WQI Benchmarking Study
Trial WN 377: Mohaka Forest

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Stand Growth Modelling Cooperative in collaboration with WQI Ltd

RADIATA PINE RESOURCE CHARACTERISATION

WQI Benchmarking Study

Laboratory Data Collection
Site 4: Mohaka Forest (Cpt 205)

A Report Prepared for WQI Ltd and made available
to the Stand Growth Modelling Cooperative members

REPORT NO. RES 8

January 2004

New Knowledge in Wood Quality

EXECUTIVE SUMMARY

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Russell McKinley, Dave Cown, Trevor Jones

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Site 4 of the 1978 Genetic Gains Trial is located in Mohaka Forest (Trial WN 377) in the Hawkes Bay region of the North Island, and was shown in a previous study (WQI Pre-screening Study) to represent one of the "medium density" sites (outerwood density 410 kg/m^3). Ten stems were selected to cover the density and diameter range within the plot and felled to yield discs at regular intervals up the tree for wood property assessments.

Discs were prepared in such a way as to give data on a range of wood properties:

1. Wood density (5-ring sample blocks)
2. Shrinkage (5-ring sample blocks)
3. Spiral grain (5-ring sample blocks)
4. Colour
5. Internal checking
6. Resinous features
7. *Fibre length*
8. *SilviScan samples*

This report documents some of the findings (1-6 above): the fibre length and SilviScan data for Mohaka will be reported later as they become available.

The site showed the largest plot DBH (582 mm) and sample stems averaged 607 mm DBH. These represent the largest stems samples in the Genetic Gains Trials. Wood properties showed within-stem patterns similar to those established at the other sites, and with values for density, shrinkage, spiral grain and colour most similar to those for the Kaingaroa replication. On the other hand, within-ring checking was 50% higher and resinous features significantly more common than in the Kaingaroa sample stems.

Summaries of groups of sites will be provided periodically, assessing the overall results to that point. A more comprehensive comparison with other sites will be provided on completion of the next two sites (Athenree and Ruatoria).

The raw data have been entered into an Access WQI database and will contribute to modelling the effects of site, silviculture and genetics on wood formation.

RADIATA PINE RESOURCE CHARACTERISATION

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BACKGROUND

A major component of WQI Objective 1 - Radiata Pine Resource Characterisation - is a survey of the existing forest resource, collecting standard wood samples (non-destructive and destructive) from a significant number of well-documented sites and completion of comprehensive analyses of site factors affecting levels and distributions of major wood properties. Previous regional wood quality studies have identified a gradient in various properties, apparently associated with climatic and site effects (Cown, 1979; Cown & McConchie 1983; Cown & Ball, 2001). These new WQI "benchmarking" studies have been planned to use trials comprising known genetic material, located in diverse environments (1978 Genetic Gains Trials). The actual stand conditions vary somewhat due to priorities of individual forest owners and environmental influences (climate, grazing, etc).

The data collection has been designed to provide comprehensive information on:

- Geo-spatial information on wood quality factors (density, shrinkage, spiral grain, microfibril angle, internal checking, fibre characteristics, resin, etc) and material properties (stiffness, strength, stability, appearance features) to yield new information on geographic and within-tree patterns of variability in major wood characteristics.
- Data on specific environmental influences on wood formation (latitude; elevation; soil type; climate).

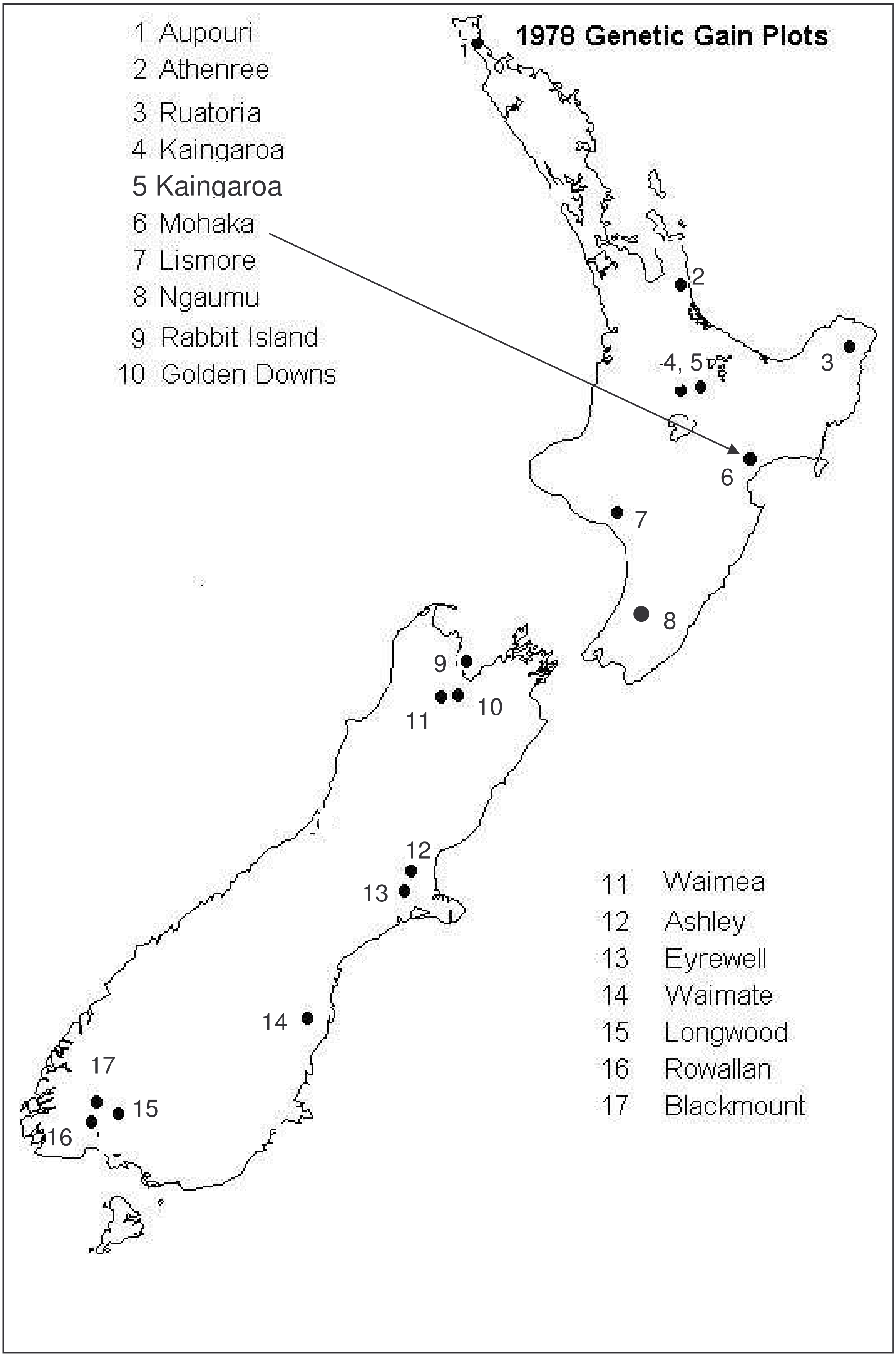
Silvicultural and genetic effects – genotype; stocking; thinning; pruning; fertilising; rotation length - will be examined later in other trials, subject to WQI priorities. The ultimate objective is to create a new archive of the major wood properties known to influence the value of radiata pine wood products, in relation to the major influencing factors, thus providing a valuable asset to WQI shareholders and new information for Decision Support Systems.

