Queensland technical methods - Forestry

Australian Biomass for Bioenergy Assessment

March 2018

This document is part of a series describing the technical methods used to publish the Queensland based data for the Australian Biomass for Bioenergy Assessment (ABBA) <arena.gov.au/projects/the-australian-biomass-for-bioenergy-assessment-project>. All documents in the series are available to view and download at <publications.qld.gov.au>.

What is the Australian Biomass for Bioenergy Assessment?

ABBA provides detailed information about biomass resources across Australia. This information will assist project developers make decisions for new bioenergy projects, and provide linkages between potential biomass feedstocks—through the supply chain—to end users. To achieve this, ABBA collects datasets, on a state- by-state basis, about the location, volumes and availability of biomass, and publishes them on the Australian Renewable Energy Mapping Infrastructure (AREMI) platform <nationalmap.gov.au/renewables>. ABBA is managed by AgriFutures Australia with funding support from the Australian Renewable Energy Agency (ARENA).

Why forest industries?

Forest industries generate large quantities of residues in a variety of forms. The residues which are analysed and presented in this report are as follows:

- Harvest residues—includes foliage, branches etc. These are the residues which are left behind in the forest and are sometime referred to as field residues.
- Wood processing residues—includes solid wood, shavings, sawdust etc. These are the residues which are a by-product of the saw milling process.

These forest residues have physical and chemical characteristics that make them attractive for a range of potential alternative uses. They concentrate chemical energy making them a good source of thermal, electrical or kinetic energy; they contain organic polymers which can be readily converted into useful chemicals; the mechanical properties of their fibrous cellulosic structure makes them suitable for bearing loads or providing thermal or acoustic insulation; and they contain nutrients that make them a good source of organic material for plant and animal feed.

In Australia, residual biomass from forest industries is already extensively in beneficial use. These uses range from energy feedstock for domestic and industrial heating or industrial processes (including powering sawmills) to landscape amenity, soil improvements and fertilisers or animal bedding. However there are many opportunities to increase the utilisation of forest industry residues (Greaves and May 2012) including:

- production of wood pellets for export to meet expected increasing global demand
- co-firing with coal in existing power stations to generate electricity
- combined heat and power production in wood processing plants to supply electricity and process heating needs
- production of synthetic diesel through gasification and the Fischer-Tropsch process
- production of bioethanol using hydrolysis followed by fermentation and distillation, or
- production of biochar for use in agriculture.

What data about forest industries is published by ABBA?

ABBA has published data about:

- infrastructure (sawmill location and timber type)

- residues (from softwood plantations and native forests)

Data about residues is published only in an aggregated form at a local government area (LGA level). This is because data about individual harvesting operations is not generally available (particular for private forests) and also to protect the privacy of sawmills and forest owners.

Methods

Infrastructure

Sawmills have been mapped by location and resource type, using data published by Queensland's Agricultural Land Audit (summarised in Table 2) <daf.qld.gov.au/business-priorities/environment/ag-land-audit>. This dataset contains the location of all saw mills in Queensland known at the date of publication (originally in May 2015 and updated in June 2016). Mill locations were initially identified using available databases and other online information, their existence was confirmed with Google maps/Google Earth and/or Queensland Globe imagery and their current status checked with industry experts. Mills included in the dataset were open at the time of publication, their location and status could be confirmed and the mill information was available in the public domain.

Residues

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 in this state.

Similarly, even though private forests are known to account for a significant proportion of products from Queensland native forests, there is also no coordinated monitoring of the amount and types of products harvested from private forests.

Data about the volume of various types of timber products sold from public native forests and plantations is however routinely collected. For the purposes of this study it was necessary to rely on relationships (obtained from a range of sources) 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. This process is described in Figure 1.

Native forest sawlog zones (Table 1) are the reporting units currently used for timber product sales from public owned native forests.

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.

