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Theme: Radiata Management

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Documentation of tree characteristics measured in 1975 Final Crop Stocking Trials at Woodhill and Golden Downs

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EXECUTIVE SUMMARY

Historically tree growth research has been carried out in isolation from tree wood property (quality) research. Consequently the data available for developing models of radiata pine stem growth is independent of the data available for developing models to predict the variation in wood properties with position in the stem.

The variability in wood properties can be better understood by considering wood formation as an integral part of tree growth. This is because the external environment (climate and soil) and the genetic make-up of trees directly influence the functioning of the crown, which in turn influences the structure of wood cells.

An objective of the FFR Radiata Theme Task 1.5 is to develop an initial version of an integrated empirical individual tree model that predicts stem growth, branch distribution and wood properties.

It is considered that the logical way to develop such an empirical model is to use datasets where growth variables, branch variables and wood property variables are measured on the same trees. Four such datasets were collected under the auspices of the Stand Growth Modelling Cooperative. Further datasets, covering the range of site conditions, silvicultural treatments and genetic material are required in order to develop robust models applicable throughout New Zealand.

In 2008 FFR supported the collection of growth, branching and wood property data from two of the 1975 final crop stocking trials (AK1056, Woodhill and NN529/1, Golden Downs). This was the last opportunity to collect such data as they were scheduled for clearfelling.

Novel sampling schemes will be required in order to collect data in a cost-effective manner from trials covering a range of silvicultural treatments and genetic material available in some trials. These trials contained seven different silvicultural treatments. Some new ideas for sampling schemes were tested.

Data were collected at three levels of intensity:

- A non-destructive “pre-screening” level to provide treatment average values for a number of wood properties. This sample allows the destructively sampled trees to be “benchmarked” against the treatment variability.
- A “low-intensity” destructive sampling to provide details of various traits at a log level, and to determine whether there is a silvicultural influence on wood properties over and above the effect of tree DBH.
- A “high-intensity” destructive sampling to provide details of branching characteristics, within-disc variation in compression wood distribution with respect to branching characteristics, and wood property variation at selected ages with reference to the silvicultural treatments.

This report outlines the data collected from the 1975 Final Crop Stocking Trials at Woodhill (AK1056) and Golden Downs (NN529/1) for the purpose of developing a prototype integrated stem growth, branching and wood property model.

The analysis of these data is documented in FFR Radiata Management Theme Report No. R020.

INTRODUCTION

Historically tree growth research has been carried out in isolation from tree wood property (quality) research. Consequently the data available for developing models of radiata pine stem growth is independent of the data available for developing models to predict the variation in wood properties with position in the stem.

The variability in wood properties can be better understood by considering wood formation as an integral part of tree growth[1].This is because the external environment (climate and soil) and the genetic make-up of trees directly influence the functioning of the crown, which in turn influences the structure of wood cells[2].

The objective of FFR Radiata Theme Task 1.5 is to develop the first iteration of an integrated model of tree growth and quality.

Four datasets, to support the development of such models, were collected previously by the Stand Growth Modelling Cooperative:

- A pilot study to determine data collection methodology was carried out by sampling one or two trees from several seedlots, and one silvicultural treatment in the Special Purpose Breed Trial, FR172/3 in Kaingaroa[3,4,5].
- Datasets were collected from the GF14 seedlot in the 1978 Genetic Gain Trials at Golden Downs NN530/2 and Mokaka WN377, providing a contrast in site conditions for the same seedlot and silvicultural treatment[6,7,8].
- A dataset was collected from the 1991 Silviculture-Breed Trial FR121/11 Canterbury. This dataset considered two seedlots (GF25 and a Long Internode Seedlot LI25/GF13)[9].

One component of Task 1.5 for 2007-2008 was to collect growth, branching and wood property data from two of the 1975 Final Crop Stocking Trials that were scheduled for clearfelling. This would provide data for developing such a model, and in particular, the ability of such a model to respond to silvicultural treatments.

The 1975 final crop stocking trials were planted at Woodhill, Kaingaroa, Golden Downs and Eyrewell, and represent one of the earliest silviculture trials planted with improved radiata pine from the “850” breed. The Woodhill and Golden Downs replicates were both scheduled to be clearfelled in 2008/9, so it was considered essential to collect branching and wood property data to complement the growth data in order to determine how this seedlot responded to the seven different silvicultural treatments (Table 1) in terms of growth, branching and wood properties.

