operations, with timber harvest and transport equipment having to function without replacement parts.
- Russian pulp mills may also find it difficult to maintain production without maintenance by European technicians (where most of the equipment is from) and also lack of replacement parts.

While this will likely impact the flow of softwood pulpwood from Russia into China more than hardwood pulpwood, it will impact the Chinese industry's Availability of virgin fibre (woodchips). Again, this underlines the importance for the Chinese industry of maintaining woodchip imports.

[56] FAO 2020. "Global Forest Resources Assessment 2020. Main report. P152

[57] FAO 2020. "Global Forest Resources Assessment 2020. Main report. P151

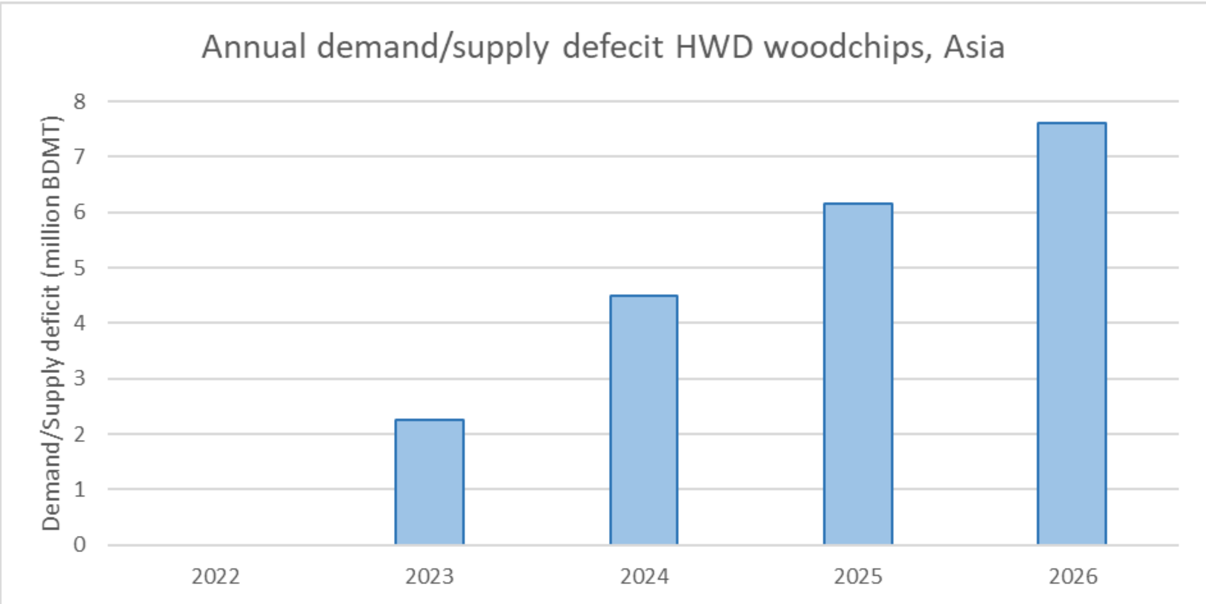
6.9 SUPPLY/DEMAND BALANCE – HARDWOOD FIBRE

These Asian country Availability estimates for hardwood woodchips are one of the main 'drivers' of hardwood woodchip export prices in the Asia-Pacific region. This is because demand exceeds supply as few countries, other than Australia, have expanded their hardwood plantations to meet future demands. This lack of supply impacts prices in Australia and elsewhere. The 2022 'International Woodchip Conference'[58] presented[59] a simplified[60] analysis of the supply/demand balance for woodchips in Asian markets to 2026.

- Demand for hardwood and softwood woodchip imports in Asia was projected based on 2022 estimated actual imports and new production units expected to start up by 2026 (Figure 43).
- However, as the rapidly expanding new Chinese pulp and paper capacity is developed, the projected demand minus projected supply (apparent deficit) increases from 2.3 million BDMT (hardwood woodchips only) in 2023 to a base case of 7.6 million BDMT in 2026.
- The forecast estimated a lower deficit of about 5.2 million BDMT in 2026 and a high-end scenario where demand outstrips supply by 9.5 million BDMT. Figure 43 uses the means of these ranges.

This, of course, will impact the 'economics' of securing any of this fibre for ethanol production – whether this is to set up in-country (like Vietnam) or be based in Australia and compete for Australian exported fibre. This is dealt with in the Prices section.

Figure 43: Supply/Demand deficit, Hardwood woodchips in Asia



MBAC suggest the shortfall of hardwood woodchip supply will be very large, and this will be a key driver of higher prices going forward.

While Availability of Asian suppliers may be very High, Accessibility to this fibre will likely be Low to Very Low.

[58] Global Woodchip and Biomass Trade Conference - Singapore in late October, 2022

[59] By Dennis Neilson of DANA Ltd and Gavin Hao of Gingko Consulting

[60] Projection of likely woodchip export volumes from existing and potential new suppliers, based on historical trends and interviews with exporters in each supplying country.

7 OTHER LIGNOCELLULOSIC FEEDSTOCKS AVAILABILITY

There are several types of non-forest lignocellulosic biomass furnish that can be used for ethanol production. These include:

- **Agricultural residues**: Crop residues such as corn stover, wheat straw, and rice straw and cotton trash can be used as a feedstock for ethanol production.
- **Industrial waste**: Residues from various industrial processes such as paper mills, breweries, and distilleries can be used for ethanol production.
- **Energy crops**: Dedicated energy crops such as switchgrass and miscanthus can be grown specifically for use as a feedstock for ethanol production.
- **Municipal solid waste**: Organic waste from households and businesses, including greenwaste and food waste, can be processed to produce ethanol.
- **Aquatic biomass**: Certain types of aquatic biomass such as seaweed and certain species of algae contain lignocellulose and can be harvested and processed for use as a feedstock for ethanol production.

Overall, non-forest lignocellulosic materials and residues offer an opportunity for sustainable and renewable ethanol production, especially where waste residue markets are limited and management of such residues is problematic (e.g. cotton trash). Conversely, some agricultural non-forest lignocellulosic biomass residues are valued for retention in the field to retain soil carbon and build soil health (e.g. wheat stubble). By using waste products and crops specifically grown for bioenergy production, these sources can help to reduce greenhouse gas emissions and provide a renewable energy source that does not compete with food or fibre production.

Most of this potential Availability is in New South Wales, south east Queensland and South Australia, based on the scale-metrics adopted in the forest based Availability sections of this report.

Table 9: Location of non-forest lignocellulosic furnish apparent Availability

Furnish	NSW	QLD	SA	Tas	WA	Quality	Price	Issues
Municipal solid waste residues	H	H	M	M	M			
Municipal solid waste	H	H	M	M	M	VL	M	Contamination
Sugar industry residues		VH						
Sugarcane bagasse		H				H	L	Competition for landscaping products
Sugarcane trash		H				VL	H	Economics of collection, soil contamination and requirement for soil carbon
Grains industry residues	H	M	VH		H			
Non-cereal straw	H		H			M	M	Competition to retain for soil nutrition and animal feed
Rice hulls	M					H	L	Competition with existing thermal bioenergy plants
Sorghum straw		M				M	M	Competition to retain for soil nutrition and animal feed
Straw/hay/silage	H	M	H		H	M	M	Competition to retain for soil nutrition and animal feed
Cotton residues	L	M						
Cotton gin trash	L	L				H	VL	Potential opportunity due to concentrated production and hygiene issues with field re-use
Cotton seed		M				H	VL	Potential opportunity due to concentrated production
Cotton straw		M				M	M	Competition to retain for soil health and nutrition

However, we need to 'look' at this regionally and, specifically, within the NPI Regions.

7.1 MUNICIPAL SOLID WASTE RESIDUES

As a feedstock for bio-industrial processes, urban waste offers a number of advantages over alternatives, such as agricultural crop residues. These include:

- Operationally—the supply of waste is comparatively consistent and reliable over time and infrastructure and processes to aggregate and store waste already exist in most instances.
- Economically—utilisation of waste converts materials that are currently a costly liability (to manage and dispose of) into a potentially valuable revenue generating asset.
- Environmentally—each tonne of waste diverted is one tonne less disposed to landfill where it generates methane, one of the most potent greenhouse gases, as well as other land, water and atmospheric pollutants.

Conversely, source control of MSW is an issue and any processing facility or technology will require the capacity to handle contaminants.

The Clean Energy Finance Corporation estimates that the Australian bioenergy and energy from waste investment opportunity to 2020 is between $3.5 billion and $5 billion (CEFC 2015)[61].

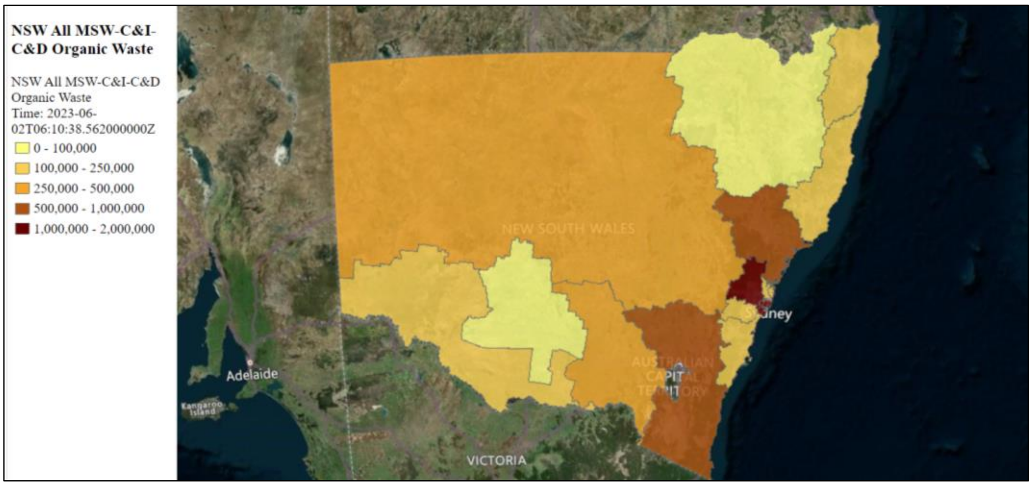
Municipal waste in NSW

This dataset estimates the mass in tonnes of Municipal Solid Waste (MSW), Commercial and Industrial (C&I) and Construction and Demolition (C&D) organic waste received at waste and transfer facilities within the Renew NSW regional groups across NSW.

Each regional group shows the average annual total for MSW, C&I and C&D organic waste for the period July 2015 to June 2018 (average of 3 years). Each regional group also shows the combined organic waste total of these three waste streams.

The organic material compositions included in the waste streams reported in this layer (Figure 44[62]) are "*Food*" (food and food products); "*Paper or cardboard*" (paper and paper products), "*Vegetation or compost*" (vegetation or garden, composts or mulches and biosolids or manures, with vegetation being the major component of this category); and "*Wood or wood products*" (wood and wood products). The MSW for Sydney is 1.6 million tonnes per year.

Figure 44: Municipal waste Availability in NSW



[61] CEFC (2015). The Australian bioenergy and energy from waste market. Report by the Clean Energy Finance. https://greenbanknetwork.org/portfolio/the-australian-bioenergy-and-energy-from-waste-market/

[62] https://nationalmap.gov.au/#share=s-zJkLpvtiUcZnkS8oNyG2ZcFxLaV

Queensland

Solid waste is commonly described as comprising three main streams:

- Municipal solid waste (MSW)—household garbage, normally collected at the kerbside from individual household bins.
- Commercial and industrial waste (C&I)—residues discarded from manufacturing (e.g. joinery offcuts) or service industries (e.g. restaurant food waste) which may be collected at the kerbside or self-hauled.
- Construction and demolition waste (C&D)—which is generally self-hauled.

Each of these streams is delivered to a transfer station, recovery facility or landfill for sorting, recovery and disposal. Irrespective of the stream from which it is derived, any one container or delivery of waste is likely to contain a diverse mix of organic components. These organic components can vary greatly in their chemical, physical and biological characteristics (Hla & Roberts 2015)[63] with important implications for the conversion technology that different components are suited to and the pre-processing they require. For this reason, solid waste data for Queensland suitable for lignocellulosic ethanol production is presented using a framework that separates it across all three streams into the following categories:

- Green waste (see Figure 45) [64]
- Paper and cardboard (see Figure 46)[65]
- Waste timber (see Figure 47)[66]

These categories align with those used in similar studies (e.g. Taylor et al 2011)[67] and with the Australian Waste Database (Hyder Consulting 2011)[68] and are illustrated in Figure 45 below.

Figure 45: Solid green waste Availability in Queensland

[63] Hla SS, and Roberts D (2015) Characterisation of chemical composition and energy content of green waste and municipal solid waste from Greater Brisbane, Australia. Waste Management 41:12–19.

[64] https://nationalmap.gov.au/#share=s-8QTgFIlfTXMqRgdWOJ0cC5bckZk

[65] https://nationalmap.gov.au/#share=s-aAJBRa99rNjYBCZoFCkvp1eQqjU

[66] https://nationalmap.gov.au/#share=s-hVXsXm8mni4aovwRa1e2BoeTiGA

[67] Taylor J, O'Connor MH, Braid A, Prestwidge D, Herr A, Crawford D, Jovanovic T, Quayle W, Raison J, and O'Connell D (2011) Regional Estimates of Victorian Biomass Resources. Report prepared for Regional Development Victoria by CSIRO

[68] Hyder Consulting (2011) Waste classifications in Australia—A comparison of waste classifications in the Australian Waste Database with current jurisdictional classifications. Report prepared for the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Figure 46: Solid wastepaper Availability - Queensland

Figure 47: Solid waste timber Availability Queensland

The combined MSW for Brisbane is 356,000 tonnes per year.

South Australia

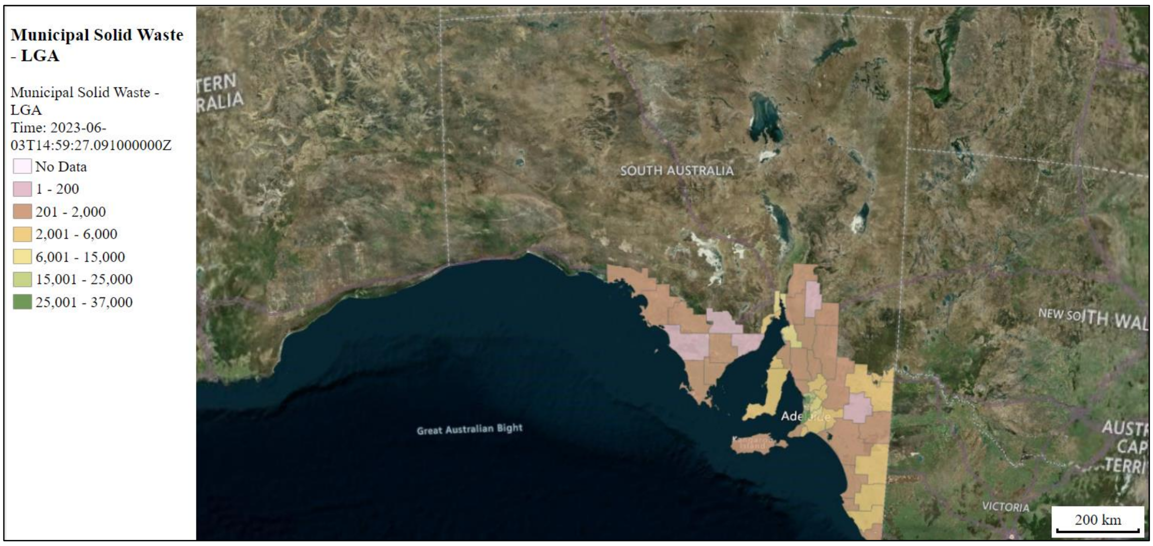
These data include information on:

- Municipal solid waste – data on Kerbside Collection (see Figure 48)[69]
- Source separated organics and Rubbish - organic fraction Other Municipal Waste
- Other organic biomass generated (as dry weight tonnes) amalgamated at Local Government Areas.

[69] https://nationalmap.gov.au/#share=s-9OeNFyljhWbAAkU2h6OEkzNloUv

In this context residues are considered to be organic materials (such as green organics) created through the production process. Residues are generally considered a waste although they may still be in beneficial use.

Figure 48: Municipal solid waste Availability South Australia

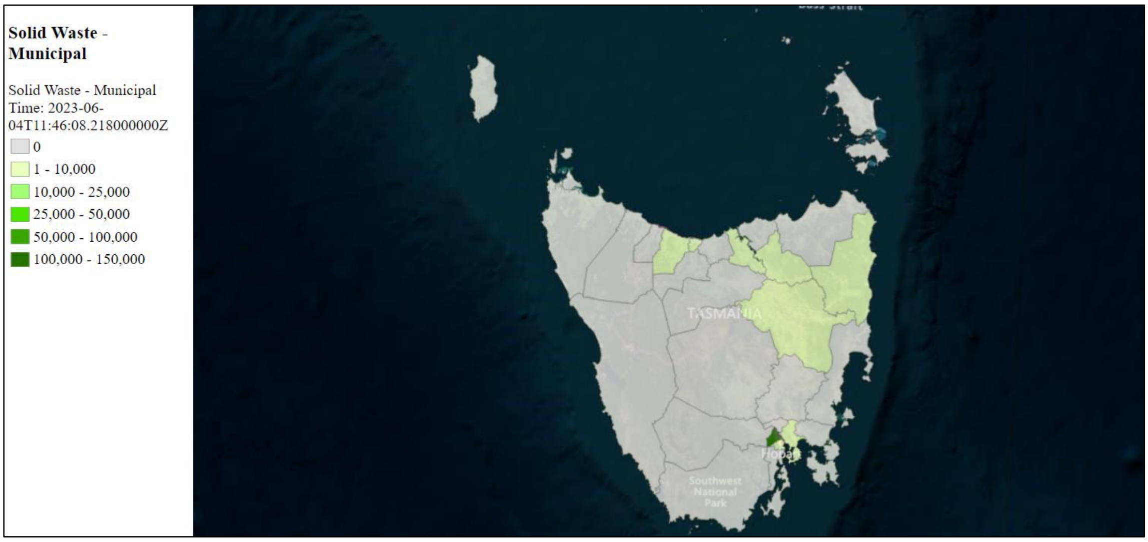


The combined MSW for Adelaide is 267,000 tonnes per year.

Tasmania

The organic residues data was compiled from the Tasmanian Residues Survey for 2016 undertaken by Dulverton Waste Management on behalf of the Department of State Growth. The survey provided information relating to, *inter-alia*, municipal solid waste. The data was compiled, summed and aggregated to the ABS SA4 (Statistical Area 4) polygon boundaries as shown in Figure 49[70] below. The MSW for Hobart is 129,000 tonnes per year.

Figure 49: Solid waste paper Availability Tasmania

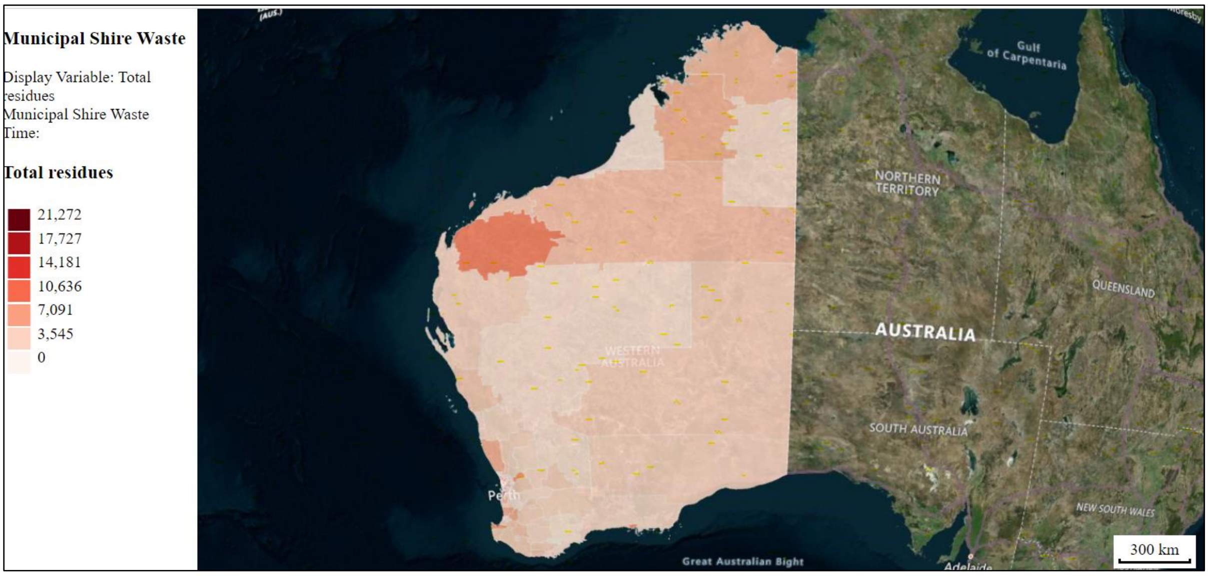


[70] https://nationalmap.gov.au/#share=s-kMym1FscNXkGtsE4BLeriGlXYJC

Western Australia

The municipal shire waste (MSW) data represents total waste produced per year by ABS statistical area 2 (SA2) boundaries. The MSW figures include recyclables, green waste and waste destined for landfill or recycling/reuse, as shown in Figure 50[71] below.

