Australian Government
Department of Agriculture and Water Resources
ABARES

Economic potential for new plantation establishment in Australia

Outlook to 2050

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Research by the Australian Bureau of Agricultural and Resource Economics and Sciences

Research report 19.4
February 2019

Cataloguing data

This publication (and any material sourced from it) should be attributed as: *Whittle, L, Lock, P & Hug, B 2019, Economic potential for new plantation establishment in Australia: outlook to 2050*, ABARES research report, Canberra, February. CC BY 4.0. https://doi.org/10.25814/5c6e1da578f9a

ISBN 978-1-74323- 423- 5

ISSN 1447-8358

This publication is available at agriculture.gov.au/publications.

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Acknowledgements

The authors would like to thank Kevin Burns, Mijo Gavran, Stuart Davey and Ian Frakes from ABARES Forest Economics for their invaluable contribution. The authors would also like to thank Jim Houghton from Forest and Wood Products Australia and Islay Robertson from HQPlantations for their invaluable advice and support in preparing this report.

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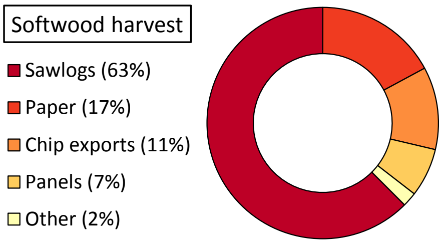
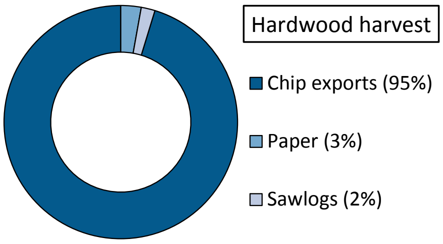
Economic Potential for new Plantation Establishment in Australia

Australia's commercial plantation estate 2015-16

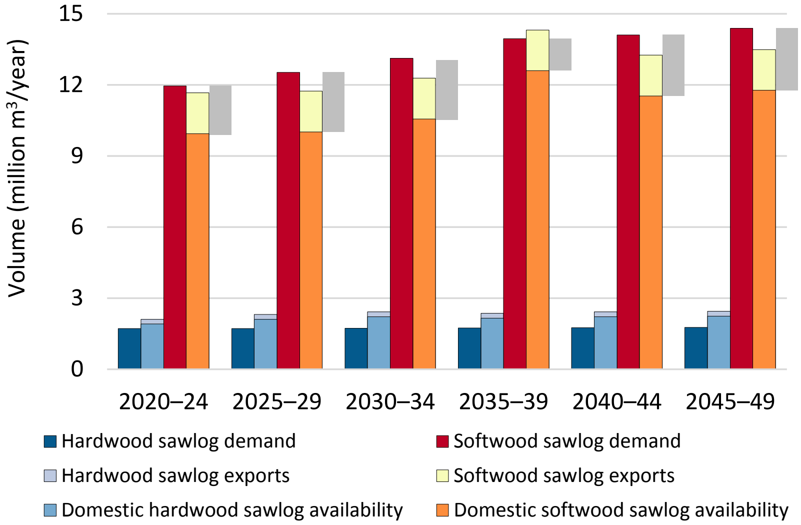
Softwood plantations account for **1.03 million hectares** with a total harvest of **16.2 million m³**, comprising mainly sawlogs



Hardwood plantations account for **0.93 million hectares** with a total harvest of **9.8 million m³**, comprising mainly pulplogs



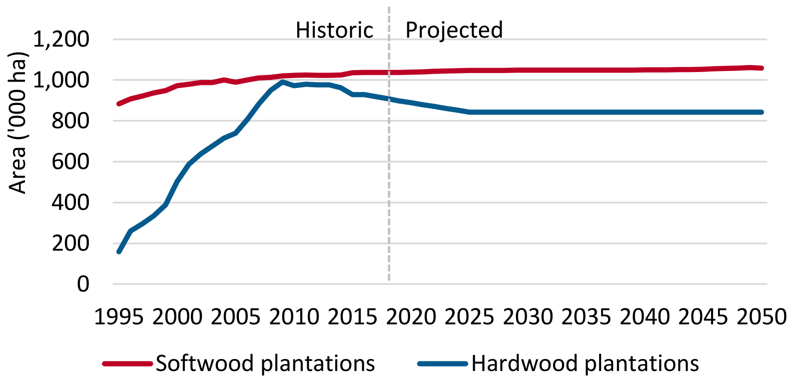
Domestic demand for softwood sawlogs is growing



Domestic **hardwood sawlog availability** from current plantations and native forests is expected to exceed future **hardwood sawlog demand**.

Domestic **softwood sawlog availability** from current plantations is expected to fall short of **softwood sawlog demand** by **3.4 million m³** in 2050—assuming log exports remain constant at 2015-16 levels.

Current and projected plantation estate



Softwood plantation area is estimated **to increase by 24 thousand hectares (2%)** by 2050.

Hardwood plantation area is estimated **to decrease by 95 thousand hectares (10%)** by 2050, due to an estimated **100 thousand hectare** reduction in the existing estate.

Key findings

New plantation investment is anticipated to be limited against existing agricultural land uses, having minimal impact on total log supply.

The majority of **logs harvested from new plantations will likely be exported**, doing little to meet the domestic softwood sawlog shortfall.

ABARES estimates that **imports of softwood sawnwood will need to double** between 2020 and 2050 to satisfy growing demand.

Summary

Australia's commercial timber plantation estate is fundamental to the sustainability and competitiveness of the Australian forestry sector and growing the estate has been a key Australian Government policy objective for some time (*National Forestry Policy Statement (1992) and Plantations for Australia: The 2020 Vision (1997))*. However, after decades of substantial growth in Australia's commercial timber plantation estate, the area of plantations declined from 2.02 million hectares in 2011–12 to 1.97 million hectares in 2015–16. This raises questions about the future availability of plantation logs and consequent impacts on the forestry sector.

In light of this decline, Forest and Wood Products Australia and ABARES jointly funded research into the long-term potential for new timber plantation establishment in Australia. This report examines the economic potential of new timber plantation establishment to 2050 under current conditions, referred to as the base case scenario. The modelling builds on previous land use change modelling developed by ABARES (Burns et al. 2011) and incorporates a range of factors such as productivity of agricultural land for growing trees, value of land under existing agricultural production and proximity of land to wood-processing facilities and markets. Policymakers and industry can use these projections to anticipate and adapt to expected changes in the industry and to better take advantage of new opportunities.

Key findings

The plantation sector is critical to the forestry industry

In 2015–16 commercial timber plantations covered 1.97 million hectares, split virtually evenly between softwood and hardwood species. While the total timber plantation area is only a fraction of the native forest area available for wood production it accounts for 87 per cent of Australia's log production. The 1.03 million hectare softwood estate is primarily managed for sawlog production for the domestic market, but also produces a substantial volume of pulplogs for paper and panel production. In contrast, 95 per cent of logs harvested from the 0.93 million hectares hardwood estate are exported as woodchips, having little impact on the domestic market.

Domestic demand for sawlogs is growing

While future availability of hardwood sawlogs will likely be sufficient to meet log equivalent demand, ABARES forecasts a shortfall in the volume of softwood sawlogs available to the domestic market. If exports of softwood sawlogs remain at 2015–16 levels the total volume of sawlogs available to the domestic market is forecast to fall short of demand by 2.6 million cubic metres per year between 2045 and 2049. With continuing growth in demand for softwood sawlogs, ABARES estimates that the domestic log availability shortfall could increase to 3.4 million cubic metres per year between 2050 and 2054. To provide context to these figures an additional 200,000 to 250,000 hectares of new softwood plantations would be required by 2050 to meet an annual deficit of 3.4 million cubic metres per year. However, given the uncertainty around future softwood sawlog supply and log equivalent demand in 2050, it has been proposed that the required area could be as high as 490,000 hectares (Omega Consulting 2017).

Future plantation investment may not be enough

Under the base case scenario, ABARES estimates that around 4,773 hectares of new short rotation hardwood plantations could be economically competitive with current agricultural land use by 2050. However, with expected declines in the existing hardwood estate, the total area of hardwood plantations is expected to fall by around 95,227 hectares, or 10 per cent, by 2050.

Around 24,009 hectares of new softwood plantations could also be viable by 2050. However, this is only a 2 per cent increase over the existing estate. Furthermore, ABARES estimates that around three quarters of the logs harvested from the new plantation estate before 2050 will be exported, doing little to meet the growing shortfall.

In order to meet growing demand, the domestic market will become increasingly reliant on imports of sawnwood. ABARES estimates that the volume of softwood sawnwood imports will more than double from 560,215 cubic metres per year in 2020 to around 1.15 million cubic metres per year in 2050. This represents a potential missed opportunity for the Australian forestry sector unless there are new policies or drivers to expand the current softwood timber plantation estate to meet growing demand.

But there may be potential opportunities in the future

In addition to the base case, ABARES estimated potential plantation investment under a range of alternative scenarios, highlighting potential barriers to and opportunities for the future expansion of the Australian timber plantation estate.

While land prices were shown to have a moderate impact on profitability and potential plantation investment, the most significant barrier to investment in new plantations is the long delay between investment and final harvest, particularly for long rotation plantations.

However, changes in future market conditions could open up opportunities. Higher domestic demand for some wood products could allow the establishment of additional softwood plantations and given the high degree of trade exposure faced by the domestic forestry industry, future decreases in the value of the Australia dollar would be highly favourable to expansion of the current estate.

Introduction

Australia's commercial timber plantation estate is fundamental to the sustainability and competitiveness of the Australian forestry sector and growing the estate has been a key Australian Government policy objective for some time (*National Forestry Policy Statement (1992) and Plantations for Australia: The 2020 Vision (1997))*. However, after decades of substantial growth in Australia's commercial timber plantation estate, the area of plantations declined from a peak of 2.02 million hectares in 2011–12 to 1.97 million hectares in 2015–16. This raises questions about the future availability of plantation logs and consequent impacts on the forestry sector.

In light of this decline, Forest and Wood Products Australia and ABARES jointly funded research into the long-term potential for new timber plantation establishment in Australia. Policymakers and industry can use projections of future new plantation establishment, and an understanding of key drivers affecting it, to anticipate and adapt to expected changes in the industry and to better take advantage of new opportunities that may arise.

This report builds on previous land use change modelling frameworks developed by ABARES (Burns et al. 2011) to estimate the potential area of new plantation investment by 2050 under current market and policy conditions. It presents estimates of location and timing of plantation investment, impact on log harvest volumes and types of agricultural land converted to plantations.

The economic viability of new plantation establishment is sensitive to several factors. Therefore, the report includes an extensive sensitivity analysis with respect to selected parameters, highlighting potential barriers to and opportunities for future expansion of the estate.

The analysis presented in this report uses the Forest Resource Use Model (FORUM), a modelling framework developed and used at ABARES to assess the optimal uses of Australia's forest resources for wood production. During the 1990s the Australian Bureau of Agricultural and Resource Economics (ABARE) created FORUM to provide a national assessment of the economic potential for forest use in Australia—accounting for domestic and international market parameters, the geographic location of forests relative to processing centres and investment opportunities. In estimating the extent of new plantation investment, FORUM also incorporates a range of factors critical to the viability of plantations—including productivity of land for growing trees, value of land under existing agricultural production and proximity of land to timber-processing facilities and markets.

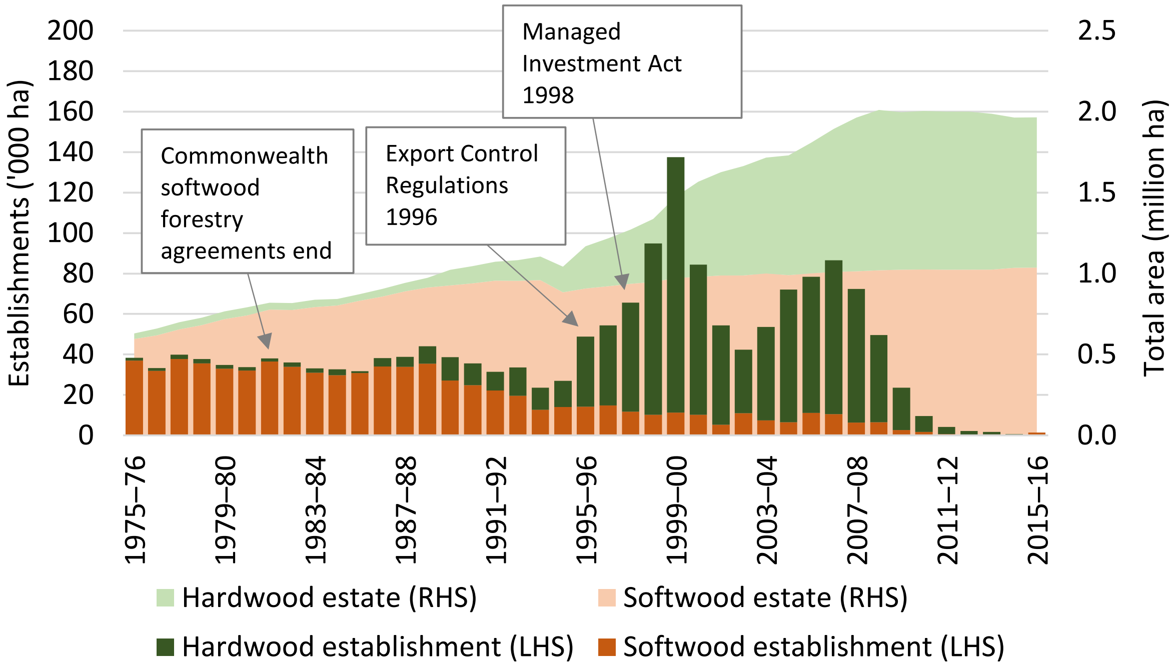
Chapter 1 provides a brief background on the recent history of timber plantation establishment in Australia and covers the timber plantation sector today. It also presents forecasts of future log availability from the current estate and forecasts of future demand for wood products to 2050–51, illustrating the growing shortfall in log availability over the coming decades. Chapter 2 outlines the modelling framework used in this report to determine the location and area of economically viable new plantations. Chapter 3 presents estimates of the potential area of new plantation establishment in NPI regions and associated log production under a base case scenario. Chapter 4 presents sensitivity analysis with respect to key parameters and assumptions. The Conclusion discusses the key implications and opportunities for the forestry sector.

1 Australia's timber plantation sector

Historical plantation investment

The Australian timber plantation estate has grown considerably over the last 40 years, increasing from 629,806 hectares in 1975–76 to 1.97 million hectares in 2015–16 (Figure 1). The hardwood and softwood plantation industries can both be classified as 'mature' industries but developed at different times as a result of different government policies.

Figure 1 Plantation estate and establishment rates, 1975–76 to 2015–16



Source: ABARES datasets

Much of the early growth in the timber plantation estate was driven by investment in softwood species in the 1960s and 1970s as a result of the Commonwealth softwood forestry agreement legislation (1967, 1972, 1976 and 1978). The agreements provided for long-term, partially interest-free loans from the Australian Government to state and territory governments with the specific objective of increasing the rate of softwood plantation establishment to around 30,000 hectares per year. Between 1975–76 and 1989–90 establishment rates averaged 33,738 hectares per year and the total softwood estate grew from 595,430 to 926,406 hectares. Most new areas established were in New South Wales, Victoria and Queensland. After the final agreement in 1976, the states continued to invest in softwood plantations for a period but from 1989–90 onwards new plantation establishment began to decline steadily, particularly in New South Wales, Victoria and Queensland. Since 2006–07 establishment rates have been well below 10,000 hectares per year, suggesting that the softwood plantation estate has reached a steady state of around 1 million hectares.

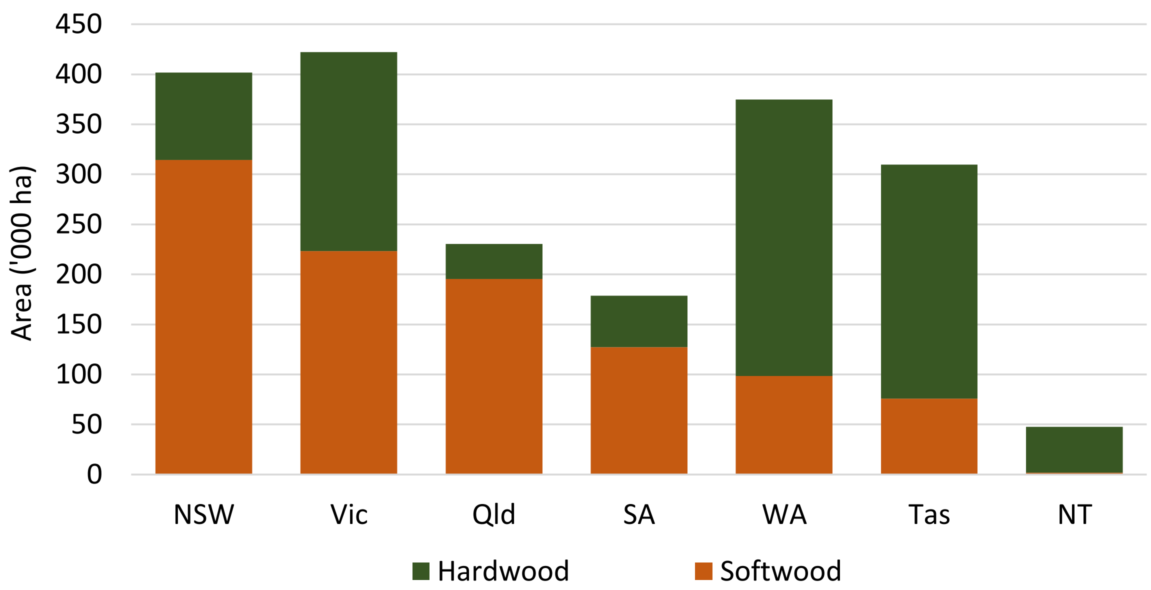
Since 1995–96, almost all growth in total timber plantation estate was the result of rapid expansion of the hardwood plantation estate (Figure 1), which is almost exclusively managed for pulplog production. The *Export Control (Hardwood Wood Chips) Regulations 1996* marked the beginning of this period of expansion. These regulations removed the need for export licences for unprocessed wood products from plantations (woodchips), reducing the sovereign risk associated with investment in plantations. The *Managed Investments Act 1998* then allowed investors to claim immediate tax deductions for investment costs associated with establishing new timber plantations. Hardwood plantation establishment rates increased rapidly as a result of these measures and favourable woodchip export prices. In 1999–2000 establishment rates peaked at around 126,210 hectares, with most investment occurring on cleared agricultural land in Western Australia, Victoria and Tasmania (SOFR 2013).

In 2008–09 several companies using managed investment schemes for funding collapsed. Establishment rates for hardwood plantations declined substantially and virtually ceased in 2011–12, and several managed investment scheme plantations were converted back to agriculture. In 2014–15 the hardwood plantation estate was 928,340 hectares, down by 62,605 hectares from its peak in 2008–09. ABARES estimates that over the next 10 to 15 years the existing commercial plantation estate may decrease by a further 80,000 to 100,000 hectares due to removal of low commerciality plantations (ABARES 2016a).

The timber plantation estate today

In 2015–16 commercial timber plantations covered 1.97 million hectares, split virtually evenly between softwood and hardwood species. The softwood plantation estate consists of predominantly radiata pine (74 per cent) and southern pines (15 per cent), and the hardwood estate consists mostly of Tasmanian blue gum (53 per cent) and shining gum (27 per cent). Plantation softwood species are dominant in New South Wales, Queensland, South Australia and Victoria, and plantation hardwood species are more common in Western Australia, Tasmania and the Northern Territory (Figure 2).

Figure 2 Plantation estate, by type and jurisdiction, 2015–16

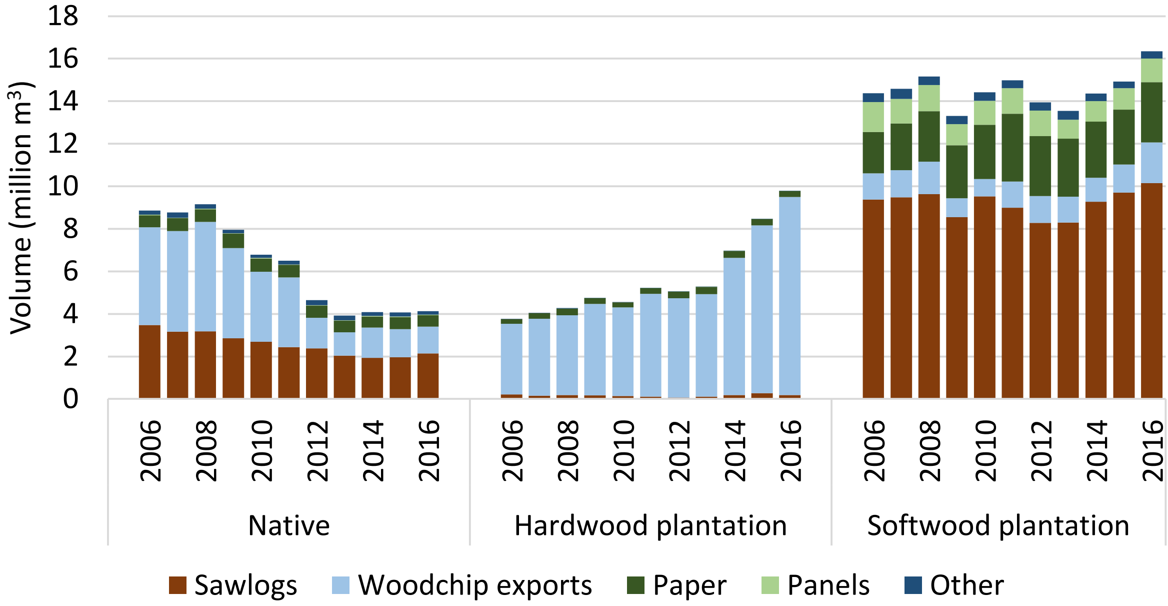


Note: Australian Capital Territory is included in the figures for New South Wales. In 2015–16 the Australian Capital Territory had around 7,400 hectares of softwood plantations.
Source: ABARES 2016b

Timber plantations represent a very small proportion of land use, accounting for only 0.5 per cent of 371 million hectares of agricultural land holdings in Australia in 2015–16 (ABS 2017). This proportion varies between regions, though, with timber plantations accounting for around 3.8 per cent of agricultural land in Victoria and 17.5 per cent of agricultural land in Tasmania.

While the timber plantation estate is only a fraction of the area of native forests available for harvesting (36.6 million hectares in 2011–12), it accounts for the vast majority of Australian log production. In 2015–16 timber plantations produced 86 per cent of Australia's total log harvest with the softwood estate accounting for almost two-thirds of this (Figure 3). Commercial timber plantations are more productive than native forests because of plant selection and breeding, and more intensive management techniques (DAWR 2017).

Figure 3 Log harvest volume, by forest type and end use, 2005–06 to 2015–2016



Note: Native includes cypress pine sawlogs. Sawlogs include logs sold domestically and exported. Years refer to financial year ending.
Source: ABARES 2017

Almost all (98 per cent) of the softwood plantation estate is managed for sawlog production, with sawlogs accounting for around 62 per cent of total harvest. However, each year softwood plantations also produce almost 5.9 million cubic metres of pulplogs. These are used in domestic paper, paperboard and wood-based panel production or exported in the form of roundwood logs or woodchips. In contrast, less than 2 per cent of the hardwood plantation estate is managed for sawlogs in Australia, with 95 per cent of hardwood plantation log production being exported as woodchips.

Future plantation log availability and demand

The availability of logs from the existing plantation estate is expected to be relatively stable going forward but domestic demand for wood products is forecast to grow over time. This represents a potential opportunity for new timber plantation establishment. This section presents ABARES forecasts of the volume of plantation logs available for harvest from the existing estate and future domestic demand for wood products. These forecasts are inputs estimated outside, or exogenous to, the modelling framework (see Chapter 2). ABARES used the modelling framework to determine whether the future shortfall in log availability would be met through a redirection of exports to the domestic market, increased imports, establishment of new plantations or a combination of the three.

Future log availability

Forecasts of log availability from the existing plantation estate are based on industry-supplied data (ABARES 2016a) while forecasts of log availability from public and private native forests are based on published forecasts of log availability and ABARES estimates of sustainable yield (ABARES 2012; Burns et al. 2015). Outcomes of the 2013 Tasmanian Forests Intergovernmental Agreement for native forests have been incorporated into the forecasts. Log availability forecasts reflect all available information as at June 2016.

