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SMALL LANDING OPERATIONS USING A MOBILE HAULER AND KNUCKLEBOOM LOADER

Loren Kellogg

ABSTRACT

A detailed study of work methods on a small landing area cable operation was undertaken. The smallest utilised landing area was 0.07 hectares (25 metres by 28 metres) and logs were sorted and stacked in a radial pattern around the hauler and loader. Truck scheduling was co-ordinated between the loader operator and mill yard dispatcher. Truck loading times averaged 19 minutes and 13 minutes for shorts and longs log trucks respectively. Interferences to the hauling operation by the loader or skiddies comprised less than 1%. The effect on landing operations was compared between two different levels of log preparation completed in the bush. Both options helped toward achieving a smooth flow of wood over the restricted working area.

INTRODUCTION

The proportion of future harvest from regions such as the East Coast, Hawke's Bay, Taranaki and Wanganui-Manawatu is projected to increase (Galbraith and Liley, 1986). These areas are characterised by more difficult and less stable soils and a higher proportion of steep terrain. Thus many of the past logging methods and management practises will need to be re-evaluated in view of new constraints.

One such area is the landing. Most current cable and skidder landings involve a relatively large area. Smaller landings may be more appropriate in many future operations because of :

- high construction cost
- the difficulty of constructing large landings on some steep terrain conditions (e.g. midslope roads)
- the use of more mobile logging equipment (e.g. Washington 88 or Madill 071)
- land taken out of tree growing production

Operations on small landing areas have been common practise in the Pacific Northwest of the United States. In that region, the use of hydraulic knuckleboom loaders with cable hauling systems is one factor that makes the use of small landings feasible. In addition, most of the log preparation is completed in the bush and relatively small log inventories are stored at the landing. Often there are many log sorts segregated on the landing, similar to New Zealand operations.

The purpose of this study was to evaluate the use of an hydraulic knuckleboom loader working on a relatively small landing with a cable hauling system. Of particular interest was the identification of interferences and delays between hauling, log preparation, sorting and loading in a restricted work area. A comparison of landing operations with two different levels of log preparation in the bush was also completed.

This study is part of a larger LIRA work programme concerned with landings and cable hauling systems. This Report is a summary of the full Project Report on the study (Kellogg, 1987(a)).

ACKNOWLEDGEMENT

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STUDY DESCRIPTION

Trial Area

The study site was a 62 year old stand of Douglas fir in Kaingaroa Forest. Crop details are :

Stocking	- 217 stems/ha
Merchantable Volume	- 741 m^3/ha
Mean DBH	- 58 cm
Mean Merchantable Tree Volume	- 3.4 m^3

Two log preparation treatments were undertaken and their effect on landing operations were studied. The two treatments reflect a relative difference in the amount of log preparation completed in the bush :

- "Partial" log preparation involved cutting one long log from the butt section of the tree after felling. The remainder of the tree was crosscut on the landing.

- "Complete" log preparation was where two long logs were cut from the tree in the bush. Broken portions of the tree above these two cuts were also hauled to the landing and cut into a random short length. Thus the total tree was not completely processed in the bush.

Both treatments required crosscutting on steep slopes up to 35° (70%). Trees were felled across the slope for crosscutting and trimming (Figure 1).

Figure 1 - Cross slope felling and crosscutting completed in the bush

Logging Equipment and Procedure

The hauler studied was a Madill 071. This machine is highly mobile with; a tank track carrier, three guylines, 15 metre tower and five operating drums that provide line capability up to approximately 500 metres. A variety of cable systems were used for uphill hauling. The study area had been previously laid out and large landings were constructed for "conventional hauling" with a big tower and front-end loader. This study was limited to working with the existing layout. The operation was restricted to the smallest landing area required, hence only a portion of the total available area was used. Maximum haul distances were approximately 230 metres, with an average of 135 metres. Average production rates ranged from 140 to 175 m^3 per day.

A 30 tonne Sumitomo Link Belt 4300 hydraulic knuckleboom log loader was used in conjunction with the Madill 071. The Sumitomo was fitted with a Prentice 610 boom and Pierce designed log grapple and heel rack. Lifting tests conducted by LIRA with Tasman Forestry Limited showed a maximum capacity of 12.6 tonnes at the minimum radius of 4.35 metres. At maximum reach (9.75 metres), the loader could lift 5.1 tonnes. Small increases in lifting capability over those reported would be possible through the addition of extra counterweighting.