The Genetic Gains Trials were established in 1978 with known genotypes (3 open-pollinated commercial seedlots), sited in (now former) state-owned production forests at 22 sites selected to encompass a broad range of climatic and site conditions (Figure 1). Two plot designs were used:

1) Large plots with trees planted at 1111spha and managed under a typical sawlog regime
2) Row plots where trees were planted in single row plots at 833spha and managed as per the surrounding commercial forest.

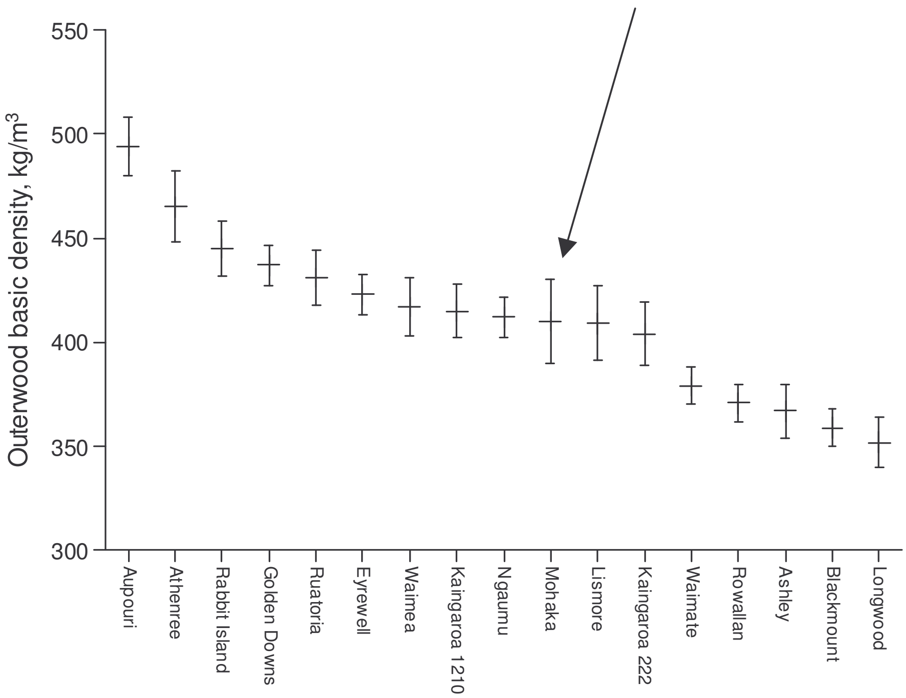
Seedlot WN76/2 (GF 14) was selected for this study as being both well represented in the trial and exhibiting relatively good growth. Classified as GF 14 stock, it represents a significant degree of genetic improvement - similar to many current crops - and is available at a relatively mature age (25 years). At the time sampling commenced (2003), in addition to varied silviculture due to management policies, several of the trials had been abandoned as research areas due to damage from excessive grazing or severe storms. The location of the Mohaka site is shown in Fig. 1.

Figure 1 – Sites in the 1978 Genetic Gain Trial Series across New Zealand



A pre-screening phase was considered advisable to check the current condition of the plots, collect outerwood density cores and assess the potential for further sampling by felling representative stems. The work was contracted to Dean Witihera (Quality Forest Management), who visited the 20 remaining trials and assessed 30 trees/trial (where available) of WN76/2 seedlot (where available), following standard non-destructive assessment techniques. Outerwood increment core sampling for basic density was undertaken, along with measurement of size (DBH over bark) and visual assessment of sample stems for stem form, branch size, internode length, external resin bleeding and suitability for felling. The results of the pre-screening assessment were documented by McKinley and Cown (2003). The pre-screening phase gave a broad picture of wood density variation within the trial (Fig. 2) and allowed for selection of 10 crop trees of reasonable stem form for possible felling, covering the wood density and diameter range at each site. The intention was to provide material for more intensive studies of major wood properties and establish within-tree, between-tree and between-site patterns and relationships between properties. The total number of sites for such intensive study is yet to be established but the intention is to provide as wide a representation of the nation's resource as possible.

Figure 2- Average BH outerwood basic density (mean and standard deviation)



The major findings from the pre-screening study were:

As expected, there was a strong trend for density to decrease southwards. The highest values were found at Aupouri Forest in Northland (494 kg/m^3), and the lowest at Longwood Forest in Southland (352 kg/m^3). These are very significant differences between the various sites in this trial and while the overall trend is clear, there are apparent departures due to local site and climate. There is evidence that the wood density values recorded are significantly reduced from those found in the previous national survey of wood properties (1977-82).

Average for other observed characteristics were:

- *Breast height diameters (average 480 cm) ranged from 356 (Eyrewell) to 580 (Longwood and Mohaka).*
- *Branch index (average 4.3 cm) – 3.4 cm (Golden Downs) to 5.9 cm (Blackmount).*
- *Visual stem resin score (average 0.9) - from 0.5 (Ruatoria, Longwood) to 2.0 (Aupouri).*

DATA COLLECTION PROCEDURES

Prior to felling, visual observation of resin were made according to the method of McConchie & Turner (2002) and the North direction marked at breast height, and a North line marked along the stem after felling. The tree stems were de-limbed and crosscut at a small end diameter of approximately 100mm. The whole stem length was recorded and a CHH Director HM200 acoustic measure made prior to sectioning the stem into log lengths and discs as per Appendix 2. Further Director acoustic measures were made on all individual logs above the 1.4m sampling position. Internode lengths down to 0.2m were measured on the second log, *i.e.* between sampling heights 5m to 10m.

One complete set of discs from all sampling heights (0m, 1.4m, 5m and subsequent 5m intervals down to a SED of approximately 100mm) was removed for basic density, shrinkage and spiral grain assessment by 5-ring groups (Cown & McConchie, 1982, 1983; Treloar and Lausberg, 1995). Samples were also prepared for shipment to CSIRO for SilviScan analyses. Prior to sectioning into 5-ring groups, diameters were recorded over bark, inside bark, for heartwood and juvenile wood (inner 10 rings). Compression wood occurrence per quartile and resinous features were also recorded, along with a total ring count and the number of heartwood rings.

Internal checking analyses were undertaken on all discs up to and including the 10m sampling height, using the "oven drying method" of McConchie (2000). Bark-to-bark strips centred on the pith and an additional adjacent strip were collected at all heights for SilviScan, wood colour and archive samples. SilviScan samples were prepared according to established procedure (*i.e.* soaked in ethanol for several weeks with two changes of ethanol) prior to dispatch to CSIRO, Melbourne. Wood colour measurements were made for heartwood and sapwood in the green and air-dry condition using a Minolta CR-200 colorimeter (Dawson *et al.,* 2003).

Two additional sample discs from all trees (1.4m and 20m) were retained for Norske Skog - for kraft pulping and fibre length and width measurement using a Kajaani Fibrelab instrument.

Results - Site 4 (Mohaka)

Plot data for the Mohaka trees, collected during the pre-screening exercise, are tabulated in Appendix 1. Due to the level of malformation and storm damage, only 15 stems were deemed suitable for sampling.

Regarding this site, Dean commented:

Plot fairly clean with some small ferns and the odd shrubby hardwood. Plot fairly open with a number of gappy areas around some of the plot trees. Some very big trees. Lots of compression wood displayed in some of the trees. Assessed on a wet day and difficult to get a good reading on the resin score.