Table 1.
Silviculture treatments in the 1975 final crop stocking trials.

Number of Permanent Sample Plots established	Initial Stocking (stems/ha)	Final Stocking (stems/ha)	Nominal mean crop height at time of thinning (m)	Age at thinning (years)
3	625	100	12	11
3	625	200	12	11
3	625	400	12	11
6	625	625	-	Unthinned
3	625	100	20	14
3	625	200	20	14
3	625	400	20	14

Data were collected from these trials at three different levels of intensity:

- A “pre-screening” of 30 standing trees per treatment, to provide average treatment effects for outerwood density, standing tree sonics and external resin bleeding.
- A “low-intensity” measurement of at least one felled tree of a common DBH from each silvicultural treatment (two DBH were selected for each experiment), to determine whether there is a silvicultural influence on wood properties over and above the effect of tree DBH.
- A “high-intensity” measurement of at least one felled “average DBH” tree from each silvicultural treatment, to explore the within-tree interactions between branching, silvicultural treatments and wood properties.

This report summarises the field data collected. FFR radiata theme Report No. 20 summarises the data analysis.

METHODS: SAMPLE TREE SELECTION

"Pre-screening" Sample

The "pre-screening" sample was designed to provide treatment average values for a selection of traits that are reasonably quick to measure on a non-destructive basis. The 10 trees closest to the plot centre were selected from each of the three replicates of the six silvicultural treatments. For the unthinned control, there were only two replicates where the current stocking was close to the planted stocking of 625 stems/ha. For this treatment, the 15 trees closest to the plot centre were selected from these two plots.

At Golden Downs, recent windthrow had destroyed 4 plots, namely:

- 1 replicate 100 sph early thin
- 1 replicate 200 sph late thin
- 2 replicates 400 sph late thin.

Extra trees were sampled from the remaining replicates to provide approximately 30 trees. Only 18 were available for sampling from the one remaining replicate of the 400 sph late thinning treatment.

Low-intensity Sample

For each site, two sets of trees were selected in the office for the low-intensity sample. Each set of trees consisted of at least one tree per treatment, but all trees had a common DBH (within 1 cm) at time of last PSP re-measurement. This approach meant that the selected trees were small trees from plots at 100 stems/ha and large trees from plots at 400 stems/ha. However there were very few options for the common DBHs. The trees measured at both Woodhill and Golden Downs are listed in Table 2.

The hypothesis to be explored during data analysis, is that local site conditions as well as tree DBH influence wood quality variables. On average, the trees at 100 stems/ha will have a greater availability of light and more wind exposure than trees at 400 stems/ha. It is suggested that the crown may rise more slowly in plots at 100 stem/ha, so heartwood formation may be slower. Also, there may be more movement in trees at 100 stem/ha, resulting in more compression wood formation and more variability in wood properties.

Table 2.
Trees selected for “low intensity sampling”.

Forest	Group	Treatment	Plotno	QuadRow	PSPtree	Assignedtree	lastPSP_dbh_mm
Woodhill	A	1	211	6	1	1	480
Woodhill	A	1	1431	20	1	13	485
Woodhill	A	2	1932	1	6	16	479
Woodhill	A	3	1023	4	28	10	480
Woodhill	A	4	914	4	23	9	484
Woodhill	A	5	1735	14	1	15	479
Woodhill	A	6	1326	1	7	11	480
Woodhill	A	6	416	0	42	4	480
Woodhill	A	7	2427	0	23	20	485
Woodhill	B	1	1431	9	6	14	438
Woodhill	B	2	512	4	47	5	440
Woodhill	B	3	313	4	23	2	438
Woodhill	B	3	1833	2	8	17	441
Woodhill	B	4	724	3	17	6	441
Woodhill	B	4	914	1	4	8	435
Woodhill	B	5	815	6	5	7	442
Woodhill	B	6	1326	3	28	12	444
Woodhill	B	6	416	0	15	3	443
Woodhill	B	7	2427	2	8	19	436
Woodhill	B	7	2427	1	5	18	438
G. Downs	C	1	1011	1	4	5	559
G. Downs	C	2	1722	0	12	6	565
G. Downs	C	2	332	4	55	3	557
G. Downs	C	3	2023	2	11	8	564
G. Downs	C	4	434	3	13	1	557
G. Downs	C	5	1115	20	3	4	561
G. Downs	C	6	2326	0	45	7	561
G. Downs	C	7	1927	3	16	9	562
G. Downs	D	1	2221	20	6	13	549
G. Downs	D	3	1413	3	11	11	543
G. Downs	D	4	2124	2	12	12	550
G. Downs	D	4	434	0	15	2	549
G. Downs	D	5	1115	8	2	10	544
G. Downs	D	6	2326	0	13	14	545