Figure 2 - Madill 071 and Sumitomo loader working from a central location

The loader worked close to the hauler and log sorting was completed from a central location (Figure 2). There were four landing sorts, with the majority of wood fitting into three sorts; 12.3 metre long logs, random

short logs (less than 6 metres) and short pulp. The fourth sort was 9.8 metre long logs. Truck scheduling was completed by the loader operator and mill yard dispatcher through radio communication.

Study Methods

A work sampling study was conducted on the landing activities for the skiddies, hauling and loading operations. Activities were recorded at a 1 minute interval. The proportion of time spent in the various activities, along with interferences, delays and idle times, was determined.

A detailed time study was also conducted on the log loading operation to determine truck loading times. A total of 32 trucks were timed (10 shorts trucks and 22 longs trucks).

Loader availability, utilisation and fuel consumption was recorded by the operator over the 28 day study period. The landing layout was measured for each landing configuration, partial and complete log preparation.

RESULTS AND DISCUSSION

Landing Layout

A typical layout of the landing organisation is shown in Figure 3. There was a log preparation area between the hauler and loader where the skiddies could work away from the hauler ropes. Partially prepared trees were repositioned from the landing chute to this work area as much as possible. After trimming and crosscutting, logs were fleeted to stacks in a radial pattern around the loader. Logs trimmed and crosscut in the bush could be directly fleeted from the landing chute.

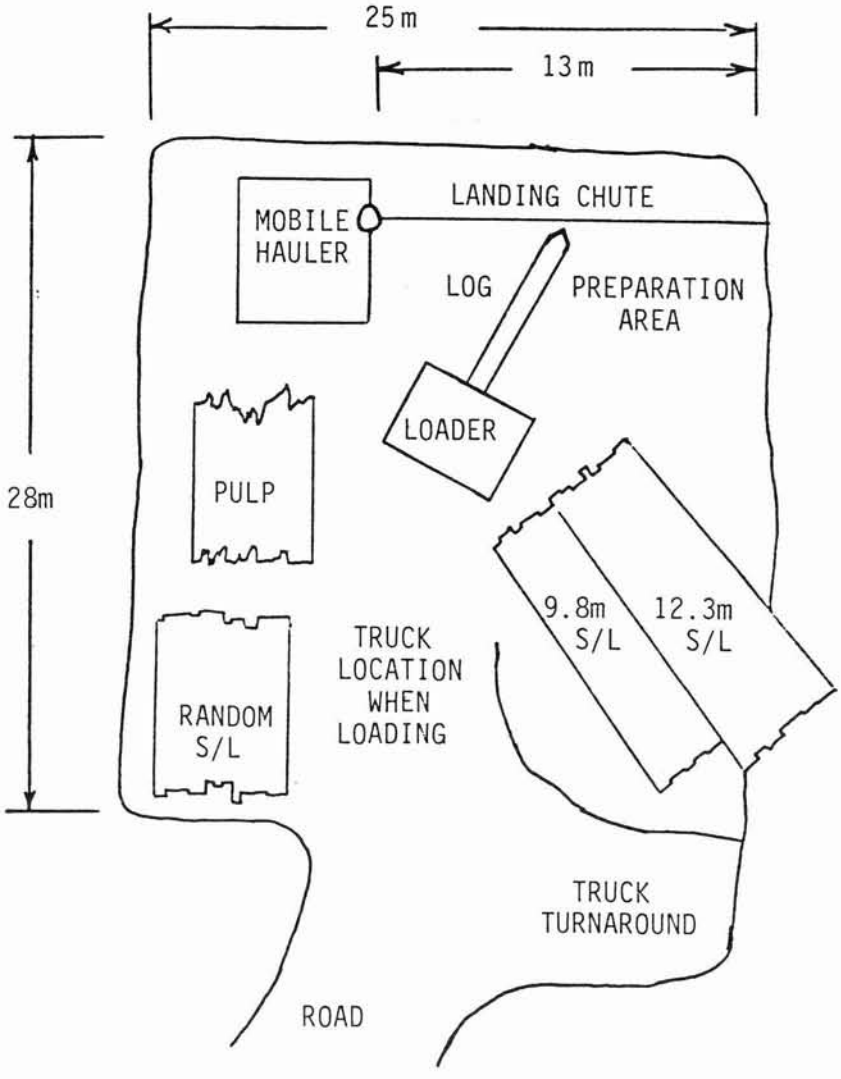

Figure 3 - Representative Landing Layout

Long log sorts were stacked adjacent to each other with some overlap at the base of the stack. Short logs and pulp were stacked approximately parallel with the loader with a small space in between the sorts. Where space is more limiting than occurred in this study, it would be feasible to stack the short logs in a radial pattern around the loader similar to the long logs.