The site was subsequently visited by Don McConchie (Wood Quality Focus), who was contracted to arrange tree felling and disc collection for the detailed wood property analyses.

Tree Stem Characteristics

Appendix 1 provides the plot information for Mohaka, as supplied by Dean Witehira. From the total trees assessed in the pre-screening phase, 10 were selected that met the criteria of suitable crop trees as well as covering the outerwood density and diameter range. Table 1 gives all the visually-assessed data from the selected plot trees.

Table 1 – Pre-screening attributes of selected trees

Forest	Tree No.	Outerwood Density (kg/m^3)	DBHOB (mm)	Visual Branch Class				Int. Index	Resin Score #	Comments
				Butt	2nd	3rd	4th			
Mohaka	2	424	805	0	3	3	3	0	0	nice big tree
Mohaka	6	383	733	0	3	3	3	0	1	nice tree
Mohaka	7	412	533	0	2	2	2	0	1	lot comp wood
Mohaka	9	439	570	0	2	2	2	0	1	
Mohaka	10	349	513	0	1	2	2	0	1	side lean
Mohaka	11	484	528	0	2	2	2	0	0	
Mohaka	12	399	661	0	3	3	2	0	0	
Mohaka	13	469	541	0	2	2	2	0	0	
Mohaka	14	373	532	0	3	3	3	0	1	
Mohaka	15	395	656	0	3	3	3	0	1	OK to fell
Sample mean		413	607	0	2.4	2.5	2.4	0	0.6	
Mean BIX					5.7	6.0	5.7			
Site mean (30 stems)		410	582	0	2.4	2.5	2.5	0	0.7	
Mean BIX					5.7	6.0	6.0			

\# 0 = Nil; 3 = Severe

BIX Score	Average Branch (cm)	Range	IIX Score	Average Internode Index	Description
0	0	No branches	**0**	0.3	No or very few internodes - < 40% of logs made of long internode material
1	3.0	3 cm or less	**1**	0.5	Some internode material - > 40% of logs made of long internode material
2	4.5	3 - 6 cm	**2**	0.7	Long internode material - > 70% of logs made of long internode material
3	7.5	6 - 9 cm			
4	>9.0	9 cm or greater			

Outerwood density and DBHOB of the sample stems averaged 413 kg/m^3 and 607 mm respectively, closely matching the plot values. The butt logs were large and pruned, but assessments of the other logs yielded visual branch assessments averaging 2.4, 2.5 and 2.4 (logs 2-4) equating to BIX values of 5.7, 6.0, and 5.7 cm respectively. None of the selected stems had long internodes and the level of external resin was low.

WOOD PROPERTIES - RESULTS AND DISCUSSION

1. Increment Cores

Previous research has indicated that as far as wood density is concerned, the Hawkes Bay forests can be quite variable, but basically cover the medium range of the scale (Cown 1979; Cown & McConchie, 1983). It was apparent from the WQI pre-screening exercise (McKinley & Cown, 2003) that outerwood wood density levels for Mohaka (30 trees) were indeed average (410 kg/m^3) – positioned roughly mid way between the extremes (Aupouri - 494 kg/m^3 and Longwood - 352 kg/m^3). The average for the selected trees was very close to the site average (413 kg/m^3 vs. 410 kg/m^3).

2. Disc Properties (diameter, bark, juvenile wood, heartwood, compression wood)

Average disc properties by height are documented in Table 2, collected according to the disc sampling as shown in Appendix 2. Juvenile wood (inner 10 rings) and heartwood are calculated as the proportion of cross-sectional area of the entire disc. Compression wood was visually assessed by quartile and disc, with Quartile 1 centred on the North line marked on the disc.

Table 2 – Average disc properties by sampling height

Disc Ht. (m)	DIB (mm)	Bark (mm)	Total Rings	Heart Wood Rings	Heart Wood (%)*	Juv Wood (%)*	Compression wood (CW) by Quartile				
							N (%)	E (%)	S (%)	W (%)	Disc (%)
0	581	33	25	8	21	29	9	8	6	6	6.5
1.4	529	26	23	7	22	38	10	7	10	14	11.0
5	486	14	21	7	25	45	7	9	8	7	8.0
10	438	10	18	7	30	53	6	8	7	7	7.5
15	386	9	16	6	29	58	4	7	7	5	7.0
20	341	8	15	5	22	65	5	5	8	8	7.0
25	290	8	12	3	13	73	4	2	2	5	3.8
30	225	6	9	2	6	99	3	4	4	3	3.8
35	174	5	7	1	4	100	5	5	5	5	5.0
							Unweighted average CW				6.6

* Area based

These data on their own are rather meaningless, and will be discussed in more in the context of the overall results from the Genetic Gains Trial sites. At that point, realistic site comparisons can be made and trends observed. At this site, the highest level of compression wood was noted at BH.

3. Wood Density

Wood density values can be assessed in a number of different ways. Outerwood increment core values were determined for plot sample trees in the course of the pre-screening study, and detailed SilviScan within-ring data (resin-extracted) will be collected at all disc sampling levels for all felled sample stems, giving information similar to past densitometry studies (Cown & Ball, 2001). In this part of the study, wood density was measured on 5-ring blocks from the pith outwards at each stem level (unextracted density), as indicated in Appendix 2. The weighted block and disc measurements (Table 3) allowed estimates density for various stem components: juvenile wood (353 kg/m^3), outerwood (392 kg/m^3), log and whole stem basic density (364 kg/m^3). These "unextracted" values are influenced to some degree by the presence of heartwood, particularly in the lower stem (Cown *et al.* 1991a).

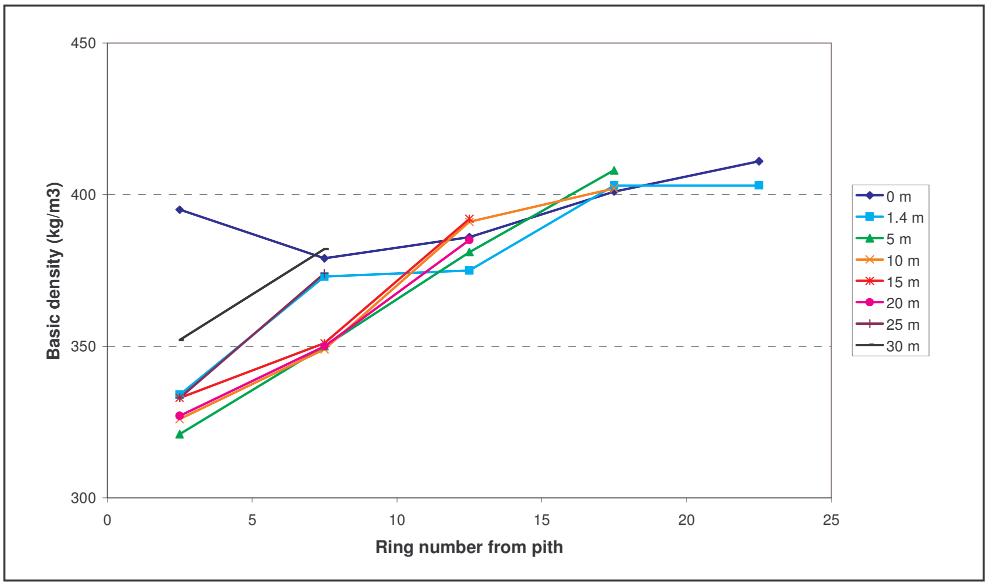
Table 3 – Pith-to-bark basic density trends by sampling height