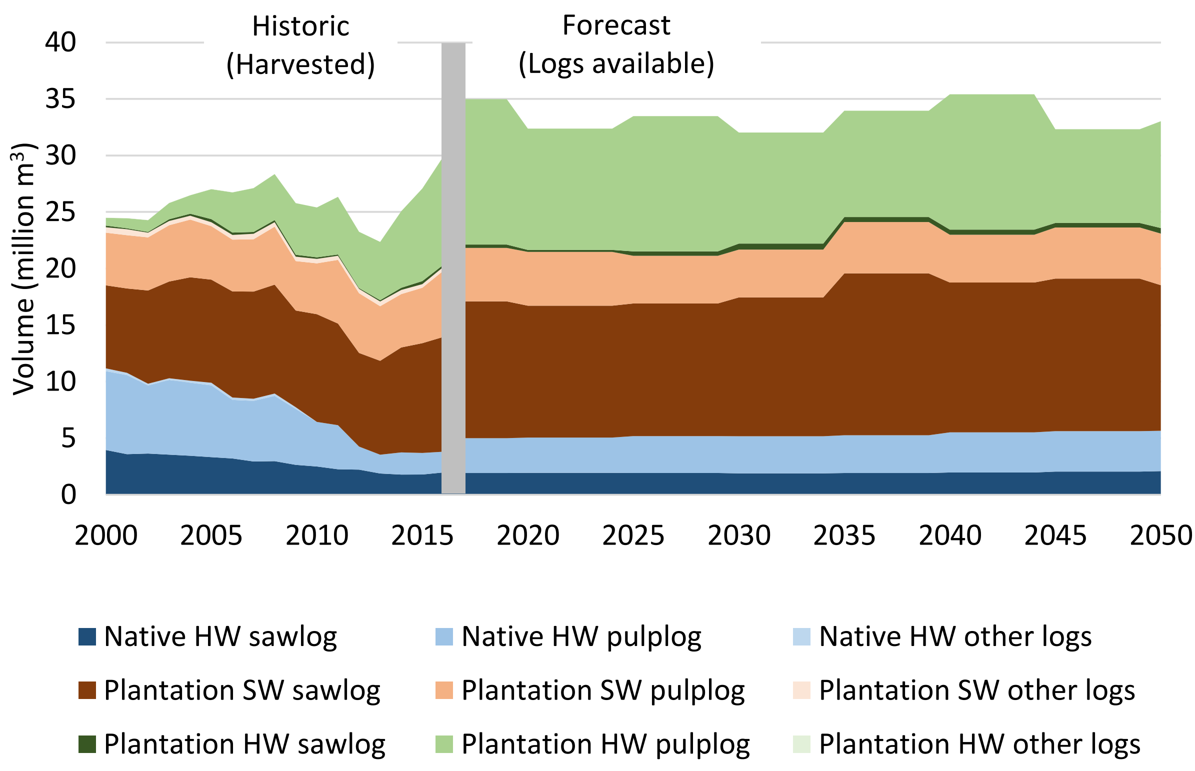
Log availability is forecasted for 12 different log types including high- and low-quality sawlogs and pulplogs from native forests, hardwood plantations and softwood plantations, as well as cypress pine sawlogs, and peeler logs. See Burns et al. (2015) for more information on these log types.

Log availability forecasts from 2015 to 2049 show the annual average volume of logs potentially available from Australia's native forests and plantation estate for each five-year period. These log availability estimates are based on the earliest time logs can be ready for harvest and assumes that all available logs are harvested at that time. FORUM determines whether these logs are actually harvested in a given period, allowing harvests to be delayed by up to 30 years for native forests and long rotation plantations, and by 10 years for short rotation hardwood plantations. However, FORUM does not account for additional growth due to delay of harvest.

Forecasts

Total log availability over the period 2015 to 2050 is expected to oscillate between 32.0 million cubic metres and 35.4 million cubic metres per year (Figure 4). Most of this variation is due to the availability of hardwood plantation pulplogs. These are forecast to decrease from around 12.9 million cubic metres per year in the 2015 to 2019 period to 8.3 million cubic metres per year in 2045 to 2049 (Figure 4). Volatility in the availability of hardwood pulplogs is the result of assumed harvesting and replanting schedules (ABARES 2016a). See Figure A1, Figure A2 and Figure A3 for a detailed breakdown of future log availability by state.

Figure 4 Historic harvest and forecasted log availability, 2000 to 2050



HW Hardwood. **SW** Softwood.
Note: Historical log volumes are actual log harvest. Forecast log volumes are average annual availability for each period. Data for 2000 to 2016 are for financial years ending. Data for 2017 to 2050 are for calendar years.
Source: ABARES 2017

ABARES has assumed that some existing hardwood plantations will not be replanted after the first rotation because they are not considered commercially viable (ABARES 2016a). Log availability forecasts presented in this report only partially include some future plantation removals.

In contrast, potential availability of softwood logs from Australian plantations is forecast to increase from around 16.4 million cubic metres per year in the 2015 to 2019 period to 18.0 million cubic metres per year in 2045 to 2049. This is driven primarily by the availability of softwood sawlogs which are forecast to increase from 12.1 million cubic metres per year to 13.5 million cubic metres per year over the period. Availability of softwood plantation pulplogs is assumed to decrease slightly (by around 4 per cent) over the same period.

Forecasted log availability from native forests is based on sustainable yield estimates and is expected to increase from around 5.0 million cubic metres per year in the 2015 to 2019 period to around 5.6 million cubic metres per year in 2045 to 2049 (Figure 4). Native forest pulplog availability is also assumed to increase slightly from 3.1 million cubic metres per year to 3.6 million cubic metres per year over the same period.

Several aspects of log availability were not considered in this study. ABARES assumed that a proportion of existing hardwood plantations will not be replanted but the forecasts do not account for other factors that may have a bearing on future volume and quality of log availability from the existing plantation estate. These factors include changes to silvicultural practices, which may improve growth rates; impacts of climate variability, which may affect tree growth rates; and competitiveness of existing wood-yielding plantations with other land uses.

Log availability forecasts are inherently uncertain because of the variability of natural resources, market cycles and the unpredictability of natural events such as bushfires. Therefore, forecasts of log availability are estimates only, and care must be taken not to extrapolate these forecasts to the operational level.

Future demand for wood products

ABARES developed forecasts for future domestic demand using the econometric time series models presented in Appendix A. The models used are similar to those developed by Gupta (2012) but where Gupta (2012) estimated future demand for three broad commodities (sawnwood, panels, and paper and paperboard) the models used in this report estimate demand for nine major commodities (Table 1). Also, the models used in this report do not distinguish between demand for imports and demand for domestically produced goods.

Table 1 Wood commodity forecasts, 2014–15 to 2049–50

Commodity	Units	2014–15	2019–20	2024–25	2029–30	2034–35	2039–40	2044–45	2049–50
Major commodities									
Softwood sawnwood **a**	‘000 m^3	5,104	5,131	5,490	5,752	6,010	6,239	6,443	6,621
Hardwood sawnwood **a**	‘000 m^3	493	493	493	493	493	493	493	493
MDF	‘000 m^3	530	517	540	564	590	616	644	673
Particleboard	‘000 m^3	986	853	923	949	972	991	1,007	1,021
Plywood **e**	‘000 m^3	486	375	400	424	448	469	490	510
Newsprint	kt	345	345	345	345	345	345	345	345
Printing and writing	kt	1,369	1,260	1,343	1,439	1,551	1,665	1,782	1,896
Household and sanitary	kt	320	350	383	419	458	501	548	599
Packaging and industrial	kt	1,591	1,594	1,625	1,660	1,698	1,734	1,770	1,803
Minor commodities									
Softwood poles **c**	‘000 m^3	261	263	281	294	308	319	330	339

Commodity	Units	2014–15	2019–20	2024–25	2029–30	2034–35	2039–40	2044–45	2049–50
Cypress pine sawnwood **c**	‘000 m³	83	83	89	93	97	101	104	107
Hardwood posts **d**	‘000 m³	45	45	45	45	45	45	45	45
Hardwood poles **d**	‘000 m³	72	72	72	72	72	72	72	72
Hardboard **e**	‘000 m³	88	86	90	94	98	103	107	112
Laminated Veneer Lumber **f**	‘000 m³	73	56	60	63	67	70	73	76
Hardwood veneer **f**	‘000 m³	43	33	35	37	39	41	43	45
Softwood veneer **f**	‘000 m³	4	3	4	4	4	4	4	5
Cross laminated timber	‘000 m³	60	60	60	60	60	60	60	60

a Sawnwood is further broken down into structural, appearance and other sawnwood products. **b** Plywood is further broken down into hardwood and softwood varieties. **c** Demand assumed to grow at the same rate as demand for softwood sawnwood. **d** Demand for hardwood posts and poles are assumed to grow at the same rate at demand for hardwood sawnwood. **e** Demand assumed to grow at the same rate as demand for MDF. **f** Demand assumed to grow at the same rate as demand for plywood.
Source: ABARES forecasts

Demand is assumed to grow proportionally over time for specific components of the nine forecasted commodities, except hardwood sawnwood and newsprint. Demand for these commodities were assumed to be constant over time. Demand for minor commodities, which did not fall under any of the major commodities forecasted, were assumed to grow at the same rate as demand for one of the nine major commodities forecasted.

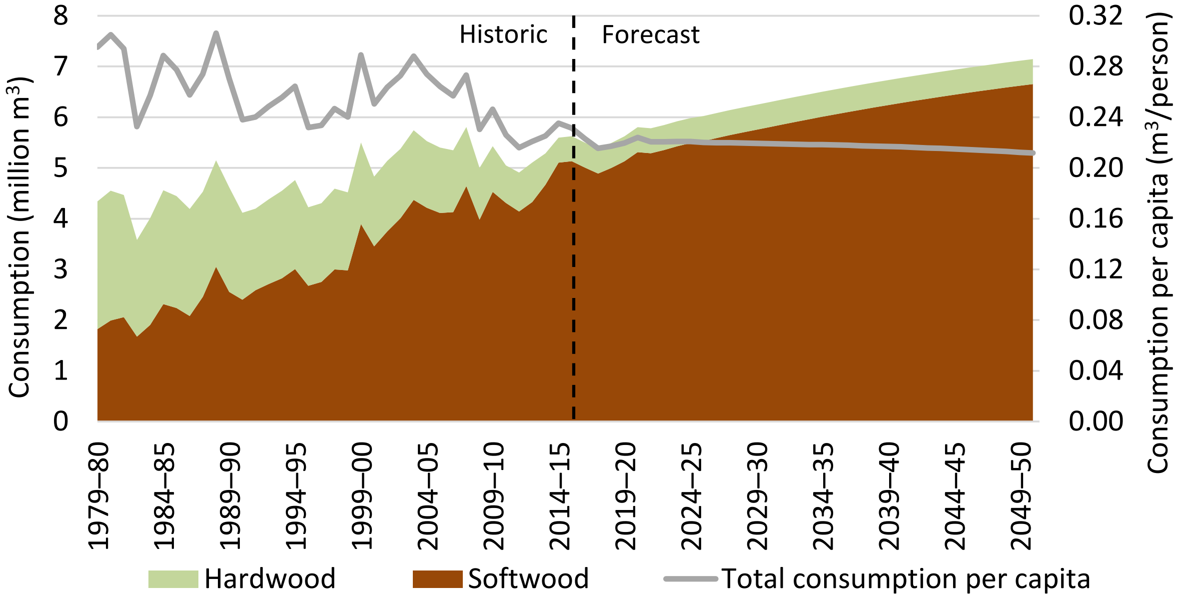
Sawnwood

Most softwood plantations are managed for sawlogs, so demand for sawnwood is a key driver of potential plantation investment. In Australia total demand for plantation softwood sawnwood is forecast to grow by 30 per cent to 6.6 million cubic metres by 2049–50 (Figure 5). Detached house commencements and real GDP growth are expected to be the primary drivers of increased demand (see Table A3). For the purposes of this analysis, softwood sawnwood includes structural, appearance and other softwood sawnwood products. Demand for softwood posts and poles and cypress pine sawnwood are assumed to grow at the same rate as demand for plantation softwood sawnwood. Demand for cross-laminated-timber, a potential substitute for softwood sawnwood, is assumed to be fixed at 60,000 cubic metres per year.

Imports of hardwood sawnwood are minimal. Therefore, domestic consumption is highly dependent on future native forest log availability and changing consumer perceptions of the native hardwood industry over time. In light of these uncertainties, future demand for hardwood sawnwood is assumed to remain constant at 2014–15 levels over the forecast period. For the purposes of this analysis, hardwood sawnwood includes structural, appearance and other hardwood sawnwood products. Demand for hardwood posts and poles is also assumed to remain constant over the forecast period.

Per capita demand for sawnwood is forecast to fall by around 10 per cent over the forecast period. This is consistent with historical trends (Figure 5) and reflects a structural shift in housing over the forecast period towards an increasing proportion of multi-dwellings. Less wood tends to be used in multi-dwellings than in detached houses.

Figure 5 Historic and forecasted demand for sawnwood, 1979–80 to 2049–50



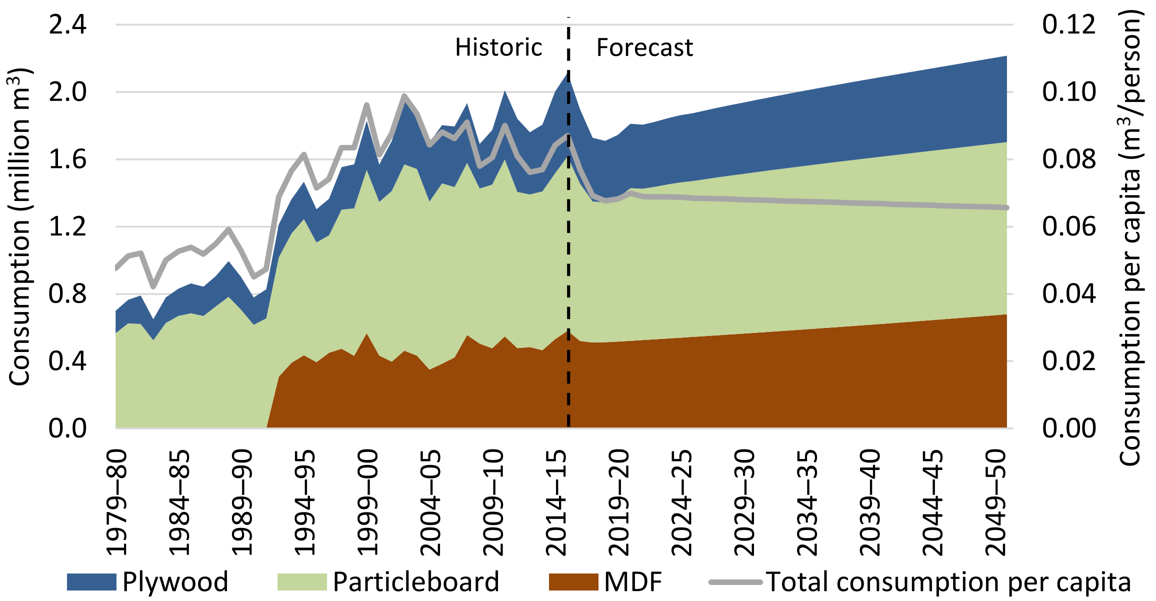
Note: Forecast period commences 2016–17.
Source: ABARES 2017

Wood-based panels

The construction industry is a large user of wood-based panels—primarily for wall and floor sheathing but also for house fixtures such as cabinets, mouldings and doors. Wood-based panels are also used in furniture manufacturing.

Total demand for wood-based panels (plywood, particleboard and medium-density fibreboard) is forecast to grow by 10 per cent to 2.2 million cubic metres (Figure 6). This increase is primarily attributed to growth in demand for medium-density-fibreboard, based on past trends (see Table A4). Demand for hardboard is assumed to grow at the same rate as that for MDF.

Figure 6 Historic and forecasted demand for wood-based panels, 1979–80 to 2049–50



Note: Forecast period commences 2016–17.
Source: ABARES 2017

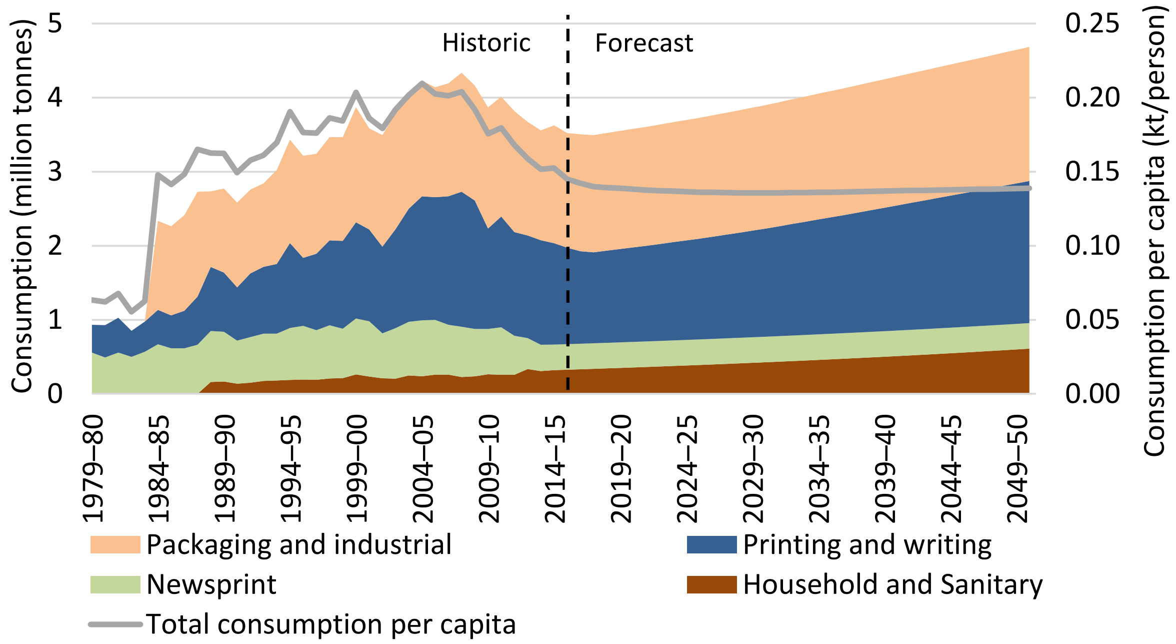
Demand for plywood and particleboard are expected to increase slightly over the forecast period, driven by growth in the number of detached and multi-dwelling commencements (see Table A5 and Table A6). For the purposes of this analysis plywood is broken down into hardwood and softwood products. Demand for laminated veneer lumber and veneers are assumed to grow at the same rate as that for plywood over the forecast period.

Over the forecast period total demand for wood-based panels is forecast to increase but demand per capita is forecast to decrease by around 22 per cent. This is consistent with recent trends showing slowing growth in demand for panels relative to population growth.

Paper and paperboard

Total demand for paper and paperboard is forecast to grow by around 28 per cent to 4,643 kilotonnes by 2049–50 (Figure 7). This is expected to be primarily driven by forecasted growth in printing and writing paper (39 per cent) and household and sanitary products (87 per cent). Forecasted growth in manufacturing activity is expected to drive growth in demand for printing and writing paper (see Table A9), due to the manufacturing sector being a significant user of printing and writing paper. Per capita demand for paper and paperboard products is expected to fall by around 9 per cent.

Figure 7 Historic and forecasted demand for paper and paperboard, 1979–80 to 2049–50



Note: Forecast period commences 2016–17.
Source: ABARES 2017

Other products

ABARES did not place any constraints on modelled demand for Australian wood product exports over the forecast period. Exports of wood products are determined in the modelling framework and depend on the relative returns of selling into the domestic market or exporting. Specifically, the domestic industry is assumed to be able to export as much as can be produced—up to the point where the marginal cost of production and delivery to ports equals the free-on-board price received for these products (after accounting for potential higher returns from selling and processing logs domestically).

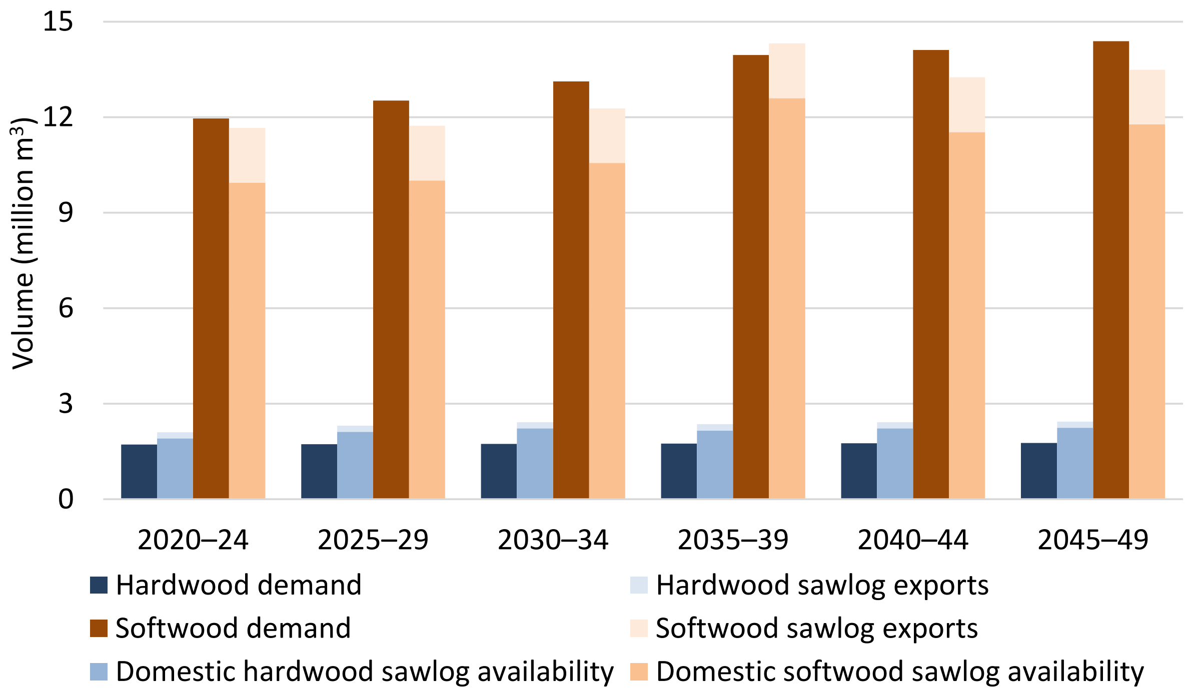
This study also examines potential recovered paper exports and wood pellet exports. It assumes domestic demand for recovered paper is driven by demand for recycled pulp used in paper manufacturing. Additional recovered paper collected above the volume required by domestic paper processors could potentially be exported. The volume of recovered paper available each period is assumed to be equal to demand for paper in that period multiplied by the estimated paper collection rate (85 per cent in 2015–16).

ABARES assumes wood pellets have no domestic market over the forecast period, so demand is solely directed to exports. However, the Australian market for wood and energy products is likely to change significantly over the coming decades. Emerging markets for engineered wood products, bioenergy products and other downstream wood products were not examined in this report.

Log equivalent demand and availability

Figure 8 compares ABARES forecasts of log availability for the existing estate with forecasts of log equivalent demand. The coefficients used to calculate log equivalent demand are based on the average recovery rate for logs processed under the base case (see Chapter 3). The volume of logs exported in 2015–16 has been subtracted from the total volume of logs available in each period to give an estimate of the potential volume of logs that could be available to the domestic market. In practice, the volume of logs exported will likely change over time with changing domestic and international market conditions.

Figure 8 Domestic annual sawlog availability and log equivalent demand, 2020 to 2049



Note: Log exports based on 2015–16 values from ABARES Gross Value of Production survey (unpublished). Demand for softwood sawnwood includes posts and poles.