Table 1: Queensland native forest sawlog zones

Zone	**Total area of zone (millions hectares)**	**Softwood plantation area (thousands hectares)**	**Native forest available for commercial forestry (millions hectares)**			
			Native forest not suitable for sawlog production	Native forest suitable for sawlog production		
				Low potential	Medium potential	High potential
South east	8.3	167.8	0.9	0.7	1.4	0.5
South west	42.0	0.029	7.7	5.0	1.5	>0.1
Central	7.2	16.6	1.3	0.9	0.6	0.2
North	68.3	13.9	20.7	3.8	3.9	0.2
Far west	59.5	0	39.8	>0.1	>0.1	>0.1

Table 2: Queensland sawmills by resource type and size

Forest type	Sawmill size class				Total
	Small-<3,000 m3	Medium 3,000–10,000 m3	Large 10,000–50,000 m3	Very large - >50,000 m3	
Plantation	4	7	9	8	28
Native forest	26	24	15	0	65
Total	30	31	24	8	93

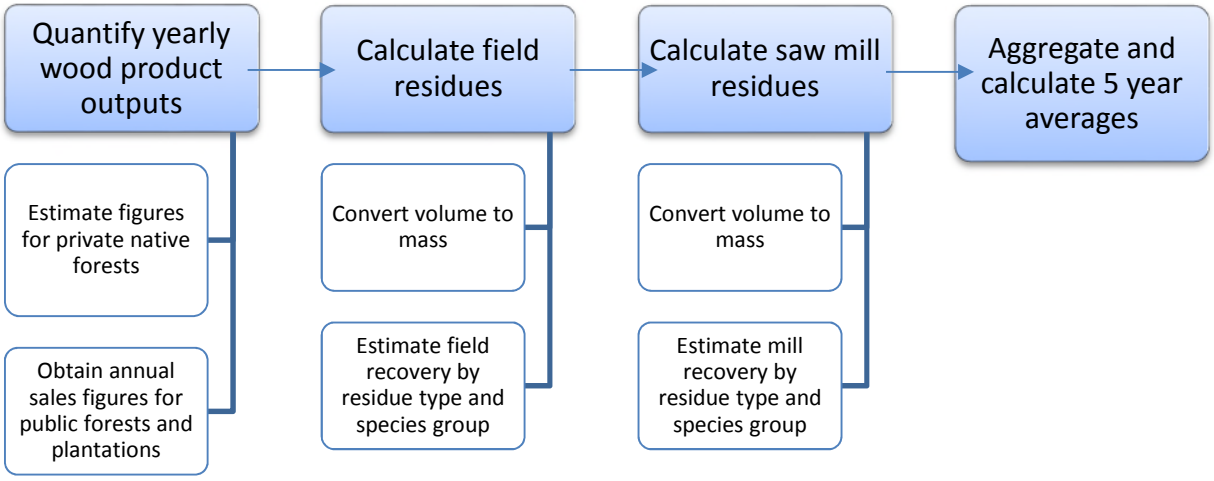

Figure 1: Process for estimating forest industry residues in Queensland

Resources of the Queensland timber industry

The amount and type of residues generated varies between the main forestry types in Queensland. These include:

Softwood plantations

Plantations in Queensland are dominated by two main softwood species; exotic pine (Southern pine) and native pine (Hoop pine), with exotic pine covering the largest area (>70%).

Native forests

Cypress (Callitris collumellaris): a highly durable native softwood that grows as a comparatively dense and uniform sub-canopy under scattered trees in inland areas principally in the southern inland of the state. Cypress currently comprises just under 50% of native timber harvested from public land but only about 5% of that harvested from private land.

Hardwoods: a large variety of hardwood species are harvested from Queensland native forests (more than 50 different species have been harvested from public forests over the past 10 years (DAF unpub.)) although Spotted Gum (Corymbia citriodora) comprises about 70% of sawlog volume with ironbarks (Eucalyptus fibrosa and others) and Blackbutt (Eucalyptus pilularis) the majority of the balance.

Commercial hardwood forests are scattered throughout the state but the most productive are concentrated in coastal and southern inland areas (presently about half the sawlog volume is sourced from the south east corner of the state). It is estimated that approximately equal proportions of hardwood timber are drawn from public and privately-owned forests respectively.

For the native forests (both private and public) residues were calculated separately for cypress and for hardwood (using the method outlined below) then combined. For the softwood plantations, residues from exotic and native pines are considered to be similar and were combined.

Harvest residues and wood processing residues were calculated for both native forests and softwood plantations using the following steps.

Step 1: Quantify yearly wood products outputs

Softwood plantations

The total volume of softwood sawlogs harvested from Queensland are published annually in the Australian forest and wood products statistics (ABARES 2016) and was collected across a 5 year period (2012-2016).

Data is presented according to state, forest type (e.g. softwood) and log type (e.g. sawlog). Note that information on pulplog volume are reported separately. The softwood sawlog volumes published by ABARES combines the total softwood plantation sawlogs and also the native cypress pine sawlogs harvested in Queensland.

