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PROJECT REPORT

PRELIMINARY TRIALS WITH THE HARRICANA STROKE DELIMBER

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Project Report

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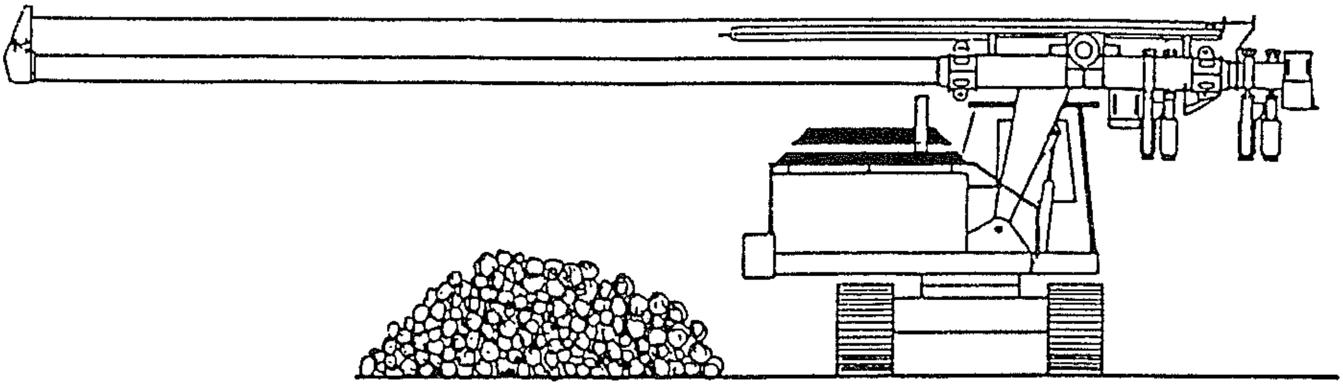

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ABSTRACT

A study of a Harricana stroke delimber working in a Radiata pine thinning operation indicated that for a range of conditions processing rates over 60 trees per hour could be achieved (0.4 m3 piece size).

The delimber worked in both a mechanised "hot deck" system in conjunction with a Bell Feller Buncher and a Cat 518 grapple skidder, and from stacks "cold decked" on the landing.

The landing operation comprised tree length delimbing and separate stacking into long and short pulpwood logs. Production rates varied widely between operators, and from day to day in different stand conditions.

The tree characteristics that most affected delimber productivity were piece size (especially length) and the incidence of malformation (forks and stem wobble). Processing small short trees and handling double leaders reduced productivity significantly. Branch size was not a limiting factor on productivity, with the Harricana delimbing trees with branches greater than 10 cm diameter to a satisfactory standard.

ACKNOWLEDGEMENT

LIRA acknowledges the assistance of Ian Patchell of Patchell Industries, Rotorua; Sam Webb of S. & M. Webb Logging Ltd, Taupo; and Tasman Forestry Ltd, Rotorua.

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1. INTRODUCTION

There has been considerable interest over the last few years in the introduction of mechanised systems to New Zealand. The requirements for successful mechanical delimbing have been well documented (Gordon 1980; O'Reilly, 1980; Cochrane et. al., 1983).

Mechanical operations, in order to be successfully introduced, must fulfill a number of requirements :

1. As low a cost as possible (relative to manual operations).
2. Meet acceptable delimbing standard.
3. Ability to handle range of piece sizes and tree malforms at an acceptable productivity rate.
4. Ability to undertake multiple functions, delimb, cut to length and diameter specification, sort and stack.
5. Maintain acceptable mechanical availability.
6. Ease of repair, simplicity of design, and well supported parts backup.
7. Minimise interference with other phases of operation.

Previous examinations of mechanised operations for New Zealand emphasised the successful delimbing of wood of less than 0.35 m3 piece size, where motor-manual techniques are very expensive (Gleason, 1982). Based on Australian experience, where stroke delimbers are not considered economic below 0.4 m3 piece size, (O. Raymond, pers. comm.) it was considered important to measure the performance of the delimber in larger piece size wood.

1.1 Trials to Date

Since early 1987 there have been two models of stroke delimber available for evaluation, the Harricana and the Denis. Trials have been undertaken by Tasman Forestry Ltd with both machines in minor species (ponderosa and contorta); and with the Denis in Radiata clearfell (0.8 and 1.15 t) and thinnings (0.21 t). The Harricana was not trialled extensively in Radiata pine.

Detailed results of the Denis trials are not available, hence this Report will deal with the performance of the Harricana delimber.

A summary of results of three days work study of the Harricana operating in Ponderosa pine with two different operators is given in Table 1.

Several points arise from this preliminary study :

1. Productivity is given in tonnes per productive machine hour. The percentage utilisation is more important than hourly productivity in determining production per year and hence cost per tonne.
2. In this study, both operators were not highly experienced, as some learning curve trends were still evident.
3. The effect of altering piece size on productivity, and other effects such as branch size and tree malformation, had not been evaluated.
4. The combined effect of "non-productive" elements of the work cycle such as clearing slash, sorting and stacking, has potential to significantly reduce the efficiency of the operation. These figures were for roadside processing and did not include any cutting to length or sorting multiple log sorts (all pulp).

1.2 Conclusions from Initial Trials

In April 1987, Harricana Metal Inc., Quebec, shipped a lot of parts to New Zealand to improve the performance of the delimber :

This included a larger hydraulic motor (80 cu. in, 2 speed, 2.8 fps faster boom speed).

Modifications to the machine to suit New Zealand conditions included extensive guarding to hydraulic fittings, extra counterweight for the base unit, and the conversion of the rear grapple

TABLE 1 : HARRICANA WORK CYCLE : PONDEROSA PINE

Element	Operator 1 min	Operator 1 %	Operator 2 min	Operator 2 %
Pick Up	0.232	26.3	0.227	31.7
Process	0.493	55.8	0.394	55.0
Clear Slash	0.054	6.1	0.016	2.2
Stack	0.026	3.0	0.013	1.8
Move	0.021	2.4	0.009	1.3
Sort	0.057	6.4	0.057	8.0
Total Cycle (Min)	0.883	100.0%	0.716	100.0%
95% Confidence Limits (min)	(± 0.061)		(± 0.059)	
C.L. (as % of mean)	7%		8%	
Productivity				
Trees/hour	68.0 (64 - 73)		83.8 (77 - 91)	
Tonne/hour (Tree Size 0.36 tonne)	24.5		30.2	

to handle larger trees (up to 65 cm diameter). This latter modification involved fitting larger grapple arms and larger hydraulic cylinders.

Hence, there was a question of the validity of data collected to date, in view of the modifications which may have improved performance (faster boom speed and better log handling). The machine had to be re-evaluated to quantify the effect of these changes.

The major conclusion from the initial trials was that stroke delimbers, such as the Denis and the Harricana, are capable of high hourly productivity rates. The question of maintaining high machine availability rates was seen as vital to the success of their introduction to New Zealand.

The LIRA view was that these machines (more than any other) have shown themselves capable of delimbing large quantities of poorly formed, heavily branched wood of a variety of species to a standard acceptable for both sawlogs and pulp. Both the Harricana and the Denis are capable of accurately cutting to measured length and to a single diameter specification (e.g. 10 cm SED). The saws cannot chamfer cut, hence multiple leaders must be either completely cut through or square cut at the fork. A high incidence of multiple leaders may have a significant effect on productivity, and this area was highlighted for further study.

Figure 1 : Roadside Processing Ponderosa Pine

The machines have the ability to operate either on landing or from roadside. For effective roadside processing the between-stand width of roadside should be at least 12 - 15 m, and there should be no high banks obstructing access to roadside log stacks.

It is anticipated that grapple skidder extraction is preferred by most operators of delimbers due to their better wood presentation and lower incidence of trees crossed over in stacks, than that of cable skidders.

