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MULTIPLE LOG SORTING WITH A HYDRAULIC KNUCKLEBOOM LOADER

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ABSTRACT

Previous studies have shown that operation on restricted landing areas is possible if log lengths are short and volume production is low. This study documented a tree length tractor operation extracting to a small roadside landing where ten logsorts were segregated. The loader system was capable of handling production levels of 200 tonnes per day. Regular truck scheduling is necessary to maintain an efficient landing layout.

INTRODUCTION

Logging operations on small landings using hydraulic knuckleboom loaders, have been described by Kellogg (1987). In this type of system, log preparation is typically completed in the bush, and relatively small log inventories are stored at the landing. The study noted, however, that there may be significant interferences and delays associated with working on restricted landing areas with tree length material. It was anticipated that a number of future logging operations will require efficient use of relatively small landings on steep terrain.

Results of LIRA studies into landing layout and organisation have shown that restricted landings are possible in operations with low volume production, short log lengths and few logsorts (Raymond, 1987). Small landing operations typically sort less than five logsorts. Whether this concept could be extended to high volume operations (> 200 tonnes per day) handling multiple logsorts has become of interest to the logging industry.

The purpose of this study was to examine the landing layout and work method of a hydraulic knuckleboom loader working in a tree length steep country logging system. The operation was selected due to its potential for high volume production and the large number of logsorts segregated on the landing.

This Report documents the organisation of the landing, and interactions between the extraction machine, loader and skiddies. The loader was timed for three days loading a variety of log types, and the loading productivity was calculated.

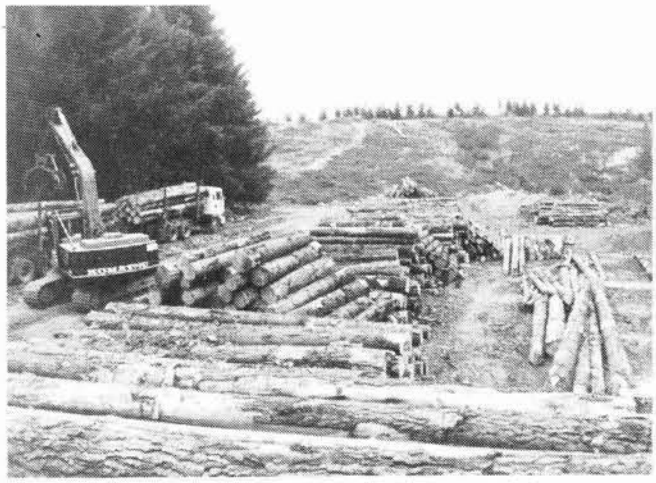

Figure 1 Layout of the Landing Operation

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STAND DETAILS

The study site was a steep section of Compartment 62 in Berwick forest with a landing constructed adjacent to a ridge top road. The stand of 31 year old radiata pine had been pruned to 5.5 m at age 14 and production thinned in 1981 to approximately 250 sph. Preharvest inventory assessment gave an extracted stem volume of 2.05 m^3.

Scaling individual extracted stems gave the following results:
Mean butt diameter (cm) - 50.6
Merch tree length (m) - 23.2
Merch tree volume (m^3) - 1.89

Figure 2 - The Loader handling Small Diameter Chipwood

LOGGING EQUIPMENT AND LANDING LAYOUT

The operation studied was a tractor crew, whose long term daily production averaged 130 tonnes per day (31,000 per annum). The mean production over the three day period of the study was 166 tonnes per day.

A 20 tonne Komatsu PC 200 hydraulic excavator-type loader was used to sort and stack processed wood and load trucks. The loader was fitted with a locally-built pulpwood-type grapple. The grapple was effective in handling both large and small diameter wood (Figure 2). The grapple arms, powered by two hydraulic cylinders, were 0.60 m wide, and had a maximum opening of 1.96 m.

Figure 3 shows the dimensions of the landing and the layout of the logstacks.

Ten different sorts were segregated on the landing: four export sorts, four grades of random sawlogs, and two sorts of chipwood. The majority of the volume was cut into three of these sorts: 12.1 m export, large pruned sawlogs and random length mill logs.

