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MECHANISED DELIMBING AT A CABLE LANDING

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ABSTRACT

A stroke boom delimber achieved a production rate of 82 logs per productive hour delimbing and processing second growth timber in a cable logging operation on the Oregon Coast Range. Delimber utilisation was relatively low at 42.6 percent. Factors contributing to low utilisation were low stand volume being logged, a production quota limit, insufficient yarding production to balance delimber capability, and interferences on the small landing due to the hot logging operation. Opportunities to enhance logging system efficiency are discussed.

INTRODUCTION

The impact of high labour costs on second growth logging has forced Pacific Northwest contractors to consider mechanising their limbing and cutting to length activities. Manual limbing and cutting to length processes consume between 50 to 70 percent of delay free felling and crosscutting time in conventional small tree harvesting operations (Burrows, 1983; Lucas, 1983; Kellogg et al 1986). Twenty-seven percent of all logging industry accidents occur during manual limbing and crosscutting operations (Anon, 1982). With Worker's Compensation rates in excess of 30 percent of wages throughout the region, demand for labour reducing log processing machinery has grown substantially. Discussions with equipment dealers in the Pacific Northwest indicate a major increase in the number of delimbing machines which have been placed in service since the 1985 industry survey of Schuh and Kellogg (1988).

While several delimbing/processor machines are capable of manufacturing precision-length log segments, only a few such as the larger Roger delimber are capable of merchandising trees up to 76 cm in diameter. The Roger is a stroke or boom delimber manufactured by Equipment Denis, Inc. of Canada. It has a 19 m long single-piece boom and can manufacture logs up to a maximum length of approximately 15 m in a single stroke. The large diameter capacity and long stroke length gives the Roger the ability to handle most of the second growth conifer timber in the Pacific Northwest region. Stroke-boom delimbers are rugged machines, a study conducted on two Roger machines, Giguere (1981), reported a long-term mechanical availability of 90 percent.

Stroke-boom delimbers are most productive when used at large roadside "cold decks" where yarding or skidding activities are completed prior to delimbing. The restrictions of steep or sensitive terrain in the Pacific Northwest however, result in cable logging operations working on small, concentrated landings, where yarding, delimbing, processing and loading activities must occur simultaneously. In such "hot logging" situations, mechanised processing costs are heavily influenced by yarding productivity.

In an application of a delimber/bucker at a cable landing, Selby and Horsfield (1986) attributed low delimber utilisation to insufficient yarding productivity. In addition to the inability to balance system production rates, equipment workspace interference and the cumulative effects of equipment downtime cause utilisation problems. If negative machine interactions are too severe, the application of capital intensive processing technology may be inappropriate.

In this study, several important aspects affecting the applicability of stroke-boom delimbers operating in western Oregon second growth conifer harvesting operations were studied. The objectives were to:

(1) determine the productivity of a stroke delimber working at a cable landing,

(2) examine how yarding and loading activities interact with and affect delimber productivity, and

(3) to examine how machine interactions affect landing layout requirements.

ACKNOWLEDGEMENTS

Logging was conducted by Don Whitaker Logging, Inc. of Oakland, Oregon. The study site was located on Georgia Pacific Corporation land in southwest Oregon.

STUDY METHODS

Simultaneous time and motion studies on the stroke-boom delimber, yarder and log loader were conducted during a two week period in August of 1987. Short-term utilisation and mechanical availability figures were determined for each machine. Productivity was determined from piece count and average piece size data. Area requirements for each machine were established by recording the landing layout at two different locations.

STUDY SITE DESCRIPTION

The study was conducted in a second-growth Douglas Fir and cedar clearfell operation near Powers, Oregon. The stand was a relatively young aged mixture of hardwoods and conifers stocked at around 170 trees/ha (approximately 200 m^3/ha). Tree size averaged 40 cm DBH. The block had been manually-felled prior to yarding. During felling operations, butt logs with butt diameters exceeding 76 cm were limbed and bucked manually.