Approximately 0.07 hectares (25 metres by 28 metres) was used in the most common layout. It was advantageous to locate the mobile hauler as close to the landing edge as possible to avoid ground clearance problems. The shortest landing chute length was 13 metres when hauling logs. The maximum length was 42 metres when hauling partially prepared trees. It is likely that the utilised area of 0.07 hectares could have been reduced further with an operation on a purpose-built restricted landing area.

Truck scheduling is an important factor when working in a restricted area. The logging operation should be viewed as a whole system with the individual elements such as hauling, loading and cartage working together. In a restricted landing, there is little space for maintaining large log inventories. The loader must help to keep the hauling operation running smoothly as well as loading trucks. Therefore trucks need to be scheduled into the operation at regular intervals throughout the day. The loader operator should also have the ability to order more trucks or cancel trucks if the need arises.

Interactions on the Landing

Loader

The proportion of time spent on loader activities is shown in Table 1 for both complete and partial log preparation treatments. Sorting logs comprised the

Table 1 - Loader Work Content

ACTIVITY	LOG PREPARATION METHOD: COMPLETE PROPORTION OF TIME (%)	COMPLETE RANGE* (± %)	PARTIAL PROPORTION OF TIME (%)	PARTIAL RANGE* (± %)
Sorting logs	35.9	2.1	33.9	1.9
Truck loading	12.9	1.4	16.6	1.5
Assisting skiddies[1]	5.1	1.0	6.7	1.0
Assisting hauling[2]	0.5	0.5	0.5	0.5
Interference - skiddies[3]	13.5	1.5	12.9	1.3
Interference - hauler[4]	9.0	1.2	8.5	1.2
Idle	11.3	1.3	8.9	1.2
Clean landing	2.0	0.6	3.1	0.7
Other[5]	9.8	1.1	8.8	1.2
Total	100.0		100.0	
Sample Size (1 minute observations)	1913		2425	

* 95% confidence level that the proportion of time for each activity is within the ± range.

Activity Definitions :

1 Assisting skiddies - mainly involves the relocation of partially prepared trees from the area in front of the hauler to an adjacent location safe for work.

2 Assisting hauling -mainly involves loader assistance during unhooking and line shifts.

3 Interference - skiddies - is where the loader is delayed because skiddies are in the way due to log preparation

4 Interference - hauler - is where the loader is delayed because of hauling operations, such as landing logs and line shifts

5 Other - is a miscellaneous category that includes loader refuelling, maintenance, repair and non-mechanical delays.

largest portion of time, at around 35% for both treatments. The truck loading proportion of time varied between treatments. This was mainly due to the relative numbers of trucks loaded for each treatment in relation to the sample size.

"Assisting skiddies" was higher (significant at the 95% level) for the partial log preparation treatment compared with complete, as expected. The proportion of time spent assisting skiddies in complete log preparation could be reduced because many of the logs set aside for the skiddies only involved minor trimming (often not needed) or because some logs already prepared in the bush were re-measured. Time could be saved by directly sorting logs from the landing chute.

"Assisting hauling" averaged 0.5% for both treatments and mainly occurred during hauler line shifts. When trucks were being loaded, the loader operator usually did not assist the skiddies or hauling. This generally did not cause hauling delays because loading time was relatively short (Table 4) and trucks arrived at the landing at varying intervals rather than at the same time.

Loader idle time occurred when there was no work to do, usually during line shifts or hauler delays. The "clean landing" activity was slightly higher for the partial log preparation treatment as would be expected.

Skiddies

The proportion of time spent in skiddy activities is shown in Table 2 for both complete and partial log preparation treatments. The number of skiddies varied from one to four, with a weighted average for both treatments of 2.5.

Table 2 - Skiddies Work Content

	LOG PREPARATION METHOD			
	COMPLETE		PARTIAL	
ACTIVITY	PROPORTION OF TIME (%)	RANGE* (± %)	PROPORTION OF TIME (%)	RANGE* (± %)
Unhook logs	4.8	0.7	6.7	0.7
Log Preparation:				
Measuring/marking	6.3	0.8	8.3	0.7
Crosscutting	1.5	0.3	5.5	0.6
Trimming broken ends	2.1	0.4	3.5	0.5
Cutting slovens	1.2	0.3	2.1	0.4
Delimbing	7.4	0.8	5.3	0.6
Total log preparation	18.5	1.2	24.8	1.2
Assisting[1] - Hauling or Loader	6.1	0.8	8.2	0.7
Waiting[2] - Hauler or Loader	60.2	1.5	47.9	1.4
Other[3]	10.3	0.9	12.4	0.9
Total	100.0		100.0	
Sample Size (1 minute observations - all skiddies)	4186		4887	

* 95% confidence level that the proportion of time for each activity is within the ± range.

