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ROADLINING WITH A HYDRAULIC EXCAVATOR

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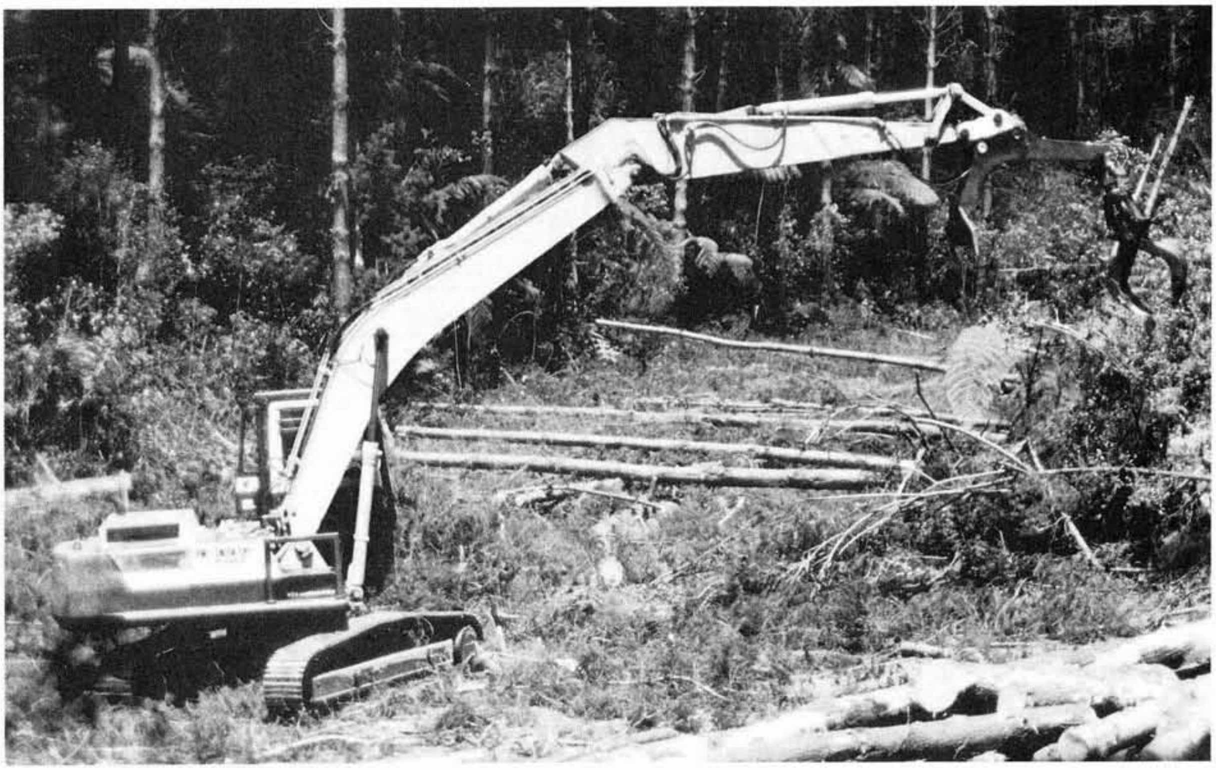

Figure 1 - Komatsu PC400 fleeting logs to stacks

ABSTRACT

A study to investigate the productivity of a Komatsu PC400 working in a roadline harvesting operation in Tarawera Forest was undertaken. Two men felled, delimbed and then cut each stem to log length. The excavator fleeted the logs to stacks along the road edge ready for loadout. During fleeting, it was necessary to have a saw operator present to remove remaining branches or branch stubs, check log quality and to mark the large end of all logs. Two days were set aside each fortnight for truck loading. The system produced on average 133 tonnes of wood on-truck per day. Delays associated with waiting for trucks were identified as having the largest effect on the productivity of this system. Possible methods for reducing the impact of these delays on the productivity of the system are outlined.

