MARLBOROUGH DATA COLLECTION and ANALYSIS: NN 469/0 77/8

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REPORT No. 88 NOVEMBER 2002

Stand Growth Modelling Cooperative

**Forest Research Output No.
31151**

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Forest Research/INDUSTRY RESARCH COOPERATIVES

EXECUTIVE SUMMARY

Three trees were destructively sampled from Plot NN469/0 77/8 Wairau (North Bank) Forest to provide data for developing the branch model BLOSSIM. New features included in the data collection procedure are discussed. The data collected were analysed to develop coefficients for some of the model functions.

DATA COLLECTION AND ANALYSIS
NN469/0 77/8

INTRODUCTION

Sample plot NN469/0 77/8 in Wairau (North Bank) Forest was planted in June 1971 at 1001 stems/ha. The plot received two thinnings, in January 1978 and in June 1984 (Appendix 1). The current stocking is 280 stems/ha. The trees had been pruned to approx. 2 m. The plot slope was approximately 39° with a SSE aspect (not 30° with a NE aspect as recorded in the PSP system).

Three trees were destructively sampled from the plot in order to provide detailed data on branching in the Marlborough area. Results from analysing the data will be used in the branch model BLOSSIM.

DATA COLLECTION AND OBSERVATIONS

The data collection procedures generally followed those used at other sites (SGMC Report No. 76). The major differences were the inclusion of new procedures: a visual assessment of the tree crowns, and non-destructive ageing of the stem.

Visual assessment

The trees crowns were visually assessed on 7th February 2000 to determine whether there were any trends in branch diameter within the tree crown (i.e. to determine whether branch size changed as a result of the thinnings). The crowns appeared light and narrow with few dead branches and lots of stem cones. Most trees appeared to have responded to the thinning with larger branches being observed higher in the crown (Table 1). From notes made in the field, each tree was assigned a code according to the change in branch diameter within the crown:

0: no change in branch diameter
1: possibly no change in branch diameter
2: possible change in branch diameter
3: definite change in branch diameter

The code value was then plotted against tree DBH measured in June 1999. There was a very slight tendency for the larger trees to have a higher response code (i.e. more likely to show an obvious response to the thinning (Fig. 1).

Figure 1 Subjective assessment of crown response to thinning

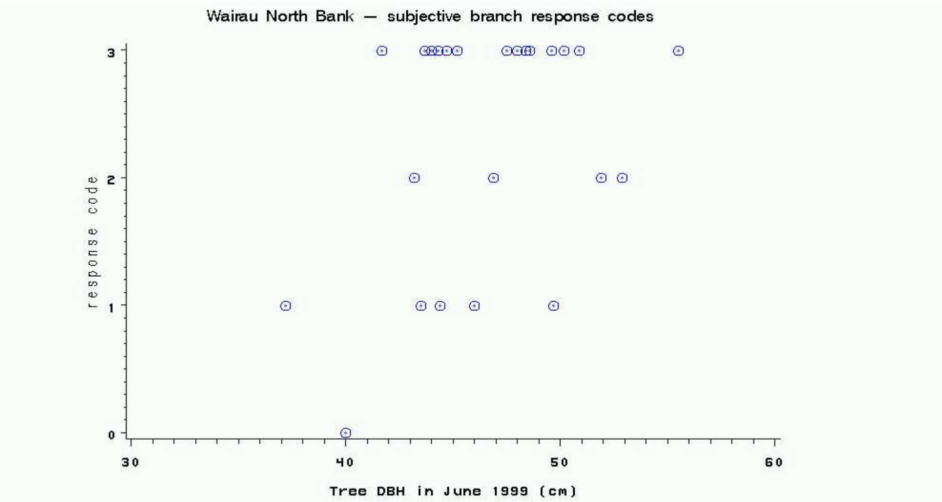


Table 1. Visual Assessment of tree crowns in NN 469/0 77/8.

Tree	DBH (cm) June 1999	Comments on crown shape	Code
1	46.0	Possibly no change in branch diameter.	1
2	35.4	-	na
3	41.7	Change in branch diameter at about 9 m.	3
4	48.0	Change in branch diameter at about 12 m. Sap on stem.	3
6	44.4	Possibly no change in branch diameter.	1
7	46.9	Possibly change in branch diameter at about 10 m.	2
8	45.2	Change in branch diameter at about 6 m.	3
10	47.5	Change in branch diameter at about 6 m. Lots of stem cones.	3
15	48.6	Change in branch diameter at about 12 m. Some sap on stem.	3
19	48.0	Change in branch diameter at about 12 m.	3
20	44.3	Change in branch diameter at about 9 m.	3
21	50.1	Several changes in leader.	na
23	51.9	Possible change in branch diameter high in crown.	2
26	50.9	Change in branch diameter at about 6 m, then again about 9 m. Possible leader change at some stage.	3
27	43.2	Possibly change in branch diameter. Possible leader change low in crown.	2
28	49.7	Possibly no change in branch diameter.	1
31	50.2	Change in branch diameter at about 6 m and again at about 9 m.	3
32	44.7	Slight increase in branch diameter at around 12 m.	3
39	43.5	Possibly no change in branch diameter.	1
42	43.7	Change in branch diameter at around 6 m.	3
43	44.0	Possible leader change at about 12 m.	na
47	40.0	Small branches most of way up stem.	0
48	48.4	Change in branch diameter at about 12 m.	3
50	37.2	Possibly no change in branch diameter. Still live branches near base of crown.	1
52	52.9	Possible change in branch diameter.	2
53	44.0	Change in branch diameter at about 6 m and again at about 12 m.	3
57	49.6	Change in branch diameter at about 12 m.	3
59	55.5	Change in branch diameter at about 14 m.	3

Sample tree selection

To choose 3 sample trees, the diameter distribution recorded in June 1996, was divided into thirds. Initially trees 31 and 53 were selected as there appeared to be two changes in branch size. These were at approximately the 80^{th} and 20^{th} percentiles. Tree 7 (at approximately the 50^{th} percentile) was selected as the third tree. These three trees were examined for ease of felling. Tree 7 would not have been easy to fell and was replaced by tree 8. Tree 53 was not easy to fell either and was replaced by tree 50 as this tree had been noted to have live branches close to the base of the crown.

