Converting a plantation resource from pulp and paper to sawn timber products

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Executive Summary

Plantation forestry is a significant forest resource for the Australian forest product industry. In recent years, the amount of native and regrowth forests allowed for harvest have been significantly reduced, so plantation sourced material will need to be harvested in order to make up for this shortfall. As the majority of plantations (83%) are bred and managed for pulp production, there are concerns over whether this resource can be properly utilized for production of sawn timber products. Issues such as internal check in Eucalyptus nitens, and growth stresses in Eucalyptus globulus, make using this plantation resource extremely difficult when not processed into wood chips. Every year the amount of plantation fibre available for the pulp and paper industry increases, which has been driving down the prices of pulp. This price increase has caused many plantation owners to shift to managing their plantations for sawn timber products, a market which gives a higher return over the pulp market. In order to successfully utilize a pulp and paper resource for sawn timber products, pruning, thinning and other silvicultural regimes need to be initiated within the first five years of the stands growth in order to significantly increase the wood quality of the stand.

KEYWORDS: Plantations, Eucalyptus, nitens, globulus, regnans, internal check, growth stresses, pulp, Australia
Introduction

This paper discusses the issues and potential strategies with utilizing a plantation resource bred and managed for pulp and paper production to one which can be used for the production of appearance and structural sawn timber products.

Plantation Forestry

“The 164 million hectares of forested land in Australia is made up of around 62% woodland forest, 28% open forest, 3% closed forest (mainly rainforest) and 1% plantation forest” (Australias Forests). While only making up a small percentage of Australia’s total forest land, plantation forestry provides a large source of wood for the Australian forest products industry. Plantations have existed in Australia since the turn of the 20th century, when radiata pine was first introduced as a potential plantation species. Extensive plantation forestry programs began in Australia in the 1960s, and since then, the area of plantations in Australia has developed to over 1.7 million hectares (DAFF). Recently there has been a substantial increase in investments by private firms into plantation forestry (Australias Forests) as modest gains can be made from owning plantations. Currently hardwood Eucalypt plantations only make up around 40% of the total number of plantations (DAFF), and are comprised of low density species, ideal for the pulp and paper industry due to the high quality pulp yields which can be obtained from them.

In 2007, the total area of Australia’s plantation forest estate increased to 1.90 million hectares, comprising of about 883 000 hectares (46%) of hardwood species (DAFF). In 2007, 86, 569 hectares of new plantations were established, comprising of 76,057 hectares of hardwood planted (DAFF). Figure 1 below shows the change in the total plantation area in Australia between 1995 and 2007.

Figure 1: Australia’s total plantation area, 1995 – 2007 (DAFF)
As you can see from Figure 1, the area of plantations has been steadily increasing from approximately 110,000 hectares in 1995 to 1.9 million hectares in 2007 (DAFF). Starting in 2000, the area of softwood plantations has stayed relatively constant, while the area of hardwood plantations being planted has steadily increased. This is an important trend for the sawn timber industry because it means that there will be an increase in potential hardwood timber volume in the next two decades.

**Hardwood Production Industry**

The hardwood solid wood product industry is an important contributor to Australia’s GDP, and has been an important industry in Australia since European colonization. The hardwood industry has relied heavily on processing mainly native and regrowth species, but recently has seen a reduction in the amount of logs from these sources that they are allowed to harvest, due to an increase in state reserve land area and a reduction of allowable harvest imposed by state and federal governments. Between 2002 and 2003, the industry processed 3.03 million m$^3$ of eucalypt logs into 1.06 million m$^3$ of timber (G. Nolan). The industry produced about $1$ billion of sawn timber in 2003-04, and generated at least as much again in further processing and other products (ABARE 2004).

“The hardwood industry in Australia currently markets between 60-70% of their production in appearance product, 20-30% in structural and 10% in industrial timber” (G. Nolan). This marketing focus is due to the fact that the majority of hardwood timber products have higher processing costs than softwood products, and can achieve a greater return as appearance products over softwood timber, due to the unique colour and appearance of hardwoods, and because of the increased durability over softwoods (G. Nolan).