Figure 50: Municipal Shire waste – Western Australia

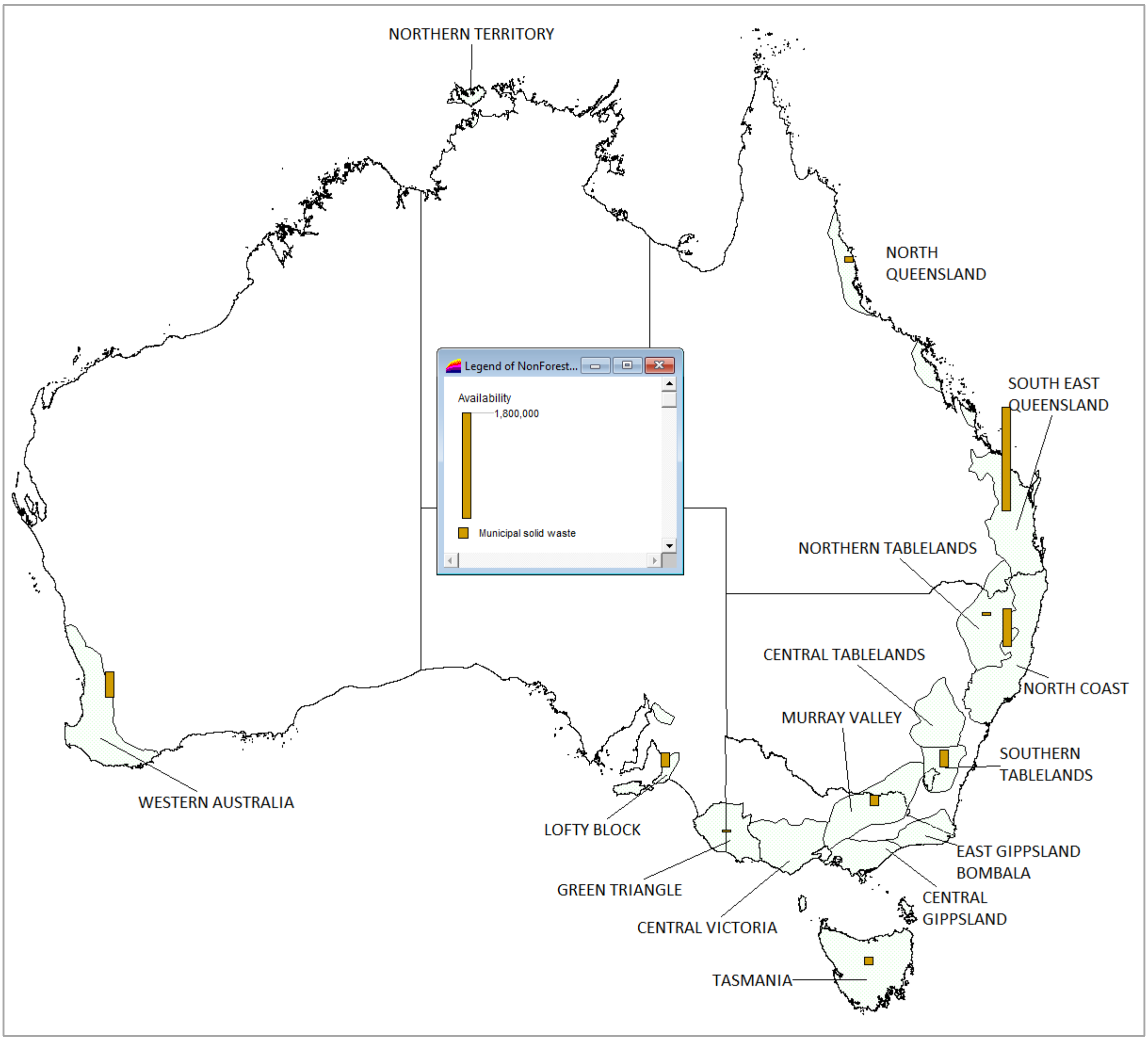


Combining the above state-based information and confining this prorata[72] to the NPI Regions, the apparent availability of combined solid waste is shown in Figure 51.

[71] https://nationalmap.gov.au/#share=s-3OLWVN9YKhc1XbmJHv0ZBbGeaNj

[72] The data were assigned to the relevant Local Government Areas (LGAs). Each LGA was clipped to within each NPI Region and the percentage of each area recorded. This percentage was applied to the Availability data and then summed for each LGA or part LGA within an NPI region.

Figure 51: Apparent Availability of municipal solid waste by NPI Region



7.2 SUGAR INDUSTRY RESIDUES

The characteristics of sugarcane residues (trash and bagasse) that make them attractive when compared with alternative potential bio-industrial feedstocks available in Australia include:

- Large quantities are produced in concentrated areas with good access to existing infrastructure networks that are flat, well-serviced with rail/road transport and close to population centres.
- The heating value is high while yields of ash and other residues is low.

The existing production systems either already concentrate residues (e.g. bagasse at mills) or can be readily customised to concentrate residues in conjunction with normal operations (e.g. through modified mechanised field harvesting).

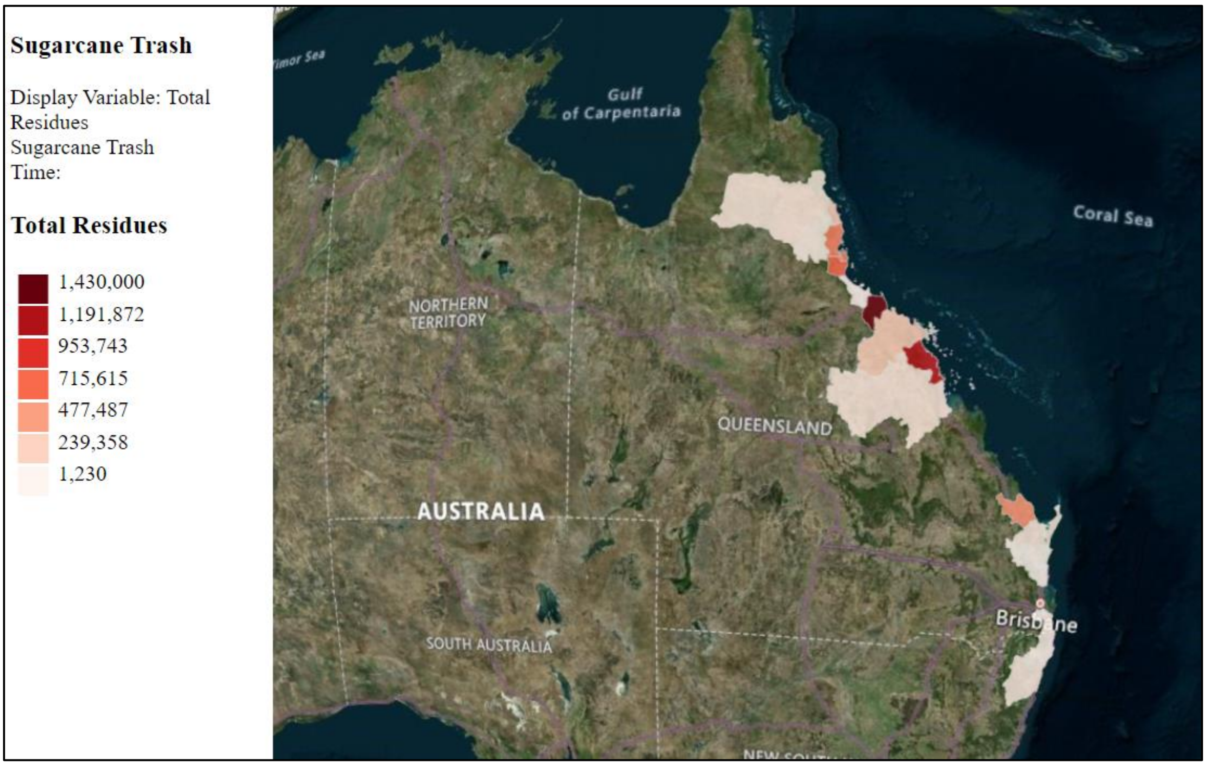
Sugar cane trash

Residues left in the field after harvesting of sugarcane (known as trash) have attracted attention as a potential feedstock for bioenergy and other bio-industrial processes such as production of plastics (Mackay Renewable- Bio commodities Pilot Plant, 2016)[73]. However, retaining trash residues in the field provides benefits for environmental sustainability including reduced sediment, nutrient and pesticide losses, while enhancing soil moisture retention, reducing weed management and improving soil health (Qld. Government, 2022)[74].

Mendoza (2001)[75] identified the primary benefits of "trash farming" as the reduction in N fertiliser required to maintain high crop yields and reduction in phosphorous requirement, generating significantly increased economic returns of up to 28% in the ratoon crop[76] when compared with conventional farming methods. Hence, there is a strong argument to retain trash in the field rather than collect it for use as a biofuel feedstock.

Regardless, the main distribution is shown in Figure 52[77].

Figure 52: Sugar cane trash Availability in Queensland



Bagasse

The sugarcane industry is widely recognised as a source of biomass feedstock with great potential for bio-industrial use in Australia. Fibrous residue from sugarcane crushing (known as bagasse) has long been used by the industry as a furnace fuel to provide steam and electricity for raw sugar production. Numerous projects have added new cogeneration facilities to a number of mills, both to upgrade old plant and to provide capacity for export of electricity to the grid.

[73] Mackay Renewable Biocommodities Pilot Plant (2016). https://www.qut.edu.au/research/why-qut/infrastructure/biorefining-research-facility/mackay-renewable-biocommodities-pilot-plant.

[74] Qld. Government (2022). Cropping - sugarcane trash. https://www.data.qld.gov.au/dataset/australian-biomass-for-bioenergy-assessment/resource/9e37e1ed-57aa-428b-a863-d1ad650ade7e

[75] Mendoza, T., Samson, R., and Helwig, R. (2001). Evaluating the many benefits of sugarcane trash farming systems. Crop Protection Newsletter 27:43-51.

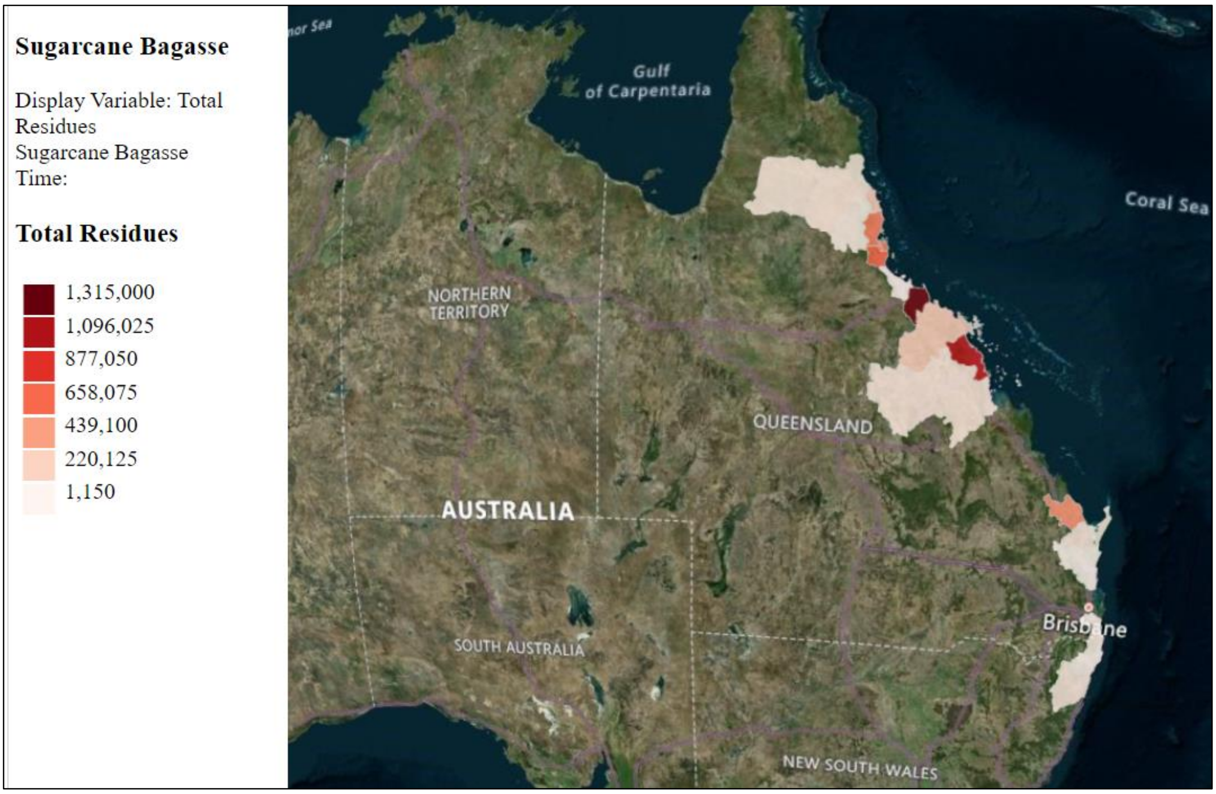
[76] Ratoon crop is one produced from the remains of the previous crop rather than replanting.

[77] https://nationalmap.gov.au/#share=s-6YgCOG5bILkmFi5QdEVpCnOYcYN

The combustion energy in bagasse is significantly in excess of the minimum required to process the cane and so factories have in the past been designed to operate at sufficiently low thermal efficiencies to ensure that all surplus bagasse is consumed over the season. In more recent years, some factories have been reconfigured to increase their thermal efficiency with the aim of producing surplus bagasse. Purpose-built high efficiency power generation equipment has been installed in these modified factories to consume surplus bagasse and generate electricity for additional export income (Stucley et al. 2013)[78].

Sugar bagasse Availability is shown in Figure 53[79]. This is concentrated in Central and North Queensland.

Figure 53: Sugar bagasse Availability

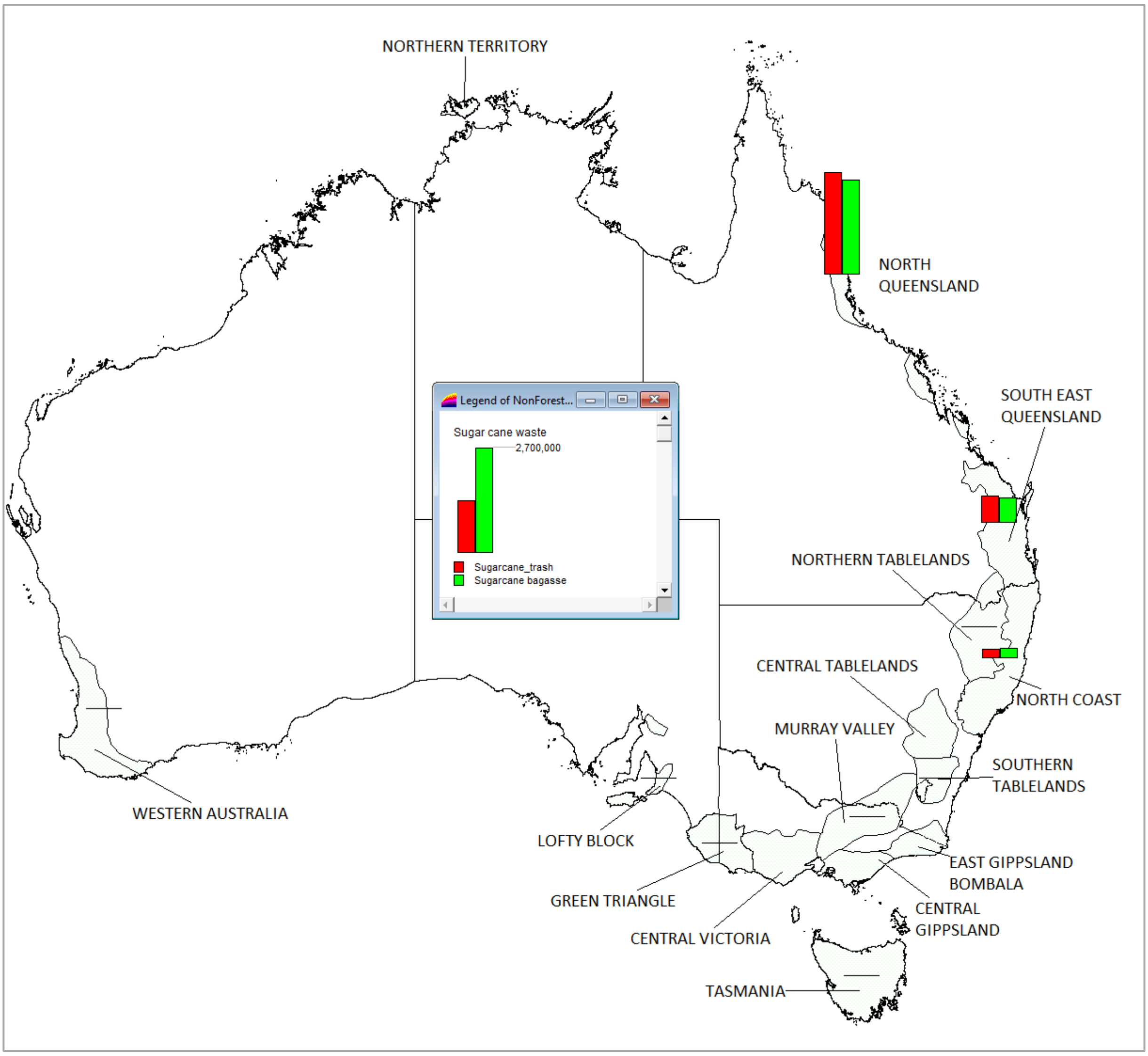


Combining the above state-based information and confining this prorata to the NPI Regions, the apparent availability of combined sugar cane waste is shown in Figure 54.

[78] Stucley C, Schuck S, Sims R, Bland J, Marino B, Borowitzka M, Abadi A, Bartle J, Giles R, Thomas Q (2013) Bioenergy in Australia: Status and Opportunities, Bioenergy Australia, Surrey Hills, Victoria.

[79] https://nationalmap.gov.au/#share=s-qRIzYUpaZDd4hTjL4ShDWftNSrk

Figure 54: Apparent Availability of sugar cane waste by NPI region



7.3 GRAINS INDUSTRY RESIDUES

Cereal straw, with potential disposal costs in some regions, provides an opportunity for bioenergy (Stucley et al, 2012)[80]. Other agricultural residues, including rice husks, maize cobs and nut shells, are also potential feedstocks. Such residues tend to have low moisture contents in the range 10-30% (wet basis) and are well suited for combustion. Evaluations overseas have indicated that there is little benefit to soil nutrient levels from returning straw into the soil (Stucley et al, 2012). This has led countries such as Denmark to lead the world in using straw for energy production. However, straw is not widely used in Australia for bioenergy. Rather, no-till farming is commonly practiced to retain and build soil carbon levels, which is critical for soil moisture and nutrient holding capacity, soil microbial activity and soil structure.

[80] Stucley, C., Schuck, S., Sims, R., Bland, J., Marino, B., Borowitzka, M., Abadi, A., Bartle, J., Giles, R., & Thomas, Q. (2012). Bioenergy in Australia: Status and opportunities. Bioenergy Australia. https://researchportal.murdoch.edu.au/esploro/outputs/report/Bioenergy-in-Australia-Status-and-opportunities/991005543289007891

To date, Australia has limited examples of agricultural residues used as fuel including sugar cane, rice hulls and macadamia nut shells. While there is use of straw and crop stubble as fuel overseas, there are no known examples of this in Australia (Stucley, 2010)[81].

Factors to be considered when looking at the use of cereal crop residues and their use in bioenergy include:

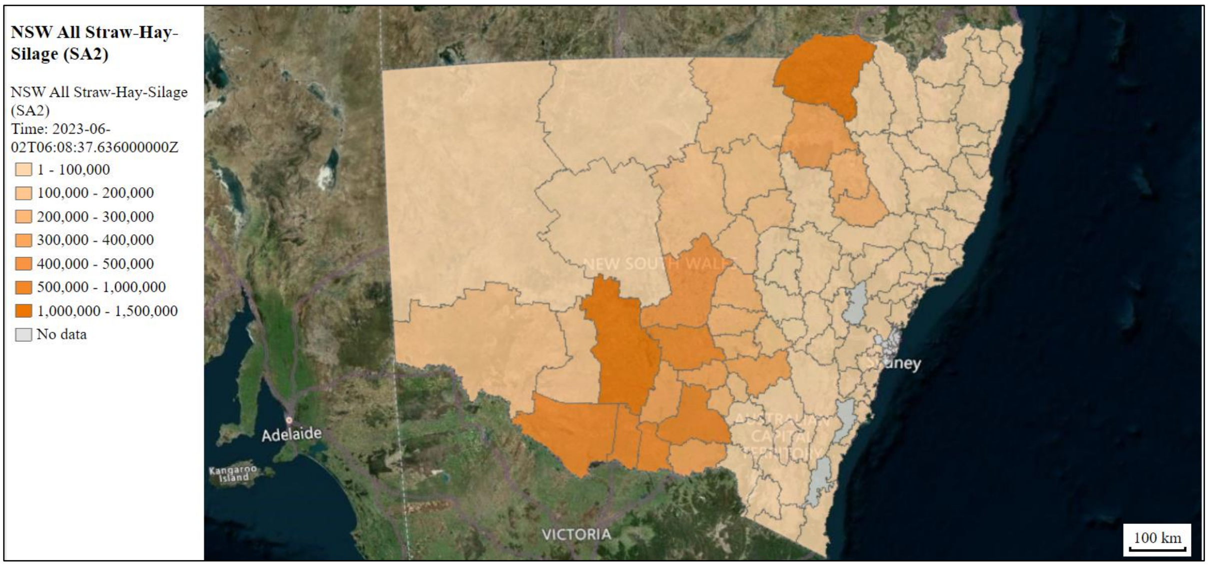
- Sustainability– retaining residues in the field has a large benefit to soil conservation and health.
- Economics and feasibility of harvesting cereal straw residues – i.e. is more energy potentially expended to gather cereal straw than would be generated as bioenergy.

Straw/hay/silage

NSW

This dataset estimates the location and mass in dry tonnes at 0% moisture content (MC) and in tonnes at harvest 'as is' MC of cereal straw, non-cereal straw and hay & silage residues across NSW, Australia (Figure 55[82]).

Figure 55: Straw, hay, silage Availability NSW



Queensland

Cereal crops in Queensland are predominantly grown in the northern grains region, from the NSW/QLD border near Goondiwindi, to Kingaroy in the east and Emerald in the north. Wheat and sorghum are the top two cereal crops grown in Queensland by area. Wheat is one of Australia's main agricultural export commodities and sorghum is the main dryland summer crop produced in north-eastern Australia's subtropical region.

Cereal crop residues were estimated for wheat and sorghum across Queensland. Residues in this context are considered to be straw that may be available for collection and use in bioenergy industries.

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[81] Stucley, C. (2010). Overview of Bioenergy in Australia. RIRDC Publication Number 10/078. https://agrifutures.com.au/wp-content/uploads/publications/10-078.pdf

[82] https://nationalmap.gov.au/#share=s-4pzUgKGM1Aflm3gas8h2qp2lhcg

Wheat straw Availability in Queensland is shown in Figure 56[83].

Sorghum Availability is shown in Figure 57[84].

