Next Generation Forest Plantation Investment

Trends in forest product development

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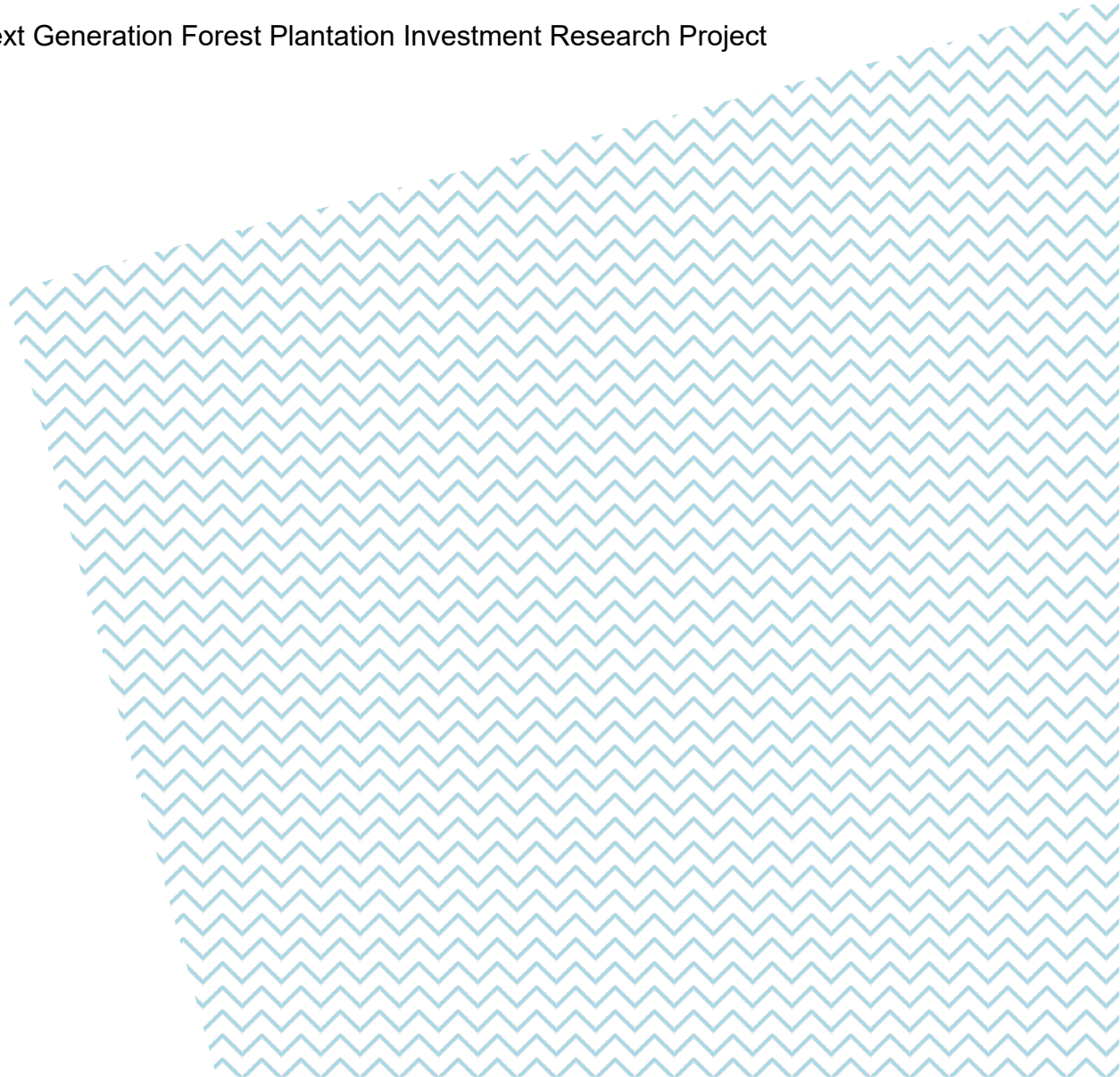
Report 6. Next Generation Forest Plantation Investment Research Project



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Acronyms

ABA	Australasian Bioplastics Association
APCO	Australian Packaging Covenant Organisation
AS/NZS	Australian Standard / New Zealand Standard
CLT	Cross Laminated Timber
LVL	Laminated Veneer Lumber
EWP	Engineered Wood Product
Glulam	Glued laminated timber
ISO	International Standards Organisation
MDF	Medium Density Fibreboard
PLA	Polylactic acid
PHA	Polyhdroxyalkanoates
WPC	Wood Plastic Composite
NGO	Non-government organisation
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

The Next Generation Forest Plantation Investment Project is a collaboration between the University of Melbourne, industry and research partners. The project aims to bring a diverse group of people together to design and test new models of investment in planted forests.

Changes in markets and product development are important determinants of plantation viability. New technologies create new uses for existing products as well as new wood-based materials, which can impact on plantations by creating added value for lower quality products and processing residues or by increasing demand for existing products.

The Australian Government's recent policy statement; *Growing a Better Australia, a billion trees for jobs and growth*, sets out the aim of growing Australia's plantation estate to establish a sustainable and secure supply of wood-based products. Central to this objective is the role of new technologies and products in driving investment in plantations, and the need to establish more trees on farms in collaborative arrangements between landholders and industry (Government of Australia 2018).

This report provides an overview of trends in wood product development and the way that these may impact on plantation forestry in Australia. It is intended for the information of project partners and in the design and testing of new business and partnership models for the integration of tree growing with agriculture. An overview of Australia's forest products is provided, followed by the identification of key trends influencing the use and development of forest products. Following this, some relatively "new" or emerging products are described, these products and their applications are:

- Cross Laminated Timber (CLT) for tall buildings;
- Bioenergy from wood pellets;
- Plywood from spindle-less lathes;
- Bio-plastics using wood residues;
- Wood Plastic Composites (WPC) as building materials; and
- Native foods as non-timber forest products.