Disc Ht. (m)	Basic density (kg/m^3) by ring group from pith					Basic density (kg/m^3)		
	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	Juv.#	Outer	Disc
0	395	379	386	401	411	384	397	393
1.4	334	373	375	403	403	357	389	374
5	321	350	381	408		338	393	363
10	326	349	391	402		339	395	359
15	333	351	392			343	392	358
20	327	350	385			339	385	351
25	333	374				361		361
30	352	382				370		370
35	350					350		350
Average Stem Density: 364 kg/m^3 Range: 317 – 415 kg/m^3						353	392	364

Inner 10 growth rings

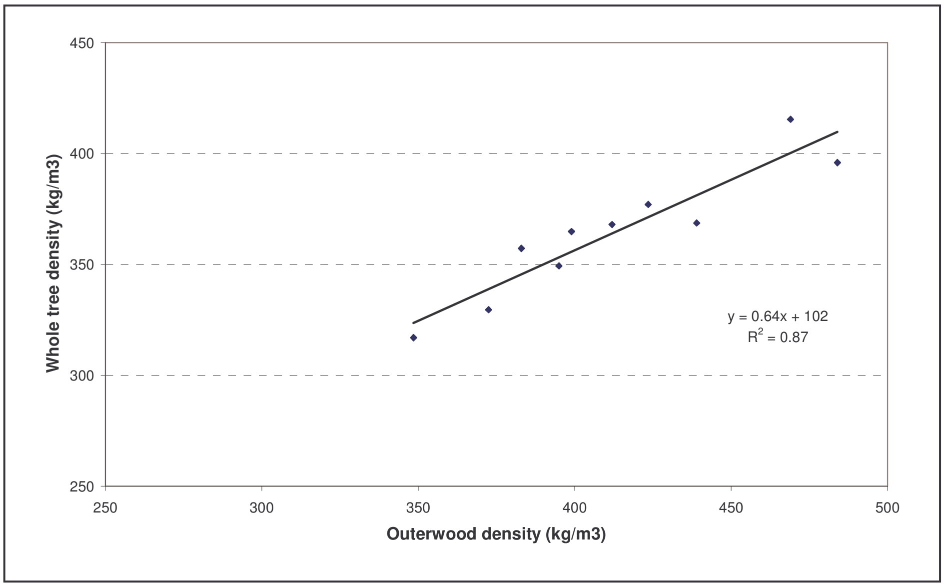
Basic wood density values consistently increase outwards from the pith as has been documented in numerous studies. Juvenile wood density increases most rapidly at most stem levels and the outerwood density decreased slightly with height up the stem, reflecting the increasingly younger wood. The relatively high values for juvenile wood for the butt (0m) disc are simply a reflection of high levels of extractives in the "older" heartwood in the samples. This is very apparent in Fig. 3.

Figure 3 – Basic wood density (unextracted) - all stem levels



Weighted whole tree density calculated from disc values using Smalian's formula averaged 364 kg/m^3 (range 317 – 415 kg/m^3). The relationship between BH outerwood density and whole-tree density for all 10 trees is shown in Fig. 4 ($r^2 = 0.87$).

Figure 4 – Basic wood density:breast height/whole stem relationship



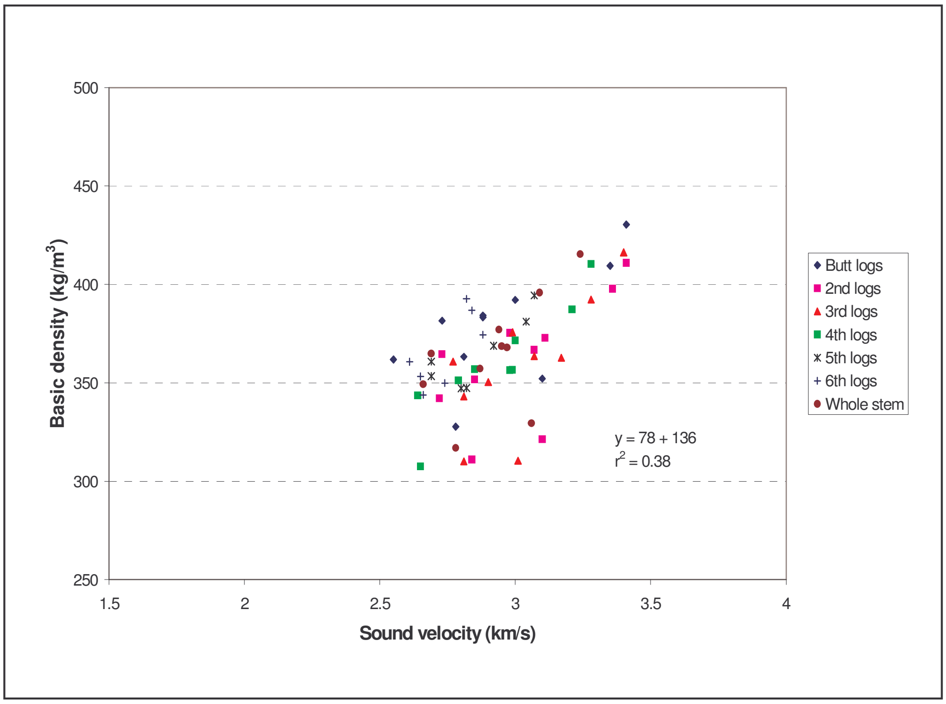
The expected high correspondence was confirmed for these trees. The dynamic stiffness data (CHH director HM 200 - Table 4) was examined in relation to average log and stem density (Fig. 5), where the relationship conforms to the pattern established previously (Cown et al. 2004).

Table 4 –CHH Director HM200 log and stem acoustic measures

Tree No.	Stem Length (m)	Acoustic data (km/s)						
		Stem	Log 1*	Log 2*	Log 3*	Log 4*	Log 5*	Log 6*
F2	30	2.94	2.88	2.98	2.99	3	2.92	2.88
F6	15	2.87	2.81	2.85	2.9	2.85	2.69	2.61
F7	28.6	2.97	2.88	3.11	3.17	2.99	2.82	2.66
F9	32	2.95	3	3.07	3.07	2.98	2.8	2.74
F10	18	2.78	2.78	2.84	2.81	2.65		
F11	35	3.09	3.35	3.36	3.28	3.21	3.04	2.84
F12	35	2.69	2.73	2.73	2.77	2.79	2.69	2.65
F13	30	3.24	3.41	3.41	3.4	3.28	3.07	2.82
F14	18	3.06	3.1	3.1	3.01			
F15	20	2.66	2.55	2.72	2.81	2.64		
Mean	26	2.93	2.95	3.02	3.02	2.93	2.86	2.74

* 5m length

Figure 5 - Relationship between basic density and sound velocity for individual logs and whole stems



Overall, there is a weak positive relationship, with little indication of trends with log height class. Further analysis of this aspect will await amalgamation of data from the other sites.

4. Shrinkage

Shrinkage values were measured on all 5-ring block samples and compared to data previously collected in the course of a national wood properties survey (Cown *et al.* 1991a). The data for Mohaka are summarised in Tables 5 and 6, and breast height trends plotted in Figure 6. Values are in line with previous results (Cown *et al.*, 1991a; 2004). Both the tangential and radial values vary with both radial position and stem height. Radial values increase from around 1% in the inner rings to around 2% in mature wood and tangential from about 3% to 5%. Longitudinal shrinkage is generally very small apart from the high values of the inner rings at the butt and breast height (in line with previous results). The negative values for the tree level longitudinal shrinkage averages reflect the difficulty of accurately detecting very small differences on the 5-ring block surfaces and possibly some apparent expansion in the longitudinal direction due to grain imperfections.