Crown Architecture

Branching patterns were assessed visually to provide a non-destructive estimate of stem age. All three trees had many stem cones and the determination of the end of an annual shoot was heavily influenced by the presence /absence of cones. Using the distance to the first set of laterals on branches to determine stem age generally agreed with our assessment based on cones. The size of the branches was more variable. There would often be large branches in the last cluster of an annual shoot, but other clusters also had large branches.

Stem ring counts

As with other sites we had difficulty in deciding when the innermost ring disappeared.

Branch diameter distributions within clusters

These trees, tree 8 in particular could be considered to exhibit typical patterns of crown architecture as described by Jacobs (1938) – a dominant cluster at the end of a shoot, and other clusters generally containing small branches.

It appears that tree 31 has exhibited autumn extension.

Marking sample branches for measurement

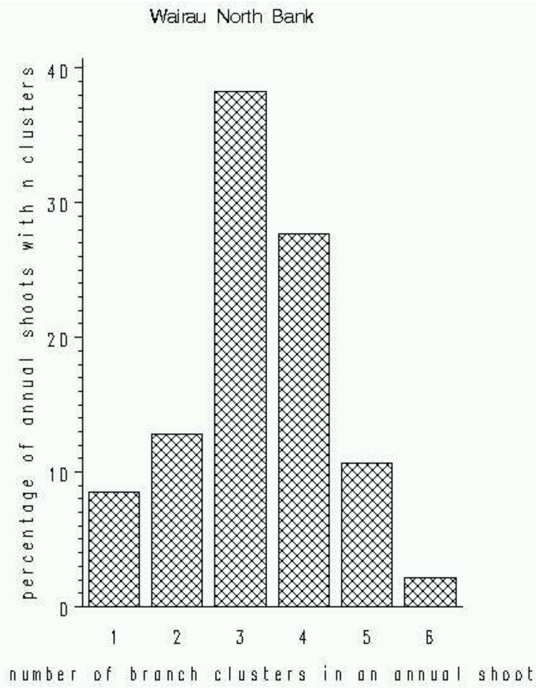
Sample branches were marked for measurement as soon as possible after planing. The growth rings are most visible at this time. While marking the sample branches it appeared that branches could be the same diameter for a number of years and then increase a mm or two in diameter. This was probably a response to thinning. It was also noticed that the angle between the stem pith and the upper side of the branch pith was very small for some branches, but much larger on other branches of a similar size.

DATA ANALYSIS

Number of branch clusters in an annual shoot using ring counts

The number of branch clusters in an annual shoot varied between 1 and 6 with a mean of 3.3 (Fig. 2).

Figure 2. Observed frequency distribution for number of clusters in an annual shoot.



Combing all the data, the number of branch clusters in the annual shoot was positively and significantly correlated with both tree age and annual shoot length. On an individual tree basis some of the correlations were not significant (Table 2 and Figs. 3 and 4).

Table 2. Correlation between number of branch clusters in an annual shoot and both annual shoot length and tree age when the cluster was formed.

Tree	Number of annual shoots	Correlation with shoot length	Correlation with tree age
8	15	0.38 (ns)	0.05 (ns)
31	17	0.68 (p=0.003)	0.31 (ns)
50	15	0.72 (p=0.003)	0.75 (p=0.001)
all trees	47	0.63 (p=0.0001)	0.40 (p=0.005)

Figure 3. Relationship between number of clusters in an annual shoot and tree age when the cluster was formed.

