

RADIATA PINE WOOD DENSITY



RPBC
Radiata Pine Breeding Co Ltd
BREEDING QUALITY

- Wood density is widely regarded as an important indicator of general wood quality, including timber strength and stiffness.
- Improved density can significantly increase the recovery of high-grade lumber, as assessed by machine stress grading.
- In the future it is likely that logs will be segregated by density and a premium paid for higher density logs, where the intended market is for structural purposes.
- Density varies within a tree, increasing from pith to bark and is strongly influenced by geographic location, site fertility, age and genetics.
- Density is highly heritable, making breeding a very effective way of increasing wood density.
- Although average family densities will vary across sites, family rankings for density tend to be consistent.

> WHAT IS WOOD DENSITY?

Wood is a complex composite material that can contain varying amounts of water absorbed within the fibre. Density therefore needs to be defined in relation to standard conditions, such as 'green', 'air-dry', 'oven-dry' or 'basic'. The most common (and useful) expression is the basic density, which is calculated as the oven-dry weight divided by the green wood volume, expressed in kg/m^3 .

Basic density varies greatly within and between species, being strongly influenced by geographic location, site fertility, age and genetics. It can also be influenced by silviculture. Radiata pine is commonly regarded as a 'medium' density softwood, with typical average tree basic density values of $400-420 \text{ kg/m}^3$. However, wood samples can cover a wide range of basic density values between 350 and 550 kg/m^3 . In common with most softwoods, radiata pine exhibits a defined annual growth ring structure. During the first part of the growing season the tree produces relatively low density light-coloured earlywood. Later in the season darker, denser latewood is formed, thus making the annual rings clearly visible. Variation in the proportions of earlywood and latewood is a major factor in determining average wood density.

Density is one of the traits identified under the *GF Plus* scheme (see Information Bulletin No. 1 'Rating the Genetic Quality of Radiata Pine').

> WHY IS DENSITY AN IMPORTANT TRAIT?



Collecting cores for wood density analysis

Wood density, along with microfibril angle (MFA), is widely regarded as an important indicator of general wood quality. Research has shown increased density to be strongly linked to favourable strength, stiffness, hardness and working properties of sawn timber, as well as wood pulp yield and

paper-making quality. It is a relatively easy trait to measure and is the best indicator of wood strength and stiffness available to date. One of the only negative features of higher density wood is that it does show greater shrinkage after drying.

Research quantifying the importance of MFA and how it interacts with density to influence wood quality is continuing and will be the subject of a future information bulletin.

> WHAT FACTORS AFFECT DENSITY?

Within Tree Position

Every stem of radiata pine exhibits a significant degree of variation in wood density, according to both the radial and vertical position in the stem. The centre of the stem contains a lower density cylinder of juvenile wood, with the highest density located around the outer portion of the lower stem.

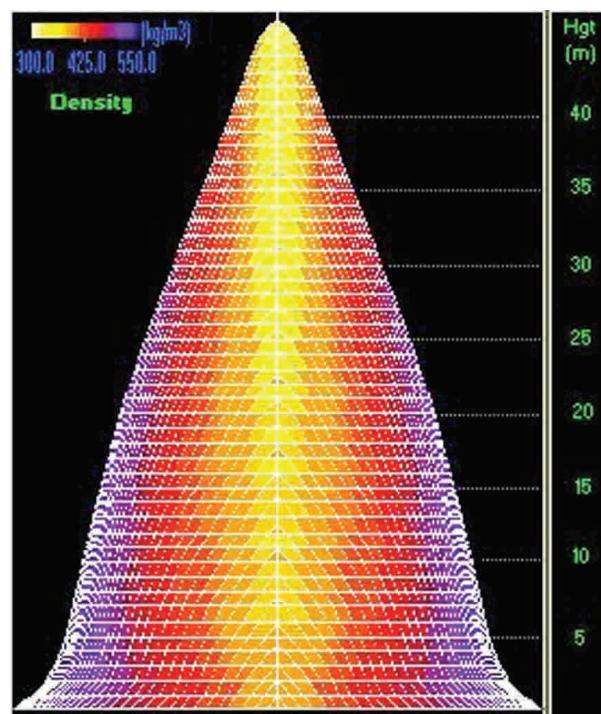


Fig. 1 Pattern of within-tree wood density variation for a 30-year-old tree in the central North Island of New Zealand