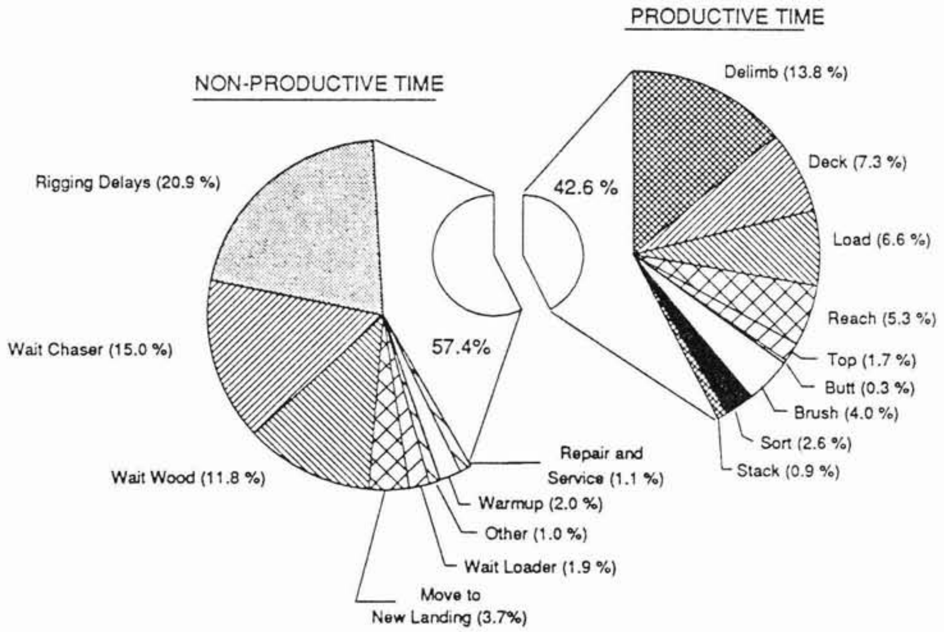
Figure 1 : The Madill 122 with Roger delimber and Barko loader on Landing 2

Machinery at the landing included the Roger delimber which was mounted on a tracked Northwest Timbermaster 45K carrier, a Madill 122 swing yarder, and a hydraulic knuckleboom log loader, also mounted on a tracked carrier. The yarding crew consised of two chokersetters (breaker-outs), a rigging slinger (chief breaker-out), one chaser (skiddy), and the yarder operator (hauler driver). Two log sorts were made at each landing. Because of an excess supply of logs at the mill, logging productivity was restricted to a quota of six truckloads-per-day. The log loader commonly loaded out the first truck before yarding operations began each day.

RESULTS

Delimber

The delimber processed a total of 1434 logs in 17.5 productive hours, for a production rate of 82 logs or 76.7 m^3 per productive hour. Delimber utilisation was low however, at only 42.6 percent of the scheduled operating hours (Figure 2). In total, the delimber worked 41.1 scheduled hours during the study. The average volume per log produced was 0.94 m^3. Log lengths ranged from 2.4 - 13.4 m (plus trim), with an average length of 10.4 m.



NON-PRODUCTIVE TIME:

DISTURBANCE TIME:

- WAIT BUCK: A delay activity, where the delimber is idle because the chaser is manually processing a tree segment in the landing chute.
- WAIT CHASER: The delimber waits for the yarder to position a turn into the landing chute, or for the chaser to unhook the turn, before it can continue working.
- WAIT WOOD: Idle time, when no wood is available at the landing for processing, and the yarder is productively engaged in the yarding cycle or hangup activities.
- WAIT LOADER: A delay occurring when the delimber must wait for the log loader to clear out the working circle before it can resume processing.
- RIGGING DELAYS: Delays caused by the rigging crew changing cable roads or making cable repairs.
- MOVE TO NEW LANDING: The total time required to take down, move, and set up all logging equipment between landings.

REPAIRS AND MAINTENANCE (common to the delimber, yarder and loader)

- REPAIRS: Time spent actively repairing the machine.
- SERVICE: Time spent fueling and lubricating the machine. Also includes WARMUP time if servicing occurs simultaneously.
- WARMUP: Time occurring while the machine is warmed up at the beginning of a shift or cooled down at the end of a shift.