For these delimbers to be accepted by the logging industry they must be proven in both Radiata pine thinning and clearfelling operations. The objective of the second trial was to undertake a short term evaluation of one model of stroke delimber, the Harricana, in radiata thinnings.

In this study, the machine's log merchandising capability was not studied. Since the radiata thinnings were processed for pulp and trucked in long lengths, the length measuring ability of the delimber was not evaluated.

2. PROJECT DESCRIPTION

2.1 The Machine

Stroke delimbers operate by holding the tree in a stationary position while the delimbing knives travel along the length of the tree stem.

These mechanisms "are potentially suitable for the most difficult delimbing conditions since the tree stem can be firmly gripped with none of the slippage or "spin out" that characterises spiked feed roll mechanisms. A second reason for good performance in large limbs can often be attributed to the "axe effect".

The weight of the sliding boom is often much higher than that of the tree being delimbed. Thus, the inertia element of the delimbing force can be much higher than that of feed roll type delimbers. (Folkema 1979)".

The delimber studied was a Harricana HM-1290-50 stroke delimber mounted on a Caterpillar 215B Special Applications excavator base. The Harricana stroke delimber consists of a standard 50' (15.2 m) boom giving an effective stroke of 35' (10.7 m).

The delimber uses two chainsaws; one for butt trimming while the topping saw cuts to length. The rear trimming saw has a 26" bar (66 cm), and is positioned behind the rear (fixed) grapple. The front topping saw has a 21" bar (53 cm). Both saws run .404 pitch chain and are driven by high speed hydraulic motors (6000 RPM) activated by on/off electric switches. Both saw bars are solid nosed and lubricated from the main hydraulic tank.

Figure 2 shows a diagram of the stroke delimber assembly.

Options fitted to the delimber included a computer length measuring device and a topping size indicator.

The excavator was powered by a Cat 3304 diesel engine (85 hp) mounted on a standard Cat 225 track base. Hydrostatic drive with independent track motors gives the unit a maximum travel speed of 3.4 km/hr.

2.2 Study Area

A production study of the delimber was undertaken during August 1987 in a thinning operation in Kaingaroa Forest.

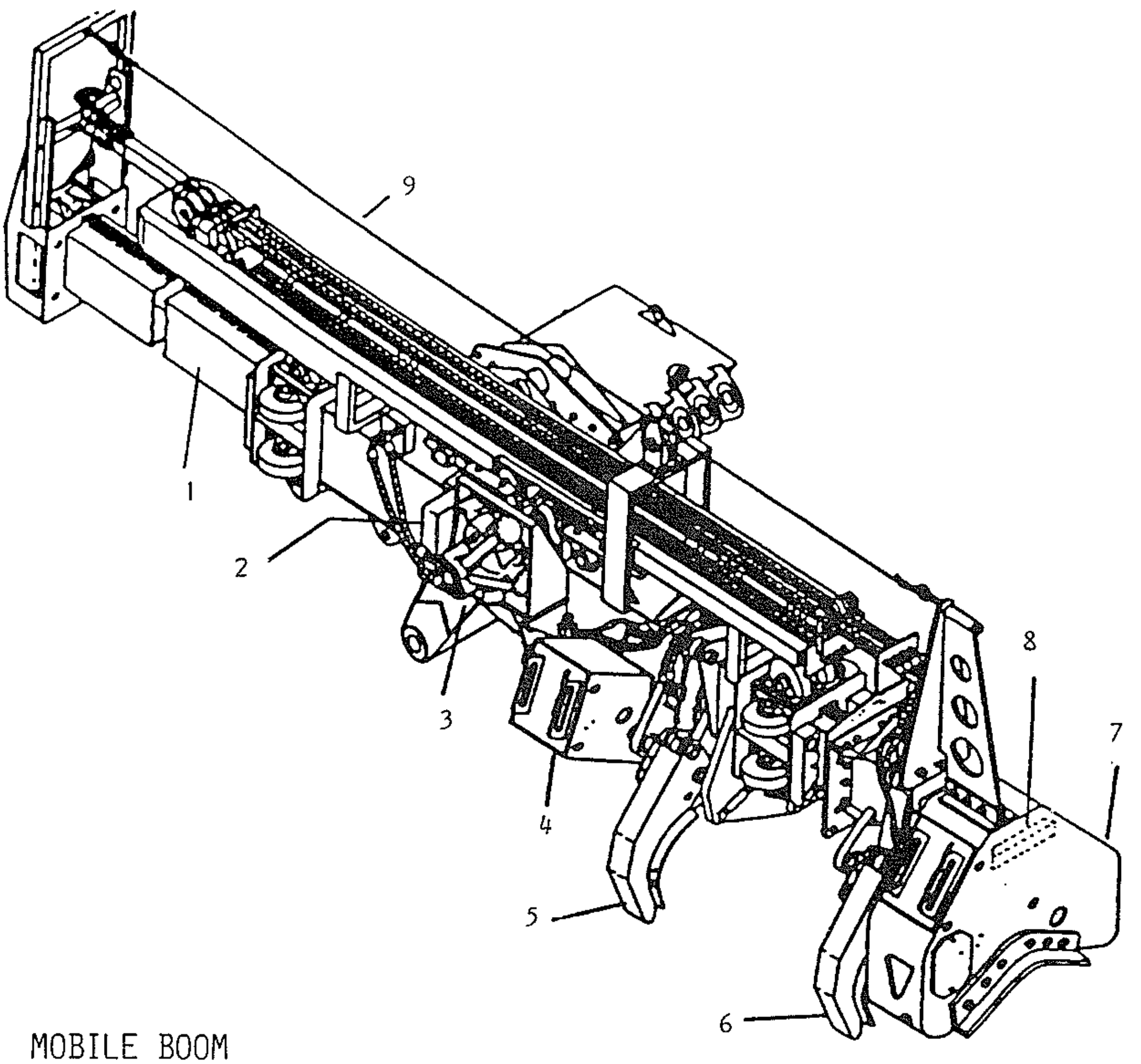
The study area comprised two stands of 18 and 19 year old radiata pine on flat terrain. Details of each stand (Table 2) were obtained from pre-thinning assessment by Timberlands' staff.

The location of three landings in each stand allowed flexibility as to the use of the delimber in either hot or cold deck operation. The work method is discussed in a later section.

Scaling of individual trees processed gave an average butt diameter of 29.6 cm and a mean merchantable tree volume of 0.44 m3 (n = 121). This is a higher volume than the inventory details mainly through loss due to breakage of the smaller diameter trees.

2.3 Study Method

Over the 12 day period of the study, data was collected on gross productivity for each operator; the total productive machine time worked per day; and the nature and duration of mechanical delays.



1. MOBILE BOOM
2. MEASURING DEVICE
3. HYDRAULIC MOTOR
4. BUTT SAW
5. REAR GRAPPLE AND FIXED LIMBING KNIVES
6. FRONT GRAPPLE AND MOBILE LIMBING KNIVES
7. TOPPING SAW
8. TOPPING SIZE INDICATOR
9. BOOM TENSIONING CABLE

Figure 2 : Harricana Delimbing Head Assembly

TABLE 2 : STAND DETAILS

DESCRIPTION	*STAND 1*	*STAND 2*
Stand Age	*18*	*19*
Total stocking (sph)	*600*	*1100*
Yield stocking (sph)	*350*	*850*
Yield Mean DBH (cm)	*28*	*25*
Mean Merch. Volume (m3)	*0.40*	*0.36*

The productive work cycle was then divided into various elements and timed to relate the usual work method to measured tree parameters such as large end diameter, length and volume.

(i) Measurement of Gross Productivity

For each productive period, the number of trees processed per hour was recorded for each operator.

This was plotted against accumulated time per operator to determine trends in learning ability.

(ii) Measurement of Machine Availability and Utilisation

Each day the amount of time spent in production was recorded in a log book, i.e. the time the machine spent performing the delimbing operation. This includes minor operational delays.