INTRODUCTION

Excavators are commonly used in the United States and Canada as extraction and road building machines (Harder 1988, Hemphill 1986, Floch 1988, Balcom 1985). In New Zealand hydraulic excavators have been predominantly used for road construction and log loading (Williams 1989, Duggan 1990, Simpson 1983, Kemp 1984). Less prevalent New Zealand applications of hydraulic excavators include bunching trees ready for grapple skidder extraction and roadline harvesting operations (Prebble 1990). Other applications have been trialled in New Zealand and these include shovel logging (Moore 1990) and contour tracking through standing timber.

During 1990 a contractor began using a 40 tonne hydraulic excavator to extract and load wood from a roadline harvesting operation in Tarawera Forest for Tasman Forestry Limited. The rationale behind using an excavator was to develop an effective roadline harvesting system for use in steep terrain. Approximately 25% of the new roading programme for the next five years in Tarawera Forest will be opening up steep land ready for hauler extraction.

Four study objectives were identified; to determine faller productivity, to determine the productivity of the 40 tonne excavator in a roadline harvesting operation, to investigate the affect system delays had on production and then recommend possible methods to reduce the affect of those delays, and to determine an average long term (six months) productivity level, estimated from weekly log stock records and total weekly uplift, and to use that information to assess the implications the system had on the cost of roadline harvesting operations in Tarawera Forest.

ACKNOWLEDGEMENTS

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MACHINE DESCRIPTION

The machine was a Komatsu PC400 hydraulic excavator with a live heel, undercarriage guarding and strengthening, a raised cab, and 12m reach (Figure 1). Another feature of this excavator is the quick attach mechanism that allows fast interchanging of the Pierce log grapple and the roading bucket. Machine specifications are given in Table 1.

Table 1 - Machine specifications

Engine	*206 kW/276 hp*
Travel Speed (high/low)	*5.5/3.1 km/hr*
Operating Weight	*48 tonne*
Lifting Capacity over Front at Ground Level	*6.4 tonne*
Lifting Capacity over Side at Ground Level	*4 tonne*
Boom and Stick Reach	*12 metres*

The excavator used in this system was relatively large compared to other machines used in similar applications in New Zealand (Moore 1990, Prebble 1990).

STUDY AREA AND OPERATION DESCRIPTION

The study was undertaken in Compartment 21 of Tarawera Forest. At the time of the two week detailed time study, approximately 90% of the roading programme in Tarawera Forest concentrated on widening roads previously used to access production thinning operations. New roading accounted for the remaining 10%. New roads consisted mainly of short stub roads leading to end landings. Stand details for Compartment 21 are given in Table 2.

Table 2 - Stand details

Stand Age (yrs)	*27*
Stocking per Hectare	*385*
Merchantable Stem Size (m^3)	*1.7*
Volume per Hectare (m^3)	*655*
Stand Quality	*62% pulp 38% sawlog*

The following describes the operation during the two week detailed time study of the excavator. Working one week ahead of the loader, two men felled, delimbed and cut each tree to log length in a 10 metre strip either side of the existing roadway. Subsequent felling of trees over those already made into logs resulted in many of the logs being covered in slash making it difficult for the excavator operator to find some logs during fleeting and/or shovel logging. During fleeting it was necessary to have a saw operator present to remove remaining branches or branch stubs, check log quality and mark the large end of all logs. The loader fleeted the logs to stacks situated at the road edge, each log type stack being repeated at 40 to 50 metre intervals along the road. Truck loading was planned for two days each fortnight. Aside to roadline harvesting, the excavator could very quickly interchange the logging grapple for a roading bucket and carry out road construction work where required.

RESULTS AND DISCUSSION

Faller Productivity

A two day study of a faller working in this operation was undertaken to get an indication of how the logmaking component of falling was affecting his productivity. Only 12.2% of the faller's time was spent logmaking. The study showed that the faller logmaking at the stump could safely fell, delimb and log make on average 40 trees per day.

The relatively low productivity rate for the faller was attributed to :

- high quality delimbing to ensure that all limbs were removed.
- Logmaking decisions and cross-cutting the stem.

