LOGGING INDUSTRY RESEARCH ORGANISATION
NEW ZEALAND

ISSN 1171-6932

REPORT

Vol. 19 No. 5 1994

AN EVALUATION OF A WARATAH MODEL HTH 234 HARVESTER IN A CABLE HAULER OPERATION

Tony Evanson
Alastair Riddle
Daniel Fraser

Figure 1 - Waratah HTH 234 and Madill 171 in Mohaka Forest

ABSTRACT

A Waratah 234 Hydraulic Tree Harvester was evaluated clearing the chute and processing trees in a cable logging radiata pine clearfell operation in Mohaka Forest. The operation included manual fallers, two breakerouts, a Madill 171 hauler, the Waratah 234, a hydraulic loader for sorting and loading, and a skidworker to unhook and check log quality.

Estimated hourly production was 75m³ per productive machine hour in an average tree size of 2.9m³. Machine utilisation was 58%. The hauler averaged productive cycles of 4.7 minutes with 2.2 pieces per cycle. Machine utilisation for the hauler was 71%.

The effect on processing time of tree form was tested and found to have a significant effect for two out of three form classes. Piece volume had the largest effect on processing time. The accuracy of the length measuring system was also assessed. There were indications that accuracy declined with log length. However, no significant relationship could be found between the difference from specification, and log grade, length or small end diameter. A comparison between log grade recovery from motor-manual processing prior to the trial, and mechanised processing, revealed little difference between the two methods.

INTRODUCTION

Traditionally, the processing of trees into logs in clearfell cable hauler operations in New Zealand has been carried out motor-manually. Recent exceptions to this practice have been the use of Denis DM3000 stroke delimbers in piece sizes > 1.5 tonnes (Robinson and Evanson, 1992) and the Bell static delimber in piece sizes < 1.5 tonnes (Jones and Evanson, 1992).

A recent innovation in ground-based processing of larger timber has been the introduction of a Waratah Hydraulic Tree Harvester Model 234 (Waratah 234) (Evanson and Riddle, 1994). A logging system based on this machine has been in operation for more than 12 months. In this time, the Waratah 234 has shown itself capable of operating in tree sizes of up to two tonnes.

There has been considerable interest in evaluating the potential of the Waratah 234 in a cable hauler-based operation. To this end, the Waratah 234 contracted to CHH, Kinleith Region was made available to CHH, Central Region for a trial beneath Mitchell Brothers' Madill 171 in Hawkes Bay.

The objective of the study was to evaluate the performance of the Waratah 234 delimbing and cutting to length the wood extracted by the Madill 171.

ACKNOWLEDGEMENTS

LIRO acknowledges the assistance of Carter Holt Harvey Forests Limited, contractors Archie Moffat and Richard Mitchell and operator, Don Locke with this study.

THE WARATAH 234

The Waratah 234, manufactured by Waratah Engineering Limited, Tokoroa is a harvester/processor designed specifically for radiata pine and is capable of delimbing trees from 10cm small-end diameter to 65cm large-end diameter. It weighs approximately 3.5 tonnes and requires a minimum 30 tonne base carrier. In this study, the Waratah 234 was mounted on a 30 tonne Caterpillar excavator.

Trees are driven through the delimbing knives by three hydraulically driven spiked drive rollers. The feed speed is approximately 3.2m/sec, and the theoretical feed power is three to four tonnes. With a bar of one metre length, the hydraulic chainsaw uses 0.404 pitch chain and has a maximum cutting diameter of 70cm. A fully computerised length measuring system has ten different programmable lengths and a diameter sensor.

OPERATION DESCRIPTION

Motor-manual Processing

The system used prior to the study consisted of a Madill 171 hauler, a Caterpillar EL300B hydraulic loader used to clear the chute, and a Caterpillar EL300B hydraulic loader to sort and stack logs that had been motor-manually processed by up to four skid workers (all required to make logs). Usually, two breakerouts were used. Seven different log grades, five random lengths and six fixed length logs were cut to a required accuracy of ± 2cm.