All non-productive time exceeding one minute in duration was also recorded. This time was categorised either as Operational delay (such as moving or clearing slash); Mechanical delay (maintenance and downtime); Non-mechanical delay (personal and social time).

(iii) Intensive Time Study

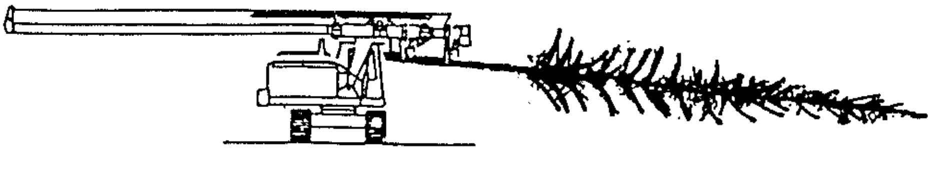
All trees extracted to one landing were numbered prior to processing and large end diameters measured. To determine the influence of individual tree characteristics on machine productivity, the delimber operation was timed processing approximately 200 merchantable trees.

2.4 Harricana Operating Method

The following is a description of two methods of operation of the Harricana delimber : Short tree delimbing and Long tree delimbing.

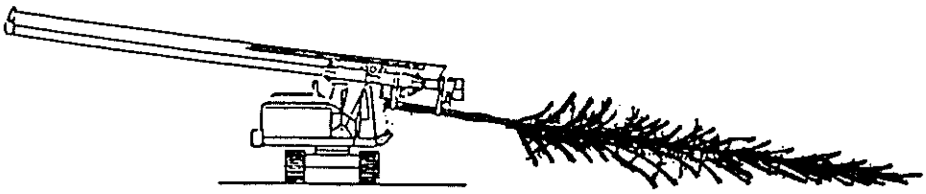
CASE 1 : SHORT TREE DELIMBING WITHOUT THE MEASURING DEVICE

A



With the front (mobile) grapple, pick up a tree and bring it past the rear (fixed) grapple.

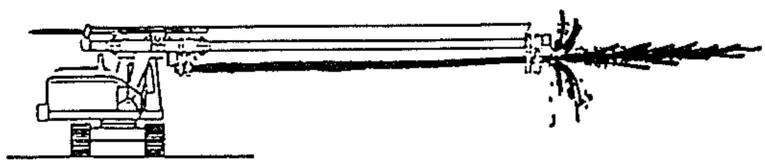
B



Grab the tree and hold it tight with the rear grapple.

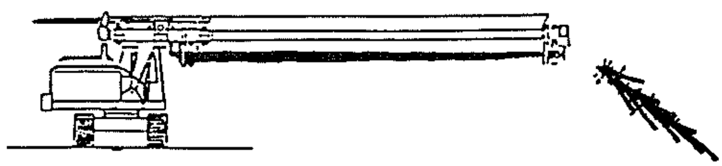
With the butt saw, remove the damaged portion of the tree (sloven).

C



Execute the delimbing operation till the end of the mobile boom stroke.

D



Top the tree using the topping saw.

Length = 10.7 m (mobile boom stroke) plus
2.0 m (fixed distance)

12.7 m

CASE 2 : LONG TREE DELIMBING USING THE MEASURING DEVICE

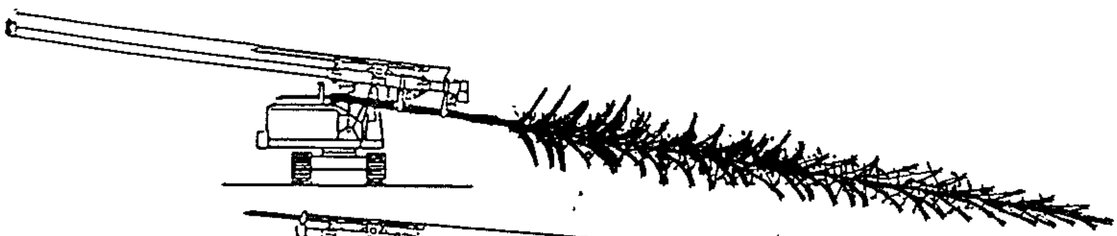
A

With the front (mobile) grapple pick up a tree and bring it up to the rear (fixed) grapple without activating the photocells.

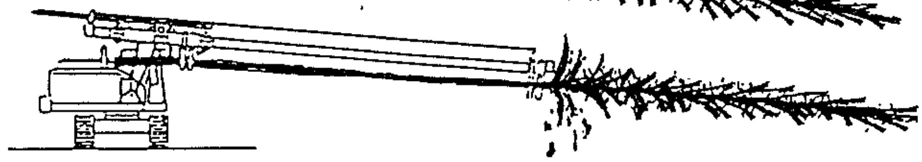
B

Grab the tree, hold it tight with the rear grapple, and trim the butt.

C

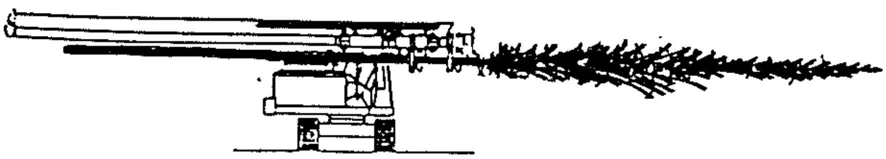


D



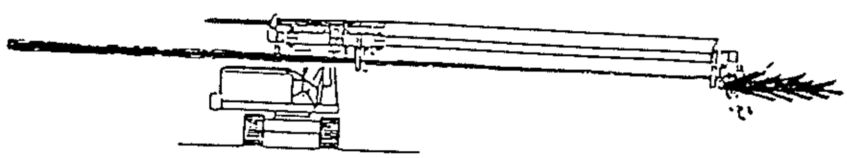
Execute the delimbing operation over a length sufficient to bring back the tree and activate the photocells afterwards.

E



With the front grapple closed and the rear grapple partially opened, bring back the tree to activate the photocells. Continue this sequence until the delimber head leans against the bumper block on the fixed boom. (Reference point for the measuring device system. - IMPORTANT).

F

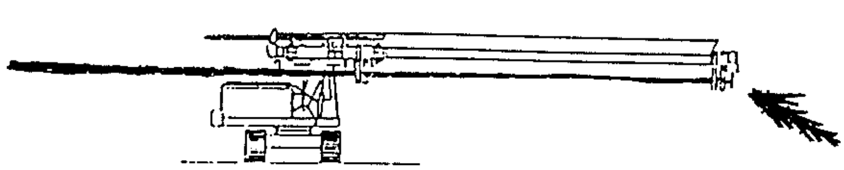


Hold tight the tree with the stationary limbing grapple.

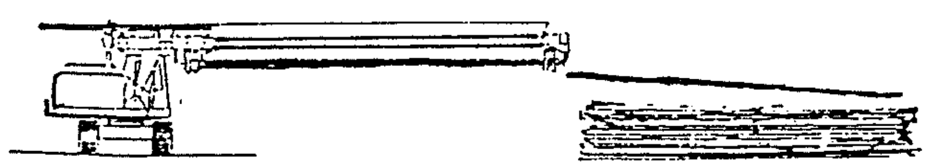
Execute the delimbing operation till the end of the mobile boom stroke.

(Note : When the stationary limbing grapple is closed, the system is adding when the mobile boom is going forward.)

G



Top the tree using the topping saw.



3. RESULTS AND DISCUSSION

3.1 Work Method

Four methods of operation were tried to establish an efficient method. All but the last method involved the delimber working out of phase with the rest of the operation, i.e. "cold deck" (Figure 3).

