RADIATA MANAGEMENT TECHNICAL NOTE (IFS)

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Destructive and Non-Destructive Key Wood Property Sampling Protocols

Summary

This technical note briefly summarises methods that may be used to collect branching and wood property data from standing or felled trees.

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Introduction

Data is an essential pre-requisite for any mathematical / statistical analyses or model development. The data collected in any study will be driven by the questions the study is intended to answer. For example, to determine whether there is a treatment response (e.g., wood quality) over and above a tree size response, trees of equal DBH could be sampled for wood properties across treatments. In this sense, the sampling design will vary according to the specific research questions being investigated. In addition to the sampling design, the sampling protocols for key wood properties are varied and need to be tailored to the specific research questions being investigated.

This Technical Note describes destructive and non-destructive key wood property sampling protocols used in the Permanent Sample Plot (PSP) re-measurement programme and in trials announced for clearfelling. From a growth perspective, data generally comes from PSPs. However, integrated growth, branching and wood property models will require the collection of additional data on branching and wood properties. Ideally, the branching and wood property data should come from the same PSPs. Data collection methodologies can be non-destructive, semi-destructive (tree is wounded in collecting data), and fully-destructive (tree is felled).

Permanent Sample Plots

Permanent Sample Plots are established to monitor tree growth and form throughout the rotation. Currently, tree DBH is measured on all trees, height on a sample of trees, and one or more “descriptive codes” may be assigned to a tree to account for stem forms, etc. Care needs to be taken to ensure that any activities carried out in PSPs (e.g., increment cores) do not compromise tree health and growth.

Branching and Stem Form

Stem form and branch dimensions are important because they influence log and board grade.

Branching and Stem Form – Qualitative Assessment

Inventory is very useful method for assessing the value of different improved seedlots/clones and/or different silvicultural regimes. Forest companies routinely measure branch dimensions qualitatively using inventory techniques, e.g. MARVL, ATLAS Cruiser. This gives the maximum branch diameter in specific stem sections. Stem form is also qualitatively assessed. The data is analysed to give stand values.

Branching and Stem Form – Quantitative, Non-destructive Assessment

TreeD is a non-destructive photographic method, that provides quantitative branching and stem form data. TreeD uses a stereo-pair of scaled digital images, that are digitised to provide branching and stem form data. Extracted branch data has typically included the height to the base and top of each branch cluster, and the diameter of the largest branch in each cluster. This approach corresponds with inventory methods. This technique is valuable to provide quantitative data for validation of the branching model, BLOSSIM.

Branching – Quantitative Destructive Assessment

Detailed data on branching patterns are best obtained by felling trees and measuring the relevant characteristics. This approach has been used in the development of the branch growth model, BLOSSIM.

There are several key branching characteristics that may be measured (calculated) once the tree has been felled and cut into individual clusters.
i) Number and relative positions of branch clusters within an annual shoot. Branch clusters in an annual shoot are obtained by measuring the height to the base and top of each branch cluster, and counting the number of stem growth rings below and above each branch cluster.

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ii) number of branches and stem cones in a cluster, iii) current diameter of branches adjacent to the stem (avoiding any nodal swelling) and their azimuth angle.

Care needs to be taken to correctly identify branch clusters, as clusters may overlap. The lowest branches in the cluster will be the smallest and the highest branches in a cluster will be the biggest. If there are small branches in the middle of a cluster then, botanically, it is probably two separate clusters.

Branch growth through time is obtained by cutting selected branches from a cluster, and then planing to expose both the stem pith and the branch pith. Stem growth rings are first identified, and then, the branch diameter corresponding to each year's growth are identified and measured. This approach is used because number of growth rings on the branch itself does not provide an accurate estimate of branch age.

Wood Property - Sampling Procedures

Samples for measuring wood properties of an individual tree may be obtained using non- to semi-destructive techniques (where the tree is wounded but remains standing) and destructive techniques (where the tree is felled).