These are but some of the products and innovations that could impact on plantations and there are several others that could have an equal or greater impact. It is also recognized that there are a range of factors that influence decision making on the establishment of, management and marketing of plantation products, as outlined in Chart 1, only some of which are explored in this report.

Chart 1: Typical influences on plantation investment decisions and management

Photo source: Timber Queensland

1.1. Key findings

The product examples described in this report show that there are innovations that have the potential to make some plantations more viable or more valuable than they once were by creating more value for lower quality logs and processing residues, or by increasing demand for existing timber products. Chart 1 summarises the overall influence that the identified product innovations in this report could have on plantation development.

Chart 1: Influence of the identified product innovations on plantation development

Product innovation	Nature of influence on plantations development
CLT for tall buildings	Wide adoption of CLT will increase overall demand for lower quality and smaller dimension softwood structural timber and potentially also for hardwood plantation timber. CLT could be a significant driver of future demand and price for plantation wood.
Bioenergy and wood pellet production	The use of wood residues for bioenergy can increase the value and demand for waste or low value products. In the context of Australia's plantations, this could help to make what would otherwise be uneconomic scenarios potentially economic.
Plywood from spindle-less lathes	Demand for plywood production and spindle-less lathe technology are already impacting on the demand for and value of Australia's hardwood plantation resource. Logs from plantations established for pulp production and thinnings from sawlog plantations are being diverted into higher value products such as plywoods and veneer based engineered wood products.
Bio-plastics using wood residues	Bioplastics could create new or higher value markets for residues from wood and pulp and paper processing. This could increase the overall value of plantation logs where there are nearby markets. They represent an opportunity for the forest industry to contribute to the reduction of fossils fuels in plastic production.
Wood plastic composites as building materials	Wood plastic composites (WPC's) could create new or higher value markets for residues from wood and pulp and paper processing. This could increase the overall value of plantation logs where there are nearby markets. In some applications, WPC can also compete with timber.
Native foods as non-timber forest products	Development of natural foods and related products could make tree growing attractive to a wider group of landowners than traditional plantations. There is scope for mixtures and diversification of planting types at farm level that could generate a range of products, both timber and non-timber.

1.2. Australia's forest products

Australia's commercial plantation area is around 2 million hectares and produces around 86 percent of Australia's 30.1 million m^3 of total log harvest of 30.1 (ABARES 2017). Material from plantations is used primarily for structural timber and pulpwood, used in paper and board manufacture (Chart 2).

Chart 2: Sources of Australia's log supply ('000m^3)

	Native forest	Hardwood plantations	Softwood plantations	TOTAL LOG HARVEST
Sawlogs and veneer logs	2,138	187	9,986	12,311
Pulplogs and other logs	1,990	9,592	6,191	17,773
TOTAL	4,127	9,779	16,177	30,083

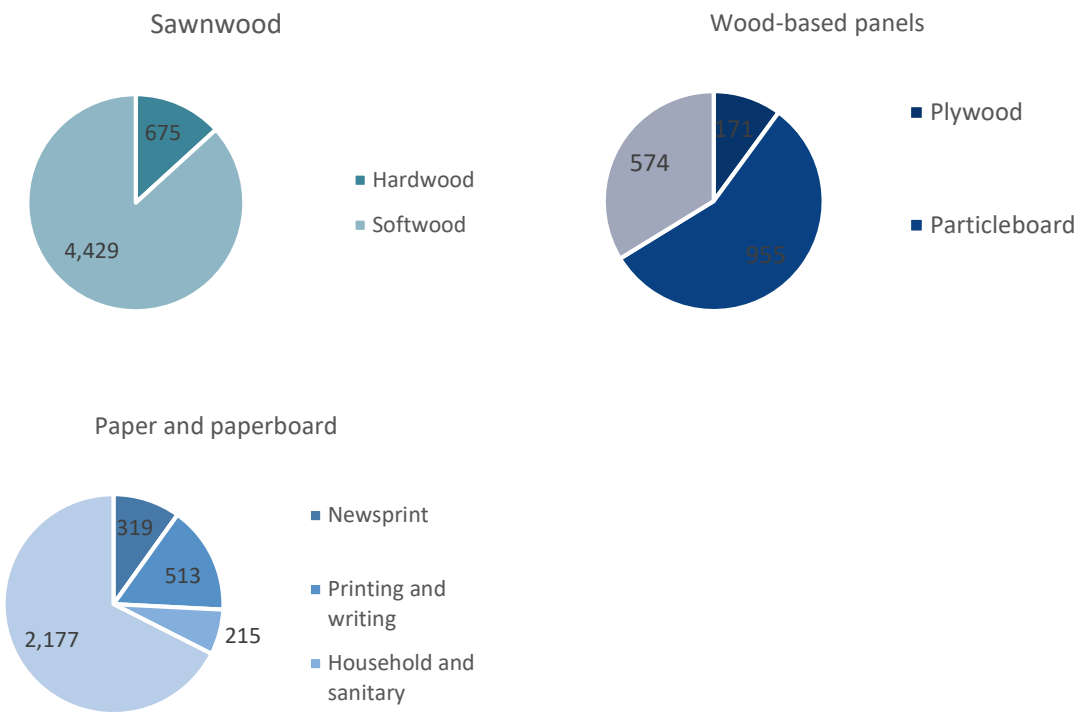
Source: ABARES 2017 (Totals may not tally because of rounding)

The wood products currently produced in Australia are categorized as sawnwood, wood-based panels and paper and paperboard products. In the decade between 2006 and 2016 some key trends in these product categories were that:

- Hardwood sawnwood production declined by 44 percent (mainly due to the decline in native forest production);
- Softwood sawnwood production increased by 16 percent;
- Wood-based panel production declined by 13 percent (also affected by native forest supply); and
- Paper and paperboard production increased by 0.5 percent (ABARES 2017).