High-intensity Sample

The number of trees sampled was constrained by funding Potential sample trees for the “high-intensity” sample were selected in the office as ones that were consistently close to plot average DBH at the time of each growth measurement. These trees were selected using the variable “Diffsum”, which was calculated by adding together the absolute value of (tree DBH – plot mean DBH) which was calculated for each PSP re-measurement.

The original objective was to:

1. Sample two average DBH trees from each of the following treatments:
    - Both treatments at 100 sph – 2 trees per treatment (4 trees in total)
    - Both treatments at 400 sph – 2 trees per treatment (4 trees in total)

2. Sample one average DBH tree from each of the following treatments to provide validation data for relationships developed using the above eight trees:
    - Both treatments at 200 sph – 1 tree per treatment (2 trees in total)
    - Control treatment – 1 tree from a plot with minimal mortality.

The potential trees and the actual sample trees are shown in Table 3 (Woodhill) and Table 4 (Golden Downs).

A hypothesis to be explored during the data analysis is that the trees at 100 stems/ha will have larger branches after silvicultural treatment, will be more exposed to wind, and will therefore show more variability in wood properties in response to the thinning operation than the trees at 400 stem/ha.

Table 3.
Potential and selected (in bold) sample trees (most average tree) for Woodhill, AK1056.

Plot	Initial SPH	Final SPH	Potential sample trees	Diffsum	DBH-cm	Ht-m	Selected trees
100 SPH, early thin - treatment 1							
2/11	**515**	**90**	**5/4**	**9.6**	**53.8**	**29.6**	**Tree 1**
14/31	430	95	18/5	13.8	55.8	-	
23/21	**420**	**95**	**8/2**	**13.1**	**61.6**	**31.5**	**Tree 2**
200 SPH, early thin – treatment 2							
5/12	**510**	**210**	**2/24**	**8.4**	**46.5**	**28.8**	**Tree 3**
19/32	420	190	22	7.6	46.0	30.3	
22/22	440	190	4/39	12.1	53.5	30.4	
400 SPH, early thin – treatment 3							
3/13	**480**	**400**	**1/ 4**	**12.2**	**36.7**	**32.2**	**Tree 4**
10/23	**600**	**380**	**24**	**7.6**	**36.8**	**28.5**	**Tree 5**
18/33	440	380	4/19	17.4	46.2	33.5	
Control treatment – treatment 4							
6/14	575	475					
7/24	625	575					
9/14	**700**	**650**	**1/6**	**7.1**	**34.6**	**-**	**Tree 6**
12/24	525	450					
15/34	400	350					
16/34	475	475					
100 SPH, late thin – treatment 5							
8/15	490	90	3/6	14.8	48.6	29.7	
11/25	**535**	**90**	**8/2**	**15.2**	**51.3**	**29.7**	**Tree 7**
17/35	**460**	**95**	**20/1**	**16.7**	**51.9**	**30.9**	**Tree 8**
200 SPH, late thin – treatment 6							
4/16	480	200	2/20	13.4	43.8	31.9	
13/26	500	220	14	7.0	37.8	27.7	
20/36	**350**	**210**	**4/27**	**9.3**	**45.0**	**32.4**	**Tree 9**
400 SPH, late thin – treatment 7							
1/17	**520**	**360**	**2/13**	**9.2**	**38.0**	**34.2**	**Tree 10**
21/37	420	380	1/1	10.7	40.5	31.0	**Tree 11**
24/27	**460**	**380**	**3/15**	**5.2**	**40.9**	**30.9**	

Table 4.
Potential and selected (in bold) sample trees (most average tree) for Golden Downs, NN529/1.