Countries such as Chile, Brazil and Spain already have an established, profitable solid wood products industry based on processing plantation eucalypts. Australia’s current plantations are all relatively young (most plantations planted after 1990) and the majority of current plantations were planted for pulp production (83%). Australia’s solid wood products industry cannot properly harvest the pulp plantation resource for the production of sawn timber products. If Australia wishes to follow the model of Chile, Brazil and Spain they must plant new plantations specifically for sawlog and solid wood product production, instead of attempting to convert trees from pulpwood plantations to sawn wood products.

One of the leading forest product companies in Tasmania is attempting to construct a new pulp mill in northern Tasmania in order to fully utilize their plantation base located in Tasmania. If this new mill does not get constructed due to restrictions by state government or an inability for the company to achieve financing, there will be a large volume of timber available to the Tasmanian wood market, as shipping the woodchips to port, and the overseas, would get to be quite costly. The solid wood products industry then has the potential to supplement the decline of the allowable native and regrowth harvest with this new plantation resource.
Silvicultural Details

*Plantation forestry practices – “Bred for Pulp”*

The plantation forest industry in Australia has a number of management principles set forth by state and federal agencies in order to provide a framework for sound plantation management. In order to comply with these standards, plantation owners must plan and manage every aspect of their plantation from selection of the land through to harvesting of the site.

The first steps in converting a site to one suitable for tree plantation is ground preparation, either by ploughing or ripping the soil, to allow the trees roots to grow. As the hardwood species used for plantation are fast growing, loose soil is much preferred to allow the tree to grow at the fastest rate possible. After the trees have been planted, the next major issue is weeds. Weeds take away water and nutrients from trees, hindering their growth, and are typically chemically removed. Every few years, the trees will need to be pruned and thinned in order to improve tree growth on the site. Eucalypts are naturally self pruning species, and have far greater self pruning ability over conifer species. Native eucalypt forests usually start germination after a disturbance such as a fires or logging. Typically after a disturbance, germination of over tens of thousands of seedlings per hectare will occur. (K. D. Montagu) This large stocking rate and fast growth rates leads to a limit in number of branches during the first few years of growth, leading to trees with a large proportion of clear wood. Plantation forests in contrast, have short rotations and low stocking rates, which lead to an increase in the number of branches and a reduction in the trees ability to self prune. This increase in retained branches leads to an increase in the number of knots in the log which is not a major issue when the logs are used for pulp, as the logs will simply be chipped in order to be processed into pulp. When these logs start to be used for sawn timber products, the increased number of knots starts to become a major issue. The large number of knots near the core of plantation logs is one reason this timber supply is better suited for the pulp industry than the sawn timber product industry. One of the main ways to reduce the amount of knots in plantation logs is to undertake a pruning regime. Pruning regimes involve going in to a plantation stand and physically removing branches from the trees, in order to reduce the number and size of branches, which directly affect the number and size of knots in the log. While pruning regimes significantly increase wood quality, the costs of undertaking a pruning regime on a plantation site used for pulp are considerably high for the increase in profits those regimes will yield.

Intensive forest management (IFM) is one forest management regime which is being utilized in pulp plantation forestry. Under IFM, special techniques involving pruning, thinning and harvesting are used to maximize the economic value and log quality of the plantation. “Intensive forest management has commonly become associated with forest plantations that have high initial investment costs in stand establishment. These intensive
plantations will probably not produce high quality wood because they will be physically and economically unstable if grown to long rotations, and so will probably need to be harvested when quite young” (Oliver).
Why Plantation sourced fibre?

Ideally, the best source of material for sawn timber products are logs sourced from native and re-growth stands, much like what has been utilized in the majority of mills in Australia since European colonization. These native and regrowth trees have large diameters, large percentages of mature wood, and consistent density and strength properties throughout the majority of the stem. As the main wood source, hardwood processors have setup their manufacturing process to process native and regrowth sourced logs and market the higher quality timber. Over the last two decades, “the volume of logs available for processing has reduced from 5.79 million m$^3$ of non conifer timber in 1980, to 3.03 million m$^3$ in 2003 (FAO).” This dramatic decrease is caused by a reduction in the amount of native and regrowth logs available for harvest, due to an increase in the area of state reserves, and a decrease in the amount of timber which the state governments allow for harvest. (Department of Agriculture, Fisheries and Forestry) Figure 2 below shows the projected log volumes available from private and public native, as well as plantation forests, from 2000-2035.