The roadside landing area measured 68 m long by 23 m wide (0.16 ha). This area comprised: log stacks (10-12 m wide); loader track (approximately 5 m wide); and the log skidding area (8-10 m wide).

Due to irregular truck scheduling, the layout was not ideal for this type of roadside operation. Lack of space between the logstacks resulted in the loader having to travel 75 m around the stacks to load trucks.

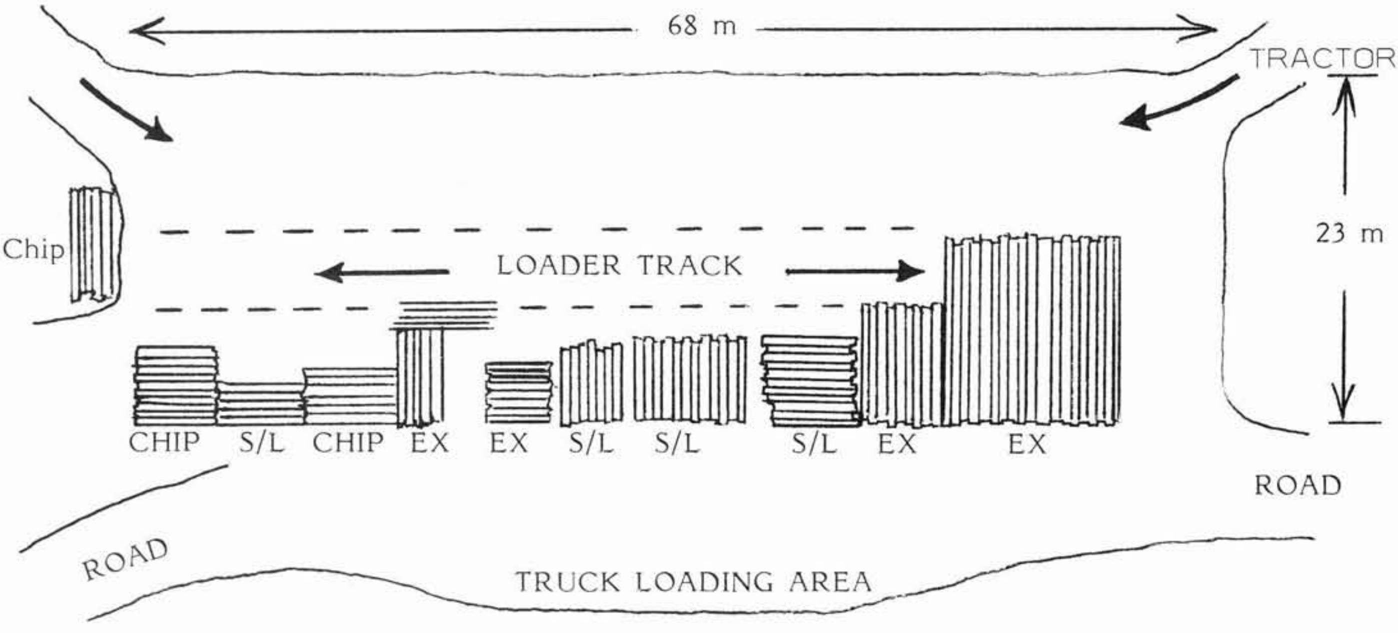

Figure 3 - Layout of the Landing

RESULTS

Landing Activity

The loader worked systematically clearing the skid (sorting and stacking processed wood), and then the operator assisted the skiddy with measuring and processing the next drag. When sorting, the loader worked close to the log skidding area, moving up and down the track to sort logs.

The sorting and stacking activity comprised the major proportion of loader time (35%). This was divided into:

(1) Stacking directly from the skid (30%)

(2) Sorting to a temporary stack and restacking at a later time (5%).

The proportion of loader time spent on various landing activities is given in Table 1.