Mechanised Processing

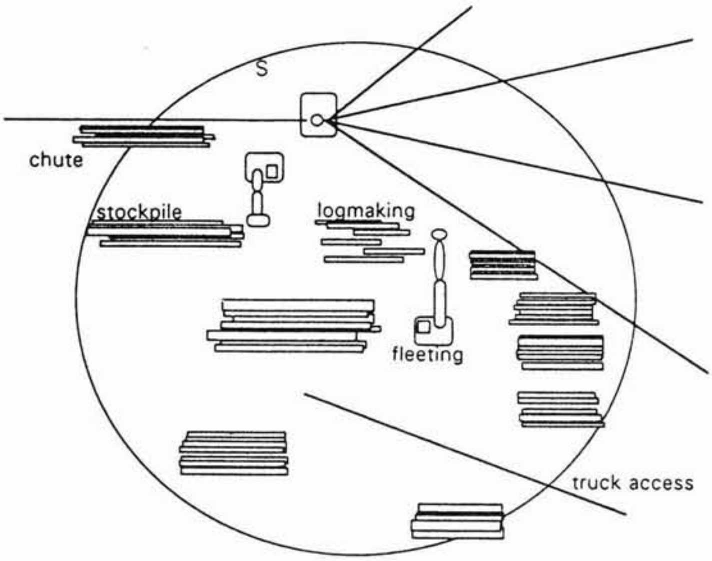

Figure 2 - Landing layout

Equipment used during the study comprised: a Madill 171 cable hauler, Waratah 234 (as a processor and for chute clearance) and a Caterpillar EL 300B (30 tonne) loader. The hauler was rigged in a North Bend configuration and three strops were used. As many as three breakerouts were used during the study. One skid worker was retained to unhook and carry out quality control on the processed logs. Eight grades and 10 fixed log lengths were cut, including pruned log grades. The loader operator controlled truck arrivals, and some loading out was carried out before, and after the hauler operating shift.

At CHH, Kinleith Region, log length tolerances for the contract were ± 5cm, while at CHH Central Region, they are ± 2cm. During the trial this specification was amended to + 5, -2 cm.

STUDY METHOD

Stand details are shown in Table 1.

Table 1 - Stand details

Age	26 years
Mean Crop Height	36.5 metres
Stocking	284 sph
Mean DBH	52.0 cm
Mean Piece Size	2.56 m^3

A continuous time study was carried out on the Waratah 234 for defined elements of the work cycle. Tree volume was estimated using a one-dimensional volume table derived from trees scaled in the setting. All delays were measured and changes in the method of operation noted. A sample of logs was measured to assess length measuring accuracy.

A tree form index was noted for each tree processed (Table 2).

Table 2 - Description of tree form class indices

Form Class	Description
1	Straight trees with light branching
2	Trees with moderate sweep and/or heavy branching
3	Forked trees and malformed stems

A three-day activity sampling study was also carried out on the Waratah 234, the hauler, loader and skid worker.

An assessment of log quality was made. A sample of logs from stacks were measured to assess grade, length and small-end diameter. Grade recovery records for the gang were provided by CHH, Central Region. The logs produced during the trial were kept separate in order to provide weight and grade recovery figures specific to the trial.

RESULTS

The operation was studied for a total of 22.2 hours of continuous timing over the three days during which 486 full processing cycles were timed. Average piece size processed was estimated at 1.98m^3 (ranging from 0.35 to 5.7m^3) and average tree size was 2.90m^3. Of the pieces processed, 64% were classed as trees and 36% were broken pieces.

An estimated 38 trees were processed per productive machine hour (PMH) producing 75m^3/PMH. Total production over the three day trial is estimated at 962m^3. Production, monitored by weighbridge was 1015 tonnes. A summary of time study results by day, and by combined data is shown in Tables 3 and 4 respectively.