Geographic Location

Geographic location is the best single predictor of average wood density for a forest stand. Research has demonstrated that in New Zealand the warmer sites tend to have higher average wood density throughout the stem, irrespective of the genetic source. Over time a large amount of density information has been collected and from this a national density model has been developed. Based on this model, distinct wood density zones have been recognised in New Zealand - referred to as High, Medium and Low.

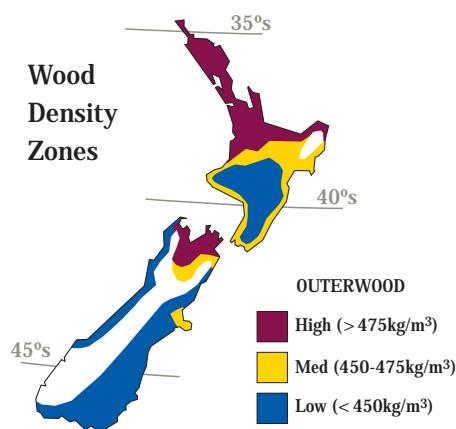


Fig. 2 New Zealand radiata pine wood density zones

Forest Research Bulletin 216: NZ pine and Douglas-fir; Suitability for Processing (1999)

Site Fertility

More fertile sites, especially those high in nitrogen, have lower average wood density than lower fertility sites. This is largely due to an increased proportion of lower density earlywood.

Rotation Age

Higher density wood is formed on the outside of the tree stem as it ages. Average tree density therefore increases with age. Typically, this rate of increase is most dramatic up to age 10 and gradually reduces as the tree ages. This age-related change in density is one of the factors that should be considered when determining harvest age.

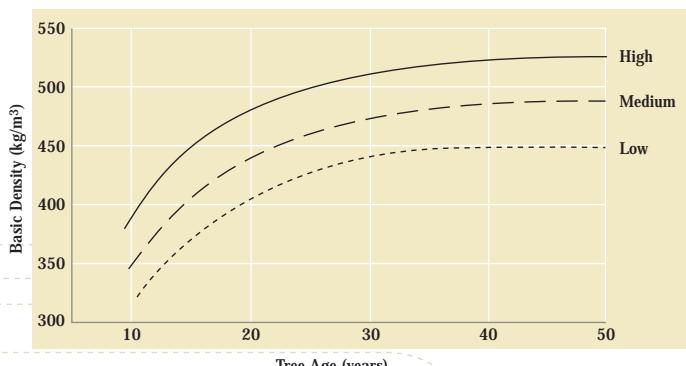


Fig. 3 Wood density trends by age and density zone

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Genetics

A large proportion of the between-tree variation in wood density is due to genetics. Results from a 20-year-old Kaingaroa trial, shown in Fig. 4, illustrate the typical range of family (genetic) variation in density. Although average family densities will vary due to influences already mentioned, family rankings for density tend to be consistent across sites - so that a family with high density wood will tend to be 'high' relative to other families across all New Zealand and Australian sites.

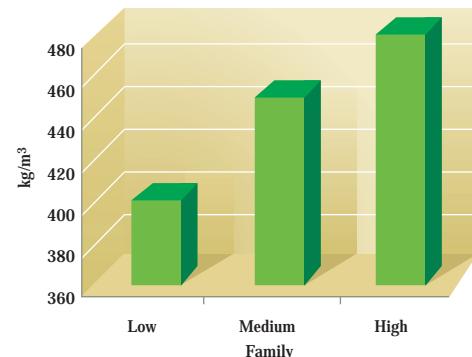


Fig. 4 Typical family outerwood density variation at age 30 years (Radiata Pine Breeding Company Kaingaroa trial)

> HOW ARE SELECTION AND BREEDING USED TO IMPROVE DENSITY?