PRODUCTIVE TIME:

ACTUAL PRODUCTIVE:

- REACH: Reaching or swinging the empty grapple head to a tree segment.
- LOAD: Acquiring and loading a tree segment for processing.
- BUTT: A bucking cut made with the butt trimming saw.
- DELIMB: Removing limbs by sliding the delimbing grapples along the stem bole.
- TOP: A bucking cut made with the topping saw.
- DECK: Placing a processed log segment on the outfeed deck.

OTHER PRODUCTIVE:

- STACK: Acquiring, loading, decking a manual processed log.
- BRUSH: Removing and piling slash and debris.
- SORT: Sorting or spreading tree segments. This activity also includes attempts to turn top-first tree segments around for butt-first processing.

Figure 2 : Total time distribution for the Roger stroke delimber

The typical operating cycle included the REACH, LOAD, DELIMB, TOP and DECK[1] activities, together accounting for nearly 35 percent of total scheduled time. The DELIMB activity was the largest single productive time element. The butting saw was used infrequently. The BUTT activity occurred on only 5% of the pieces processed. Mean times for cycle elements are shown in Table 1 for the delimber, yarder and loader.

Other productive time elements, those activities not directly related to the delimber's processing cycle, accounted for an additional 7.5 percent of scheduled hours. The BRUSH activity typically occurred during slack times, while the delimber was waiting for wood to process. Therefore, BRUSH time could have been placed in the WAIT WOOD or RIGGING DELAY non-productive time categories.

Much of the time lost to the SORT activity was attributable to the large number of tree segments yarded to the landing top-first. It was difficult for the delimber to turn these pieces around for processing and it was generally unsuccessful without the assistance of the loader. This was also the primary cause of the WAIT LOADER non-productive time.

Over 20 percent of scheduled operating time was lost to yarder RIGGING DELAYS consisting of cable road changes and cable repairs. WAIT CHASER delays, which included all times when the delimber could not process logs because of productive yarding activites occurring in the chute[2] were also a major source of non-productive time. WAIT WOOD delays occurred when there was no wood available at the landing for processing while the yarder was productively engaged in inhaul, outhaul, hook or hangup activities. Most of the MOVE TO NEW LANDING delay was also attributable to yarder rig down, move, and rig-up delays. Very little operating time was lost to loader-related (WAIT LOADER) non-productive time.

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[1]*See Figure 2 for description of delimber production activities.*

Yarder

The yarder brought in a total of 1098 pieces, or 1389.6m^3 over a total of 27.6 productive hours, for a production rate of 50 m^3 per productive hour. Trees had been cut into an average of 1.35 logs prior to extraction. Pieces were yarded in the form of either whole trees (average size 1.28 m^3); tree segments (broken or bucked segment of a whole tree) or processed logs (exceeding 76 cm in butt diameter). The yarder was observed for a total of 41.5 scheduled hours over the course of the study.

Seventy-three percent of the turns yarded during the study occurred at landing 1. The cable system was rigged in a Grabinski (scab skyline) configuration while the yarding progressed counter-clockwise through the first four yarding roads studied. As deflection increased, it became time consuming to slack the tailrope sufficiently to drop the chokers to the ground and, the rigging was changed to a mechanical slack-pulling carriage system. In total, the yarder was rigged with the carriage for approximately 51 percent of the turns yarded at landing 1. The average external yarding distance at landing 1, during the study, was 311 m. A mobile tailhold was used on all of the cable roads studied.

At landing 2, the cable system was rigged in a highlead configuration for the small portion of downhill yarding in the unit. As the yarding distance increased, the system was changed to a Grabinski (69% of the total turns to this landing). The average external yarding distance was 152 m; stumps were used for tailhold anchors.