Plot	Initial SPH	Final SPH	Potential sample trees	Diffsum	DBH-cm	Ht-m	Selected trees
100 SPH, early thin - treatment 1							
6/31	530	65	9/6 (CK)	12.9	62	-	
10/11	**415**	**100**	**4/4**	**10.8**	**63.3**	**42.4**	
22/21	**430**	**95**	**5/4**	**16.8**	**65.2**	**44.5**	**Tree 6**
200 SPH, early thin – treatment 2							
3/32	**560**	**200**	**45**	**12.0**	**59.5**	**42.0**	**Tree 3**
15/12	470	180	14 (SW)	27.8	59.4	39.6	
17/22	390	200	31 (SW)	18.0	55.1	39.7	
400 SPH, early thin – treatment 3							
5/33	**580**	**420**	**22**	**14.2**	**48.3**	**-**	**Tree 4**
14/13	**480**	**380**	**14**	**11.8**	**42**	**38.7**	
20/23	380	360	15 (SW)	10.8	45.7	37.2	
Control treatment – treatment 4							
2/34	550	325					
4/34	575	575					
13/14	450	450					
16/14	425	425					
18/24	400	400					
21/24	**675**	**675**	**16**	**20.6**	**44.3**	**38.8**	**Tree 5**
100 SPH, late thin – treatment 5							
1/35	535	85 (TR05)	12/5 (SW)	19.9	64.3	39.8	
11/15	**520**	**95**	**5/2**	**20.1**	**68.9**	**45**	**Tree 1**
24/25	**490**	**90**	**4/4**	**23.3**	**70.0**	**40.6**	
200 SPH, late thin – treatment 6							
7/36	540	190(TR05)	14 (fork)	9.7	60.9	40	
9/16	440	190	44	14.0	53.5	-	
23/26	**450**	**200**	**24**	**13.5**	**57.2**	**43.1**	**Tree 7**
400 SPH, late thin – treatment 7							
8/37	500	380(TR05)	11 (fork)	16.2	45.3	-	
12/17	**440**	**400**	**21**	**13.7**	**44.7**	**36.1**	
19/27	**460**	**400**	**8**	**15.5**	**42.6**	**39.9**	**Tree 8**

RESULTS: SITE CONDITIONS AND CHARACTERISTICS MEASURED

Site Conditions

The Woodhill trial was in good condition, and most of the sample trees selected in the office were suitable for felling. The site was fairly flat, and easy to move around. The number of trees sampled was close to the original proposal.

The Golden Downs trial had suffered some recent windthrow since the last PSP re-measurement, and some of the sample trees selected in the office were windthrown. The site was steep and had difficult access due to the recent windthrow, both of which slowed up the data collection. For this reason, and also because of the loss of some of the selected sample trees, the number of sample trees was reduced.

Characteristics Measured on "Pre-screening Trees"

Pre-screening traits measured were:

- DBHOB (stem diameter over bark at DBH)
- Outerwood density[10] – two 5 mm cores per tree
- External resin bleeding (assessed using standard procedures[11]
- Acoustic measurements of velocity using the ST300 tool (two measurements per tree).

Characteristics Measured on "Low-intensity Trees"

TreeD Images[12]

TreeD images were taken of all the sample trees to provide a visual reference of the tree, and if desired, quantitative measurements of stem and branching characteristics. If required, TreeD data will be examined to confirm other field measurements.

Log Measurements

After the sample trees were felled, the full stem velocity was measured using the HM200. The tree was then cut into 5 m sections up to a SED of approximately 100 mm. The sonic velocity was measured for each log using the HM200.

Disc Measurements

At Woodhill, discs that avoided branch clusters were cut from the stem at approximately 0.0 m, 1.4 m, and at the small end of each log. These discs were bought back to Rotorua and the following recorded/calculated:

- Diameter over bark
- Diameter under bark
- Diameter for the inner 10 rings (juvenile wood)
- Diameter of heartwood
- Total number of stem growth rings
- Number of rings of heartwood
- Compression wood percentage by quartiles
- Occurrences of
    - Resinous latewood
    - Resin pockets
    - Resin patches
    - Blemishes
    - Needle traces
    - Dimples
- Disc density for the inner 10 rings
- Disc density for the remainder of the rings.

At Golden Downs, the steepness of the site and the distance of the sample trees from the vehicle tracks precluded bringing out whole discs. Discs that avoided branch clusters were cut from the stem at approximately 0.0 m, 1.4 m, and at the ends of the logs up to a SED of approximately 100 mm, and then a bark-to-bark strip was cut avoiding any compression wood, and bought back to Rotorua.