Figure 2: Projected saw log availability, 2000-2035 (G. Nolan)

Between 2000 and 2035, the total amount of hardwood sawlogs is projected to decrease by 23%, as well as the amount of logs sourced from public native forests (G. Nolan). Since the amount of logs from private native forests is projected to stay relatively constant, the reduction in logs from native sources is projected to come increasingly from plantation sources (G. Nolan). Unfortunately, only half of this log availability lost from private and public forest over the same time span is projected to come from plantation forests, to only approximately 18% of the total log availability in 2035 (G. Nolan).

This reduction in total log supply has caused the industry to shift from many small operations to fewer larger operations, able to operate more efficiently. In the next several years a considerable amount of plantation
sourced material will be reaching the harvest age and become available on the market. “Eucalypt hardwood plantations do not bring a new or different solid wood product to the market. They will supplement the supply of hardwood logs from native forests” (G. Nolan). Every year the amount of native and re-growth material which can be harvest decreases, and these mills will need to start harvesting plantation sourced material to maintain their current level of production. As the number of plantation stands reaching the harvest age increases, sawmills will need to use more of this new resource, to the point where it could potentially make up the majority of the mills wood source.
Saw log managed plantations

Currently, Over 17% of Australia’s plantations are managed for sawlog production with 79% of these plantations located on the north coast of Tasmania or New South Wales (G. Nolan). A significant proportion of these sawlog managed plantations are owned by or established in cooperation with state agencies (G. Nolan). These state agencies are investigating the costs and requirements for managing plantations for saw logs, and will report the findings to the industry, in order to encourage plantation owners to shift to planting their plantations for sawlog production. 62% of these plantations have been planted since 1995, and with a rotation age between 20-35 years, are still relatively young (G. Nolan).

Figure 3: Hardwood plantations for sawlog production by location and age (G. Nolan)

![Graph showing areas planted for sawlog production by age](image)

It is unlikely that plantation sites managed for pulp production will yield logs suitable for sawlogs or solid wood products, and will not respond to late silvicultural changes (after age 4) in a way that significantly improves the wood quality (G. Nolan). Managing plantation sites for sawlog production is a long term investment, as it requires a high initial capital cost, and takes between 25 and 30 years before the logs can be harvested and any gains made. Plantation ownership is a risky high investment industry, as the price of woodchips or sawlogs 20 years in the future is unknown at the time of planting, so knowing whether a plantation site will be profitable or not at the time of planting is extremely difficult to know. This high initial cost and the long period before any gains can be made, causes the majority of plantation owners’ to favor managing their plantations for pulp production, as their return on investment can be seen quicker. “Industrial and small-scale eucalypt growers in Australia have been hesitant to manage Eucalyptus species . . . for pruned sawlog (clear wood) production, because of uncertainties in best silvicultural practice, financial returns, and for Eucalyptus species particularly, doubt regarding the quality of the
One reason plantation owners are shifting from growing eucalypts for pulp to growing for sawn timber products is the increase in transportation costs of wood chips due to the rising costs of fuel, as well as a steady decline in pulp prices as the amount of pulp plantations has rapidly increased in Australia as well as overseas. “Pulp prices decreased by approximately 20% between the mid and late 1990s, in part due to the rapid increase in plantation areas established for pulpwood production in countries such as Australia, Chile and Uruguay.” (K. D. Montagu) The higher costs of shipping wood chips to port and lower pulp prices have led an increasing amount of plantation manager’s shift to managing their plantations for sawlog production.

Different silvicultural regimes yield different quality and sizes of logs. Unthinned and Unpruned stands yield small slowly grown trees with little clear wood and a large knotty core (G. Nolan). From thinned and unpruned stands, self pruning species shed their branches and can yield higher proportions of clear wood, while non self pruning species grow larger stems but do not shed their branches, and so have a larger knotty core (G. Nolan). Thinned and pruned stands can grow large stems with clear wood quite quickly (G. Nolan). These results do not occur for every species in the same way; for example, a 32 year old late thinned and unpruned stand yielded logs where only 14% met the minimum sawlog specifications, while a 22 year old thinned and pruned stand of a different species had 94% of logs satisfy that same requirement (G. Nolan).
Changes in silvicultural regimes

