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Effect of Reduced Rotation Length on Araucaria Wood Quality

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Prepared for the

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Research & Development Corporation

by

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Effect of reduced rotation length on wood quality

by Kevin Harding

Introduction

Current rotation length of Araucaria plantations is around 45 to 55 -60 years. A strategic review undertaken by DPI Forestry established that demand from current Araucaria processors was likely to exceed the capacity of the existing resource to supply premium log products, based on non-declining future resource supply scenarios (Anon 2001). Further, the significant improvements in genetic resources and silvicultural management techniques could only be realised during the re-establishment phase of the next rotation. The increased demand in the short to medium term can be met by harvesting plantations at a reduced rotation age. This would also enable the grower (DPI Forestry) to bring on stream the genetically improved second rotation (2R) plantations at an earlier stage.

A reduction of rotation length for the existing thinning age stands will change the nature of the Araucaria resource, by reducing log ASV and increasing the proportion of juvenile wood and knotty core in the harvest at clearfall. This could impact on both total and grade recovery. However, as the industry gradually moves into higher yielding, genetically improved stands under direct regime stockings, the current recovery of clearwood may be equalled or exceeded and the proportion of loose knots and dead branches may be reduced.

The crux of the issue for DPI Forestry and the processing industry is the likely impact on returns of selling 45-year-old rather than 55- to 60-year-old trees, particularly as some of the most valuable wood is laid down in the last ten years of growth in the current resource.

Tree parameters affecting wood quality

The Araucaria Australia Group was formed to reposition hoop pine (*Araucaria cunninghamii*) as Araucaria, a premium grade, quality, tropical softwood through industry collaboration and co-operation. As part of this repositioning, high value markets were to be identified and targeted. The types of products achieving high returns are generally those in appearance products, such as mouldings, joinery, panels and furniture. Desirable raw material properties for such applications include stability, uniform and satisfactory density, defect free or clear wood and an absence of distortion problems.

Tree and wood characters influencing wood quality in Araucaria include basic density, tracheid length, micellar angle, spiral grain, stability and distortion, compression wood incidence, knot size, frequency and type, brown-stain heartwood, kiln stain, and the volume of juvenile wood (Palmer and Palisi 1992). Available information on these properties of Araucaria was reviewed to determine if and how a reduction in rotation length and/or a reduced average stem volume might affect these properties.

Average wood property values for Araucaria for most parameters of interest have been described (Smith and Eccles 1979). However, in the current project investigation of the effects of a reduction in rotation length, the within-tree variation in properties is probably of greater importance. Within-tree wood properties of plantation Araucaria were intensively studied for a small sample of stems in the late 1950s and early 1960s, when most of the resource was around 25 to 30-years-old. Whole tree and wood properties were also investigated for 51-year-old plantation Araucaria in the 1980s. The key findings from a review of the available information are summarised below.

Basic density

Decreases from breast height to relatively constant values up the stem with a slight increase in the upper part of the merchantable stem.

Tracheid length and micellar angle

There is a definite trend for tracheid length to increase and micellar angle to decrease with distance from the pith.

Spiral grain

Spiral grain mean values show an initial increase in the first 6 growth rings years from the pith and then decrease. The core of wood in Araucaria with grain spirality likely to affect distortion of sawn timber is about 135 mm in diameter. There is a general increase in spiral grain with height in the stem and decreasing distance from pith. Increases in mean spiral grain lead to increases in the proportion of material affected by twist whereas increases in stem size have the opposite effect.

Shrinkage (stability) and distortion

Transverse shrinkage, from green to air dry, is very low in Araucaria (Smith and Eccles 1979), and unit shrinkage in Araucaria ranges from 0.23 in the tangential direction to 0.18 in the radial direction (Kingston and Risdon 1961). Investigations of shrinkage found that it varied within the stem and between stems independently of stem size (Balodis 1966). Longitudinal shrinkage increased with height and decreased with distance from the pith (Balodis 1966). Tangential and radial shrinkage both increased with distance from the pith and with height in stem (Balodis 1966).

Twist is the main cause of seasoning degrade in Araucaria, followed by spring (Smith and Eccles 1979). A significant linear relationship was established between twist and spiral grain in Araucaria (Balodis 1972), as discussed above. Twist was the most serious seasoning defect observed in sawn material of plantation-grown Araucaria, while spring and bow were confined to occasional boards and cupping was practically non-existent (Balodis 1966). Spring plus bow was independent of position in the stem while twist increased with height in stem and decreased with increasing distance from the pith (Balodis 1966).

Compression wood

In Araucaria compression wood is fairly common in the butt logs of older trees and it impacts on the amount of usable product obtained from such trees (Blake and Greve 1986). Compression wood in Araucaria is characterised by higher basic density, shorter fibres, thicker cell walls, higher micellar angle and lower cellulose and higher lignin contents (Smith and Smart 1972). Its strength as sawn timber in tension and shear is generally lower than that of normal wood through the effects of its shorter, thicker-walled tracheids with poorer cell wall organisation and higher lignin content (Smith and Eccles 1979). The tendency to spring and or bow in drying is higher, as is longitudinal shrinkage. It also gives lower cellulose yields and poorer quality pulp (Smith and Smart 1972).