Production volumes of key wood products, from both native and plantation forests, are shown in Chart 3.

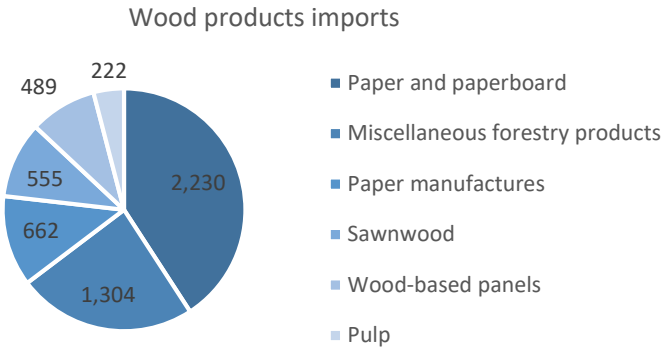
Chart 3: Wood product production in Australia ('000m^3)



Source: ABARES 2017

In terms of imports, Australia imports $5.5 Billion worth of wood products annually with the main product categories being paper and paperboard and miscellaneous forestry products (Chart 4).

Chart 4: Wood product imports in Australia ('000m^3)



Source: ABARES 2017

2. Key trends

Broad trends influencing the use of wood and wood products and the development of plantations in Australia are outlined below.

Changing wood product mix

As noted in Section 1.2 above, structural timber (from softwood plantations) and pulplogs (from hardwood plantations) have been the core products derived from Australia's plantations. This product mix will change in future with, among other factors, the development of the hardwood plantation estate (increasing availability of hardwood sawlogs) and the adoption of new processing methods that utilise small hardwood logs. Relatedly, Engineered Wood Products (EWPs) and wood panels are being used more often and in a wider range of applications.

Increasing imports of wood products

Australia currently imports $5.5 Billion worth of wood products and this is expected to increase due to increasing consumer demand and a stable plantation resource area. The processing and use of imported wood products will become a more significant component of the industry. For example, re-processing and assembly of imported materials, as is now occurring with CLT panels, could become more prevalent.

Use of non-timber substitutes

While wood products are being more widely used and recognised, so too are substitute products. Steel framing is widely used and is recyclable and easy to work with. There are also a range of panel products comprised of non-timber materials available. Wood Plastic Composite (WPC) products are also being used more widely and can both complement and compete with traditional timber, these are discussed in more detail in Chapter 3.

Recognition of the environmental values of timber

The awareness among the public of the environmental values of wood relative to other building components is increasing. This has been driven by campaigns promoting the use of wood on the basis that it:

- Is a renewable material when sourced from sustainably managed forests;
- Stores carbon throughout its life-cycle; and
- Requires less energy to produce than alternative products like concrete, steel and aluminium.

The *Wood Naturally Better* and *Make it Wood* initiatives have been successful examples of industry, NGO's and partners taking a proactive and collaborative approach to engage with markets and improve the understanding and perception of forestry and forest products.

In addition to environmental benefits, the health benefits of using wood as part of design along with other natural features (natural light, plants and gardens) are being recognized and used more frequently in commercial and residential buildings.

A note on carbon sequestration

This review has not considered carbon sequestration and offsets in detail as this has been done in other sections of the Next Generation Forest Plantation Investment project. For Carbon sequestration to influence plantation development, a key requisite is the establishment of policies that recognise sequestration in plantations and the adoption of mechanisms for the sale of offsets. A policy and regulatory framework that encourages tree growing by creating incentives for carbon sequestration would be positive for plantation development and for the mitigation of emissions.

3. Emerging Products

This section provides a summary of some emerging products that could influence plantation development. For each product, consideration is given to:

- Product applications;
- Market trends;
- Status in Australia;
- Key market opportunities and risks;
- Policy issues;
- Processing requirements;
- Skills requirements; and the
- Impact on plantation timber demand and log value

3.1. Cross Laminated Timber for tall buildings

Cross Laminated Timber (CLT) or massive (mass) timber is a large panel of laminated pieces of structural timber.

Product applications	CLT is used as a load bearing element in walls, floors and roofs and in many applications can be a substitute for concrete, masonry and steel. Its' use in tall buildings has been a significant recent development in the commercial construction industry and it is also increasingly being used in residential projects.
Market trends	CLT was developed in Europe in during the 1990's, its use has spread from this base to North America and is now being widely adopted elsewhere. European countries, primarily Austria, Germany and Switzerland, are still responsible for the large proportion of global production and these three countries represented 80% of production capacity in as recently as 2015 (Musynzski et al 2017).
Status in Australia	In Australia, the supply chain and uptake of CLT in Australia is in the early stage of development. However imports of CLT are growing and both the national and international markets are predicted to grow (VTT 2013). There are currently around 50 medium – tall buildings in Australia already constructed or being constructed using mass timber products. The first Australian CLT production facility was opened in Woodonga, Victoria in March 2018, a $30 million investment. This plant sources timber from the Murray Valley plantation region and Northern Victoria and XLam's business model includes the design, manufacture and installation of CLT materials for domestic and potentially overseas customers. Lend Lease have established a fabrication center for CLT and other engineered timber in Sydney. This operation imports the CLT panels for manufacture into components that are transported to site for assembly and use in commercial building projects. There is a strong commitment to the development of CLT and mass timber products. Collaborative research programs such as through the *ARC Future Timber Hub*, are leading to the wide recognition of mass timber products and the information available on their properties and applications.