Figure 56: Wheat straw Availability QLD

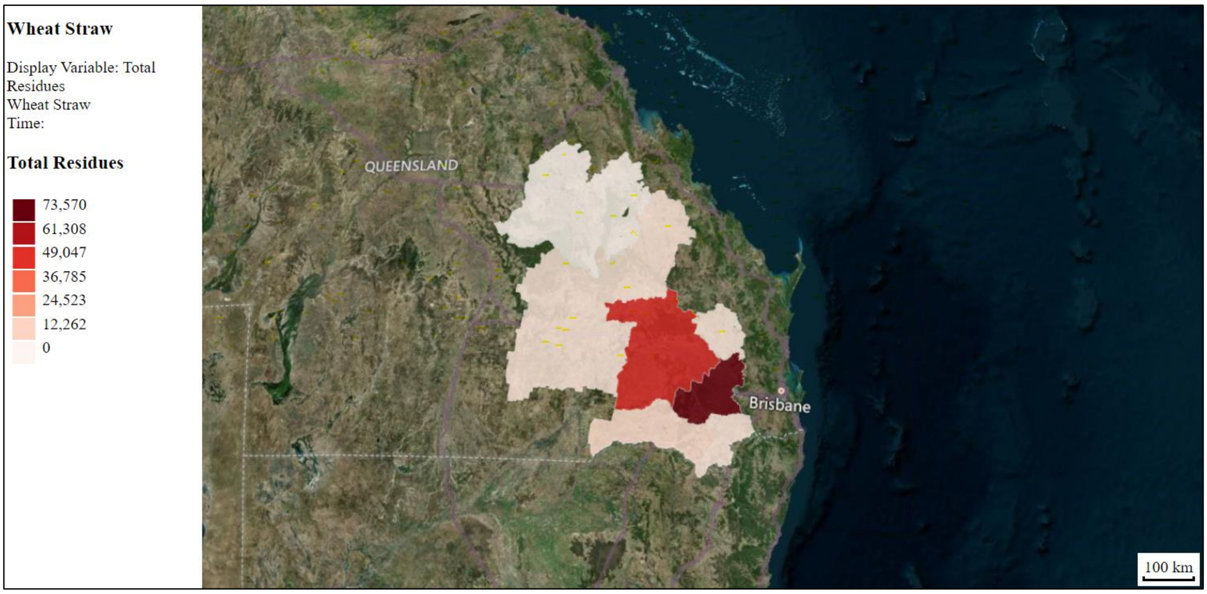
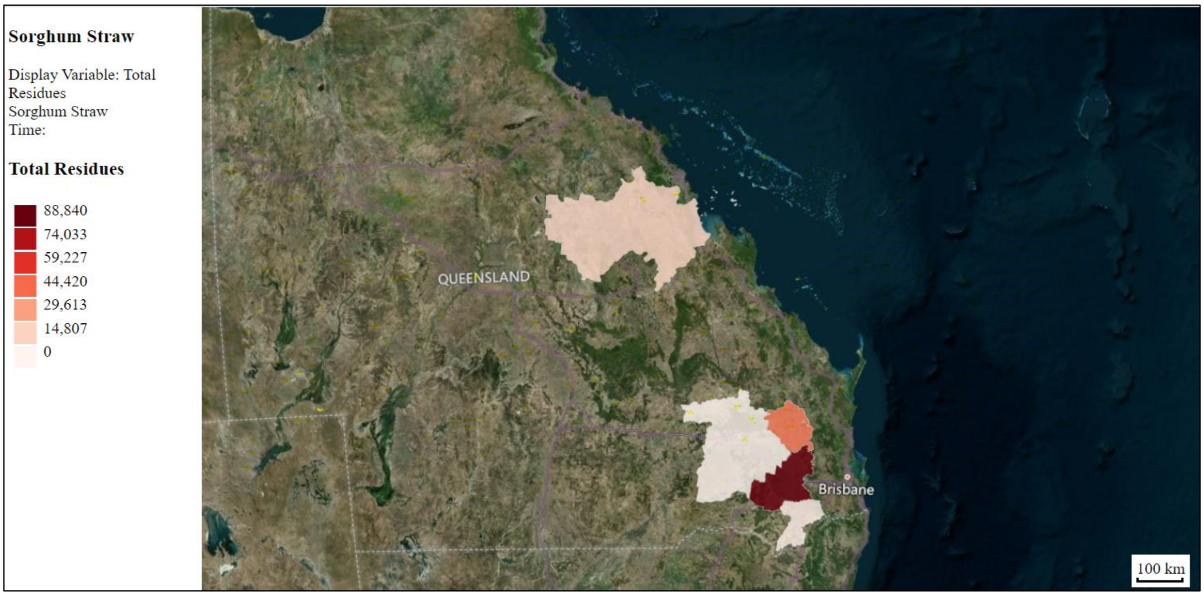


Figure 57: Sorghum Availability in QLD



South Australia

The ABS released data contains final estimates for data items collected in the 2014–15 Rural Environment and Agricultural Commodities Survey (REACS). The statistics on crop and horticultural area and production were used to estimate biomass volumes.

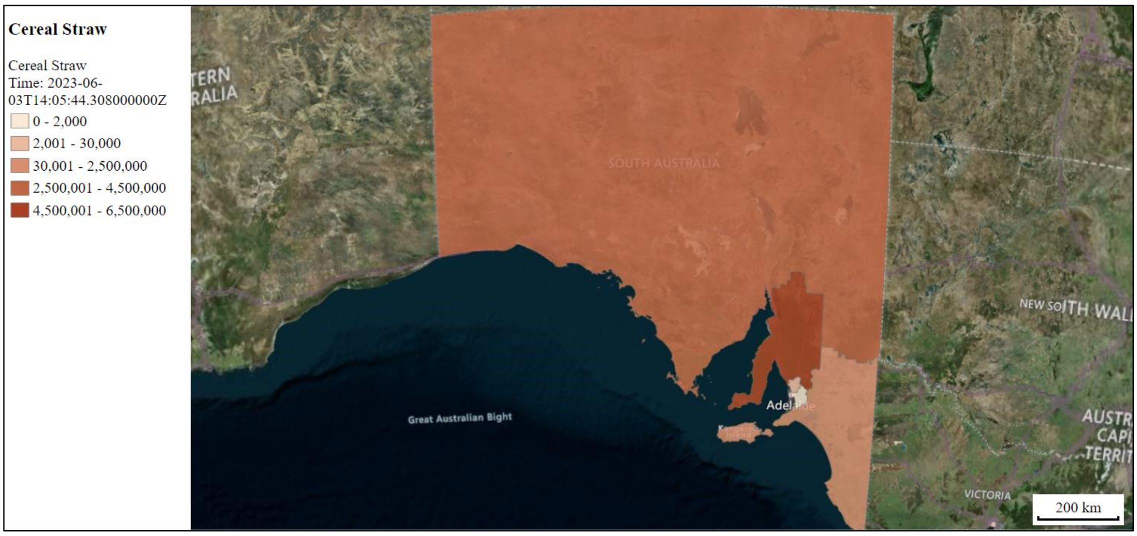
[83] https://nationalmap.gov.au/#share=s-98iwrzdwQ5RtcxTc9clSwOEFAVo

[84] https://nationalmap.gov.au/#share=s-6gXlmGv72qQYy2ZwFhB0Wn54JwP

Agriculture landuse footprints for the data were derived from the latest landuse mapping for South Australia (2008). These are indicative areas and should be used as a general guide only. See RenewablesSA website for more information including metadata and data sources[85].

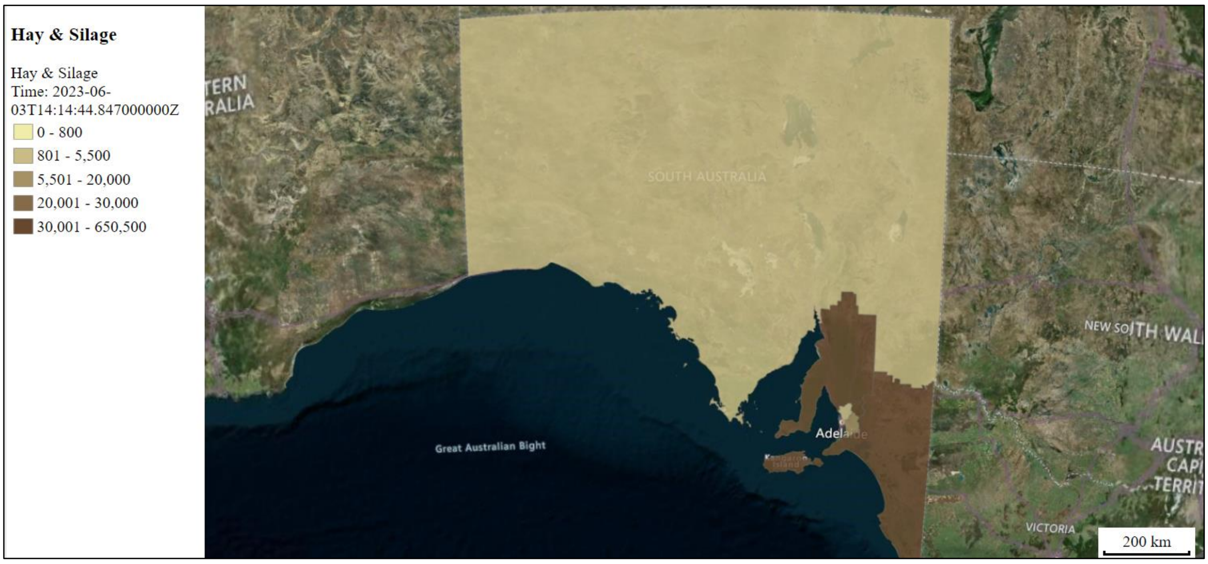
This data includes information on cereal crops such as wheat, barley and triticale[86] (as dry weight tonnes) amalgamated at ABS SA4 Regions. Residues are generally considered a waste although they may still be in beneficial use. Cereal straw Availability is shown in Figure 58[87].

Figure 58: Cereal straw Availability - SA



The data in this service includes information on Hay and Silage (as dry weight tonnes) amalgamated at ABS SA4 Regions. Residues are generally considered a waste although they may still be in beneficial use. Hay and sileage Availability is shown in Figure 59[88].

Figure 59: Hay and sileage Availability in SA



[85] http://www.renewablessa.sa.gov.au/investor-information/bio-energy-roadmap/biomass-for-bioenergy-assessment

[86] Triticate is a wheat/rhye hybrid.

[87] https://nationalmap.gov.au/#share=s-2W3UMtA5mfD1JOXRs2zESwwWw7P

[88] https://nationalmap.gov.au/#share=s-uFmkbGYsBS7O1ynRIzLeqARlxJW

Tasmania

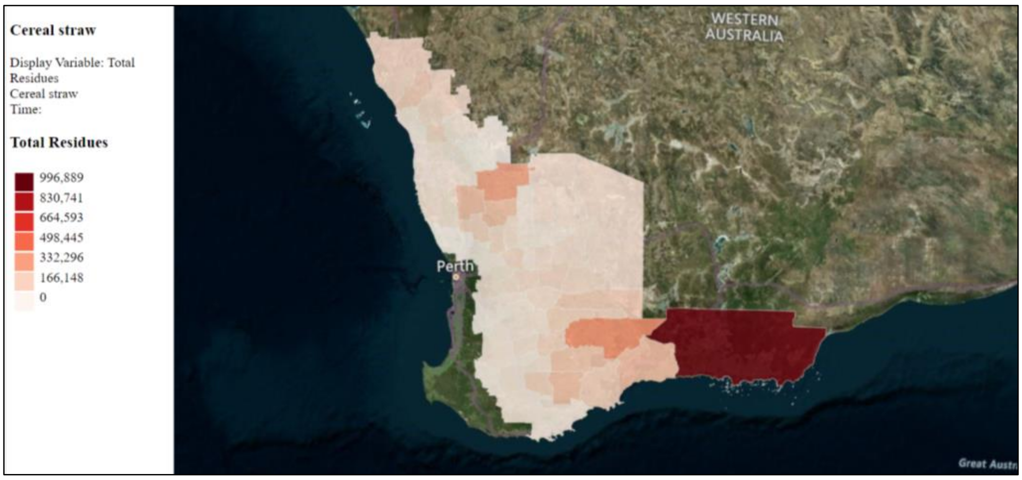
The cropping residue data contained in this dataset were derived from the Tasmanian Residues Survey (2016). Cereal straw Availability for Tasmania is shown in Figure 60[89].

Figure 60: Cereal straw Availability – TAS

Western Australia

The cereal straw residue data summarizes per hectare residue yields that are based on average yields from estimates of five years of data (2006 - 2010), to give an indication of likely yield of cereal residue per shire in Western Australia. Cereal straw Availability for Western Australia is shown in Figure 61[90].

Figure 61: Cereal straw Availability – WA



Rice hulls

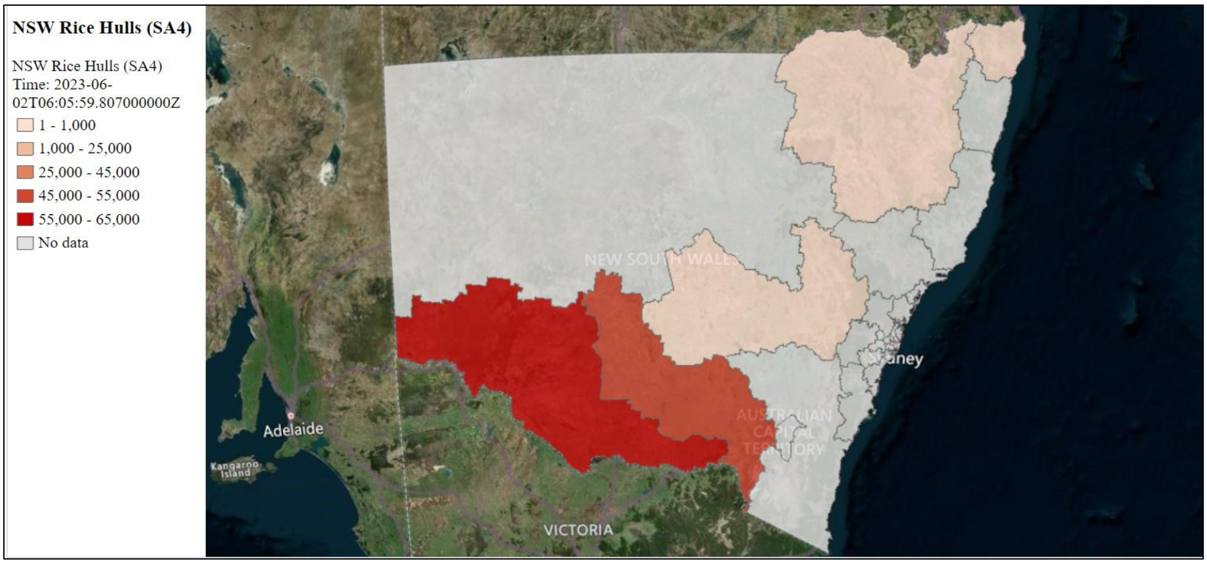
This dataset estimates the location and mass in dry tonnes at 0% moisture content (MC) and in tonnes at post-milling 14% MC of rice hull residues across NSW, Australia. Rice hulls Availability for NSW is shown in Figure 62[91].

[89] https://nationalmap.gov.au/#share=s-5DBsQRN7bb5jOirZJ08qCmbioLZ

[90] https://nationalmap.gov.au/#share=s-uBVlVaWsWagbPvil4pDsccVRkU4

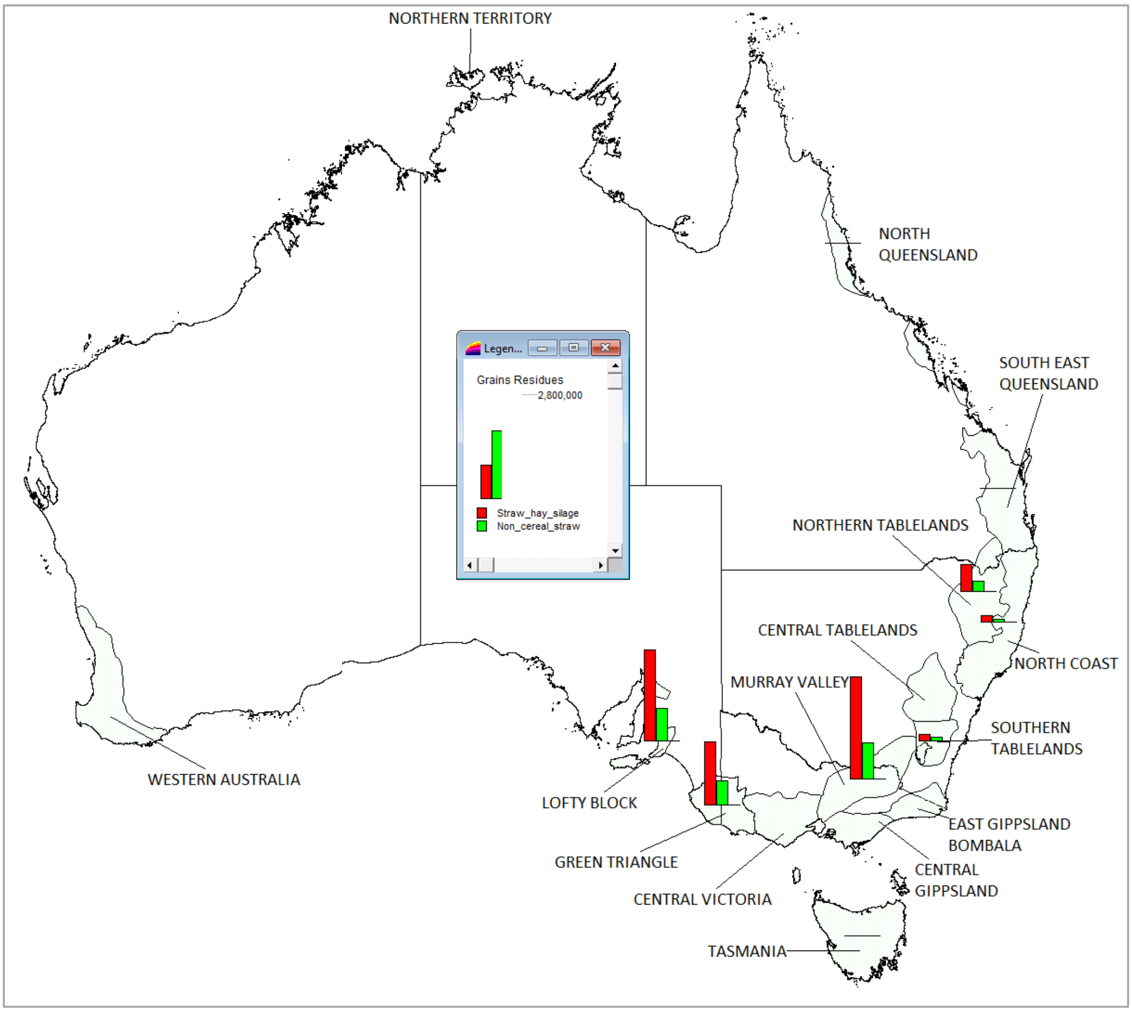
[91] https://nationalmap.gov.au/#share=s-tdT46EFot5rIrTJWPZqoENVlxbs

Figure 62: Rice hulls Availability – NSW



The above data for grains residues are amalgamated under their respective NPI Regions in Figure 63 below, excluding WA which records these data in a different (incompatible) format.

Figure 63: Apparent Availability of Grains Residues by NPI region



7.4 COTTON RESIDUES

Cotton trash is a voluminous, light substance which becomes a burden to store, sell or convert effectively into a form of organic fertiliser, and is generally considered a nuisance by cotton ginners (Williams, 2019)[92].

In cotton farming regions, there is significant potential for the by-products or cotton crop residues to be used to produce bio-energy. This includes cottonseed for biodiesel, cotton stalk and cotton gin trash (CGT) for ethanol and biogas or direct combustion (Chen et al, 2013)[93]. An assessment of CGT in the 2009-10 harvest year across Australia identified a potential renewable energy resource equated to 78 million litres of ethanol (New South Wales Government, 2012)[94].

The residues from the cotton ginning process (cotton seed and CGT) are produced and concentrated at specific locations. Some cotton gins across Australia can generate up to 100,000t of CGT in a season with associated costs of approximately $60,000 in handling and storage (Hamawand et al. 2016; Pittaway and Roberts 2000)[95].

The direct reapplication of cotton trash to farms is strongly discouraged due to the risk of contamination of soil borne pathogens and pesticides. Other cotton residues such as the straw or stalk left after harvest has also attracted attention regarding its potential bioenergy use. Cotton straw is quite woody in nature and the energy content of the stalk has been compared to the energy content of other wood products (Coates 2000)[96]. However, benefits of retaining cotton straw or stalk in the field includes managing for pest resistance and soil health (through carbon sequestration) (Hulugalle and Scott, 2008)[97].

A case study by AgEcon of a gin trash to ethanol plant at Narrabri in NSW found a modest yet positive return based on a hypothetical plant converting gin trash to ethanol situated in the Namoi Valley of NSW, due to accessibility and volumes of gin trash from gins in the region (Williams, 2019)[98]. This is partially in the Northern Tablelands NPI Region.

The baseline analysis returned a positive net present value, payback in year 12 of 25 and an internal rate of return of nine percent.

Potential ethanol production from the entire Australian cotton industry has been estimated at around 33–47 million litres with a potential revenue of $33–47 million at $1/L (Hamawand et al. 2016)[99].

Compared to other ethanol feedstocks, gin trash is more competitive than grains and comparable to the lower-cost feedstock molasses, which is currently converted in an ethanol plant in Sarina, Queensland. The key differences between these feedstocks as suitable sources is the zero-feedstock market price of gin trash. Conversely, the variable costs to process gin trash are almost two-and-a-half times that of molasses, wheat and sorghum.

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[92] Williams, A. (2019). Converting waste to energy: does trash stack up? Spotlight on Cotton R&D. Summer 2018-19. p12. https://www.crdc.com.au/sites/default/files/pdf/Spotlight%20Summer%202018-19.pdf

[93] Chen, G., Sandell, G., Yusaf T., Baillie, C. (2013) Evaluation of alternative energy sources for cotton production in Australia. In: SEAg 2013: Innovative Agricultural Technologies for a Sustainable Future, 22-25 Sept 2013, Barton, Western Australia

[94] NSW Government. (2012). Bioethanol prospects from cotton gin trash.

[95] Hamawand. I, Sandell. G, Pittaway P, Chakrabarty S, Yusaf T, Chen G, Seneweera S, Al-Lwayzy S, Bennett J and Hopf J (2016). Bioenergy from Cotton Industry Wastes: A review and potential, Renewable and sustainable energy reviews 434-448

[96] Coates W.E. (2000). Using cotton plant residue to produce briquettes. Biomass-Bioenergy 18, 201-208.

[97] Hulugalle, N.R. and Scott, F. (2008). A review of the changes in soil quality and profitability accomplished by sowing rotation crops after cotton in Australian Vertosols from 1970 to 2006, Australian Journal of Soil Research, 46, 173- 190.