Delay-free cycle time was 1.68 minutes per processed piece. Machine utilisation was 58%, with mechanical availability 92%. A major delay, occurring at the close of day two and the start of day three, concerned a seal failure on one of the drive roller motors. This was repaired largely out of shift time and so most of the delay caused was not included in gross study time.

A summary of cycle time is shown in Table 5.

Table 3 - Summary of estimates : by day

	Day 1	Day 2	Day 3
Processing method #1	100 %	51	-
#2	-	36	51
#3	-	23	22
#4	-	-	27
Number of pieces processed	143	174	169
Study time (hours)	6.98	8.28	6.94
Productive time (hours)	4.91	3.78	4.07
Machine utilisation (%)	70	46	59
Mechanical availability (%)	97	85	94
Estimated mean tree size (m^3)	3.14	3.09	2.57
Estimated mean piece size (m^3)	2.05	1.86	2.02
Mean no. of logs cut per piece	2.77	2.84	2.84
Estimated trees processed per PMH	29.1	46.0	41.5
Estimated production (m^3) per PMH	59.6	85.6	83.8
Estimated daily production (m^3)	293	323	341

Note : Processing method
#1 Clear chute and stack before process
#2 Clear chute and process
#3 Process from the stack
#4 Process shovel logged trees

Table 4 - Summary of estimates derived from combined data

Processing method # 1	48 %
#2	31%
#3	13%
#4	8%
Number of pieces processed	486
Study time (hours)	22.14
Productive time (hours)	12.76
Machine utilisation (%)	58
Mechanical availability (%)	92
Estimated mean tree size (m^3)	2.90
Estimated mean piece size (m^3)	1.98
Mean no. of logs cut per piece	3.02
Estimated trees processed per PMH	38.1
Estimated production (m^3) per PMH	75.4
Estimated total production (m^3)	962

Delays to the Waratah 234

Half of all operational delays to the Waratah 234 could be attributed to the hauler (Table 6). Most of this delay was comprised of interference, where tree heads ran foul of the hauler ropes, and hauler ropeshifts. The loader contributed very little delay time in comparison.

Table 5 - Summary of cycle time elements (min)

Element	Number of Cycles	Mean per occurrence	Mean per cycle	Range (±) *	Percentage of total time
Clear chute	208	0.95	0.40	0.07	14
Pick up tree	345	0.26	0.18	0.02	6
Process	483	1.06	1.04	0.06	37
Clear slash	41	0.59	0.05	0.02	2
Sort		0.65	0.01	0.01	0
TOTAL			1.68		
Personal delay	13	16.90	0.44		16
Operational delay	116	1.98	0.46		16
Mechanical delay	24	4.73	0.23		9
TOTAL			2.81		

* Range for 95% Confidence Interval

Table 6 - Idle and inference delays (min)

	Number of cycles	Mean per occurrence	Mean per cycle	Percentage total
Interference : Hauler	66	1.14	0.15	68
Interference : Loader	4	0.6	0.005	2
Wait for wood to process	10	3.19	0.06	29
Wait for removal of processed wood	2	0.33	0.001	1
Total delay time :	110.55 minutes	(48% of all operational delay)		