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[2]*Landing chute is the area between the yarder and landing edge where trees or logs are dropped for unhooking; see Figure 6.*

Table 1 : Operating Cycle Element Times
(All times in centi-minutes)

Activity	Sample Size	Mean	Standard Deviation
A. Delimber			
Actual Productive			
Reach	1338	9.6	6.2
Load	1332	12.1	6.6
Butt	69	10.2	7.9
Delimb	1356	24.7	13.6
Top	1313	3.2	2.4
Deck	1311	13.4	7.3
Other Productive			
Move	4	30.8	11.5
Sort	272	23.5	14.0
Brush	307	32.3	29.6
Stack	71	30.3	15.0
B. Yarder			
Actual Productive			
Hook	321	188.4	92.6
Inhaul	311	117.0	46.7
Unhook	305	89.0	51.3
Outhaul	308	86.4	34.5
Lateral Inhaul	122	24.3	9.6
Lateral Outhaul	115	77.1	24.1
Other Productive			
Hangups	28	106.2	79.1
C. Loader			
Actual Productive			
Deck	914	41.5	23.6
Load	1029	40.2	18.1
Clear Chute	142	64.2	47.4
Other Productive			
Sort	99	34.1	14.7
Spread Deck	13	51.6	56.8
Brush	94	79.6	86.5
Unload Trailer	36	170.6	86.7
Walk Between Decks	5	218.2	155.0

1. Note that element times are per occasion not per cycle.

For both landings combined, yarder utilisation averaged 66.5 percent, with the HOOK[3] time element accounting for almost 25 percent of the total scheduled operating time (Figure 3). The amount of time attributable to HANGUPS was minimal and reflected the good deflection available at the site. When the mechanical slackpulling carriage was in use, 14% of the time was occupied with lateral in and outhaul. However, because less than 40% of all turns studied at both landings occurred with a mechanical slackpulling carriage, overall only 5 percent of the total scheduled time was attributable to lateral yarding activities.

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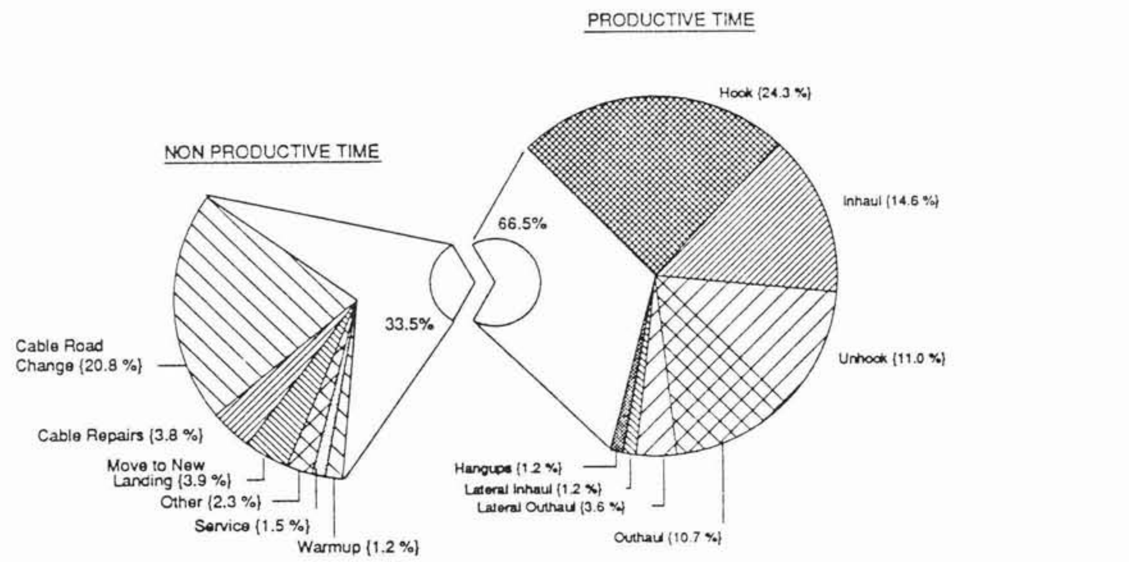
[3]*See Figure 3 for description of yarder production activities.*

The majority of the yarder's non-productive time was spent in CABLE ROAD CHANGE activities. Included in this delay element is the time spent changing from the Grabinski to the mechanical slackpulling system at landing 1. A total of 7 and 12 road changes occurred at landings 1 and 2, respectively. All cable splicing activities were coded as CABLE REPAIRS. During the study, the mainline broke twice. After the second occurrence, the rigging crew swapped lines between the yarder's mainline and slackpulling drums. The dropline also required splicing. Rig down, move, and rig up activities occurring during the move between landings are all accounted for by the MOVE TO NEW LANDING delay element. Disturbances to the yarding operation from interferences either by the loader or delimber were negligible (included in OTHER category in Figure 3).