Taking wood cores is a commonly used technique that is considered semi-destructive. Cores are usually collected at beast height on a standing tree. The size of the wound will depend on the number of directions sampled and the dimensions of any cores taken. Cores may be 5mm or 12 mm in diameter, and either just over 50 mm in length or from pith to bark.

There will need to be compromises between the number of trees sampled and the number of measurements collected per tree.

Wood Properties - General

Trees need to be mechanically reliable to grow and survive over a rotation. Trees adjust their mechanical properties through the addition of new cells and through the structure of these new cells. Both tree flexure (when the stem moves in response to wind and returns to a vertical position), and lean correction (which occurs when a stem has been "permanently" displaced from the vertical) contribute to varying cell structures, particularly in the circumferential direction, which in turn contributes to the variation in the many different wood properties that may be measured.

This circumferential variation has rarely been quantified, but is important from a cutting pattern perspective and the effect on boards cut throughout the stem cross-section.

Compression Wood

This term is used to describe wood that is formed in response to stem lean in conifers. It has a different colour, and different properties from other wood, e.g., higher MFA and wood density.

Many studies have avoided measuring the properties of compression wood. To be able to understand and model within-tree variability, it essential to measure samples from multiple directions.

Compression Wood – Standing Tree Assessment

Compression wood has been estimated non-destructively from pith to bark cores using a qualitative assessment score assigned by a trained observer.

Compression Wood - Destructive Assessment

Percentage compression wood on a disc (based on colour) may be estimated visually or measured quantitatively using G2ring software.

Sapwood and Heartwood

Sapwood and heartwood are terms used to describe the wood involved/not involved in water conduction. Heartwood has more extractives and is a different colour from sapwood. Number of rings and/or width of heartwood are usually measured on discs collected from felled trees.

Chemistry

The chemical structure of individual cells influences wood properties of interest to the forest grower and wood processor.

New techniques are being developed within FFR Radiata Management Theme Objective 2, to provide microscale chemical assays for understanding wood formation processes in seedlings.

Other chemical techniques include measuring near infra-red (NIR) spectra on discs using an NIR line

camera (Scion) or on 12 mm cores (CSIRO, Australia).

An NIR calibration model is required which predicts more relevant wood properties from the spectra. Ideally, the wood properties required should be measured for some samples on all sites and seedlots to confirm that a previously developed NIR calibration model is applicable.

NIR could therefore be considered a relatively inexpensive tool for obtaining a larger sample of wood properties for a given site, than are measured by direct methods. It does not replace direct methods of measuring wood properties (see below).

Density – Standing Tree Assessment

Outerwood cores are routinely used to provide an estimate of outerwood density for particular stands. A sample size of 30 trees is recommended.

Generally the cores collected are slightly longer than 50 mm. They are then cut down to 50 mm and analysed to give outerwood density for a tree.

For young trees, 5 ring cores should be analysed. 5 ring cores are also more appropriate for comparing between different treatments.

5 mm pith to bark cores may be collected and analysed on Scion's X-ray Densitometer to provide a pith to bark trace of wood density.

12 mm pith-bark cores may be analysed using SilviScan (CSIRO) to provide a high-resolution pith to bark trace of wood density. This is most appropriate if other properties are to be measured at the same time (see below).

Density – Destructive Assessment

Blocks may be cut from stem discs for density of the inner 10 rings and outer–rings, or other relevant variants.

Pith to bark strips may be cut from discs for analysis using SilviScan (CSIRO), which provides a high-resolution pith to bark trace of wood density.

Stiffness (Modulus of elasticity, MOE) – Standing Tree Assessment

Standing tree velocity, which is an indication of stiffness, is measured using sonic tools, e.g., the ST300 and IML hammer. Two probes are put into the stem a given distance apart, and one probe is tapped. The sound wave only goes through the outer layers of wood. Such a tool is useful for quickly providing data that is related to log stiffness.

12 mm pith to bark cores may be analysed using SilviScan (CSIRO) to provide a high-resolution pithto bark trace of MOE.