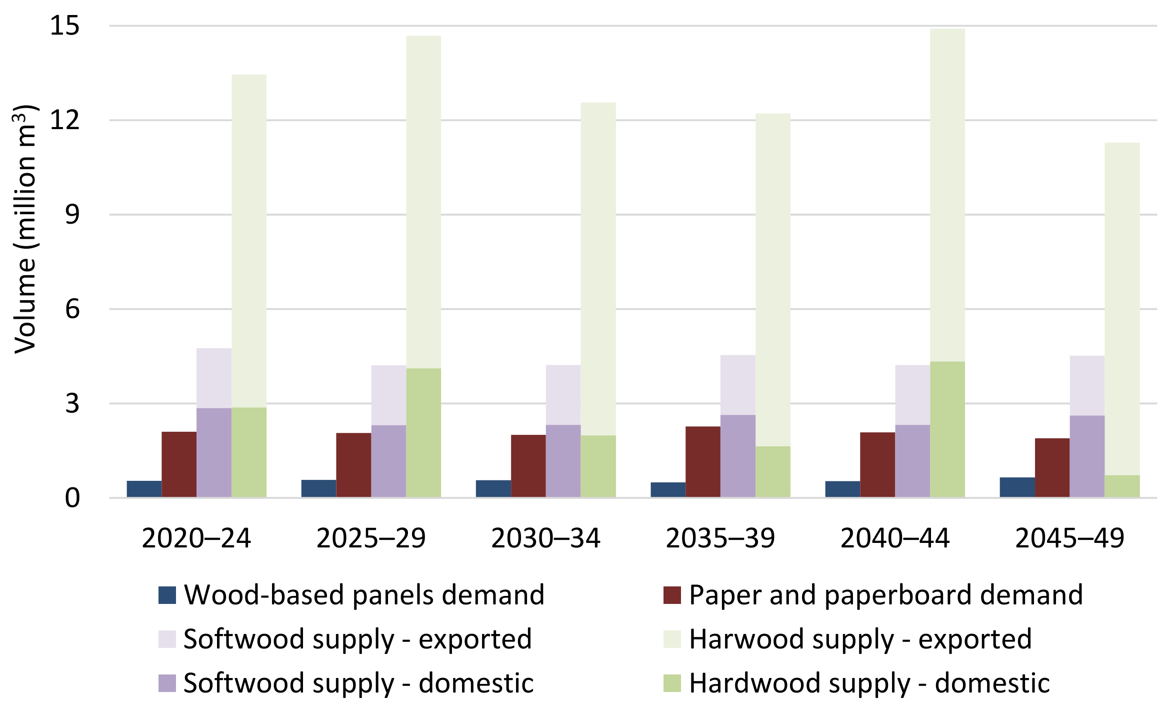
Based on ABARES estimates, future availability of hardwood sawlogs would be sufficient to meet log equivalent demand from 2020 onwards. The volume of hardwood sawlogs available to the domestic market is forecast to exceed domestic demand by over 471,761 cubic metres per year between 2045 and 2049 (Figure 8). These surplus logs will either be exported as roundwood or their harvest delayed.

In contrast, ABARES forecasts a growing shortfall in softwood sawlog availability. Specifically, the total volume of softwood sawlogs available for harvest is forecast to fall short of demand by 893,395 cubic metres per year between 2045 and 2049. However, if exports of softwood sawlogs remain at 2015–16 levels, the volume of softwood sawlogs available to the domestic market could fall short by 2.6 million cubic metres per year. With continuing growth in demand for softwood sawlogs, ABARES estimates that this domestic log availability shortfall could increase to 3.4 million cubic metres per year between 2050 and 2054. To provide context to these figures an additional 200,000 to 250,000 hectares of new softwood plantations would be required by 2050 to meet an annual deficit of 3.4 million cubic metres per year (based on an assumed growth rate of 13.5 to 17.0 cubic metres of sawlogs per hectare). However, given the uncertainty around future softwood sawlog supply and log equivalent demand in 2050, it has been proposed that the required area could be as high as 490,000 hectares (Omega Consulting 2017).

Comparisons of log availability and log equivalent demand for paper and panels are more complex because panel and paper production use a combination of pulplogs and residues from sawmills. In estimating log equivalent demand for paper and panels ABARES assumed that for each cubic metre of pulplog processed a certain volume of residues is also available. In practice, the availability of residues for paper and panel production is contingent on there being a sufficient supply of sawlogs to domestic processors.

Wood-based panel production primarily uses softwood pulplogs but the aggregate paper industry uses hardwood and softwood pulplogs—depending on the final product. Nevertheless, the estimated total availability of pulplogs alone appears to be sufficient to meet domestic demand at the national level to 2050, even taking into account exports of roundwood and woodchips (Figure 9).

Figure 9 Domestic annual pulplog availability and log equivalent demand, 2020 to 2049



Note: Log exports based on 2015–16 values from ABARES Gross Value of Production survey (unpublished). Wood-based panel production primarily uses softwood pulplogs while production of paper and paperboard products uses a mix of hardwood and softwood logs and pulp.

The estimated domestic log availability shortfall for softwood sawlogs assumes that domestic demand for wood products is fixed, exports remain at 2015–16 levels, and there are no new plantations established. Aside from reductions in demand, any future shortfall in the volume of logs available to the domestic market can be met through:

1) redirecting exports from the existing estate to the domestic market (if suitable for local processing)
2) increasing imports of final wood products

3) establishing new plantations.

The extent to which each of these contributes to a reduction in the domestic log availability shortfall depend on available processing capacity, processing costs and domestic and international prices. See Chapter 2 for the modelling framework used to determine the optimal mixture of these channels to satisfy domestic demand.

2 Model framework

The analysis in this report is based on simulations run using the Forest Resource Use Model (FORUM)—a simplified modelling framework designed to reflect resource allocation decisions made by agents operating in the forestry sector (Figure 10). ABARES developed FORUM to assess the optimal use of Australia's forest resources for wood production. It is used to forecast future harvest volumes, assess future processing investment opportunities and determine the most economically efficient mix of domestic production and net trade to meet Australia's future demand for wood products.

FORUM framework

FORUM is a dynamic mixed-integer linear programming model that uses a cost–benefit analysis approach to simulate the flow of resources in the forestry sector and maximise the present value of returns from use of the wood resource. The model determines the optimal allocation of the wood resource to mills and final markets by considering harvesting, transport and processing costs, mill capacity and recovery rates, mill investment opportunities and final demand for wood products. The FORUM framework was extended as part of this project to include establishment of new plantations on cleared agricultural land within the 15 National Plantation Inventory (NPI) regions (Figure 11).

Given the importance of transport costs in the forestry industry ABARES mapped the physical location of agricultural land areas, forests, wood processors and markets so that road distances, and associated transport costs between locations, could be calculated and incorporated into FORUM. FORUM tracks the physical flow of wood resources from forests to mills and from mills to markets, while determining the optimal amount of wood processing investment and new timber plantation establishment.

Economic assumptions

The optimal allocation of logs harvested from forests to mills, and products from mills to markets, is based purely on maximisation of the present value of profits at the industry level. Many other factors affecting allocation of logs among processors and products among markets were not considered. These include long-term supply contracts and information constraints.

Forecasts of log availability for existing forests, domestic demand for wood products and wood product prices (see Table A10) are exogenous assumptions in FORUM. This means they are determined outside of the model and are unaffected by changes in other parameters of the model. It is also assumed that agents operating in the forestry sector have perfect foresight with respect to these parameters and make decisions accordingly.

The model requires domestic demand be met each period through either domestic supply or wood product imports (Figure 10). Imports are assumed to be sold into the domestic market at domestic market prices. The industry will favour imports over domestic production where the costs of meeting demand through imports are less than the costs of domestic production (including any potential forgone returns from exporting domestic production).

Figure 10 Forest Resource Use Model (FORUM)

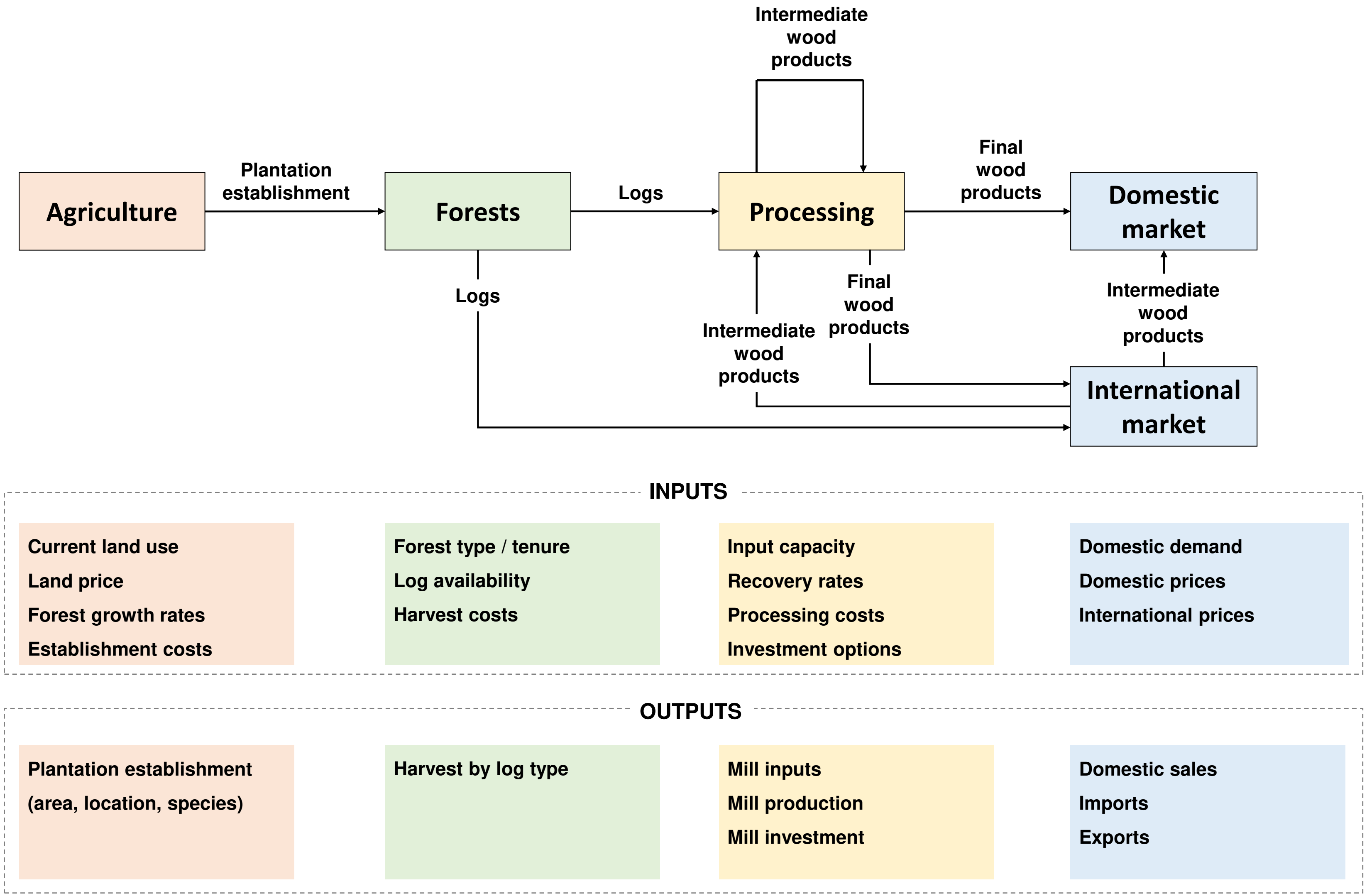
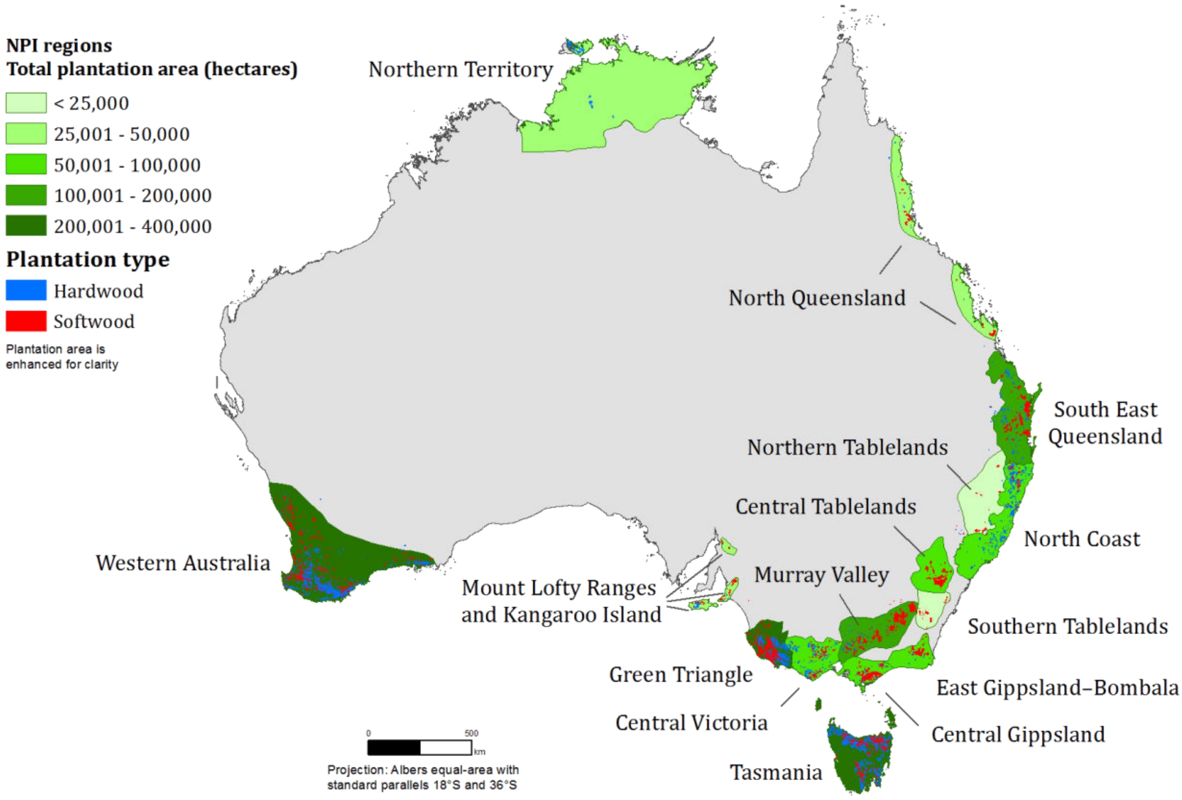


Figure 11 National Plantation Inventory regions



Source: ABARES 2016b

Demand for Australian wood product exports is unconstrained in the model framework. The volume of exports is determined by the relative returns of selling into domestic markets or exporting, subject to the requirement that domestic demand must be met.

Future investment options

The economic viability of timber plantations in Australia will partially depend on the availability of domestic processing capacity and cost of expanding this capacity. Future investment may take many forms, including in new wood-processing facilities or modifications and improvements to existing infrastructure. New wood-processing facilities can take advantage of additional domestic log availability from new or existing plantations or may use current log supplies, leading to the replacement of existing wood-processing facilities. New investments may also be made in downstream supply chain processing, providing an opportunity to value-add to the current mix of domestic wood processing.

This report considers a limited set of investment options (see Table A12). Recovery rates and wood-processing costs are based largely on existing practices. Potential technological advances allowing production of existing products from lower grade logs, or new products from existing log types, were out of scope.

ABARES determined site locations for potential new wood-processing facilities by evaluating region-specific surplus log availability over current processing capacity, and trial simulations. It did not consider other factors such as cost of electricity, gas, water or labour or the environmental or social impacts of particular investments.

This is primarily a nation-wide study, so many regional specific factors were not incorporated into the analysis. Distinct land use restrictions and environmental or developmental regulations for major infrastructure projects apply in many states, territories and regions. Many investments may also need additional inputs or resources, such as available labour force, road or port infrastructure or water availability. ABARES did not model these factors specifically but did consider some when determining the set of available investment options.

Transport distances and costs

Forests (including plantation areas), agricultural land areas, wood-processing facilities and markets are mapped spatially such that road distances and associated transport costs between locations can be incorporated into FORUM. In calculating distances between forest areas and wood-processing facilities, maximum distances of 325 kilometres along the road network and 25 kilometres off the road network were applied. It is assumed that transporting logs and intermediate products further distance would be economically unviable. Major regional town centres are used as proxy locations for domestic markets. Distances from wood-processing facilities to nearest ports are used as proxies for distances between wood-processing facilities and export markets.

Transport costs between forests, wood-processing facilities and markets are based on the lowest-cost route and an assumed cost per tonne per kilometre for each product type. This takes into account the costs of transporting logs and wood products along different road types. See Table A13 for weights given to each road type, representing the cost of transport relative to a dual carriageway or principal road.

New plantation establishment module

For this analysis ABARES extended the FORUM framework to include establishment of new softwood and hardwood plantations on cleared agricultural land in NPI regions. Softwood species considered in the analysis include radiata pine (*Pinus radiata*), maritime pine (*Pinus pinaster*), Carribbean pine (*Pinus caribaea*) and southern pines (hybrids of Caribbean pine and slash pine). Hardwood species include Tasmanian blue gum (*Eucalyptus globulus*), shining gum (*Eucalyptus nitens*) and spotted gum (*Corymbia maculata*). Tasmanian blue gum plantations can be managed for either sawlogs (long rotation) or pulplogs (short rotation). Shining gum plantations are assumed to be managed for pulplogs and spotted gum plantations for sawlogs. All softwood plantations are assumed to be managed for sawlog production, with thinnings producing a combination of pulplogs and sawlogs.

The area of Araucaria pine plantations in Queensland is substantial (around 45,000 hectares). However, the analysis did not consider establishment of new areas because spatial data on potential growth rates were unavailable. According to Harrison and Herbohn (2006), Araucaria pine is unlikely to be profitable where agricultural land prices exceed $800 per hectare and growth rates in these low value areas are unlikely to be sufficient to produce commercial wood products. Future Araucaria pine establishment is, therefore, expected to be limited.

In order to model plantation investment up to 2050 forecasts of wood product demand and log availability from existing forests were extended out to 2099. The forecasted demand for each wood product was extended beyond 2050 by assuming constant linear annual growth equal growth forecasted for 2049–2050. This avoided explosive growth or peaks in demand between 2050 and 2099. For simplicity, forecasts of log availability from native forests (ABARES 2012; Burns et al. 2015) were assumed to be equal to the average forecasted volume available over the period 2040 to 2054. In contrast, the extended log availability forecasts for plantations were based on an assumed 25 year cycle for sawlogs and 10 year cycle for pulplogs. This allowed the forecasted volatility in plantation log availability over the period 2015 to 2059 (ABARES 2016a) to be carried forward.

State and territory policies and legislation prohibit or restrict clearing of native vegetation (including native forests) for new plantation development (Montreal Process Implementation Group for Australia and National Forest Inventory Steering Committee 2013). Therefore, it is not considered in this report. Commercial tree growing can be incorporated into farming systems in ways that support agricultural production (farm forestry). However, this analysis does not consider these opportunities due to the heterogenic nature of farming systems and uncertainty about area of suitable land.

Site preparation and maintenance costs

Plantation establishment is assumed to include upfront costs associated with site preparation, seedling purchase and planting; as well as ongoing costs associated with maintenance and management. Table 2 summarises assumed costs of new plantation establishment and maintenance costs by regime. Costs for each regime are assumed to be the same across all regions. In practice, establishment and maintenance costs will vary between regions and site by site so these represent average costs. The estimated costs are based on assumptions in Matysek and Fisher (2016), previous ABARES work (Burns et al. 2011), and consultation with forest growers. Timber plantation yields and thinning regimes are based on ABARES (2016a).

Table 2 New plantation establishment and maintenance costs

Regime	Establishment ($/ha)	First year ($/ha)	Ongoing ($/ha)	Rotation length (years)
Softwood				
Radiata pine	1,900	482	82	30
Maritime pine	1,900	482	82	40
Caribbean pine	1,900	482	82	30
Southern Pines	1,500	640	90	30
Hardwood				
Tasmanian blue gum–long rotation	2,100	140	180	25
Tasmanian blue gum–short rotation	2,100	140	25	10
Spotted gum (sawlogs)	2,100	140	180	25
Shining gum (pulplogs)	2,100	140	25	10

Note: All figures are in Australian dollars.
Source: Burns et al. 2011; Matysek and Fisher 2016

Agricultural land prices

In FORUM establishment of a new plantations is assumed to require purchase of the land at the estimated land price. At the end of each rotation, FORUM determines whether newly established plantations are replanted or returned to their previous agricultural land use. Land converted back to its previous use is assumed to be sold at the original purchase price for the land, and conversion of timber plantations back to agriculture is assumed not to have other associated costs. These assumptions favour establishment of new timber plantations because in practice substantial costs are associated with converting timber plantations back to agriculture.

ABARES generated estimates of land prices for each parcel of agricultural land using reported land values from ABARES farm surveys (ABARES 2016c). A land price map was created for dairy, livestock and cropping farms by calculating a weighted average of the 30 nearest reported land values for farms of the same type. Reported land values were the median value over 2005–06 to 2015–16. This increased the number of usable observations (because some farms did not participate across all 10 years) and minimised the effects of annual variations in reported land price. Weights were inversely proportional to the distance between the agricultural land parcel and the location of the survey response. Sugar cane is not included in ABARES broadacre farm surveys, but land values for sugar cane were estimated using responses to the 2015 survey (ABARES 2015). The survey provided estimates of average land price for each major sugarcane-growing region in 2013–14 (see Table A13).

ABARES used the Land use of Australia 2010–11 data set (ABARES 2016d) to determine the farm type and land price applicable to each parcel of agricultural land. This involved categorising

17 specific land uses from the data set into four broad categories: pasture, modified pasture, cropping and sugar cane (see Table A14). ABARES excluded other agricultural land uses (such as horticulture) because spatial information on land values was not available and because timber plantations are unlikely to be competitive against agricultural returns on this land.

Matching broad land use with the appropriate land price layer generated a single spatial layer of land prices. Land areas classified as pasture were given livestock land prices, land areas identified as cropping were given cropping land prices and land areas identified as modified pasture were given dairy land prices. Costs and returns associated with the purchase and sale of agricultural land were discounted using a rate of 7 per cent per annum, consistent with the rate assumed for forestry related projects in FORUM.

Growth rates and silvicultural regimes

ABARES estimated plantation growth rates using the Physiological Processes for Predicting Growth (3-PG2) spatial model, originally developed by Landsberg and Waring (1997). The 3-PG2 model calculates mean annual increment (MAI) based on biological inputs including nutrition, soil drought, atmospheric vapour pressure deficits and stand age. MAIs were calculated for Tasmanian blue gum (short and long rotation), spotted gum, radiata pine, maritime pine and Caribbean pine. Calculated growth rates for shining gum were unavailable, so MAI outputs for short-rotation Tasmanian blue gum were used. MAIs for cleared agricultural land were combined with assumed plantation yields to give potential log availability from establishing a particular species on a particular parcel of land. For this report, MAIs were capped at 30 cubic metres per year.

Strengths and limitations of the analysis

The FORUM framework uses comprehensive ABARES datasets on the forestry sector—including logs harvested, processing infrastructure, forest areas, and log availability from native forests and plantations. This ensures that the model accounts for real world biophysical and infrastructure constraints in determining optimal plantation investment. The model incorporates forecasts of domestic demand and prices—so it accounts for the relative returns to supplying domestic versus export markets and relative costs of sourcing products from domestically versus overseas.

However, FORUM has several limitations that should be considered when interpreting the results. For example, many regions, log types and wood products have been aggregated in this analysis because of data limitations. As a result, the modelled allocation of logs, residues and products will often differ from reality. ABARES calibrates model outputs to current market conditions, but this process is approximate. Additionally, model projections are contingent on assumptions around future log availability, wood product demand and prices.

The optimal allocation of logs and wood products is based on maximisation of net returns. It does not reflect other considerations that may affect the allocation of logs among wood-processing facilities, such as long-term supply agreements between forest managers and wood processors or other regional constraints. The analysis also does not account for landholder preferences around land use change and assumes that economic returns are the sole influencer in decisions.

The framework does not explicitly consider the impacts of climate variability, potential carbon abatement opportunities or water use. ABARES has examined some of these issues in previous research (ABARES 2012). However, the analysis necessary to adequately incorporate future climate variability impacts, carbon abatement opportunities and water allocations costs was too complex and broad to be within the report scope and time frame. Future research could consider impacts of carbon abatement opportunities and water allocation costs.

Finally, the framework does not assess some potential future market opportunities and assumes that current technologies will remain in place. For example, downstream value-adding opportunities such as development of innovative engineered wood products and bioenergy products and use of mill and harvest residues may become more important over time. These opportunities could provide the forestry sector with new products that could change the structure of the domestic wood-processing industry.

3 Forecasts of potential new plantation establishment

ABARES estimated the potential area of new plantation establishment for the period 2020 to 2050 under current conditions and assumptions, referred to as the base case. Short-term results have been omitted to avoid comparisons with short-term forecasts of wood commodities, because they are based on factors that differ from the long-term parameters examined in this analysis.

These estimates show the upper limit of what is economically viable under current conditions and assumptions of future demand. Uptake of new plantation establishment will depend critically on availability of suitable agricultural land for purchase, permissions to establish commercial timber plantation and sufficient labour and capital (Polglase et al. 2011).