1 Assisting mainly occurs for hauling, during line shifts

2 Waiting on hauling occurs when there are no trees on the landing for log preparation and it occurs during line shifts. Waiting on the loader occurs when the loader's activity interferes with work that could be completed by skiddies.

3 Other is a miscellaneous category that includes saw refuel and repair, saw stuck and non-mechanical delays.

The longer unhooking time in the partial log preparation treatment was mainly caused by difficulties associated with the North Bend cable system. Different cable systems (gravity and slackline) were used for the area with the completely prepared logs and unhooking difficulties were reduced.

There was a significant difference (99% confidence level) between log preparation time for the two treatments. As expected, more time was spent in the partial log preparation option, with most of the difference attributed to crosscutting time. As previously discussed, the skiddies spent a higher proportion of their time in log preparation with the complete preparation treatment than was required. This was primarily a function of the high number of skiddies and because they were working with a new technique.

The skiddies spent most of the time waiting for work, especially in the complete log preparation treatment. The majority of waiting time was attributed to the hauler rather than the loader.

Only one skiddy was required all the time with complete log preparation and it is interesting to compare the time for one skiddy with those shown in Table 2 :

One Skiddy
Complete Log Preparation

	Proportion	*Range*
Total log preparation	*32.3%*	*± 3.3*
Waiting	*41.2%*	*± 3.5*

There is a significant difference (at the 99% level) between complete log preparation with one skiddy and partial log preparation with an average of 2.5 skiddies. As expected, one skiddy spent less time waiting and more time working on log preparation, thus being more fully utilised. Two skiddies were adequate to keep up with the work load in partial log preparation.

Hauling

The proportion of time spent during hauling for the two log preparation treatments is shown in Table 3. Interference from either the loader or skiddies is minimal in both treatments. Hauling operations were not delayed from working in the relatively restricted landing area.

Table 3 - Hauler Work Content

	LOG PREPARATION METHOD			
	COMPLETE		PARTIAL	
ACTIVITY	PROPORTION OF TIME (%)	RANGE* (± %)	PROPORTION OF TIME (%)	RANGE* (± %)
Hook	31.2	2.1	24.3	2.3
Inhaul	19.6	1.8	20.6	2.2
Unhook	11.9	1.4	16.4	1.9
Outhaul	12.6	1.4	8.8	1.6
Hauling delays[1]	1.2	0.4	2.2	0.7
Other delays[2]	7.2	1.1	3.9	1.1
Interference - Loader[3]	0.2	0.5	0.1	0.5
Interference - Skiddies[4]	0.1	0.5	0.0	0.0
Line Shift	16.0	1.6	23.7	2.3
Total	100.0		100.0	
Sample Size (1 minute observations)	1913		1402	

* 95% confidence level that the proportion of time for each activity is within the ± range.

1 Hauling delays occur while logs are hauled to the landing

2 Other delays are delays outside the normal hauling cycle and include rigging equipment, wire rope or hauler problems

3 Interference - Loader occurs when loader activity delays the hauling operation

4 Interference - Skiddies occurs when skiddy activity delays the hauling operation

Data showed differences in hauling activities that can be attributed to differences between log preparation methods, cable systems and hauling direction (covered in a separate LIRA Report, Kellogg, 1987(b)).

TRUCK LOADING

Times for loading shorts and longs log trucks are shown in Table 4. The loading times are with an operator that had previous experience on an 18 tonne hydraulic knuckleboom loader before this trial with the 30 tonne loader.

Truck preparation time was only about 1.5 minutes longer for the shorts trucks compared with the longs trucks. Logs were loaded on both truck types from the back of the truck (Figure 4).

Truck loading times were about five minutes longer for short logs compared with long logs (mean number of logs per load was 75 and 20 respectively). With long logs positioned at approximately a 35° to 45° angle from the truck, there was a minimum distance to swing logs from the log deck to the truck. Also, the loader was positioned behind the truck and adjacent to the log deck so that it could easily grab logs and immediately place them in a heeling position for loading. Little time was spent adjusting the log in the grapple before swinging. Short logs were not heeled when loading; they could be easily rotated in the grapple (if needed) while swinging logs from the deck to the truck. There was approximately a 90° angle for swinging short logs.