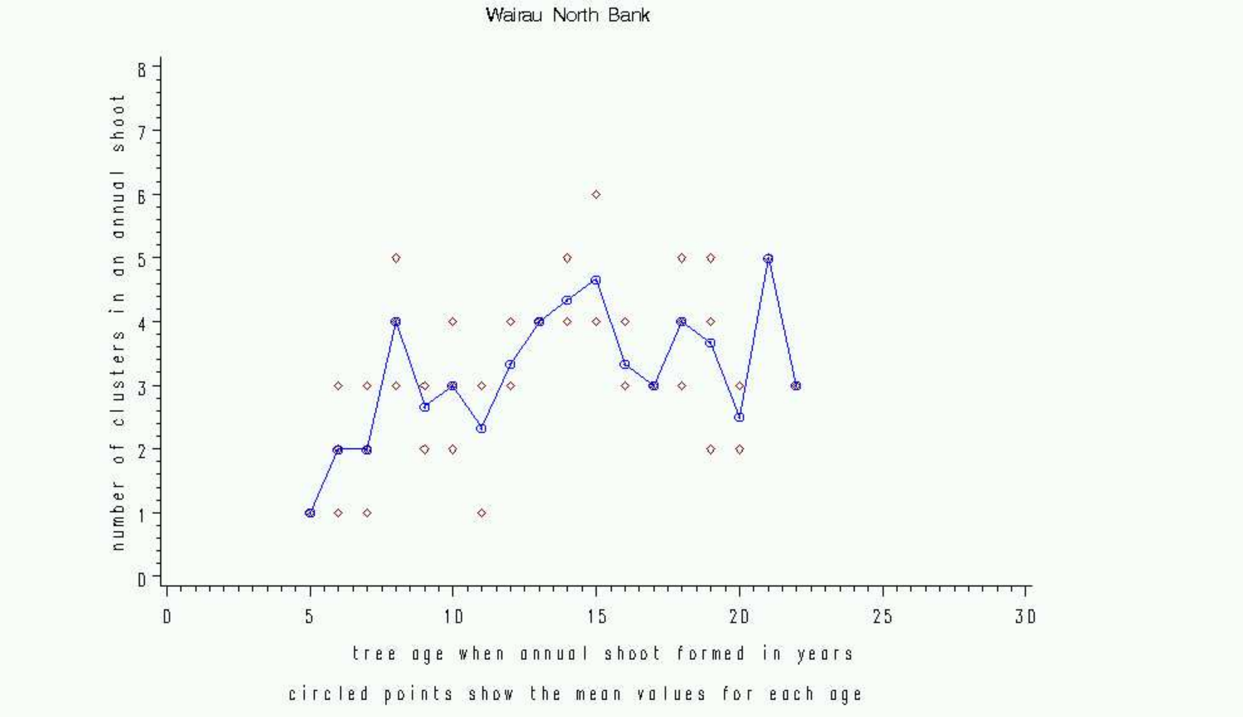
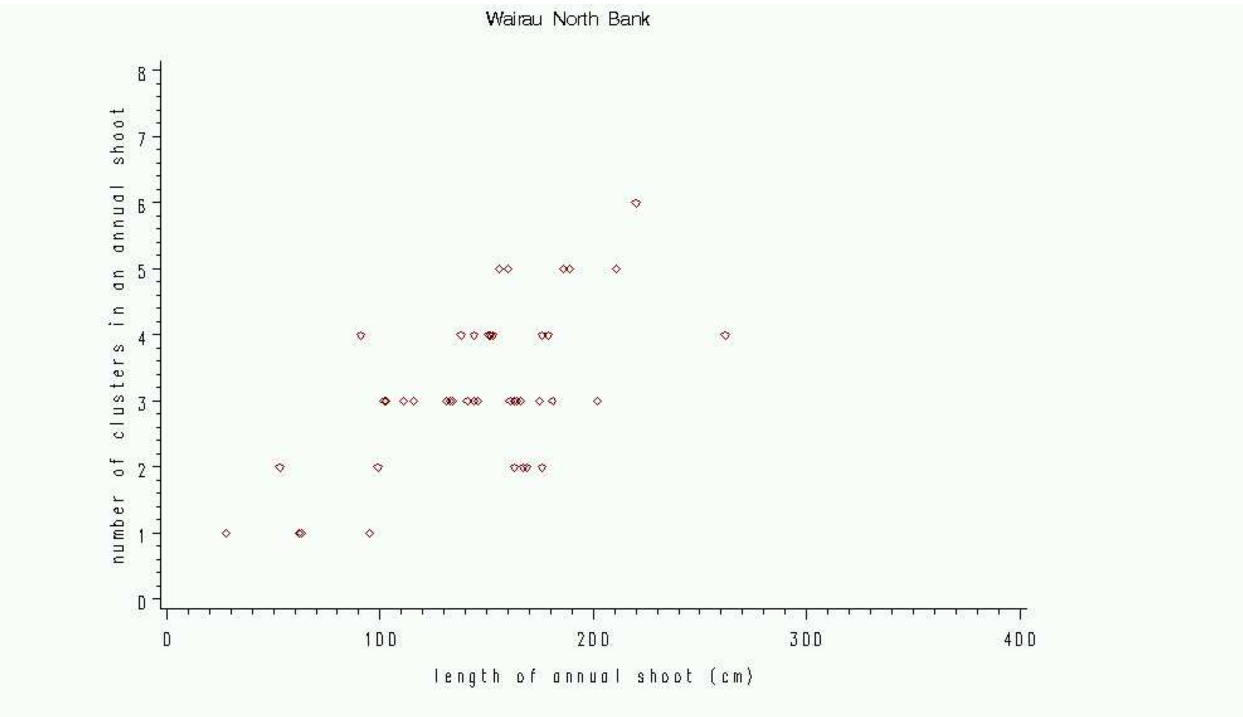


Figure 4. Relationship between number of clusters in an annual shoot and annual shoot length.



Equation 1 has been used to predict the number of clusters in an annual shoot (SGMC Report No. 66).

$$NC = a \times A^b \times L^c \qquad (1)$$

where:

NC is the number of clusters in an annual shoot
A is the tree age (years) when the cluster was formed
L is the annual shoot length (m)
a, b, c, are model coefficients

The predicted coefficients for Eqn. 1 using these data are shown in Table 3.

Table 3. Predicted coefficients from fitting Eqn. 1 to the data from Wairau North Bank.

Coefficient	Predicted value	Asymptotic standard error
A	0.607	0.176
B	0.533	0.100
C	0.874	0.135

Relative position of clusters within an annual shoot (using ring counts).

All annual shoots with a given number of branch clusters were combined to determine the relative position of each cluster within an annual shoot (Table 4).

Table 4. Relative position of branch clusters within an annual shoot.

Number of clusters in annual shoot	1	2	3	4	5	6
Number of annual shoots observed	4	6	18	13	5	6
Position of cluster in annual shoot						
1	1.0	0.72	0.39	0.29	0.20	0.18
2		1.0	0.76	0.54	0.40	0.34
3			1.0	0.83	0.68	0.60
4				1.0	0.86	0.68
5					1.0	0.81
6						1.0