Table 5 – Average air-dry shrinkage by sampling height

Disc ht. (m)	Air-dry shrinkage* (%)		
	Longitudinal	Radial	Tangential
0	0.06	1.7	4.4
1.4	0.00	1.7	4.0
5	-0.04	1.4	3.7
10	-0.04	1.5	3.7
15	-0.04	1.4	3.6
20	-0.04	1.3	3.4
25	-0.03	1.1	3.2
30	0.04	1.1	3.0
35	-0.02	1.2	2.9

* Adjusted to 12% m.c.

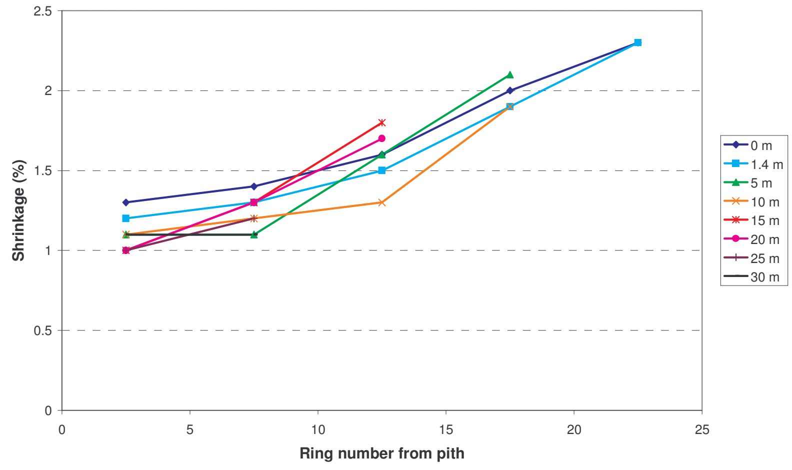
Table 6 – Pith-to-bark air-dry shrinkage trends by sampling height

Disc ht. (m)	Air-dry shrinkage* (%) by ring group from pith									
	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25
	Longitudinal					Radial				
0	0.62	0.04	-0.11	-0.12	-0.11	1.3	1.4	1.6	2.0	2.3
1.4	0.19	0.11	-0.08	-0.07	-0.15	1.2	1.3	1.5	1.9	2.3
5	0.09	0.00	-0.06	-0.17		1.1	1.1	1.6	2.1	
10	0.08	-0.05	-0.08	-0.12		1.1	1.2	1.3	1.9	
15	0.06	-0.05	-0.12			1.0	1.3	1.8		
20	0.04	-0.05	-0.12			1.0	1.3	1.7		
25	0.00	-0.05				1.0	1.2			
30	0.06	0.03				1.1	1.1			
35	-0.02					1.2				
	Tangential									
0	3.3	4.4	4.5	4.7	5.0					
1.4	3.7	3.2	4.1	4.5	4.7					
5	2.9	3.5	4.0	4.3						
10	3.2	3.8	3.7	4.2						
15	3.1	3.6	4.0							
20	2.8	3.7	3.9							
25	2.8	3.5								
30	2.7	3.2								
35	2.9									

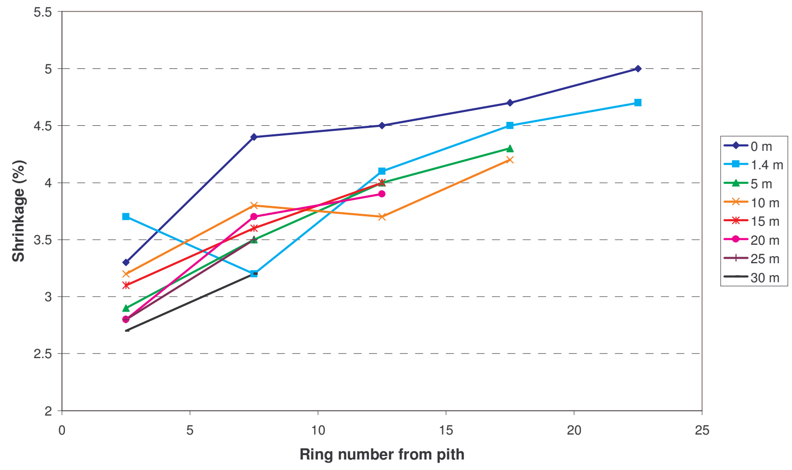
* Adjusted to 12% m.c.

Figure 6 – Shrinkage (green to 12% MC) for all stem levels

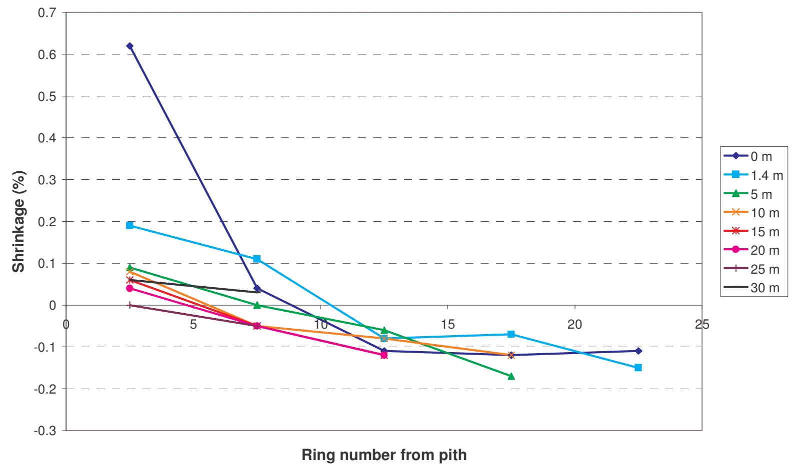
6a: Radial shrinkage



6b: Tangential shrinkage



6c: Longitudinal shrinkage



5. Spiral Grain

Average spiral grain values are summarised in Table 7 and Fig. 7. The average inner wood values (rings 5) 2.5^0 in the lower stem to 5.5^0 in the mid stem region, and the outerwood angles (outside ring 10) from to 1.3^0 to 2.6^0, in accordance with previously established broad patterns for the central North Island (Cown *et al.* 1991b). More detailed analyses will await data from more sites.