The initial stocking rate when planting a plantation has a huge impact on the ability of the stand to produce the desired volume or quality of timber desired, and also affects the further silvicultural operations required on the stand. The vast majority of pulpwood plantations have been planted with an initial stocking rate of 1300-1700 stems/ha, while plantations managed for sawlogs in South Africa have been planted at a rate of 1000-1100 stems/ha (Jenkins). While lower stocking rates yield higher quality logs, a sufficient number of trees still need to be selected in order to allow a sufficient selection of stems when the stand reaches harvest age. In a research trial involving planting E. nitens for sawlog production, an initial stocking of 1000 stems/ha is recommended, and thinning down to 250 stems/ha final crop over a 30 year rotation yielded promising results (A.M. Gerrand). It has been proven that logs sourced from native forests will tend to yield higher quality clear timber over logs sourced from plantation forests. For pulp and paper, whose raw materials are wood chips, clear timber is not required to improve the quality of the finished product. If this resource is to be utilized for sawn timber products, this becomes a major issue. Pruning regimes will need to be implemented to reduce the number of branches in the first few years of the trees growth. By pruning the trees regularly within the first 2-3 years, it will reduce the amount of knots found at the core of the tree and promote the growth of clear wood. It has been shown that pruning increases the recovery of select grade boards over unpruned logs. Another option for increasing log quality in the stands is by thinning. Thinning is the process of removing selected trees in order to allow the neighbouring trees more room to grow. While thinning does reduce the total volume of wood on the stand, it increases the growth of trees retained on the site. Thinning has been shown to increase the basic density, heartwood proportion and growth of individual trees on plantation stands (G. Nolan). Increasing tree spacing during site planting has also shown to improve log quality. By increasing the spacing between trees and lowering the site stocking rate, there is an increase in tree growth, reduced stand growth rate and a reduced basic density gradient between the pith and the bark, i.e. more consistent density all the way through the log (G. Nolan). By growing the trees much longer than the typical 15-20 year rotation cycle, the small end diameter of the logs will be much larger and become closer in size to what is currently utilized in the industry. As all of these changes in silvicultural practices are quite economically intensive, there must be significant increases in log recoveries for a plantation owner to undertake these practices. “Generally, a mean annual increment at age 10 of at least 20 to 25 m³/ha is required for operations to be profitable” (G. Nolan).

Breeding for improved quality

Breeding for pulp, and breeding for sawn timber products are two drastically different breeding regimes. Breeding for pulp and paper targets increasing growth rates, reducing tyloses which reduce permeability, and increasing drought and frost resistance to enable a species to grow in more areas. Current genetically modified plantations
have been developed from over 60 years of breeding (DAFF), with all the current improvements achieved through conventional breeding techniques, as there are currently no genetically modified trees planted in Australia (DAFF).

Tree breeding involves selecting high quality trees from a stand, collecting the pollen from some of these trees and pollinating the flowers on the others. The seeds which are produced are then planted, and typically produce higher quality trees. Some common traits which are normally attempted to improve through breeding are reduction in the degree of internal checking, increased wood strength and stiffness, resistance to frost, insects and disease, and a reduction in the size of the juvenile wood core (G. Nolan). So far, there have been no investigations into the relative importance of each of the various traits for solid wood product applications, as for solid wood applications, there is still a need to quantify “quality” (G. Nolan).
Juvenile Wood

Juvenile wood is a major issue in young plantations. Juvenile wood is a zone of wood in the tree that starts at the pith and extends outwards for a period of time, which varies depending on the species of wood, but is typically between 5 to 20 years. After this period, the tree starts producing mature wood, which extends to the outside of the tree. These two different zones (juvenile wood zone and mature wood zone) have significantly different physical properties. Throughout the juvenile wood zone, strength properties gradually increase, until they reach the mature wood zone, at which time they stay relatively constant. In fast growing tree species such as plantation eucalypts, the juvenile wood zone usually makes up a significant amount of the stem, sometimes spanning to the outside of the stem if the trees are relatively young, such as trees used for pulping, which have a rotation age less than 20 years. Some characteristics of juvenile wood are wide growth rings, lower density and stiffness, high grain spiraility and microfibril angle and high longitudinal shrinkage (J. Illic). The pulping industry has adapted to the increasing amount of juvenile wood in their fiber supply by “blending it with mature wood from other trees or species and by improved pulping technology” (United States Department of Agriculture). However, the solid wood products industry is still adapting to processing logs with an increased amount of juvenile wood. It has been shown that juvenile wood decreases the ultimate strength of the wood by between 30-50% (United States Department of Agriculture)
Plantation Species