Wood was extracted to the landing and stacked approximately 2 - 2.5m high with an open side to the right of the delimber. The delimber started at the right hand side of the stack, working right to left. Firstly the delimber processed the trees, stacking them

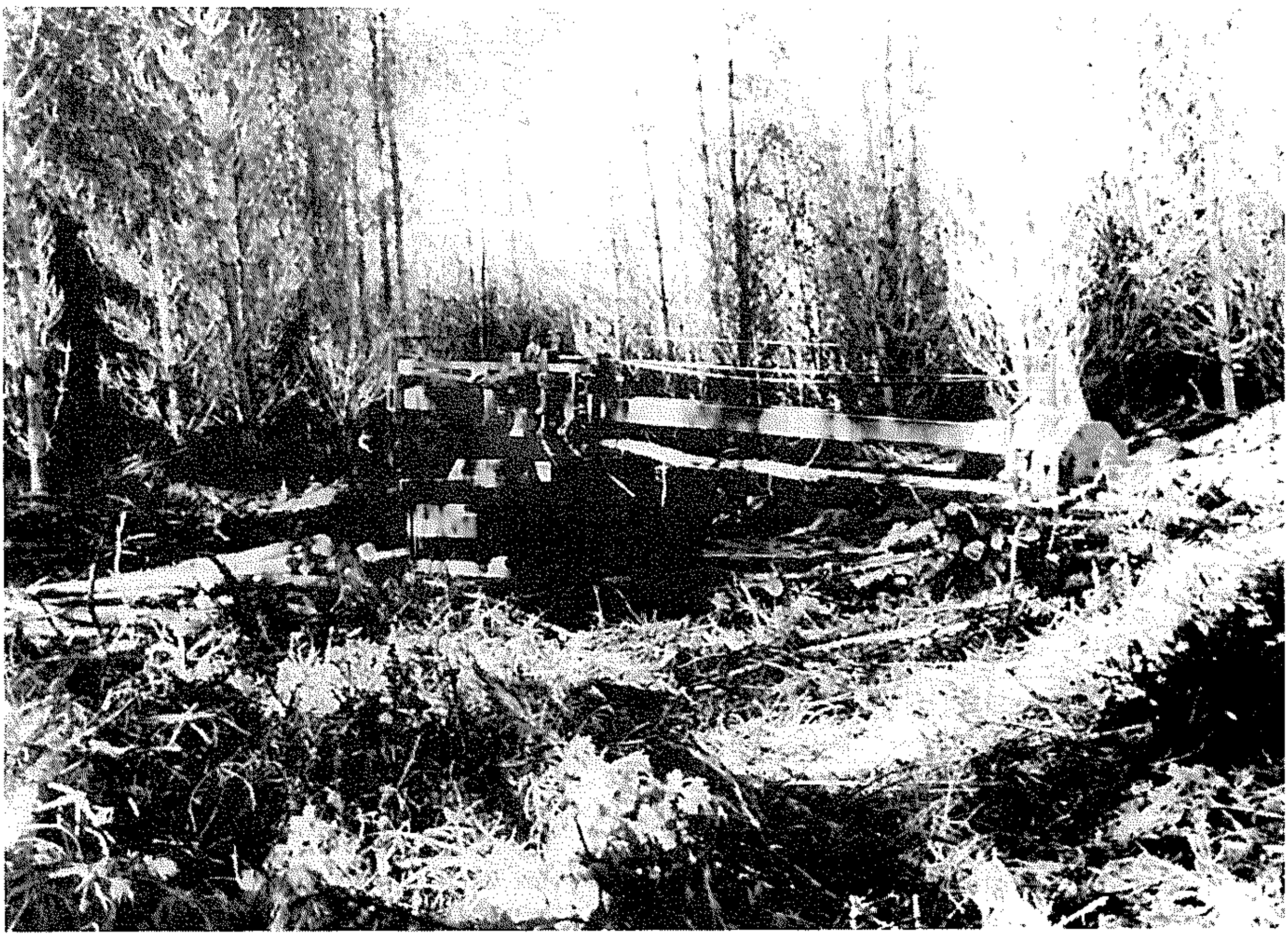
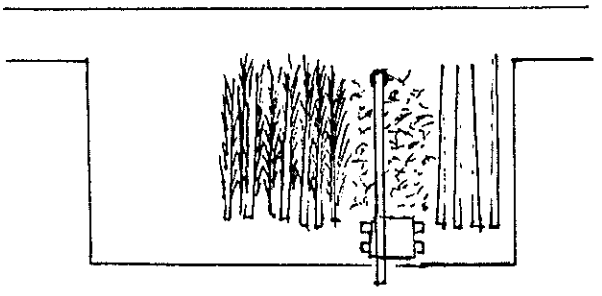
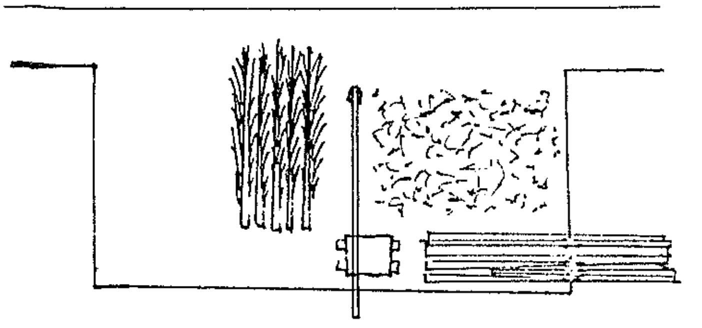


Figure 3 : Delimbing radiata pine on the landing



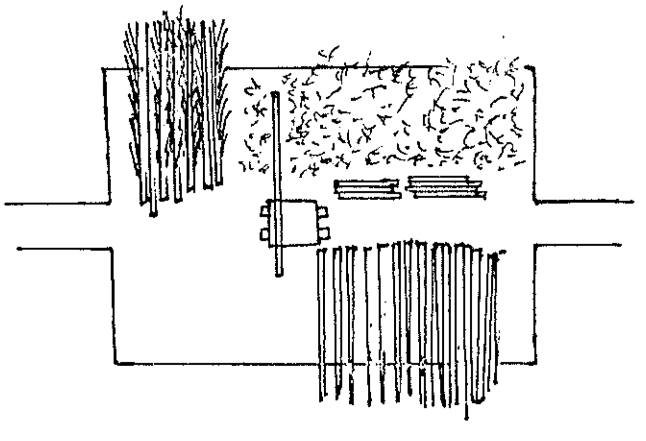
Method 1 :

Cold decking with stacking parallel



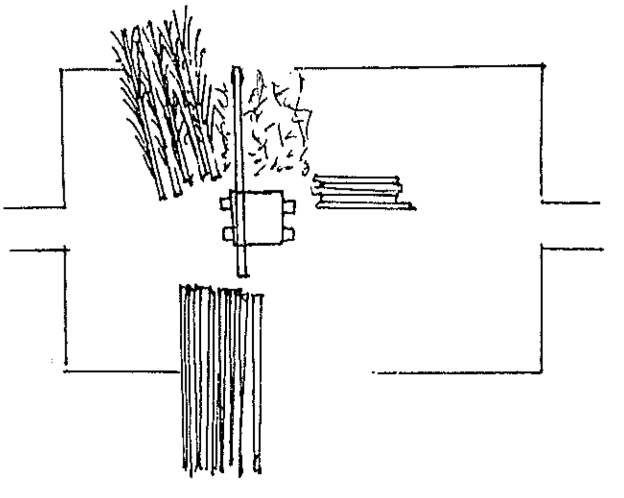
Method 2 :

Cold decking with shorts and longs stacked at right angles



Method 3 :

Cold decking with longs stacked behind and shorts to right hand side



Method 4 :

Hot decking with longs stacked behind and shorts to the right hand side

Figure 4 - Work Methods Evaluated

parallel to the unlimbed wood. This method was found to be impractical due to the large amount of slash accumulating, resulting in excessive clearing time.

Secondly, the delimber stacked the processed long lengths at right angles to the unlimbed wood. It was found that although this separated the processed wood from the slash, it was not fleeted well enough for load out and subsequently incurred a large amount of loader fleeting time.