Excavator Productivity

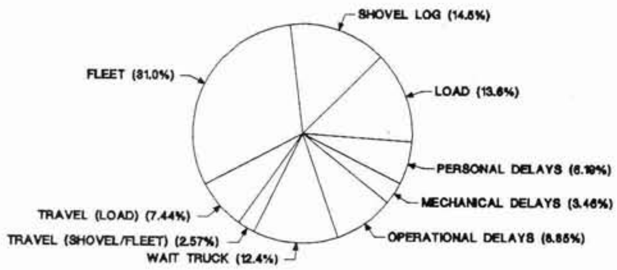

Figure 2 - Time allocation of roadlining operation

The production achieved during the ten day detailed time study was 1291 tonnes. If loading and the associated delays were excluded from the analysis then daily productivity was 194 tonnes.

The production cycle incorporated four elements *(shovel log, fleet, travel to shovel or fleet and operational delays)* and accounted for 56.9% of the scheduled machine time. Fleeting incorporated that time moving logs into stacks whereas shovel logging was the time spent moving logs closer to their respective stacks. Loading trucks *(load, travel to load and wait truck)* accounted for 33.5% of the scheduled time. "Waiting for truck" delays accounted for 37% of the loading time. Mechanical and personal delays accounted for the remaining 9.6% of scheduled time (Figure 2).

Long term productivity is illustrated in Figure 3. Fluctuations in weekly production may reflect production delays or the variability of weekly log stock records. For example, during week 13 and 14, 61 loads were uplifted over four days, the following week's production was much lower. The high production associated with weeks when loadout occurred suggests log stocks were under-estimated in the weeks prior to loadout. Although loadout was planned for two days of every fortnight, achieving this was often difficult due to truck scheduling constraints and the necessity to uplift certain log grades as produced. Production for the six month period was 13,264 tonnes. The average daily production for the six month period was 133 tonnes.

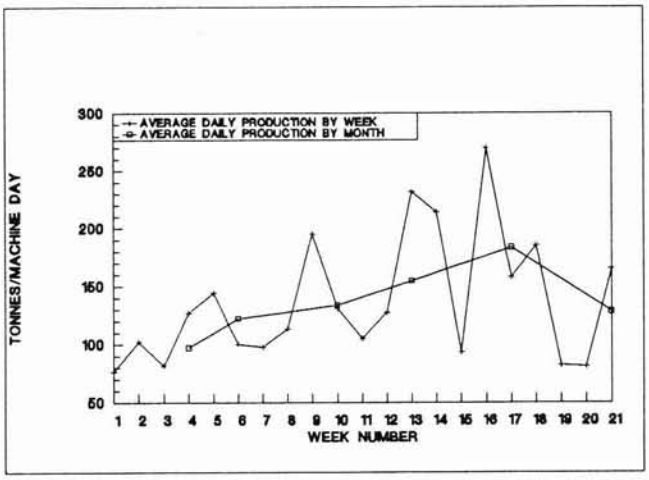

Figure 3 - Production of system for a six month period

Advantages of Excavator Roadline Harvesting System

- Excavator roadline harvesting operations do not require landings.

- The excavator has the capability to stump roadlines and carry out road formation work. The excavator is also capable of carefully placing stumps and spoil to reduce the environmental impact of roading and minimising the interference of road formation on subsequent extraction.

- The on-truck wood cost per tonne for this roadline harvesting operation compared favourably to more conventional roadline harvesting operations, i.e. rubber tyred skidder. Conventional roadline harvesting operations in similar working conditions produce approximately 200 tonnes per day.

Disadvantages of Excavator Roadline Harvesting System

- The system could be limited to fewer log sorts than more conventional type operations.

- Trucks occasionally have difficulty with access through unformed sections of road.

- Partial loads of log types left at the end of dedicated loadout days become susceptible to sapstain degrade.

- As large log stocks for this operation are common, a long time exists between imposing market driven cutting changes and the time for those changes to come into affect.