Key findings

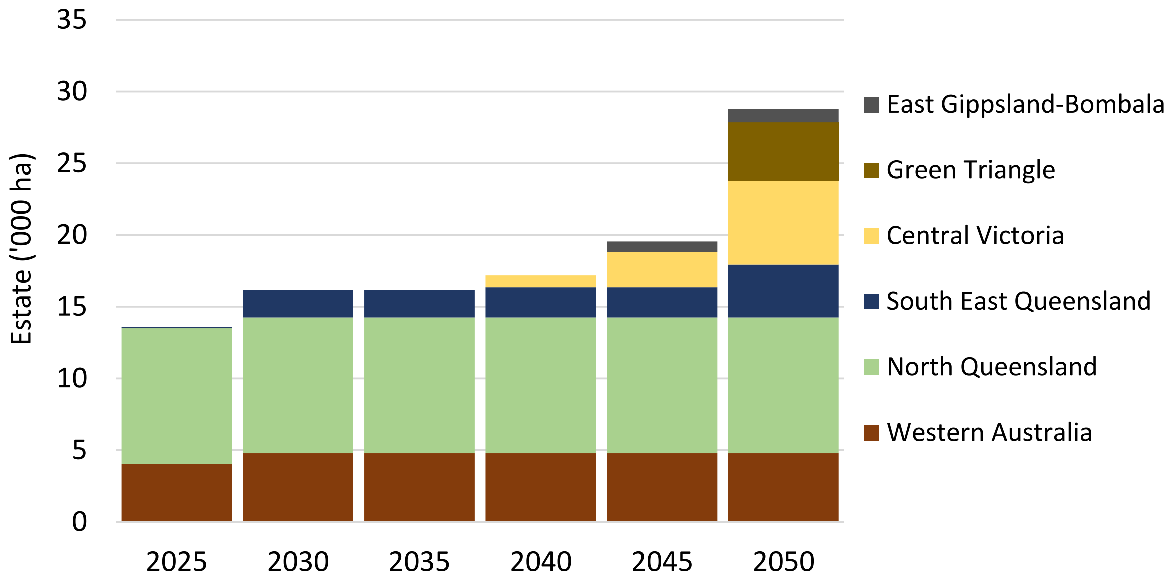
- ABARES estimates that by 2050 around 28,782 hectares of new plantations would be economically viable under current policy and economic conditions. Around 82 per cent (24,009 hectares) of the potential area is softwood plantations and the remaining 18 per cent (4,773 hectares) is short-rotation hardwood plantations.
- Under the base case, new softwood plantations are estimated to be economically competitive with current agricultural land use in Queensland, Victoria and New South Wales. Short rotation hardwood plantations, however, are only economically viable in Western Australia.
- ABARES estimates suggest that few to no new long-rotation hardwood plantations will be established under current policy settings and economic conditions.
- Under the base case, new plantations may be economically viable on pasture and cropping land, but high land prices preclude establishment of new plantations on modified pasture and sugarcane land.
- Log production from potential new plantation areas is expected to peak in 2050 at around 1.5 million cubic metres.

Potential new plantation establishment

Estimates of establishment

ABARES estimates that under base case around 28,782 hectares of land across six of the 15 NPI regions will be economically viable for new plantation establishment by 2050 (Figure 12). Of this, around 24,009 hectares will be suited to softwood plantation species and 4,773 hectares to short-rotation hardwood plantations. The potential new plantation areas include southern pines in Queensland, radiata pine in New South Wales and Victoria, and short-rotation blue gum in Western Australia (see Table B1). Plantations will only be established in the Victorian part of the NPI Green Triangle region.

Figure 12 Cumulative new plantation area by NPI region, base case, 2025 to 2050



NPI National Plantation Inventory.

ABARES estimates that almost half of the potential new plantation area (13,157 hectares) is in Queensland and around one-third (9,926 hectares) in Victoria. Almost half of the potential new plantation area is projected to be established by 2025 (mostly in North Queensland and Western Australia) and around one-third after 2045 (mostly radiata pine in New South Wales and Victoria).

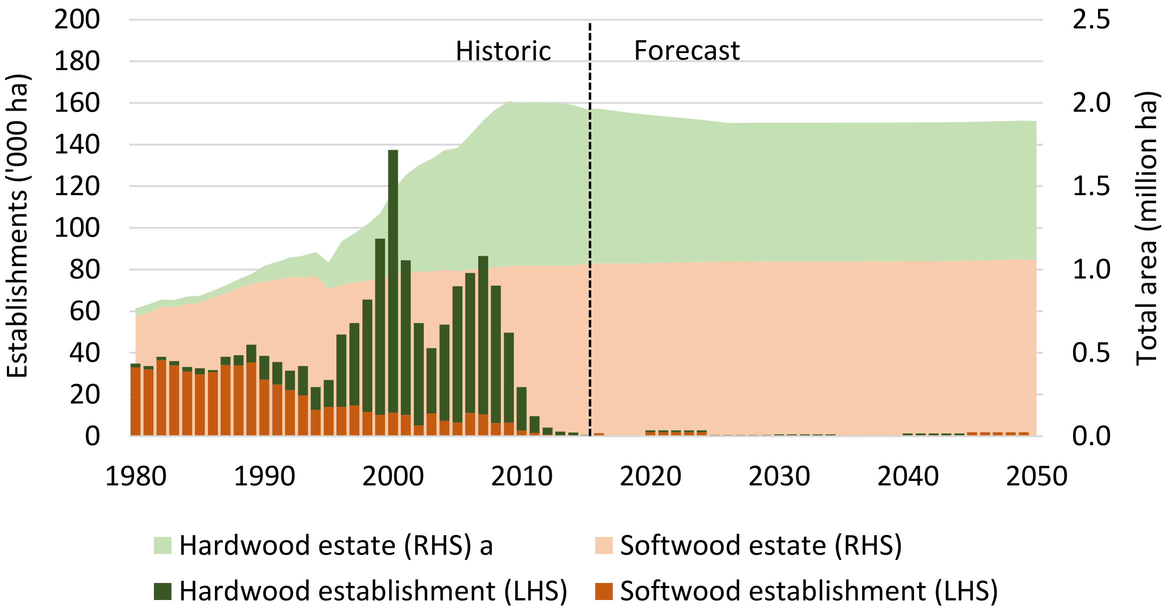
The area of agricultural land economically viable for new plantation establishment in each NPI region (Figure 12) is relatively small compared with that for the existing plantation estates, except for Central Victoria and North Queensland. The potential area of new plantations established in Central Victoria was estimated to be 20 per cent of the existing estate and for North Queensland 30 per cent. However, Central Victoria and North Queensland are small NPI regions, each having only around 30,000 hectares of softwood plantations. The potential area of new hardwood plantations established by 2050 was estimated to be less than 2 per cent of the current Western Australia estate.

The national softwood estate is estimated to increase by around 2.1 per cent (24,009 hectares), from 2020 to 2050, if all potentially economically viable areas are converted (Figure 13). In contrast, the hardwood estate could shrink by between 8.1 per cent (75,227 hectares) and 10.3 per cent (95,227 hectares)—depending on potential future removals of hardwood plantations. However, the volume of hardwood pulplogs available is not expected to decrease proportionally because most hardwood plantations that are not expected to be replanted are low yielding.

Historical context

Potential new plantation establishment rates are relatively consistent with actual establishment rates observed in recent years (Figure 13). For example, potential establishment rates for hardwood plantations are estimated to average around 800 hectares a year over the period 2020–25. This is similar to actual establishment rates observed in 2013–14 (1,321 hectares) and 2014–15 (513 hectares). From 2020 to 2025 potential new softwood establishment rates are estimated to average 1,910 hectares a year. This is similar to the area established in 2015–16 (1,414 hectares).

Figure 13 Historic and forecasted plantation establishment and estate, base case, 1980 to 2050



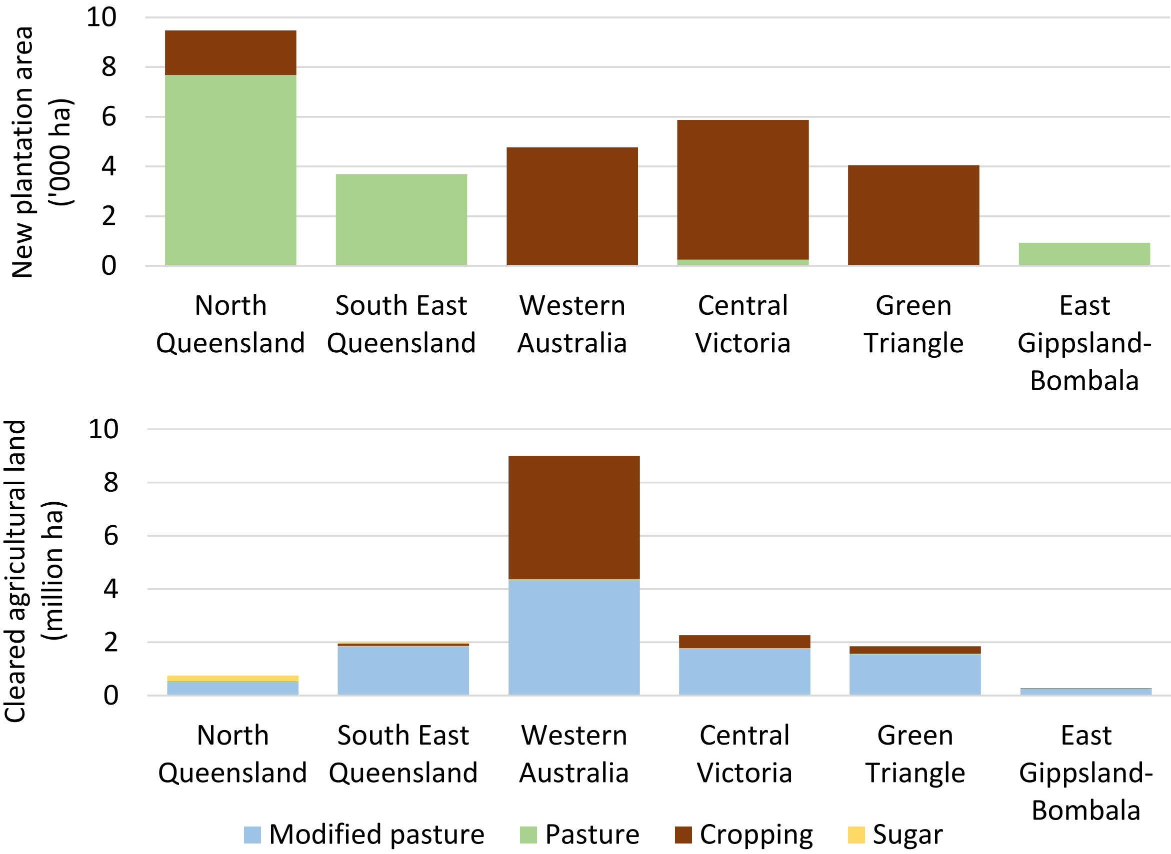
a Assumed decline in existing hardwood estate from 2016–17 to 2025–26 of 100,000 hectares based on ABARES (2016a).
Note: Establishment is new plantation establishment only and not re-establishment of existing plantations. Data for 1980 to 2016 are for financial years ending. Data for 2017 to 2050 are for calendar years.
Source: ABARES 2017

Current agricultural land use

Nationally, new plantations are expected to be established on pasture and cropping land only but the mix differs substantially between NPI regions. Almost all potential new plantations in Western Australia and Victoria are projected to be on cropping land. In contrast, in Queensland and New South Wales only pasture land was estimated to be economically viable for conversion to plantation. This can be attributed largely to the dominant agricultural land uses in each state but also to relative land prices for various agricultural activities in each region. For example, low-value cropping land is abundant in Western Australia and Central Victoria but higher land prices prevent conversion of other agricultural land—such as modified pasture, irrigated cropland and sugarcane land.

The estimated area of new plantation establishment is small relative to the total area of cleared agricultural land available (Figure 14). For example, less than 1.3 per cent of cleared agricultural land in North Queensland is economically viable for new plantation establishment. For other regions the proportion is even smaller. Therefore, for all NPI regions any expansion of the plantation estate is expected to have a negligible impact on current agricultural production or land prices.

Figure 14 New plantation area and available agricultural land by NPI region and land use, base case, 2050



NPI National Plantation Inventory.
Note: Plantations are projected to be established in the Victorian part of Green Triangle region only.

Transport costs, land prices and growth rates

Agricultural areas that are economically viable for conversion to plantation tend to have high tree growth rates, low land prices (or agricultural returns) and proximity to existing wood-processing or port facilities. For the base case, land values for potential new plantation areas ranged from $1,090 to $5,092 per hectare. The average land value across all potential sites was $2,906 per hectare (Table 3). Average values varied considerably across NPI region. The lowest average land values were in North Queensland ($2,078 per hectare) and South East Queensland ($1,882 per hectare) while Green Triangle had the highest values (over $5,000 per hectare).

The average effective distance from potential new plantation areas to wood-processing or export facilities ranged from 35 kilometres to 214 kilometres. Average distance across all potential sites was 99 kilometres. New plantation areas in South East Queensland and Central Victoria tended to be further from wood-processing or export facilities. Average distances for South East Queensland were 153 kilometres and for Central Victoria 151 kilometres. New plantation areas were relatively close to export and processing facilities in Western Australia (38 kilometres) and the Green Triangle (41 kilometres).

Table 3 Characteristics of new plantation areas by NPI region, base case

NPI region	Area in 2050 (ha)	Average land value ($/ha)	Average distance (km) a	Average MAI (m^3/yr) b
North Queensland	9,471	2,078	100	25.8
South East Queensland	3,685	1,877	153	18.1
Western Australia	4,773	2,900	38	30.0
Central Victoria	5,872	3,487	151	26.1
Green Triangle	4,054	5,088	41	30.0
East Gippsland-Bombala	926	2,260	113	26.0
All	**28,782**	**2,906**	**99**	**26.2**

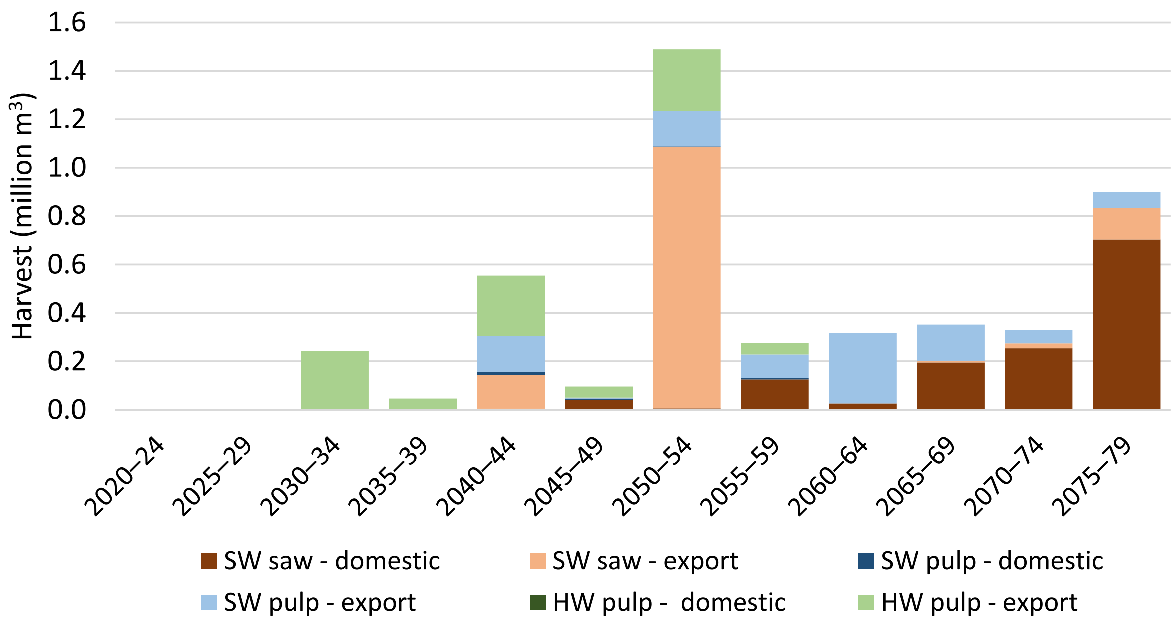
a Average 'effective' distance from new plantation areas to wood-processing or export facilities. Effective distance is equal to dual carriageway–equivalent distance. **b** Average mean annual increments are for identified new plantation areas. **MAI** mean annual increment. **NPI** National Plantation Inventory.

Tree growth rates for potential new plantation areas ranged from 15.5 cubic metres to 30 cubic metres per year, averaging 26.2 cubic metres per year across all potential areas. New plantation areas in Western Australia and the Green Triangle were the highest yielding, averaging 30 cubic metres per year. Growth rates for new plantation areas in South East Queensland were the lowest yielding, averaging 18.1 cubic metres per year.

Potential log harvest from new plantations

Log production from potential new plantation establishment is expected to peak at around 1.5 million cubic metres per year, when southern pine plantations in North Queensland reach maturity and hardwood plantations in Western Australia reach the end of their third rotation (Figure 15). However, total harvest is estimated to be much lower in other periods—ranging from 46,186 cubic metres to 899,087cubic metres per year (see Table B2).

Figure 15 Potential logs harvested from new plantation areas, base case, 2020 to 2079



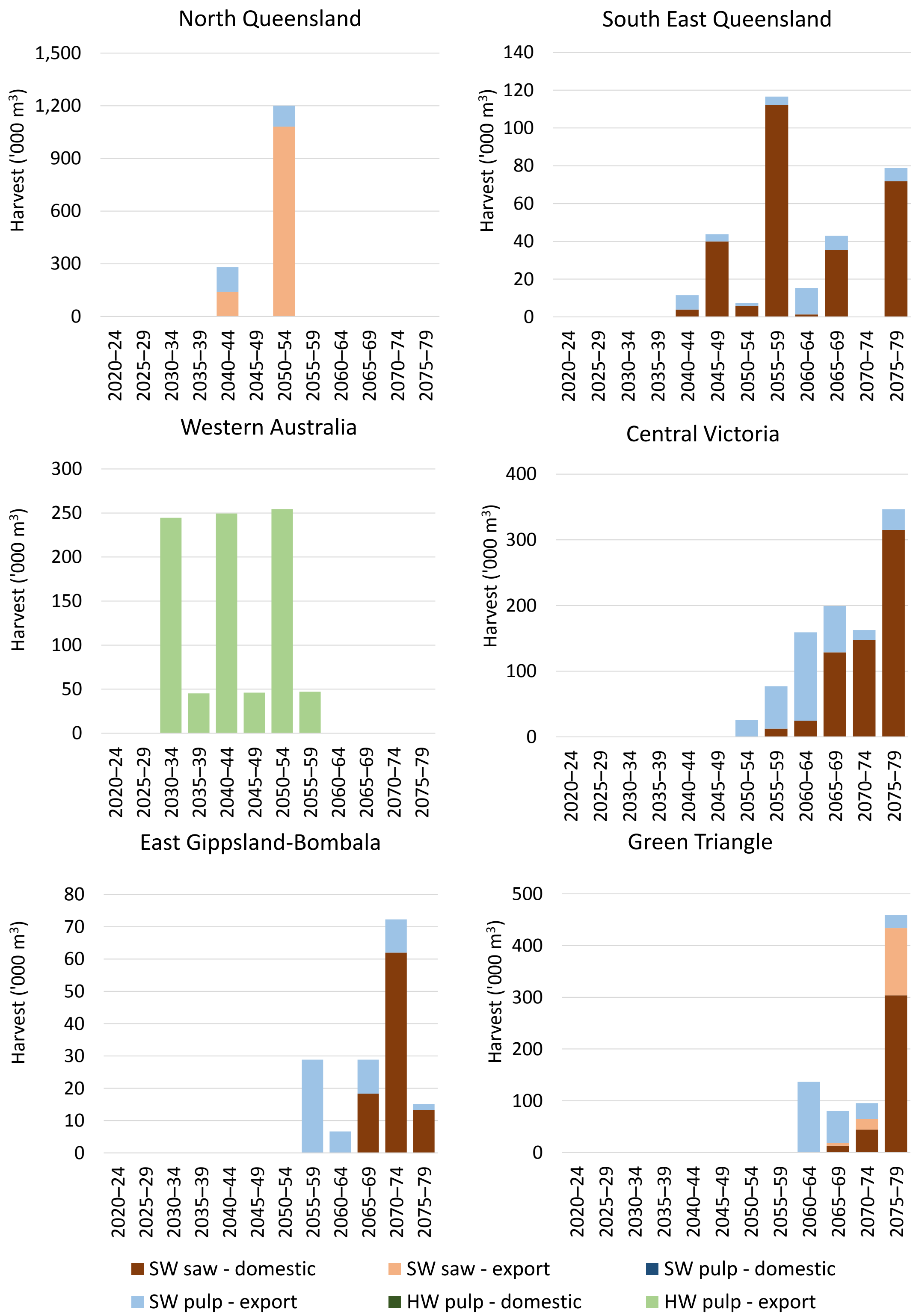
HW Hardwood. **SW** Softwood.

Around 920,440 cubic metres of softwood sawlogs are projected to be harvested from the new plantation estate before 2050, with only around a quarter of these logs (219,690 cubic metres) being sold into the domestic market Figure 15. This will likely be insufficient to meet growing domestic demand for softwood sawnwood and, as a result, ABARES estimates that the volume of softwood sawnwood imports will more than double from 560,215 cubic metres per year in 2020 to around 1.15 million cubic metres per year in 2050.

However, the proportion of logs projected to be sold into the domestic market differs significantly by NPI region and over time (Figure 16). For example, modelling results suggest that all sawlogs harvested from new plantations in New South Wales (East Gippsland–Bombala), Central Victoria and South East Queensland will be sold exclusively into the domestic market, but all logs harvested from new plantations in North Queensland will be exported as roundwood. The North Queensland bias towards exports is due to limited domestic wood-processing capacity within an economically viable distance of new plantation areas combined with favourable sawlog export prices.

In contrast, around 757,200 cubic metres of hardwood and softwood pulplogs are projected to be harvested prior to 2050, almost exclusively exported as roundwood or woodchips. This is consistent with current practice for hardwood pulplogs—because demand in Australia is limited—and with increases in softwood woodchip exports observed since 2013–14.

Figure 16 Logs harvested from new plantation areas by NPI region, base case, 2020 to 2079



NPI National Plantation Inventory. **HW** hardwood. **SW** softwood.

4 Sensitivity analysis for key parameters and assumptions

The base case results suggest that the potential area of new plantation establishment will be limited if current economic and policy conditions persist. However, these results are highly dependent on a range of assumptions affecting relative returns for timber plantations. The sensitivity analyses presented in this section provide an indication of the potential extent of plantation establishment under other plausible assumptions (Table 4) and highlight the importance of various factors in driving or impeding establishment rates at the national level. Estimates of new plantation area in 2050, by NPI region, are presented for all scenarios in Table B3.

Table 4 Summary of sensitivity analysis

Sensitivity analysis	Base case assumptions	Sensitivity analysis assumptions
Productivity improvements	New plantation growth rates are assumed to increase by 1 per cent every five years.	New plantation growth rates of 2 per cent and 3 per cent every five years.
Agricultural land price	Based on reported land values from ABARES farm surveys.	An immediate reduction in agricultural land prices of 15 per cent and 30 per cent.
Demand for wood products	See Table 1 for demand for broad commodities.	Increases of 15 per cent and 30 per cent in demand for wood products (over base case growth) by 2050.
Exchange rate	See Table A10 for export and import prices.	Immediate decreases of 5 per cent and 10 per cent in the exchange rate, resulting in a proportional increase in international prices for wood products (when expressed in Australian dollars).
Required rate of return (discount rate)	7 per cent	Discount rates of 5 per cent and 6 per cent.

The results presented in this section are only indicative of the potential area of agricultural land that could economically be converted to plantations and not necessarily representative of the trajectory that the plantation sector will take. ABARES and Forest & Wood Products Australia are currently undertaking research into the viability of alternative uses of wood residues, such as biofuel and bioenergy. For this reason, they have not been included in the sensitivity analyses.

Key findings

- Higher forest growth rates of 3 per cent every five years increased the estimated potential area of new hardwood plantations in 2050 to 68,682 hectares and the potential area of new softwood plantations in 2050 to 99,245 hectares. However, a large portion of these areas are not expected to become viable until after 2045, having little impact on log availability before 2055.
- Agricultural land prices were found to be a potential barrier to the establishment of new plantations in National Plantation Inventory regions with a 30 per cent reduction in land prices increasing the potential area of new hardwood and softwood plantations in 2050 to 83,928 hectares and 117,017 hectares, respectively. A decrease in land prices was found to improve the viability of higher value land close to port and processing facilities. This had a substantial impact on the types of agricultural land that could be viable for plantation establishment.
- Holding prices constant, a 30 per cent increase in future demand for wood products was estimated to increase the potential area of new softwood plantations in 2050 to 157,722 hectares, but had no effect on the potential area of new hardwood plantations.

Similar to the base case, ABARES found that the log availability shortfall would likely be met through a combination of new plantation establishment, redirection of exports to the domestic market, and increased imports of final wood products.