NON-PRODUCTIVE TIME:

DISTURBANCE TIME:

- CABLE ROAD CHANGE: The time required to rig a new yarding road, including a change in the skyline configuration.
- MOVE TO NEW LANDING: The total time required to take down, move, and set up all logging equipment between landings.
- CABLE REPAIRS, SPLICING: Splicing delays.

REPAIRS AND MAINTENANCE (same as delimber)

PRODUCTIVE TIME:

ACTUAL PRODUCTIVE:

- HOOK: The time element occurring while the chokersetters build a payload.
- INHAUL: Pulling a payload in from the stump to the landing chute. Hangup activities occurring during INHAUL are considered separately. LATERAL INHAUL time is also considered separately.
- UNHOOK: The time interval when the chaser is releasing the chokers at the landing.
- OUTHAUL: Haulback pulling the chokers out to the logs to hook another turn. Does not include LATERAL OUTHAUL time.
- LATERAL INHAUL: Pulling a turn in toward the skyline while the carriage is held in a fixed position.
- LATERAL OUTHAUL: Chokersetters pulling the chokers out to the logs while the carriage remains in a stationary position.

OTHER PRODUCTIVE:

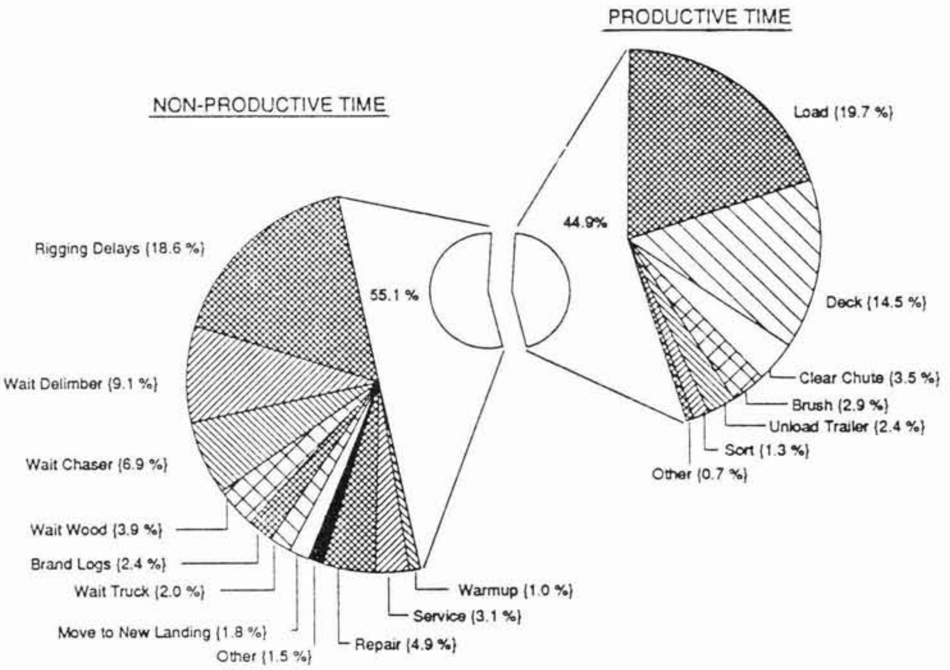
- HANGUPS: Time element occurring when a turn gets stuck on stumps, debris, or the ground during INHAUL or LATERAL INHAUL.

Figure 3 : Total time distribution for the Madill 122 yarder

Log Loader

The log loader loaded a total of 1371 logs in 19.5 productive hours, for a production rate of 70 logs, or 65.8m^3 per productive hour. In total, 34 truck loads were sent out during the study period. Loader utilisation over the study period was 45 percent (Figure 4). The loader worked a total of 43.4 scheduled hours.