Loading and Truck Scheduling

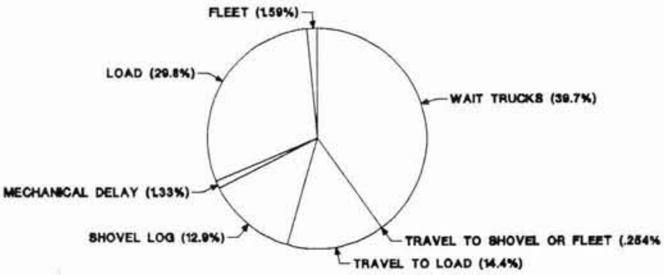

Figure 4 - Allocation of time for load out days

The time distribution for allocated loadout days is illustrated in Figure 4. The excavator was idle for a large proportion of time waiting for trucks (40%). In most conventional systems truck loading has limited impact on the overall productivity of the operation. In this system, the excavator doubles as the extraction and loading machine. Therefore, any delays to the excavator lowers system productivity increasing the on-truck wood cost.

Table 3 - Cost comparison of two systems

Cost Comparison		
Cost Centre	*Current System*	*Addition of a 20 Tonne Excavator*
PC400 Hydraulic Excavator	*760*	*760*
Operators	*155*	*310*
Fallers	*3x126 = 380*	*4x126 = 506*
Chainsaws	*4x28 = 112*	*5x28 = 140*
Stores	*32*	*45*
Transportation	*110*	*165*
PC200 Hydraulic Excavator	-	*410*
Overheads @ 2.5%	*37*	*58*
Total	*1586*	*2394*
Profit @ 10%	*158.6*	*239.4*
$/tonne rate	***13.12***	***13.12***
Required Production	*133*	*201*

Fluctuations in market requirements were identified as having the greatest overall affect on this system. With log stocks often exceeding 50 loads prior to loadout and limited weekly markets for some log types, allocations of these log types must be held for this operation so that total loadout can be achieved.

The Cost of Truck Arrival Delays

The cost of delaying the excavator (owning+lost production) is almost twice the cost of delaying a truck. Supplying excess trucks to the loading operation to reduce loading time, thus increasing the time available for extraction may well reduce the overall wood cost at the mill. Given that truck scheduling is efficient, it may be better to investigate other options to lessen the impact of "waiting for truck" delays.

Table 3 gives a comparison of two excavator roadlining systems. Costs have been derived using LIRA's costing format (Wells 1981). Indicative costs for the current system are outlined in column two.

The second system, column three (a hypothetical case), incorporates a smaller less expensive excavator for truck loading. The 40 tonne excavator has the capacity to produce approximately 194 tonnes per day. At this production rate, the smaller excavator (besides loading trucks) would be required to fleet only 9 tonne per day to maintain an equivalent on-truck logging and loading rate per tonne. The extra labour to cover the increase in production has been accounted for in the cost structure

CONCLUSION

The faller study indicated that a faller could safely fall, delimb and cut to log length 40 trees per day. At this level of faller productivity two fallers are capable of producing 136 tonne per day. It was necessary for a third saw operator to be present when the excavator was fleeting logs to stacks to, remove remaining branches or branch stubs from logs, check log quality and mark the large end of all logs.

It was identified from the ten day detailed productivity data collection that any delays resulting in lost production had a large effect on wood cost. The waiting for truck delays was identified as having the greatest affect on the day-to-day production and therefore cost of the system. One suggested method to alleviate this delay would be to over-supply this operation with trucks during loadout days. A further option to reduce the impact of waiting for truck delays could be to incorporate a smaller less expensive excavator dedicated to loading.

Loadouts scheduled early in the week provide greater flexibility for both the harvest planners and the truck schedulers. The timing of loadout is important not only from the aspect of meeting markets but also to ensure the loader can carry on with normal operation if truck delays are excessive.

At the time of both the ten day and the long term studies, the excavator roadline harvesting operation described by this Report was the most productive system the contractor had developed. Mean production for a six monthly period was 133 tonnes per day, giving an on-truck wood cost of $13.12/tonne.

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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 and do not necessarily represent the actual costs for this operation.

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