- Decreases in the value of the Australian dollar had a relatively large impact on potential plantation establishment, highlighting the exposure of the industry to international markets. A 10 per cent reduction in the value of the Australian dollar was estimated to increase the potential area of new hardwood plantations in 2050 to 86,798 hectares and the potential area of new softwood plantations in 2050 to 180,463. A lower Australian dollar was found to not only promote exports of Australia's wood products but also increase supply to the domestic market as a result of higher import prices.
- Reductions in the required rate of return for forestry projects had the largest impact on new plantation establishment of all the parameters considered. The forestry industry is particularly sensitive to changes in discount rates due to long periods between investment outlays and returns. A two per cent reduction in the required rate of return for forestry projects (a 5 per cent discount rate) was estimated to increase the potential area of new softwood plantations in 2050 to 723,267 hectares. This is similar to the observed impacts of the softwood forestry agreements of the 1960s, 1970s and 1980s. In comparison, the potential area of new hardwood plantations in 2050 was estimated to increase to 261,221 hectares, reflecting the shorter rotation length for hardwood plantations managed for pulplogs.

Productivity improvements

Plantation yields are higher than those for native forests because of intensive management techniques and selective breeding. Under the base case, it is assumed that growth rates for new plantations improve at a rate of 1 per cent every five years. Further improvements in these techniques and the genetic stock can allow future conversion of land that was otherwise economically unviable (for example, due to high land prices).

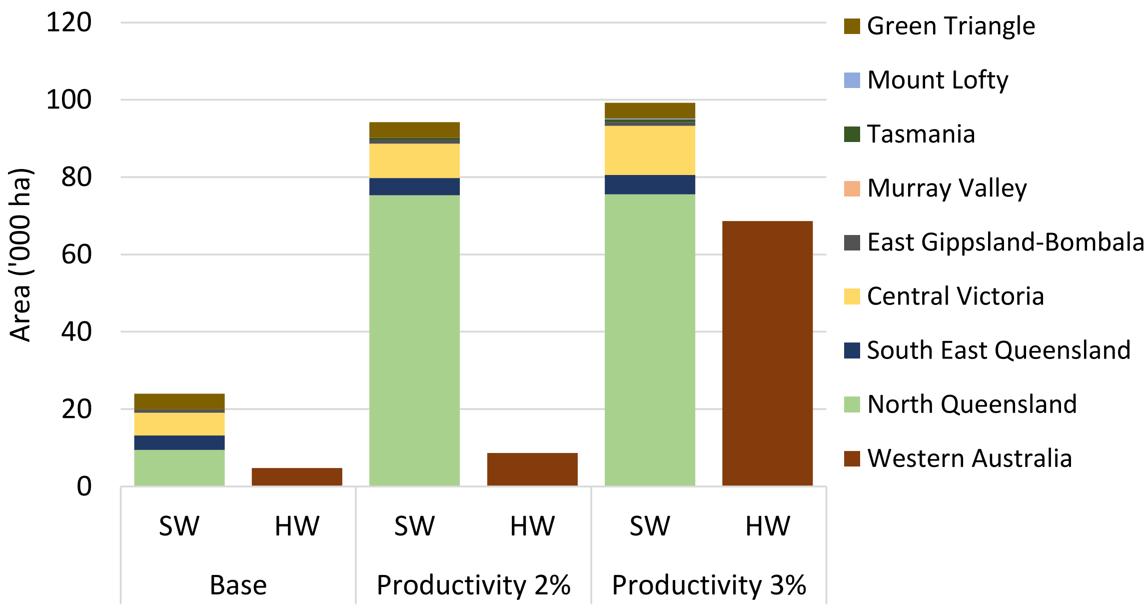
This section explores impacts of increased growth rates over time by considering higher rates of improvement—2 per cent and 3 per cent every five years. ABARES assumed that improvements in yield apply to new plantations only and from the time of establishment. Therefore, plantations established in 2050 will have higher yields than those established in 2020.

ABARES found that productivity improvement rates of 2 per cent every five years could increase the potential area of new softwood plantations in 2050 from 24,009 hectares to 94,221 hectares but have little impact on the potential area of new hardwood plantations (Figure 17). Increasing the rate of improvement to 3 per cent encouraged only an additional 5,024 hectares of softwood plantations but increased the area of new hardwood plantations in 2050 from 8,676 hectares to 68,682 hectares.

Higher rates of productivity improvement are expected to have little effect on the area of plantations established before 2045 (Figure 18). For example, under the 3 per cent productivity scenario only around 30,180 hectares of new plantations are expected to be established by 2044 (See Table B4). However, from 2045 to 2049 establishment rates are expected to be around 36,000 hectares per year, bringing the total area of new plantations in 2050 to 167,927 hectares.

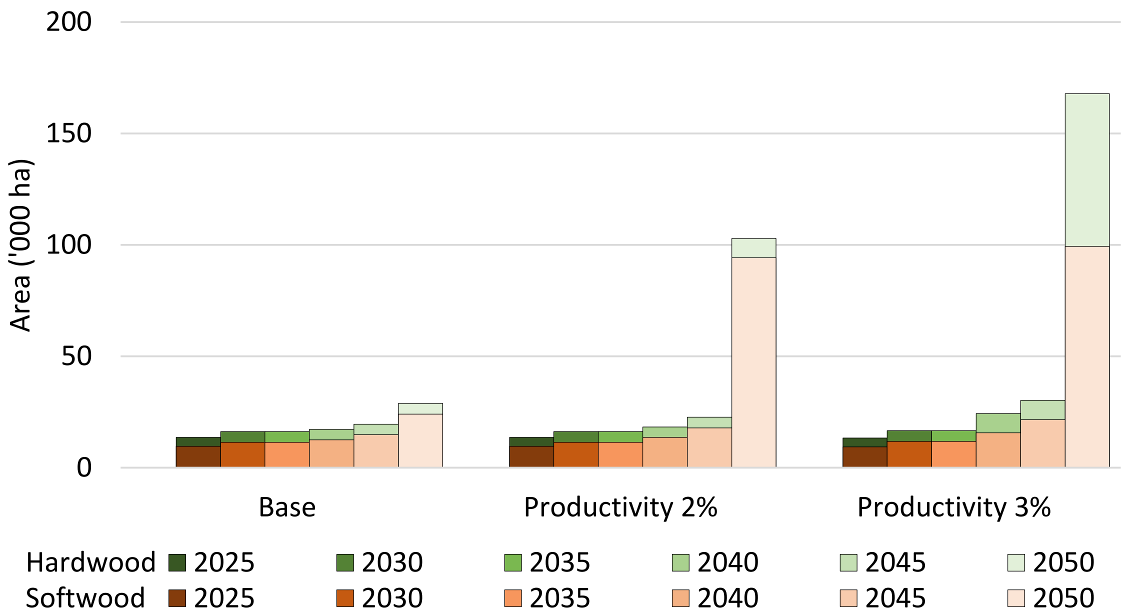
Improvements in forest growth rates allow establishment of plantations on land that would otherwise be economically unviable. Land may be unviable because land prices are too high, yields are too low or transport distances too far. Regardless, yield improvements have a positive effect on profitability.

Figure 17 New plantation area by NPI region, base case and productivity scenarios, 2050



NPI National Plantation Inventory. HW Hardwood. **SW** Softwood.
Note: Base case assumes a 1 per cent increase in yield every five years.

Figure 18 Cumulative new plantation area over time, base case and productivity scenarios, 2025 to 2050



Note: Base case assumes a 1 per cent increase in yield every five years. Data are for calendar years.

Table 5 presents land price, average distance transported to processing or ports and mean annual increments (MAIs) for areas of land converted to plantation under the base case and for additional areas converted under the 2 per cent and 3 per cent productivity scenarios. The additional area established under the 2 per cent productivity scenarios refers to the areas that are additional to those under the base case, and the additional areas established under the 3 per cent productivity scenario refers to areas that are additional to those under the 2 per cent productivity scenario.

Table 5 Characteristics of new plantation area, base case and productivity scenarios

Species	Variable	Unit	Base case	2% productivity scenario a	3% productivity scenario b
Softwood	Additional area in 2050	ha	24,009	70,213	5,024
	Average price for additional land	$	2,907	4,107	3,189
	Average distance for additional land	km	112	86	160
	Average MAI for additional land **c**	m^3	25.4	25.2	24.5
Hardwood	Additional area in 2050	ha	4,773	3,903	60,006
	Average price for additional land	$	2,900	2,791	2,616
	Average distance for additional land	km	38	73	79
	Average MAI for additional land **c**	m^3	30.0	30.0	28.4
Total	Additional area in 2050	ha	28,782	74,116	65,030
	Average price for additional land	$	2,906	4,038	2,660
	Average distance for additional land	km	99	85	85
	Average MAI for additional land **c**	m^3	26.2	25.5	28.1

a Plantation area, average price, average distance and average MAI for areas established under the 2% productivity scenario additional to base case. **b** Plantation area, average price, average distance and average MAI for areas established under 3 per cent productivity scenario additional to 2 per cent productivity scenario. **c** Average MAI refers to unadjusted MAI. **MAI** mean annual increment.

Note: Base case assumes a 1 per cent increase in yield every five years.

For softwood plantations, higher yields make establishment of new plantations on higher value agricultural land economically viable. For example, the additional areas established under the 2 per cent productivity scenario had an average land price of $4,107 per hectare—over 40 per cent higher than $2,907 per hectare for areas established under the base case. The higher land cost was partially offset by shorter transport distances with an average distance to port or processing facilities of 86 kilometres (rather than 112 kilometres for areas established under the base case). The additional areas established under the 3 per cent productivity scenario had a lower average land price ($3,189 per hectare) than the additional areas established under the 2 per cent productivity scenario but were, on average, much further from port or processing facilities (160 kilometres rather than 86 kilometres).

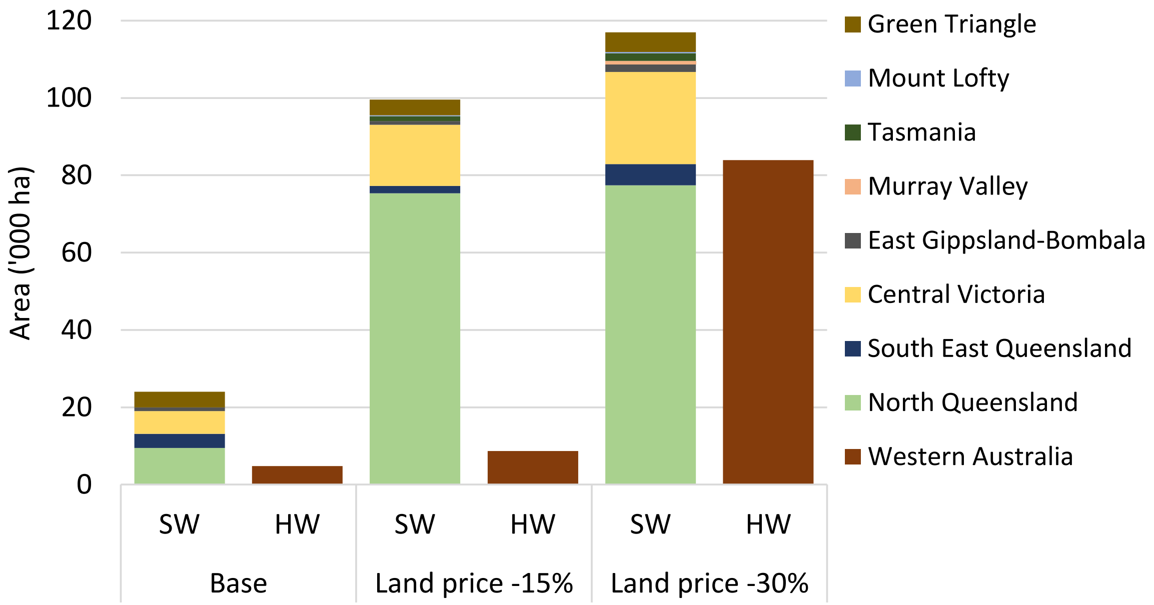
For new hardwood plantations, increased yields make agricultural land area further from port facilities viable for plantation establishment. For example, the additional areas established under the 2 per cent productivity scenario were, on average, 35 kilometres further from port facilities than areas established under the base case. These higher transport costs were partially offset by lower land prices with the average land price being $2,791 per hectare (rather than $2,900 per hectare for areas established under the base case). The additional areas established under the 3 per cent productivity scenario were, on average, only 6 kilometres further from port facilities than the additional areas established under the 2 per cent productivity scenario, but were also lower in value with an average price of $2,660 per hectare.

Agricultural land prices

Potential income from agricultural production represents a major opportunity cost of establishing new plantations on agricultural land. Therefore, high agricultural land prices (or high agricultural returns) are often considered a major barrier to new plantation establishment. ABARES ran two scenarios to examine the potential effect of agricultural land prices on potential area of new plantation establishment—the first assumed an immediate 15 per cent decrease in land prices and the second an immediate 30 per cent decrease. ABARES assumed no flow-on effects to the area of existing forests and plantations. However, in practice higher agricultural land prices may discourage replanting of existing plantations and lead to a reduction in the existing estate. This could have implications for new plantation establishment.

ABARES estimates show that lower land prices could noticeably affect the potential area of new plantation established (Figure 19). A 15 per cent reduction in land prices was estimated to increase the potential area of new plantations established by 2050 to 108,273 hectares—consisting of 99,597 hectares of new softwood plantations and 8,676 hectares of new hardwood plantations (see Table B5). A 30 per cent reduction in land prices was estimated to increase the potential area of new plantations by 2050 to 200,944 hectares—consisting of 117,016 hectares of new softwood plantations and 83,928 hectares of new hardwood plantations.

Figure 19 New plantation area by NPI region, base case agricultural land price scenarios, 2050



NPI National Plantation Inventory. HW Hardwood. **SW** Softwood.

These findings also suggest that improvements in plantation profitability through decreases in land prices could have a much larger impact on the potentially viable area of new plantations in some regions over others. For example, decreases in land prices had little effect on the potential area of new plantations established outside of Queensland, Western Australia and Central Victoria. This may be because more marginally profitable agricultural land within an economically viable distance of wood-processing or export facilities is available in these regions. However, it could also suggest that factors other than plantation profitability (such as wood processing capacity constraints and access to markets) could be more important in preventing new plantation areas from being established.

Discounted land prices (like yield increases) allow new plantations to be established on agricultural land that otherwise would be economically unviable. Table 6 presents land price, distance transported and MAI for areas of land converted to plantation under base case and for the additional areas converted under the 15 per cent and 30 per cent land price scenarios. The additional area established under the 15 per cent land price scenario refers to the areas that are additional to those under the base case, and the additional areas established under the 30 per cent productivity scenario refers to areas that are additional to those under the 15 per cent land price scenario.

Table 6 Characteristics of new plantation areas, base case and land price scenarios

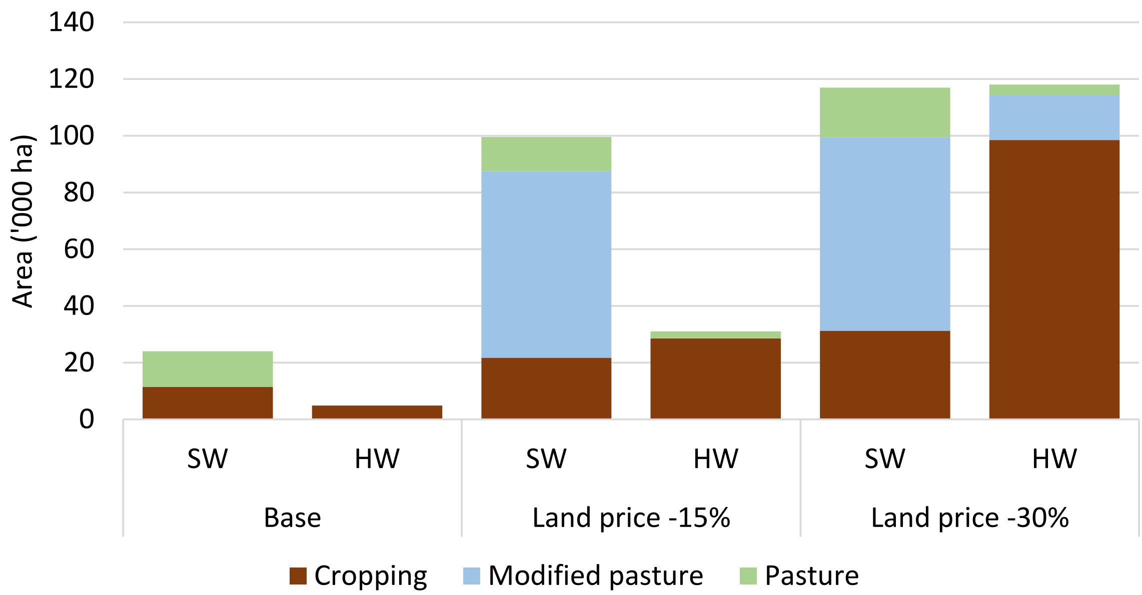
Species	Variable	Unit	Base case	15% land price scenario a	30% land price scenario b
Softwood	Additional area in 2050	ha	24,009	75,589	17,419
	Average price for additional land	$	2,907	3,476	2,874
	Average distance for additional land	km	112	91	135
	Average MAI for additional land **c**	m^3	25.4	25.5	24.8
Hardwood	Additional area in 2050	ha	4,773	3,903	75,252
	Average price for additional land	$	2,900	2,372	2,106
	Average distance for additional land	km	38	73	68
	Average MAI for additional land **c**	m^3	30.0	30.0	28.0
Total	Additional area in 2050	ha	28,782	79,492	92,671
	Average price for additional land	$	2,906	3,422	2,251
	Average distance for additional land	km	99	90	81
	Average MAI for additional land **c**	m^3	26.2	25.7	27.4

a Plantation area, average price, average distance and average MAI for areas established under the 15 per cent land price scenario that are additional to the base case. **b** Plantation area, average price, average distance and average MAI for areas established under the 30 per cent land price scenario additional to the 15 per cent land price scenario. **c** Average price refers to adjusted land price accounting for the assumed discount in agricultural land prices. **MAI** mean annual increment.

For softwood plantations, discounted agricultural land prices make higher value land economically viable even after accounting for the discount. For example, the additional areas planted under the 15 per cent land price scenario had an average value of $3,476 per hectare (rather than $2,907 per hectare under the base case). Around 87 per cent of the additional plantation area was projected to be established on modified pastures (Figure 20). The higher cost of land (incorporating the assumed 15 per cent discount) was offset by shorter transport distances with the average distance to port or processing facilities being 91 kilometres (rather than 112 kilometres for areas established under the base case). In contrast, the additional plantation areas established under the 30 per cent land price scenario were much lower in value than the additional areas established under the 15 per cent land price scenario and much further from export ports or processing facilities.

For hardwood plantations, discounted agricultural land prices make lower value agricultural land further from export port or processing facilities viable for establishment. For example, the additional areas established under the 15 per cent land price scenario were, on average, 35 kilometres further from port facilities but had an average value of only $2,372 per hectare (rather than $2,900 per hectare under for areas established under the base case). The additional plantation area established under the 30 per cent land price scenario were closer to processing and port facilities and lower in value than the additional plantation areas established under the 15 per cent land price scenario. However, these additional plantation areas also had lower tree growth rates with an average MAI of 28 cubic metres per year (rather than 30 cubic metres per year for the other scenarios).

Figure 20 New plantation area by current agricultural land use, base case and land price scenarios, 2050



HW Hardwood. **SW** Softwood.

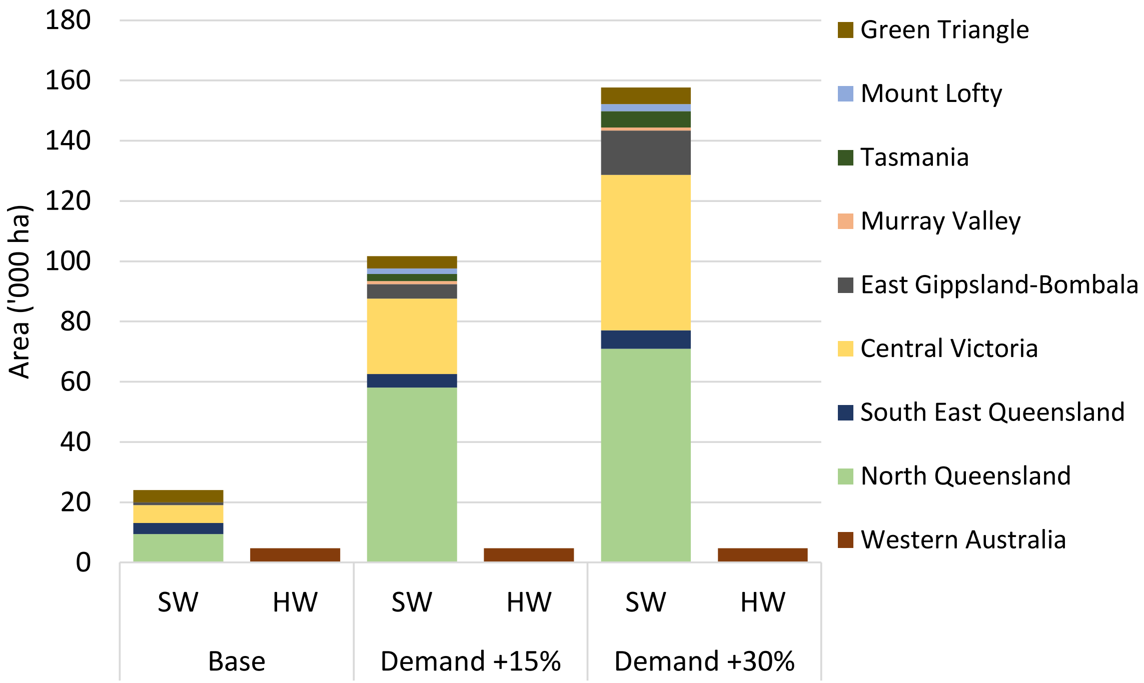
Demand for wood products

Projections of demand for wood products under the base case are only one possible trajectory the industry might take. This section explores the extent of potential new plantation establishment based on a 15 and 30 per cent increase in demand for wood products above the base case.

In developing the scenarios, ABARES applied a uniform proportional increase in domestic demand, over the base case, to all final wood products. A proportional increase in domestic demand for final wood products creates additional opportunities for new plantation investment in areas where regional demand was previously a constraining factor under the base case. Where regional demand for final wood products is fully met by regional supply under the base case, an increase in demand simply allows more logs to be processed, where the growers receive a higher return. If processing capacity is the constraining factor, then an increase in demand for final wood products can provide the necessary economies of scale to justify investment in new processing facilities needed to accept logs from new plantations. Financial returns to selling logs into the regional market may exceed the returns to selling into the export market for a number of reasons including differences in transport costs, the efficiency of regional processing facilities, and differences in prices received in export and regional markets.

ABARES estimates show that the potential area of new hardwood plantations is unaffected by increases in domestic demand (Figure 21). This is because logs harvested from hardwood plantations are almost exclusively exported as roundwood logs or woodchips. This is not the case for softwood plantations, where increases in domestic demand have an impact on the area of new plantations established. In the case of a 15 per cent increase in demand by 2050, the total potential area of new softwood plantations established by 2050 increased to 101,661 hectares (see Table B6). The effects of higher domestic demand were proportionally smaller for a 30 per cent increase in demand—with the area of new softwood plantations established by 2050 increasing to 157,722 hectares.

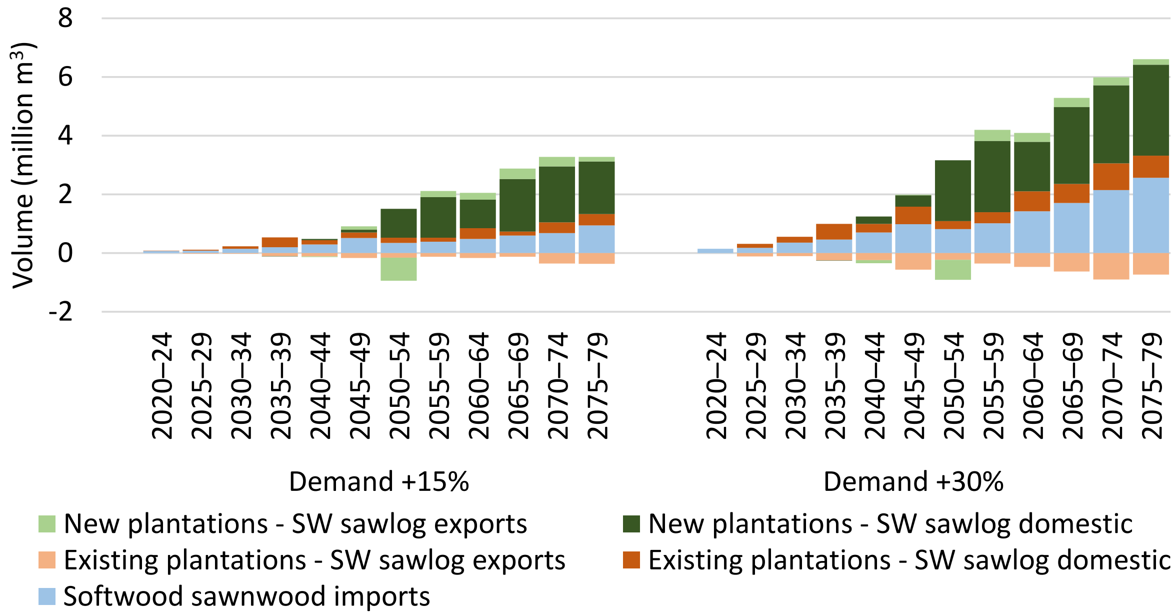
Figure 21 New plantation area by NPI region, base case and demand scenarios, 2050



NPI National Plantation Inventory. **HW** Hardwood. **SW** Softwood.