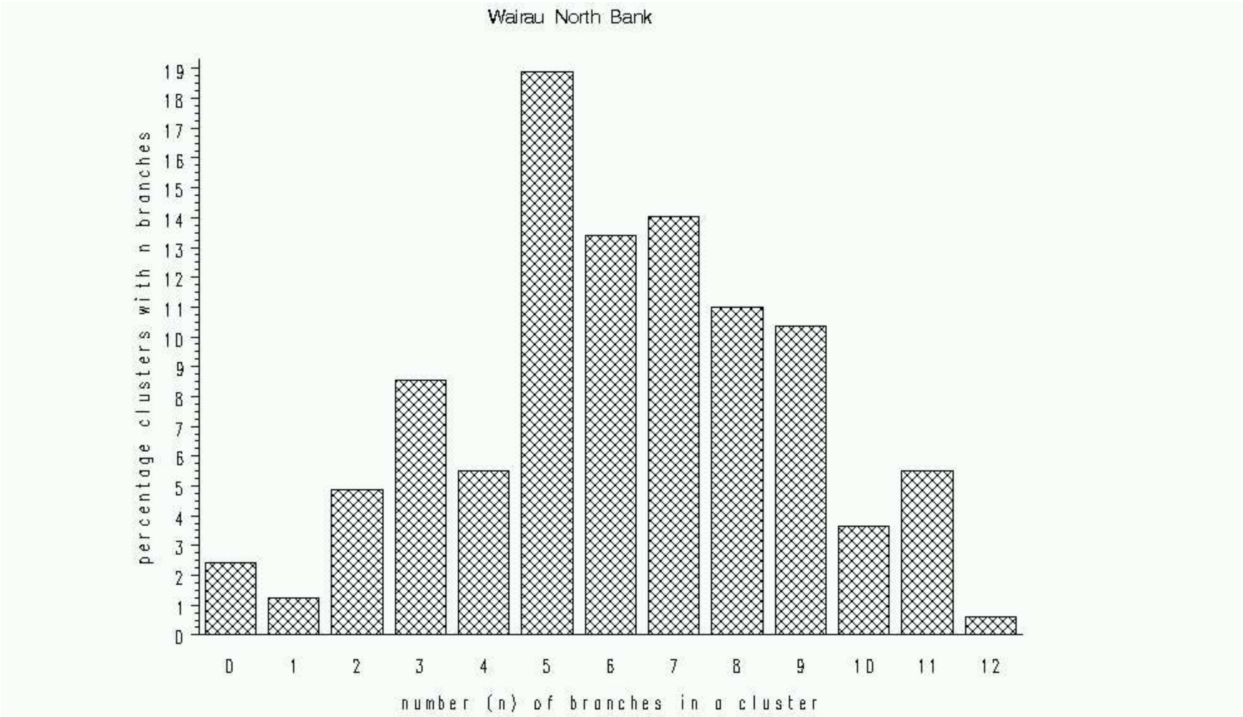
It is interesting to note that in annual shoots with two clusters, the mean position for the first cluster is approximately ¾ of the way up the annual shoot. This is in agreement data from Pigeon Valley near Nelson (Bannister, 1962), and is the perceived pattern for bimodal annual shoots. In contrast, the mean position for bimodal annual shoots at other sites has been closer to 0.5.

Apart from this, the values are similar to other sites.

Number of branches in a cluster

The number of branches in a cluster varied between 0 and 12 with a mode of 5 (Fig. 5).

Figure 5. Observed frequency distribution for number of branches in a cluster.

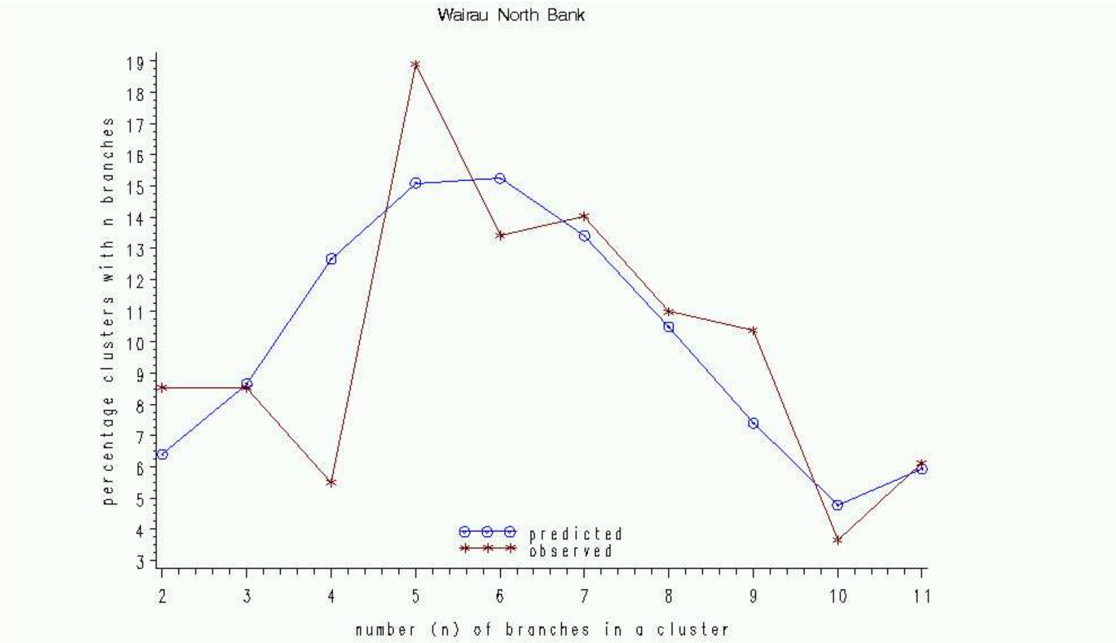


A Polya-Aeppli was appropriate for predicting the number of branches in a cluster (SGMC Report No. 68), and was fitted to these data. The predicted coefficients are shown in Table 5. Observed and predicted distributions (Fig. 6) were compared using a χ^2 goodness of fit test (Bailey, 1958). Clusters with 2 or less branches were combined and clusters with 11 or more branches were combined to avoid small number of observations in any class. The Polya-Aeppli was considered acceptable for predicting number of branches in a cluster.