The Queensland Department of Agriculture and Fisheries collects data on the volume of native cypress pine sawlog harvested annually (Department of Agriculture and Fisheries 2015). To calculate the yearly sawlog volumes harvested from the softwood plantations only the volumes of the native cypress pine were subtracted from the total volumes presented in the ABARES data.

Native forests

Annual timber products sales data (volumes by product type and reporting area) across a 5-year period (2012-2016) from for public native forest was obtained from the state agency responsible for timber production on public native forest (at the time of publication this was the Department of Agriculture and Fisheries).

To factor in the additional contribution of production from private native forests these data were multiplied by the following: 2 for hardwood sawlog and poles; 1.67 for hardwood girder; and, 1.05 for cypress sawlog. These factors were derived from published sources (Burns et al 2009, Lewis et al 2010, Gavran et al 2014,) and expert advice.

Timber sold as fencing and other secondary products was not included in the calculations because no information is available from which to derive an equivalent ratio, it does not undergo processing (and hence doesn't generate sawmill residues) and it is often a by-product (and hence a component of residues) itself.

Step 2: Calculate harvest residues by category

To generate figures for the various types of field residues the following equation was used:

Field residues (dry tonnes) = total log volume (sawlogs m3)

X Basic density[1]

X (1 – field product recovery)

X Breakdown by residue type

Basic densities were obtained from published sources (principally Bootle 1986). For cypress the published figure 580 kg/m3 was used alone, whereas for hardwoods a weighted average was calculated from the published figures for the three main species harvested (Table 3).

The two dominant softwood plantation species have the same basic density (450kg/m3).

When calculating the bark and foliage biomass totals the proportions these components represented of field residues were adjusted to account for their lower basic density. This was based on a best-guess approximation of 50% of that used for the woody components. Information at sufficient detail to accurately determine this variation is not available for these species.

For the native forests data ratios for field product recovery and breakdown by residue type were estimated initially from published data and then validated with direct measurements of a sample of trees at existing harvesting operations (at St Mary's and Gallangowan in SEQ and Barakula in the Southern inland) before being checked with experts. For hardwoods a weighted average was calculated across the mix of species in the same way as when estimating basic density. For plantations the figures used were sourced from published studies. These ratios are presented in Table 4.

1 Basic density is a measure of the mass of actual fibrous material, lignin and extractives present in a wood sample. It is calculated as the oven-dry mass of a specimen divided by its green volume (Bootle 1986).

Table 3: Basic densities of tree species most commonly harvested from Queensland

Species	Estimated average proportion of timber harvested	Basic density (kg/m3)
Softwood plantations		
Exotic pine	85	450
Native pine	15	450
Softwood plantation density used in calculations		450
Native forests		
Cypress		580
Spotted Gum	80	740
Red Ironbarks (broad-leafed and narrow-leaved) (representing a group of dense hardwood species)	10	910
Blackbutt (representing a group of light hardwood species)	10	710
Weighted average for hardwoods used in calculations		754

Table 4: Estimated product recovery rates and ratios of field residues by type

Resource type	Proportion recovered to timber products	Field residue proportion by type				Source
Softwood plantations						
		Branches	Bark	Cones	Needles	
Exotic and native pine	81.2%	12.2%	0.8%	1.9%	3.9%	Ghaffariyan & Apolit, 2015
Native forests						
		Stump	Bark[2]	Branches	Foliage	
Cypress	45%	10%	0%	35%	10%	Burrows et al 2001, Taylor et al 2005
Hardwood	40%	10%	15%	33%	2%	Ximenes et al 2006, 2016

Step 3: Calculate wood processing residues by category (dry weight)

To generate figures for the various types of wood processing residues the following equation was used:

Wood processing residues (dry tonnes) = total log volume [sawlogs only] (m3)

X Basic density

X (1-sawn product recovery)

X Breakdown by residue type

2 In Queensland all hardwood logs are debarked in the bush whereas cypress and plantation logs are transported to the mill with bark on.

The same basic density figures were used (Table 3) for all components.

Sawn timber recovery rates and breakdown by residue types (Table 5) were estimated using data from available published sources checked with industry experts. Only limited volumes of native forest wood products sold in Queensland are dried and dressed, so shavings were omitted from the calculations for native forests.