Knots

Knots often have a much greater effect on processed product yields and value than the inherent clearwood properties (Smith and Eccles 1979). Live knots result in less degrade in board stock, appearance grade veneers and the outer veneers of structural plywood than the loose, unsound and/or defective knots due to dead branch enclosure. Branches of Araucaria are generally thin and flat-angled which results in a less depreciative effect on strength and appearance of sawn and peeled timber products (Smith and Eccles 1979). However, live knots can be troublesome in Araucaria, due to their impregnation with “hard resin”, resulting in chipping when machined (Smith 1977).

Brown-stain heartwood

An obvious brown-stain occurs in the central zone of many *Araucaria cunninghamii* trees, which persists through milling and drying and affected boards are often consigned to lower value grades. A review of brown-stain in Araucaria (Catchpoole, S. 2001) revealed:

- brown-stain is generally associated with a condition known as wetwood, which is characterised by higher than normal moisture contents;
- it is commonly associated with bacterial infestation, but it is not a form of decay (fungal origin);
- no study has conclusively established the cause of brown-stain or wetwood in Araucaria or any other affected species;
- it generally occurs in the heartwood zone in the lower stem section but occasionally extends beyond this zone;
- the amount of brown-stain has been observed to increase with increasing tree size or age.

Juvenile wood

From the preceding review of key wood properties of Araucaria, spiral grain appears to be the most important factor defining the extent of the juvenile wood zone. Basic density showed minimal pith to bark variation, unlike most exotic conifers that display a distinct increase and subsequent levelling off in basic density with distance from the pith. Available information on tracheid length and micellar angle indicated a trend of increasing tracheid length and decreasing micellar angle maximum with distance from the pith. Detailed within-stem data on spiral grain variation for trees aged 51 years revealed that in the lower two-thirds of the trees, spiral grain angles were predominantly less than 3° beyond 20 rings from the pith. In the upper third of the trees, spiral grain was predominantly greater than 5° to at least 25 rings from the pith. Inside 14 rings from the pith up the entire length of the stem, spiral grain values were predominantly greater than 5°. Based on this information, the juvenile core could be considered as being contained within the first 20 rings. The real problem material, with spiral grain values of greater than 5%, would be contained within the first 15 rings from the pith.

Analysis of impacts

There were two issues under consideration in this part of the AAG project. One is a reduction in rotation length from around 55 years to around 45 years. The second is a reduction in average stem volume (ASV) that will occur regardless of what rotation length is adopted. Both may potentially affect the value of Araucaria through their influence on the tree and wood properties reviewed above. The effect on juvenile wood is considered first, since the extent of juvenile wood in the stem also affects a number of related wood properties in Araucaria, including the proportion of wood with high spiral grain, shorter tracheids and tracheids with high micellar angle.

A reduction in rotation length may result in an increase in the proportion of juvenile wood. Due to the high grain angles that occur in the juvenile core this could increase problems with stability and distortion in sawn boards. To determine to what extent a reduced rotation length and/or reduced ASV might affect juvenile wood proportions, the WEEDS/PLYSIM system (DPI Forestry) and STEPS software (Catchpoole and Nester 2001) were used to model 45- and 55-year-old plantation Araucaria trees for Imbil State Forest. It was assumed that the initial effective stocking was 750 stems/ha, pruning was to 5.4 m and one commercial thin was conducted at 30 years. Four site indexes, 21, 24, 27 and 30, were investigated. To estimate the volume of mature wood in 45-year-old, versus 55-year-old trees, it was assumed that the juvenile core was contained in the first 15 rings from the pith. The WEEDS/PLYSIM system and STEPS software was used to determine diameter at breast height of a 15-year-old tree for the four site indexes chosen. It was not possible, however, to determine the volume contained in the first 15 rings from the pith within a 45 or 55-year-old tree using the WEEDS/PLYSIM system and STEPS software. Instead, volume contained within the first fifteen rings from the pith was calculated using actual data for six trees from the CON64 research database. The results of the simulation allowed analysis of the effect of a reduction in rotation length for a given site index and analysis of the effect of a reduction in ASV, for a given rotation length, on the proportion of juvenile wood in a tree. Given the assumptions made the output results should be regarded as indicative only.

Summary of impacts of reduced rotation length

The review of existing information has identified the following:

- the juvenile core in Araucaria is probably contained within the first 15 growth rings from the pith, with spiral grain being a chief determinant of its extent within the stem;
- a reduction in rotation length for a given site index will reduce ASV and mature wood volume, with an increase in the proportion of juvenile wood;
- for a given rotation length, lower ASV stems were estimated to contain a lower proportion of juvenile wood (based on the assumptions made and crude simulations using WEEDS, PLYSIM and STEPS software); regardless of juvenile wood proportions, smaller stems will yield a higher proportion of pith-in material;
- an increase in the proportion of juvenile wood, due to a reduction in rotation length, could affect wood quality due to an increase in the proportion of the recovery containing high spiral grain, shorter tracheids and higher micellar angle;
- high spiral grain and high micellar angles adversely impact on wood quality through their influence on twist and longitudinal shrinkage, respectively;
- positive outcomes from a reduction in rotation length might include an increase in the proportion of live knots in upper stem sections and a reduction in the extent of brown-stain heartwood;
- the uniformity in basic density within Araucaria stems means reduced rotation lengths and lower stem ASVs are unlikely to have a major impact on this wood property, and
- the effect of a reduction in rotation length on the incidence of compression wood and timber susceptible to kiln staining could not be established from the available information.

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