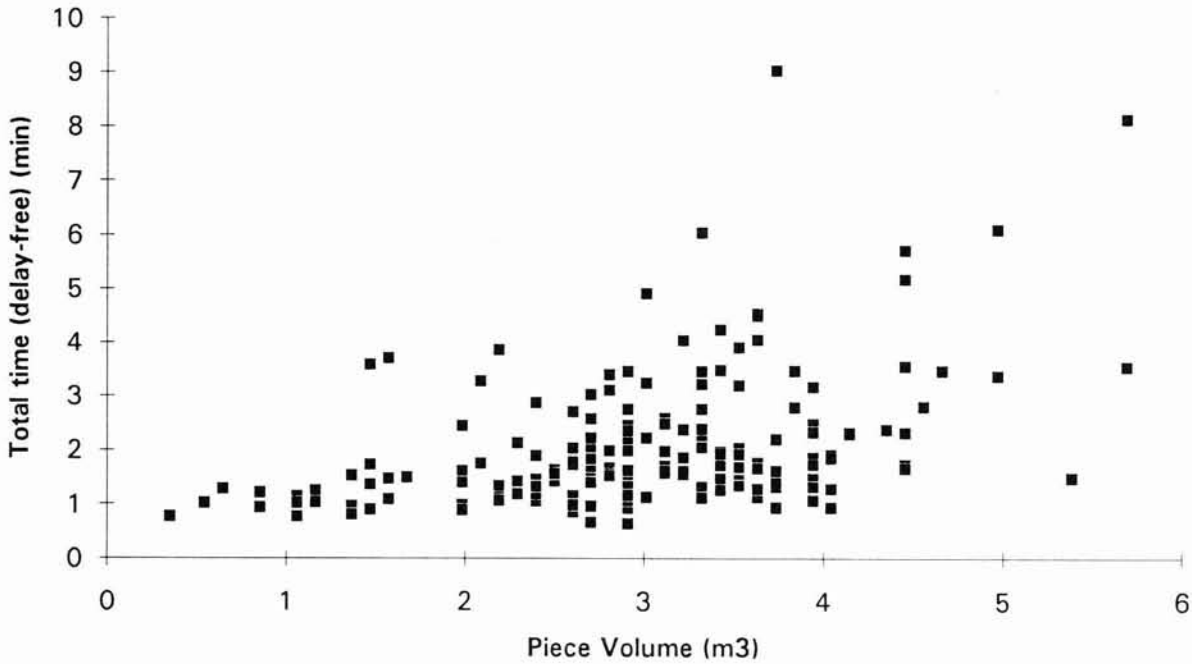

Figure 3 - The effect of piece volume on total (delay free) cycle time

The majority of trees processed were extracted from the chute and processed butt first. The few that were extracted head first took longer to process because they had to be turned 180° before processing.

Effect of Tree Form and Volume on Processing Time

When classified by tree form class, 36% were classed as class 1, 53% class 2, and 11% were class 3. The effect of tree form on processing time was tested, together with the effect of piece volume, using linear regressions. An influential factor in determining processing time was whether or not the processing head was reversed to delimb the piece from the large-end. Normally, most trees were delimbed and crosscut from the large to the small end. A head reversal was used to delimb (and sometimes re-shape) a particularly rough tree or piece, usually a form class 2 or 3 tree. The effect of head reversal on processing time was also tested.

Stem volume, tree form 1, 2, and head reversal were found to be significant at the 0.05 level. The effect of piece volume on total (delay free) cycle time is shown in Figure 3. There was no significant difference between process time for form 2 and form 3 trees. The difficulty of assessing trees before felling for form makes the use of tree form as a predicting variable impractical, likewise, head reversal.

Four different methods were used to process trees. Mean total process times (clear chute + pick + process) for these methods were compared using a two-sample t test. The results are detailed in Table 7. Processing from a stack is the best option. Clearing and stacking before processing was the least efficient method. However, there was a priority on clearing the chute, so practically speaking, a combination of methods would likely be used in the course of a setting.

Table 7 - Mean total process time for different processing methods

Processing method	Mean processing time (min)
1. Clear chute and stack before process [ac]	1.92
2. Clear chute and process [ab]	1.45
3. Process from the stack [bc]	1.11

Means from methods marked with the same letter are different at the 0.05 level of significance.

