What to Do with Structurally Low-Grade Wood from Australia's Plantation Eucalyptus; Building Application?

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About one million hectares of plantation hardwoods, mostly eucalyptus trees of different sub-species (*E*. *nitens* and *E*. *globulus*), are annually being managed in Australia, which provides a promising resource of raw materials for fibre industries. However, the timber boards required by the Australian hardwood sector are still being either imported from other countries or harvested from the native forests. There is a need to find a practical way to use the plantation eucalyptus in the Australian timber industry. However, the fibre-managed plantation eucalyptus produces structurally low-grade timber which could not be used as individual boards for structural applications—such as building construction. Unsuitable for appearance applications, the structurally low-grade boards may be suitable for producing innovative high-mass engineered timber products. This editorial will briefly discuss drivers, opportunities, and challenges associated with conducting such a research project.

Keywords: Plantation hardwood; Structurally low-grade wood; Timber building; Eucalyptus

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The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) estimates that more than two million hectares of plantation softwood and hardwood species exist in Australia—with a total area of 976,400 hectares for hardwood plantations (Gavran 2014). Such a large volume of plantation hardwood trees has the potential to provide a significant portion of the wood resource required to service Australia's timber construction sector. However, most plantation hardwoods in Australia are eucalyptus species, primarily managed for pulp log production. According to ABARES, nearly 84.4% of logs currently harvested from hardwood plantations are being used in Australia's pulp and paper industries or exported as woodchips. Current plantation hardwood genetics have been selected for their fast growth to compliment short rotation cycles in largely unthinned and unpruned stands. Recovered plantation hardwood logs generally produce structurally low-grade timber when sawn, producing boards that contain strength-reducing characteristics. While this plantation hardwood resource exists, Australia's hardwood lumber sector still relies on milling logs from native forests and imported wood species (McGavin *et al.* 2015). Although native hardwood species are well regarded for their strength and visual properties, supply has decreased steadily from the 1970s (Nolan *et al.* 2005). Given this decline in supply and the lack of expansion in the plantation softwood estate, there is a drive to develop higher-value solid wood products and corresponding applications in building construction for some part of the plantation hardwood resource in order to fill growing market gaps. The aim of this editorial is to highlight and discuss the main issues likely to impact the development of any high-mass timber components manufactured from structurally low-grade boards recovered from Australia's plantation eucalypts.

Developing and producing engineered high-mass timber components—such as Glue Laminated Timber (GLT) and Nail Laminated Timber (NLT) panels—from structurally low-grade plantation hardwood boards could be one option. Not competing with the current softwood processing sector, this approach could generate a value-added product suite for a new plantation hardwood processing sector. It could also support the markets expected to form as Australia's building professionals increasingly adopt timber-rich construction options for multi-residential and commercial buildings. Developing engineered products for building applications from structurally low-grade plantation eucalypt timber is a straightforward goal; however, commercial innovation and experimental works are also needed to find a practical process for using this material in a product that economically and structurally satisfies the requirements established in the Australian construction industry.

Eucalyptus g*lobulus* (known as Tasmanian or Southern blue gum) and *Eucalyptus nitens* (known as Shining gum) are the major plantation hardwood species grown in Australia. Southern blue gum makes up 54.6% of the current estate while 24.2% is Shining gum (Gavran 2014). The estate was mainly planted after 1995, and both species were selected for their high growth rate. The overwhelming majority of the estate was planted and is managed in unthinned and unpruned stands to economically maximise fibre production. The lack of thinning produces tall but thin stems, while the lack of pruning results in regular branch stubs in the wood—especially in Shining gum. While relatively unimportant for fibre production, both factors complicate recovery of solid wood products. Due to the current economics of growing wood in Australia, fibre production drives management practices and most hardwood plantations are harvested between 15 to 20 years old. As a result, the diameter of logs potentially suitable for solid wood production is low–averaging 345 mm at the small end diameter. Since the stems are unpruned, the wood includes regular knots and other natural features. This largely precludes its acceptance in appearance applications, but it may be suitable for a new generation of structural engineered products. Sawing the logs and drying the boards from this resource presents challenges. Recovery from the small logs is low without purpose-designed equipment, and both species are prone to cell collapse during drying–again, especially Shining gum. The radial and tangential shrinkage rates for both species are high, and their sapwood is lyctus susceptible. In conventional milling for appearance products, these species would be quarter sawn to reduce drying degrade and the sapwood removed. However, quarter sawing and sapwood exclusion reduce volume recovery from young logs with relatively wide sapwood bands. To increase recovery for high-mass timber components, logs need to be sawn for volume and sapwood may need to be retained. Drying degradation in boards and lyctus susceptibility then need to be accommodated in later production stages.