For these strips the following were recorded:

- Diameter over bark
- Diameter under bark
- Diameter for the inner 10 rings (juvenile wood)
- Diameter of heartwood
- Total number of stem growth rings
- Number of rings of heartwood.

Characteristics Measured on "High-intensity Trees"

TreeD Images[12]

TreeD images were taken of all the sample trees to provide a visual reference of the tree, and if desired quantitative measurements of stem and branching characteristics. If required the TreeD data will be examined to confirm other field measurements.

Foliage Data

Data on foliage mass and its position on branches were used to develop equations that predict ring width and wood density at any point on the stem[5,6].

The above approach is one option that may be used to develop an integrated tree, branching and wood properties model. It would be a particularly appropriate approach if research in FFR Radiata Theme Objective 4 indicates that crown structure can be estimated from Lidar or other aerial methods.

For the current study, the original plan was to sample six branches that appeared undamaged by the felling from each of the sample trees at 100 or 400 stems/ha (i.e., eight trees in total). Due to the age of the trees and the size of the sample branches at 100 stems/ha, the sample size was reduced to 4 trees at Woodhill and no trees at Golden Downs (as we already have such data from another site in Golden Downs).

The branches selected from each tree were a large and small diameter branch from upper, middle and low thirds of the live crown.

The measurements collected for each branch were:

- diameter of the branch adjacent to the stem
- weight of the branch with foliage present
- distance from the stem to the balance point of the branch with foliage present
- weight of the branch with the foliage removed
- distance from the stem to the balance point of the branch with foliage removed.

These data allow the relationships between foliage mass, branch mass and branch diameter to be examined.

Cluster Position and Age

Functions within the integrated tree growth and branching model, TreeBLOSSIM[13,14], predict the:

- number of branch clusters within an annual shoot
- relative position of the clusters within the annual shoot.

Data to validate these functions were obtained by measuring the height to the base and top of each branch cluster, and either recording the number of stem growth rings below the branch cluster or, for approximately the last 10 years of growth, estimating the number of rings from patterns on the stem bark.

Stem Disc Digital Images
Between the top of the pruned zone, up to a height where the trees had approximately 10 stem growth rings, a 5 cm stem disc was cut immediately below each branch cluster and digitally imaged. These images will be used to examine the influence of branches and timing of silviculture on visual variability in wood properties. If required, the images will be quantitatively analysed to provide estimates of compression wood, heartwood and resin pocket distributions.

Branch Cluster Data
For the zone where stem images were collected, the angular position of each branch and stem cone, and the diameter of each branch, were measured for each branch cluster.

SilviScan Samples
For each tree, samples for SilviScan analysis were collected from six stem discs. One disc was at breast height. The other five discs were chosen based on the ring count so that they were a given number of years before/after the applied thinning treatments (Table 5). This approach meant that the discs were selected once the ring counting was complete. As there is generally more than one cluster in an annual shoot, there were several options for the disc to be selected. The first choice was a disc near the centre of the annual shoot, as this should minimise any errors in ring counts (Table 6). If that disc was not available (e.g., not imaged due to damage), the next available disc was selected. The disc numbers are shown in Table 7 (Woodhill) and Table 8 (Golden Downs). In some instances it was not feasible to collect a disc with the required number of stem growth rings. In these cases the next most suitable disc was collected.

For the Woodhill trees, all the discs were bought back to Rotorua where the selected SilviScan samples were cut.

Two or three SilviScan samples were cut from each disc in such a way that any variability in wood properties due to compression wood would be measured, i.e.:

- If there was a patch of compression wood that was likely to be related to stem form, three samples were cut, one through the compression wood, one opposite the compression wood and one at right angles to the compression wood.
- If there were multiple patches of compression wood that were likely to be related to branching, one sample was cut through a patch of compression wood, and one was cut through a non-compression wood patch.

If there was no obvious compression wood, a bark-bark strip was cut to provide two samples.

At Golden Downs, site conditions precluded carrying large discs out of the forest. A wide bark to bark strip was cut from each disc to pass through any obvious compression wood and bought back to Rotorua where two pith-to-bark SilviScan samples were cut..

At both sites, the way these samples were cut will provide an indication of how density, MFA and MOE vary within a disc.