Due to the loader operator spending a large proportion of his time off the loader doing skid work (20%), bottlenecks occurred in the sorting phase of the operation. Subsequently the major form of interference on the landing involved the tractor waiting while the loader cleared the skid. Analysis of tractor productivity shows 11 occurrences of this type of interference, averaging 3.1 mins per occasion (2% of total loader time). The other category of interference involved the loader waiting while the tractor arrived on the landing (0.2% of total time). There was no observed interference between the skiddy and either machine.

Loader idle time ranged from 3.0 to 14.5 minutes per day, dependent on both the tractor work cycles and the number of trucks scheduled. This idle time comprised only 2% of total daily time.

TABLE 1 : LOADER ACTIVITY vs TRACTOR PRODUCTIVITY
(% of Loader Time)

LOADER ACTIVITY	DAY 1	DAY 2	DAY 3	MEAN
Sort Skid	29.0	27.1	34.6	30.0
Restack	4.9	3.1	6.7	4.8
Skid Work (by operator)	25.4	16.2	18.4	20.1
Truck Loading	11.1	21.3	12.1	15.0
Truck Prep & Despatch	8.8	5.7	5.5	6.7
Travel	1.4	3.7	1.6	2.3
Interference	0.9	3.7	3.0	2.5
Idle	2.8	0.6	2.6	2.0
Non-Mechanical Delay (smoko, etc)	14.5	15.2	13.8	14.5
Mechanical Delay (maintenance)	0.9	3.3	0.5	1.6
Loader Assistance (to tractor, skiddy)	0.3	0.1	1.2	0.5
Total	100.0	100.0	100.0	100.0
TRACTOR PRODUCTIVITY				
Average Haul Distance (m)	165	92	75	108
Tractor Productivity (m^3/hr)	20.0	26.8	26.2	24.3
Trucks Loaded	4	8	4	5

ANALYSIS OF LOG SORTING

The loader operator preferred having a number of drags accumulate before sorting from the skid. An analysis of time spent sorting directly to the logstacks on Day 1 indicated that productivity was higher when sorting a number of drags, 0.95 min/m^3, than when sorting a single drag, 1.23 min/m^3.

This is influenced by the tractor cycle times and the number of trucks to be loaded. On the second day of the study, the shorter haul distances combined with the simultaneous arrival of three trucks to be loaded prevented the effective clearing of wood from the landing. Interference to the tractor increased from 2.7 mins per day on Day 1 to 18.3 mins on Day 2.

Due to poor truck scheduling, there were problems with the layout of some stacks. This resulted in a large amount of loader travel while sorting. The loader operator stressed the solution to the multiple log sort problem was in improving truck scheduling, thus enabling an efficient layout to be maintained. The use of temporary stockpiles and stacking off the edge of the landing was a common practise for this crew. Log sorting productivity is given in Table 2.

TRUCK SCHEDULING AND LOADING

Due to the restricted area for stacking logs, the scheduling of trucks for loadout becomes a critical factor.

In this study the number of logsorts (10) and level of production (166 tonne/day) was such that keeping the skids clear occupied 30% total loader time. The scheduling of trucks at regular intervals is necessary to ensure that the loader is not occupied loading several trucks to the detriment of tractor access to the landing. With a production rate of 24.3 m^3/hour, approximately one truck per hour would be required throughout the day. In this operation, truck scheduling was not under the loader operator's control. Consequently, there were instances where trucks would arrive simultaneously and where long periods passed without any truck arrivals.

The loading of seven longs trucks and nine shorts trucks was timed during the three days of the study. The average loading time for all trucks was 13.9 mins (25.3 tonnes per load).

Times for loading short and long log trucks are shown in Table 3. The loader operator had approximately twelve years' experience on excavator-type log loaders and this is reflected in the relatively short loading times.

There was no truck preparation time for shorts trucks because the trailers were towed. All logs were centre loaded due to the absence of a heel rack on the loader boom.