Table 5: Estimated sawn timber recovery rates and ratios of field residues by type

Resource type	Proportion recovered to timber products	Sawmill residue proportion by type				Source
		Woodchip /offcut /heart	Bark[3]	Sawdust and other fines	Shavings	
Softwood plantations						
Softwood	47%	35%	6%	7%	5%	Goble and Peck, 2013
Native forests						
Cypress	40%	30%	10%	20%		SEFE, 2011, Goble and Peck, 2013
Hardwood	35%	40%	0%	25%		Taylor et al, 2005

Step 4: Aggregate and present data

The final outputs are presented as 5-year averages amalgamated at a LGA level. This is because the ratio of public vs private production and the species mix used to derive residue quantity in both native forests and softwood plantations are long-term averages only and will certainly vary from year-to-year depending on markets, licence conditions, and other factors.

For harvest residues, the allocation to LGA was done according to the proportion of land use for both native forests and softwood plantations using the following data sets:

- Native forest - Queensland Land Use Mapping Program <qld.gov.au/environment/land/vegetation/mapping/qlump>
- Softwood plantation - Department of Agriculture and Fisheries Agricultural Land Audit - Current forestry plantation dataset <daf.qld.gov.au/business-priorities/environment/ag-land-audit>

For wood processing residues, the allocation to LGA was done according to the proportion of saw mills located in each LGA for a particular wood type. The location of saw mills was obtained using the following data set:

- Department of Agriculture and Fisheries Agricultural Land Audit - Current saw mills dataset <daf.qld.gov.au/business-priorities/environment/ag-land-audit>

LGAs which had residues with less than 500 tonnes per annum were excluded from the dataset.

The final data is rounded to the nearest 10 by the following rules:

- Data at the midpoint is rounded up (e.g. 35 has been rounded to 40)
- Data less than five is given a value of zero
- Data five or larger (but less than 10) is given a value of 10.

3 In Queensland all hardwood logs are debarked in the bush whereas cypress and plantation logs are transported to the mill with bark on. The bark proportion for softwood plantations is reported after a log has been de-barked

Outputs

- Location of saw mills
- Native forests—harvest residues by LGA (dry tonnes) for both cypress and hardwood species
- Native forests—wood processing residues by LGA (dry tonnes) for both cypress and hardwood species
- Softwood plantations—harvest residues by LGA (dry tonnes)
- Softwood plantations—wood processing residues by LGA (dry tonnes)
- Softwood plantations—pulplog produced by LGA (dry tonnes)

Assumptions

The assumptions made when calculating the residues for the Queensland forest industry include:

- Calculations do not take into account the different technologies employed by individual sawmills which will impact on the amount of wood product recoverable, sawdust produced etc.
- All residues are calculated as a dry weight. Green residues can be assumed to have a moisture content in the range of 40% to 60% whilst dry material will have a moisture content in the range of 12% to 14%.
- Residues from softwood plantations do not take into account pulplog produced and those from native forests do not include ‘optional (or residue)’ logs calculated for public forests. For softwood plantations pulplog figures are published yearly and have been reported as a separate layer as an average annual figure (dry tonnes).
- Calculations do not include biomass from failed plantation or thinnings from plantations or native forests.
- Calculations do not account for the variable nature of actual harvesting operations employed (which can have large difference in the biomass residues left on site). For the purposes of this study it was assumed that all plantation harvesting is cut-to-length (CTL) operations.
- Harvest residue calculations do not take into account the below-ground biomass components and for plantations do not include the stump.
- Calculations do not take into account the quantity of residue that is already accounted for internally within and between sawmills and processing facilities.

Future potential

Production of residues from forest industries in Queensland declined over the past decade by on average about 1.5% per year. A range of factors contributed to this decline.

With increased policy certainty and a strong domestic construction sector, production figures over the last two years have increased in both plantation softwoods and native forests. Whilst these figures are still below those of a decade ago, wood flow forecasts predict stable or slightly increased production of both plantation and native forest sawlogs in the medium and long-term (Gupta et al 2013).