Key market opportunities and risks	*OPPORTUNITIES* The most widely promoted opportunity for use of CLT is in multi-storey buildings. Key advantages of CLT over other construction materials, particularly in commercial projects, are: shorter construction time, improved safety for workers, reduced cost, and lower embodied emissions and other sustainability advantages of timber as a building material. CLT and mass timber is becoming widely recognized by architects, designers, structural engineers and builders and the use of these products in all types of commercial and residential buildings is increasing. *RISKS* CLT has different properties to the materials that it substitutes and it is important to ensure the properties and appropriate applications of CLT are well understood. As with any material, building design needs to allow for the unique characteristics of CLT with consideration given to: structural design and installation, fire design, acoustics, treatment for termites and moisture. Information on these aspects is readily available but care needs to be taken to ensure appropriate use of the product.
Policy issues	The recognition and use of mass timber in building codes will help drive the manufacture and use of CLT in Australia. There are not currently specific standards in place in Australia for CLT so the one domestic manufacturer, XLam, reportedly follows relevant codes for Glulam and LVL, which are similar in that they are also manufactured from finger jointed, dried timber using glue lamination under pressure. These codes that relate in general terms to CLT are: • AS/NZS 1328 Glue Laminated Timber Parts 1 & 2 • AS/NZS 1491:1996 Finger jointed structural timber. In addition to these, an International Standards Organisation (ISO) standard for CLT is currently under development: • ISO/TC 165/SC N695 (Working Draft): Timber Structures – Cross Laminated Timber – Part 1: Component Performance and Production Requirements A recent development in the USA is that Oregon State amended its building code for *Tall Wood Buildings* to allow timber structures to be built higher than six stories without needing permission, which was previously necessary. This change was made after product testing and research and explicitly recognizes the role of CLT, mass timber and other engineered wood products as a safe and viable mode of construction (State of Oregon 2018). Similar recognition in Australia would be a positive for the industry.
Processing requirements	The production of CLT uses structural timber, primarily softwood, which is pressed into layered panels with adhesive. An analysis of the potential for CLT production in the Green Triangle found that, in this region, there is enough material for a new CLT plant, if co-located with an existing sawmill. The investment for a 60,000 m^3 capacity plant would cost approximately $40 million with a payback period of 3 to 5 years (VTT 2013). This analysis is broadly consistent with the reported investment in the XLam Wodonga facility of $30 million.
Skill requirements	The skills required in manufacture of CLT or mass timber components are similar to Glulam, LVL and other engineered wood products, making it a relatively easy technology to adopt in regions where there is an existing processing industry.

	A feature of all mass timber products is that they reduce the amount of construction on-site construction in building projects. A large proportion of the construction process is conducted in off-site processing facilities, with on-site activities focused on assembly of components.
Input specifications	CLT panels consist of 3 or more layers of structural timber boards stacked crosswise and glued together on their wide faces. Thickness of the individual boards can vary from around 15 to 50 mm with widths of 60 to 240 mm. Lengths can be variable as any shorter pieces are finger joined (which enables the utilisation of small logs). Prior to assembly into a CLT panel, timber is generally kiln dried to 10-12% moisture content and visually-graded or machine stress-rated (Mohammad et al 2012). CLT and other similar products have so far been reliant on softwoods for input stock as these species are generally light enough and of a strength to substantially gain from reconstitution. There also scope for the use of lower density hardwoods in CLT, as are found in many of Australia's hardwood plantations, the use of alternative species in CLT not been fully investigated but preliminary trials are being conducted.
Impact on plantation timber demand and log value	Given the range of applications and their scale, the uptake of CLT could be a significant driver of future demand and price for plantation wood. Wide adoption of CLT will increase overall demand for lower quality and smaller dimension softwood structural timber and potentially also for hardwood plantation timber. CLT could compete for input stock with woodchips (potentially reducing woodchip exports) and other uses of lower value logs.

Photo 1: A typical CLT panel

Source: Timberbiz

Photo 2: On site building assembly with CLT panels

3.2. Bioenergy and wood pellet production

Bioenergy from wood residues can provide renewable, dispatchable (used on demand) and baseload energy at an enterprise or household level and as input into electricity grids.

Product applications	Key product applications that utilize wood products for bioenergy include: • Biomass pellets made from pressed wood residues for use in electricity generation, including in co-firing with coal power stations; • Wood briquettes and pellets made from pressed wood residues for heating; • Firewood for heating; and • Conversion into liquid fuels such as biodiesel for use in transportation. This section is focussed on commercial scale wood pellet production for use in electricity generation. Firewood is not assessed in detail in this report, however it is recognised as an important and widespread use of plantation wood, particularly in southern Australia, and it is likely that the demand and use of firewood will continue in future.
Market trends	Bioenergy is a mainstream energy source in many parts of the world and it is widely used in Europe, Asia and North America. Global electricity production capacity from bioenergy is 87 GW and this is predicted to increase to 130 GW by 2025 (EY 2016). In Asia, many governments are encouraging bioenergy as a means of reducing their emissions and increasing their bioenergy capacity. A large proportion of bioenergy production in Asia uses wood pellets and demand for these has been rising. Global production of wood pellets has increased from 6 Mt in 2006 to 26 Mt in 2015 (IEA Bioenergy 2017). This growth in global capacity and the availability of accessible and responsibly managed wood residues in Australia positions local producers well to supply Asian markets.
Status in Australia	In Australia bioenergy is yet to be widely adopted as an energy source, it accounts for 1% of national electricity production and 1-3% of fuel production. The likelihood of wide adoption of bioenergy as a mainstream energy source in Australia is uncertain due to the political climate and the ready availability of alternative energy sources. Australia's production of wood pellets is currently negligible on a world scale but could be significantly increased. There are currently two large scale wood pellet producers in Australia selling into export markets and scope for more to enter the market. Altus Renewables, based in the south-east Queensland plantation region has a 125,000 mt annual production capacity. In Western Australia, the newly re-opened Plantation Energy Albany plant has a 250,000 mt annual capacity after a $7 million refurbishment. This plant began a 6 month trail operation period in July 2018. There is interest in the developing similar wood pellet production operations in Tasmania as well as in other regions.
Key market opportunities and risks	*OPPORTUNITIES* The forest processing industry is uniquely well placed to use bioenergy itself and to provide feedstock for use by other energy producers. Positive aspects of bioenergy for large scale producers are well recognised and can include: • A secure and stable energy supply (relative to other renewables);