The important initial stage in producing any high-mass timber components from this material is to establish a robust understanding of the resource's physical, mechanical, acoustical, and fire-resistant properties. While significant research into the properties of Australia's plantation species has occurred, much of this has focused on the properties of boards milled from logs from thinned and pruned stands grown in longer rotations. Inadequate work has occurred on boards sawn for volume from logs recovered from unthinned and unpruned stands. The multiplicity of knots, drying degradation features such as checks and unrecovered collapse, growth stress, the effects of tension wood, and nonuniform fiber orientation along the longitudinal axis can complicate the workability and performance of boards and groups of boards assembled into engineered timber components. These complications need to be defined and understood. Factors that can influence the development of suitable, economic products from this resource include accelerated drying, drying degrade, board grading approaches and methods of material assembly.

Logs cut for volume will produce a range of backsawn, quarter sawn, and transitional boards. If this resource is to be processed economically, accelerated drying is likely to be necessary, and the additional drying degradation generated in this variety of boards needs to be managed. However, the impact of the different types of drying degradation on board and panel workability and performance for each species and their increase with accelerated drying is not well understood. Additional checking is unlikely to be critical, but increased board deformation may create problems. These impacts need to be confirmed if a useful balance between drying speed and acceptable board degrade is to be identified. Alternative grading rules are also needed to accommodate plantation resources that will be used in high-mass engineered timber components. Existing structural grading rules are rigorous and designed to ensure that the performance of an individual board for an unknown future application meets building standards. For individual boards with regular strength reducing characteristics such as knots, the grading rules are constrictive and neglect to consider that multiple low-grade boards will to be used in combination in a purpose-designed engineered component. While the individual boards may not be suitable to use as a single building element, such as a beam or post, they may contribute to the performance of a multi-member assembly such as GLT and NLT panels. Alternative grading rules can therefore potentially accommodate the patterns of features likely in each piece and their performance relative to board orientation in the finished panel.

Simply docking out strength-reducing characteristics and rejoining 'clear' sections will be labour-intensive and make any final panel uneconomical. In a high-mass timber component, boards need to be joined along their length and side-to-side. An efficient end-to-end joining system is therefore vital to overcome length limitation and ensure efficient board utility. Finger jointing is the common end-to-end joining techniques, but there is a lack of information on the effectiveness of finger joints in plantation eucalypt cut for volume and dried quickly. In addition to the features in the wood, drying degradation may have a major influence on finger joint performance. Boards also need to be effectively joined side-to-side to make a panel: either glued, nail-laminated, or stress laminated. Each approach will result in different structural performance in a panel (which needs to be defined) and in different opportunities in fabricating the panels economically. Glue laminating panels requires skill in machining, adhesive management, and product assembly but can provide a reliable product from a varied resource. Nail lamination is a more diverse process for regional producers to adopt, but may only be viable if board deformation is constrained before assembly. Stress laminating may now also be possible given the extensive range of large screws now available on the market. Given the unique nature of the resource and the problem, innovative approaches are needed. An approach where sawn boards are milled, joined, and green glued into large elements before seasoning, may not offer a commercial solution to assembling timber engineered component from Shining and Southern blue gum into panels, but the response of this material to green gluing may inform more efficient ways of assembling dry boards effectively.

This editorial indicates that drivers exist to develop higher-value solid wood products and corresponding applications in construction for some portion of Australia's extensive plantation hardwood resource. Unsuitable for appearance applications, recovered boards may be suitable for novel and innovative high-mass engineered timber components. Repurposing the fibre-grown resource into purpose-designed timber engineered components suitable for building construction in Australia to meet potential market gaps may be a solution. However, the form of the resources and their management complicates its use. Research is needed that seeks to understand and balance the technical, performance, and production issues along the supply chain: from the resource and the feedstock that may be recovered from it; through the production process in fabrication facilities of differing scale and skill level; to the products that have to provide satisfactory performance in a range of building applications.

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