Irrespective of any growth in the industry, there is considerable scope to increase utilisation of forest residues in Queensland under existing conditions:

There was very little evidence across the industry of utilisation of harvest residues. In native forests there are some markets for small diameter, short, and/or defective roundwood cut from the crowns of trees harvested for sawlog, girders or poles, for use as landscaping, fencing, or mining props but these markets are fickle and only a very small proportion of the material generated by current harvesting operations is utilised in these ways. In softwood plantations residues from trees damaged by cyclones (Marcia 2015 and Yasi 2011) are currently being chipped for export. In addition some small diameter wood is used in wood panel production however the bulk of residues from routine softwood plantation sawlog harvesting are currently left in the field. It is worth noting however that there are environmental benefits in both native forest and plantations to retaining residues in situ, as well as practical impediments to their collection (e.g. inorganic contamination), both of which are significant barriers to their use.

The effects of tropical cyclones on the softwood plantations in central and northern Queensland will be felt for some

time. In the central region salvage operations are still in progress but once they are completed the plantations are not expected to produce sawlog sized timber for several decades. The plantations in the northern region have been replanted however they will not produce sawlogs for the next decade

In 2000, as part of its decision to progressively withdraw public native forests in South East Queensland from harvesting, the government committed to a hardwood plantation program. Around 14,500 hectares of hardwood plantation has been established under this program. This estate is primarily managed to produce pulpwood and is still relatively immature and yet to produce a final crop (State of Queensland, 2012). These plantations were recently estimated to have the potential to produce 50,000 m3/year of residues suitable for the production of fuel pellets by 2025 (GHD 2015). Further hardwood plantations were established over a similar period across Queensland by various private interests. Many of these plantations have failed and are in the process of reverting to agricultural use. However, 27,600 hectares remain under tree cover and would be potentially available now, or in the future, for biomass harvesting.

Figures from the most recent survey across Australia (Gavran et al 2014) indicate that less than half of residues generated by sawmills are currently utilised. Solid wood residues are the category of sawmill residues most commonly used (around 50% principally to woodchip for export) with sawdust, bark and other fines less commonly used (around 10 to 20% for energy, landscaping, or animal bedding).

Anecdotal information and the few responses received from sawmills in this study indicate that in Queensland the level of utilisation of residues amongst plantation softwood sawmills is quite high, whilst that amongst native-forest-based sawmills is variable and can be low. Queensland plantation timber processors are generally quite large (and hence more likely to generate residues in sufficient quantities to justify investment in residue aggregation or processing equipment) and are located with easy access to ports and other infrastructure for export. There is also a sizeable domestic market for softwood chips in the fabrication of wood panels. There are a number of softwood processors in South East Queensland that are reliant on sawmill residue to produce wood panels. Native forest sawmills on the other hand are small and are often isolated from each other and from industries that are the most likely users of residues. In the past, native forest residues in South East Queensland were in demand to supply a hardboard manufacturing plant near Ipswich, however this plant is no longer operating.

Some native forest sawmills (large hardwood and smaller cypress) who responded to this survey reported that 100% of the sawdust they generated was supplied directly to intensive animal industries for use in bedding. Others are known to contribute residues through an established aggregator who supplies landscaping businesses with material collected from mills across southern Queensland. Others are known to still dispose of residues by burning or to landfill. The proportion of residues treated in these respective ways is unknown.

Another potential opportunity to increase biomass from native forestry and plantations is through residues generated from thinnings.

In southern Queensland there is about 2.5 million hectares of privately owned native forest with potential for commercial sawlog production (MBAC 2003a, 2003b). A number of studies have noted that these forests, particularly those in near-coastal areas which have the highest production potential, are commonly in a poor condition (Lewis et al 2010, MBAC 2003a, Jay and Dillion, 2016). Many of them have a history of repeated ‘high-grading’ (a practice where the best trees are selectively removed from a forest without any consideration of future management) and other poor silvicultural practices, which have left the forests overstocked with a high proportion of small defective trees. The benefits of silvicultural treatment (e.g. by thinning to remove suppressed defective trees and to concentrate growth on those with the best form and growth potential) for future production have been clearly demonstrated (Ryan and Taylor, 2006) however the economics are marginal. Creating an opportunity to generate revenue at the time the cost is incurred through sale of residues from such silvicultural operations would reduce this financial disincentive. There are also potentially significant environmental and land management benefits including increased groundcover for better erosion control and ground fauna, as well as improved structural diversity. It is estimated that silvicultural treatment of private native forests within South East Queensland could yield a significant amount of small roundwood. Thinnings from softwood plantations in Queensland generate approximately 200,000 m3 of wood volume per year. These thinnings have not been factored into the residue data calculated for the ABBA project. This resource may already be in beneficial use.

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