Table 5.
Tree age and ring counts for internodes that will be selected for SilviScan samples

Tree age when internode formed	Years before or after thinning at 11 years	Years before or after thinning at 14 years	Number of stem growth rings (excluding current year)
Breast height			
7 years	-4	-7	26
10 years	-1	-4	23
13 years	+2	-1	20
16 years	+5	+2	17
19 years	+8	+5	14

Table 6.
Method of selecting discs for SilviScan analysis based on the number of clusters in an annual shoot.

Number of clusters in annual shoot	Disc selected below nth cluster in annual shoot
1	1
2	2
3	2
4	2
5	3
6	3
7	4
8	4
9	5

Table 7.
Disc numbers for SilviScan samples at Woodhill.

Tree	26 rings	23 rings	20 rings	17 rings	14 rings
1	112	94	82	69	59
2	85	72	63	53	44
3	95	82	74*	63	55
4	90	79	65	51	42
5	77	67	59	50	41
6	118	101	82	missing	49
7	67	52	38	30	24
8	101	84	69	62*	48
9	108	96	84	71	60*
10	111	92	79	63	54
11	81	69	61	54	44

Note: Samples marked with an asterisk had one more growth ring, but were the nearest suitable disc.

Table 8.
Disc numbers for SilviScan samples at Golden Downs.

Tree	26 rings	23 rings	20 rings	17 rings	14 rings
1	75	69	62	51	42
3	105	93	82	68	54
4	56	46	34	23	12
5	82	76	65	54	44
6	76*	71	61	50	40
7	75*	71	63	55	45
8	77*	70	62	52	44

Note: samples with a * were from below the lowest branch cluster, and only had 25 growth rings.

Spiral Grain Samples
Up to eight of the imaged discs per tree were selected for measuring spiral grain. Samples from Woodhill are shown in Table 9. Samples from Golden Downs are shown in Table 10.

The discs were selected from four zones, based on ring counts:

- Zone 1: Clusters with 24 or 25 growth rings (excluding current year)
- Zone 2: Clusters with 21 or 22 growth rings (excluding current year)
- Zone 3: Clusters with 18 or 19 growth rings (excluding current year)
- Zone 4: Clusters with 15 or 16 growth rings (excluding current year),

and then, based on the diameter of the largest branch in a cluster:

- small - cluster where the largest diameter was small relative to other clusters in that zone
- large - cluster where the largest branch diameter was large relative to other clusters in that zone.

Table 9.
Numbers of discs saved for Spiral Grain measurements from Woodhill.

Tree	Zone 1 small	Zone 1 large	Zone 2 small	Zone 2 large	Zone 3 small	Zone 3 large	Zone 4 small	Zone 4 large
1	101	99	87	83	79	-	63	65
2	82	78	64	66	54	56	-	48
3	88	84	79	75	68	69	57	61
4	85	82	75	71	60	54	49	50
5	70	69	64	61	55	52	43	46
6	108	110	96	-	78	75	51	53
7	59	55	48	46	36	34	28	27
8	97	89	72	75	63	64	-	-
9	101	105	87	85	77	79	-	-
10	101	102	87	88	73	74	-	56
11	73	75	65	63	56	57	48	47

Table 10.
Numbers of discs saved for Spiral Grain measurements from Golden Downs.

Tree	Zone 1 small	Zone 1 large	Zone 2 small	Zone 2 large	Zone 3 small	Zone 3 large	Zone 4 small	Zone 4 large
1	70	74	63	67	56	55	45	44
3	96	104	89	83	76	75	58	59
4	53	55	37	39	30	25	16	17
5	81	77	71	74	59	58	51	49
6	74	73	66	64	59	-	46	42
7	73	74	67	66	61	62	49	51
8	73	74	67	64	58	55	47	48

SUMMARY

This report documents the data collected from the 1975 Final Crop Stocking Trials at Woodhill (AK1056) and Golden Downs (NN529/1) for the purpose of developing integrated stem growth, branching and wood property models.

Data were collected at three levels of intensity:

- A non-destructive “pre-screening” level to provide treatment average values for a number of wood properties. This sample will allow the destructively sampled trees to be “benchmarked” against the treatment variability.
- A “low-intensity” destructive sampling providing details of various traits at a log level.
- A “high-intensity” destructive sampling providing details of branching characteristics, within-disc variation in compression wood distribution, and wood property variation at selected ages with reference to the silvicultural treatments.

The analysis of these data is documented in FFR Radiata Management Theme Report No. R020.

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