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TREE LENGTH THINNING WITH THE LAKO HARVESTER

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ABSTRACT

The Lako 3T grapple harvester was studied in a tree length radiata pine thinning operation to determine the factors affecting machine productivity and performance.

The work method involved the removal of every seventh row with selection thinning between outrows.

Branch size had a major effect on machine performance. Processing trees with branches greater than 6 cm diameter, malformation or double leaders severely reduced productivity.

Production rates averaged 28 m³ per productive machine hour during the study. Total daily production is dependent on machine utilisation, which was not reliably established in this trial. Improved machine utilisation could be achieved through working two shifts per day, minimising personal delays and scheduling out-of-shift repairs and maintenance.

INTRODUCTION

This Report describes a 1987 study of the Lako harvester production thinning radiata pine in Kaingaroa Forest.

Since its introduction, the Lako has operated successfully in tree length selection thinning and has also been trialled in shortwood operations. As part of the on-going development of efficient work techniques, an evaluation of combined outrow and selection thinning was undertaken. This method of thinning was adopted primarily to improve access for the machine and reduce damage to crop trees. Other potential benefits included improved efficiency of the bunching and skidding phases of the operation.

The objectives of the study were :

- to evaluate the work method of the harvester.
- to determine the stand conditions having a significant influence on machine productivity.
- to determine the costs associated with this method of mechanical thinning.

ACKNOWLEDGEMENT

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THE MACHINE

The Lako 3T grapple harvester fells, delimbs, cuts to length, and roughly bunches trees of up to 55 cm in diameter. It can be mounted on different base machines such as excavators, forwarders and skidders of 75 kW or greater engine output. The machine was introduced into New Zealand during 1986.

The Lako 3T was mounted on a Foresteri 1278 crane with a reach of around 9 metres. The base machine was a Martimex LKT 120-A skidder. Specifications are given in Table 1.

The harvester unit has an hydraulic chainsaw for felling and cutting to length. Delimbing is achieved by driving the stem through two sets of wrap-around knives, via three hydraulic drive feed tracks (Figure 1).

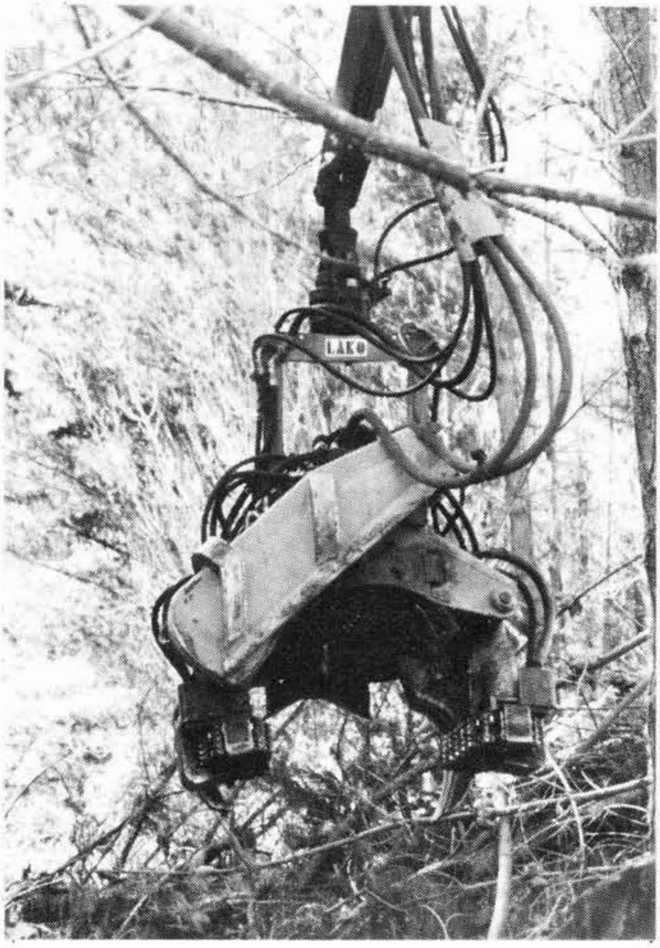

Figure 1 - The Lako 3T Grapple Harvester

TABLE 1 : MACHINE SPECIFICATIONS

Martimex LKT 120A	
Height	*3.00 m*
Width	*2.65 m*
Length	*6.60 m*
Op. weight	*9900 kgs*
Max. forward speed	*25 km/hr*
Max. reverse speed	*20 km/hr*
Rated engine power	*84 kW*
Lako Grapple Harvester	
Hydraulic System :	
- Flow	*200 l/min*
- Pressure	*20 MPa*
Weight (incl. rotator)	*820 kg*
Max. Feed Speed	*3.5 m/s*