Thirdly, the delimber processed the long lengths and slewed round 180° to stack them behind. This resulted in a progressively higher stack as it moved across the skid, and minimised fleeting time. Short lengths were stacked in front of the delimber at right angles to the unprocessed wood. This method was found to be the best cold deck layout, and was the method studied intensively.

Lastly, an attempt at "hot-deck" processing was tried. This involved the skidder pulling wood directly to the delimber and clearing the accumulating slash on its return to the bush. Although not trialled extensively, it was felt that this method showed the most potential for the use of a stroke delimber under the existing landing system for radiata thinnings. Several factors which could affect system productivity need to be further evaluated. These include the effect on skidder cycle time of slash removal; the balancing of skidder and delimber productivity, especially at longer haul distances; the safety of both machines working in close proximity; and the possible requirement for a loader to fleet short pulpwood to a satisfactory standard and to augment the skidder in slash removal.

3.2 Machine Travel

Although the maximum walking speed of the delimber is 3.7 km/hr, the operational speed averaged 2.8 km/hr. This gave an average travel time between skids of just under 8 minutes for an average distance of 370 m.

The cold deck system under which the delimber was operating meant that travel between skids was required at least once, and sometimes twice, a day.

Ideally, the "hot deck" operation is the most productive for the delimber operating on a landing since time spent positioning in front of stacks and moving between skids is minimised.

3.3 Gross Productivity

Daily productivity rates varied markedly for the same operator day to day, and also between operators (Figure 5).

For the same operator, fluctuations in productivity rates on a daily basis ranged up to 23%. This variation was largely due to inexperience and the effect of fatigue due to working long periods without a break. Each operator worked the delimber an average of 3.0 and 3.5 productive hours per day respectively. Ideally, work periods should not exceed 2 hours and it is considered important for operators to take regular breaks, even if only of short duration (e.g. 5 minutes). It is essential that two operators are available and are able to substitute to keep the machine working to peak production.

It appears that the machine learning time is highly dependent on the operator. Over the period of the trial, however, both operators had learnt the basic machine operation. Further improvements to hourly productivity would be slower to achieve and would depend on operator motivation, and improvements to the work method and system layout.

3.4 Machine Availability and Utilisation

The breakdown of the standard work day is given in Figure 6. Over the 12 day period of the study, total scheduled ("on-job") time averaged 9.5 hours per day (568 mins). Available machine time (scheduled time less mechanical delays), averaged 7.8 hours

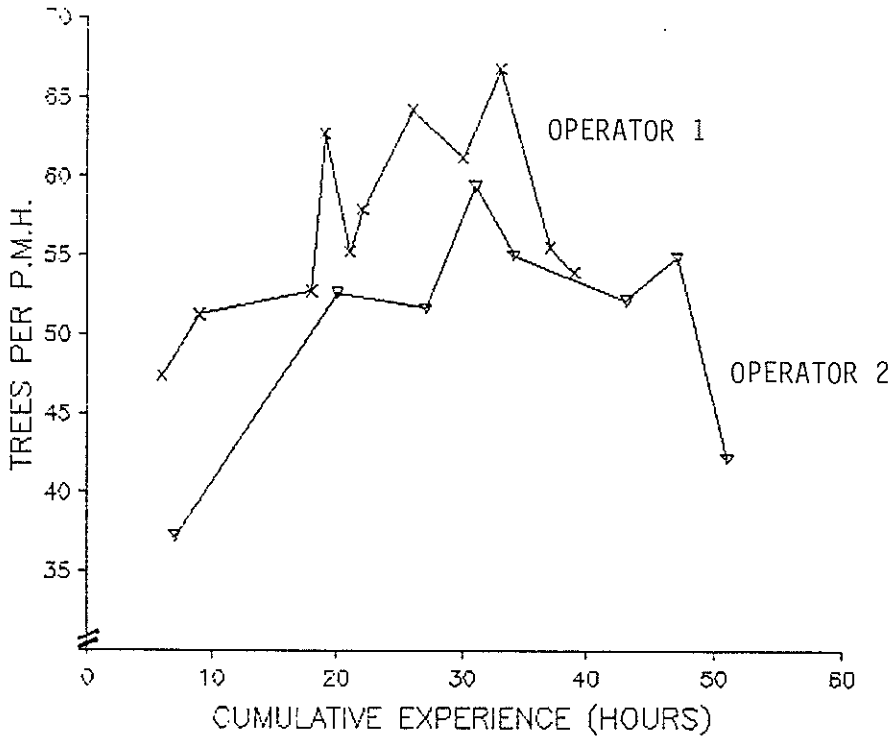


Figure 5 : Gross Productivity (Trees/P.M.H.)

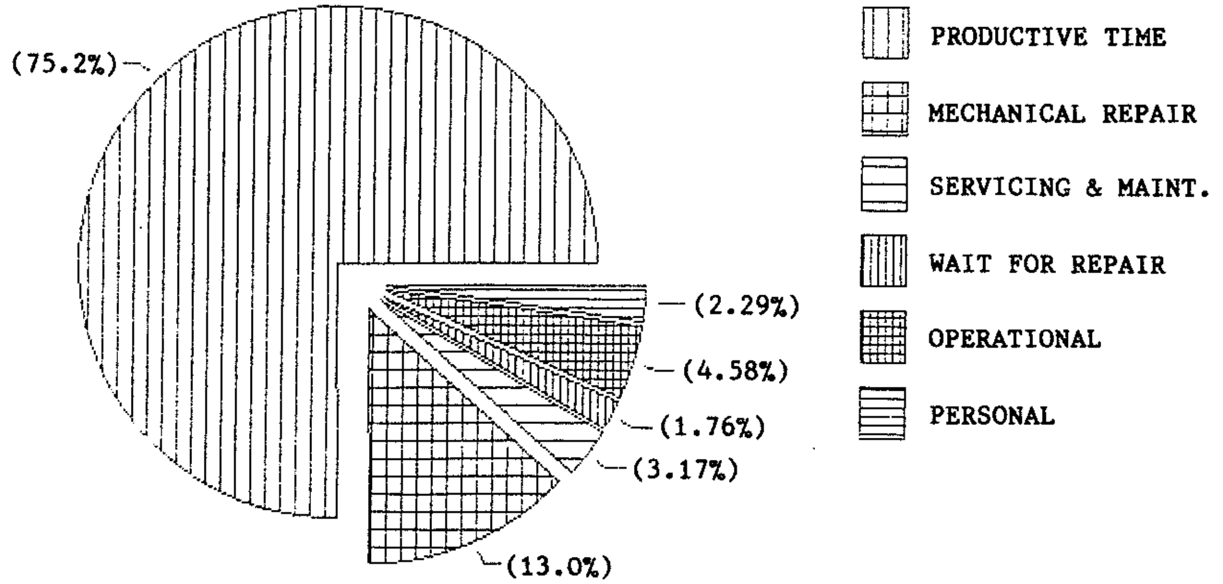


Figure 6 : Breakdown of Work Time
(% of scheduled "on-job" time)

per day (82.%). Gross productive machine time averaged only 6.5 hours per day (68.9%). This figure was adjusted to remove non-allowable delays such as time spent talking to machinery suppliers, visitors and researchers. This adjustment gave a nett productive time of 7.1 hours per day (75.1%).

Adjustments to overall mechanical availability were made on occasions where downtime was scheduled during the work day which should have been out-of-shift repairs. Two examples are where extra guarding was added to protect the rear saw hydraulic hoses (26 minutes), and where on two occasions time was taken to fit lights for night operation (105 minutes).

The mechanical availability and the utilisation of the Harricana over time is shown in Figure 7.

Details of each category of delay are given in Table 3. As can be seen, the major causes of mechanical downtime were related to boom hydraulics, saws and the boom drive. These problems predominantly occurred during the last three days of the trial.