Table 5. Fit of Polya-Aeppli distribution to number of branches in a cluster

Model coefficient, μ	5.85248
Model coefficient, ρ	0.94843
Number of groups	10
χ^2	7.5
Number of degrees of freedom	7
Predicted distribution acceptable at 5%	yes

Figure 6. Observed and predicted distribution for number of branches in a cluster.



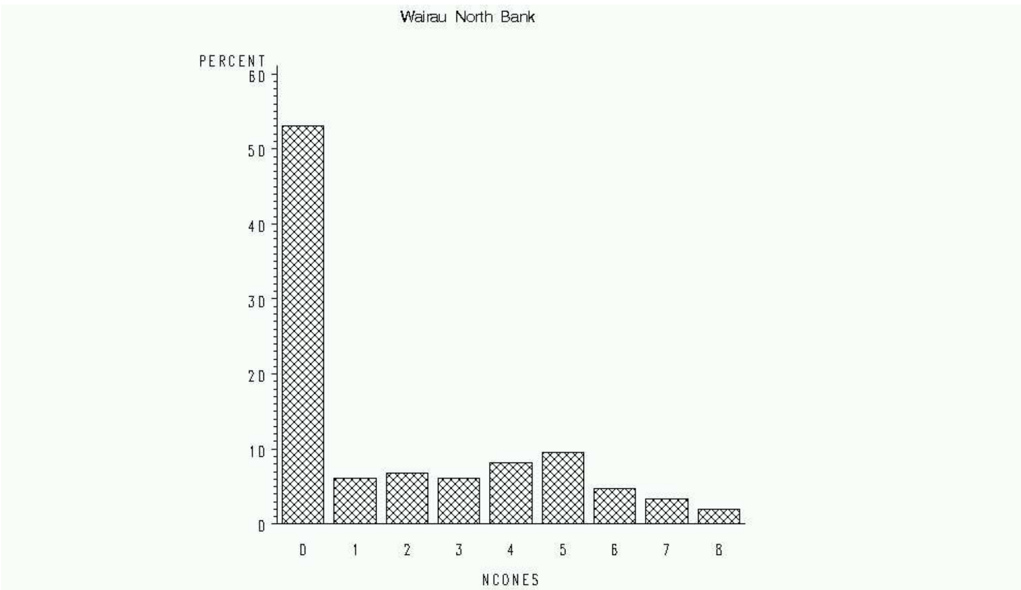
Probability tree has reached reproductive maturity (forming stem cones)

The sample size of 3 trees is too small to develop a model for percentage mature trees at a given age. The tree age when cones were 1st formed were 7 (Trees 8 and 31) and 10 years (Tree 50).

Number of cones in a cluster

Clusters formed in years prior to the tree reaching reproductive maturity (forming stem cones) have been excluded from the data set when developing a probability distribution for number of cones in a "mature" cluster. The number of cones in a cluster, once the tree had reached reproductive maturity, varied between 0 and 8 (Fig. 7).

Figure 7. Observed frequency distribution for number of cones in a cluster.



A Polya-Aeppli distribution was realistic for describing the number of cones in a cluster for 4 out of 5 datasets (SGMC Report No. 68). The Polya-Aeppli distribution was fitted to these data. The predicted coefficients are shown in Table 6.

Table 6. Fit of Polya-Aeppli distribution to number of cones in a cluster

Model coefficient, μ	0.91269
Model coefficient, ρ	0.48787
Number of groups	6
χ^2	20.0
Number of degrees of freedom	3
Predicted distribution acceptable at 5%	no

Observed and predicted distributions were compared using a χ^2 goodness of fit test (Bailey, 1958). Clusters with 5 or more cones were combined to avoid small number of observations in any class. The Polya-Aeppli distribution did not provide a good fit to these data. There are now 2 out of 7 datasets where this distribution did not provide a realistic fit to the data. The other dataset was RO905. It is interesting to note these both had unimproved seed sources. The distinguishing feature of these datasets appears to be the number of clusters with over 5 cones.

Azimuth angle of largest branch in a cluster

The Rayleigh test of uniformity was used to determine whether the azimuth angle of the largest branch in a cluster was uniformly distributed round the circumference of the stem, or whether there was a preferred direction (see SGMC Report No. 74 for methods used).