Density is a highly heritable trait, which means that selection and breeding can be effectively used to improve density. However, in the early stages of the New Zealand radiata pine breeding programme, very little selection was done for wood properties. Growth and form were the main selection criteria emphasised until the mid-1970s. In more recent times density has become increasingly recognised as an important wood quality trait, and selective breeding has been undertaken to produce families with higher average wood density. The comparative ease of assessment and the close association between density and stiffness have been used to provide a convenient surrogate measure of value for structural lumber.

High wood density individuals have been identified and incorporated into seed and plant production populations used by seed producers and nursery growers. As there is a reliable relationship between juvenile wood density and mature wood density, selections from field trials can be made for higher density individuals at a relatively early age, thus speeding up the breeding programme. This has also enabled the creation of customised breeds matched to site and/or end use requirements. In addition, research is currently focusing on reducing within-tree pith to bark density gradients by improving the density of juvenile wood for increased timber stiffness and stability.

> HOW DOES DENSITY INTERACT WITH OTHER TRAITS?

Breeding for increased wood density can be achieved without incurring significant penalties through negative associations with other traits. Although there is a weak genetic correlation between increased wood density and decreased diameter growth it has been possible to select parent trees with high values for both growth rate and wood density.

> HOW ARE GF PLUS DENSITY TRAIT RATINGS DERIVED?

GF Plus density ratings are derived directly from the 'breeding values' estimated for each tested parent tree contributing to improved radiata pine seedlots. The breeding values themselves provide a single, national ranking of the parent trees for average wood density, and are based on 'density core' data from thousands of progeny trees growing in comparison trials in New Zealand and southeast Australia. Under the *GF Plus* rating system, the higher the rating the greater the genetic improvement in density.

> HOW DOES DENSITY AFFECT VALUE?

Density provides a good indication of wood stiffness, especially when combined with MFA. Research is currently under way to quantify the impact of MFA on wood quality. Where machine stress grading is used to grade sawn timber a significant improvement in high quality grade outturn can be expected for improved density material.

Using the example in the last figure, the differences in family breast height outerwood (Low, Medium, High) will be reflected in sawlog average densities of about 375, 415 and 440 kg/m³ respectively. These values, in turn, will result in increased recoveries of F5 and better structural lumber for the Medium and High families compared to the Low family, as assessed by machine stress grading. The majority of crosses being deployed today are medium and high density. Figure 5 shows gains for this example, as predicted by the Forest Research STANDPAK software program. The impact on value is also shown, assuming 2002 lumber values and

Family	F5 and Better	\$/m ³ Gain (Log)	\$/ha Gain
Med	+ 30%	\$8.00	\$3,500
High	+ 45%	\$12.00	\$5,500

Fig. 5 Gains from increased density, compared to low density family for central North Island site (RPBC Kaingaroa trial).

total recoverable volume of 600m³/ha with a 75% structural log proportion.

Most log processors do not currently pay a price premium for improved density logs. Rather, pricing is based on diameter, length, straightness and knot size. As log processors become increasingly aware of the importance of density it is highly likely that logs will be segregated on the skid site based on density, and premium prices paid for higher density. Tools are already available for measuring log stiffness at the forest skid site, and as already noted, wood density and stiffness in logs are related.

Basic density, as a measure of dry weight content, also provides an excellent indication of the potential recovery of fibre from pulpwood. The improvements in intrinsic value of the High family versus the Low family for the pulplog and sawmill chip components are about 10% and 25% respectively. Pulp producers recognise this and it is possible that pricing differentials for pulp logs, based on density, could be introduced.

The values above are based on family averages, and still reflect significant variation in wood density within family groups. Clones have the potential to further improve the genetic component of wood density and ensure greater consistency. By including wood density as a criterion in clonal selection still higher wood densities could be achieved by increasing the average and minimising the variation.

It is important for the forest grower to consider that, when purchasing genetically improved planting stock, density is just one of the traits described under the *GF Plus* scheme. Increased financial returns from improved density will be in combination with improvement in other traits such as growth rates, stem straightness, branching habit, grain spirality and disease resistance.

For more information

Freephone 0800 00 GFPLUS (0800 00 437587)

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