Boom hydraulic problems arose from leaking fittings around the rear trimming saw; a blown hose fitting on the motion control valve; and a leaking fitting on one of the main boom pipes (two stoppages averaging two hours each). These machine commissioning problems could have been avoided by attention to the use of good quality fittings and the addition of extra guarding prior to the machine commencing operation.

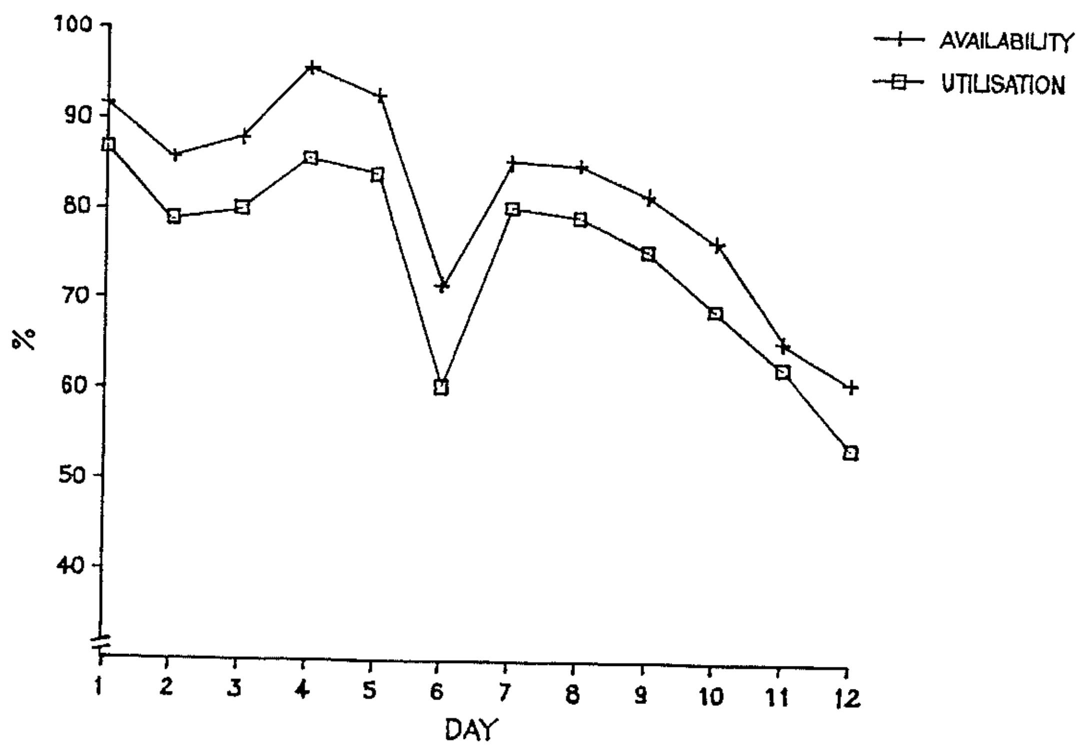


Figure 7 : Adjusted Availability and Utilisation (% of scheduled "on-job" time)

TABLE 3 : SUMMARY OF DELAYS
(minutes per working day)

TYPE OF DELAY	NUMBER OF OBSERVATIONS	RANGE (min)	MEAN PER OBSERVATION (min)	MEAN PER DAY (min)	% OF SCHED TIME
MECHANICAL DELAYS					
Servicing & Maintenance					
- Grease & Oil	3	12-23	17	4	0.7
- Fuel Up	6	4-18	10	5	0.9
- Warm Up/Adjust	8	5-30	13	9	1.6
				18	3.2%
Repair					
- Saws	10	3-55	23	19	3.3
- Boom Drive	4	10-60	35	12	2.1
- Boom Hydraulics	7	18-123	68	40	7.8
- Track Base Repair	2	7-30	18	3	0.5
				74	13.0%
Wait for Repair	1	-	119	10	1.8%
Total Mechanical				102 min	18.0%
NON-MECHANICAL DELAYS					
Operational					
- Talk to crew/supervisor	6	1-22	6	3	0.5
- Position on skid	26	1-6	2	5	0.9
- Travel between skids	17	5-21	11	15	2.6
- Interference loader/ skidder	7	1-9	4	2	0.4
- Tree stuck on tray	4	1-7	5	1	0.2
				26	4.6%
Personal					
- Smoko/Personal	12	1-34	11	11	1.9
- Swap operator	7	2-6	3	2	0.4
				13	2.3%
Total Non-Mechanical				39 min	6.9%
TOTAL DELAYS				141 min	24.8%
PRODUCTIVE MACHINE TIME				427 min	75.2%

Saw problems were largely eliminated through guarding to prevent limbs jamming the saw or flicking the chain off. The speed of the hydraulic ram activating the saw bar may need to be dampened. The high speed of the bar coming down onto the stem created sufficient force to break the bar mounting bolts and locating dowels, on at least four occasions.

The boom foot bolts needed constant tightening due to the impact of delimbing heavy branched trees. This problem has since been alleviated by the mounting of a large pin through the boom to prevent the bolts from loosening, and the use of Nylock nuts or "Locktite" on existing bolts.

The boom chain and tensioning rope should be regularly tightened to maintain the drive chain and sprockets. The life of the boom chain and rope is anticipated to be approximately one year. Regular greasing is also required for the delimber components, drive mechanism and boom chain. The delimbing knives should be periodically sharpened to maintain the delimbing quality.

3.5 Intensive Time Study

Productivity of the two operators was measured by timing the various elements of the work cycle (Appendix 1). Results are given in Tables 4 and 5.

The data obtained was from a relatively small sample of the machine's operation. Therefore the elemental time values do not represent the overall performance of the machine. The mean total cycle times for each operator, however, are at either extreme of the gross productivity figures recorded throughout the trial. The gross productivity data can be taken to represent the range of productivity results over the period of the study and the intensive time study used to highlight this range.

3.6 Effect of Branch Size

The data was divided into three classes determined for each tree by the size of the largest branches, and whether or not the tree had multiple leaders.

Branch Index 1 (BI=1) : Trees of normal form where no branch exceeded 7 cm in diameter.

Branch Index 2 (BI=2) : Normal formed trees where branch size exceeded 7 cm in diameter.

Branch Index 3 (BI=3) : All trees with excessive malformation or multiple leaders.

TABLE 4 : HARRICANA WORK CYCLE - OPERATOR 1

ELEMENT	N	MEAN PER OBSERVATION (min)	MEAN PER CYCLE (min)	% OF TOTAL CYCLE
Pick Up	94	0.265	0.240	30.1
Process	94	0.554	0.501	62.9
Clear	2	1.233	0.024	3.0
Sort	10	0.318	0.031	3.9
Stack	1	0.150	0.001	0.1
TOTAL	104		0.797 min ± 0.072 min	100.0%

Productivity 104 trees in 82.9 min = 75.3 trees/PMH
95% confidence interval = 69.0 - 82.7 trees/PMH

TABLE 5 : HARRICANA WORK CYCLE - OPERATOR 2

ELEMENT	N	MEAN PER OBSERVATION (min)	MEAN PER CYCLE (min)	% OF TOTAL CYCLE
Pick Up	80	0.332	0.332	27.1
Process	79	0.831	0.831	67.8
Clear	3	0.683	0.020	1.7
Sort	6	0.486	0.028	2.4
Stack	3	0.400	0.011	1.0
TOTAL	98		1.222 min ± 0.092 min	100.0%

Productivity 98 trees in 120.9 min = 48.6 trees/PMH
95% confidence interval = 45.2 - 52.5 trees/PMH

The means for the processing cycle where BI=1 and BI=3 were significantly different. No significance was found in comparing the means of other branch indices (Table 6).

The data was highly variable and relationships between cycle time and tree diameter, length and volume were not reliable.This may be a function of operator variability, imprecise description of tree characteristics such as the use of a branch description index rather than direct measurement, and the small sample of trees measured (n = 98).