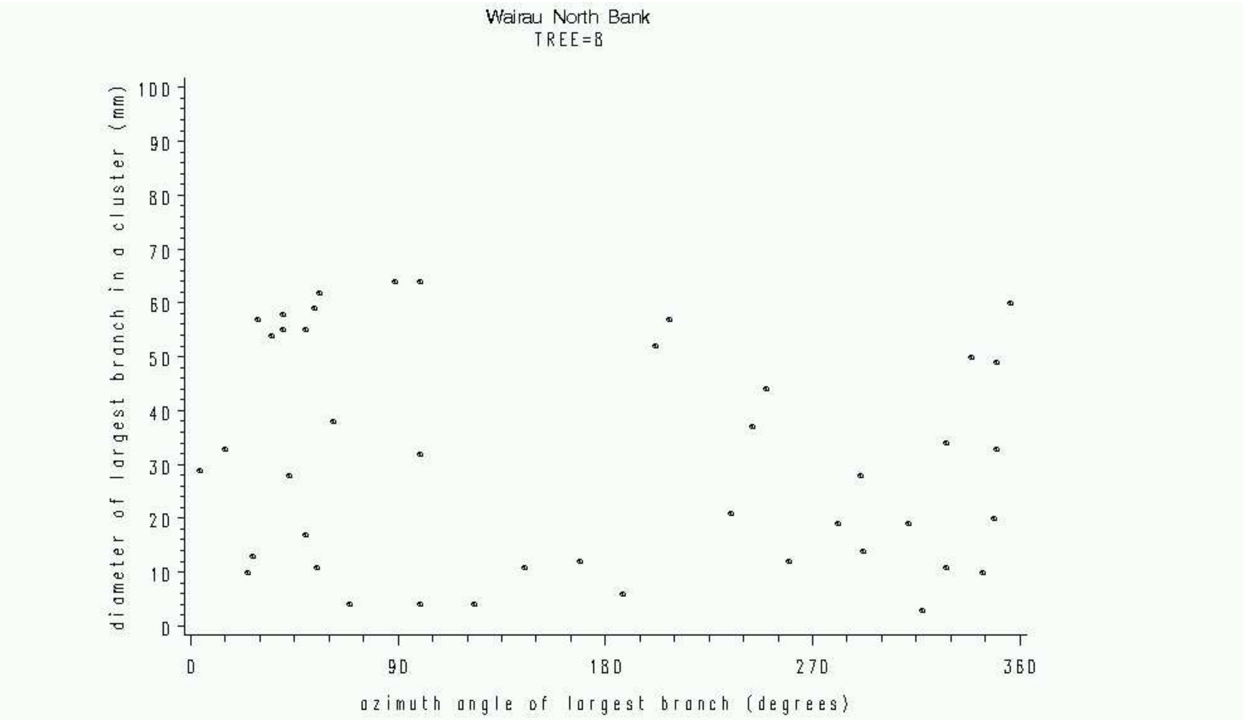
For all trees the azimuth angle of the largest branch was highly variable. Southerly aspects tended to be avoided (Fig. 8). While this PSP was on a south-facing slope, it was fairly near the top of the ridge, and while we were measuring the trees the sunlight from the north was penetrating into the plot. The preferred azimuth direction was towards the north for two of the trees. The distribution could be considered uniform for the third tree (Table 7).

Table 7. Circular statistics for sample trees.

Tree	Number of clusters	Mean vector length	Mean azimuth angle (degrees)	Significant ($p \leq 0.05$)
8	43	0.35	17	Yes
31	54	0.28	324	Yes
50	39	0.26	300	No

The correlation between branch diameter and azimuth angle, calculated using the method described in SGMC Report No. 74, was not significant for any of these trees.

Figure 8. Relationship between diameter of the largest branch in a cluster and its azimuth angle.



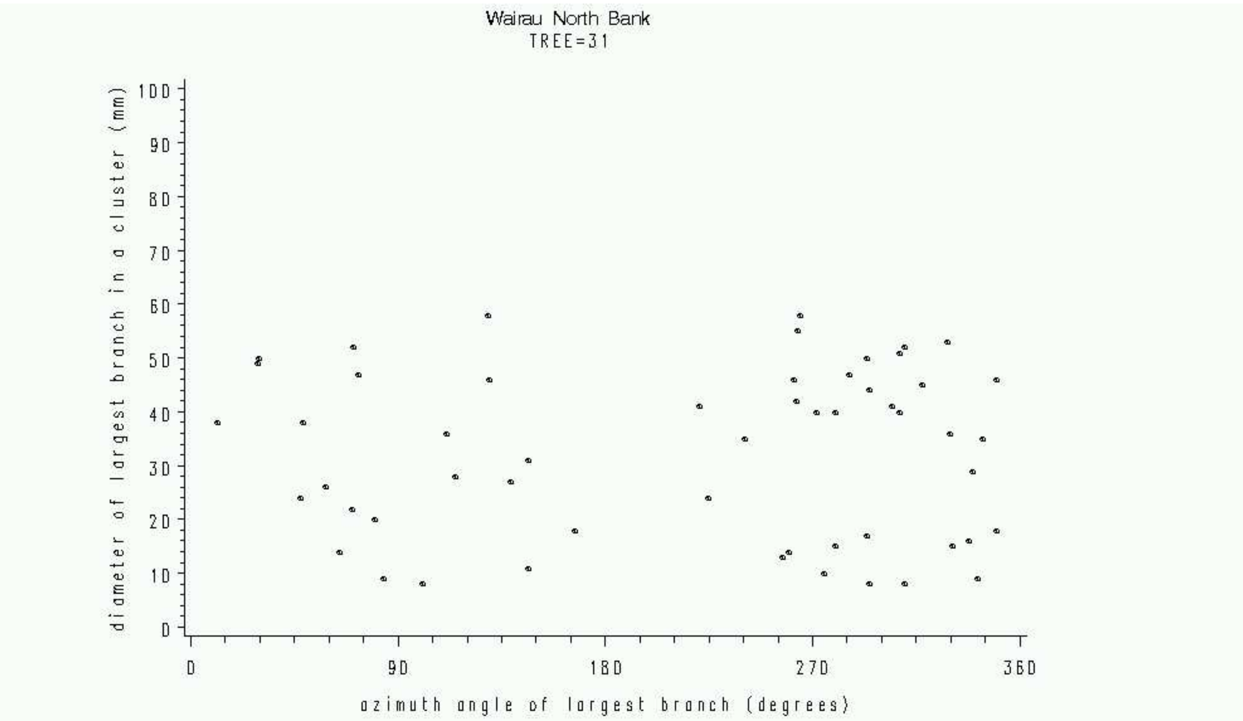
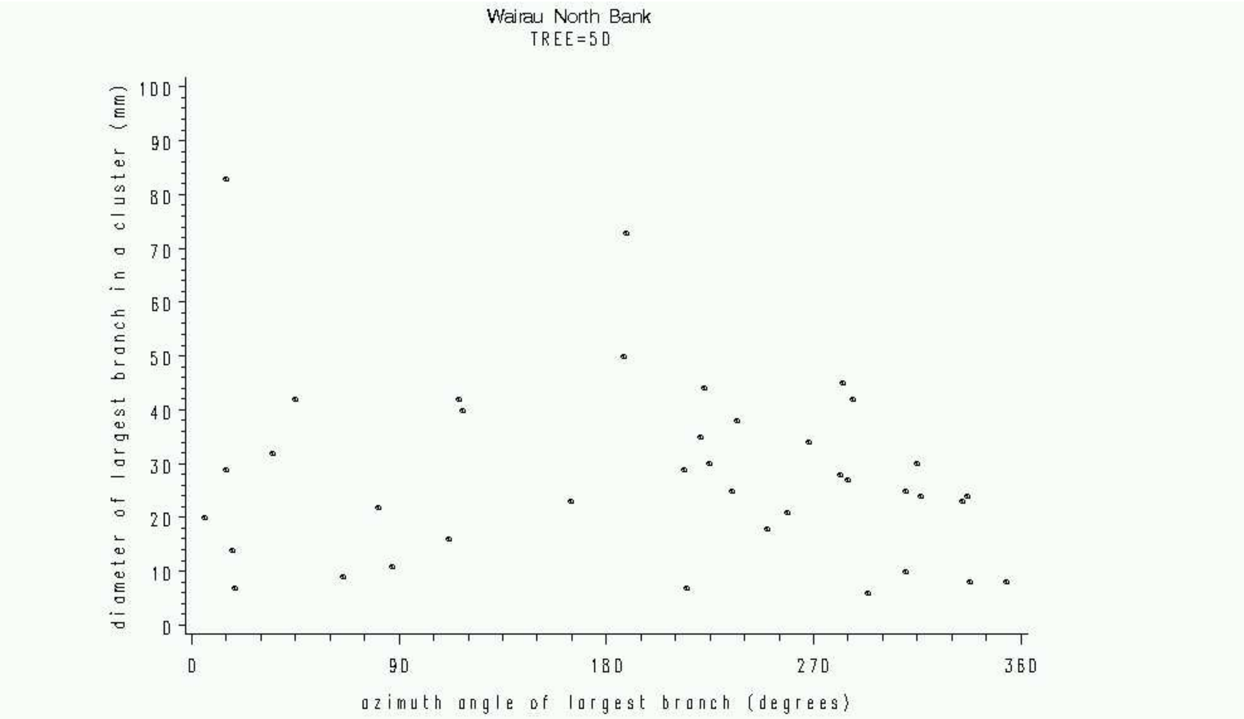