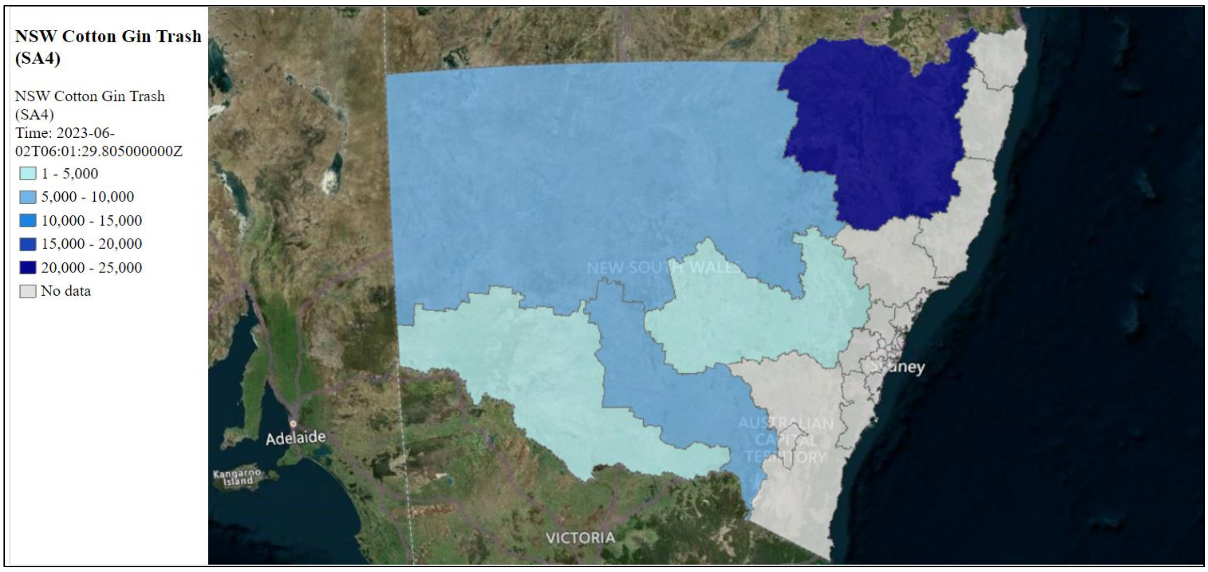
[98] Williams, A. (2019). Converting waste to energy: does trash stack up? Spotlight on Cotton R&D. Summer 2018-19. p12. https://www.crdc.com.au/sites/default/files/pdf/Spotlight%20Summer%202018-19.pdf

[99] Hamawand. I, Sandell. G, Pittaway P, Chakrabarty S, Yusaf T, Chen G, Seneweera S, Al-Lwayzy S, Bennett J and Hopf J (2016). Bioenergy from Cotton Industry Wastes: A review and potential, Renewable and sustainable energy reviews 434-448.

Ginning trash - NSW

This dataset estimates the location and mass in dry tonnes at 0% moisture content (MC) and in tonnes at post-ginning 5% MC of cotton gin trash across NSW as shown in Figure 64[100].

Figure 64: Cotton gin trash Availability – NSW



Cotton trash - Queensland

The cotton residues which are included in this assessment are:

- Cotton gin trash (CGT) – sticks, leaves, burs, soil particles etc and other trash which are separated from the lint during the cotton ginning process.
- Cotton seed – the seed recovered after the cotton ginning process.
- Cotton straw – residue or stalk left over in field after harvest.

Cotton Australia produces statistics on the number of bales produced in Australia each year. The number of bales produced in Queensland for the past 5 years was provided by Cotton Australia (Cotton Australia 2017a)[101]. Generally, for one unit of seed cotton:

- 42% is lint
- 48% is cotton seed
- 10% is CGT

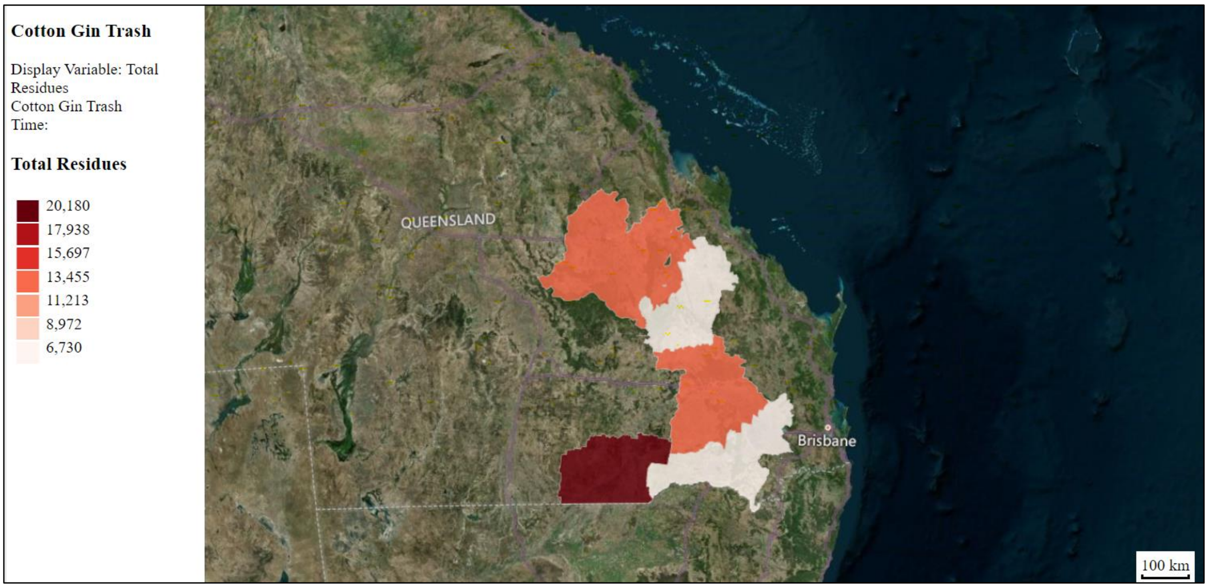
Cotton gin trash Availability in Queensland is shown in Figure 65[102].

[100] https://nationalmap.gov.au/#share=s-sAW52qzBYeHManxiRzm9TVJZ9wG

[101] Cotton Australia (2019) 'Processing, exporting and marketing', Cotton Library, Fact Sheets, Cotton Australia - https://cottonaustralia.com.au/cotton-library/fact-sheets/processing-exporting-and-marketing

[102] https://nationalmap.gov.au/#share=s-mtL7uSwKqiwbGTVfsbQ3r4tnMuh

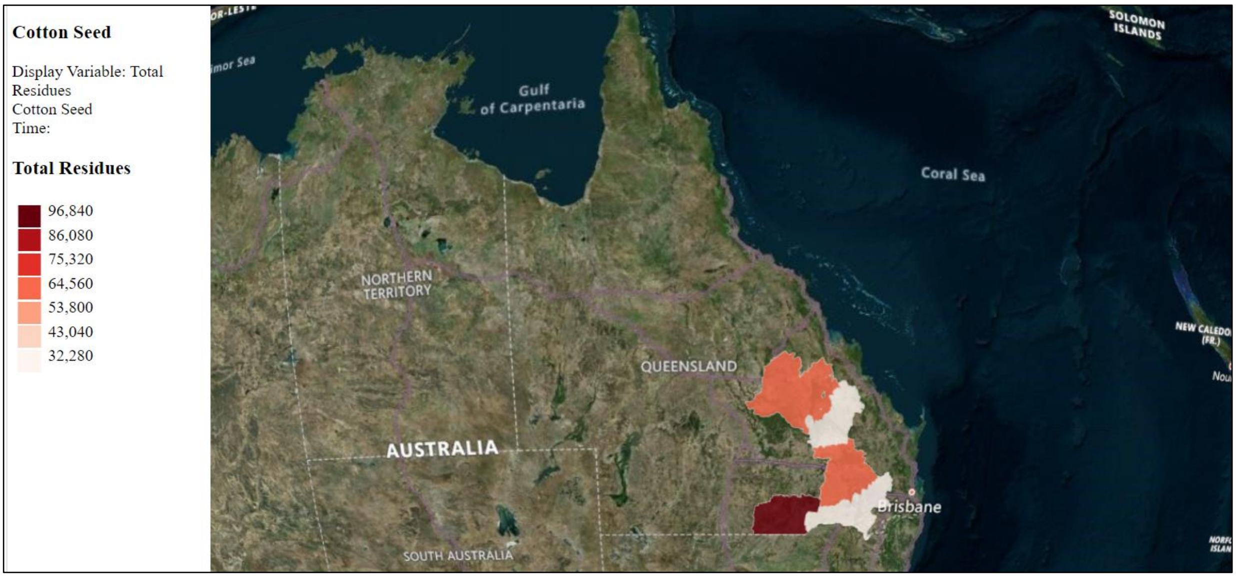
Figure 65: Cotton gin trash Availability – QLD



Cotton Seed

Refer Figure 66[103] for Queensland Availability.

Figure 66: Cotton seed Availability – QLD

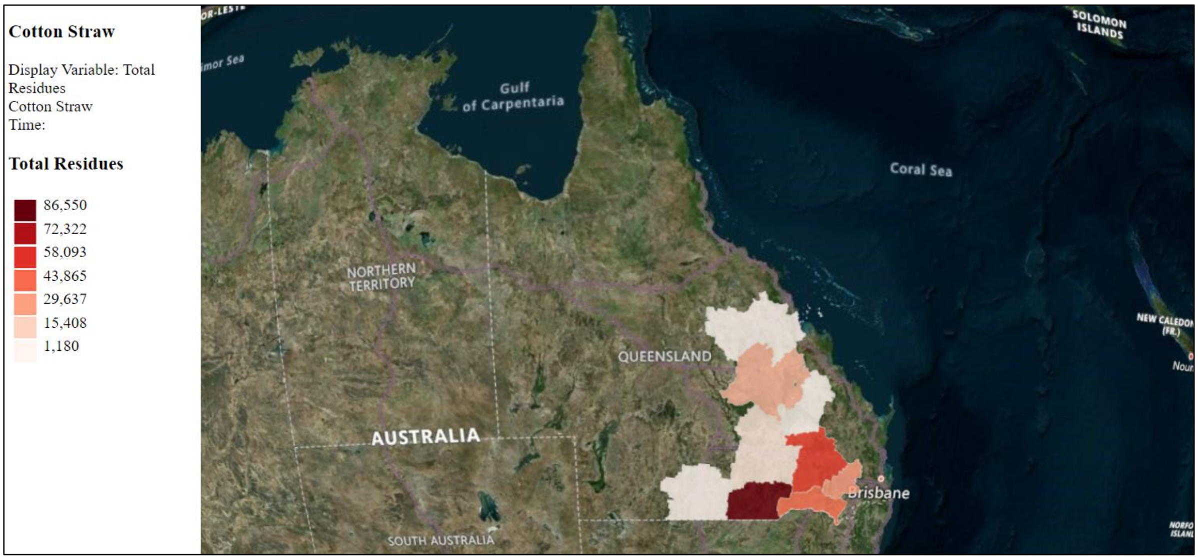


Cotton Straw

Refer Figure 67[104] for Availability in Queensland.

[103] https://nationalmap.gov.au/#share=s-88gFVSEc4rhkCBXC4QNDrKf8cEG
[104] https://nationalmap.gov.au/#share=s-bQHWJwVDx85c5RdWSsxziqVvpqK

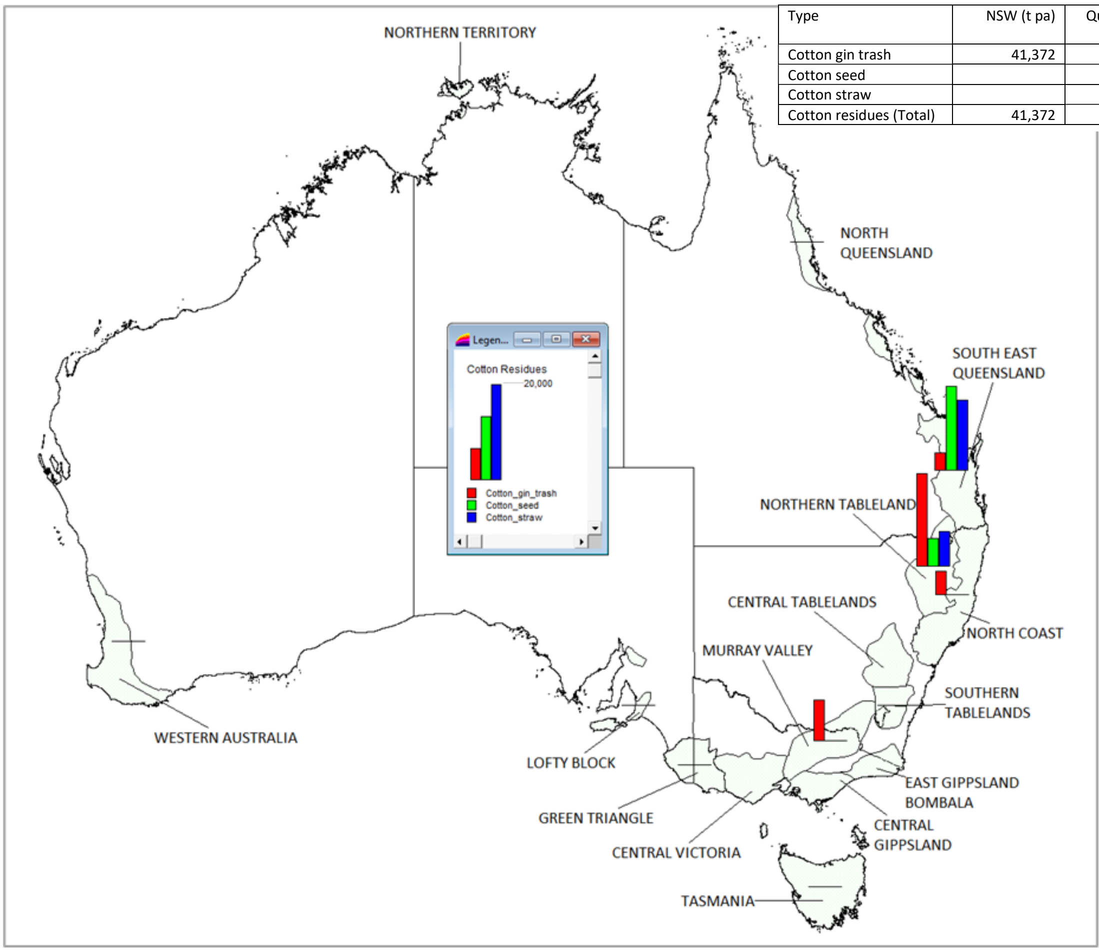
Figure 67: Cotton straw Availability – QLD



The Availability of cotton residues by NPI Region is shown in Figure 68. Note, the available data is reported differently for different states. NSW reports only Gin trash while Queensland reports gin trash, cotton seed and cotton straw. A breakdown of these volumes at a state level is shown as a table below.

Figure 68: Apparent Availability of Cotton residues by NPI Region

Type	NSW (t pa)	Queens-land (t pa)	Total (t pa)
Cotton gin trash	41,372	67,270	108,642
Cotton seed		322,800	322,800
Cotton straw		248,570	248,570
Cotton residues (Total)	41,372	638,640	680,012



7.5 FRUIT RESIDUES

The approximate lignocellulosic ethanol potential of selected fruit residues is summarised below:

- Apple pomace contains a significant amount of cellulose and hemicellulose, making it suitable for lignocellulosic ethanol production. The ethanol yield from apple pomace can range from 150-250 litres per ton of pomace.
- Citrus peel contains substantial amounts of cellulose and hemicellulose, and the ethanol yield can range from 100-200 litres per ton of peel.
- Banana peels have a lower cellulose content compared to other fruit residues, resulting in a relatively lower ethanol yield. The ethanol yield from banana peels can range from 50-100 litres per ton.

The availability and location of potential fruit residues is summarised below based on the data presented in the Australian Biomass for Bioenergy Assessment 2015-2021 (ARENA, 2021).

7.6 ALL AGRICULTURAL RESIDUES BY NPI REGIONS

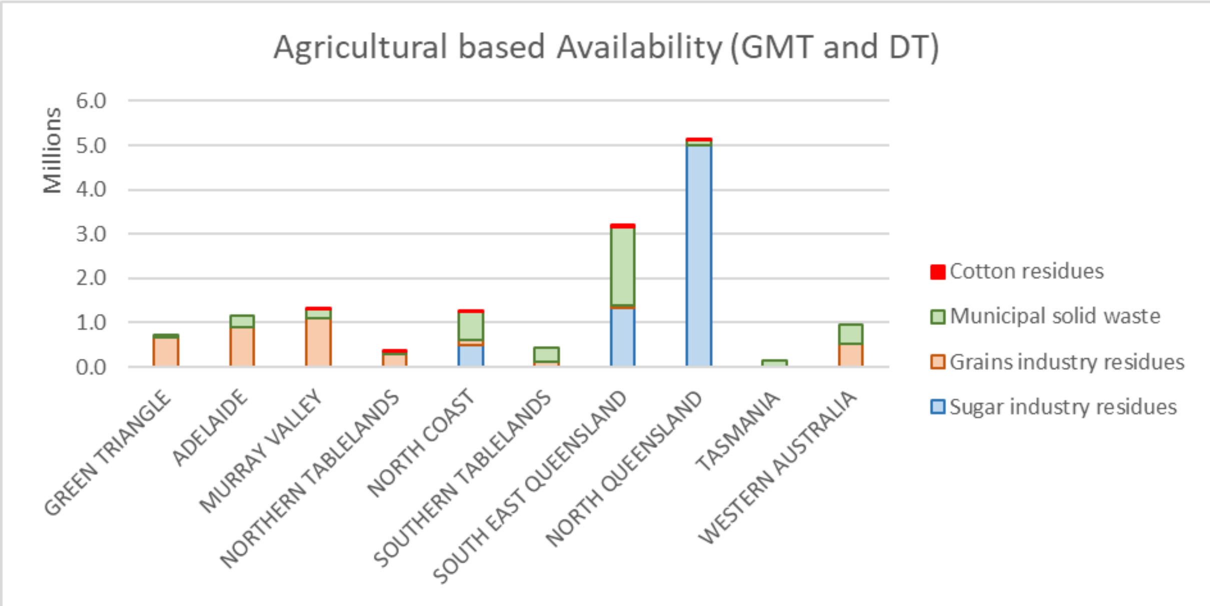
The data here are provided in Appendix 4 and summarised by NPI Region in Table 10.

Table 10: Apparent Availability of waste type ('000 t pa)

Waste type	GREEN TRIANGLE	SOUTH AUSTRALIA - LOFTY BLOCK	MURRAY VALLEY	NORTHERN TABLELANDS	NORTH COAST	SOUTHERN TABLELANDS	SOUTH EAST QUEENSLAND	NORTH QUEENSLAND	TASMANIA	WESTERN AUSTRALIA
Straw/hay/silage	1,717	2,452	2,759	736	209	192	37	-	0	-
Non-cereal straw	674	899	1,002	289	95	113	-	-	-	-
Straw residue	-	-	-	-	-	-	-	-	-	514
Rice hulls	-	-	108	0	0	-	-	-	-	-
Sorghum straw	-	-	-	5	-	-	67	1	-	-
Municipal solid waste	41	260	184	58	646	310	1,761	104	146	441
Sugarcane trash	-	-	-	2	251	-	694	2,602	-	-
Sugarcane bagasse	-	-	-	2	256	-	640	2,404	-	-
Cotton gin trash	-	-	9	19	5	-	4	-	-	-
Cotton seed	-	-	-	6	-	-	17	-	-	-
Cotton straw	-	-	-	7	-	-	14	0	-	-
Fruit and nuts general	1,230	115	-	-	-	-	-	-	-	-
Vegetables	518	98	-	-	-	-	-	-	0	-
Grape Marc	-	-	-	-	-	-	-	-	-	20
Macadamia shells and husks	-	-	-	0	28	-	-	-	-	-
Almond shells and hulls	-	-	9	-	0	-	-	-	-	-
Flower	-	-	-	-	-	-	-	-	8	-
Pome Fruit Residue	-	-	0	-	-	-	-	-	-	6
Avocado Residue	-	-	-	-	-	-	-	-	-	4
Mallee Stems	-	-	-	-	-	-	-	-	-	3
Olive Husk	-	-	-	-	-	-	-	-	-	2
Stone Fruit Residue	-	-	0	-	-	-	-	-	-	1
Citrus Residue	-	-	-	-	-	-	-	-	-	1
Winery viticulture	-	-	-	-	-	-	-	-	0	-
Orchard pruning	-	-	-	-	-	-	-	-	0	-
Total	**4,180**	**3,823**	**4,071**	**1,123**	**1,490**	**615**	**3,235**	**5,111**	**154**	**992**

These data are aggregated and presented in Figure 69.

Figure 69: Aggregated non-forest (Agricultural) furnish Availability estimates



Note, we have not attempted to assess non forest (agricultural) furnish Accessibility, as there is insufficient information to undertake this.

8 PRICES (FOR ACCESSIBILITY MODEL)

The price categories used for forest-based products in this report are shown in Table 11 below.

Table 11: Price categories used in this report

Price category	Code	Delivered price ($/GMT)
Very High	VH	150
High	H	100
Medium	M	75
Low	L	50
Very Low	VL	20
Free	F	<20

8.1 AUSTRALIAN WOODCHIP DELIVERED PRICES

There is a substantial trade in hardwood woodchips in the Asia-Pacific region. Historically and presently, the volumes are largely used by the pulp and paper industry in China, Japan, Indonesia, Korea, Taiwan and increasingly India. However, the fibre can be sold to the 'highest and best use'. As mentioned earlier, there is increasing interest in selling Australian fibre domestically, although international pulp and paper buyers are likely to dominate for years if not decades to come.

For this report, MBAC has assumed those that can pay the export parity price can secure either pulpwood or woodchip volumes. However, determining export parity pricing is not simple. The following for forest-based products is based on capacity-to-pay for wood rather than 'actual' prices paid. This distinction is important.

- The starting point is the Free-On-Board (FOB) price paid for woodchips leaving Australia for Asia-Pacific destinations[105].
- This dynamic value is set in US dollars and while generally 'known' within the industry, the value or values are essentially non-transparent to an external observer.
- For our purposes, the current FOB price for hardwood woodchips exported from Australia mainland ports expressed in Australian Dollars is around $245 per BDMT.
- Assuming 50% moisture content and allowing for stockpile and chipper losses, chipping costs (at the port) and exporters' margin, the wharf-gate price of logs (yet to be chipped) is around $90 per GMT (capacity-to-pay). The actual prices being paid may be below this apparent price.
- Assuming 'average' haulage distance and 'average' harvest costs and allowing for a group of small more-or-less 'fixed' costs[106], the capacity-to-pay stumpage price (i.e. the parity price) may be around $56 per GMT. This is what the tree-owner will be 'seeking' for the pulpwood logs. The actual range here could be from the low-$30's to (say) $60/GMT.