Overall, the loader was loading logs for one-fifth of the total scheduled operating hours. Very little of the DECKING time occurred while trucks were available at the landing. The CLEAR CHUTE activity generally entailed turning top-first trees around for the delimber. Almost 20 percent of scheduled operating time was lost to RIGGING DELAYS experienced by the yarding crew. WAIT DELIMBER, (which included times when the delimber had not processed trees in the chute), were also a major source of non-productive time. In addition, WAIT CHASER delays contributed to non-productive time. WAIT WOOD delays occurred when there was no wood available at the landing for processing while the yarder was productively engaged in inhaul, outhaul, hook or hangup activities. Most of the loader downtime was related to the tracks on the undercarriage.



DISTURBANCE TIME:

- WAIT WOOD: This delay activity occurs when there is no truck at the landing to load, the delimber has no wood to process, and the yarder is engaged in the yarding cycle or hangup activities.
- WAIT CHASER: The loader must wait for the yarder/chaser to land and UNHOOK a turn in the landing chute before it can continue.
- WAIT DELIMBER: The loader must wait for the delimber to finish activities before it can continue.
- RIGGING DELAYS: Delays caused by the rigging crew changing cable roads or making cable repairs.
- WAIT TRUCK: The loader is idle while waiting for a truck to arrive or position itself for loading.

  Time taken by the loader operator to brand the logs on the truck while the truck driver attaches the load binders.

OTHER PRODUCTIVE:

- SORT: Picking up a processed log at one log deck and moving it to another deck.
- BRUSH: Removing and piling slash and debris.
- UNLOAD TRAILER: The loader pulls the rear end of a pole trailer from the forward bunk and places it in position for loading.

Figure 4 : Total time distribution for the log loader

DISCUSSION

Yarder-related delays were almost entirely responsible for the poor level of delimber utilisation during the study. Much of the delimber's non-productive time was directly attributable to system imbalance, or the yarder's inability to supply enough wood to keep the delimber busy. Yarder production was not high enough to build up a stockpile at the landing to buffer the effects of cable road changes and other rigging delays on delimber productivity. It was also insufficient to keep the delimber busy during actual yarding cycles. Hence, the large WAIT WOOD delay for the delimber.

It is hard to assess the yarder's productivity because of the production quota imposed by the mill. The relatively low timber stocking appeared to contribute to the long cycle times and a high frequency of cable road changes. Using a feller-buncher to windrow or bunch trees prior to yarding would increase yarding productivity. In addition, yarding grapples would decrease the HOOK and UNHOOK cycle element times, which together accounted for 35 percent of the yarder's scheduled operating time in this study. Using a feller-buncher would also eliminate top-first yarding which, in this study, would have reduced delimber non-productive time.

Where cable yarding productivity limits the utilisation of a potentially high producing piece of equipment, such as a delimber, it is important to look for opportunities to increase the flow of material to the delimber. For instance, in some units, it is feasible to use a ground skidding system around parts of a cable logging area. With proper planning and scheduling, a dual skidding/yarding system could provide more trees to the delimber than one machine alone.

In other situations where there is high yarder productivity, (productivity in excess of the delimber's capabilities) landing space limitations would probably preclude the stockpiling of more than a few yarding turns of whole trees. Here a skidder could be used to swing whole trees away from the landing to a nearby processing site (two-staging). This would provide the delimber with a supply of trees during rigging delays. Moving the delimber to an adjacent landing would also eliminate workspace interference, which was a cause of non-productive time in this study. The additional equipment cost incurred by using a skidder to either supplement yarder production or swing material away from the landing would need to be evaluated in relation to productivity gains.

Although the delimber could have worked during much of the RIGGING DELAY time if a stockpile of trees had been available, certain cable repair and road change activities required the delimber to shut down due to workspace interference. This was especially true at landing 1, where processing activities took place in the landing chute directly in front of the yarder (Figure 4). The delimber and loader were placed on opposite sides of the yarder, which created a small landing area layout with several advantages. First, processing in the chute minimised delimber swing time because the manufactured logs were simply dropped in place for log loader access. Second, it allowed the delimber to make maximum use of the available landing area to deck unprocessed portions of whole tree stems, Third, the log loader was close enough to the landing chute to turn around whole trees that arrived at the landing top-first. Obviously though, processing operations had to stop when a drag arrived in the chute. This was the source of the WAIT CHASER time experienced by the delimber and the loader.