System Utilisation

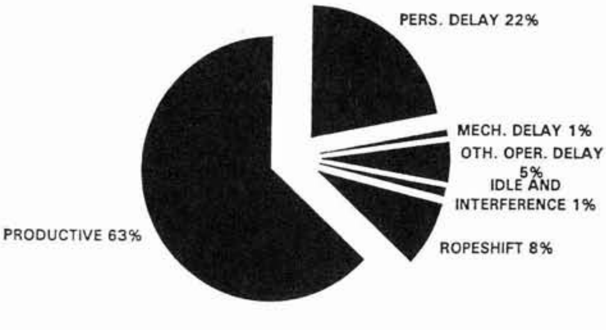

Figure 4 - Time distribution for the hauler

The hauler was productive for 63% of the observed time (Figure 4). When ropeshifts were included, utilisation increased to 71%. A total of 197 drags were extracted, with an average 2.19 pieces per cycle and a average cycle time of 4.7 minutes.

The Waratah was productive for 64% of the observed time (Figure 5) with the majority of the time used for processing.

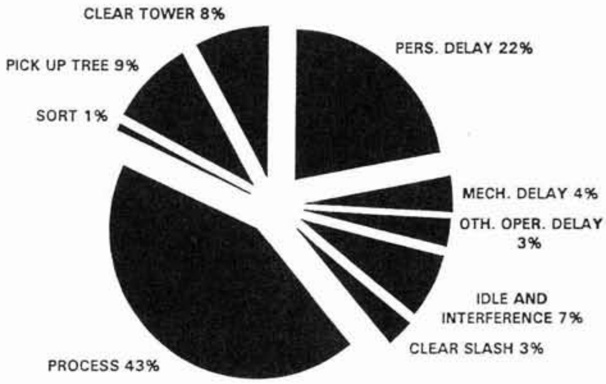

Figure 5 - Time distribution for the Waratah 234

The skid worker was idle for over a quarter of his time (Figure 6).

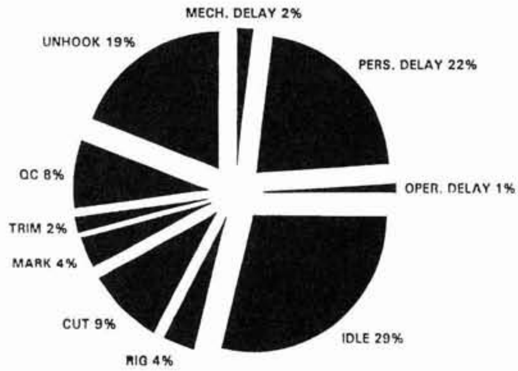

Figure 6 - Time distributiuon for the skid worker

Length Measurement and Grade Recovery

The length measurement equipment was frequently calibrated, the scale factor (or relationship) between measuring wheel circumference and distance was set by the operator (via the computer) by comparing computer length readings with tape measurements on a delimbed log. A total of 551 logs were measured to assess the length aspect of log quality (Table 8).

A large standard deviation indicates more variation in measured lengths.

Table 9 shows the distribution of out of specification logs. For example, for log

Table 8 - Log measurement results by grade

log type	logs measured	mean length (m)	standard deviation
A 4.15	113	4.167	7.3 cm
A 8.25	139	8.283	9.37
B 4.15	88	4.19	6.28
Fixed 5.0	53	4.995	9.16
Random 4.3	34	4.332	7.12
Random 5.5	50	5.479	4.71

Table 9 - Logs out of specification (as percentages) for different tolerances

	Tolerances (cm)								
Logtype	± 1	± 2	± 3	± 4	± 5	± 6	± 7	±10	±15
A 4.15	77	60	44	40	31	23	15	7	5
A 8.25	82	66	57	44	32	32	24	11	6
B 4.15	82	74	56	46	31	24	20	12	6
Fixed 5.0	82	74	56	46	31	24	20	12	6
Fixed 5.5	70	58	44	28	18	16	10	2	0

type A4.15, 77% fell outside ± 1 cm of the desired length, 60% fell outside ± 2 cm of desired length, 44% fell outside ± 3 cm, etc.