As expected, sawlogs harvested from the additional softwood plantation areas are primarily sold into the domestic market as their establishment is driven by an increase in domestic demand (Figure 22). However, the estimated volume of logs harvested from new plantation areas will be insufficient to cover increases in demand under the higher demand scenarios. The remaining domestic log availability shortfall is met through a combination of softwood sawnwood imports and redirection of log exports to the domestic market (assuming that exported logs are suitable for domestic processing). For example, over the period 2020 to 2079, a 15 per cent increase in domestic demand is estimated to increase softwood sawnwood imports by between 70,407 and 935,354 cubic metres per year, relative to the base case, and reduce log exports from the existing estate by between 20,472 and 370,887 cubic metres per year. Over the same period, a 30 per cent increase in domestic demand is estimated to increase imports of softwood sawnwood by between 141,495 and 2.56 million cubic metres per year and reduce log exports from the existing estate by between 109,938 and 897,028 cubic metres per year.

Figure 22 Change in softwood sawlog harvest and imports of sawnwood from base case, demand scenarios, 2020 to 2079



HW Hardwood. **SW** Softwood.

In both scenarios, some newly established plantation areas still export a small portion of harvested sawlogs For example, under the 15 per cent increase in domestic demand scenario an additional 584,138 cubic metres of sawlogs are exported from new plantation areas over the period 2020 to 2079, and under the 30 per cent increase in domestic demand scenario an additional 687,766 cubic metres of sawlogs are exported. This is due to limited domestic processing capacity in some regions and more favourable returns in the export market.

Exchange rate

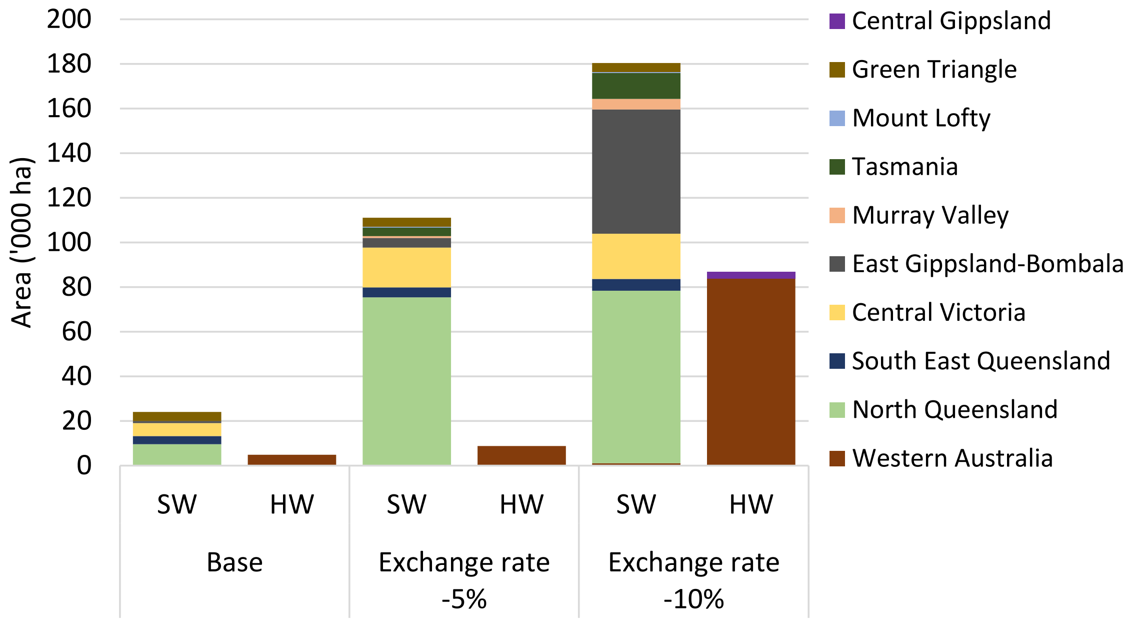
A large proportion of Australia's wood products are exported every year. As such, changes in the exchange rate can have potentially large impacts on industry profitability and composition of imports and exports. For example, a decrease in the value of the Australia dollar against the US dollar increases prices received for exported goods and prices paid for imported goods. This favours domestic production and potential new plantation investment.

All trade price data used in FORUM is reported in Australian dollars. Therefore, no explicit assumptions on the exchange rate are made in FORUM. The implied exchange rate under the base case is based on the average exchange rate for the input data collection period. This varies across inputs. For example, trade prices are based on an average of eight years of data and domestic prices are based on more recent data. Changes in the implied exchange rate are implemented in FORUM through proportional changes in the assumed export and import prices and investment costs. Domestic prices are assumed to remain fixed.

The effects of changes in the exchange rate on agricultural land prices were not considered in this analysis. In practice, exchange rate decreases are likely to positively affect agricultural returns and therefore land prices—given that a large proportion of agricultural production in Australia is exported. Profit margins for wood products and agricultural returns are small, so even moderate exchange rate changes can have large effects on agricultural returns.

A 5 per cent decrease in the value of the Australian dollar against the US dollar was estimated to increase the total potential area of new plantation establishment in 2050 from 28,782 hectares to 119,733 hectares, and a 10 per cent decrease in the exchange rate increased the total potential area to 267,260 hectares (Figure 23). Small exchange rate changes had a positive effect on investment in new softwood plantation establishment. For example, the softwood estate increased by 87,049 hectares in response to a 5 per cent decrease (see Table B7). In contrast, investment in hardwood plantations was only responsive to a larger exchange rate fall of 10 per cent.

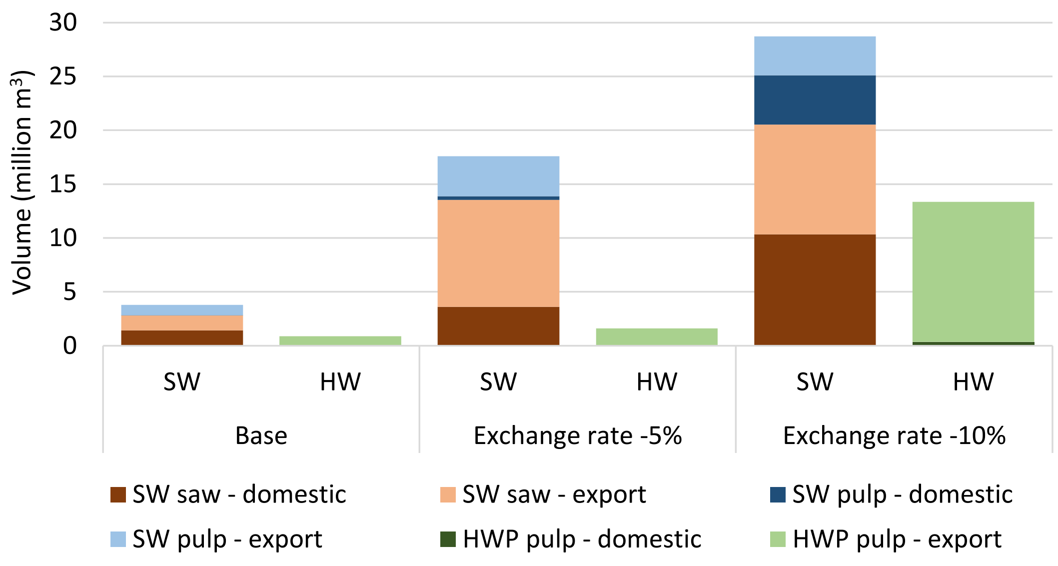
Figure 23 New plantation area by NPI region, base case and exchange rate scenarios, 2050



NPI **National Plantation Inventory. HW** Hardwood. **SW** Softwood.

Overall, investment in new softwood plantations was more responsive to exchange rate changes than investment in new hardwood plantations. Hardwood plantations are primarily established for woodchip exports, but many logs from softwood plantations are also exported or processed into final products for export. An exchange rate fall also increases the price of imports, making domestic production more cost effective than imports. For this reason, larger exchange rate decreases have a positive effect on domestic log processing (Figure 24).

Figure 24 Log harvest from new plantation estate by market, base case and exchange rate scenario, 2030 to 2080



HW Hardwood. **SW** Softwood.

Required rate of return

Long investment periods and high risk are often cited as major barriers to new plantation investment in Australia (House of Representatives Standing Committee on Agriculture, Fisheries and Forestry 2011). The discount rate or required rate of return is the rate used to convert future costs and revenues into present dollars. It accounts for risk associated with future costs and revenue as well as the time-value of money. Therefore, a reduction in the discount rate could reflect a reduction in perceived risk of plantation or mill investment or lower interest rates.

Under the base case, ABARES applied a real pre-tax discount rate of 7 per cent to all future returns and costs associated with timber plantations and wood-processing investment projects. This is broadly consistent with the discount rates reported by state forest corporations (Table 7) and the discount rate for public projects recommended by the Australian Government Office of Best Practice Regulation (Australian Government 2016). ABARES ran two scenarios (discount rates of 5 per cent and 6 per cent) to assess the sensitivity of potential plantation investment to the assumed discount rate.

Table 7 Discount rates used in forestry, 2014–15

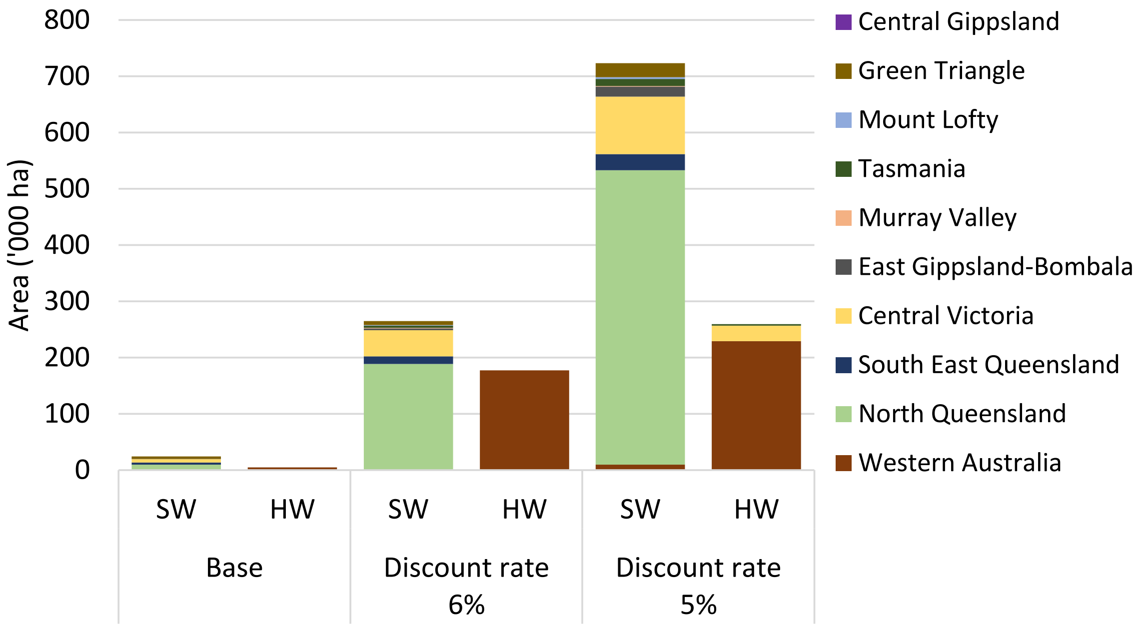
Organisation	Discount rate
Forestry Tasmania	8.4
Forestry Corporation of NSW	7.5
VicForests	7.7
ForestrySA	8.5
Forest Products Commission	9.5

Sources: FPC 2016; Forestry Corporation 2016; ForestrySA 2016; Forestry Tasmania 2016; VicForests 2016

In changing the assumed discount rate ABARES did not account for changes in incentives for foreign investment in Australia, due to interest rate differences between countries, or for potential flow-on effects to exchange rates or land prices. For this reason, the changes in discount rates modelled in this report are consistent with changes in the perceived risk associated with forestry returns rather than economy-wide lending rates (interest rates).

ABARES estimates indicate that even small changes in the assumed discount rate have a large effect on the projected area of new plantation established over the modelling period (Figure 25). For example, reducing the discount rate from 7 per cent to 6 per cent increased the total potential area of new plantations from 28,782 hectares to 441,952 hectares. Around 60 per cent of the area (264,520 hectares) consists of softwood species and the remainder (177,432 hectares) short-rotation blue gum (see Table B8). Most new softwood plantation establishment is in North Queensland, and new hardwood plantations continue to be economically viable almost exclusively in Western Australia. Further reductions in the discount rate result in substantial increases in the total potential new plantation area but are more favourable to softwood species. For example, an assumed discount rate of 5 per cent increases the total potential plantation area to 984,488 hectares with around three-quarters being softwood species.

Figure 25 New plantation area by NPI region, base case and discount rate scenarios, 2050



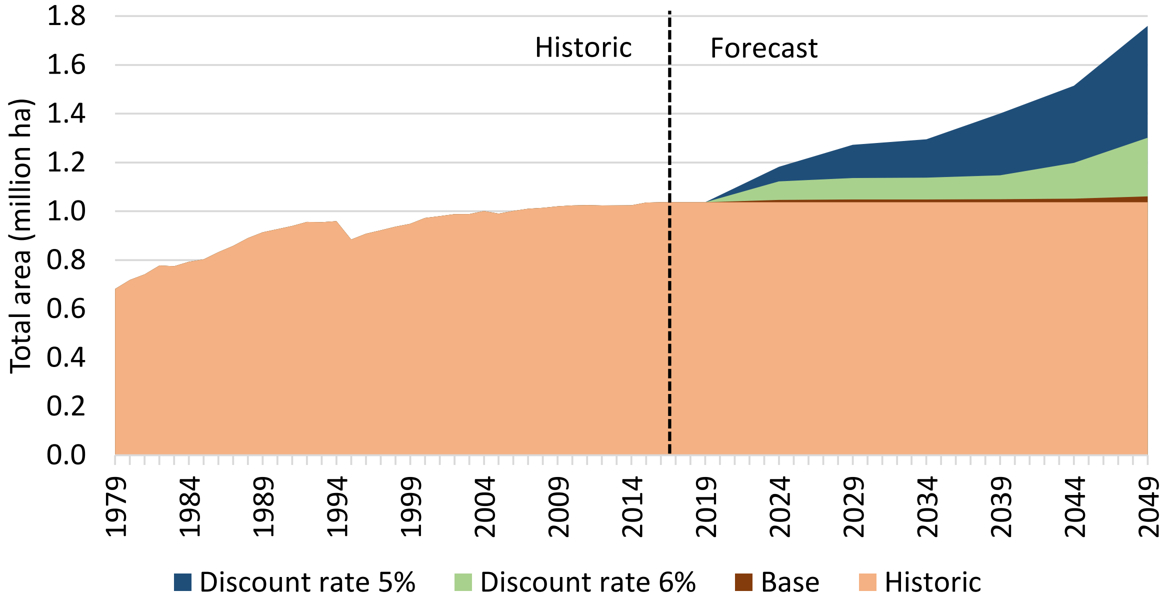
NPI National Plantation Inventory. HW Hardwood. **SW** Softwood.
Note: Base case assumes a universal discount rate of 7 per cent.

Lowering the discount rate has a proportionally larger impact on the viability of softwood species compared with hardwood species because softwood plantations managed for sawlogs have much longer rotation lengths and therefore pay-off periods. The effect of the discount rate on profitability increases with pay-off period due to compounding. For example, a 1 per cent reduction in the discount rate increases the present value of log harvest revenues in 30 years by a third but increases the present value of log harvest revenues in 15 years by only 15 per cent.

For the same reason, lowering the discount rate has the largest impact on the profitability of long-rotation hardwood plantations. However, only a small area (2,724 hectares) of long-rotation hardwood plantations is established under a 5 per cent discount rate scenario. This suggests that long-rotation hardwood plantations are simply less profitable given current prices, costs of plantation management and wood-processing capacity.

The forestry sector has long been aware that lower discount rates support investment. The softwood forestry agreements of the 1960s and 1970s provided concessional loans to state governments for establishment of softwood plantations (see Chapter 1). The results presented here suggest that a lower required rate of return for forestry projects could encourage substantial investment in new plantations with the forecasted trajectory of the softwood estate being similar to that observed in the 1960s and 1970s (Figure 26).

Figure 26 Historic and projected softwood plantation area, base case and discount rate scenarios, 1979 to 2049



Note: Base case assumes a universal discount rate of 7 per cent. Data for 1979 to 2016 are for financial years ending. Data for 2017 to 2049 are for calendar years.

Conclusion

Australia's commercial timber plantation estate is fundamental to the sustainability and competitiveness of the Australian forestry sector. The Australian commercial timber plantation estate peaked in 2011–12 at 2.02 million hectares after decades of substantial growth. In 2015–16 it had declined to 1.97 million hectares, leading to questions about future plantation log availability and the forestry sector. In light of this, Forest & Wood Products Australia commissioned ABARES to undertake research into the long-term potential for new timber plantation establishment in Australia.

The total timber plantation area is only a fraction of the native forests area available for wood production (36.6 million hectares in 2011–12) but accounts for the vast majority of Australian log production. In 2015–16 timber plantations produced 86 per cent of total Australian log harvest, and the softwood estate accounted for almost two-thirds of this.

Based on ABARES estimates (Burns et al. 2015), the future availability of hardwood sawlogs from native and plantation forests is sufficient to meet log equivalent domestic demand over the forecast period to 2050. From 2025 to 2050 log availability will exceed domestic demand by between 396,658 and 681,642 cubic metres per year. However, domestic softwood sawlog availability is forecast to fall short of demand over the coming decades, reaching 3.4 million cubic metres per year by 2050.

ABARES estimates that by 2050 establishment of around 28,782 hectares of new plantations will be economically viable under current policy and economic conditions (base case scenario). Potential new plantation establishment rates would be relatively consistent with actual establishment rates observed in recent years. Around 82 per cent (24,009 hectares) of the potential area could be softwood plantations and the remaining 18 per cent (4,773 hectares) hardwood plantations.

ABARES modelling suggests that new softwood plantation establishments could be economically viable under the base case in Queensland, Victoria and New South Wales. In contrast, new short-rotation hardwood plantations were estimated to be economically viable in Western Australia only.

The estimated area of potential new plantations is less than 1.3 per cent of total area of cleared agricultural land in any National Plantation Inventory (NPI) region. For this reason, the impacts of new plantation establishment on agricultural production or land prices will likely be minimal. ABARES modelling suggests that new plantations will likely only be economically viable on unmodified pasture or cropping land because land prices for modified pastures and sugarcane farmland are too high.

A sensitivity analysis with respect to key parameters revealed several potential barriers to and opportunities for new plantation establishment. For example, small increases in tree growth rates over time and reductions in land prices could positively affect the potential economically viable area of new plantations. However, even substantial decreases in land prices were found to be insufficient to encourage new plantation establishment in some NPI regions, indicating that processing capacity constraints and yields may be more important drivers in some specific regions. The most important drivers of new plantation establishment were found to be the exchange rate and required rate of return—highlighting the high degree of trade exposure and long payoff periods that characterise the plantation sector.

Decreases in value of the Australian dollar had a relatively large impact on potential new plantation establishment. A lower Australian dollar not only promotes exports of Australian wood product exports but also increases supply to the domestic market (due to higher import prices).

Reductions in the required rate of return for forestry projects had the largest impact on potential area of new plantation establishment of all the parameters considered. The forestry industry is particularly sensitive to changes in discount rate due to long periods between investment outlays and returns. The estimated impact of a 2 per cent reduction in required rate of return for forestry projects (5 per cent discount rate) on softwood plantation establishment rates was similar to that of the softwood forestry agreements of the 1960s, 1970s and 1980s.

While there are some limitations of the modelling framework used in this research, the analysis in this report highlights some of the key factors that could influence location and degree of new timber plantation establishment over the coming decades. It also highlights potential missed opportunities for the forestry sector, unless there are new policies or drivers to expand the current softwood timber plantation estate to meet growing demand for plantation wood products.

Appendix A: Data and assumptions used in FORUM framework

This appendix presents detail on data and assumptions used in the Forest Resource Use Model (FORUM) framework. Table A1 Data used in FORUM summarises key inputs used in FORUM. For more information on FORUM see Burns et al. (2015).

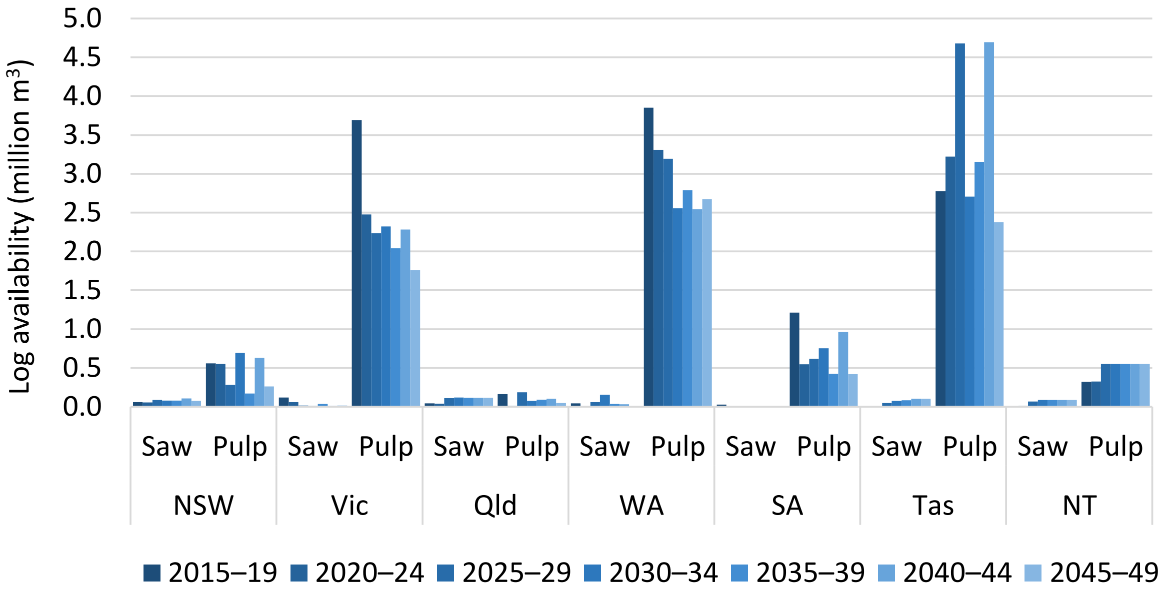
Table A1 Data used in FORUM

Data	Source
Existing forests	
Current native forest area	National Forest Inventory (2015)
Log availability – native forests	Burns et al. (2015)
Current plantation areas	ABARES 2016b
Log availability – plantations	ABARES 2016a
Harvest costs	ABARES Gross Value of Production survey (unpublished) and Burns et al. (2011)
Markets	
Demand for wood products	ABARES econometric models (discussed in this Appendix)
Wood product prices	Domestic prices obtained from industry consultation. Trade prices obtained from ABS trade extracts (unpublished).
Processing infrastructure	
Wood processing infrastructure	Updates of Gavran et al. (2014)
Wood processing investment options	ABARES datasets; ESD Consulting (2005); FFIC (2011); Gunns (2011); IndustryEdge (2012); RISI (2007); URS (2012)
Agriculture and plantation establishment	
Current agricultural land use	ABARES 2016d
Potential growth rates for future plantations (mean annual increment)	CSIRO's Physiological Processes Predicting Growth model, 3-PG2 Spatial, developed by Landsberg & Waring (1997)
Plantation yields	ABARES 2016a
Plantation establishment costs	Matysek & Fisher (2016) and industry consultation
Agricultural land prices	ABARES 2016c
Transport costs and distances	
Road distances between forests, wood processors and markets	ABARES road dataset

Log availability, by state

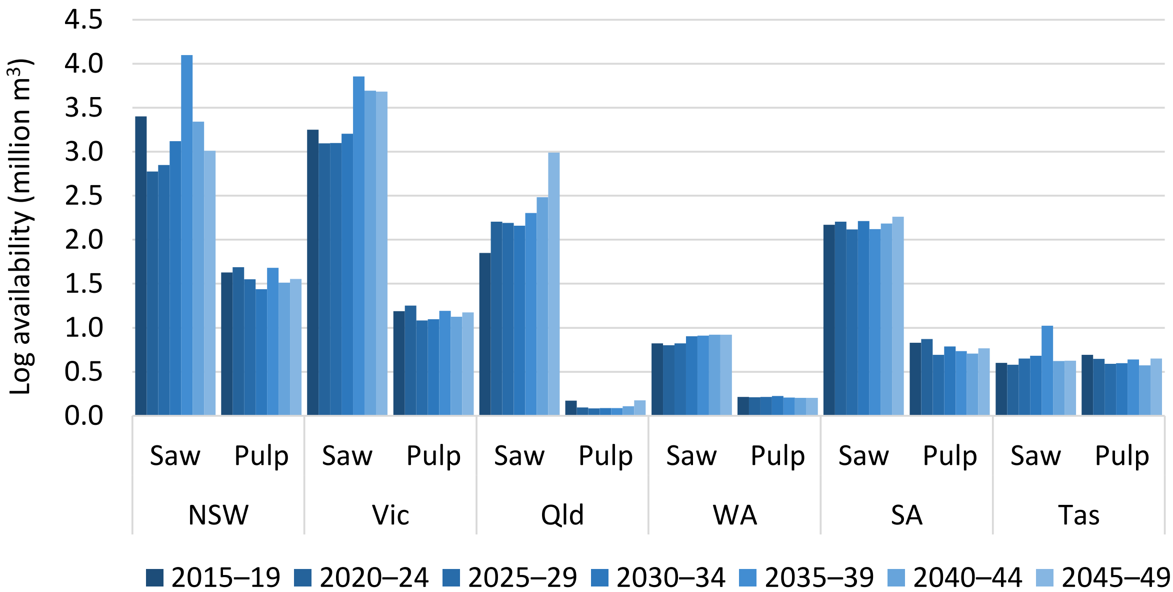
Figure A1, Figure A2 and Figure A3 present estimates of log availability by state, from 2015 to 2049. Tasmania is expected to have the largest volume of plantation hardwood logs available in the period 2015 to 2019, but availability is forecast to decline over time. Softwood sawlog availability is expected to increase in Victoria, Queensland and Western Australia but decline in New South Wales over the period. Native forest sawlog and pulplog availability is forecast to increase in all states except Tasmania. South Australia and the territories are not included in these forecasts because they do not harvest native forests.