Very little workspace interference occurred at landing 2, where 69 percent of the turns studied were yarded with the landing laid out as shown in Figure 5; the landing 2 configuration allowed the delimber to move trees aside and process them parallel to the chute area, minimising yarder interference. However, trees yarded top-first had to be processed top-first, since the loader could not reach the chute area to turn the trees around.

Workspace interference can also be reflected on a more fundamental level than machine utilisation; the effect of physical machine interactions on landing layout.

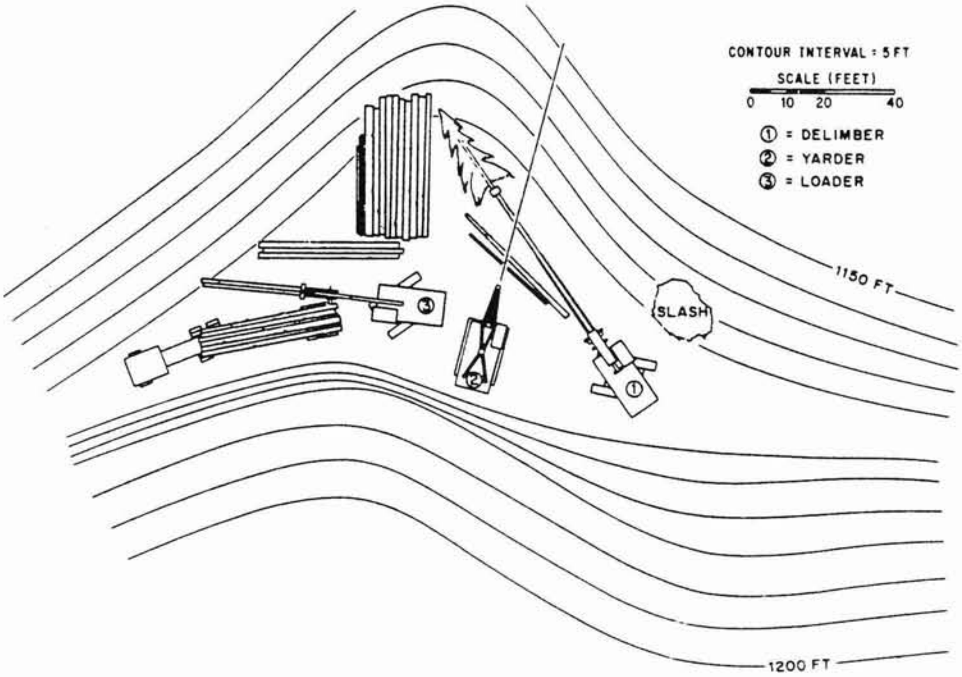


Figure 5 : Landing 1 organisation, area is 0.18 acres (.073 ha)