For this report, assuming the ethanol industry requires woodchips rather than pulpwood logs, these would most likely be converted into woodchips in the forest (referred to as infield chipping) and the resulting woodchips hauled similar distances to an ethanol plant as the logs would have been hauled to the export port. If so, then:

- Export parity stumpage is $56 per GMT.
- Harvest cost may be $22 per GMT.

[105] This itself is partly determined by the woodchip delivered price in the importing country, less cartage from the port to mill, less port handling costs, less shipping costs. The latter cost is highly volatile. There are also scale economies, sustainability, quality, contracts, supply/demand and many other factors to consider.

[106] Industry levy cost, harvest planning cost, roading cost, certification cost and harvest supervision cost

- Infield chipping cost may be $14 per GMT.
- Haulage cost may be $11 per GMT.

If so, then the apparent delivered capacity-to-pay parity price or cost of woodchips is therefore c. $103 per GMT.

While there are 'several dollars' of difference between hardwood and softwood woodchip costs and prices, for this report we have assumed the delivered parity price for softwood woodchips is $2 per GMT less than for hardwood woodchips. This results in both potential furnishes being in the High price category (>$100/GMT delivered).

Importantly, this is the estimated delivered cost for export grade woodchips. However, the ethanol industry would not require such high quality. Rather, this industry could accept more bark, more branches, more leaves/needles, more undersize woodchips etc. In effect, this involves removing 'would-be' residues with the trees and processing this all into woodchips at the roadside. If so, this would increase the volumes removed from any hectare harvested relative to the woodchip export business. If so, then this would reduce the effective cost per tonne into the ethanol industry. Assuming a 15% increase in volume, then the actual delivered price may be around $90 per GMT or around $180 per BDMT. However, offsetting this 'plus' is there may be higher harvesting costs and the ethanol industry may need to pay slightly more than the export woodchip business simply to secure the volume.

Thus, MBAC has maintained the $103 per GMT price for the subsequent Accessibility modelling in this report.

A hardwood woodchip delivered price of $103 per GMT is about $206 per BDMT. This compares reasonably with ABARES[107] 2021 "*market prices for wood products* …" of $160 per BDMT for softwood woodchips and $175 per BDMT for hardwood plantation woodchip. The price of woodchips has risen considerably since 2021.

The MBAC prices appear reasonable for this high-level report in the present time (2023).

8.2 FOREST BASED FURNISH DELIVERED PRICES

The assumed delivered prices are:

- For hardwood woodchips is about $103/GMT (see later). This is an equivalent export parity capacity-to-pay price.
- For softwood woodchips is about $101/GMT (see later)
- For forest residues delivered to an ethanol plant, price here is $57 per GMT. This consists of $45 to harvest and process (chipping) and $12 for transport (see Appendix 5 The Model) and assumes the residue is free of stumpage to the forest owner.
- For sawmill residues, price is $45/GMT delivered, assuming the ethanol plant is close by.
- For mallee, price could be $45/GMT to the grower[108] plus + $15/GMT harvesting to roadside + $15/GMT chipping + $15/GMT transport = $90 to an MBAC estimated $102/GMT, based on previous work (brought to 2023 values).

Importantly, these remain relative prices and simply place a furnish or product in a VH, H, M, L or VL cost range. It is this range that is used in the 'Accessibility model', rather than 'absolute' price or cost.

[107] Lock, P & Whittle, L 2018. Future opportunities for using forest and sawmill residues in Australia, ABARES, Canberra, November. P31

[108] Spencer B, Abadi A, Bartle J, et al. 2020. Determinants of the economic viability of mallee eucalypts as a short rotation coppice crop integrated into farming systems of Western Australia. GCB Bioenergy. P2. $45/GMT 'stumpage

8.3 NON-FOREST BASED FURNISHES DELIVERED PRICES (FOR ACCESSIBILITY MODEL)

Quantity data have been derived from the Australian Biomass for Bioenergy Assessment (ABBA) 2015-2021 (ARENA, 2021)[109]. Quality assessment is based on a review the literature and Verterra's direct experience with the various feedstock types and associated production systems. Delivered price data has been compiled from a variety of literature sources.

High level price estimates (High, Medium, Low etc.) are provided in Table 12, noting here were refer to price rather than price attractiveness (as in the forestry sections).

The most attractive, from an apparent price perspective, are sugar cane bagasse, rice hulls and cotton residues (cotton gin trash and cotton seed).

The primary locations for these, using the NPI Regions, are:

- North Queensland (sugar cane waste)
- North Coast NSW (sugar cane waste)
- South Western NSW (rice hulls)
- Northern Tablelands (NSW) (cotton gin trash)
- South central Queensland (cotton gin trash and cotton seed)

North Coast NSW and Northern Tablelands are two NPI Regions with significant forest-based furnish Availability.

Table 12: Non-forest based furnish prices

Component	Quality	Price	Issues
Mallee Stems	VH	H	Economics of harvesting
Municipal solid waste	VL	M	Contamination
Sugarcane bagasse	H	L	Competition for landscaping products
Sugarcane trash	VL	H	Economics of collection, soil contamination and requirement for soil carbon
Non-cereal straw	M	M	Competition to retain for soil nutrition and animal feed
Rice hulls	H	L	Competition with existing thermal bioenergy plants
Sorghum straw	M	M	Competition to retain for soil nutrition and animal feed
Straw/hay/silage	M	M	Competition to retain for soil nutrition and animal feed
Cotton residues			
Cotton gin trash	H	VL	Potential opportunity due to concentrated production and hygiene issues with field re-use
Cotton seed	H	VL	Potential opportunity due to concentrated production
Cotton straw	M	M	Competition to retain for soil health and nutrition

8.4 GENERAL

Note the forest-based furnish prices are relative prices. This is because the Model assigns a price to a broad range $0-20, $20-25, $50-75, $75-100, $100-150, $150+/GMT (VL, L, M, H, VH). Hence, changing prices by (say) $10 for the forest-based material, likely makes no difference to the Accessibility % estimation, unless it moves a furnish from a higher to a lower attractiveness class.

Regardless, these 'prices' can be changed.

[109] ARENA (2021). Australian Biomass for Bioenergy Assessment 2015-2021. https://arena.gov.au/assets/2021/04/australian-biomass-for-bioenergy-assessment-final-report.pdf

9 THE FOREST BASED FURNISH ACCESSIBILITY MODEL

9.1 ATTRACTIVENESS 'RULES' – COMMERCIAL PLANTED FORESTS

Using the "simple" model developed by MBAC, an analysis was conducted to assess the availability, quality, price, and supply/demand (the factors) of different forest-based furnishes by NPI Regions. The objective was to determine the relative attractiveness of each region and furnish to a potential buyer.

Numeric values were assigned to each factor, and these values were then summed to provide an Attractiveness rating for each region and furnish combination. Higher sums indicated greater Attractiveness and Accessibility, while lower sums indicated less Attractiveness and Accessibility. The detailed numerical assignments for each factor are presented in the table below (refer to Appendix 5 for the numerical values).

Table 13: Attractiveness 'rules' for availability, quality, price and supply & demand

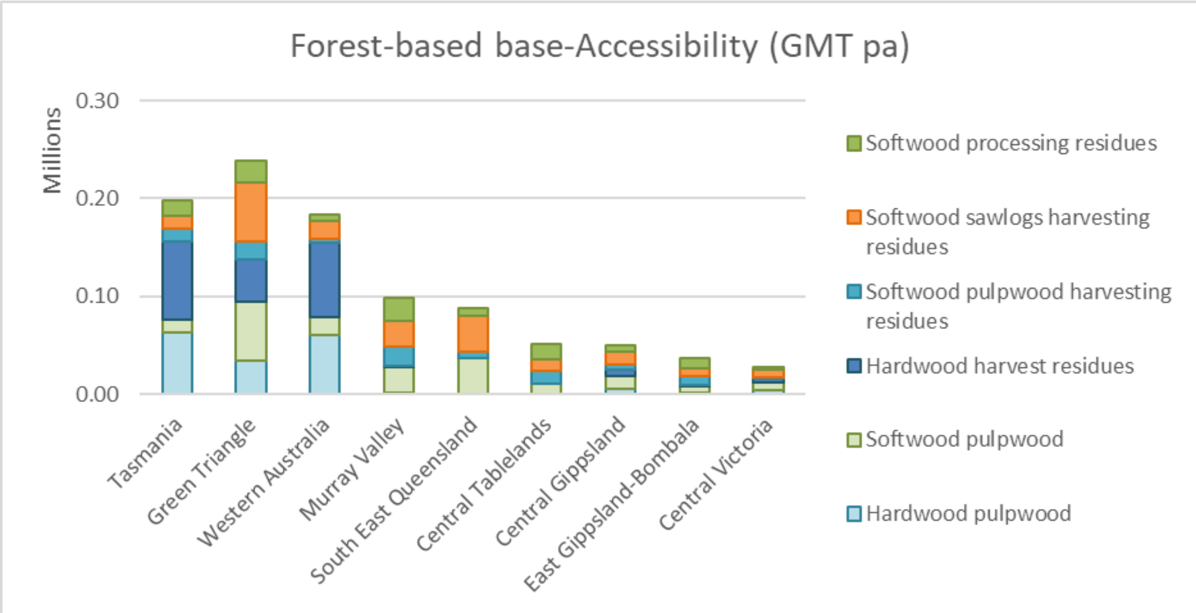
Furnish Attractiveness Factors	Assignment ranges	Subjective Attractiveness values
Availability	>1 million GMT	3
	100,000-999,999	2
	1,000-99,999	1
	<1,000	0
Quality	Hardwood/Softwood pulpwood	3
	Hardwood/Softwood harvest residues	1
	Softwood processing residues	2
Price	>= $150 per GMT	1
	$100-149 per GMT	2
	$75-99 per GMT	3
	$50-75 per GMT	4
	$20-49 per GMT	5
	$0-19 per GMT	6
Supply/Demand	Hardwood/Softwood pulpwood - Demand >>> Supply	0
	Hardwood/Softwood harvest residues - Supply <<< Demand	3
	Softwood Processing Residues - Demand > Supply	1

By summing the assignment numbers for each of the 60 region/furnish combinations, a relative attractiveness ranking was obtained. Specific rules were applied to determine the relative Accessibility based on the sum of the values:

- A sum of 0-2 was Very Low and equated to an Accessibility of 0%
- A sum of 3-4 was Low with an Accessibility of 2.5% (i.e. able to release 2.5% of Availability)
- A sum of 5-6 was Medium with an Accessibility of 5%
- A sum of 7-8 was High with an Accessibility of 10%
- A sum of 8-10+ or more was Very High with an Accessibility of 20%

Summarising, the base Accessibility by Region is shown in Figure 70, the main Accessibility regions are the Green Triangle, Tasmania, the Murray Valley, Western Australia and the South East Queensland.

Figure 70: Base Accessibility by region – from commercial forests



The MBAC model allows us to modify the assignment variables (see Table 13).

The model determined the apparent relative Accessibility in percentage terms and, by MS-Excel goal-seek function, the required level of Accessibility percentage to secure 150,000 GMT pa as an average of the volumes in the three largest regions (450,000 GMT in total) for each furnish type. The results are presented in Table 14.

Base Accessibility (refer below) is thus the Accessibility we have 'determined' may be accessible to (say) the ethanol industry. In this case 2.5% suggests very low Accessibility while 10% suggests higher Accessibility.

Table 14: Base Accessibility % and % required to achieve 150,000 GMT pa for each furnish

1	2	3	4	5	6	7
Region	**Hardwood pulpwood**	**Hardwood harvest residues**	**Softwood pulpwood**	**Softwood processing residues**	**Softwood pulpwood harvest residues**	**Softwood sawlogs harvest residues**
Largest	Tasmania	Tasmania	Murray Valley	Green Triangle	Murray Valley	Green Triangle
2nd largest	Western Australia	Western Australia	Green Triangle	South East Queensland	Green Triangle	South East Queensland
3rd largest	Green Triangle	Green Triangle	Tasmania	Murray Valley	Tasmania	Murray Valley
Accessibility figures below here						
Largest GMT pa	79,000	64,000	23,000	61,000	18,000	61,000
2nd largest GMT pa	76,000	61,000	23,000	37,000	18,000	37,000
3rd largest GMT pa	43,000	34,000	16,000	27,000	13,000	27,000
Base Accessibility %	2.5%	10%	2.5%	10%	10%	10%
Multiplier to = 150k GMT pa	2.3	2.8	7.3	3.6	9.1	3.6
Required accessibility	5.7%	28%	18%	36%	91%	36%

The precise Accessibility numbers are more important in relative rather than absolute terms. In addition, the 150,000 GMT figure relates to a particular furnish type rather than the sum of all furnishes in any one NPI region. For example, the average hardwood pulpwood in the three largest NPI regions = 66,000 GMT. The base case suggests Accessibility may be 2.5% of this. To derive Accessibility of an average of 150,000 GMT per region over those three regions you will need to secure 5.7% of the hardwood pulpwood, over double the Accessibility that may be possible. Likewise, with the hardwood harvest residue, Accessibility may be 10%, but to secure 150,000 GMT, you are going to need 28.4%, closer to triple what may be achievable. The point here is that in relative terms, securing large volumes of residues may be more difficult than securing the same volumes of pulpwood. It is only the relative differences that we can point to rather than the absolute values.

For hardwood pulpwood Accessibility (column 2 above)

- Tasmania, Western Australia and the Green Triangle had a base Accessibility of 2.5% i.e. it would be very difficult to secure much volume as prices and supply/demand are so strong.
- This 2.5% would 'release' 79,000 GMT pa from Tasmania, 76,000 GMT pa from Western Australia and 43,000 GMT pa from the Green Triangle – an average of 66,000 GMT pa.
- To 'release' an average of 150,000 GMT pa from these three regions, the Accessibility % would need to increase 2.3 times the base case.
- To 'release' 150,000 GMT the Accessibility in the 3 major regions would need to be 5.7%.

For hardwood harvest residues (column 3)

- Relative Accessibility is higher at 10% and, if this could be secured, could generate 64,000, 61,000 and 34,000 GMT pa in Tasmania, Western Australia and the Green Triangle respectively, based on the data.
- To achieve an average of 150,000 GMT for these three regions, you would need an Accessibility percentage of 28%. This would appear to be a 'challenging' level.

For softwood pulpwood:

- 2.5% Accessibility was determined as the base case.
- This would 'release' 23,000, 23,000 and 61,000 GMT pa from Murray Valley, the Green Triangle and Tasmania respectively.
- To release an average of 150,000 GMT in these regions would require an Accessibility of 18%. This would appear to be a difficult level to achieve.

For softwood pulpwood harvesting residue (i.e. mostly thinnings) (column 6):

- 10% Accessibility would 'release' 18,000, 18,000 and 13,000 GMT pa from Murray Valley, the Green Triangle and Tasmania respectively.
- 91% Accessibility would release an average of 150,000 GMT in these regions, i.e. a seemingly 'impossible' level of Accessibility.

For softwood sawlogs harvest residues (mostly clearfell):

- 10% Accessibility would release 61,000, 37,000 and 27,000 GMT pa from the Green Triangle, South East Queensland and Murray Valley respectively.
- 36% Accessibility would release an average of 150,000 GMT pa in these regions, a likely difficult level to achieve.

Finally, for softwood sawmilling residues:

- 10% Accessibility would release 61,000, 37,000 and 27,000 GMT in the Green Triangle, South East Queensland and Murray Valley regions.

- 36% Accessibility would release an average of 150,000 GMT pa in these regions, a likely difficult level of Accessibility.

Thematic maps are presented for:

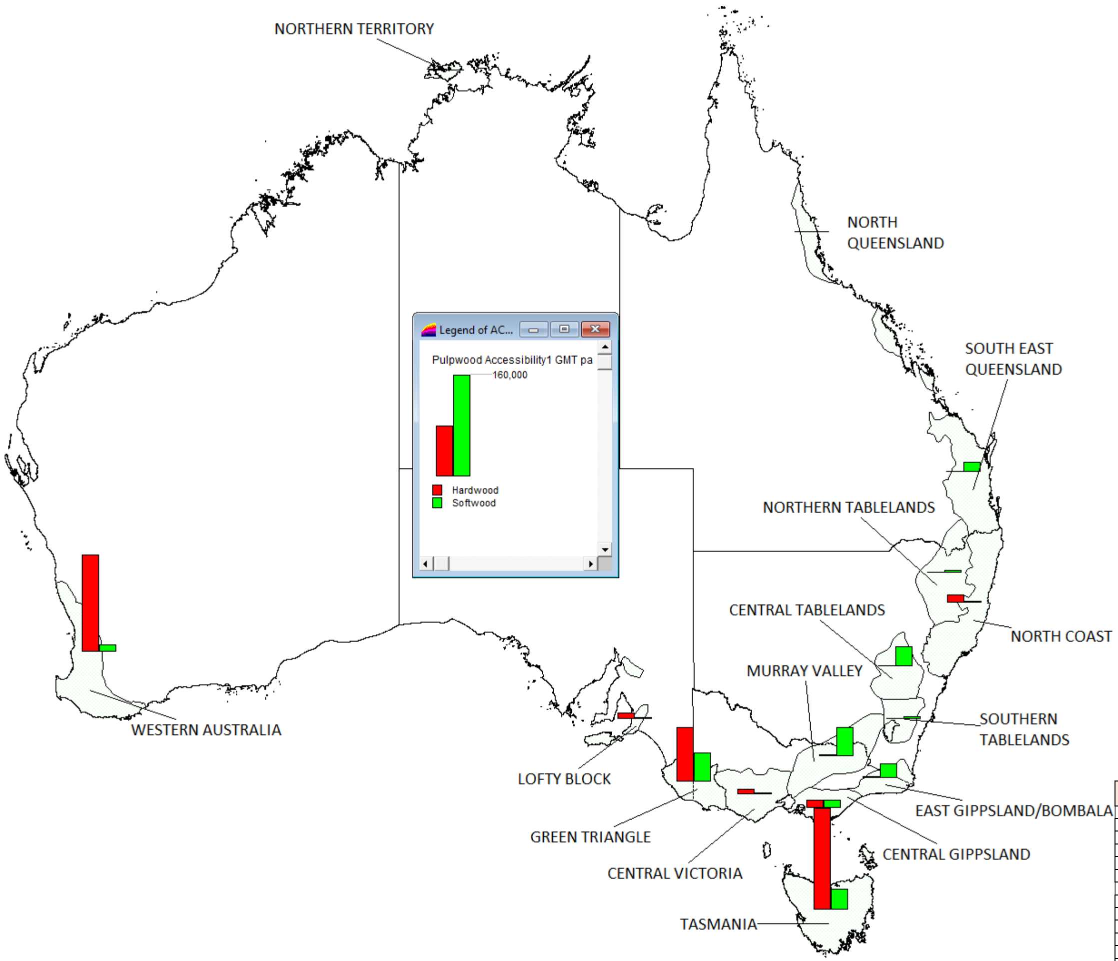
- Location and scale of SWD and HWD pulpwood and harvesting residues apparent Accessibility Figure 71.