Table 7 – Average pith-to-bark spiral grain patterns by sampling height

Disc ht. (m)	Spiral grain (°) by ring number from pith				
	5	10	15	20	25
0	2.5	1.2	1.3	2.0	2.2
1.4	2.7	1.4	1.4	2.4	1.9
5	3.7	1.7	2.1	1.8	
10	5.3	3.6	1.8	1.3	
15	5.5	3.1	1.4		
20	4.8	4.5	2.6		
25	4.1	2.8			
30	4.3	3.4			

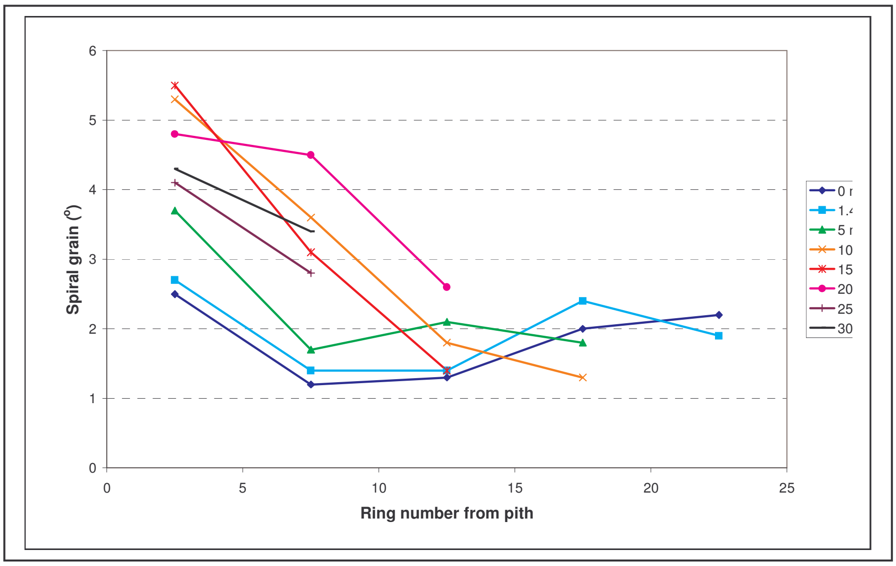


Figure 7 – Spiral grain pattern for all stem levels

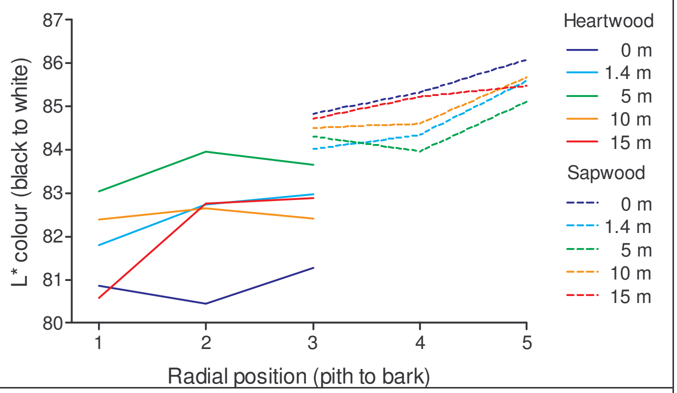
6. Wood Colour

The LAB system of wood colour measurements showed differences in heartwood and sapwood colour with height and radial position within the trees. The heartwood became lighter with height from 0 to 5 metres (lightness L* values increased), and then decreased slightly to 15 metres, with a slight increase in lightness from the inner to outer heartwood (Figure 8a). The sapwood was lighter in colour that the heartwood, though the differences were small at 5 metres, and showed less variation with height than heartwood, with a slight increase in lightness from inner to outer sapwood.

The heartwood and sapwood red colour (a* values) were similar, except at 0 metres height where the heartwood was more red in colour (Figure 8b). The heartwood red colour decreased with height from 0 to 5 metres, and then increased slightly to 15 metres. There was wide variation from inner to outer heartwood. The height trends were reversed for sapwood, with a decrease in red colour from the inner to outer sapwood. For many of the trees from Mohaka it was difficult to differentiate between the sapwood and heartwood colour, there being little difference in the red colour.

The heartwood was more yellow in colour (b* values higher) than the sapwood, except at 5 metres height where it differed only in the inner heartwood and outer sapwood (Figure 3). The heartwood yellow colour decreased with height from 0 to 5 metres, and then increased slightly to 15 metres, with a decrease from the inner to outer heartwood. The height trends were reversed for the sapwood, but the differences were relatively small. The yellow colour decreased from the inner to outer sapwood.

Figure 8 – Colour data - Mohaka

<table>
<tr><td>8a) Height and radial patterns of the L* colour co-ordinate (black to white).
Radial positions: 1-3 heartwood, 4-6 sapwood.</td><td>
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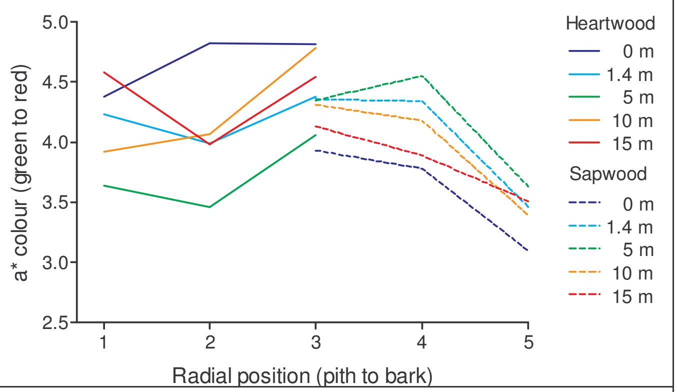
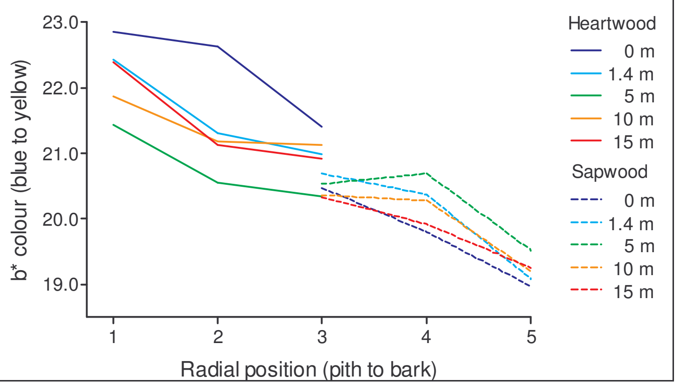
<tr><td>8b) Height and radial patterns of the a* colour co-ordinate (green to red).
Radial positions: 1-3 heartwood, 4-6 sapwood</td><td>
</td></tr>
<tr><td>8c) Height and radial patterns of the b* colour co-ordinate (blue to yellow).
Radial positions: 1-3 heartwood, 4-6 sapwood.</td><td>
</td></tr>
</table>

7. Internal checking

Within-ring internal checks are often observed at the base of the stem and there have been suggestions that site, climate, genotype and tree age can all have an effect on the levels found (Cown *et al* 2003; Beets *et al.,* 2002). At this site, 7 of the 10 felled trees exhibited internal checking (total of 312 checks, or an overall average of just over 44checks per affected tree for the site). Appendices 3a and 3b give the detailed data by tree number and disc height where it is seen that individual stems vary dramatically in level and timing of incidence. Fig. 9 shows that only the lower 10m section is affected and a general reduction with stem height. Fig. 10 shows the distribution according to years at BH. Occurrence is spread over 13 years, with peaks in 1985, 1991 and 1992.