Approximately 39% of the plantations in Australia are hardwood Eucalypts, which are an ideal candidate for pulp plantations as they are fast growing, produce large pulp yields in short rotations, and some species thrive on a monoculture site (DAFF). The most commonly grown plantation eucalypt species are Southern Blue Gum (E. globulus), Shining Gum (E. nitens) and Mountain Ash (E. regnans).

Eucalyptus Globulus

Eucalyptus Globulus (Southern Blue Gum) is the most predominant hardwood plantation species, comprising 65% of the plantation forest area in Australia (DAFF). E. globulus is generally found in low elevations, up to 400m above sea level, with best growth achieved in cool damp areas with well drained soils (AGDNP). The species is found in its native habitat growing in both pure stands, and in mixture with Tasmanian Oak (E. obliqua), and mountain ash (E. regnans) (Skolmen). E. globulus ability to withstand a variety of environmental conditions, as well as its fast growth rate (up to 2m per year) makes it the ideal choice for eucalypt plantations in southwest Australia as well as overseas (AGDNP), and with pulp yields of up to 20-30 m³/ha/year, makes it an ideal species for pulp production (USDA GRIN).

E. globulus has four subspecies recognized, but the main subspecies is “the type tree, subspecies globulus, which is largely confined to the southeast coast of Tasmania but also grows in small pockets on the west coast of Tasmania, on islands in the Bass Strait north of Tasmania, and on Cape Otway and Wilson's Promontory in southern Victoria, Australia.”(Skolmen)

Figure 4: Location of E. globulus plantations in Australia (Wikipedia)
Silviculture
A native species to Tasmania and southern Victoria, *E. globulus* has been planted in Spain, Portugal, New Zealand, South Africa, California, Hawaii and Macaronesia (USDA GRIN). The ideal climate for *E. globulus* has been found to be the eastern coast of Portugal, with a mean annual rainfall of 900mm, and a minimum temperature never below -7°C (Skolmen). Growth rates of *E. globulus* vary significantly between sites in Australia as well as plantations overseas. In Tasmania, growth of 35 m$^3$/ha was reported, while growth rates in Spain varied dramatically, with northern Spain recording growth rates averaging 20 m$^3$/ha and southern Spain averaging only 5-6 m$^3$/ha (Skolmen). In Ethiopia and Portugal, the highest quality site had a growth rate of only 20 m$^3$/ha (Skolmen). As you can see, Tasmania is one of the ideal locations to grow this species, as it gives some of the highest growth rates for *E. globulus* in the world.

Pulp Production
Based on its light colour and high fibre yield, *E. globulus* has predominately been bred and planted for pulp production. Also, retained bark is acceptable in the pulping process, which adds greatly to the pulp yields (Skolmen). For the pulping industry, a lower percentage of heartwood is desired, as the higher percentage of extractives in the heartwood increases the chemical requirements in the pulping process and reduces the pulp yield (Gominho). Recently, research projects have been initiated looking at breeding heartwood free eucalypts. The research project “Towards the Development of Heartwood-free Eucalypts” wants to explore opportunities in utilizing molecular tools to reduce the amount of heartwood in commercial eucalypts for pulp production as “the heartwood permeability may be less than 1% that of sapwood. Even modest gains in permeability will significantly reduce [pulping] processing costs” (L. Wilson). The reason for the difference in permeability is the presence of tyloses$^1$ in the heartwood. By reducing the amount of heartwood in the trunk, pulping processing costs would be able to significantly decrease the chemicals used to break down the fibres due to increased chemical penetration into the wood fibre.

Production
Utilizing plantation *E. globulus* in Australia is still relatively uncommon, as the majority of logs go towards wood chip production for pulp and paper. As the distance between the plantation site and port increase, the transportation costs start to become higher, and other potential markets for the timber source start to look more

$^1$ Tyloses are physical barriers which develop in the sapwood/heartwood transition zone, and limit the spread of invading micro organisms which can potentially spread from the sapwood.
promising. As it currently stands, sawlogs produced from plantation *E. globulus* have shown high amounts of distortion due to growth stresses in the wood, which can reduce board recovery from logs by up to 80%.