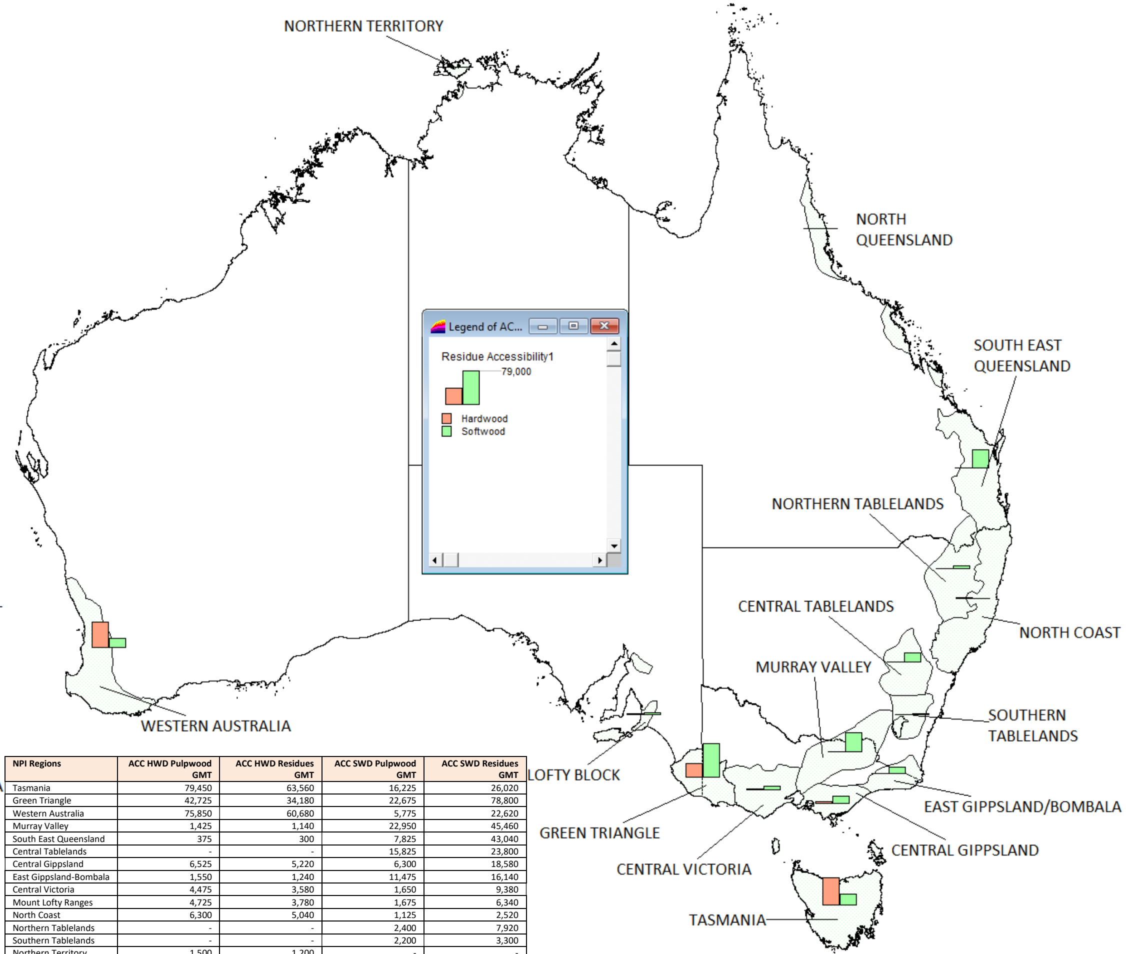
Figure 71: Location and scale of SWD and HWD pulpwood and harvesting residues apparent Accessibility

SWD and HWD pulpwood

Accessibility GMT pa

SWD and HWD harvesting residues





NPI Regions	ACC HWD Pulpwood GMT	ACC HWD Residues GMT	ACC SWD Pulpwood GMT	ACC SWD Residues GMT
Tasmania	79,450	63,560	16,225	26,020
Green Triangle	42,725	34,180	22,675	78,800
Western Australia	75,850	60,680	5,775	22,620
Murray Valley	1,425	1,140	22,950	45,460
South East Queensland	375	300	7,825	43,040
Central Tablelands	-	-	15,825	23,800
Central Gippsland	6,525	5,220	6,300	18,580
East Gippsland-Bombala	1,550	1,240	11,475	16,140
Central Victoria	4,475	3,580	1,650	9,380
Mount Lofty Ranges	4,725	3,780	1,675	6,340
North Coast	6,300	5,040	1,125	2,520
Northern Tablelands	-	-	2,400	7,920
Southern Tablelands	-	-	2,200	3,300
Northern Territory	1,500	1,200	-	-
North Queensland	-	-	200	1,300
TOTAL	224,900	179,920	118,300	305,220

9.2 SMALLER REGIONS TO CONSIDER ACCESSIBILITY

Tasmania - Southeast section:

In the South Tasmania region, several factors are aligning, presenting potential opportunities for the lignocellulosic ethanol industry. These include:

- Norske Skog Newsprint Pulp and Paper Mill: The primary pulpwood processor in this region is the Norske Skog newsprint pulp and paper mill, which consumes approximately 550,000 GMT of pulpwood annually.
- Change in Ownership: In 2020, Norske Skog sold their own forests to an institutional investor but retained a short-term pulpwood supply agreement for hundreds of thousands of GMT annually. However, the long-term sustainability of the newsprint mill is uncertain.
- Excess Pulpwood Export: There is a gradual increase in the export of excess pulpwood volume from the Port of Hobart. However, this operation has both advantages and disadvantages, given its location in a busy capital city that attracts many tourists.
- Proposed Alternative Industries: The region is witnessing proposals for various alternative industries such as Cross Laminated Timber (CLT), Oriented Strand Board (OSB), Glue Laminated Timber (GLT), and Laminated Veneer Lumber (LVL) facilities. These industries can utilize products that fall between sawlogs and pulpwood, with some processes maximizing log recovery through veneer production. These industries are expected to become major consumers of both softwood and hardwood pulpwood, as well as small sawlog products, not only in Tasmania but also in other major NPI Regions across Australia.
- Geographic Limitations: The Southern Tasmanian softwood and hardwood forests are situated too far from the major northern Tasmania ports of Burnie and Bell Bay for woodchip exports. In the absence of the Hobart Port, virgin forest products would likely be exported from these northern ports.
- Potential Drawback: One drawback in this region is the limited availability of waste wood from forestry processing industries and possible shortages of agricultural waste products.

Tasmania - Northwest section:

In the Northwest section of Tasmania, the key opportunity lies in a substantial continuous hardwood estate covering around 100,000 hectares.

- This estate has a dedicated chipper[110] that consumes all the pulpwood in the area (the forest and the chipper is owned by the same entity). However, the processor faces challenges with residues, particularly undersized fines from the chipper.
- Exploring the combination of forest residues with chipping and screening residues could be an attractive solution in this context.

Tasmania - Northeast section:

The Northeast section of Tasmania, particularly the Bell Bay area near Launceston, is home to three chipping operations[111] and a large softwood sawmill.

- Collectively, these operations process significant volumes of hardwood logs for woodchip export and significant volumes of softwood logs, processing these into sawn lumber.
- These processes generate significant residues, which currently have designated uses but still represent a resource of significant importance.

[110] New Forests Surrey Hills chipper producing substantial BDMT pa

[111] ARTEC 0.6 million BDMT pa, New Forests 0.4 million BDMT pa and Reliance Forest Fibre unknown but c. 0.4 million BDMT.

- The 'move' to domestic uses here are very strong but 'complex'.

Murray Valley (NSW side):

Figures Figure 27 and Figure 28 on pages 22 and 23, we highlight a notable increase in the apparent availability of softwood harvesting residues and softwood sawmill residues in the Murray Valley region on the New South Wales side.

- This increase is attributed to the extensive softwood plantations that were affected by the 2020 fires, covering hundreds of thousands of hectares.
- These areas have been replanted, and as a result, there will be a peak in softwood thinnings in approximately 10-15 years, followed by a peak in softwood sawmill residues in another decade or so.
- Due to the distance from ports, exporting both pulpwood and residues internationally from these plantations is 'marginal'.
- However, there will be domestic opportunities for markets located within this region.
- Additionally, the region shows economic haulage distances to a greenfield mallee plantation in the 400-600 mm long-term rainfall region, with a significant area of land for greenfield plantation development.

Distant from port Regions (i.e. non-export regions)

- The regions are North Queensland (nearest Port is Bundaberg), Northern Tablelands (nearest Port is Brisbane), Central Tablelands (nearest port is Wollongong) and Murray Valley (nearest port Wollongong or Geelong).
- The 'target' here would be first thinning (T1) of softwood plantations and associated harvest residues, especially from the fire-replant areas mentioned previously.
- However, the largest pulpmill in the NSW regions is Visy, located near Tumut. This mill has the largest wood supply region of any processor in Australia. This extends to the full Murray Valley Region, in which it is located and accepts wood from the Bombala Region and the Central Tablelands.

Western Australia (Albany region … referred to as the Lower Great Southern Region)

- Significant concentration of hardwood plantations estimated by MBAC as between 70,000 and 80,000 hectares of industrial plantations (i.e. aligned with the woodchip export industry) and additional non-industrial plantations (largely non-blue gum plantings on private lands).
- There are two wood chipping operations in and around Albany – Australian Bluegum Plantations (ABP) and Albany Plantation Export Company (APEC).
- There are existing mallee plantations with unknown areas within 100 km of Albany.
- There are significant areas of non-preferred eucalypt species that are less suitable for woodchip export. These are scattered throughout the region, mostly as smaller holding on agricultural properties.

Note, demand for woodchips in all these regions likely exceeds supply. In addition, these are highly competitive regions, with 'entrenched' relationships between landowners, tree owners and processors. Gaining access to fibre in these regions is not a 'simple' pursuit.

10 CONCLUSIONS AND RECOMMENDATIONS

Numerous non-forestry lignocellulosic residue sources and residues are produced by a wide range of industries. These include:

- Purpose-grown oil mallee plantations (typically for biomass and complementary environmental services)
- Municipal solid waste
- Sugar industry residues
- Grains industry residues (including rice hulls and non-cereal crops)
- Cotton residues
- Vegetable processing residues
- Nut residues
- Fruit residues
- Orchard prunings
- Winery residues
- Flower industry residues

Of these:

- Oil mallee, particularly south west Western Australia plantations, may provide a source of lignocellulosic feedstock, especially as hopes for bioenergy production have not materialised to the level anticipated. However, an efficient system to harvest, process and transport oil mallee may limit the economic viability of this option.
- Municipal Solid Waste presents a number of advantages over alternatives, such as agricultural crop residues: Operationally, the supply of waste is comparatively consistent and reliable over time and infrastructure and processes to aggregate and store waste already exist in most instances; economically, utilisation of waste converts materials that are currently a costly liability (to manage and dispose of) into a potentially valuable revenue generating asset, and environmentally, each tonne of waste diverted is one tonne less disposed to landfill where it generates methane, one of the most potent greenhouse gases, as well as other land, water and atmospheric pollutants. Additionally, large quantities are available close to all major population centres. However, Municipal Solid Waste also presents challenges, with limited source control and a high potential for contamination.
- Sugar cane residues are available in large quantities and are produced in concentrated areas with good access to existing infrastructure networks. The existing production systems either already concentrate residues (e.g., bagasse at mills) or can be readily customised to concentrate residues in conjunction with normal operations (e.g., through modified mechanised field harvesting). However, there is competition for these residues with production of energy from bagasse, and reincorporation of trash to maintain soil carbon.
- Cereal straw, rice husks, maize cobs are potential feedstocks with low moisture contents. However, straw is not widely used in Australia for bioenergy. Rather, no-till farming is commonly practiced to retain and build soil carbon levels, which is critical for soil moisture and nutrient holding capacity, soil microbial activity and soil structure. However, issues include the value of retaining residues in the field given their large benefit to soil conservation and health, and the economics and feasibility of harvesting cereal straw residues, with more energy potentially expended to gather cereal straw than would be generated as bioenergy.

- Rice hulls represent a significant feedstock source in southern NSW, however, competition from other industries is unknown. These may present an opportunity to supplement forest residues.
- Non-cereal crop residues such as canola, oil seeds and pulses were identified in South Australia and Tasmania. They are generally considered a waste although they may still be in beneficial use, and may present an opportunity to supplement forest residues.
- Cotton trash is a voluminous, light substance which becomes a burden to store, sell or convert effectively into a form of organic fertiliser, and is generally considered a nuisance by cotton ginners. The direct reapplication of cotton trash to farms is strongly discouraged due to the risk of contamination of soil borne pathogens and pesticides. In cotton farming regions, there is significant potential for the by-products or cotton crop residues to be used to produce bio-energy. An assessment of CGT in the 2009-10 harvest year across Australia identified a potential renewable energy resource equated to 78 million litres of ethanol. Other cotton residues such as the straw or stalk left after harvest has also attracted attention for potential bioenergy use, although there are benefits in retaining cotton straw or stalk in the field includes to manage for pest resistance and soil health. NSW and southern and central Queensland are the main cotton producing areas.
- Vegetable processing residues such as beans, carrots, potatoes and are generally considered a waste although they may still be in beneficial use. Concentrated residue sources have been identified in South Australia, Tasmania and Western Australia.
- Nut residues provide a rich potential source of ethanol, with yields generally ranging between 50-100 litres per ton. Concentrated sources have been identified in north-east and south-west NSW, and south-east Australia. Macadamia nut shells are also produced in south-east Queensland.
- Fruit residues also provide a rich potential source of ethanol, with yields generally ranging between 50 to 250 l/ton. Concentrated sources have been identified in south-west and north east western Australia, although these residues will also be produced in other fruit growing regions including Victoria, NSW and Queensland.
- Orchard pruning data indicate availability of small quantities in south-eastern Tasmania. This residue may be difficult to aggregate.
- Winery residue data also indicate availability of small quantities in south-eastern Tasmania.
- Flower industry residue data indicate availability of small quantities in north-western Tasmania.

In terms of potential forestry lignocellulosic feedstocks, it would be convenient to think of forestry as a simple business with stable forest areas, a reasonably even woodflow, two major species groups (softwood and hardwood), two major product groups (sawlogs and pulplogs) and two major market types (domestic and export). Unfortunately, the forest industry is the opposite of this, with rapidly changing areas and age classes, multiple species, uneven woodflows, innumerable products, selling to a range of customers with demands that ‘ebb and flow’ and many other complexities.

Regardless, the ethanol industry can benefit the forestry industry by accommodating a wide range of furnish qualities and being ‘nimbler’ and more opportunistic in sourcing products. As Ethtec advises “*the Ethtec process is not feedstock-specific, we can process multiple types of lignocellulosic material simultaneously. This important feature may enhance the economics of utilising forest materials as well as woody weeds as feedstocks, if used in combination with other available lignocellulosic materials*.”[112]

[112] Personal communications Ethtec 10 May 2023

However, the variables and difficulties in this process are significant. The only certainty in this report is that our projections of lignocellulosic uses, supply, Availability, prices, and Accessibility are certain to be wrong. However, the information and spatial representations do point to where there may be concentrations of different types of furnish.

In conclusion, the market into which the ethanol industry is seeking its place is complex, but it can become an integral part of the lignocellulosic supply chain by taking into account the Availability, quality, price, and Accessibility of different types of furnish and being flexible in its approach.

The apparent most attractive forest-furnish NPI Regions (see Table 15), in order, appear to be:

1. Green Triangle
2. Tasmania
3. Western Australia
4. Murray Valley

Within these regions, the apparent most attractive sub-regions (see Table 15) and their NPI Region (in brackets) are:

1. NE Tasmania (Tasmania) – centred around Bell Bay.
2. Albany (Western Australia)- centred around Albany.
3. NW Tasmania (Tasmania) – centred around Burnie.
4. Murray Valley NSW (Murray Valley) – centred around Tumut.

A very high-level table (Table 15) combines the findings from the Regions and sub-regions based on the many assumptions in this report.

From an agricultural waste perspective, the most attractive regions are:

1. Murray Valley
2. Northern Tablelands
3. Green Triangle

Table 15: Attractiveness summary by region and sub-region

NPI Region	HWD pulpwood	HWD harvest residues	SWD pulpwood	SWD processing residues	SWD pulpwood harvesting	SWD sawlogs harvesting	Mallee	Non-commercial	Carbon forests	Municipal waste	Grain residues	Sugar residues	Cotton residues
Green Triangle	✓	✓	✓	✓	✓	✓			✓		✓		
Tasmania	✓	✓	✓		✓				✓				
Western Australia	✓	✓							✓				
Murray Valley			✓		✓	✓	✓			✓	✓		✓
South East Queensland				✓		✓		✓					✓
North Coast (NSW)								✓		✓	✓	✓	
Northern Tablelands											✓		✓
Mount Lofty Ranges											✓		
North Queensland												✓	
Central Tablelands													
Central Gippsland													
East Gippsland-Bombala													

NPI Region	HWD pulpwood	HWD harvest residues	SWD pulpwood	SWD processing residues	SWD pulpwood harvesting	SWD sawlogs harvesting	Mallee	Non-commercial	Carbon forests	Municipal waste	Grain residues	Sugar residues	Cotton residues
Central Victoria													
Southern Tablelands													
Northern Territory													
Sub regions													
NE Tasmania – Bell Bay	✓	✓	✓		✓				✓				
Albany Region	✓	✓					✓		✓				
NW Tasmania - Burnie	✓	✓							✓				
Murray Valley (NSW) - Tumut					✓	✓	✓			✓	✓		✓

The ‘route’ to forest based furnish is via:

- Sawmilling entities, such as the largest in Australia - Associated Kiln Driers (AKD) – which is a private company with 6 softwood sawmills located in Victoria, New South Wales and South East Queensland, processing over 2 million cubic metres of sawlogs per year and Timberlink in Tasmania and South Australia (part of the New Forests group). There are many other sawmilling entities.
- The major plantation owners, such as New Forests – the largest plantation owner in Australia – with plantations in Tasmania, Victoria, South Australia, New South Wales and Western Australia, or the US-based Hancock Group, with major plantations in Victoria and Queensland. There are other large plantation owners and many smaller entities.
- The major woodchipping entities, such ABP, APEC, New Forests, Pentarch and Midway, for example. There are some smaller entities.

Appendix 1 – Terms of Reference

Ethtec-ARENA Funding Agreement - Milestone 3, Part (viii) Deliverable

"***Provision of an Independently Prepared Report to include***
Cellulosic Feedstock Availability ***in Australian and Asian Markets***"

Terms of Reference

1. Comments on the dependence of cellulosic feedstock quality and Availability on the price that can be paid for the feedstock
2. Estimates of pulpwood and residues* from Australian commercial planted softwood and hardwood forests
3. Estimates of pulpwood and residues* from Australian commercial planted hardwood forests that may potentially be:
   - converted from short to long rotation under the Carbon Emissions Reduction Fund (CERF) (CERF Schedule 2)**
   - avoided deforestation plantations under the CERF (CERF Schedule 3)**
4. Estimates of pulpwood and residues* from Australian potential commercial greenfield planted forests that may be established under the CERF (CERF Schedule 1)
5. Comments on the potential to enhance the carbon emission reduction and the financial underpinning of the activities listed in points 3 and 4 above by, at the end of the forest growth phase, sale of the wood for conversion to ethanol fuel used to replace fossil petroleum fuels.
6. Estimates of pulpwood and residues* from Australian commercial native forests
7. Estimates of biomass from non-commercial sources (e.g. camphor laurel 'forests')
8. Estimates of pulpwood and residues from the following Asian commercial planted forests:
   - China
   - Japan
   - Vietnam
   - Thailand
   - Malaysia
   - Indonesia
9. A literature review of Australian and Asian potentially available other cellulosic feedstocks including:
   - Industrial residues (e.g. sawmilling, demolition)
   - Municipal solid waste residues
   - Agricultural (non-forest) industry residues including:
     - Sugar industry (sugar cane trash and bagasse)
     - Grains industry (e.g. wheat stubble, corn stubble)
     - Other food and fibre industry residues (e.g. cotton stubble and ginning trash, vegetable processing, etc.)

* Assumes timber is directed to the highest and best value (sawlog, peeler log, poles etc.) and that ethanol fuel production may compete with pulpwood and/or access residues.
** Avoided reversion to agriculture as without the additional carbon value, the highest and best use becomes agriculture rather than remaining as forest.

Appendix 2 – Consulting team

Rod Meynink – MBAC

Rod has over 40 years experience in the Australian and international forestry sector. He is well known in the industry and forest growing sectors throughout Australia (and internationally). His principal fields of expertise are forest due diligence, forest valuations, expert witness, resource assessment, carbon sequestration, forest inventory, remote sensing, marketing and wood-flow planning systems. He has undertaken over 300 projects in Asia (China, Lao PDR, Malaysia, Indonesia, Singapore, Philippines and Vietnam); Oceania (Australia, New Zealand, Fiji, Solomon Islands and Vanuatu); Americas (United States, Argentina and Suriname); Africa (South Africa, Mozambique, Angola, The Congo, Egypt, South Sudan and Zambia) and Europe (Finland and UK). Prior to forming MBAC in 2001, Rod Meynink held the position of Vice President of Jaakko Pöyry Consulting and worked internationally with Jaakko Pöyry from 1990 to 2001.

Dr. Glenn Dale - Verterra

Glenn is a Senior Consultant with MBAC. Glenn has over 25 years experience in the Australian and international forestry sector. His principal fields of technical expertise are tree breeding, clonal forestry, forest biotechnology, species-site matching, forest inventory, growth modelling, statistical analysis, plantation management, plantation water-use, carbon sequestration and forestry research. Glenn worked for a number of years in north-Queensland rainforest management and has substantial experience in mixed species tropical forest management, including inventory and resource assessment, sustained yield estimation and harvesting management controls. Glenn has undertaken numerous projects both within industry and as a consultant, including new species development, species trialling and assessment, and evaluation of plantation development projects in the Northern Territory, Queensland and NSW. He has international experience working in the United States, New Zealand, Brazil, England, Spain, Portugal, Columbia, Malaysia, and China. He is currently advising on plantation projects in South America and Australia. In recent years, Glenn has undertaken and directed a number of projects involving large scale land capability assessments including extensive soil surveying, vegetation mapping and air photo interpretation.

Andrew Yates - Verterra

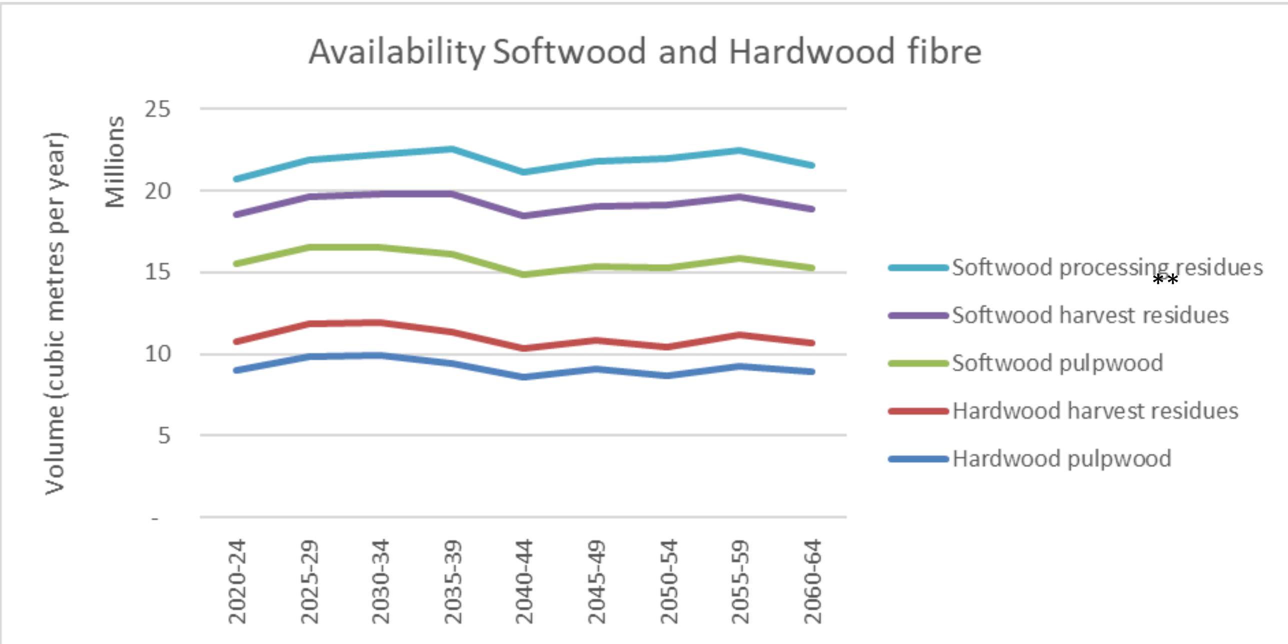
Andrew is a Senior Land Resource and Carbon Specialist with over 20 years' experience. He holds a BSc (Forestry) and Graduate Diploma in Data Science. Andrew's career has spanned several roles with expertise in forest and land management, including, production forestry, carbon farming, strategic and operational planning. Andrew now heads up Verterra's carbon farming-based projects and over the past 12 months has delivered consultancies for Queensland based utilities, Victorian CMAs, and the NSW government. Andrew is currently working in partnership with others to develop carbon farming projects for water quality improvement.