Figure 9 – Internal checks by height (7 trees affected)

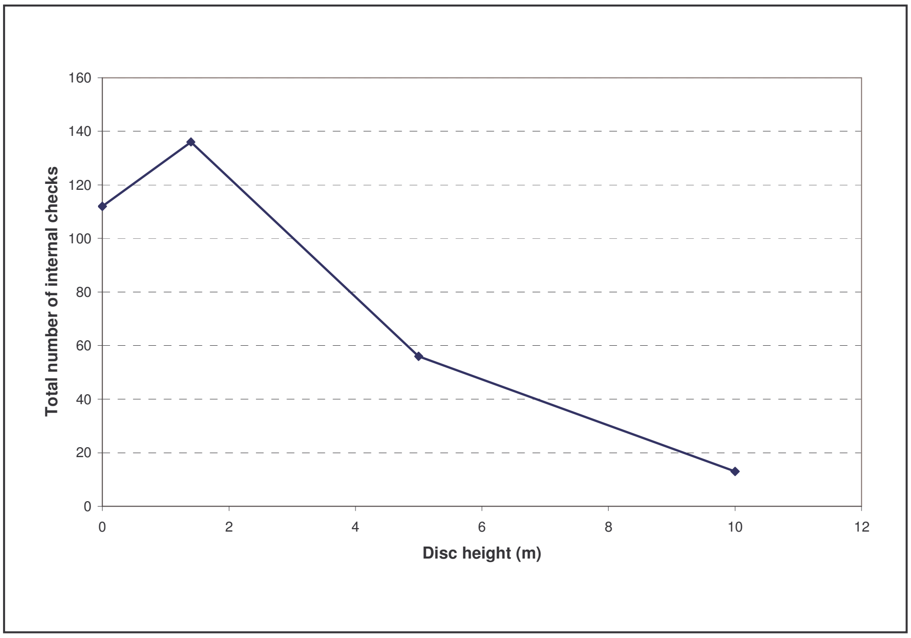
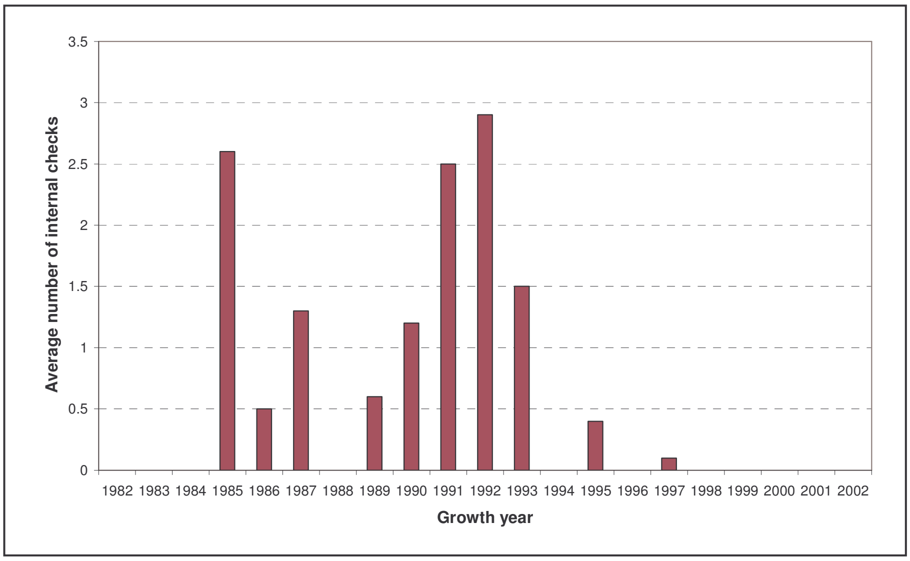


Fig. 10 – Internal check by year (BH level)



8. Resinous Features

In the field, notes were made of the occurrence of resin pockets, blemishes, needle flecks and green intra-ring checks on the fresh discs. The totals for the Southland sites are given in Table 8. Relatively few defects were present in the 15 stems, and most were found in the lower 5m. Needle fleck was an exception – occurrence increasing with stem height. However, none of the felled trees was completely free of blemishes.

Table 8 – Resinous features (totals) by height class

Disc Ht (m)	Resin pockets	Resinous patches*	Blemishes	Needle Fleck	Green Int. checks
0	3	20	15	0	0
1.4	5	0	4	0	0
5	8	1	1	1	0
10	1	0	1	5	1
15	4	0	2	4	1
20	1	0	1	4	0
25	0	0	0	3	0
Totals	22	21	24	17	2

* includes resinous latewood

Note: 4 trees had galls and 1 tree had large wet heartwood zone with a pink outer edge

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References

Beets, P.N.; Kimberley, M.O.; McConchie, M. 2002: Internal checking in *Pinus radiata* – an examination of genetic and nutritional factors associated with its occurrence at the Kaingaroa seed orchard. Forest Research, August, 2002 (Unpublished contract report for FCF).

Cown, D.J. 1979: Radiata pine wood properties survey (1978) Interim Report 5 – Southland Conservancy. FRI Forest products division Report FP/WQ 30: 70pp. (Unpublished).

Cown, D.J. and McConchie, D.L. 1982: Rotation age and silvicultural effects on wood properties of four stands of *Pinus radiata.* New Zealand Journal of Forestry Science 12(1): 71-85.

Cown, D.J. and McConchie, D.L. 1983: Studies on the intrinsic properties of new-crop radiata pine. II: Wood characteristics of 10 trees from a 24-year-old stand grown in central North Island. FRI Bulletin No.37.

Cown, D.J. and McConchie, D.L. 1983: Radiata pine wood properties survey (1979-1982). F.R.I. Bulletin No. 50.

Cown, D.J., McConchie, D.L. and Young, G.D. 1991a: Radiata pine wood properties survey. FRI Bulletin No. 50 (revised).

Cown, D.J., Young, G.D. and Kimberley, M.O. 1991b: Spiral grain patterns in plantation-grown *Pinus radiata*. New Zealand Journal of Forestry Science 21(2/3): 206-216. Reprint No. 2435.

Cown, D.J.; Ball, R.D. 2001: Wood Densitometry of 10 *Pinus radiata* families at seven contrasting sites: Influence of tre age, site and genotype. NZ Jour. For. Sci. 31(1): 88-100.

Cown, D.J., McConchie, D.L.; McConchie, M. 2003: Intra-ring Internal Checking in Radiata Pine (P. radiata D. Don) in New Zealand. WQI Report APP1 21pp.

Cown, D.J.; McKinley, R.D.; Jones, T. 2004: Radiata Pine Resource Characterisation. WQI Benchmarking Study: Summary of site 1-3 (Aupour1, Kaingaroa, Southland). Report No. Res 7. 26pp.

Dawson, B.; Riley, S.R.; Cown, D.J. 2003: Colour measurements of wood. Wood Processing Newsletter, Issue No. 33, July, 2003.

McConchie, M.S. 2000: Internal checking: the oven dry technique. Forest Research Directions Issue No. 28: 5.

McConchie, D.L.; Turner, J. 2002: How external resin on radiata pine logs relates to clearwood quality and value. Wood Processing Newsletter, Issue No. 32, December, 2002.

McKinley, R.B.; Cown, D.J. 2003: Pre-secreening National Survey of 17 "Genetic Gain" Trials for Outerwood Density and Visual Stem Characteristics. WQI Report RES 1.

Treloar, C.; Lausberg, M. 1995: Sampling an data handling techniques for wood quality analyses. *In* Forest Research Wood Quality Workshop ’95. FRI Bulleting No. 201, Klitscher, Cown, Donaldson, eds.