STUDY AREA

The study was undertaken in a 15 year old stand of Radiata pine on flat terrain in Kaingaroa Forest. The stand had been previously waste thinned to 645 stems per hectare at age six and had received various pruning treatments.

Stand data and the results of sectional measurement of tree lengths collected prior to the study are given in Table 2.

TABLE 2 : STAND DETAILS

Crop stocking	*250*
Merch. yield stocking (sph)	*380*
Mean merch. DBH (cm)	*25*
Mean merch. length (m)	*13.8*
Mean merch. piece size (m^3)	*0.35*
*% of small branched trees (BI=1) **	*81%*
*% malformation (BI=4)**	*4%*

* *The index of branch size is explained in "Study Method".*

STUDY METHOD

Prior to the thinning all yield trees were marked and diameter and pruned height measured.

The elements of the typical harvester work cycle are :

1. "select" the tree to be felled;
2. "fell" the tree;
3. "delimb" (includes any cutting and heading off);
4. "move" the machine along the row, or within the bays.

Detailed timing was undertaken for a period of two days.

From previous studies of the Lako operation, it was apparent that tree branch size was an important predictor of machine performance. An index of branch size was formulated which could be easily applied to each stand scheduled for thinning by the Lako (Table 3). The number and distribution of branches were not part of this index.

WORK METHOD

The harvester worked a 7th row outrow. During thinning, every seventh row was felled and processed. The machine selectively thinned the three adjoining rows on each side of the outrow in the same pass. The work method used differed from common methods of grapple harvester operation in two ways :

TABLE 3 : BRANCH INDEX CLASSIFICATION

Branch Index 1	*(BI=1)*	*: Trees with branches all less than 4.0 cm diameter*
Branch Index 2	*(BI=2)*	*: Trees with some branches between 4.0 - 6.0 cm diameter*
Branch Index 3	*(BI=3)*	*: Trees with branches greater than 6.0 cm diameter*
Branch Index 4	*(BI=4)*	*: Malformed trees (includes double leaders)*

1. The outrows were not extracted prior to thinning between the outrows (bays);

2. The harvester was driven into the bays to thin these rows rather than operating from the outrow using the boom.

This resulted in both forward and reverse travel, as the machine had to reverse back onto the outrow before moving ahead. The width between the rows was approximately 25 m.

The harvester felled the yield trees in a herring bone pattern with all butts facing towards the outrow (Figure 2).

The outrow was kept clear of processed logs.

As skidder productivity was maximised by tree length extraction, the Lako attempted to keep the processed length as long as possible.

In this study, 15% of trees processed required cutting into two or more lengths. The reasons for this were :

- malformation and tree forking;
- breakage on processing;
- large diameter trees becoming stuck into the ground during delimbing;
- hangups during felling.

The following techniques were used to overcome some problems with difficult trees :

1. Swinging the log and delimber head back and forth to add impetus to the movement of the tree through the delimbing knives. This technique was used for processing heavily branched trees;

2. Reversing the delimbing head to cut the tree adjacent to a whorl and defect, thus minimising waste. This technique was also used when processing forked trees;