▪

Appendix 3 – High-level Estimated Regional Availability

Region	Product	Availability '000 GMT pa								
		2020-24	2025-29	2030-34	2035-39	2040-44	2045-49	2050-54	2055-59	2060-64
Tasmania		**4,853**	**5,108**	**4,854**	**4,753**	**4,603**	**4,815**	**4,572**	**4,604**	**4,707**
	Hardwood pulpwood	3,178	3,303	3,139	2,940	2,944	2,898	2,662	2,721	2,921
	Hardwood harvest residues	636	661	628	588	589	580	532	544	584
	Softwood pulpwood	649	645	590	613	556	686	713	677	624
	Softwood pulpwood harvest residues	130	129	118	123	111	137	143	135	125
	Softwood sawlogs harvest residues	130	185	190	245	202	257	261	263	227
	Softwood processing residues	130	185	190	245	202	257	261	263	227
Green Triangle		**4,352**	**4,778**	**4,862**	**4,504**	**4,304**	**4,416**	**4,413**	**4,538**	**4,342**
	Hardwood pulpwood	1,709	2,047	2,124	1,734	1,541	1,536	1,554	1,720	1,557
	Hardwood harvest residues	342	409	425	347	308	307	311	344	311
	Softwood pulpwood	907	872	868	856	797	828	835	809	910
	Softwood pulpwood harvest residues	181	174	174	171	159	166	167	162	182
	Softwood sawlogs harvest residues	607	638	636	698	749	790	773	752	691
	Softwood processing residues	607	638	636	698	749	790	773	752	691
Western Australia		**4,278**	**4,552**	**4,376**	**4,200**	**4,142**	**4,462**	**4,083**	**4,312**	**3,961**
	Hardwood pulpwood	3,034	3,267	3,156	3,021	2,976	3,283	2,818	3,097	2,805
	Hardwood harvest residues	607	653	631	604	595	657	564	619	561
	Softwood pulpwood	231	234	208	196	181	168	223	193	195
	Softwood pulpwood harvest residues	46	47	42	39	36	34	45	39	39
	Softwood sawlogs harvest residues	180	175	170	170	177	160	217	182	180
	Softwood processing residues	180	175	170	170	177	160	217	182	180
Murray Valley		**1,712**	**1,857**	**2,228**	**2,767**	**2,385**	**2,117**	**2,439**	**2,340**	**2,065**
	Hardwood pulpwood	57	48	69	23	22	28	23	29	22
	Hardwood harvest residues	11	10	14	5	4	6	5	6	4
	Softwood pulpwood	918	1,006	1,118	1,307	1,108	909	1,045	974	919
	Softwood pulpwood harvest residues	184	201	224	261	222	182	209	195	184
	Softwood sawlogs harvest residues	271	296	402	585	514	496	579	568	468
	Softwood processing residues	271	296	402	585	514	496	579	568	468
South East Queensland		**1,129**	**1,086**	**1,110**	**1,075**	**1,114**	**1,107**	**1,093**	**1,096**	**1,091**
	Hardwood pulpwood	15	21	39	41	27	26	18	24	15
	Hardwood harvest residues	3	4	8	8	5	5	4	5	3
	Softwood pulpwood	313	241	243	239	226	225	247	248	246
	Softwood pulpwood harvest residues	63	48	49	48	45	45	49	50	49
	Softwood sawlogs harvest residues	368	386	386	369	405	403	387	385	389
	Softwood processing residues	368	386	386	369	405	403	387	385	389
Central Tablelands		**982**	**998**	**935**	**925**	**849**	**927**	**905**	**981**	**950**
	Hardwood pulpwood	-	-	-	-	-	-	-	-	-
	Hardwood harvest residues	-	-	-	-	-	-	-	-	-
	Softwood pulpwood	633	643	591	545	502	557	571	625	604
	Softwood pulpwood harvest residues	127	129	118	109	100	111	114	125	121
	Softwood sawlogs harvest residues	111	113	113	136	123	129	110	115	113
	Softwood processing residues	111	113	113	136	123	129	110	115	113
Central Gippsland		**886**	**878**	**954**	**1,034**	**982**	**948**	**887**	**932**	**912**
	Hardwood pulpwood	261	203	226	134	28	2	1	27	1
	Hardwood harvest residues	52	41	45	27	6	0	0	5	0
	Softwood pulpwood	252	289	302	362	447	445	412	413	424
	Softwood pulpwood harvest residues	50	58	60	72	89	89	82	83	85
	Softwood sawlogs harvest residues	135	144	160	219	206	206	196	202	201
	Softwood processing residues	135	144	160	219	206	206	196	202	201
East Gippsland-Bombala		**764**	**659**	**718**	**476**	**631**	**621**	**755**	**829**	**743**
	Hardwood pulpwood	62	4	83	16	51	49	9	91	9
	Hardwood harvest residues	12	1	17	3	10	10	2	18	2
	Softwood pulpwood	459	406	368	273	361	363	445	386	378
	Softwood pulpwood harvest residues	92	81	74	55	72	73	89	77	76
	Softwood sawlogs harvest residues	70	83	88	65	68	63	105	128	139
	Softwood processing residues	70	83	88	65	68	63	105	128	139
Central Victoria		**455**	**446**	**474**	**568**	**491**	**690**	**674**	**695**	**680**
	Hardwood pulpwood	179	202	212	303	214	363	386	396	384
	Hardwood harvest residues	36	40	42	61	43	73	77	79	77
	Softwood pulpwood	66	46	41	38	37	37	35	37	34
	Softwood pulpwood harvest residues	13	9	8	8	7	7	7	7	7
	Softwood sawlogs harvest residues	81	74	85	80	95	105	84	88	89
	Softwood processing residues	81	74	85	80	95	105	84	88	89
Mount Lofty Ranges		**407**	**614**	**567**	**530**	**244**	**134**	**555**	**472**	**348**
	Hardwood pulpwood	189	401	369	338	102	29	341	310	276
	Hardwood harvest residues	38	80	74	68	20	6	68	62	55
	Softwood pulpwood	67	54	69	62	54	38	58	48	6
	Softwood pulpwood harvest residues	13	11	14	12	11	8	12	10	1
	Softwood sawlogs harvest residues	50	34	21	25	28	27	38	21	5
	Softwood processing residues	50	34	21	25	28	27	38	21	5

Region	Product	Availability '000 GMT pa 2020-24	2025-29	2030-34	2035-39	2040-44	2045-49	2050-54	2055-59	2060-64
North Coast		**389**	**357**	**334**	**364**	**356**	**372**	**358**	**368**	**371**
	Hardwood pulpwood	252	224	204	203	200	184	166	176	217
	Hardwood harvest residues	50	45	41	41	40	37	33	35	43
	Softwood pulpwood	45	41	40	56	53	68	74	75	52
	Softwood pulpwood harvest residues	9	8	8	11	11	14	15	15	10
	Softwood sawlogs harvest residues	16	20	20	26	26	35	35	33	24
	Softwood processing residues	16	20	20	26	26	35	35	33	24
Northern Tablelands		**235**	**148**	**147**	**142**	**110**	**96**	**150**	**164**	**194**
	Hardwood pulpwood	-	2	-	-	6	-	2	1	5
	Hardwood harvest residues	-	0	-	-	1	-	0	0	1
	Softwood pulpwood	96	57	60	64	49	49	73	81	92
	Softwood pulpwood harvest residues	19	11	12	13	10	10	15	16	18
	Softwood sawlogs harvest residues	60	39	37	32	22	18	30	33	39
	Softwood processing residues	60	39	37	32	22	18	30	33	39
Southern Tablelands		**136**	**160**	**138**	**206**	**146**	**112**	**166**	**159**	**126**
	Hardwood pulpwood	-	-	-	-	-	-	-	-	-
	Hardwood harvest residues	-	-	-	-	-	-	-	-	-
	Softwood pulpwood	88	99	79	88	77	55	100	84	64
	Softwood pulpwood harvest residues	18	20	16	18	15	11	20	17	13
	Softwood sawlogs harvest residues	15	21	22	50	27	23	23	29	25
	Softwood processing residues	15	21	22	50	27	23	23	29	25
Northern Territory		**72**	**187**	**384**	**816**	**576**	**792**	**858**	**840**	**840**
	Hardwood pulpwood	60	156	320	680	480	660	715	700	700
	Hardwood harvest residues	12	31	64	136	96	132	143	140	140
	Softwood pulpwood	-	-	-	-	-	-	-	-	-
	Softwood pulpwood harvest residues	-	-	-	-	-	-	-	-	-
	Softwood sawlogs harvest residues	-	-	-	-	-	-	-	-	-
	Softwood processing residues	-	-	-	-	-	-	-	-	-
North Queensland		**32**	**67**	**119**	**187**	**199**	**192**	**112**	**159**	**195**
	Hardwood pulpwood	-	-	-	-	-	-	-	-	-
	Hardwood harvest residues	-	-	-	-	-	-	-	-	-
	Softwood pulpwood	8	23	49	65	67	73	47	61	73
	Softwood pulpwood harvest residues	2	5	10	13	13	15	9	12	15
	Softwood sawlogs harvest residues	11	20	30	55	59	52	28	43	54
	Softwood processing residues	11	20	30	55	59	52	28	43	54



Furnish	2020-24	2025-29	2030-34	2035-39	2040-44	2045-49	2050-54	2055-59	2060-64
Hardwood pulpwood	8,996,000	9,878,000	9,941,000	9,433,000	8,591,000	9,058,000	8,695,000	9,292,000	8,912,000
Hardwood harvest residues	1,799,200	1,975,600	1,988,200	1,886,600	1,718,200	1,811,600	1,739,000	1,858,400	1,782,400
Softwood pulpwood	4,732,000	4,656,000	4,626,000	4,764,000	4,515,000	4,501,000	4,878,000	4,711,000	4,621,000
Softwood harvest residues	3,052,200	3,159,000	3,284,600	3,708,200	3,605,800	3,664,600	3,841,600	3,784,400	3,566,800
Softwood processing residues	2,105,800	2,227,800	2,359,400	2,755,400	2,702,800	2,764,400	2,866,000	2,842,200	2,642,600
Total	20,685,200	21,896,400	22,199,200	22,547,200	21,132,800	21,799,600	22,019,600	22,488,000	21,524,800

*** Note significantly greater volumes of long-rotation softwood products are removed per hectare relative to short-rotation hardwoods. This produces significantly greater softwood residues per GMT of softwood products.*

Appendix 4 – Literature Review of Availability

Hardwood plantation harvest residues

NSW

This dataset estimates the biomass (dry tonnes) for average annual harvest residues and pulp logs in plantation hardwood forests in NSW. Each region shows the average annual total of plantation hardwood residues for the period January 2011 to December 2015 (average of 5 years). The key species are: Flooded Gum, Blackbutt Silvertop Stringybark, Blue leaved Stringybark.

https://nationalmap.gov.au/#share=s-qtGFl6IAPh6bHD0wGLB79n454XD

South Australia

This dataset represents forestry residues and was derived from production volumes contained in the Australian Plantation Log Supply 2015 – 2059.

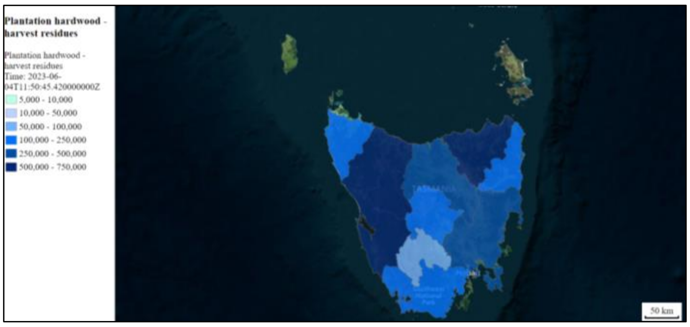
This includes information on pulp log residues (for hardwood plantations). These are the residues which are a by-product of harvesting pulp logs.

The information contained in this dataset is derived from Australia's plantation log supply 2015-2059 report which presents forecasts of sawlog and pulplog volumes available from softwood and hardwood plantations.

https://nationalmap.gov.au/#share=s-tzYz47VPVbfubmK4qpNkxMe2lTI

Tasmania

This dataset estimates the green biomass volume (green metric tonnes) of harvest residues in planted hardwood and native forest across all tenures in Tasmania.

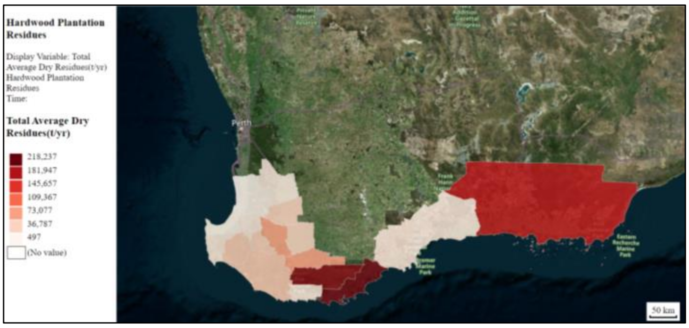


The annual harvest residue data contained in the dataset were derived from a set of 30 year forest harvest simulation models developed as part of the 'Residues Solution Study' (http://www.stategrowth.tas.gov.au/forestry/residues).

https://nationalmap.gov.au/#share=s-95svWseW4fx9AbjgIzHxymAOhZ9

Western Australia

This hardwood data includes a range of eucalypt species, however, the vast majority of the plantation estate (>90%) is *E. globulus* or Tasmanian Bluegum.

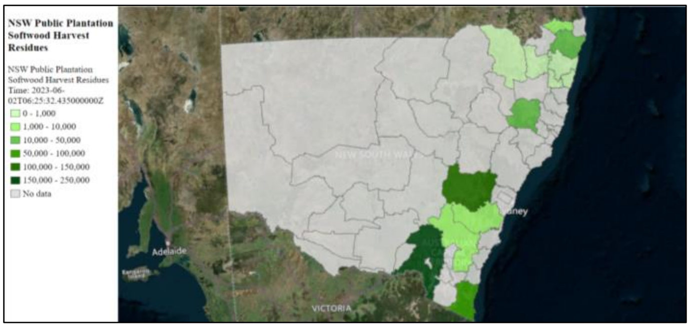


https://nationalmap.gov.au/#share=s-sWKsSoMvGVnxSd7fjf9e8OmpIBM

Softwood plantation harvest residues

NSW

This dataset estimates the biomass (dry tonnes) of harvest residues from plantation softwood forests in NSW.



Each region shows the average annual total of plantation softwood residues for the period January 2011 to December 2015 (average of 5 years). Biomass components include crown and branches, stumps and pulp logs. The predominant species is Radiata pine, but small quantities of Loblolly pine and Slash pine are also recorded.

https://nationalmap.gov.au/#share=s-78TXhGjneD0OPP4ftKYmdDCXD1I

Queensland

It is not possible to directly quantify forestry residues in Queensland. There is no regular or comprehensive assessment or monitoring of the generation or utilisation of native forest or plantation residues.

Data about the volume of various types of timber products sold from public native forests and plantations is, however, routinely collected. Based on relationships from a variety of sources, this data was used to derive the quantity and type of residues generated by forestry operations and processing of products sourced from both private and public forests and plantations across Queensland.

The volume of softwood sawlogs harvested from Queensland are published annually in the Australian forest and wood products statistics (ABARES 2016). These data sources have been used to derive the residue values in this assessment.

https://nationalmap.gov.au/#share=s-15dlm74Uf175XhUlFqnHTPgfVvZ

South Australia

This dataset represents forestry residues and was derived from production volumes contained in the National Plantation Inventory, 2015 – 2059.

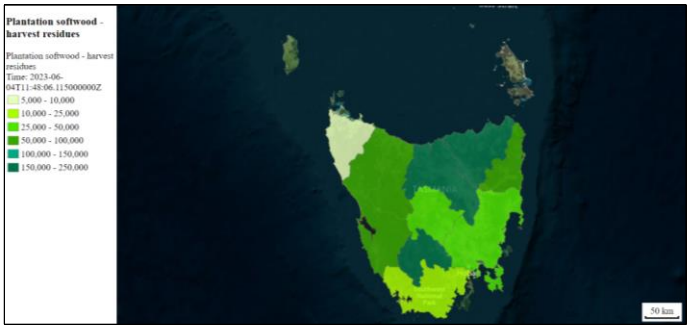
This includes information on forestry residues including field residues (foliage, branches etc). These are the residues which are left behind in the forest.

https://nationalmap.gov.au/#share=s-oOeiF4b3swvo24u0HTfFooCSbah

Tasmania

This dataset estimates the green biomass volume (green metric tonnes) of harvest residues in planted softwood forest across all tenures in Tasmania.

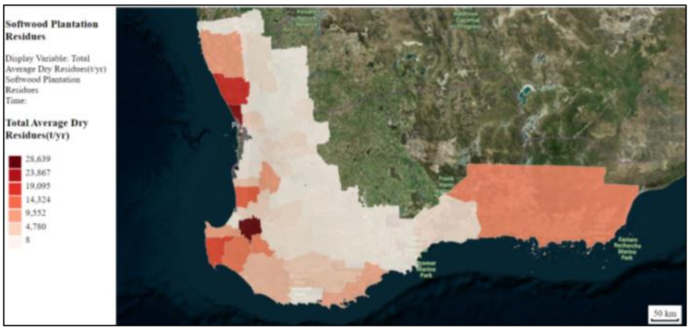
The annual harvest residue data contained in the feature dataset were derived from a set of 30-year forest harvest simulation models developed as part of the 'Residues Solution Study' (http://www.stategrowth.tas.gov.au/forestry/residues).



https://nationalmap.gov.au/#share=s-mO1AMgXR7d0lJVH9xohHq37weKD

Western Australia

This softwood data includes a range of Pine species, however, the vast majority of the plantation estate (>90%) is *P. radiata* and *P. pinasta* with *P. pinasta* occurring primarily north of Perth and in the inland LGA's whilst the *P. radiata* plantations are mainly in the southwest.



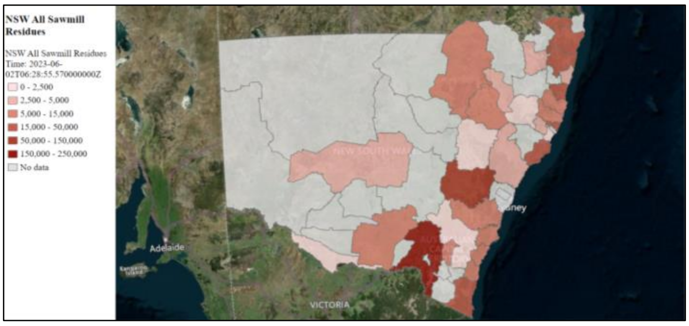
https://nationalmap.gov.au/#share=s-p5DPwbih98crKB9ehXS5nANg5xE

Sawmill residues

NSW

This dataset that estimates the biomass (dry tonnes) of sawmill residues from native hardwood/cypress forests, from plantation hardwood forests and from plantation softwood forests in NSW for the purposes of determining availability of biomass for bioenergy.

Each region shows the average annual total of sawmill residues for the period January 2011 to December 2015 (average of 5 years) and the combined residue total of native and plantation residues which are made up of hardwood, softwood and cypress pine residues depending on the region.



https://nationalmap.gov.au/#share=s-dLPWc6nAvlUxsooBIUmivpaPYAj

South Australia

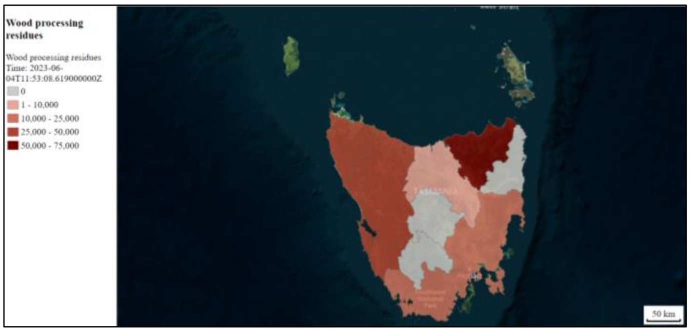
This dataset represents was derived from production volumes contained in the National Plantation Inventory, 2015 – 2059.

This includes information on forestry residues including sawmill residues (solid wood, shavings, sawdust etc). These are the residues which are a by-product of the saw milling process.

https://nationalmap.gov.au/#share=s-qKmVdcf54KxiVED1iuDGZbIDP9

Tasmania

The wood processing residues data contained in this dataset were derived from the Tasmanian Residues Survey (2013).



https://nationalmap.gov.au/#share=s-70qeuZRizrXuBfiHhKaKgQ8M8qE

Vegetable processing

South Australia

These data include information on vegetable crops such as beans, carrots, potatoes and onions (as dry weight tonnes) amalgamated at ABS SA4 Regions. Residues are generally considered a waste although they may still be in beneficial use.

https://nationalmap.gov.au/#share=s-1cRXhmWbaxy5BQ0sB0xVTDLBddC

Tasmania

This dataset estimates the biomass volumes of residues for horticulture activities in Tasmania. The data is are based on the ABS SA4 boundaries. The horticulture residue data contained in the feature dataset were derived from the Tasmanian Residues Survey (2016) which was undertaken.

https://nationalmap.gov.au/#share=s-evXWaSP9ueemawuHPJhbqt5P9ld

Western Australia

The mechanically harvested vegetable residue production data is based on the estimated carrot, potato and onion production, from the 2015-16 statistical area 2 (SA2) level. LGA's with less than 5 tonnes of carrot, potato or onion production were excluded from the analysis. Additional vegetable residues are produced and recorded from Northern Western Australia including the Ord Region, but regional quantities are small (less than 619 dry tons for any region) and have been excluded.

https://nationalmap.gov.au/#share=s-yqNs5tAWtDl6amq5zgc0V8GLKGA

Nut residues

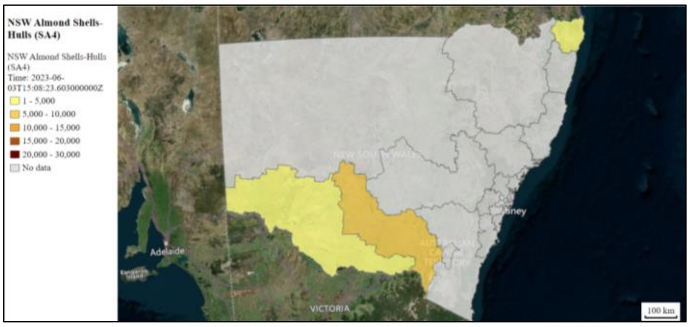
The approximate lignocellulosic ethanol potential of selected fruit residues is summarised below:

- Walnut shell ethanol potential is influenced by factors such as the lignin content and accessibility of cellulose.
- The ethanol yield from walnut shells can range from 50-100 litres per ton.
- Almond shells are similar to walnut shells. Ethanol yield can also range from 50-100 litres per ton.
- Peanut shells can yield approximately 50-100 litres of ethanol per ton.

