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RADIATA BRANCH CHARACTERISTICS AND DELIMBING FORCES

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INTRODUCTION

When selecting conventional logging equipment, the need for information on factors such as; piece size, average haul distance, topography, and daily volume is well recognised. Selection of mechanised delimbing equipment requires more specialised information (tree diameter, whorl spacing, branch size, and number of branches per whorl) in order to match machine capacity to the material being handled.

This Report describes an evaluation of the branch characteristics of a 13 year old radiata pine stand, and the forces required for delimbing.

ACKNOWLEDGEMENTS

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BRANCH CHARACTERISTICS

The trees studied were selected from a 13 year old stand of radiata pine at Hanmer State Forest park. These had been planted at 1200 sph beneath an overstorey (60 sph) of 80 year old European larch. In 1978, the radiata pine was thinned to waste down to 666 sph and in 1979, parts of the stand were low pruned.

Twenty-eight trees, ranging in dbh from 13 to 28 cm, were felled and skidded to the landing. Unpruned trees were trimmed enough to give access for felling. Care was taken to minimise branch breakage during skidding. At the landing, the following factors were measured :

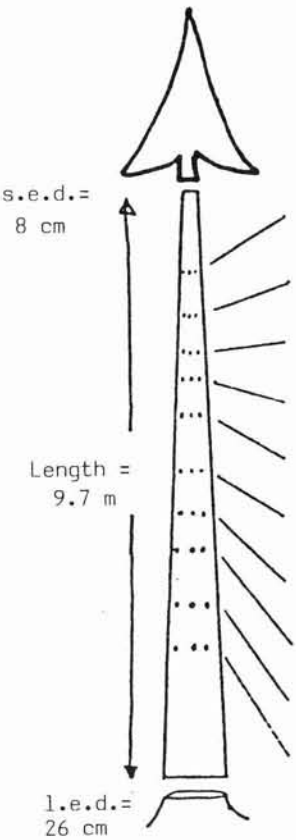
tree height	whorl spacing
merchantable length	tree diameter at whorl
l.e.d.	branch size
dbh	branch
s.e.d.	number of branches per whorl

From these calculations, the merchantable tree volume and total branch area per whorl were calculated. The measurements of the typical or median tree is summarised in Table 1 and Table 2.

Table 1 - Typical tree characteristics

CHARACTERISTICS	MEDIAN	RANGE
Tree height	13.9 m	8.5 - 20.3 m
Merchantable length	9.7 m	5.0 - 16.6 m
l.e.d.	26 cm	16-33 cm
dbh	22 cm	13-28 cm
s.e.d.	8 cm	
Volume	0.23 m^3	0.07 - 0.50 m^3
Branches	55	34 - 144
Angle	60°	30 - 90°
Branch spacing	.6 m	.2 - 1.9 m

Table 2 - Typical tree branch and whorl characteristics



WHORL	NUMBER OF BRANCHES PER WHORL		BRANCH SIZE (cm)	
	Median	Range	Median	Range
10	6	(3-8)	2	(1-5)
9	5	(3-8)	2	(1-7)
8	5	(2-8)	2	(1-5)
7	5	(3-12)	2	(1-6)
6	5	(2-11)	2	(1-6)
5	5	(2-10)	2	(1-8)
4	6	(2-10)	2	(1-5)
3	5	(2-10)	2	(1-7)
2	7	(3-12)	3	(1-5)
1	6	(3-8)	3	(1-6)

Overseas research into mechanised delimbing has found that the force required to shear limbs is a function of branch area (Ref. 1). On radiata pine, branches grow in whorls, so the force required to delimb would be expected to be a function of total branch area in a whorl. To get a better understanding of the relationship between tree size and total branch area, the twenty-eight trees were split into four classes, based on l.e.d. The average branch characteristics for each class are shown in Table 3.

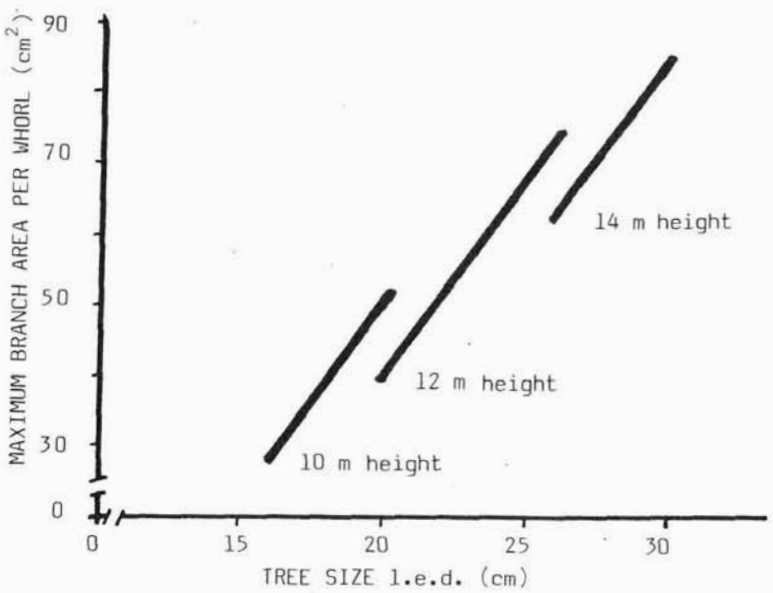
Table 3 - Average branch area characteristics by diameter class