3. Delimbing branches on the lower stem prior to felling (pre-trimming). The delimbing head was located on the stem

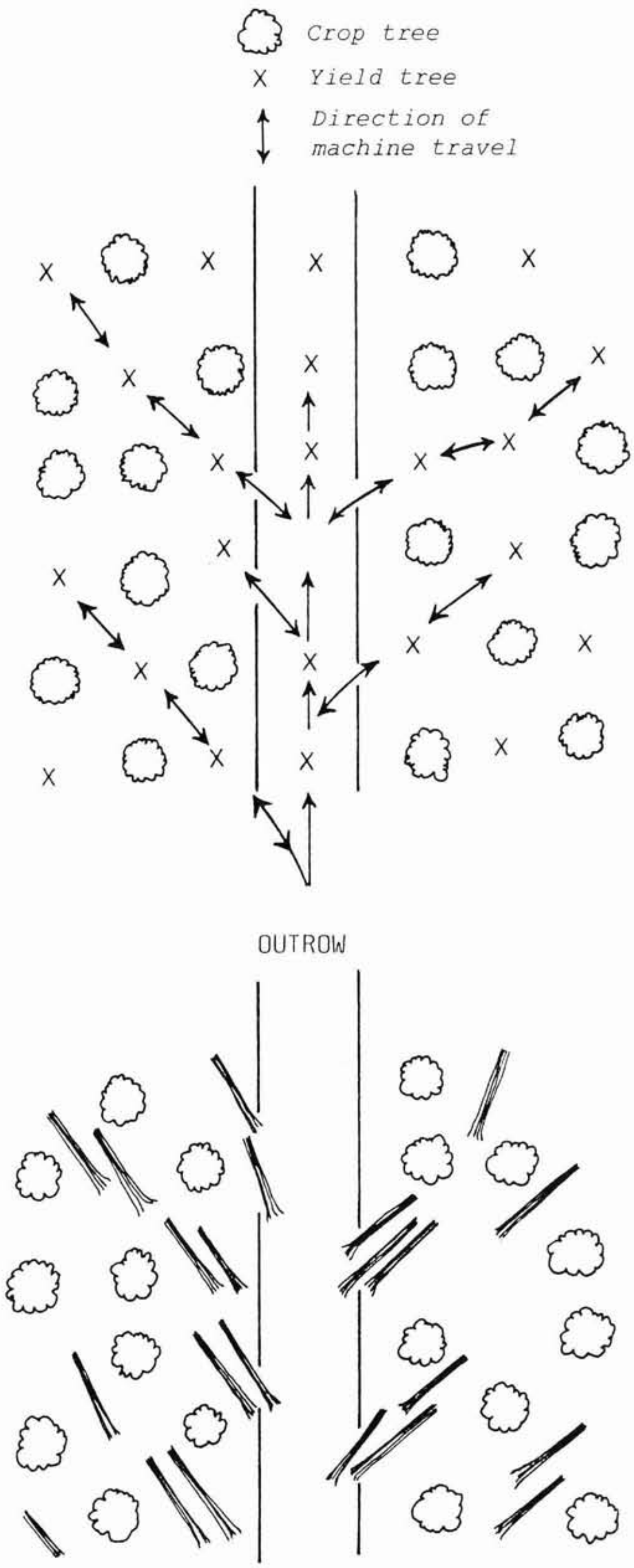

Figure 2 : Work Method for Tree Length Thinning

with the knives slightly open. Delimbing was achieved by raising and lowering the boom, instead of using the drive tracks.

The processed tree length wood was bunched by a Bell Logger for extraction by a Clark 664 grapple skidder.

The orientation of the felled stems in the direction of haul and semi-bunching by the Lako considerably increased the productivity of the Bell Loggers. The Bells were commonly building bunches of 7 to 8 pieces (averaging 2.35 tonnes per bunch). Preliminary analysis gave Bell bunching productivity of 39.6 m^3/P.M.H. Further studies of the Bell Logger in this mechanised system have been undertaken (Ashby & Vaughan 1988).

RESULTS AND DISCUSSION

A summary of the work cycle of the Lako is given in Table 4. This data represents total processing of 320 merchantable trees ranging from 10 to 40 cm dbh.

Regression analysis indicated a positive relationship between processing time per tree (select, fell and delimb) and tree diameter. For all trees, processing time (excluding move and delays) is given by :

$$y = -0.1276 + 0.0174 * DBH (cm) + 0.1889 * BI \quad (r^2 = 0.59)$$

Analysis of the data collected showed that branch index had the greatest effect on delimbing time. When the standard time for machine movement and operational delays is applied to the above equation, total cycle time can be predicted. Figure 4 shows the productivity per machine hour over the range of tree size studied.