	• Reduced emissions relative to fossil fuels – bioenergy produced from wood processing residues can have life cycle emissions around 2 to 4% of those from coal and gas (SCION 2018); and • Reduced price volatility relative to fossil fuels (Global Forest Coalition 2015). Wood residues are already used within the processing industry in the form of sawdust, bark and black liquor from pulp and papermaking as fuel sources to provide heat and electricity. *RISKS* Risks and limitations to the increased use of bioenergy in Australia include: • The uncertain policy and political environment; • Alternate biomass sources that may be cheaper or more available than wood residues such as agricultural by-products; and • Concerns about sustainability of biomass for large-scale energy production, internationally this generally relates to concerns about inappropriate land use and land clearing while in Australia there are related concerns around the use of native forest wood for bioenergy;
Policy issues	Strong policy support for bioenergy in Australia is complicated by its association with emissions reduction policy. A clear policy and regulatory environment is needed to encourage further investment. Internationally, the value of bioenergy in emissions reduction is widely recognized in frameworks such as the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC) which recognizes bioenergy as renewable when forest are sustainably managed. There is strong interest both locally and internationally regarding the use of native forests as a bioenergy feedstock and international NGO's are active in working to ensure that the use of bioenergy does not contribute to deforestation, particularly in developing countries, refer for example (Global Forest Coalition 2015 and WWF 2012).
Processing requirements	There are four main methods to generate heat and electricity using biomass feedstocks all of which can be used with wood residues, generally in the form of pellets: • Direct firing—Biomass is the only fuel used at a given power plant. The feedstock is fed into a boiler, which in turn powers a steam turbine to generate electricity. • Co-firing—Biomass is substituted for a portion of the coal burned in a coal-fired power plant. A coal-fired power plant can be modified to accommodate biomass and use it to supply up to 20 percent of its fuel requirements. • Cogeneration—Fuel is burned to produce both electricity and heat. As with direct firing, the biomass fuel powers a steam turbine generator. However, unlike direct firing, cogeneration uses the resulting exhaust flow for further electricity generation or heat generation. • Gasification—Feedstock is processed in a hot oxygen-starved area to produce a gas, composed mostly of carbon monoxide and hydrogen. This gas fuels a turbine to produce electricity (Roos and Brackley 2012).

Skill requirements	The skills involved in wood pellet manufacture are broadly similar to other timber processing operations.
Input specifications	Based on existing plants in Australia and internationally, a large commercial scale wood pellet production facility is likely to cost in the order of $100 million to establish. These need to be close to a consistent source of wood residue, typically a sawmill and, if exporting, within reasonable transport distance to a port. It is likely that a single wood pellet plant in each major plantation region would absorb most of the available supply.
Impact on plantation timber demand and log value	The use of wood residues for bioenergy can increase the value of waste or low value products. In the context of Australia's plantations, this could help to make what would otherwise be uneconomic scenarios potentially economic. Investment in wood pellet processing in key plantation regions would underpin this. The continued use of firewood and wood briquettes for heating will also contribute to utilization of lower quality material. This market will be best suited to smaller scale woodlots and farm forestry.

Photo 3: Wood pellets that are used in bioenergy production and home heating

Photo 4: Wood briquettes packaged for use in home heating

Source: Ecofriendly Solutions

3.3. Plywood from spindle-less lathes

Spindle-less lathes have enabled the production of veneer using smaller diameter logs than is possible with standard lathes.

Product applications	Veneer from spindle-less lathes can be used in the manufacture of products for structural and appearance applications. Common structural applications include structural plywood, formwork plywood for concrete construction, packaging, marine ply and LVL. Decorative uses include architectural finishes, furniture and joinery.
Market trends	Traditionally, only the largest and best quality logs were suitable for veneer production. Using standard spindled veneer lathes log utilisation rates were relatively low, often less than 50%. The development of spindle-less lathe technology and its low capital cost (less than 20% of a spindled lathe) are now capable of producing quality veneer from a low-cost small diameter resource and achieving recoveries above 60% (ACIAR 2017). The use of small spindle-less lathes has already caused significant shifts in wood markets, stemming from uptake in China, Vietnam and other Asian countries. This trend has been driven by demand for plywood in China and elsewhere and is diverting logs that what would otherwise be pulplogs into higher value use in veneer production. China's annual plywood production grew from around 9 million m^3 in the mid 1990's to over 55 M m^3 by 2011 (Arnold et al 2013) and it has continued to increase since. Associated with this demand, small-scale veneer mills have proliferated and are processing eucalypts, acacias and other plantation species. In 2011 there were over 5,000 such mills in China with a collective annual processing capacity of over 15 million m^3 of logs (Arnold et al 2013).
Status in Australia	The demand for plywood in the region has led to logs from Australian hardwood plantations, which were established for pulplog production, being exported to China for use in veneer production. Veneer production using spindle-less lathes has not yet been widely adopted in Australia but this could occur through existing plywood manufacturers adopting spindle-less lathe technology, or new (likely smaller-scale) operations being established using spindle-less lathes.
Key market opportunities and risks	*OPPORTUNITIES* International demand for plywood and the emergence of spindle-less lathe technology has the potential to transform the existing lower value hardwood pulp resource into higher value feedstock for veneer production. There is also greater opportunity to market thinned logs from plantations established for sawn timber. A lack of good markets for thinned material has to date been a limitation to the viability and establishment of sawlog plantations. *RISKS* Export demand for small Australian plantation logs will be influenced by the availability of input stock in China and elsewhere, exchange rates and the costs of transport and shipping. There is a limited level of higher grade veneer sheets in typical Australian hardwood plantations (McGavin et al 2014). As such, there is a need to confirm the target