Figure 4 - Sumitomo loader end-loading 12 metre long logs

LOADER DELAYS

The mechanical availability of the loader for the 28 days of the study was 95%. There were 2.9 hours lost to a broken hose (one occurrence) and a broken O-ring on the main hydraulic control bank (one occurrence). An additional 3.8 hours of delay was attributed to the grapple (one occurrence). Accounting for smokos and personal delays, the machine was used 87% of the time.

Adding in the operational delay times (loader waiting for work) of 11%, resulted in a machine utilisation of 76%.

The fuel consumption rate was 15.4 litres per operating hour.

Table 4 - Truck Loading Times

(Mean and Range : Minutes per Load)

TRUCK TYPE	NUMBER OF OBSER-VATIONS	LOADING CYCLE[1]	DELAYS[2] FOREIGN ELEMENTS	TOTAL	TRUCK PREP-ARATION[3]	NO. OF LOGS PER LOAD
Shorts	10	16.6 (13.8-19.6)	2.2 (0.0-4.0)	18.8 (14.7-25.7)	4.5 (2.6-5.8)	75 (54-107)
Longs	22	12.1 (7.3-25.8)	1.2 (0-4.0)	13.3 (7.5-26.6)	2.9 (2.1-4.8)	20 (12-37)

[1] Loading Cycle consists of three elements : sort logs in deck, swing load to truck and adjust logs on truck, if needed, swing unloaded back to deck.

[2] Delays that occur during the loading cycle and stop work. Foreign elements that occur occasionally during the loading cycle, such as moving the loader to a new position.

[3] Truck Preparation is the time to unload the trailer and hook up

CONCLUSIONS

This study showed an effective use of a hydraulic knuckleboom loader working on a restricted landing area with a cable hauling system. The main study conclusions related to landing size and organisation are :

- there were minimal interferences and delays between hauling, log preparation, sorting and loading in a restricted work area. The landing activities integrated well and there was a smooth wood flow from the bush to the truck. Scheduling of trucks was an important factor for the success of this operation.

This conclusion is, however, limited to the characteristics of the case study (e.g. hauler production level, number of log sorts and landing space utilised). More time would be required for fleeting or truck loading in a system with a higher production level, less available landing space, or more log sorts. The study data indicates, however, that there is potentially more time available for the loader to work on fleeting or truck loading than occurred in this study.

- the results of landing interference and delays were similar between partial and complete log preparation options. Complete log preparation as carried out in this study, involved only one additional log cut than partial log preparation.

It appears that there are further opportunities available in other conditions when a substantial portion of the log preparation is completed in the bush. Firstly, less loader time is spent assisting skiddies to complete log preparation. More time can then be spent on loading. Secondly, the number of skiddies can be reduced when more of the log preparation work is completed in the bush. The extra skiddy would contribute more towards breaking out or felling and log preparation. Thirdly, the hauler can be positioned closer to the landing edge when hauling the shorter pieces. This is an advantage when ground clearance is limiting on the cable span, especially close to the landing edge with short tower mobile haulers.

There may be significant interferences and delays when working on restricted landing areas with tree length material. A truly complete preparation of all logs in the bush may result in too many small pieces for hauling. Therefore, in addition to landings, felling practices and hauler production rates need to be studied further for different log preparation options.

- the smallest utilised landing area, with four log sorts and complete processing, was 0.07 hectares (25 metres x 28 metres) including a landing chute of 13 metres. Partial log preparation required a longer landing chute; other space requirements were similar. There are opportunities for working on a smaller landing area and increasing the number of log sorts.

- general observations regarding landing layout :

* loader activities should be confined to an area adjacent to the hauler with minimal movement around the landing.

* when operating on a central landing, log sorts should be located radially around the loader with the piles slightly overlapped at the base. A similar concept could be followed for a continuous roadside landing; log sorts can also be arranged adjacent to each other on both sides of the road.

* the location and space needed for each log sort is influenced by the relative proportion of wood in each sort, and how fast the hauler is changing lines and adjusting position on the landing (more critical with a mobile hauler). Also important is the direction that the hauler is moving; either towards existing log sorts or away from them.

* non-excavated, cutover areas, outside the designated landing area, can often be used for stacking logs.

It is anticipated that a substantial number of future logging operations will require efficient use of relatively small landing areas on steep terrain. LIRA will continue investigating these possibilities.

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For further information, contact:

N.Z. LOGGING INDUSTRY RESEARCH ASSOC. INC.
P.O. Box 147,
ROTORUA, NEW ZEALAND.

Telephone: (073) 87-168

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