Figure A1 Forecasts of hardwood plantation log availability, 2015 to 2049



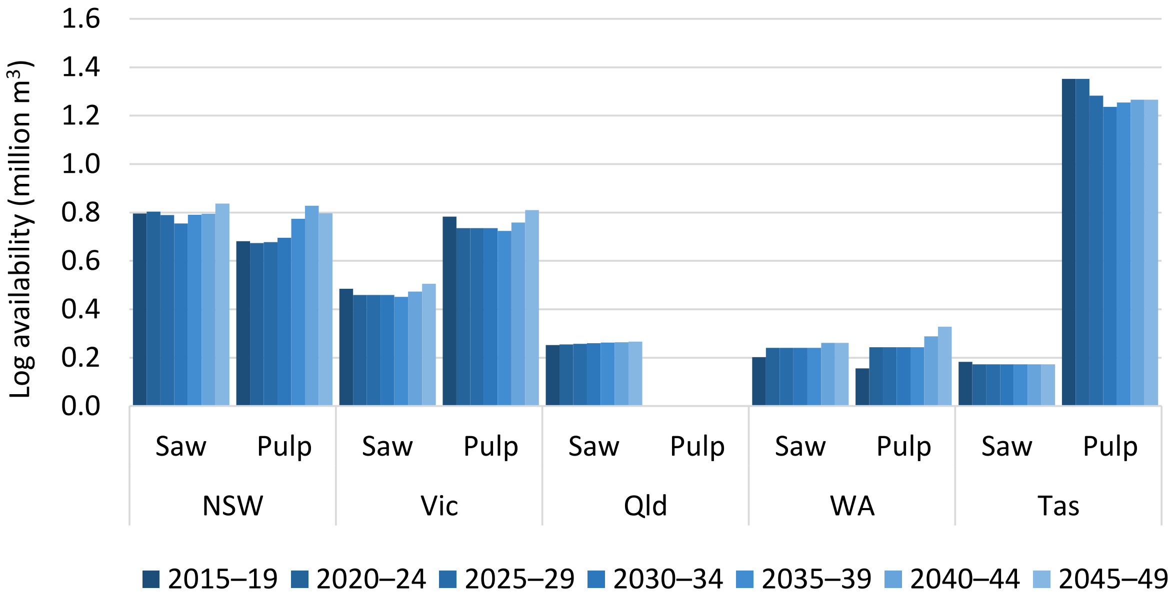
Note: Australian Capital Territory included with New South Wales. Data are for calendar years.

Figure A2 Forecasts of softwood plantation log availability, 2015 to 2049



Note: Australian Capital Territory included with New South Wales. Softwood log availability for the Northern Territory was not forecasted due to the small area planted. Data are for calendar years.

Figure A3 Forecasts of native forest hardwood log availability, 2015 to 2054



Note: Native forests are not harvested in South Australia and the Australian Capital Territory. Cypress pine is not included because it is a native softwood. Data are for calendar years.

Models of demand for wood products

This section presents the econometric models developed by ABARES to forecast demand for sawnwood, wood-based panels and paper and paperboard to 2049–50. The models are based on historic demand, long-term trends and moving average terms. They also use exogenous forecasts of explanatory variables, including real GDP, manufacturing activity and dwelling commencements. During development, diagnostic tests were undertaken to ensure that the models were statistically robust and inform variable selection and transformations.

Forecasts of demand for sawnwood

Softwood

Forecasts of demand for softwood sawnwood are based on a long-term trend, and forecasts of detached dwelling commencements and real GDP. The first difference of the natural logarithm of all variables (excluding the constant term) was taken prior to estimation. As such, the coefficient estimates (Table A2 Coefficient estimates for model of softwood sawnwood demand) represent the percentage growth in demand for softwood sawnwood in response to a 1 per cent increase in the explanatory variable. For example, demand for softwood sawnwood is forecast to increase by 0.48 per cent for every 1 per cent increase in the number of detached dwellings and by 0.46 per cent for every 1 per cent increase in real GDP per capita. The coefficient on the constant term is an estimate of the long-term trend, indicating that per capita demand for softwood sawnwood is expected to fall by 0.3 per cent a year, assuming all else is constant.

Table A2 Coefficient estimates for model of softwood sawnwood demand

Explanatory variable	Coefficient estimate
Constant term	–0.003
Detached dwelling commencements **a**	0.48
Real GDP **a**	0.46

a Coefficient significant at the 1 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of softwood sawnwood demand. The first differences of the natural logarithm of detached dwelling commencements and real GDP were taken prior to estimation. Estimates based on sample size of 36 observations.

Hardwood

In contrast to softwood sawnwood, which is predominantly used in construction, hardwood sawnwood is now used mainly for high-value appearance applications, including flooring, decking, veneers and furniture. For this analysis, demand for hardwood sawnwood was assumed to remain constant at 2015–16 values. This was due to difficulties in measuring the shifts in consumer preferences for appearance products such as hardwood sawnwood. Changing consumer perceptions about the native hardwood industry will affect future demand for hardwood sawnwood.

Forecasts of demand for wood-based panel products

ABARES used econometric models for forecasting demand for medium-density fibreboard (MDF), particleboard and plywood.

MDF

Forecasts of demand for MDF are based on a long-term quadratic trend (including a constant term and a trend term) and past demand for MDF (see Table A3 Coefficient estimates for model of medium-density fibreboard demand). The natural logarithm of demand for MDF was taken prior to estimation such that the coefficient estimates represent percentage changes in demand for MDF. Demand was found to have a strong long-term trend component (growth of 4.59 per cent per year). For every 1 per cent increase in demand in the previous year, demand was forecast to increase by 0.22 per cent. However, forecasts of demand for MDF are highly uncertain due to the small sample size (23 observations).

Table A3 Coefficient estimates for model of medium-density fibreboard demand

Explanatory variable	**Coefficient estimate**
Constant term **a**	4.59
Trend term **b**	0.01
Previous year's demand for MDF	0.22

a Coefficient significant at the 1 per cent level. **b** Coefficient significant at the 5 per cent level.
Note: The dependent variable for the model was the natural logarithm of demand for MDF. The natural logarithm of the previous year's demand for MDF was taken prior to estimation. Estimates based on sample size of 23 observations.

Particleboard

Forecasts of demand for particleboard are based on forecasts of detached and multi-unit dwelling commencements. Moving average terms were included in the model to capture the flow-on impacts of unexpected changes in demand. The first difference of the natural logarithm of all variables (excluding moving average terms) was taken prior to estimation such that the coefficient estimates (see Table A4 Coefficient estimates for model of particleboard demand) represent the percentage growth in demand for particleboard in response to a 1 per cent increase in the explanatory variable. For example, demand for particleboard is forecast to increase by 0.21 per cent for every 1 per cent increase in detached dwelling commencements and 0.28 per cent for every 1 percent increase in multi-unit dwelling commencements. The coefficients on the moving average terms imply that forecasts of future demand are revised upwards in response to unexpected increases in past demand.

Table A4 Coefficient estimates for model of particleboard demand

Explanatory variable	Coefficient a
Detached dwelling commencements	0.21
Multi-unit commencements	0.28
Moving average term of 2 years	0.38
Moving average term of 3 years	0.28
Moving average term of 5 years	0.92

a All coefficients are significant at the 1 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of demand for particleboard. The first differences of the natural logarithm of detached dwelling and multi-unit commencements were taken prior to estimation. Moving average terms refer to the forecast errors from previous years. Estimates based on sample size of 37 observations.

Plywood

Forecasts of demand for plywood are based solely on forecasts of multi-unit dwelling commencements (Table A5). The first differences of the natural logarithm of both variables were taken prior to estimation such that the coefficient estimate (0.65) represents the percentage growth in demand for plywood in response to a 1 percent increase in multi-unit dwelling commencements.

Table A5 Coefficients for forecasting plywood demand

Explanatory variable	Coefficient a
Multi-unit commencements	0.65

a Coefficient is significant at the 1 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of demand for plywood. The first difference of the natural logarithm of multi-unit commencements was taken prior to estimation. Estimates based on sample size of 35 observations.

Forecasts of demand for paper and paperboard

Econometric models were used for forecasting demand for printing and writing paper, and packaging and industrial paper. Forecasts of demand for household and sanitary paper were based solely on a long-term growth rate of 1.8 per cent and forecasts of demand for newsprint were assumed to remain fixed at 2015–16 levels.

Printing and writing paper

Forecasts of demand for printing and writing paper are based on forecasts of manufacturing activity and on past demand for printing and writing paper. A moving average term was included in the model to capture flow-on effects of unexpected past changes in demand. The first difference of the natural logarithm of all variables (excluding the moving average term) was taken prior to estimation such that the coefficient estimates (Table A6) represent the percentage growth in demand for printing and writing paper in response to a 1 per cent increase in the explanatory variable. For example, demand for printing and writing paper is forecast to increase by 3.43 per cent for every 1 per cent increase in manufacturing activity and decrease by 0.08 per cent for every 1 per cent increase in demand from the previous year. The coefficient on the moving average term implies that forecasts of demand for printing and writing paper should be revised downwards for unexpected increases in demand in the past, suggesting a cyclical pattern.

Table A6 Model for forecasting printing and writing paper demand

Explanatory variable	Coefficient
Value of manufacturing activity **a**	3.43
Previous year's demand for printing and writing paper	–0.08
Moving average term of 3 years **a**	–0.92

a Coefficient significant at the 1 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of demand for printing and writing paper. The first differences of the natural logarithm of the value of manufacturing activity and the previous year's demand for printing and writing paper were taken prior to estimation. The moving average term is the forecast error from three years prior. Estimates based on sample size of 35 observations.

Packaging and industrial paper

Forecasts of demand for packaging and industrial paper are based on forecasts of manufacturing activity and past demand. The first differences of the natural logarithm of all variables were taken prior to estimation such that the coefficient estimates (Table A7) represent the percentage growth in demand for packaging and industrial paper in response to a 1 per cent increase in the explanatory variable. For example, demand for packaging and industrial paper is forecast to increase by 1.26 per cent for every 1 per cent increase in manufacturing activity and forecast to decrease by 0.31 per cent for every 1 per cent increase in demand in the previous year, indicating a cyclical pattern.

Table A7 Coefficients for forecasting packaging and industrial paper demand

Explanatory variable	Coefficient
Value of manufacturing activity **a**	1.26
Previous year's demand for packaging and industrial paper **b**	–0.31

a Coefficient significant at the 1 per cent level. **b** Coefficient significant at the 5 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of demand for packaging and industrial paper. The first differences of the natural logarithm of the value of manufacturing activity and the previous year's demand for packaging and industrial paper were taken prior to estimation. Estimates based on sample size of 29 observations.

Forecasts of real GDP, manufacturing and dwelling commencements

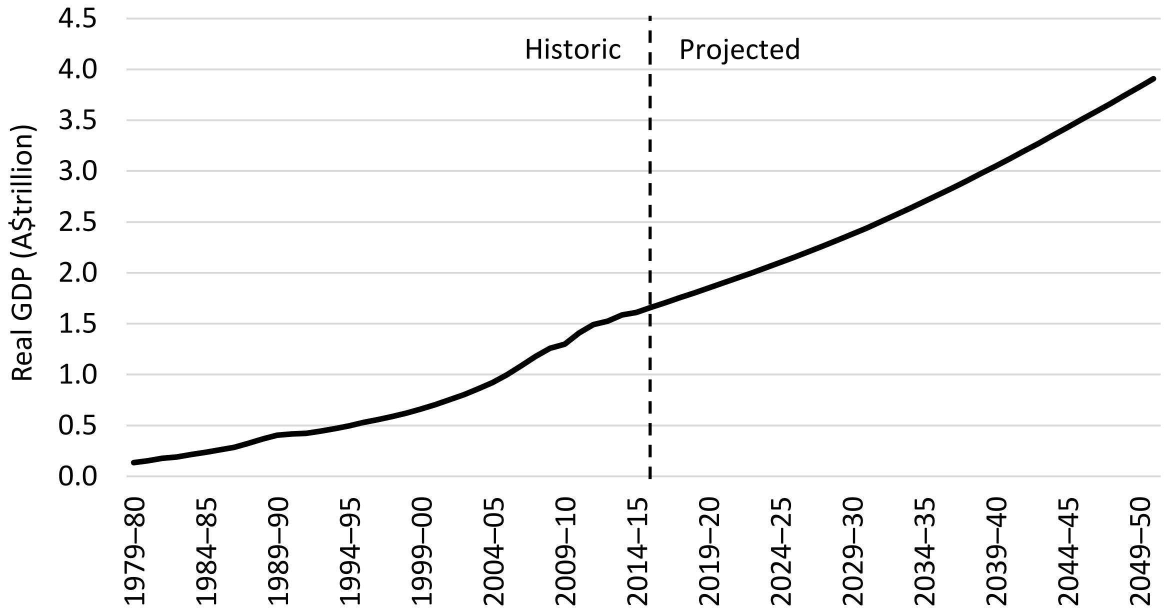
Real GDP

Forecasts of real GDP were based on an estimated quadratic trend and used as a broad measure of economic activity (Figure A4). Real GDP is forecast to increase by around 2.5 per cent per year, on average, over the period 2015–16 to 2049–50.

Dwelling commencements

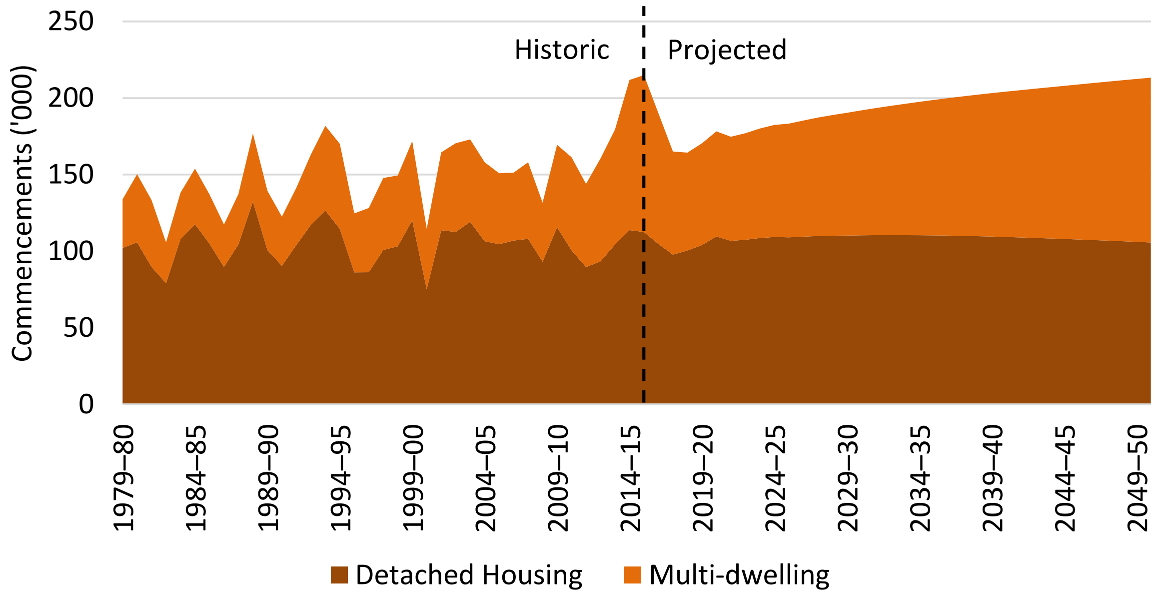
Housing and multi-unit dwelling commencements constitute one of the largest markets for wood products. Forecasts of these commencements are derived using the same method outlined in Gupta et al. (2012) and amended to include the latest available data (Figure A5). The number of detached dwelling commencements is forecast to remain constant over the forecast period, but the number of other multi-unit dwelling commencements is expected to continue to increase.

Figure A4 Historic and forecasted real GDP, 1979–80 to 2049–2050



Source: ABS 2016; ABARES forecasts

Figure A5 Historic and forecasted dwelling commencements, 1979–80 to 2049–2050



Source: ABARES 2017; ABARES forecasts

Manufacturing activity

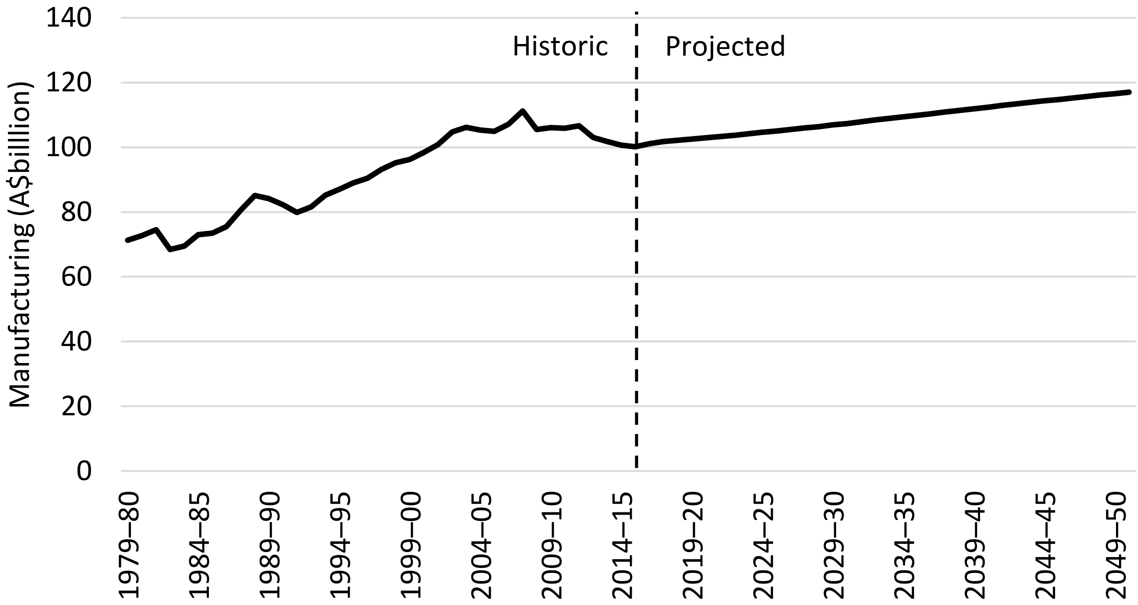
Domestic manufacturing is a key user of paper and packaging products. Forecasts of domestic manufacturing (Figure A6) are based on forecasts of real GDP. The first difference of the natural logarithm of all variables was taken prior to estimation such that the coefficient estimates represent the percentage growth in manufacturing activity in response to a 1 per cent increase in real GDP (Table A8). For example, the value of manufacturing is expected to increase by 0.68 per cent for every 1 per cent increase in real GDP per capita in the same period but decrease by 0.40 per cent for every 1 per cent increase in real GDP per capita from two years prior. These estimates imply that the effects of real GDP on manufacturing are larger in the short term than in the long term.

Table A8 Coefficient estimates for models of Australian manufacturing

Explanatory variable	Coefficient a
Real GDP in current period	0.68
Real GDP of 2 years prior	–0.40

a Coefficient significant at the 1 per cent level.
Note: The dependent variable for the model was the first difference of the natural logarithm of the value of manufacturing activity. The first difference of the logarithm of real GDP was taken prior to estimation. Estimates based on sample size of 34 observations.

Figure A6 Historic and forecasted manufacturing activity in Australia, 1979–80 to 2049–2050



Source: ABS 2016; ABARES forecasts

Wood product prices

There are a large range of wood products available in Australia. Each has specific features, such as structural performance and quality of appearance. Wood products made from different fibres and using alternative technologies can often be substituted with each other or with non-wood products in downstream markets. Nevertheless, analysis of these products requires some degree of aggregation.

Some of these aggregated products cover a relatively wide range of uses and prices. For example, plywood covers a range of structural and appearance applications, using very different log qualities and deriving different prices in final markets. While it would be preferable to disaggregate these types of products, it was beyond the scope of this analysis.

This report does not examine the entire value chain of wood processing in Australia. Many of these primary wood products will undergo some downstream value-adding before reaching the retail market, which will create more value-added and increase the market prices of products.

Export prices are calculated using ABS detailed monthly trade data and based on the average price from 2010–11 to 2014–15. These prices are quoted in Australian dollars and therefore reflect a combination of international prices and exchange rates over the period. Domestic prices are based on previous estimates agreed to in a series of industry workshops (Burns et al. 2015) and scaled up by inflation.

The product categories are fairly broad. This may result in large disparities between export and domestic prices where there are differences in the types of specific products sold domestically and those that are exported.

Table A9 summarises the domestic and export market prices assumed in FORUM. Product prices determine the optimal allocation of logs to different processors and final wood products to markets. Intermediate products (for example, pulp) and export products (for example, woodchips and roundwood log exports) do not have an assumed domestic price because their value is determined endogenously in the model. Products that are imported are assumed to sell at the domestic market price. Where import costs are less than the costs of domestic processing, imports will be more attractive. However, where import prices are less than domestic prices but greater than domestic processing costs, the industry will favour domestic production over imports.

Table A9 Product prices, in Australian dollars

Product	Unit	Domestic price ($)	Import cost ($)	Export price ($)
Sawnwood, post and poles				
Appearance hardwood	m^3	1,224	1,225	540
Structural hardwood	m^3	795	1,032	285
Other hardwood	m^3	308	462	–
Hardwood pole	m^3	904	1,355	–
Hardwood post	m^3	482	1,355	–
Appearance softwood	m^3	1,051	575	409
Structural softwood	m^3	453	452	260
Other softwood	m^3	171	257	–
Softwood pole	m^3	544	817	–
Cypress pine sawnwood	m^3	531	–	–
Panels and engineered wood products				
Particleboard	m^3	461	438	406
MDF	m^3	464	440	350
Hardboard	m^3	1,054	1,001	563
Hardwood plywood	m^3	1,167	1,108	133
Softwood plywood	m^3	912	866	140
LVL	m^3	1,297	1,297	–
Hardwood veneer	m^3	487	1,439	467
Softwood veneer	m^3	517	1,439	–
Pulp and paper				
Hardwood pulp	t	–	708	297
Softwood pulp	t	–	863	344
Mechanical pulp	t	–	700	No exports
Recycled pulp	t	–	–	–
Newsprint	t	1,028	977	634
Household and sanitary paper	t	1,727	1,664	2,690
Packaging paper	t	1,816	1,727	1,634
Printing and writing paper	t	1,172	1,098	973

Product	Unit	Domestic price ($)	Import cost ($)	Export price ($)
Recycled paper	t	–	84	168
Logs and woodchips for export				
Hardwood plantation pulplogs for export	m^3	–	–	55
Hardwood plantation low-quality sawlogs for export	m^3	–	–	90
Hardwood plantation high-quality sawlogs for export	m^3	–	–	170
Softwood plantation pulplogs for export	m^3	–	–	60
Softwood plantation low-quality sawlogs for export	m^3	–	–	90
Softwood plantation high-quality sawlogs for export	m^3	–	–	110
Hardwood native woodchips	t	–	–	158
Hardwood plantation woodchips	t	–	–	175
Softwood plantation woodchips	t	–	–	160
Wood pellets	t	–	–	200

LVL Laminated veneer lumber. **MDF** Medium-density fibreboard.
Note: Some pulp and paper products do not have a domestic price because they are intermediate products. Products that are not exported (imported) do not have an export (import) price.