	markets and likely demand for the types of veneer products that could be produced from the Australian plantation resource.
Policy implications	Technology such as spindle-lathes could help to make existing plantations more viable and create new or different markets for wood products. The Australian Government's policy statement; *Growing a Better Australia, a billion trees for jobs and growth* could be more viable given the opportunities that are created by this technology.
Processing requirements	The capital costs of spindle-less lathes can be as little as 20% of the cost of traditional veneer lathes, (ACIAR 2017). This technology is not new but relatively recent advances in design have enabled its wide adoption and it is now readily available and accessible. The core veneer lathe can be purchased for as little as USD 20,000 in China although they are generally more expensive. An analysis of set up costs for a new veneer production facility using spindle-less lathes in Australia estimated that total capital costs could range from $200,000 to $10 M depending on the scale and end product (Blackburn and Nolan 2017).
Skill requirements	The process of veneer production with spindle-less lathes is similar to traditional veneer production, with similar skills requirements. The small veneer mills that have proliferated through Asia are relatively easy to operate and have been used successfully by thousands of small operators.
Input specifications	Small veneer mills can process logs from trees of around 5 years with small end diameter of less than 15 cm.
Impact on plantation timber demand and log value	Demand for plywood production and spindle-less lathe technology are already impacting on the demand for and value of Australia's hardwood plantation resource. Logs from plantations established for pulp production and thinnings from sawlog plantations are being diverted into higher value products in plywoods and veneer based engineered wood products.

Photo 5: A log being peeled on a spindle-less lathe

Source: ACIAR

Photo 6: Small scale veneer production in Vietnam showing small diameter logs in the background

Source: ACIAR

3.4. Bio-plastics using wood residues

Bioplastics are plastics made from renewable biomass which can be sourced from wood residues as well as other biomass, usually combined with recycled plastic.

Product applications	Bio-based plastics can be used to replace petroleum-based plastics in a variety of applications from: packaging, catering products, electronics, automotive, agriculture/horticulture, toys textiles and others. The most common uses are currently in plastic bags and packaging for food and consumer goods (British Plastics Federation 2018).
Market trends	The annual value of worldwide plastic production is USD 80–120 billion of which 95% is disposed of each year. In this context, the development and use of bioplastics has increased, driven by demand for sustainable products and advances in new materials. Currently, bioplastics represent about one percent of the 320 million tonnes of plastic produced annually. Global production capacity is predicted to increase from around 2 million tonnes in 2017 to 2.5 million tonnes in 2022 (European Bioplastics 2017). Production of bioplastics is concentrated in Asia, with over 50 percent of global production. Research, development and consumption of bioplastics is currently dominated by European countries.
Status in Australia	Bioplastics are produced in Australia using wood residues as well as other feedstocks in combination with recycled plastic. The Australasian Bioplastics Association (ABA) provides certification of companies to the Australian Standard for composing and biodegradable plastics. There are currently 14 certified companies operating in Australia. There is scope for the forest industry to further engage with the bioplastics industry to explore the potential for wood residues to be used as a feedstock in local manufacturing. The research organisation SCION is already a member of ABA which could be an avenue for engagement.
Key market opportunities and risks	*OPPORTUNITIES* With strong public sentiment against the use of single use plastics, there is an opportunity for the forest industry to contribute to solutions to enable the reduction and elimination of fossil fuels as feedstock for plastic production. This would come with the multiple benefits of: conserving resources, reducing emissions and reducing waste to landfill. *RISKS* In addition to sawdust, there are several other sources of biomass feedstock for bioplastic production. The relative demand for wood-residues as feedstock may fluctuate and the likely scale of demand for wood residue as a feedstock in local manufacturing is not yet clear.
Policy implications	There are strong policy signals for the increased production and use of bioplastics which could increase the demand for wood residue as a feedstock. At the beginning of 2018, China significantly reduced its import of recyclable plastics. This created a large surplus of plastics recyclables that may now be sent to landfill at a cost, creating problems for waste management authorities (Indufor 2018). Bioplastics

	manufacturers with the capacity to process a wide range of low quality plastics, in conjunction with biomass will now have a cost advantage over other manufacturers. Responding to the reduction of Chinese imports of recyclables, in July 2018 the Australian Commonwealth, state and territory environment ministers announced a commitment to the use of 100% recyclable, compostable or reusable Australian packaging by 2025. The Australian Packaging Covenant Organisation (APCO) will be work with its 950 member companies and governments and to deliver on the commitment.
Processing requirements	There are a several types of bioplastics and a range of approaches and technologies involved in their manufacture. A key type of bioplastic that can use wood residues combined with recycled plastic in their production are Polyhydroxyalkanoates (PHAs). PHAs have a wide range of potential applications however more research is needed to identify cost effective methods of production. Kurcera et al (2017) tested the production of PHA's using sawdust and found it to be one of the most promising and cost effective materials for use in the production of PHA's as well as other types of bioplastic.
Skill requirements	Bioplastic production is a specialised process that is undertaken by plastics manufacturers. It is likely that wood processing operations would supply to these manufacturers and therefore there would not be specialist skills required within the forest industry.
Input specifications	Bio-based plastics can be manufactured from renewable plant materials such as starch, cellulose, oils (e.g. rapeseed oil), lignin (wood), proteins (e.g. maize) and polysaccharides (e.g. xylans). Recent technological developments have shown that it is now possible to utilise organic waste materials and petroplastics (e.g. PET) to produce synthetic bio-based plastics (like PHAs, referred to above) (British Plastics Federation 2018).
Impact on plantation timber demand and log value	Bioplastics could create new or higher value markets for residues from wood and pulp and paper processing. They represent an opportunity for the forest industry to contribute to the reduction of fossils fuels in plastic production.

Photo 6: Examples of types of bioplastics

3.5. Wood Plastic Composites as building materials

Wood plastic composites (WPCs) are building materials composed of wood mixed with new or recycled plastic fibres.