L.E.D. CLASS (cm)	L.E.D. (cm)	HEIGHT (m)	NUMBER OF WHORLS	TOTAL BRANCH AREA PER WHORL	
				AVERAGE (cm^2)	MAXIMUM (cm^2)
15-19	17	10.4	8	19	34
20-24	21	12.1	8	28	50
25-29	27	14.0	12	30	58
30-34	31	17.4	17	33	66

The maximum force required to delimb a tree should depend on maximum whorl branch area. Analysis of maximum whorl branch area showed a relationship to tree diameter and height. The relationship is described by the following equation and shown by the graph in Figure 1.

Maximum branch area (cm^2) = 5.49 x (l.e.d., cm) - 5.12 (height, m) - 8.71
r^2 = .70 (70% of the relationship explained by the equation)

Figure 1 - Maximum branch area per whorl versus tree diameter and height



Other trends showed up in the information :

(1) For a given tree diameter, shorter trees tended to have a larger maximum branch area per whorl than taller trees with the same diameter.

(2) The maximum whorl branch area occurred in the first three whorls of most trees.

(3) Branch angle, which is reported to have an effect on delimbing force, varied from 30° to 90° and averaged 60°. There was no significant relationship between branch angle and position on the tree, or tree size.

FORCES TO DELIMB

An additional fifteen trees were selected from the same stand and skidded to the landing. To facilitate branch and force measurements, the branches were cut to 30 to 50 cm in length. Seven of these trees were partially delimbed, leaving a uniform number of branches per whorl on each tree (see Figure 2). All branches on the remaining trees were left intact. Branch characteristics were measured and recorded.

The Hunt processor (Ref. 2) was used for delimbing, with a load cell fitted between the grapple shear and the tree. To eliminate the "axe" or momentum effect, the delimber feed was stopped between whorls. A pengraph recorder was used to plot the force per whorl which occurred during delimbing.

Figure 2 - Radiata pine trees prepared for force measurements

RESULTS

No clear relationship was found between total branch area per whorl and the delimbing force. The absence of a strong relationship indicates that factors other than whorl branch area affect delimbing force. These could include; friction between knives and stem, knife angle, problems with stem alignment, and nodal swelling. In actual practice, a delimbing machine may not need to develop the maximum force calculated. Once the tree or knife is moving, the momentum developed will add to the machine's static force capabilities.

The average force developed per whorl was 126 kg force/cm^2, with an expected range of 105 to 147 kg/cm^2 (95% confidence interval). The maximum force recorded was 5360 kg on a whorl with nine branches (total branch area - 36 cm^2).

The expected maximum and average delimbing force for a stand of trees in the trial area was calculated using the average force (126 kg/cm^2) and the maximum and average branch areas per whorl. These values are listed in Table 4.

Table 4 - Calculated delimbing force for each class

Diameter class (cm)	15-19	20-24	25-29	30-34
Maximum whorl branch area (cm^2)	34	50	58	66
Force per maximum whorl (kg)	4300	6300	7300	8300
Average whorl branch area (cm^2)	19	28	30	33
Force per average whorl (kg)	2400	3500	3800	4200

The maximum force calculated exceeded the maximum force observed (5360 kg) in all but the smallest diameter class. This may be due to the small number of measurements in the larger tree sizes, resulting in an over-estimate of the required delimbing force.

CONCLUSIONS

The results in this Report represent a small sample from one forest. Some trends were evident with the relationship between maximum branch area and tree diameter and height. Further work is needed to determine if these relationships are valid in other forests. Branching characteristics will vary with age, site factors, silvicultural treatments, and genetic characteristics.

There was a wide variation in the recorded delimbing forces in relation to total branch area. Consequently, forces required for delimbing may vary from the calculated values.

This study provides a base for future work to identify young age radiata pine branching characteristics. More work is needed to determine the relationship between force and branch area per whorl. This type of information will be valuable for evaluation of existing and new concepts for mechanised delimbing.

Ref. 1 Boyd, J.A. "An Investigation into the Prospects for Development of Mechanised Delimbing Machinery for Woods Operations in the Northern Interior of British Columbia", Pulp and Paper Research Institute of Canada, No. 30, 1971.

Ref. 2 Gleason, A.P. "Delimbing Radiata Pine with the Hunt Processor", LIRA Report, Vol. 10 No. 1, 1985.

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