Small-end diameter measurements showed that 3.6% of the 4.15m A grade logs measured were under the nominal diameter (inside bark) of 30cm. No B grade logs measured were under 20 cm, but 10.1% of the 8.25m A grade logs were under 30cm (only 1.4% were under 28cm). These errors may have been due to the fact that the machine measures diameter outside the bark while the specification is an inside bark measure.

Log Grade Recovery

Table 10 shows the crew's recent log grade recovery statistics on the left and the trial results on the right. Results are similar, though an increase in value recovery in some grades and decrease in others may not apply for a larger sample.

COSTS

The Waratah 234 and base were costed using a standard LIRO format (Wells, 1981).

With a capital cost of $620,000 and a residual value of $250,000 at 8,000 productive hours, a base cost of $135 per hour, or $950 over a 7 hour day was calculated. This excludes operator wages, transport, operating supplies, overheads and profit.

Table 10 - Log grade recovery (%)

Grade	Pre trial yield	Trial yield
Pruned grade	18	24
E grade(epicormics)	2	3
H2 grade(half pruned)	4	2
A grades	45	46
B grade	9	6
Short sawlog	0	3
Pulp grades	22	16

DISCUSSION

The contractor and his operators were happy with the way that the Waratah 234 fitted into the operation. It improved total gang production and offered a safer working environment.

The contractor was not satisfied with the length measuring accuracy. Further research is needed in the area of length measurement. Links between measuring inaccuracy and length, diameter, log roughness and operator technique require investigation. There may also be the justification, in conjunction with such research, to relax log length specifications to say $\pm$ 5 cm.

The forest manager agreed with the contractor about safety improvements and was also pleased with the presentation of the logs. It was felt that the log maker had a better view of the logs than in the motor-manual situation and it was an advantage to have only one log maker per gang which would give better consistency of product and make communication easier.

Manpower

The addition of a Waratah 234 might not require any fewer men on the job as extra men could be used for breaking out and for preparing hauler moves. During the operator training process there might also be a need for chainsaws on the skid to help keep the landing work ahead of the hauler. With three machines in a logging system, there would be a need to have trained backup operators and an ongoing training programme.

Clearing The Landing

Slash should not be left to accumulate under the Waratah 234 for too long before clearing the area. It could be removed by the loader grapple as was done during the trial.

Paint Codes for Log Identification

The Waratah 234 operator had no difficulty seeing painted grade marks sprayed by fallers to aid identification of pruned logs. To assist the loader operator to identify the various pruned log grades, log marking equipment could be added to the Waratah head, with control of such marking added to the computerised measuring system.

CONCLUSIONS

The Waratah 234 produced an estimated 75m^3/PMH in a mean tree size of 2.9m^3 (mean piece size 1.98m^3). Machine utilisation was 58% and mechanical availability was 92%.

The study showed that the Waratah 234 is suited to clearing the chute, and processing logs to an acceptable standard in a high producing hauler operation. It has also clearly demonstrated the potential to improve the production and safety of many current hauler operations, particularly in large size timber.

REFERENCES

Evanson, T., Riddle, A. (1994) : "Evaluation of a Waratah Tree Harvester Model HTH 234", LIRO Report Vol. 19 No. 3.

Jones, G., Evanson, T. (1992) : "The Bell Static Delimber in a Cable Clearfell Operation, LIRO Report Vol. 17 No. 21.

Robinson, D, Evanson, T. (1992) : "A Mechanised Swing Yarder Operation in New Zealand", LIRO Report, Vol. 17 No. 22.

Wells, G. C. (1981) : "Costing Handbook for Logging Contractors". LIRA. June 1981.

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

For further information, contact:

LOGGING INDUSTRY RESEARCH ORGANISATION
P.O. Box 147,
ROTORUA, NEW ZEALAND.

Fax: 0 7 346-2886 Telephone: 0 7 348-7168