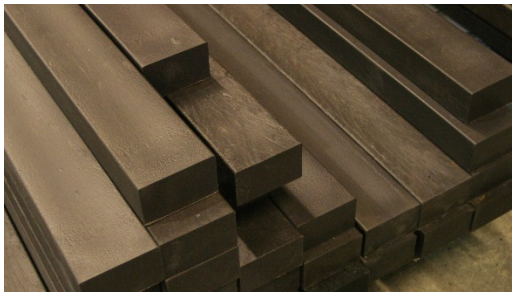
Product applications	WPCs combine saw dust with a variety of plastic polymer types and other fillers. They are most commonly used in building products like decking, fencing, industrial flooring, landscape timbers, railings and mouldings, where they can replace treated timber (Indufor 2018). There is generally 50% to 80% wood in WPC products, as chips or sawdust. WPC's offer better mechanical properties such as rigidity and strength compared to other plastic materials, and improved weather resistance and lower maintenance needs compared to traditional timber.
Market trends	As a sustainable bioproduct, the demand for WPCs is set to grow steadily with innovations in materials recycling and production technology. Manufacturing is growing worldwide due to increasing demand and the availability of automated processing equipment. Most manufacturers of WPC are in China, Japan and North America.
Status in Australia	There are several Australian suppliers and manufacturers of WPC products, most of which produce materials for decking, fencing, cladding, outdoor furniture and related uses. There may be scope to encourage expansion of WPC production in the main timber processing regions.
Key market opportunities and risks	*OPPORTUNITIES* Increasing use of WPC's will increase demand for wood residues and pulplogs as a feedstock. The largest growth area for WPCs has been building products, like decking, fencing, industrial flooring, landscape timbers, railings and moldings, where they can replace natural timber. Growth in the WPC market may also stem from the phase-out of chromated copper arsenate (CCA) treated wood. Advancements in WPCs are being investigated to replace treated timber currently used to support piers and absorb the shock of docking ships (Indufor 2018). *RISKS* While they use wood residues as feedstock, in many of their applications WPCs do compete with wood products in the marketplace. Care needs to be taken to communicate the benefits of WPC as well as timber and the suitability of both products in different applications.
Policy implications	As for bioplastics, there are strong policy drivers to support the uptake of WPCs. The Chinese restriction on imports of plastic recyclables creates incentives for WPC producers that can utilise recycled plastic along with wood residues.
Processing requirements	WPCs are produced by mixing ground wood particles with heated plastic resins, then processed in a similar to plastic manufacture. Extrusion and injection moulding are the most common approaches to deliver the desired shape for the WPC and which require specific equipment.
Skill requirements	Specialised manufacturers currently produce WPC's and it is likely that this will continue. However the production process for WPC is broadly similar to Medium

	Density Fibreboard (MDF) production and there would be scope for existing MDF operations to retrofit their equipment to produce WPC products.
Input specifications	Residues from nearly any wood and paper processing operations can potentially be used in WPC production. Hardwood residues are generally used in WPC production because of their durability and strength properties.
Impact on plantation timber demand and log value	Wood plastic composites could create new or higher value markets for residues from wood and pulp and paper processing.

Photo 7: An outdoor table constructed with WPC materials

Source: Advanced Plastic Recycling

Photo 8: "Plastic lumber", an example of a WPC product



Source: EcoPost

3.6. Native foods as non-timber forest products

Native foods encompass a range of fruits and tree products that are sourced or derived from forest trees.

Product applications	Native foods have a range of uses as an ingredient or flavouring, in cosmetics and in medicinal uses. While these products are not derived from traditional plantation species, they are tree products and are increasingly being grown in plantation conditions. There is scope to incorporate native foods production into farm plantation models. There are several native foods products that have been or could be commercialised, some of the more recognisable products are: • Finger Lime; • Davidson Plum; • Kakadu Plum; • Native pepper; • Wattleseed; and • Lemon myrtle.
Market trends	Growth in the popularity of native foods has stemmed from the trend towards natural products and consumer interest in the origin of food products. The last few years have seen substantial growth in this industry through local and international demand for the products, media coverage and the increasing numbers of growers (PWC 2017). One example of the interest in native food products is the Kakadu Plum, a native plant in northern Australia that is high in Vitamin C and is now seen as a 'superfood'. The number of wild-harvest locations have increased, and the first harvest has recently been conducted in an agricultural plantation. New markets and applications have been identified, including for increasing the shelf life of red meats, in skincare and health applications (PWC 2017).
Status in Australia	All native foods are currently niche products that are sold to both local and export markets. Their production is currently small scale and the industries tend to be comprised of multiple small producers. There is scope for greater commercialisation of these products which will require improvements to: product awareness, supply aggregation and processing capacity, product standard development and related aspects.
Key market opportunities and risks	*OPPORTUNITIES* Most native food products are supply limited, creating scope to maximise value through local processing and targeted marketing. In the context of plantations, there are opportunities to incorporate native foods and other non-timber products with traditional plantation species. This could create a broader appeal among some landowners for tree growing and lead to more diverse plantation based farm enterprises. *RISKS* Most native foods are emerging or niche products with specialised production and quality requirements. These types of products come with inherent risks and tend to require a higher level of commitment from producers as products are developed and become more widely recognised. This sort of commitment may or may not suit tree growers.