3.7 Effect of Log Product Type

Log volume and processing cycle time data was divided into groups depending on product type (long and short pulpwood) and whether the delimbing quality was to either Tasman or Pan Pac specification.

The specification for Panpac pulpwood is generally not as strict hence represents wood of a "rougher" standard of presentation (LIRA, 1978). When the data was divided up and analysed it was found that there was no significant difference in total cycle

TABLE 6 : EFFECT OF BRANCH SIZE ON CYCLE TIME

ELEMENT		BRANCH INDEX 1	2	3
Total Cycle	mean	1.17 min	1.38 min	1.71 min
	s.d.	0.383 min	0.467 min	0.539 min
Productivity (Operator 2; Trees/PMH)		51	44	35

TABLE 7 : EFFECT OF LOG TYPE ON PROCESSING TIME

PRODUCT TYPE	PIECE VOLUME (MEAN M3)	TOTAL PROCESS TIME[1] (MIN/PIECE)
Longs (Tasman & Panpac)	0.47 m3	1.38
Shorts (Tas an & Panpac)	0.34 m3*	1.04*
All Tasman (Longs & Shorts)	0.44 m3	1.18
All Panpac (Longs & Short)	0.48 m3	1.37

* Significant difference at 95% level.
1 Process time is the sum of the pickup and process elements (excluding delays).

time between Tasman longs and Panpac longs, or between Tasman shorts and Panpac shorts. Hence it appears from preliminary analysis that delimbing to a higher quality specification does not adversely affect productivity rates.

Combining the data on log length showed that the difference in both log volume and processing cycle time between all longs and all shorts (irrespective of delimbing quality) was statistically significant (Table 7). Processing short lengths however does affect overall productivity in tonnes per hour due to the lower volume throughput counteracting the shorter processing time. Variability in the data was such that prediction of productivity rates against log volume and diameter was not satisfactory.

3.8 Further Possible Improvements to Machine

Some operational difficulty with the operation of the rear knives was noted. Since the addition of larger rear grapple cylinders, the rear grapple appears to operate both faster and more positively. This creates difficulties in using the rear limbing knives to delimb whorls close to the butt. An improvement could be to change the control from on/off electric to a proportional hydraulic control.

Downtime related to the topping saw could be eliminated through converting the topping chainsaw to a double acting hydraulic shear.

One suggested modification to improve grapple operation is the addition of a second "finger" to one of the front grapple arms. The offset placement of the two front grapple arms causes uneven pressure on the tree (especially with small diameter pieces), creating difficulties when aligning into the rear grapple. Modifying one grapple arm into two parts or "fingers" would balance the pressure placed on the log and prevent this problem. Another possible modification would be the addition of a guide plate in front of the rear grapple to correct the alignment of logs into the grapple (Figure 8).

3.9 Productivity and Cost

Over the duration of the trial, Operator 1 averaged 57 trees per P.M.H. on a daily basis, and Operator 2 51 trees/P.M.H. to give a weighted mean productivity of 54 trees/P.M.H. In this study, differences in productivity between operators of similar experience working under the same conditions have been measured as high as 33% (56 vs 42 trees/hour). This is corroborated by Australian experience with stroke delimbers (O. Raymond, 1986).

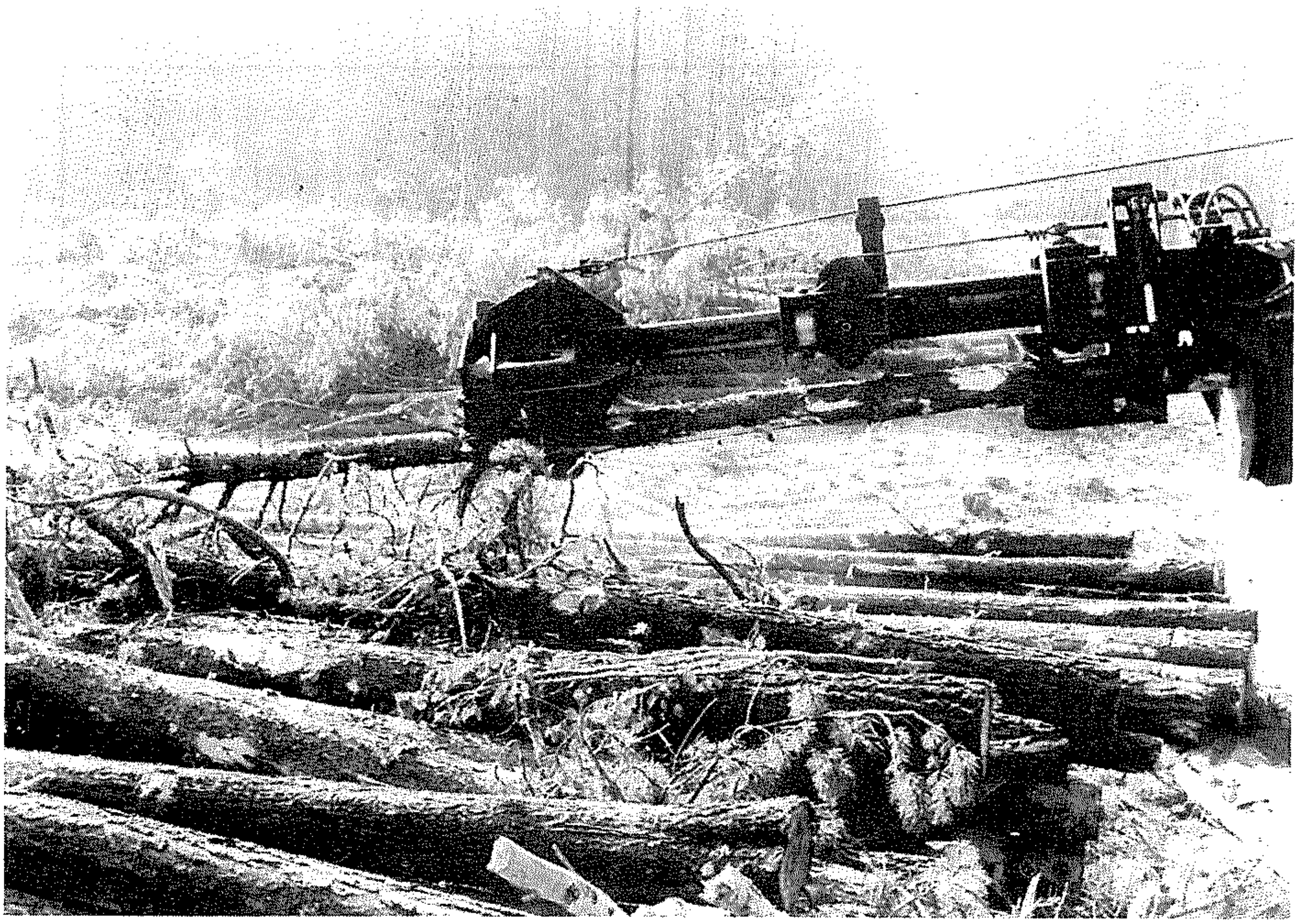


Figure 8 : Denis Delimbing Head Showing Guide Plate into Rear Grapple

As discussed previously, daily utilisation averaged 7.1 hours per day, hence gross productivity is calculated as :

54 trees/P.M.H. x 7.1 P.M.H./day x 0.40 m3 (av. tree size) = 153 m3/day

at 0.9 m3/tonne,
Production = 170 tonne/day

Costings are based on the standard LIRA format (Wells, 1981). Given a capital cost of $290,000 for the Harricana on a Cat 215 base, a working life of five years and resale values of $64,000 (40%) for thon a Cat 215 base, a working life of five years and resale values of $64,000 (40%) for the base and $26,000 (20%) for the delimber, machine ownership costs are calculated at $56.00/hr.

Operating costs such as fuel, oil, saw bars and chains, and overall repair and maintenance (at 80% of depreciation) give a total of $40 per operating hour.