TABLE 2 : LOG SORTING PRODUCTIVITY

	Total Sorting Time (min per day)	Volume Sorted (m^3)	Productivity (min/m^3)	(m^3/hour)
Day 1	175	141.8	1.23	48.7
Day 2	162	170.2	0.95	62.9
Day 3	187	166.7	1.12	53.4
Total	524	478.7	1.10	54.8

TABLE 3 : TRUCK LOADING WORK CYCLE
(Mean minutes per load and 95% Confidence Limits)

TRUCK TYPE	No	LOADING CYCLE [1]	OPERATIONAL DELAYS [2]	TOTAL LOADING TIME	TRUCK PREPARATION [3]	DESPATCH [4]
Longs	7	12.74 (± 0.81)	0.66 (± 0.63)	13.40 (± 0.76)	7.34 (± 1.93)	3.80 (± 0.29)
Shorts	9	12.69 (± 1.87)	1.63 (± 0.58)	14.32 (± 1.82	- -	2.70 (± 1.88)

[1] Loading Cycle comprises picking up logs, swing load and swing unloaded.

[2] Operation Delays such as selecting and adjusting logs, move time etc.

[3] Truck Preparation consists of unloading trailer and hooking up.

[4] Despatch is the time taken to write the load docket.

Factors Affecting Loading Time

Loading productivity is give in Table 4. Data for all sawlog loads was analysed to investigate the variables that influenced total loading time.

As discussed in a previous study of wheeled loaders (Twaddle, 1979), there are three variables that affect loading time within a given log size. These are:

- the number of logs loaded
- the volume of wood loaded
- the number of loading cycles taken to load the truck

Linear regression equations relating these variables to loading time were calculated for the hydraulic excavator-type loader.

Load time - 4.41 + 0.70 (load vol, tonnes) + 0.062 (No. boom swings),(mins) ($r^2 = 0.49$)

Load time = -5.53 + 0.77 (load vol, tonnes) + 0.012 (No. logs per load), (mins) ($r^2 = 0.48$)

Thus, for this class of loader, loading sawlogs ranging from 4.1 to 12.1 m in length, an estimate of load time can be calculated from easily measured variables.

Figure 4 - Truck Loading on the Widened Roadside

TABLE 4 : LOADING PRODUCTIVITY
(Mean and 95% Confidence Limits)

TRUCK	TOTAL LOADING TIME (min)	NO. OF LOGS PER LOAD	TRUCK PAYLOAD (tonnes)	NO. BOOM SWINGS	TIME PER SWING (min)	LOADING PRODUCTIVITY (min per tonne)
Longs	13.40 (± 0.82)	18.4 (± 0.7)	24.44 (± 0.80)	12.3 (± 0.45)	1.04 (±0.09)	0.55 (±0.03)
Shorts	14.32 (± 1.93)	51.9 (±20.5)	25.99 (± 0.94)	20.4 (± 2.0)	0.62 (±0.08)	0.55 (±0.07)

CONCLUSIONS

The typical landing layout for this operation (with stacks along the roadside and spaces between for loader access to the roadway) was very effective in minimising the constructed area of the landing.

Despite the large number of logsorts handled on the landing, the loader managed to effectively sort and stack processed wood and load trucks. The proportion of time the loader caused interference to the hauling phase of the operation, (2.5%), could have been reduced by the loader operator spending more time sorting the processed wood rather than assisting with the skidwork. The high proportion of time the operator spent off the loader doing skidwork is evidence that the loader system was capable of handling higher production.

On Day 2 of the study, eight trucks were loaded. It is felt that if the layout of the landing was altered to give better access for truck loading, loader production could easily have exceeded 200 tonnes per day.

This study showed that the scheduling of trucks is the critical factor affecting the productivity of the whole operation. Matching the production rate of the tractor without subsequent build up of logstacks required one truck per hour throughout the day. The problems caused by irregular truck scheduling are evidence that the loader operator should direct the truck schedule through radio communication with the various mills.

The landing size was 0.16 ha, which was possibly larger than that required given regular truck scheduling. Traditionally, log landings in New Zealand have been very large and their size is influenced mainly by production factors such as tree size, daily production rates and the number of logsorts segregated (Raymond, 1987). This study of a medium production rate operation has shown that processing to ten different logs sorts on a small landing is possible with the use of a hydraulic knuckleboom loader. This continuous roadside landing layout would also be suitable for higher production operations.

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