Figure 8. cont.



Bark inclusion above branches

Planed sample branches were visually coded according to the amount of bark trapped:

> Defect code 0 – no bark trapped above the branch
> Defect code 1 – bark trapped covered less than half the branch
> Defect code 2 – bark trapped covered more than half the branch

A discriminant function for predicting bark inclusion above branches from overbark branch diameter at the time of felling was developed using data collected at Compartment 905, Kaingaroa and Taringatura Southland (both "850" seed lots) (SGMC Report No. 76). This function predicted:

a defect code of 0, if overbark diameter < 41.6 mm
a defect code of 1, if overbark diameter ≥ 41.6 mm and < 58.6
a defect code of 2, if overbark diameter ≥ 58.6 mm

When applied to these branches (Table 8), it correctly identified:

> 80% of branches with defect code 0
> 22% of branches with defect code 1
> 33% of branches with defect code 2

Table 8. Observed and predicted defect code using overbark branch diameter at time of felling.

	Defect Code observed =0	Defect Code observed=1	Defect Code observed=2
Overbark diameter < 41. 6 mm	56 **65**	7	2
41.6 mm ≤ Overbark diameter < 58.6 mm	14	2 **20**	0
Overbark diameter ≥ 58.6 mm	4	0	1 **5**

Note: predicted numbers of branches with each defect code are in bold.

A probability model for predicting the severity of bark inclusion based on the maximum diameter attained by the branch was also developed using the data from Kaingaroa and Taringatura data (SGMC Report No. 67). The results from applying the model to these data are shown in Table 9. The model is a poor predictor for branches over 40 mm, and for branches with defect code 2. The model was also a poor predictor for Esk (SGMC Report No. 87). It is wondered whether the average size of branches at a particular site needs to be taken into account when predicting bark inclusion.

Table 9. Observed and predicted (using maximum branch diameter) defect codes.

Maximum branch diameter (mm)	Number of obs	Actual and predicted number of sample branches with each defect code					
		0 actual	0 pred	1 actual	1 pred	2 actual	2 pred
0-20 mm	17	15	16	2	1	0	0
20-40 mm	45	38	39	5	5.5	2	0.5
40-60 mm	24	21	14.5	2	7.5	1	2

The branches with defect code 2 could easily be separated from other branches on the basis of branch angle (y value at last measurement / stem radius) (Fig. 9), but not on the basis of branch diameter (Fig. 10).

Figure 9. Influence of branch angle and primary age on defect code.