**Growth Stresses**

*E. globulus* plantations bred for pulp production do not make a suitable log source for sawlog production. The timber is quite heavy, and has high degrees of shrinkage in drying, which makes it a less than ideal species for lumber production (Skolmen). The logs also develop a high number of growth stresses when growing. Research into growth stresses in *E. globulus* plantations in Australia have shown growth stresses in young plantation trees (10 years old) create significant sawlog recovery loss due to distortion. Growth stresses occur throughout the trees diameter, with more compressive stresses near the pith of the tree and tension stresses near the bark. “As the diameter increases, the stresses are spread over a larger area and the stress gradient decreases, i.e. there is an inverse relationship between the stress gradient within the tree and its diameter” (Fegley). The growth stresses in these young trees cause spring, resulting in a significant loss in recovery. Growth stress indicators such as spiral grain, microfibril angle, tangential density and shrinkage can be tested on core samples taken from standing trees to predict the amount of distortion in the tree without having to cut them (FWPA). Figure 5 below shows how the growth stresses vary across the diameter of the tree.

Figure 5: Growth stress variances from pith to bark (Haslett A.N. 1988).

![Growth stress variances from pith to bark](image)

In sawlogs, growth stresses usually manifest as either end split in logs or spring directly after sawing and/or drying. Figure 6 shows how the growth stresses manifest and change with parallel saw cuts after rip sawing from the bark to the pith of the log. At the edge of the log, the tension stresses in the wood causes the board to bow away from the saw. As more saw cuts are made, the growth stresses in the different boards transition from tension stresses to compression stresses, which cause the boards cut from the middle of the log to split due to opposing stress gradients from pith to bark.
End split in logs occurs after the trees have been felled, and can be caused by “pre-existing shakes within the tree, by poor felling technique or poor control of felling direction so that the forces generated on impact are greater than they need to be, e.g. trees hitting rocks or fallen logs” (Fegley). Logs that have growth stresses either split immediately or up to a week later, in transport or in the log yard.

Growth stresses occur in all species of eucalypts, but the majority of documented research deals with growth stresses pertaining to *E. globulus* and the loss of value resulting from these stresses.
**Eucalyptus Nitens**

Eucalyptus Nitens (Shining Gum) is a fast growing frost resistant eucalypt species native to Victoria and eastern New South Wales, which can grow to over 70m in height and 1-2m at DBH, and is naturally resistant to many pests of other eucalypt species (DPI). *E. nitens* naturally occurs at higher elevations (800-1300m) in scattered pockets. Plantation sites of *E. nitens* require a minimum annual rainfall of 700 mm/year, and wet slopes with the best growth occurring in higher elevations (DPI). *E. nitens* plantation sites with growth rates of between 20 – 30 m³/ha/year are common, with pulp logs being produced in 10-15 years, and sawlogs in 20-30 years.

**Silviculture**

In Tasmania, there are over 54,000 ha of *E. nitens* plantations, most of which have been planted since 1990 for pulpwood production. Government owned plantations are being viewed for sawlog production from pruned stands, in order to allow private and public plantation growers to see the commercial returns and volumes of different sawlog products which can be obtained from these managed plantations (A.M. Gerrand). An example of this government investment was a program to develop industry initiatives which included the establishment of 6000 ha of *E. nitens* plantations for the production of sawlogs, funded under the Intensive Forestry Management (IFM) program, to work alongside a five year research project developing silvicultural techniques and regimes for these plantations (A.M. Gerrand). In order to successfully produce sawlogs from these stands, intensive forest management is required in order to produce sawlog quality logs on acceptable rotation lengths (A.M. Gerrand).

**Pulp Production**

*E. nitens* is highly desirable in the pulp and paper industry due to the relatively light colour of the wood and the high fibre yields which can be achieved (DPI). The light colour of the fibre is desirable for the pulp and paper industry as it makes it easier to bleach. The heartwood is usually a light straw colour, but can range from brown or blonde to pink (DPI). The heartwood so closely resembles the sapwood, and so less bleaching is required to get *E. nitens* fibre to a pale consistent colour.