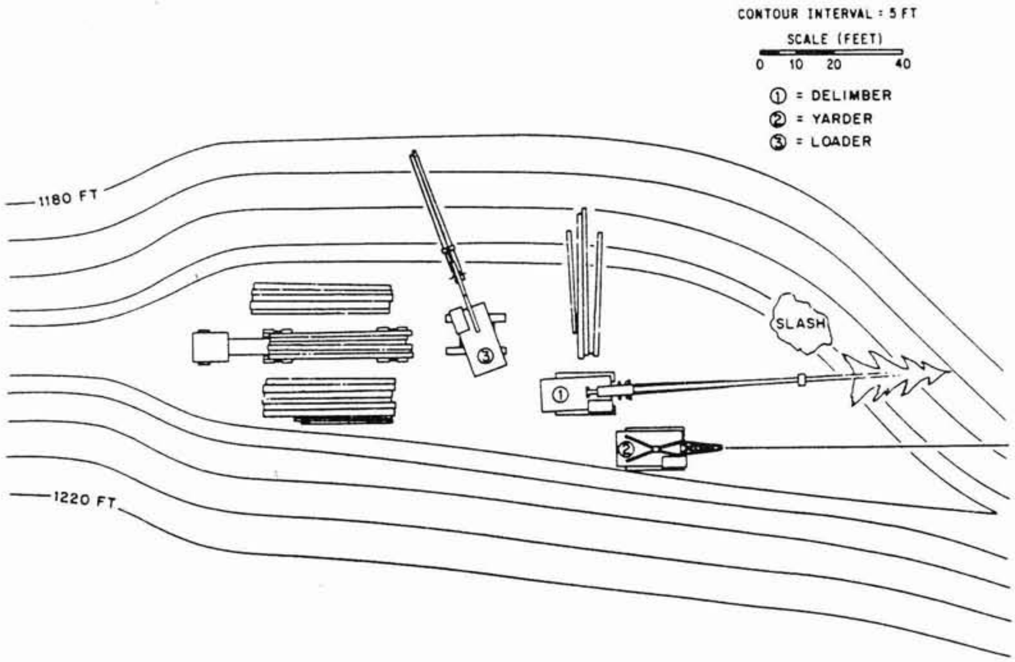
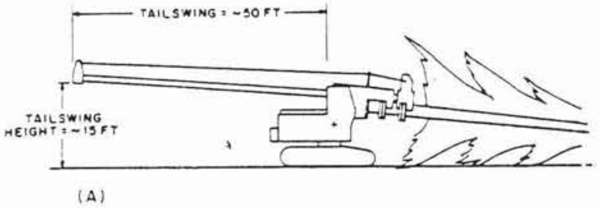


Figure 6 : Landing 2 organisation, area is 0.24 acres (.097 ha)

Figure 7 : A high cutbank at landing 1 caused problems for the delimber processing trees parallel to the chute



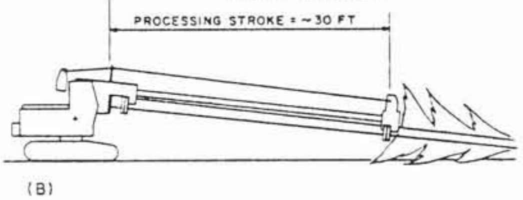


Figure 8 : Tailswing (A) and processing stroke (B) for Roger (single piece boom) delimber.

For example, the tailswing required for single-piece booms. The Roger delimber has approximately a 15 m maximum tailswing (Figure 8a). In this study, because of a steep cutbank and hillside at landing 1, the delimber had difficulty processing trees parallel to the landing chute (see Figure 7). At landing 2, however, this wasn't a problem.

Depending on yarder type, it may also be difficult to arrange the landing layout to ensure that the boom tailswing doesn't interfere with yarder guylines. The Madill 122 used in this study only required three guylines, thus it wasn't difficult to set the Roger delimber in an unrestricted position. At landing 1, the delimber kept a safe distance from the guylines by working in the landing chute. Also, positioning the delimber slightly behind the yarder at landing 2, the delimbing boom could swing a full 90 degree arc without creating a potentially unsafe condition between boom tailswing and the yarder tower.

With a tower using four or more guylines, both the tailswing and the forward portion of the delimber's working area could create additional problems from those observed in this study. To the front of the Roger delimber, the working area is defined by the length of the whole trees being processed, rather than the processing stroke length (Figure 8b).

CONCLUSIONS

This logging study demonstrates that single-piece stroke-delimbers can be safely and efficiently placed in service at small cable landings in steep terrain. However, terrain and landing size limit the ability to reduce workspace interferences and therefore limit delimber productivity. Although yarder production in this study was insufficient to keep the delimber fully engaged, delimber utilisation would undoubtedly improve at sites with greater stocking and without production quota limitations.

There are additional opportunities to enhance overall logging system efficiency that should be studied in Pacific Northwest operations. First, a steep slope feller-buncher and grapple yarding system might improve yarding production, especially with smaller tree sizes. Second, swinging whole trees away from a landing to a separate delimbing site could eliminate yarder-related workspace interference delays and create a stockpile of trees for the delimber. Third, a source of material for mechanised delimbing from more than one cable yarding or ground skidding operation would increase delimber utilisation.

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