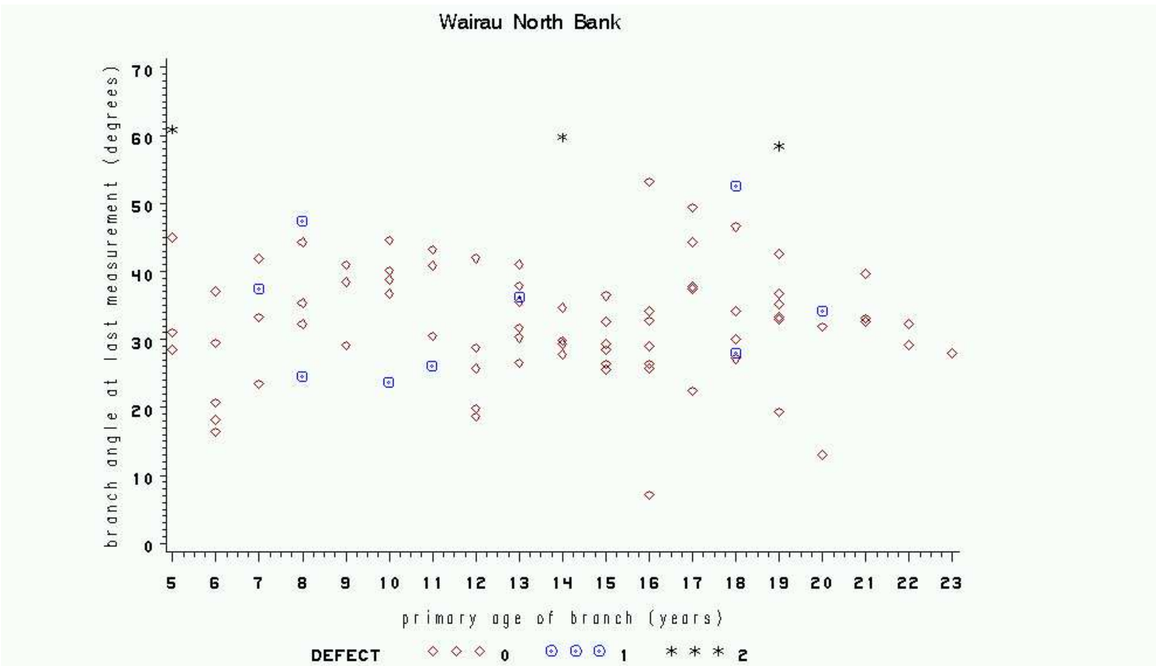
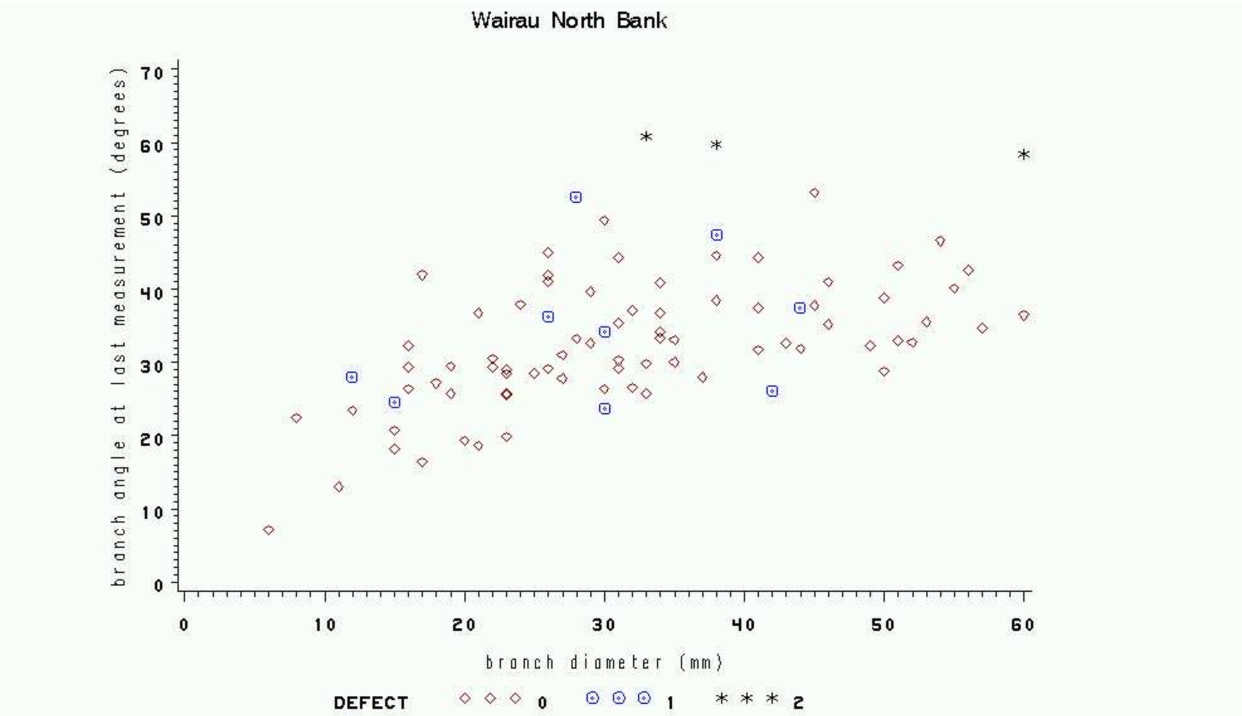


Figure 10. **Influence of branch angle and branch diameter on defect code.**



Two of the 3 branches with defect code 2 were in the middle of an annual shoot on the basis of both ring counts and morphology. The third branch was near the base of the three where there was only one cluster in the annual shoot.

It is interesting to note that one of these branches had a primary age of 20 indicating that bark inclusion is not necessarily confined to the lower part of the crown.

REFERENCES

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APPENDIX 1. Tree age, ring counts and time of thinning for NN 469/0 77/8

Year	Tree Age	Stem rings	Comments
99/00	29	1	
98/99	28	2	
97/98	27	3	
96/97	26	4	
95/96	25	5	
94/95	24	6	
93/94	23	7	
92/93	22	8	
91/92	21	9	
90/91	20	10	
89/90	19	11	
88/89	18	12	
87/88	17	13	
86/87	16	14	
85/86	15	15	
84/85	14	16	
83/84	13	17	2nd thin Jun. 84 (290 sph)
82/83	12	18	2 ring at thin2
81/82	11	19	3 ring at thin2
80/81	10	20	4 ring at thin2
79/80	9	21	5 ring at thin2
78/79	8	22	6 ring at thin2
77/78	7	23	1st thin Jan. 78 (590 sph)
76/77	6	24	2 ring at thin1
75/76	5	25	3 ring at thin1
74/75	4	26	4 ring at thin1
73/74	3	27	5 ring at thin1
72/73	2	28	6 ring at thin1
71/72	1	29	Planted Jun. 71 (1000 sph)