TABLE 4 : WORK CYCLE OF THE LAKO

DESCRIPTION	n	MEAN PER CYCLE (min)	95% CONFIDENCE LIMITS (min)	% OF TOTAL CYCLE
Select	320	0.128	± 0.007	17.0
Fell	320	0.125	± 0.005	16.6
Delimb	320	0.291	± 0.026	38.8
Move	208	0.183	± 0.012	24.4
Op. Delay	31	0.024	± 0.004	3.2
TOTAL CYCLE	320	0.752	± 0.034	100.0
TREES PER P.M.H.		79.9	± 3.6	

PRODUCTIVITY = 80 trees per Productive Machine Hour x 0.35 m^3/tree = 28.0 m^3/ P.M.H.

Figure 3 - Tree Length Radiata Pine Thinning

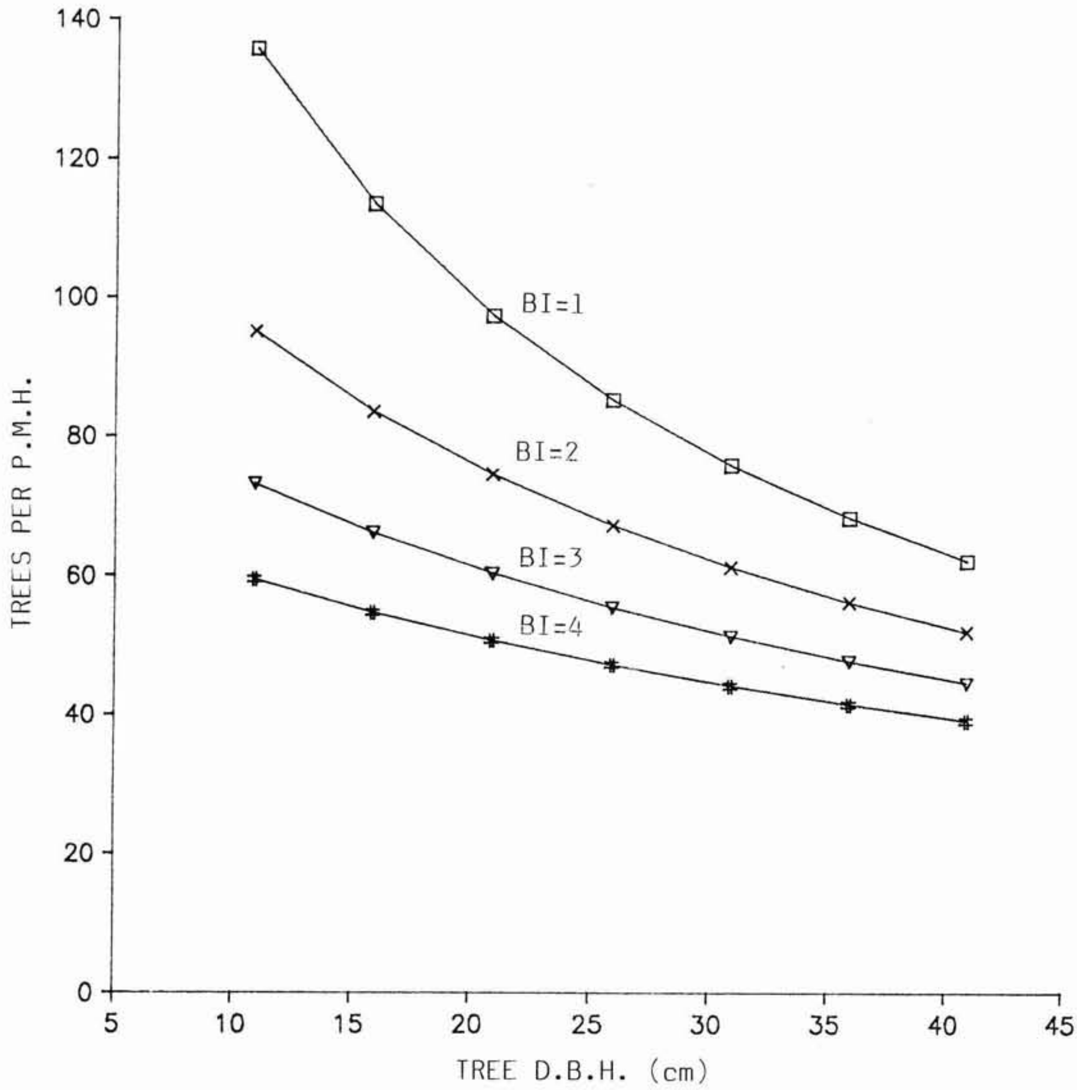

Figure 4 - Effect of Tree Size & Branch Index on Productivity

Malformation (BI = 4) was defined as trees with steep angled branches, kinks, excessive sweep or double leaders. High proportions of malformation in the stand resulted in severely reduced productivity.

The delimbing standard was acceptable to local mill standards. The Lako harvester best performed delimbing lightly branched trees and adequately delimbed medium branched trees. Heavy branched trees were often difficult and at times impossible to delimb.

MACHINE AVAILABILITY AND UTILISATION

A total of 31 minor operational delays were recorded during the study (3.3% of total cycle). These delays included clearing slash, felling unmerchantable trees and aligning processed stems. Apart from these operational delays that occurred as part of the normal work cycle, there were several periods of mechanical downtime during the study. Most of the downtime was associated with the hydraulics system. Other mechanical delays included :

- saw chain coming off;
- changing saw chain (approx. every 2 hours);
- thrown drive track.

Overseas studies suggest that the machine utilisation level of grapple harvesters is around 70% (O. Raymond, pers. comm.). It may however be unrealistic to expect to maintain this figure in New Zealand due to the fact that the machine is a one-off model, without an infrastructure of mechanical support.

Experience in identifying and repairing recurring problems together with out-of-shift repair and maintenance has resulted in improvements to the mechanical availability of the Lako.

MACHINE COSTING

Machine rate costs were calculated for the Lako harvester and base machine, using the LIRA costing format (Wells, 1981). The measured productivity rate of 28.0 m^3/ P.M.H. and utilisation of 70% was used to calculate total felling and delimbing costs.

Two options were examined :

1. Single operator working 8 hours per day :