Processing infrastructure

Existing infrastructure

FORUM includes over 380 wood-processing facilities (including export facilities) covering 30 different wood-processing types and 40 product lines. It links every wood-processing facility with a location, processing capacity, recovery rates and processing costs.

ABARES collects generalised data on processing recovery rates for sawmills and some wood-based panel mills. ABARES has derived recovery rates from other sources for other wood-based panel mills and paper and pulp facilities. Assumptions for estimating processing costs and depreciation rates are based on ABARES research, surveys of wood processors and extensive workshops with industry and government stakeholders. Processing costs have been adjusted to calibrate FORUM to actual harvest and production levels in 2014–15.

Table A10 and Table A11 show ABARES estimates of the number of wood processors operating, or with the potential to re-open, in Australia as at June 2016, along with their aggregated input or output capacity.

Table A10 Modelled wood-processing capacity in Australia—sawmill and posts and poles, 2014–15

Jurisdiction	Hardwood sawmill		Softwood sawmill		Cypress pine sawmill		Posts and poles	
	No. of mills	Input capacity ('000 m^3)	No. of mills	Input capacity ('000 m^3)	No. of mills	Input capacity ('000 m^3)	No. of mills	Input capacity ('000 m^3)
New South Wales	63	772	14	2,869	4	48	3	np
Victoria	28	612	12	1,477	–	–	7	163
Queensland	48	281	17	1,859	15	127	3	np
South Australia	–	–	13	1,750	–	–	1	np
Western Australia	15	205	3	np	–	–	3	np
Tasmania	35	362	4	469	–	–	2	np
Australia **a**	189	2,232	63	8,424	19	175	19	163

a Total does not include capacities of jurisdictions with small numbers of processors. **np** Not provided; data for jurisdictions with small numbers of processors are included in modelling analysis but have not been provided in the table. Data in table represent mills (and their capacities) that operated or were closed but may reopen in the future.
Note: Modelling analysis presented in this report considered all such mills as available for processing logs and residues.

Table A11 Modelled wood-processing capacity in Australia—panels, paper and paperboard, pulp and log and woodchip exports, 2014–15

Jurisdiction	Wood-based panels		Paper and paperboard		Pulp		Log and woodchip exports b	
	No. of mills	Input capacity **c** ('000 m³)	No. of mills	Input capacity ('000 m³)	No. of mills	Input capacity ('000 m³)	No. of mills	Input capacity ('000 m³)
New South Wales	7	819	7	2,111	4	4,759	5	np
Victoria	3	np	11	1,374	5	2,227	8	np
Queensland	5	548	2	279	1	np	4	np
South Australia	2	np	2	np	–	–	1	np
Western Australia	2	np	–	–	–	–	6	np
Tasmania	5	362	2	np	1	np	9	np
Australia **a**	24	1,729	24	3,764	11	6,986	33	np

a Total does not include capacities of jurisdictions with small numbers of processors. **b** Includes ports used for exporting woodchips from infield mobile chipping. **c** Total potential input capacity; actual input may be logs or residues. **d** Includes pulp machines co-located with paper mills and mills using recovered paper. **np** Not provided; data for jurisdictions with small numbers of processors are included in modelling analysis but have not been provided in the table.
Note: Data in table represent mills (and their capacities) that operated or were closed but may reopen in the future. Modelling analysis presented in this report considered all such mills as available for processing logs and residues.

Future investment options

Future investment options include sawmills of varying sizes, wood-based panel mills and pulp and paper facilities. Capital cost and processing capacity are drawn from a variety of sources. Recovery rates are assumed to be similar or identical to recovery rates for existing facilities of the same type (Table A12).

Table A12 Investment options—modelling parameters

Mill type	Input capacity ('000 m³)	Capital cost ($m)	Input type
Sawmills			
Large hardwood sawmill	100	50	High- and low-quality hardwood plantation sawlog
Medium softwood sawmill	300	69	High- and low-quality softwood sawlog
Small softwood sawmill	100	30	High- and low-quality softwood sawlog
Engineered wood product facilities			
Hardwood ply mill	200	100	High-quality hardwood native and plantation sawlog; hardwood veneer
Softwood ply mill	200	100	High-quality softwood plantation sawlog; softwood veneer
Laminated veneer lumber	200	150	High-quality softwood sawlog
Medium-density fibreboard	300	150	Softwood pulplog/residue
Particleboard	300	115	Softwood pulplog/residue
Veneer – peeler	160	30	Hardwood peeler log
Hardboard	150	60	Hardwood pulplog/residue
Pulp and paper facilities			
Chemical pulp – hardwood	3,000	2,300	Hardwood pulplog/residue
Mechanical pulp	700	1,300	Hardwood/softwood pulplog/residue
Recycled pulp	80	90	Recovered paper
Paper – packaging and industrial	3,600	400	Chemical/mechanical pulp – softwood; recycled pulp
Paper – printing and writing	3,600	400	Chemical pulp – hardwood; recycled pulp
Export facilities			
Log export	50	5	Hardwood logs/softwood logs
Hardwood woodchips	1,000	20	Hardwood pulplog/softwood pulplog/residue
Wood pellets	250	25	Hardwood pulplog/softwood pulplog/residue

Note: Each mill investment option can be applied up to four times at the one site location.
Source: ABARES; ESD Consulting (2005); FFIC (2011); Gunns (2011); IndustryEdge (2012); RISI (2007); URS (2012)

Transport costs

Table A13 shows the cost weightings applied to roads of various types. For example, the cost of transporting goods was assumed to be 30 per cent higher on secondary roads than on dual carriageways and principal roads. Straight-line off-road distances of up to 25 kilometres were assumed to have a cost weighting of two. This accounts for potentially poorer-quality roads and the difference between the straight-line distance and actual distance travelled.

Table A13 Transport cost weights

Road type	Cost weighting
Dual carriageways and principal roads	1.00
Secondary roads	1.30
Minor roads and tracks	1.85
Off-road	2.00

Note: Off-road distances account for limitations of the road network dataset. A conservative cost weighting of 2.00 was applied to off-road distances.

Agricultural land and plantation establishment

Average land prices for sugarcane farmland (Table A14) are based on responses to the ABARES sugar survey for the 2013–14 financial year (ABARES 2015).

Table A14 Land values for sugar farms, by sugar-growing region

Sugar region	Assumed land price (A$/ha)
New South Wales	12,989
Far North Queensland	12,862
Burdekin–Mackay	7,060
Bundaberg	15,721
South Queensland	26,265

Source: ABARES 2015

Table A15 shows the concordance between land use defined under the Land Use of Australia dataset (ABARES 2016d) and the broad land use and farm type ABARES used to determine land prices.

Table A15 Land use aggregation and value mapping

Land Use of Australia dataset a	Broad land use	Farm type
2.1.0 Grazing native vegetation	Pasture	Livestock
3.2.0 Grazing modified pastures	Modified pasture	Dairy
4.2.0 Grazing irrigated modified pastures		
3.3.0 Cropping	Cropping	Wheat and other grains
3.3.1 Cereals		
3.3.2 Beverage and spice crops		
3.3.3 Hay and silage		
3.3.4 Oilseeds		
3.3.8 Pulses		
4.3.0 Irrigated cropping		
4.3.1 Irrigated cereals		
4.3.2 Irrigated beverage and spice crops		
4.3.3 Irrigated hay and silage		
4.3.4 Irrigated oilseeds		
4.3.8 Irrigated pulses		
3.3.5 Sugar	Sugar	Sugar
4.3.5 Irrigated sugar		

Source: ABARES 2015; ABARES 2016c; ABARES 2016d

Appendix B: Data and assumptions used in FORUM framework

Base case

Table B1 Cumulative new plantation area by NPI region, base case, 2025 to 2050

Regime	NPI region	New plantation area (ha)					
		2025	**2030**	**2035**	**2040**	**2045**	**2050**
Softwood **a**	Central Victoria	0	0	0	842	2,460	5,872
	Green Triangle	0	0	0	0	0	4,054
	East Gippsland-Bombala	0	0	0	0	743	926
	North Queensland	9,471	9,471	9,471	9,471	9,471	9,471
	South East Queensland	78	1,942	1,942	2,104	2,104	3,685
Total softwood	**Australia**	**9,549**	**11,413**	**11,413**	**12,417**	**14,778**	**24,009**
Hardwood **b**	Western Australia	4,034	4,773	4,773	4,773	4,773	4,773
Total hardwood	**Australia**	**4,034**	**4,773**	**4,773**	**4,773**	**4,773**	**4,773**
Total	**Australia**	**13,583**	**16,186**	**16,186**	**17,190**	**19,552**	**28,782**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprised entirely of short-rotation blue gum. NPI National Plantation Inventory.

Table B2 Potential logs harvested from new plantation areas, base case, 2030 to 2079

Log type	Market	Annual log harvest ('000 m³)									
		2030–34	2035–39	2040–44	2045–49	2050–54	2055–59	2060–64	2065–69	2070–74	2075–79
Softwood sawlog	Export	–	–	140.2	–	1,081.2	–	–	5.6	20.4	130.1
	Domestic	–	0.1	3.9	39.9	5.9	124.9	26.0	195.5	253.9	703.9
Softwood pulplog	Export	–	–	147.8	3.8	146.9	97.9	291.5	150.7	56.1	65.0
	Domestic	-	0.8	13.1	6.3	0.4	6.3	–	–	–	–
Hardwood pulplog	Export	244.5	45.2	249.4	46.1	254.4	47.1	–	–	–	–
	Domestic	–	–	–	–	–	–	–	–	–	–
Total	**Export**	**244.5**	**45.2**	**537.3**	**50.0**	**1,482.5**	**145.0**	**291.5**	**156.3**	**76.5**	**195.2**
	Domestic	**–**	**1.0**	**16.9**	**46.3**	**6.3**	**131.2**	**26.0**	**195.5**	**253.9**	**703.9**

Sensitivity analysis

Table B3 New plantation area in 2050, base case and sensitivity analyses

Regime	NPI region	Base case	2% Productivity	3% Productivity	-15% Land price	-30% Land price	15% Demand	30% Demand	-5% Exchange rate	-10% Exchange rate	6% Discount rate	5% Discount rate
Softwood **a**	Western Australia	-	-	-	-	-	-	-	-	1,058	-	9,671
	Tasmania	-	520	743	1,265	1,982	2,444	5,439	3,782	11,581	3,981	12,677
	Mount Lofty	-	14	240	260	260	1,787	2,405	339	493	909	3,003
	Green Triangle	4,054	4,054	4,054	4,054	5,137	4,054	5,506	4,054	4,054	6,900	25,020
	North Queensland	9,471	75,287	75,543	75,332	77,421	58,062	70,946	75,309	77,322	188,508	523,587
	South East Queensland	3,685	4,512	5,003	1,942	5,513	4,512	6,114	4,512	5,280	13,473	28,195
	Murray Valley	-	-	-	-	937	937	937	937	4,794	937	937
	Central Victoria	5,872	8,908	12,735	15,818	23,827	25,013	51,581	17,863	20,266	46,801	102,549
	East Gippsland-Bombala	926	926	926	926	1,939	4,851	14,795	4,261	55,616	3,012	17,629
Total Softwood	**Australia**	**24,009**	**94,221**	**99,245**	**99,597**	**117,017**	**101,661**	**157,722**	**111,057**	**180,463**	**264,520**	**723,267**
Hardwood **b**	Western Australia	4,773	8,676	68,682	8,676	83,928	4,773	4,773	8,676	83,928	177,432	228,913
	Central Gippsland	-	-	-	-	-	-	-	-	2,870	-	-
	North Coast	-	-	-	-	-	-	-	-	-	-	1,628
	Central Victoria	-	-	-	-	-	-	-	-	-	-	27,956
	Tasmania	-	-	-	-	-	-	-	-	-	-	2,724
Total hardwood	**Australia**	**4,773**	**8,676**	**68,682**	**8,676**	**83,928**	**4,773**	**4,773**	**8,676**	**86,798**	**177,432**	**261,221**
Total	**Australia**	**28,782**	**102,897**	**167,927**	**108,273**	**200,944**	**106,434**	**162,495**	**119,773**	**267,260**	**441,952**	**984,488**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprises short-rotation blue gum in all regions except Tasmania where long-rotation blue gum is planted instead. **NPI** National Plantation Inventory.

Table B4 Cumulative new plantation area, productivity scenarios, 2025 to 2050

Scenario	Regime	NPI region	New plantation area (ha)					
			2025	2030	2035	2040	2045	2050
2% productivity scenario	Softwood **a**	Mount Lofty	–	–	–	–	14	14
		Central Victoria	–	–	–	2,014	4,686	8,908
		Green Triangle	–	–	–	–	49	4,054
		East Gippsland-Bombala	–	–	–	–	926	926
		Tasmania	–	–	–	–	520	520
		North Queensland	9,471	9,471	9,471	9,471	9,471	75,287
		South East Queensland	97	1,942	1,942	2,048	2,157	4,512
	Total softwood	**Australia**	**9,568**	**11,413**	**11,413**	**13,533**	**17,823**	**94,221**
	Hardwood **b**	Western Australia	4,034	4,773	4,773	4,773	4,773	8,676
	Total hardwood	**Australia**	**4,034**	**4,773**	**4,773**	**4,773**	**4,773**	**8,676**
	Total	**Australia**	**13,602**	**16,186**	**16,186**	**18,306**	**22,596**	**102,897**
3% productivity scenario	Softwood **a**	Mount Lofty	–	–	–	226	240	240
		Central Victoria	–	347	347	3,548	7,022	12,735
		Green Triangle	–	–	–	–	1,167	4,054
		East Gippsland-Bombala	–	–	–	–	302	926
		Tasmania	–	–	–	–	743	743
		North Queensland	9,082	9,471	9,471	9,471	9,471	75,543
		South East Queensland	188	1,942	1,942	2,416	2,559	5,003
	Total softwood	**Australia**	**9,270**	**11,760**	**11,760**	**15,661**	**21,504**	**99,244**
	Hardwood **b**	Western Australia	4,034	4,773	4,773	8,676	8,676	68,682
	Total hardwood	**Australia**	**4,034**	**4,773**	**4,773**	**8,676**	**8,676**	**68,682**
	Total	**Australia**	**13,304**	**16,534**	**16,534**	**24,338**	**30,180**	**167,927**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprised entirely of short-rotation blue gum. **NPI** National Plantation Inventory.

Table B5 Cumulative new plantation area, land price scenarios, 2025 to 2050

Scenario	Regime	NPI region	New plantation area (ha)					
			2025	**2030**	**2035**	**2040**	**2045**	**2050**
15% reduction in land prices	Softwood **a**	Mount Lofty	–	–	–	245	260	260
		Central Victoria	2,242	5,270	5,270	7,881	10,995	15,818
		Green Triangle	–	11	11	11	480	4,054
		East Gippsland-Bombala	–	–	–	–	662	926
		Tasmania	–	–	–	–	1,265	1,265
		North Queensland	9,471	26,839	65,854	75,332	75,332	75,332
		South East Queensland	78	1,223	1,223	1,333	1,333	1,942
	Total softwood	**Australia**	**11,791**	**33,343**	**72,358**	**84,803**	**90,327**	**99,597**
	Hardwood **b**	Western Australia	4,773	4,773	4,773	8,676	8,676	8,676
	Total hardwood	**Australia**	**4,773**	**4,773**	**4,773**	**8,676**	**8,676**	**8,676**
	Total	**Australia**	**16,564**	**38,116**	**77,131**	**93,479**	**99,003**	**108,273**
30% reduction in land prices	Softwood **a**	Mount Lofty	–	–	–	245	260	260
		Murray Valley	–	–	–	–	–	937
		Central Victoria	3,540	8,328	8,328	11,932	16,629	23,827
		Green Triangle	4,054	4,054	4,054	4,054	4,054	5,137
		East Gippsland-Bombala	–	–	–	–	1,159	1,939
		Tasmania	–	–	–	1,076	1,982	1,982
		North Queensland	75,543	75,565	75,565	75,565	75,907	77,421
		South East Queensland	619	3,526	3,526	3,788	3,794	5,513
	Total softwood	**Australia**	**83,756**	**91,473**	**91,473**	**96,660**	**103,785**	**117,016**
	Hardwood **b**	Western Australia	8,676	23,922	23,922	83,928	83,928	83,928
	Total hardwood	**Australia**	**8,676**	**23,922**	**23,922**	**83,928**	**83,928**	**83,928**
	Total	**Australia**	**92,432**	**115,395**	**115,395**	**180,587**	**187,713**	**200,944**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprised entirely of short-rotation blue gum. **NPI** National Plantation Inventory.

Table B6 Cumulative new plantation area, demand scenarios, 2025 to 2050

Scenario	Regime	NPI region	New plantation area (ha)					
			2025	**2030**	**2035**	**2040**	**2045**	**2050**
15% increase in demand	Softwood **a**	Mount Lofty	0	0	93	184	936	1,787
		Murray Valley	0	0	0	0	0	937
		Central Victoria	2,874	8,335	8,335	11,880	16,945	25,013
		Green Triangle	0	0	0	1,829	4,054	4,054
		East Gippsland-Bombala	389	389	389	389	2,980	4,851
		Tasmania	0	0	0	689	1,732	2,444
		North Queensland	7,774	15,448	23,529	34,396	45,953	58,062
		South East Queensland	0	1,942	1,942	1,942	1,942	4,512
	Total softwood	**Australia**	**11,038**	**26,114**	**34,288**	**51,308**	**74,543**	**101,661**
	Hardwood **b**	Western Australia	4,034	4,773	4,773	4,773	4,773	4,773
	Total hardwood	**Australia**	**4,034**	**4,773**	**4,773**	**4,773**	**4,773**	**4,773**
	Total	**Australia**	**15,072**	**30,887**	**39,061**	**56,081**	**79,316**	**106,434**
30% increase in demand	Softwood **a**	Mount Lofty	0	538	1,590	2,405	2,405	2,405
		Murray Valley	0	0	0	0	0	937
		Central Victoria	7,110	15,378	16,737	22,382	33,654	51,581
		Green Triangle	2,130	4,054	4,054	4,054	4,054	5,506
		East Gippsland-Bombala	926	926	926	3,742	8,379	14,795
		Tasmania	0	520	520	2,900	5,113	5,439
		North Queensland	11,440	23,377	35,051	46,487	58,044	70,946
		South East Queensland	0	3,937	3,937	4,512	4,941	6,114
	Total softwood	**Australia**	**21,606**	**48,730**	**62,815**	**86,483**	**116,591**	**157,722**
	Hardwood **b**	Western Australia	4,034	4,773	4,773	4,773	4,773	4,773
	Total hardwood	**Australia**	**4,034**	**4,773**	**4,773**	**4,773**	**4,773**	**4,773**
	Total	**Australia**	**25,640**	**53,503**	**67,588**	**91,256**	**121,364**	**162,495**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprised entirely of short-rotation blue gum. **NPI** National Plantation Inventory.

Table B7 Cumulative new plantation area, exchange rate scenarios, 2025 to 2050

Scenario	Regime	NPI region	New plantation area (ha)					
			2025	**2030**	**2035**	**2040**	**2045**	**2050**
5% decrease in Australian dollar	Softwood **a**	Mount Lofty	–	–	79	324	339	339
		Murray Valley	213	937	937	937	937	937
		Central Victoria	3,182	7,071	7,071	10,336	13,840	17,863
		Green Triangle	–	–	–	–	317	4,054
		East Gippsland-Bombala	926	926	926	926	1,406	4,261
		Tasmania	–	704	704	2,150	3,782	3,782
		North Queensland	9,471	13,992	73,423	75,309	75,309	75,309
		South East Queensland	129	2,387	2,387	2,877	2,877	4,512
	Total softwood	**Australia**	**13,921**	**26,017**	**85,527**	**92,859**	**98,807**	**111,057**
	Hardwood **b**	Western Australia	4,773	8,676	8,676	8,676	8,676	8,676
	Total hardwood	**Australia**	**4,773**	**8,676**	**8,676**	**8,676**	**8,676**	**8,676**
	Total	**Australia**	**18,694**	**34,692**	**94,202**	**101,535**	**107,483**	**119,733**
10% decrease in Australian dollar	Softwood **a**	Western Australia	–	347	347	347	347	1,058
		Mount Lofty	–	–	233	478	493	493
		Murray Valley	937	3,153	3,153	3,153	3,332	4,794
		Central Victoria	2,353	7,027	7,027	9,067	14,352	20,266
		Green Triangle	–	–	–	–	1,063	4,054
		East Gippsland-Bombala	11,054	17,935	22,114	32,639	42,447	55,616
		Tasmania	601	1,850	1,850	4,731	8,035	11,581
		North Queensland	75,543	76,088	76,476	76,476	77,034	77,322
		South East Queensland	838	3,340	3,340	3,340	3,947	5,280
	Total softwood	**Australia**	**91,326**	**109,740**	**114,540**	**130,231**	**151,050**	**180,464**
	Hardwood **b**	Western Australia	68,682	68,682	68,682	68,682	68,682	83,928
		Central Gippsland	–	–	192	3,001	3,598	2,870
	Total hardwood	**Australia**	**68,682**	**68,682**	**68,874**	**71,683**	**72,280**	**86,798**
	Total	**Australia**	**160,008**	**178,422**	**183,413**	**201,914**	**223,330**	**267,260**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprised entirely of short-rotation blue gum. **NPI** National Plantation Inventory.

Table B8 Cumulative new plantation area, base case and discount rate scenarios, 2025 to 2050

Scenario	Regime	NPI region	New plantation area (ha)					
			2025	2030	2035	2040	2045	2050
6% discount rate	Softwood **a**	Mount Lofty	–	–	232	440	606	909
		Murray Valley	–	–	–	–	–	937
		Central Victoria	5,422	12,903	12,903	18,298	27,335	46,801
		Green Triangle	2,607	4,054	4,054	4,054	5,497	6,900
		East Gippsland-Bombala	691	691	691	691	2,031	3,012
		Tasmania	–	–	–	1,755	3,852	3,981
		North Queensland	76,066	76,390	77,724	78,392	112,383	188,508
		South East Queensland	838	5,283	5,283	6,880	9,816	13,473
	Total softwood	**Australia**	**85,624**	**99,321**	**100,887**	**110,509**	**161,519**	**264,520**
	Hardwood **b**	Western Australia	4,773	8,676	8,676	83,928	99,346	177,432
	Total hardwood	**Australia**	**4,773**	**8,676**	**8,676**	**83,928**	**99,346**	**177,432**
	Total	**Australia**	**90,397**	**107,997**	**109,563**	**194,437**	**260,866**	**441,952**
5% discount rate	Softwood **a**	Western Australia	0	0	0	1,058	2,828	9,671
		Mount Lofty	253	470	1,175	1,838	2,405	3,003
		Murray Valley	524	887	887	887	887	937
		East Gippsland-Bombala	926	1,529	1,529	4,352	10,130	17,629
		Central Victoria	13,511	30,588	41,476	58,582	80,972	102,549
		Green Triangle	4,080	5,163	7,635	11,471	17,671	25,020
		Tasmania	0	680	680	4,149	8,228	12,677
		North Queensland	122,886	186,780	194,380	269,200	334,959	523,587
		South East Queensland	3,184	9,399	10,360	12,643	19,678	28,195
	Total softwood	**Australia**	**145,364**	**235,497**	**258,121**	**364,181**	**477,760**	**723,267**
	Hardwood **b**	Western Australia	20,851	177,432	177,432	220,138	220,138	228,913
		North Coast	–	–	–	226	226	1,628
		Central Victoria	–	–	–	–	–	27,956
		Tasmania	–	–	–	1,058	2,828	9,671
	Total hardwood	**Australia**	**20,851**	**177,432**	**177,432**	**221,422**	**223,192**	**268,168**
	Total	**Australia**	**166,215**	**412,928**	**435,553**	**584,544**	**698,123**	**984,488**

a Comprises radiata pine in all regions except North Queensland and South East Queensland where Southern pines are planted instead. **b** Comprises short-rotation blue gum in all regions except Tasmania where long-rotation blue gum is planted instead. **NPI** National Plantation Inventory.

Glossary

Term	Definition
FORUM	Forest Resource Use Model
MAI	Mean annual increment
MDF	Medium Density Fibreboard
NPI	National Plantation Inventory regions
NPV	Net present value

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