Policy implications	Considerations for policy and industry development relating to native foods include: • The identification of business models that can help to develop product recognition and assist with aggregation, processing and marketing. To date, most native foods have been driven by individual farmers/entrepreneurs, this needs to evolve to an industry approach to encourage wider adoption. • There is existing involvement of indigenous producers in native foods production and scope to expand this. This could present an avenue for greater engagement between the forest industry and indigenous people, particularly in northern Australia. • Industry bodies and government have an important role in developing native foods. Current supporting organisations include the Australian Native Food and Botanicals is a peak industry body and the Cooperative Research Centre (CRC) for Developing Northern Australia. • Formal market access arrangements will be necessary to underpin sales of 'new' products. This might include bilateral trade and biosecurity arrangements (for export markets) and quarantine protocols. • Certification will be important for some products, this can help to achieve premium prices but is also an additional administrative and economic burden.
Processing requirements	The nature of processing depends on the input product which could include fruits, leaves, seeds bark and others. At this stage processing of native foods is small scale and a common challenge is to ensure that appropriate processing facilities are available to small and larger producers.
Skill requirements	Native foods encompass a range of products and the skills needed in the growing, harvesting, handling and processing of these varies. In the context of plantations, the skills required of the grower to produce native foods will be somewhat different to those required for timber production, requiring more of an agricultural production approach.
Input specifications	Input specifications for food products are dependent on the product type, how it is harvested and stored and the nature of processing.
Impact on plantation timber demand and log value	Development of natural foods and related products could make tree growing attractive to a wider group of landowners than traditional plantations. There is scope for mixtures and diversification of planting types at farm level that could generate a range of products, both timber and non-timber. The impact of these products is likely to be realised for some producers in specific locations, they are unlikely to influence the plantation sector as a whole.

Photo 9: Examples of Australian native foods showing finger lime, Davidson plum and others.

Source: Daleys Fruit Tree Nursery

Photo 10: Native pepper grown in plantation conditions adjacent to a forest area

Source: Australian Native Food and Botanicals

4. Conclusion

Australia's plantations currently produce mainly structural timber and pulpwood. These products will continue to be important but the range and value of products from Australia's plantations will evolve, as will the markets they are sold to. At the same time, economic trends such as population, construction starts, interest in sustainable products, all indicate a growing demand for wood and wood based products.

The product examples described in this report show that there are innovations that have the potential to make some plantations more viable or more valuable than they once were by creating more value for lower quality logs and processing residues, or by increasing demand for existing timber products. Chart 5 summarises the overall influence that the identified product innovations in this report could have on plantation development.

Many of the identified emerging products utilise wood residues or small and lower quality logs. This is an encouraging trend as, collectively, these products will lead to a greater market tolerance for lower quality logs across the plantation estate. This could impact on plantation management, as silvicultural practices that are geared towards sawlog production would not be necessary where logs are harvested at a young age or directed to markets that can accommodate lower quality logs.

Chart 5: Influence of the identified product innovations on plantation development

Product innovation	Nature of influence on plantations development
CLT for tall buildings	Wide adoption of CLT will increase overall demand for lower quality and smaller dimension softwood structural timber and potentially also for hardwood plantation timber. CLT could be a significant driver of future demand and price for plantation wood.
Bioenergy and wood pellet production	The use of wood residues for bioenergy can increase the value and demand for waste or low value products. In the context of Australia's plantations, this could help to make what would otherwise be uneconomic scenarios potentially economic.
Plywood from spindle-less lathes	Demand for plywood production and spindle-less lathe technology are already impacting on the demand for and value of Australia's hardwood plantation resource. Logs from plantations established for pulp production and thinnings from sawlog plantations are being diverted into higher value products such as plywoods and veneer based engineered wood products.
Bio-plastics using wood residues	Bioplastics could create new or higher value markets for residues from wood and pulp and paper processing. This could increase the overall value of plantation logs where there are nearby markets. They represent an opportunity for the forest industry to contribute to the reduction of fossils fuels in plastic production.
Wood plastic composites as building materials	Wood plastic composites (WPC's) could create new or higher value markets for residues from wood and pulp and paper processing. This could increase the overall value of plantation logs where there are nearby markets. In some applications, WPC can also compete with timber.
Native foods as non-timber forest products	Development of natural foods and related products could make tree growing attractive to a wider group of landowners than traditional plantations. There is scope for mixtures and diversification of planting types at farm level that could generate a range of products, both timber and non-timber.

The scale and nature of the impact that product innovations have will vary. For example, some products could increase demand across the plantation estate while others will affect a particular log type or plantation region. Chart 6 provides a more detailed overview of the nature of the impact that the production innovations could have.

Chart 6: Assessment of how product innovations could affect plantation development

Product innovation	Input product or material	Specificity of input requirements [1]	Location and transportation [2]	Key influencing markets [3]	Type of market [4]	Cost of adoption [5]
CLT and mass timber	Timber	High	Existing processing region	Domestic	Mainstream	High
Bioenergy and wood pellet production	Residues	Low	Existing processing region	International	Mainstream	High
Plywood from spindle-less lathes	Logs	Medium	New processing location	International	Mainstream	Low
Bio-plastics using wood residues	Residues	Low	Existing processing region	Domestic	Mainstream	High
WPC for building materials	Residues	Low	Existing processing region	Domestic	Mainstream	High
Native foods as non-timber forest products	Fruits, seeds, nuts, leaves	High	New processing location	Domestic	Niche	Medium

Notes:
1 – The degree of specific product requirements at the point of processing (using a scale of High, Medium, Low)
2 – The geographical location where products could be manufactured (either in an Existing processing region or a New processing location)
3 – The key markets that could drive the development and uptake of the product (either International or Domestic)
4 – The type of market that the identified products would be sold in (Mainstream or Niche)
5 – The cost of adoption of the identified product (using a scale of High, Medium, Low)

4.1. Next steps

This report is intended as an overview and the conclusions drawn are general and preliminary in nature. Steps to develop the ideas in this report and further explore how the identified product innovations could facilitate plantation development include:

- Exploring other products that have not been considered in this report;
- More detailed analysis of the viability of a particular product in a specific plantation region;
- For a given region, engaging with local industries e.g. bioplastics, WPC to better understand the scope for forest industry to supply in the local context;
- Testing the possible impact of new products be incorporating them into plantation business models; and
- To collectively engage with other industries and partners to understand how best to position the forest sector for the uptake of these products.

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