measurement of branching characteristics, which have a strong impact on product yield and quality.
- Radiata pine is highly variable in stem, branching and wood properties
- Most wood properties are highly heritable – and can be changed relatively easily if clear directions are given to tree breeders.
- Radiata pine lumber is suitable for a wide range of processes and products, but limited by poor stiffness and stability of the juvenile wood. Microfibril angle (MFA) was not measured initially and there was no indication of its likely importance. Later work (with Silviscan) confirmed the low heritability of MFA and relatively small contribution to stiffness of in-grade products.
- Radiata pine can be used in a wide range of processes, but genetic variability is such that material segregation technology is required to ensure product quality. The raw material is compatible with the modern equipment tested, but the inherent variability of tree stems requires that uniformity must be "engineered" into products, often at added cost.

On completion of the 3-year project a user survey was undertaken with participating companies which revealed that the 3 most valuable aspects of the Value Recovery Project were:

1. Results of the clonal wood processing studies, indicating consistent variations in quality and performance.
2. Networking between companies.
3. Contact with Forest Research researchers.

From a research point of view, the greatest challenges were:

1. Creating an initial case for the companies to invest and convincing corporate managers to "sign up".
2. Agreeing on "marketing" studies that were generic and not in conflict with individual company activities.
3. Maintaining the interest of individual companies over 3 years with constantly changing industry personnel.

Forest Research has since gone on to repeat parts of these studies (e.g. the manufacture of trial LVL) for individual commercial clients using material from their own resource. Some study methods developed in the course of the project have become "standard methods" by which alternative resources and processing strategies can now be compared and benchmarked.

Radiata pine wood quality assessments in the 21st Century

Graeme Young[1]

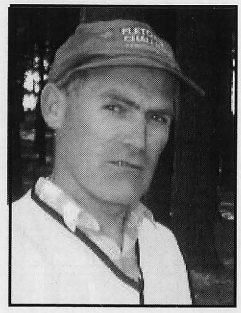
There is possibly as much knowledge about radiata pine wood quality as for any other timber species in the world. This is the result of the New Zealand forestry industry's concentration on radiata pine as the principal plantation species for the last 100 years. Back this intense focus with some world-renowned leaders in wood quality research and .... BINGO!; a wealth of knowledge waiting to be tapped by foresters interested in resource description. This doesn't mean that all the answers are available. Far from it. As we promote radiata pine into more and more demanding processing and utilisation options then difficulties, which previously were insignificant, can become far more important.

The need to grow wood rather than trees

However, it would be fair to say that in general, the New Zealand industry has ignored the wood in their haste to grow bigger and straighter trees in increasingly shorter rotations. There is a very real need to understand the effects of the many contributing factors to the wide range of wood quality parameters that affect products and processing and then to apply this knowledge to log segregation and timber (or lumber) segregation.

This industry approach of growing trees rather than growing wood has resulted in an unfortunate dearth of industry-based wood quality knowledge and a glance through the CVs of forestry students looking for holiday work fails to find any with an interest in a career in this vital area of forest growing. This doesn't mean we are not producing good forestry graduates, but perhaps does signal the fact that we are not attracting people from as diverse a range of interests as we could. Wood quality spans breeding programmes, silvicultural operations, climatic and geographic effects, soil characteristics, log grading, processing options, marketing and product applications.

There is no quick route to wood quality resource description. The foundation is a reasonable understanding of the various contributing intrinsic wood properties and experience with the issues relating to processing and timber in use. Routine and ongoing measurements provide the data which, when combined with trial work to determine the effects of these properties



[1] *Graeme Young is Manager of Resource Quality for Fletcher Challenge Forests.*

on processing streams, enable meaningful description and segregation.

At Fletcher Challenge Forests, staff have been assessing the wood quality of the resource, in a structured manner, for 10 years. This was initiated by forester Dave Lowry, while working for Forestry Corporation, as an attempt to describe the planned annual harvest. He used STANDPAK to model DOS (Diameter Over Stubs) from stand records and, with destructive sampling, developed a rudimentary version of Forest Research's recently promoted PLI calculator to predict Pruned Log Index using MARVL estimated SED (Small End Diameter) and the predicted DOS.

With assistance from Forest Research staff he developed an estimate of suitability for strength or stiffness applications by firstly measuring breast height outerwood basic density (BHOBD) from 5mm increment core samples and assessing branch size by log height class. Then using SAWMOD, with inputs of log density, branch index, and log size, percentages of machine stress grades were determined for each stand by log height class. At the time of field assessments an internode length estimate was also made, so for each stand the suitability for different processing streams was determined. Subsequently this first generation of resource quality determinations has seen many alterations and additions and the data is now also applied across a wider range of applications.

Identifying the resource suitable for structural purposes

But there is probably no easier place to start determining resource quality than with simple BHOBD. Wood density is an indicator of a wide range of general properties and suitability for use, and is easy to assess and relatively cheap. For FCF it serves as the basic determinant of suitability for machine stress graded product that culminates in our very successful Origin brand of structural timber. A systematic programme of sampling individual trees to determine relationships for individual logs and to cover the resource geographically and by age has enabled the development of algorithms specific to our resource to predict density forward (or backward) to any age or tree portion. Our database currently has data from around 7,000 stand assessments of which about 4,500 are from stands that have not yet been harvested.