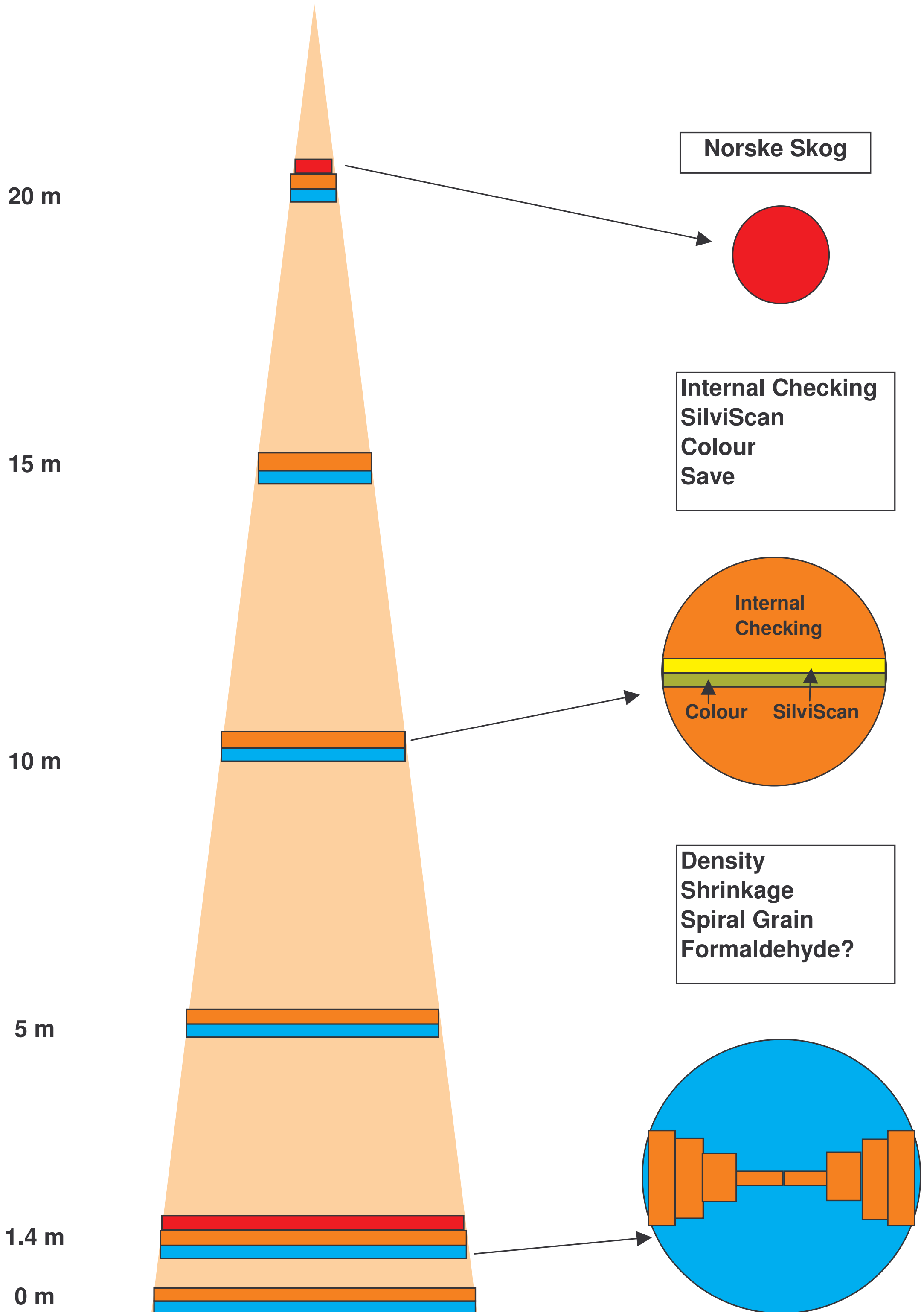
Xin, Tian, Cown, D.J. and Lausberg, M. 1996: Modelling of Radiata Pine Wood properties. Part 1: Spiral Grain. NZ Jour. of Forestry Science 25(2): 200-213.

Appendix 1: Sample Plot Stem details

Trial WN377, Mohaka Forest, Cpt 205
Forest Owner PPFP

Plot No.	Plot#	Tree#	O. Wd. BD	DBH	BIX Log 1	BIX Log 2	BIX Log 3	BIX Log 4	IIX	Resin	Suitable to Fell (Y/N)	Acceptable Crop Tree (Y/N)	PSP #	COMMENTS
12	6/41	1	382	497	0	2	3	-	0	1	n	n	79	double leader at 15m, malformed top
12	6/41	2	424	805	0	3	3	3	0	0	y	y	80	nice big tree
12	6/41	3	468	529	0	3	3	3	0	2	y	y	51	bit of side lean
12	6/41	4	377	754	0	3	3	3	0	1	y	y	52	heavy lean, very big tree
12	6/41	5	374	465	0	2	2	-	0	0	y	y	57	malform top at 14m
12	6/41	6	383	733	0	3	3	3	0	1	y	y	8	nice tree
12	6/41	7	412	533	0	2	2	2	0	1	y	y	61	lot comp wood
12	6/41	8	419	414	0	2	2	-	0	1	n	n	64	malformed top, broken at 15m
12	6/41	9	439	570	0	2	2	2	0	1	y	y	65	
12	6/41	10	349	513	0	1	2	2	0	1	y	y	66	side lean
12	6/41	11	484	528	0	2	2	2	0	0	y	y	68	
12	6/41	12	399	661	0	3	3	2	0	0	y	y	70	
12	6/41	13	469	541	0	2	2	2	0	0	y	y	-	
12	6/41	14	373	532	0	3	3	3	0	1	y	y	-	
12	6/41	15	395	656	0	3	3	3	0	1	y	y	-	OK to fell

APPENDIX 2: DISC SAMPLING PLAN



Appendix 3a – Internal Checking – Disc data (5 of 10 stems)

Tree ID	Sample ht. (m)	Strip width (mm)	HW bdy (mm)	Rings Affected	Total checks	Growth year																				
						82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	2000	01	02
F6	0	100	86	11	70						1		13	17	13	11	6		3	2	2	1			1	
	1.4	100	87	8	72						1		3	11	16	21	15		4		1					
	5	100	89	5	6											1	1						1		2	1
	10	100	91	3	4																2		1		1	
F9	0	100	84	1	1						1															
	1.4	100	84	3	21				19	1	1															
	5	100	86	1	13						13															
	10	100	89	1	2									2												
F10	0	100	85	7	32				2	7	12	1	3		3	4										
	1.4	100	86	5	22						8		3	1	8	2										
	5	100	88	3	30								6		11	13										
	10	100	89	2	7										3	4										
F12	0	100	86	3	5						1		1			3										
	1.4	100	85	5	21				7	4	3				1	6										
	5	100	87	2	4									2		2										
	10	100	88	0	0																					
F14	0	100	86	1	4						4															
	1.4	100	88	0	0																					
	5	100	89	1	3											3										
	10	100	90	0	0																					
Total					**317**				**28**	**12**	**45**	**1**	**29**	**33**	**55**	**70**	**22**		**7**	**2**	**5**	**1**	**2**			

Appendix 3b – Internal checking – Totals for checked trees (5 of 10 stems)

Disc ht (m)	**No. of checked trees**	**Years affected**	**Total Checks**	**Growth year**																				
				82	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**2002**
0	5	14	112				2	7	19	1	17	17	16	18	6		3	2	2	1			1	
1.4	4	10	136				26	5	13		6	12	25	29	15		4		1					
5	5	9	56						13		6	2	11	19	1						1		2	1
10	3	6	13									2	3	4					2		1		1	
Overall Totals			317				28	12	45	1	29	33	55	70	22		7	2	5	1	2		4	1
Site Average (10 stems)			31.7				2.8	1.2	4.5	0.1	2.9	3.3	5.5	7.0	2.2	0	0.7	0.2	0.5	0.1	0.2	0	0.4	0.1