**Structural Products**

Forest Enterprises Australia LTD., a leading timber producer in Tasmania, currently produces their EcoAsh® line of products out of plantation sourced mountain ash (*E. nitens*). FEA LTD. Sources their wood from their own plantations, and processes the logs at a sawmill located in Bell Bay, northern Tasmania. The logs are processed on FEA’s state of the art Hew saw specifically designed for these smaller diameter plantation logs with small end diameter ranging from 16cm to 34cm. In 2009-10, FEA LTD’s bell bay sawmill aims to process 400,000 tonnes of plantation sourced wood, and plans to increase this to 500,000 tonnes by 2012-13 (FEA LTD.) Because EcoAsh® is milled from unpruned plantation stands, its strength properties are still significantly less than native or regrowth sourced materials, which caused FEA Ltd. to establish a new plantation grade standard supported by local engineers to quantify and document the engineering properties of EcoAsh®, for use in structural applications.
FEA Ltd.’s EcoAsh® product is one of the first successful examples of utilizing a plantation grown eucalypt resource for structural grade products in Australia, and was only possible because FEA managed their plantations specifically for the production of their EcoAsh® product. By working with engineers to get their product certified, FEA Ltd. has introduced a plantation grown product which can compete with structural products made from softwoods as well as other hardwoods.

**Internal Checking and Collapse**

One of the major wood quality issues facing *E. nitens* is the development of internal checks and collapse after drying of boards. “Internal checking is common in ... *E. nitens* and can affect up to 50% of pieces.” (G. Nolan) Internal collapse is very difficult to predict, but what has been found is that it normally occurs during the initial drying stages, as the free water is removed from the grain fibres. “Collapse is caused by hydrostatic tension forces within the cell and, when capillary size is small and cell walls thin, these forces exceed the compressive strength of the cell wall leading to a flattening of the cell.” (Chafe 1985, Chafe et al. 1992) “Collapse is different from normal shrinkage in that it occurs as moisture is removed from the cell lumens (*i.e.* above fibre saturation point). Normal shrinkage occurs after water has been removed from the lumens, and is caused by the removal of water from the cell wall.” (Kube, Raymond 2002) This flattening of the cells causes the cells to be torn apart from each other, forming voids in the wood, most commonly in the radial direction. Most commonly checking occurs in the early wood bands of the timber, but sometimes if the checking is severe the checks can spread into the higher density latewood bands as well. On the surface of the boards, the flattening of the cells causes the board to form a washboard appearance, with the peaks above the latewood bands and the valleys (areas where collapse is more severe) above the earlywood bands, which have thinner cell walls causing an increase in the severity of collapse in those areas.

*Figure 7: Internal check in 11 year old *E. nitens* after drying (G. Nolan)*

![Image of internal check in 11 year old E. nitens after drying](image-url)
While Internal check and collapse occur in all eucalypt species with thin cell walls in the early wood, the majority of research into the cause and effects of checks and collapse deals with $E. \text{nitens}$, as it is one of the main plantation eucalypt species currently being harvested for structural applications.
**Eucalyptus Regnans**

Eucalyptus Regnans (Mountain Ash, Tasmanian Oak), is native to southeastern Australia, primarily Tasmania and Victoria (Tas Timber). The species is known as the tallest flowering plant, achieving heights of over 100m, surpassing Douglas fir to be the tallest form of vegetation known.

**Silviculture**

*E. regnans* is the most environmentally demanding of all the ash species, requiring an annual rainfall of 1200mm/year, as well as deep well drained soils and shelter from wind (Florence). This causes *E. regnans* to be restricted to only near ideal habitats due to its high rate of water use and protection from wind (Florence). In sites with less than optimal rainfall, *E. regnans* would be replaced with more drought tolerant species (Florence). *E. regnans* is primarily planted in the central Gippsland region of Australia, which spreads from Melbourne east to Bairnadle and north to the Great Dividing Range. The majority of *E. regnans* plantations in this area are between 30-50 years old, and there are currently over 9,000 hectares planted in the area (Department of Agriculture,Fisheries and Forestry). These older plantations of *E. regnans* are some of Australia’s oldest hardwood plantations, with only small areas being planted in recent times.