   8 hrs x 70% utilisation x 235 days
   = 1316 hrs/yr

2. Double shift, 8 hours per shift :

   16 hrs/day x 70% utilisation x 235 days
   = 2632 hrs/yr

Input :

Capital	$380,000
Life	3 years
Resale : Option 1	25% of purchase price
Option 2	10% of purchase price
Interest	20%
Insurance	3%
R & M : Option 1	80% of depreciation
Option 2	120% of depreciation

Output :

	Option 1	Option 2
Owning Cost per hour	$122.00	$66.56
Operating Cost per hour	$65.90	$60.13
Machine cost per PMH	$187.90	$126.69
Plus Labour Cost per PMH	$19.87	$21.57
Total Cost per PMH	$207.77	$148.26
Fell & Delimb Cost ($ per m^3)	7.42	5.29

CONCLUSIONS

This study in ideal stand conditions has shown that the Lako harvester is capable of high productivity in tree length operations. The machine processed logs in a way that improved the following phases of the operation.

The outrow system is considered essential for efficient mechanised harvesting. The 7th row outrow system appeared to work effectively under the conditions studied.

A mean piece size of 0.25 - 0.35 m^3 ideally suited the Lako harvester, enabling high levels of production to be achieved. Nevertheless the branch size distribution within the stand is a more important parameter than tree size. Lightly branched normal formed trees were processed very quickly. Trees with malforms or large branches took 83% and 128% longer to process respectively. Hence the frequency of these stems in stands to be harvested mechanically will significantly influence machine productivity.

Good utilisation levels must be achieved if high production is to be sustained. This can be improved by increased shift time and undertaking repairs and maintenance out-of-shift, where possible. Costing the operation on two options of differing shift length showed the advantage of double shifting. The critical factor affecting overall performance of the Lako and any other mechanised system is machine availability. Studies undertaken by LIRA to date suggest that mechanical reliability and access to mechanical backup will determine the success or failure of mechanised tree harvesting systems.

The costs stated in this 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.

REFERENCES

Ashby, H. & Vaughan, L.W. (1988) : "Comparison of a Bell Logger in a mechanised and motor-manual system." LIRA Report (in prep.).

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