The availability and location of potential fruit and nut feedstocks is summarised below based on the data presented in the Australian Biomass for Bioenergy Assessment 2015-2021 (ARENA, 2021).

Almond shell hulls

This dataset estimates the location and mass in dry tonnes of almond shell and hull residues across NSW.



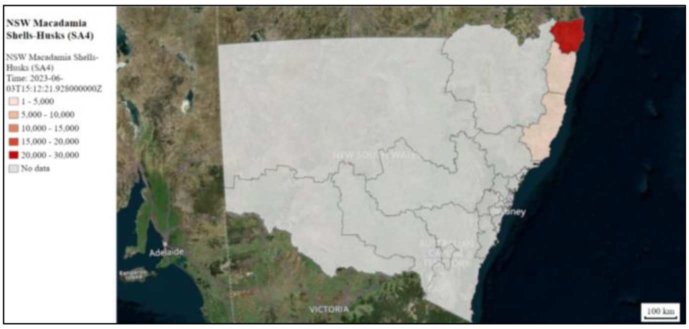
Each SA4 region shows the annual average, minimum and maximum tonnes of almond shell and hull residues at 0% moisture content (MC). Data is also available for at pre-milling 10% MC, for the period July 2013 to June 2018 (average of 5 years).

The literature and industry contacts (DPI and processors) indicate that the almond moisture content is ~10% when delivered from the harvesting stage to the processing stage. The whole nut on average is composed of ~30% kernel, ~16% shell and ~54% hull.

https://nationalmap.gov.au/#share=s-dcukQoXTB4f0MvFUFAX9aWisQPq

Macadamia shell hulls

This dataset estimates the location and mass in dry tonnes of macadamia shell and husk residues across NSW, Australia.



Each SA4 region shows the annual average, minimum and maximum tonnes of macadamia shell and husk residues at 0% moisture content (MC) and also shells at pre-milling 10% MC and husks at post-harvest 20% MC, for the period July 2013 to June 2018 (average of 5 years).

The literature and industry contacts (DPI and processors) indicate that the macadamia nut-in-shell (NIS) moisture content is ~10% when delivered from the harvesting stage to the processing stage and the husk component is ~20% (which is removed on the farm). The whole nut on average is composed of ~46% NIS and ~54% husk. The NIS component is ~33% kernel and ~67% shell.

https://nationalmap.gov.au/#share=s-5VOaMIGRYL0RLySIdMvGdPa7BI7

Fruit and nuts general

ABS released data contains final estimates for data items collected in the 2014–15 Rural Environment and Agricultural Commodities Survey (REACS). The statistics on crop and horticultural area and production were used to estimate biomass volumes.

https://nationalmap.gov.au/#share=s-9XhG27P2mPWYPtQotlXwoGsfepu

Fruit residues

Avocado

Avocado residue production data is based on the avocado production, from the 2015-16 statistical area 2 (SA2) level, an Australian Statistical Geography Standard (ASGS). LGA's with less than 5 Tonnes of avocado production were excluded from the analysis.

https://nationalmap.gov.au/#share=s-fVpOBkdGldhRYMUEudN8ad4Un4j

Citrus

Citrus residue production data is based on the Citrus production, from the 2015-16 statistical area 2 (SA2) level. LGA's with less than 5 Tonnes of Citrus production were excluded from the analysis.

https://nationalmap.gov.au/#share=s-iEeZdQ8boP8CumJLJ6lDTqK81ar

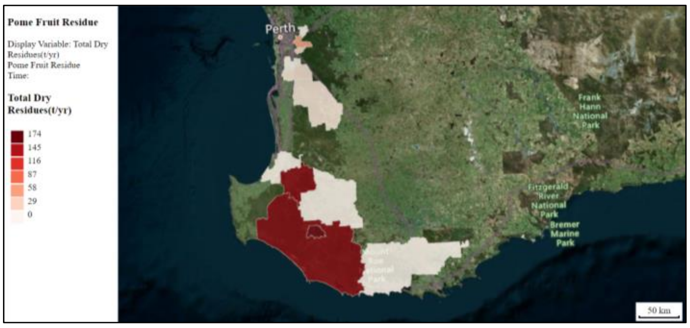
Olive

The olive residue production data is based on the estimated olive production, from the 2015-16 statistical area 2 (SA2) level. LGA's with less than 5 Tonnes of Olive production were excluded from the analysis.

https://nationalmap.gov.au/#share=s-kAparDugyKJsucxrY9HXVTC46Rs

Pome fruit

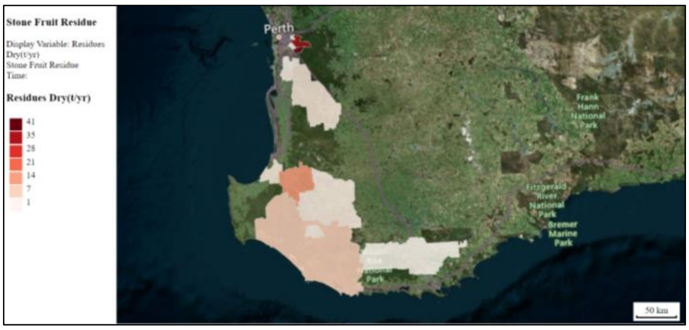
Pome Fruit residue production data is based on the Pome Fruit production, from the 2015-16 statistical area 2 (SA2) level. LGA's with less than 5 Tonnes of Pome Fruit production were excluded from the analysis.



https://nationalmap.gov.au/#share=s-3InyX9MCy9B0etPYUhwpxUqf3yq

Stone fruit

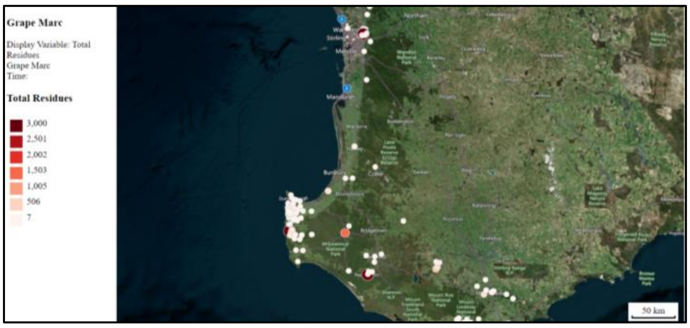
Stone Fruit residue production data is based on the Stone Fruit production, from the 2015-16 statistical area 2 (SA2) level. LGA's with less than 5 Tonnes of Stone Fruit production were excluded from the analysis.



https://nationalmap.gov.au/#share=s-aunarN85SaBQPTIXVFxCMQGE7Fg

Grape marc

Grape marc volumes have been estimated by using a conversion factor from the amounts that are listed as crushed in publicly available documents. Grape marc volumes from crushed grapes can vary greatly, and a range of 13 – 35% has been cited in the literature.

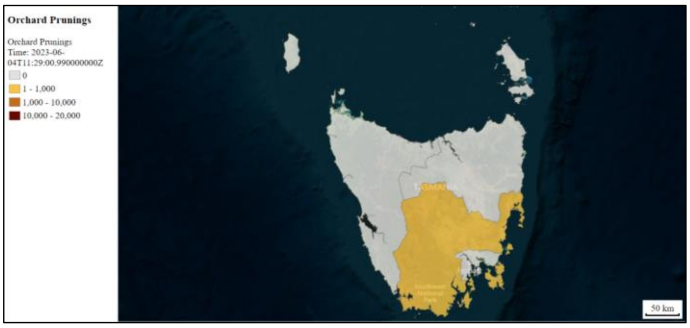


https://nationalmap.gov.au/#share=s-f3nZopOr3BmMW8G3D9bxYw5YzHu

Miscellaneous

Orchard prunings

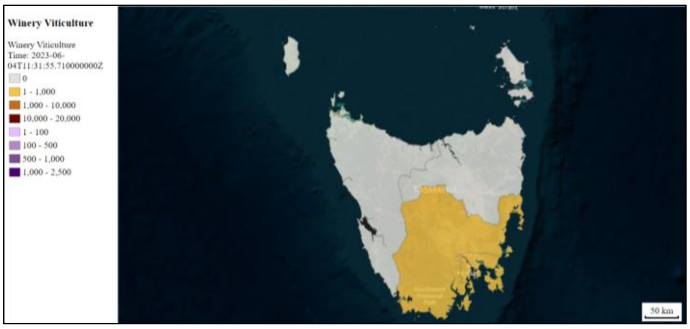
The orchard prunings data were derived from the Tasmanian Residues Survey (2016) which was undertaken to estimate the biomass volumes of residues for horticulture activities in Tasmania.



https://nationalmap.gov.au/#share=s-goPq5mYB4BhPnDmFHrOUM5JLfgG

Winery viticulture

The horticulture winery viticulture data were derived from the Tasmanian Residues Survey (2016) which was undertaken to estimate the biomass volumes of residues for horticulture activities in Tasmania.



https://nationalmap.gov.au/#share=s-smvmBA74xYRjnWyJtsraB1gaUs9

Flowers

The flower residue data were derived from the Tasmanian Residues Survey (2016) which was undertaken to estimate the biomass volumes of residues for horticulture activities in Tasmania.

https://nationalmap.gov.au/#share=s-s43Jd4es4ULPJpJKZAY6BlodsWu

Appendix 5 – The Accessibility Model

Score	Key	Scale	*Availability* (GMT pa)	*Availability* (GMT pa)
4	Very High	VH	>10 million	10,000,000
3	High	H	>1 million	1,000,000
2	Medium	M	>100,000	100,000
1	Low	L	>1,000	1,000
0	Very Low	VL	>=0	-

Availability (GMT pa)	Hardwood pulpwood (GMT)	Hardwood harvest residues (GMT)	Softwood pulpwood (GMT)	Softwood processing residues (GMT)	Softwood pulpwood harvesting residues (GMT)	Softwood sawlogs harvesting residues (GMT)	Total (GMT)
Tasmania	3,178,000	635,600	649,000	130,400	129,800	130,400	4,853,200
Green Triangle	1,709,000	341,800	907,000	606,600	181,400	606,600	4,352,400
Western Australia	3,034,000	606,800	231,000	180,000	46,200	180,000	4,278,000
Murray Valley	57,000	11,400	918,000	271,000	183,600	271,000	1,712,000
South East Queensland	15,000	3,000	313,000	367,800	62,600	367,800	1,129,200
Central Tablelands	-	-	633,000	111,400	126,600	111,400	982,400
Central Gippsland	261,000	52,200	252,000	135,400	50,400	135,400	886,400
East Gippsland-Bombala	62,000	12,400	459,000	69,600	91,800	69,600	764,400
Central Victoria	179,000	35,800	66,000	80,600	13,200	80,600	455,200
Mount Lofty Ranges	189,000	37,800	67,000	50,000	13,400	50,000	407,200
North Coast	252,000	50,400	45,000	16,200	9,000	16,200	388,800
Northern Tablelands	-	-	96,000	60,000	19,200	60,000	235,200
Southern Tablelands	-	-	88,000	15,400	17,600	15,400	136,400
Northern Territory	60,000	12,000	-	-	-	-	72,000
North Queensland	-	-	8,000	11,400	1,600	11,400	32,400
Total	**8,996,000**	**1,799,200**	**4,732,000**	**2,105,800**	**946,400**	**2,105,800**	**20,685,200**

Availability (scale)	Hardwood pulpwood (Scale)	Hardwood harvest residues (Scale)	Softwood pulpwood (Scale)	Softwood processing residues (Scale)	Softwood pulpwood harvesting residues (Scale)	Softwood sawlogs harvesting residues (Scale)	Total (Scale)
Tasmania	H	M	M	M	M	M	H
Green Triangle	H	M	M	M	M	M	H
Western Australia	H	M	M	M	L	M	H
Murray Valley	L	L	M	M	M	M	H
South East Queensland	L	L	M	M	L	M	H
Central Tablelands	VL	VL	M	M	M	M	M
Central Gippsland	M	L	M	M	L	M	M
East Gippsland-Bombala	L	L	M	L	L	L	M
Central Victoria	M	L	L	L	L	L	M
Mount Lofty Ranges	M	L	L	L	L	L	M
North Coast	M	L	L	L	L	L	M
Northern Tablelands	VL	VL	L	L	L	L	M
Southern Tablelands	VL	VL	L	L	L	L	M
Northern Territory	L	L	VL	VL	VL	VL	L
North Queensland	VL	VL	L	L	L	L	L
Total	H	H	H	H	M	H	VH

Availability score (3=H, 1=L)	Hardwood pulpwood (Score)	Hardwood harvest residues (Score)	Softwood pulpwood (Score)	Softwood processing residues (Score)	Softwood pulpwood harvesting residues (Score)	Softwood sawlogs harvesting residues (Score)	Total (Score)
Tasmania	3	2	2	2	2	2	3
Green Triangle	3	2	2	2	2	2	3
Western Australia	3	2	2	2	1	2	3
Murray Valley	1	1	2	2	2	2	3
South East Queensland	1	1	2	2	1	2	3
Central Tablelands	0	0	2	2	2	2	2
Central Gippsland	2	1	2	2	1	2	2
East Gippsland-Bombala	1	1	2	1	1	1	2
Central Victoria	2	1	1	1	1	1	2
Mount Lofty Ranges	2	1	1	1	1	1	2
North Coast	2	1	1	1	1	1	2
Northern Tablelands	0	0	1	1	1	1	2
Southern Tablelands	0	0	1	1	1	1	2
Northern Territory	1	1	0	0	0	0	1
North Queensland	0	0	1	1	1	1	1
Total	3	3	3	3	2	3	4

Delivered price ($/GMT)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	102.5	57	101	50	57	57
Green Triangle	102.5	57	101	50	57	57
Western Australia	102.5	57	101	50	57	57
Murray Valley	102.5	57	101	50	57	57
South East Queensland	102.5	57	101	50	57	57
Central Tablelands	102.5	57	101	50	57	57
Central Gippsland	102.5	57	101	50	57	57
East Gippsland-Bombala	102.5	57	101	50	57	57
Central Victoria	102.5	57	101	50	57	57
Mount Lofty Ranges	102.5	57	101	50	57	57
North Coast	102.5	57	101	50	57	57
Northern Tablelands	102.5	57	101	50	57	57
Southern Tablelands	102.5	57	101	50	57	57
Northern Territory	102.5	57	101	50	57	57
North Queensland	102.5	57	101	50	57	57
FOB $/BDMT	245		242			
FOB $/GMT	122.5		121			
less $ to wharf gate	20		20			
Wharf gate $/GMT	102.5		101			
Harvest residue $/GMT		35			35	35
Communition		10			10	10
Transport (80km) $/GMT		12			12	12
Delivered $/GMT		57			57	57
In-bin $/GMT				40		
Transport (30km)				10		
Delivered $/GMT				50		

Code		Delivered price ($/GMT)
VH	Very High	150
H	High	100
M	Medium	75
L	Low	50
VL	Very Low	20
F	Free'	-

SuppplyPrice (VH, H, M, L, VL)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	H	L	H	VL	L	L
Green Triangle	H	L	H	VL	L	L
Western Australia	H	L	H	VL	L	L
Murray Valley	H	L	H	VL	L	L
South East Queensland	H	L	H	VL	L	L
Central Tablelands	H	L	H	VL	L	L
Central Gippsland	H	L	H	VL	L	L
East Gippsland-Bombala	H	L	H	VL	L	L
Central Victoria	H	L	H	VL	L	L
Mount Lofty Ranges	H	L	H	VL	L	L
North Coast	H	L	H	VL	L	L
Northern Tablelands	H	L	H	VL	L	L
Southern Tablelands	H	L	H	VL	L	L
Northern Territory	H	L	H	VL	L	L
North Queensland	H	L	H	VL	L	L

SupplyPrice (3=good, 1=Poor)/Demand (3=Good, 1=bad)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	2	4	2	5	4	4
Green Triangle	2	4	2	5	4	4
Western Australia	2	4	2	5	4	4
Murray Valley	2	4	2	5	4	4
South East Queensland	2	4	2	5	4	4
Central Tablelands	2	4	2	5	4	4
Central Gippsland	2	4	2	5	4	4
East Gippsland-Bombala	2	4	2	5	4	4
Central Victoria	2	4	2	5	4	4
Mount Lofty Ranges	2	4	2	5	4	4
North Coast	2	4	2	5	4	4
Northern Tablelands	2	4	2	5	4	4
Southern Tablelands	2	4	2	5	4	4
Northern Territory	2	4	2	5	4	4
North Queensland	2	4	2	5	4	4

Quality (1=low,2,3=high)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	3	1	3	2	1	1
Green Triangle	3	1	3	2	1	1
Western Australia	3	1	3	2	1	1
Murray Valley	3	1	3	2	1	1
South East Queensland	3	1	3	2	1	1
Central Tablelands	3	1	3	2	1	1
Central Gippsland	3	1	3	2	1	1
East Gippsland-Bombala	3	1	3	2	1	1
Central Victoria	3	1	3	2	1	1
Mount Lofty Ranges	3	1	3	2	1	1
North Coast	3	1	3	2	1	1
Northern Tablelands	3	1	3	2	1	1
Southern Tablelands	3	1	3	2	1	1
Northern Territory	3	1	3	2	1	1
North Queensland	3	1	3	2	1	1

Suppply/Demand (3=Good, 1=bad)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	0	3	0	1	3	3
Green Triangle	0	3	0	1	3	3
Western Australia	0	3	0	1	3	3
Murray Valley	0	3	0	1	3	3
South East Queensland	0	3	0	1	3	3
Central Tablelands	0	3	0	1	3	3
Central Gippsland	0	3	0	1	3	3
East Gippsland-Bombala	0	3	0	1	3	3
Central Victoria	0	3	0	1	3	3
Mount Lofty Ranges	0	3	0	1	3	3
North Coast	0	3	0	1	3	3
Northern Tablelands	0	3	0	1	3	3
Southern Tablelands	0	3	0	1	3	3
Northern Territory	0	3	0	1	3	3
North Queensland	0	3	0	1	3	3

Price/Quality/Suppl:Demand score	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	5.0	8.0	5.0	8.0	8.0	8.0
Green Triangle	5.0	8.0	5.0	8.0	8.0	8.0
Western Australia	5.0	8.0	5.0	8.0	8.0	8.0
Murray Valley	5.0	8.0	5.0	8.0	8.0	8.0
South East Queensland	5.0	8.0	5.0	8.0	8.0	8.0
Central Tablelands	5.0	8.0	5.0	8.0	8.0	8.0
Central Gippsland	5.0	8.0	5.0	8.0	8.0	8.0
East Gippsland-Bombala	5.0	8.0	5.0	8.0	8.0	8.0
Central Victoria	5.0	8.0	5.0	8.0	8.0	8.0
Mount Lofty Ranges	5.0	8.0	5.0	8.0	8.0	8.0
North Coast	5.0	8.0	5.0	8.0	8.0	8.0
Northern Tablelands	5.0	8.0	5.0	8.0	8.0	8.0
Southern Tablelands	5.0	8.0	5.0	8.0	8.0	8.0
Northern Territory	5.0	8.0	5.0	8.0	8.0	8.0
North Queensland	5.0	8.0	5.0	8.0	8.0	8.0

Accessibility %	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Green Triangle	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Western Australia	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Murray Valley	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
South East Queensland	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Central Tablelands	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Central Gippsland	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
East Gippsland-Bombala	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Central Victoria	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Mount Lofty Ranges	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
North Coast	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Northern Tablelands	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Southern Tablelands	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
Northern Territory	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%
North Queensland	2.5%	10.0%	2.5%	10.0%	10.0%	10.0%

0.0%	Accessibility % calculator		
	Code		Score
20.0%	VH	Very High	10
10.0%	H	High	8
5.0%	M	Medium	6
2.5%	L	Low	4
0.0%	VL	Very Low	2

Accessibility (GMT pa)	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Tasmania	79,450	63,560	16,225	13,040	12,980	13,040
Green Triangle	42,725	34,180	22,675	60,660	18,140	60,660
Western Australia	75,850	60,680	5,775	18,000	4,620	18,000
Murray Valley	1,425	1,140	22,950	27,100	18,360	27,100
South East Queensland	375	300	7,825	36,780	6,260	36,780
Central Tablelands	-	-	15,825	11,140	12,660	11,140
Central Gippsland	6,525	5,220	6,300	13,540	5,040	13,540
East Gippsland-Bombala	1,550	1,240	11,475	6,960	9,180	6,960
Central Victoria	4,475	3,580	1,650	8,060	1,320	8,060
Mount Lofty Ranges	4,725	3,780	1,675	5,000	1,340	5,000
North Coast	6,300	5,040	1,125	1,620	900	1,620
Northern Tablelands	-	-	2,400	6,000	1,920	6,000
Southern Tablelands	-	-	2,200	1,540	1,760	1,540
Northern Territory	1,500	1,200	-	-	-	-
North Queensland	-	-	200	1,140	160	1,140
Total	224,900	179,920	118,300	210,580	94,640	210,580
Average	14,993	11,995	7,887	14,039	6,309	14,039
Largest	79,450	63,560	22,950	60,660	18,360	60,660
2nd largest	75,850	60,680	22,675	36,780	18,140	36,780
3rd largest	42,725	34,180	16,225	27,100	12,980	27,100
Average	**66,008**	**52,807**	**20,617**	**41,513**	**16,493**	**41,513**
Base case	2.50%	10%	2.50%	10%	10%	10%
Multiplier on base case	127%	184%	628%	261%	809%	261%
Access % to achieve 150000	5.70%	28.40%	18.20%	36.10%	90.90%	36.10%
# times more than base	2.3	2.8	7.3	3.6	9.1	3.6

Region	Hardwood pulpwood	Hardwood harvest residues	Softwood pulpwood	Softwood processing residues	Softwood pulpwood harvesting residues	Softwood sawlogs harvesting residues
Largest	Tasmania	Tasmania	Murray Valley	Green Triangle	Murray Valley	Green Triangle
2nd largest	Western Australia	Western Australia	Green Triangle	South East Queensland	Green Triangle	South East Queensland
3rd largest	Green Triangle	Green Triangle	Tasmania	Murray Valley	Tasmania	Murray Valley
Largest GMT pa	79,000	64,000	23,000	61,000	18,000	61,000
2nd largest GMT pa	76,000	61,000	23,000	37,000	18,000	37,000
3rd largest GMT pa	43,000	34,000	16,000	27,000	13,000	27,000
Base Accessibility %	2.5%	10%	3%	10%	10%	10%
Multipler to = 150k GMT pa	2.3	2.8	7.3	3.6	9.1	3.6
Req. accessibility	5.7%	28%	18%	36%	91%	36%