**Appearance Products and Wood Chips**

Over 85% of the native old growth *E. regnans* logs have been logged by major forest companies for the production of sawn timber products and more recently, wood chips for pulp export (Flanagan). *E. regnans* is an ideal plantation species for woodchip production as its straight fast growing long trunks are much more commercially viable to the wood chip industry over other eucalypt species.

*E. regnans* is one of the three species which make up Tasmanian oak, a species highly utilized for appearance grade products. For appearance grade products, wood with clear straight grain and no knots or other defects is ideal, while highly knotty material will not even make the lowest appearance grade. By managing plantations of *E. regnans* for appearance grade products, even though the rotation age will be quite high, the return on investment will be significant as the amount of native and regrowth stands of *E. regnans* has significantly decreased due to reduction in harvest amounts and deforestation. This decrease in native forest is an ideal market to fill with plantation grown material, but only from well managed stands managed for the production of high value logs.
Conclusion

The significant reduction in the amount of native and regrowth forests available to the industry makes harvesting sawlogs from plantations an absolute necessity if the industry is going to stay viable.

The majority of the current plantation resource (83%) was not managed for sawlog production, and so is not economically feasible for sawn timber products if harvested at the same rotation age at which pulp logs are harvested. If the plantation site has a pruning regime undertaken, then by increasing the rotation age to 25-30 years over the 10-15 year rotation age of pulp, the stand could potentially produce logs which are suitable for structural grade products, but not appearance grade products due to the increased number of knots present in the log.

Plantation sites which are managed for sawlog production right from when the site is planned will produce the highest quality of sawlogs, but only with significant economic and physical intervention. The longer rotation required for sawlog production will increase the payback period of the initial investment required to finance the plantation site, but the gains will be much higher than those returned from a short rotation pulp managed site. Thinning and pruning regimes will need to be undertaken on sawlog plantation sites to reduce the amount of stems, but maximize the trees production of clear wood and reduce the size of the knotty core, leading to an overall increase in the amount of high quality timber.

In order to successfully convert a plantation site from pulp production to sawlog production, intervention within the first five years of the trees growth is necessary in order to maximize wood quality at the harvest age. As the trees age increases, the effects of intervention significantly decrease, and pruning and thinning regimes do not have as large an impact. They will still improve the wood quality, but not at the same level as if the regimes were implemented on the stand at a young age. As a significant amount of plantation sites are older than 5-10 years, if they are to potentially be utilized for sawlog production, pruning and thinning regimes will need to be initiated as soon as possible if the solid wood products industry hopes to utilize this resource in the near future.
Recommendations

Gunns Ltd.

Gunns Ltd. is the largest owner of hardwood plantations in Australia, as well as the leading appearance grade sawn timber product producer in Tasmania. Gunns has always managed their 200,000 hectares of plantations for wood chip exports for the pulp and paper industry, but as a leading manufacturer of appearance grade products, there is a potential market for them to start managing their younger plantations for sawlog production for low grade structural products such as fencing and pallets. If the new mill in northern Tasmania does not get constructed, Gunn’s large estate of plantations in Australia will have no market, so undertaking this low grade solid wood products opportunity might be a necessary option for them to stay profitable in the future.

E. nitens

Plantation sourced E. nitens is already being utilized for structural products by FEA Ltd. There is huge market potential to utilize this resource for both solid wood and composite wood products. Plywood, LVL, OSB or particle board are all examples of composite products which E. nitens could potentially be utilized for. There is currently a research project being undertaken by the University of Tasmania for Forest and Wood Products Australia investigating the structural properties of plywood and LVL produced from plantation E. nitens. The results of this trial will be significant as there is huge market potential for this market.

E. globulus

There are already small plantations of E. globulus managed for saw log and appearance grade products. As this species is highly desired for the pulp industry, as the price of pulp declines and the transportation costs of wood chips increase, there is a huge potential to utilize this pulp managed resource for structural and appearance grade products. The higher amount of knots in the pulp managed resource might limit the amount of appearance or structural sawn boards which can be obtained from the logs, but plywood and LVL are a viable option for this resource.

E. regnans

Since E. regnans is used mainly for appearance grade products when it is utilized for solid wood products, the best option for plantations of this species would be to manage them for appearance grade products as the amount of native stands of this species are in fast decline, and the wood is a high valued timber species in appearance applications.
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