This gives a total daily machine rate of $680.00, and a delimbing cost of $4.70 per tonne (Appendix 2).

Operating in a system with two manual fellers, one Bell logger, a grapple skidder and a loader, the costs of the delimber operation can be compared with the conventional operation. This is equivalent to a comparison between the cost of six cutters and that of two cutters, the delimber and operator (Table 8).

It is felt that the use of the fleeting loader could be eliminated from the mechanised system. This would reduce daily cost by $315 ($1.85/tonne). This is dependent on the development of an efficient work method whereby slash is removed by the skidder without adversely affecting extraction productivity, and whether the delimber can satisfactorily fleet short pulpwood.

TABLE 8 : COST COMPARISON OF THE TWO SYSTEMS

Delimber System			*Manual System*		
1 Harricana	=	$680	9 men @ $120	=	$1080
6 men @ $120	=	$720	6 chainsaws @ $23	=	$ 138
2 chainsaws @ $23	=	$ 46	1 Bell Logger	=	$ 210
1 Bell Logger	=	$210	1 Cat 518 Skidder	=	$ 410
1 Cat 518 Skidder	=	$410	1 520B Loader	=	$ 315
1 520B Loader	=	$315			
Total Daily Cost		$2381	Total Daily Cost		$2153
÷ 170 tonne/day = $14.00/tonne			÷ 143 tonne (target) = $15.05/tonne		

Overseas experience, however, should teach us that mechanised operations are not always cheaper than manual methods (especially in the long term) (O'Reilly, 1980). The benefits to both contractor and management of mechanising mechanising the delimbing phase include increasing man-day productivity and reducing dependence on the fluctuating labour supply (Folkema, 1979).

4. CONCLUSIONS

4.1 Potential in Radiata Thinnings

This study has shown that the Harricana delimber is capable of delimbing radiata pine thinnings, but that attention must be paid to work organisation.

The Harricana is capable of operating over a range of working conditions and tree sizes to delimb, sort and stack wood to a standard acceptable to two major processing plants. Delimbing to different log quality specifications did not adversely affect productivity.

Production rates measured between operators over the full day period ranged from 42 to 67 trees per hour. There was wide variation both between operators working in the same conditions, and with the same operator in different stands.

The major tree characteristics influencing delimber productivity in m3/PMH were the degree of malformation, and the tree size. The necessity of handling trees with multiple leaders significantly reduced productivity. Processing small diameter, short trees also limits the productivity of the delimber. It is estimated that stands of 0.35 m3 piece size or greater best suits the stroke delimber operation. Operating in small piece size stands should therefore be avoided. The size and number of branches on processed trees did not appear to limit the performance of the delimber.

Acceptable machine availability was achieved throughout the period of the trial. High daily production is dependent on maximising machine availability and utilisation through preventative maintenance, and through working overlapping operator shifts to minimise personal delays.

Operational delays such as travel between skids and positioning at stacks must be minimised through careful attention to the organisation of the work method. Mechanical delays involving hydraulics should also be minimised through the provision of good mechanical backup. This will ensure the successful introduction of these machines into the New Zealand logging industry, over the next few years.

4.2 Implications for Management

(a) Unless production is maximised for the system, high capital cost, sophisticated machinery will result in high cost wood. This will mean longer shifts per day, or working 6 days a week. Many overseas operations are scheduled to work this way, in order to get the most out of the machinery.

By working a two-shift, 12-hour day, owning cost is reduced in the order of 25-30%, which more than offsets the increase in operating cost due to higher R. & M. (8-10%). Overall improvement to total hourly cost is in the order of 15-17%.

(b) To maintain this high production, and reduce downtime, good field backup is necessary to carry out repairs (and maintenance) when required. Thus, competent welders, hydraulics engineers and mechanics will become more common in the logging workforce.

(c) Machine availability must be kept high in order to keep costs down, and management must support the operation in order to increase productivity and reduce downtime. Often the problem of low machine availability and utilisation lies with management organisation and operator maintenance. Planning and control of the operation must be a priority.

(d) Spare parts availability will become increasingly important, and for sophisticated machinery, this may involve a large inventory of spare parts. N.Z. experience to date shows that these stroke delimbers require considerable attention early in their operating life. It is expected that this will be followed by a period of less frequent repair, with mechanical availability constant over a relatively long period of time.

(e) Operating flexibility may be reduced with the adoption of a mechanised system. The cost of shifting machinery from one site to another will be higher. Once a system is operating, the cost of stopping to alter it will be higher.

(f) Ergonomics : Mechanising harvesting operations results in a reduction in the labour input required. This replacement of manual methods by mechanised systems has highlighted the importance of the human element. Operator characteristics such as co-ordination, depth perception, and motivation, become more important skills than in conventional logging operations. It is important to note that for loggers the attraction of being able to work at their own pace, without the pressure of close supervision, may be lost with the move to mechanised systems. A highly mechanised system will require a different type of worker than the traditional bushman, and the logging industry will find itself in direct competition with other industries for these operators.

LIRA NOTE

Since its introduction to New Zealand in February 1987, the delimber and base unit have undergone considerable modification. This trial describes equipment and systems that are in a state of development. LIRA will continue to monitor and report on further developments with the Harricana stroke delimber.

The costs derived in this Project Report have been derived using the procedure shown in the LIRA Costing Handbook for Logging Contractors. They are only an estimate and do not necessarily represent the actual costs for this operation.

5. REFERENCES

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APPENDIX 1

DESCRIPTION OF ELEMENTS IN THE DELIMBING CYCLE

The delimber's processing activity consists of repetitive and easy to identify cycles involving two basic elements :

1. **Pick Up** :

   This is the time taken from the dropping of the last processed stem on the stack till the start of the delimbing stroke. The boom is swung back from over the processed stack, and is extended out to break out the next tree from the stack. The boom is retracted until the tree is positioned in the rear holding grapple, and the grapple is closed.

2. **Process** :

   This is the time taken to fully process the tree, including topping, cutting to length and stacking. With the rear grapple closed on the butt of the tree, the boom is extended outwards, shearing off the limbs. At maximum boom extension, the front grapple is closed and the tree moved past the back grapple. This is repeated until the tree is completely delimbed. The tree is then topped and dropped on the stack of processed wood.

OTHER ELEMENTS

1. **Sort** :

   This element describes the time taken to pick up a tree that does not require delimbing and stack it directly on the appropriate log stack.

2. **Stack** :

   This is the time spent in fleeting up the stack of processed wood, aligning the butts or readjusting the position of logs in the stack.

3. **Clear** :

   This is the time spent clearing slash and debris away from the machine or from in front of the processed stack. This is usually done by closing the front grapple and extending the boom outwards, pushing the slash away.

4. **Move** :

   This involves either repositioning closer to the stack of unlimbed wood, or where the machine moves to another part of the skid to continue work. This element, along with the clear element, comprises the major operational delay in the work cycle.

APPENDIX 2

COSTING OF HARRICANA HM 1290-50/CAT 215 BSA (AUGUST 1987)

Costing basis	=	Single shift 7.1 P.M.H. per day
Capital Cost	=	$290,000
Resale Value	=	$90,000
Life of Machine	=	5 years
Productive Hours per Year	=	1630 hours
Interest Rate	=	22%
Insurance	=	2.5%
Fuel Consumption	=	16.7 litres per P.M.H.
Oil Consumption	=	2.0 litres per P.M.H.
R. & M. factor	=	80% of depreciation

Owing Cost

Depreciation	24.51
Return on Investment	28.34
Insurance	3.22
Total Owning Cost per P.M.H.	$56.07

Operating Cost

Fuel	11.52
Oil	5.00
Bars & Chains	3.67
R. & M.	19.61
Total Operating Cost per P.M.H.	$39.80

Total Machine Rate per Day	=	$680.67
Total Labour Cost per Day	=	$120.00
		$800.67
÷ 170 tonne per day	=	$4.70 per tonne