Density is first assessed at the time of pre-production thinning or mid-rotation inventory as a routine part of these assessments. These data, when used with the age relationships, enable medium-term broad predictions of quality and warn of changes due to combinations of age class and geographic distribution. They also serve as an indicator of variance due to breed. We were well warned and prepared to deal with the '850' breed as these stands came due for harvest. This first attempt at selection for 'tree improvement' resulted in a 7-10% decrease in density with all of the associated utilisation problems.

At the 5-year pre-harvest inventory (5 years prior to planned harvest) measurement of BHOBD provides a more accurate short-term indicator for individual stands. The values can be applied in the development of harvest programs where individual stands can be held over (or brought forward) to ensure an adequate supply of suitable timber for our processing plants. A final assessment at pre-harvest inventory (6 to 18 months prior to harvest) confirms our forecast and sets the final structural and pulp log grades. But our structural log segregation doesn't end there.

An in-house development of sonic technology to identify logs by stiffness has been applied at our major stem processing yards. Stems from stands which don't achieve our density 'hurdle' for structural use are assessed using this tool which we have named SWAT (Stress Wave Acoustic Tester). The stem cut pattern is then set based on the result of this assessment along with the routinely applied external log features. This development received the FIEA Technology Innovation Award in 1999 and has been in use now for around three years. In that time two million stems have been measured with upgrade running around 50%.

Fig. 1: Routine stiffness assessment using the FCF acoustic tool improves profitability of processing to machine stress graded timber.

Pruned log quality

So much for logs with branches. As the NZ Forest Owners Association (Anon 2002) figures describe, 60% of the value in a tree is in the pruned butt log. In the past, one of the most time consuming tasks in the process of determining PLI was in DOS prediction. This involved hundreds of individual STANDPAK runs to determine DOS for each stand in each annual harvest plan. The bad old days are over for us. As optimisation of the timing of pruning applications developed so too did the realisation of the need to capture DOS at time of pruning and to record this in the stand records. So now DOS determination is simply extracted from the corporate database.

We have also embarked on an annual program of PLI determination by destructive sampling by Jim Park and his team from Interface Forest & Mill Ltd. There are a

range of reasons why stands are selected for this programme but one major outcome is that the wealth of data has enabled us to refine the original DOS/SED algorithm and part of our program of destructive sampling is simply to monitor this factor. So from the time of the final lift and collection of appropriate pruning data, at either routine inventory or specific silvicultural QC, we can model PLI for each stand to any age. We have developed log grades based on PLI and now routinely also incorporate these into our medium-term modelling of harvest quality, short-term harvest programmes and estate valuation.

However PLI only describes the predictable part of pruned log quality. We also attempt to include the less predictable; intra-ring checking and resinous defects. The oven-dry disc assessment method of measuring intra-ring checking began with our inclusion of discs cut from log ends within kiln charges of lumber cut from the same logs. It worked but it was clumsy and disruptive of normal production. So we took the idea to Forest Research and suggested they develop and refine it further. I am sure industry will agree that this work carried out by McConchie and McConchie (2001) has been a hugely successful development in understanding this problem and has enabled us to develop a structured program of trials to learn to deal with it. We now routinely analyse all stands over a set minimum pruned volume. Sampling is carried out a year before harvest to ensure the resulting data are as applicable as possible to final quality. Individual log trials through our processing plants ensure that field measurements are calibrated to give a meaningful grading system that can be applied to suit our mills.

To improve our ability to predict resinous defects we collaborated with Forest Research on a major trial where external signs of resin bleeding and stem lesions were scored on standing trees with 40 selected for a range of severity ratings and sawn as log batches. Results, although not formally published yet (McConchie *et al* in prep), were spectacular enough to encourage us to include the scoring system into our entire radiata pine inventory. We hope to further understand distribution of resinous characteristics within our resource, perhaps gain an understanding of the causal factors, and in the longer term maybe even introduce results into a pruned log specification.

Critical to successful marketing of logs described by PLI is a sophisticated customer base that understands what PLI means to their particular mill configuration, saw-patterns and markets. To this end we have developed models applicable to our own pruned log sawmill and carry out an ongoing program of mill studies to ensure continual compliance with lumber grade expectations.

The future?

In the future I see much more of the same routine data collection and application but, as a company, we are working with a range of research providers endeavouring to improve our understanding of wood quality or in developing tools and techniques to measure features that are important. Significant developments have occurred in the last few years in our ability, as an industry, to measure some key wood properties. These include some of the techniques described above and others unmentioned such as CSIRO's Silviscan-2 which has revolutionised cellular measurement (Evans & Ilic 2001).

Fig. 2: Severe resin bleeding can indicate that value of pruned clear lumber grades may be reduced by more than 50%.

But there are many areas of research required and I, for one, am excited about the future industry collaboration in the Forest Industry Council's Wood Quality Initiative. This coordinated approach should ensure that the maximum knowledge is gleaned from trial areas being clearfelled, that experts in cellular componentry from all around New Zealand can join forces in unlocking the knowledge we need to understand some of the more complex quality problems such as stability, and finally it should ensure that our forestry representatives will exchange knowledge and methodologies more freely than has occurred in the past. I can't wait!

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