Stiffness (Modulus of elasticity, MOE) – Destructive Assessment

Log acoustic measurements may be obtained using the Director HM200 to provide an estimate of likely stiffness.

Strips cut from discs may be analysed using SilviScan (CSIRO) to provide a high-resolution pith to bark trace of MOE.

There are standard timber engineering bending tests that are used to directly measure stiffness from small clear board sections.

Microfibril Angle

Gradients in microfibril angle (MFA) are important as they influence the stability of wood during processing.

A pith to bark trace in microfibril angle may be obtained from SilviScan (CSIRO) using either 12 mm cores or a 12 mm strip cut from a disc.

Spiral Grain – Standing Tree Assessment

Bark windows (semi-destructive) are cut in standing trees and allow measurement of spiral grain using a scribe. This provides an estimate at one age only.

An instrument called the Spiralometer was developed by the Wood Quality Initiative (WQI) to estimate spiral grain from cores, but this only provides a relative angle.

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Spiral Grain – Destructive Assessment

Spiral grain for individual growth rings are best measured using a disc. Here, a section is cut from the discs, and each ring cleaved away and spiral grain measured using a scribe. Usually two sections are cut at 180° to each other, and the values from the two directions averaged. This approach, allows for the disc not being cut perpendicular to the stem direction, but may hide some of the variation in spiral grain.

A recent technique, that is quicker than the above is the Disc-Splitting Method where a disc is split into two and spiral grain is measured on the split surfaces.

Spiral grain may also be measured using an instrument called the T2 (Scion). Here, the reflection of light at a range of angles (specular reflection) is measured on a cut radial – longitudinal surface. The results are sensitive to surface preparation.

Modulus Of Rupture (MOR)

Modulus of rupture (MOR) is a measure of the maximum strength of the wood, and varies between green and dry wood. Green MOR influences the probability of stem breakage and leader change.

Estimates of modulus of rupture are usually made using a bending/breakage test on small clear sections 300 mm in the longitudinal direction by 20 mm by 20 mm.

An instrument, called the Fractometer may be used to estimate modulus of rupture from 5 mm increment cores.

Shrinkage

Shrinkage occurs in the longitudinal, radial and tangential directions when wood is dried. Shrinkage results from variability in wood properties within the piece of wood.

Longitudinal shrinkage may be measured using the “pin method“, which measures shrinkage along the grain.

Longitudinal shrinkage may also be measured using the “block method” which measures shrinkage in the longitudinal direction of the tree. Variations in spiral grain will contribute to the variability in results obtained using this method.

Radial and tangential shrinkage are both measured using small blocks (usually 5 rings in the radial direction).

Resin

Resin pockets are undesirable for clearwood. Resin bleeding may be assessed visually on standing trees. WQI have developed a photographic protocol for measuring external resin bleeding, and has carried out studies to determine the relationship between external resin bleeding and clearwood grade recovery.

Resin pockets on discs may be visually counted or quantitatively assessed using image analysis techniques (CSIRO).

Intra-ring Checking and Collapse

Intra-ring checking is the separation of fibres within growth rings, and is another issue affecting appearance or structural timber. WQI have developed a standard method for predicting the propensity for intra-ring checking, which is based on the amount of collapse on 12 mm increment cores.

Summary

The wood property data collected from any particular study will be determined by the specific objectives of the study.

Wood properties are influenced by silvicultural treatment. At breast height, the response between different silvicultural treatments is most pronounced in the few years following treatment. The response is also more pronounced for microfibril angle compared to density. However, by the end of the rotation and averaged across all the growth rings, wood property differences between treatments are often masked and minor. It is therefore recommended that pith to bark samples be the preferred tool for collecting data to model within stem distributions of wood properties and develop integrated growth, branching and wood property models. Silviscan (CSIRO) is an ideal technology that provides relative cost-effect data for a wide range of wood properties. Scion’s Densitometer similarly provides relative cost-effect data, albeit limited to wood density.