HARVESTING TECHNICAL NOTE

Vol: 3 Number: 5
August 2010

Landings Size and Characteristics

Summary

Landings are an integral part of harvesting operations in New Zealand. A representative sample of 142 landings were measured using GPS; twelve recently constructed and unused, 38 live and the remaining 92 were older and closed out. The average landing size was 3900 m2, with a range from 1370 to 12540m2. On average 11 log sorts were cut, the landings in use for 4 weeks, and estimated daily production was 287 m3/day. Log processing was mechanised on 53% of the landings and 47% was manual processing, and most (79%) of the operations used tracked grapple loaders (21% used front-end loaders). A regression equation to model landing size indicated that number of log sorts and production levels are the two main factors that determine landing size. Landing size tended to increase over time, with used landings on average being 900m2 larger than newly constructed (unused) landings. Most recently constructed landings were much larger than the company design specifications; whereby either 40x60m or 40x80m were common specifications. A comparable study in 1987 showed the average landing to be just over 1900 m2, indicating landing size has nearly doubled in the last 20 years. Landings serviced by front-end loaders were on average 1100m2 larger than those serviced by tracked grapple loader, but this result is partially explained by the fact that front-end loaders were more commonly used in high production systems.

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Introduction

A forest landing or skid is a term used to describe a designated area in the forest constructed prior to harvest specifically for the purpose of landing full tree stems for further processing to logs, sorting into different log sorts and loading out to customer (Stokes et al 1989). This designated area is constructed by clearing the area of obstacles such as trees and stumps, to create a flat even surface which can vary in size and shape and cost depending on the terrain and the processing, storage and loading out requirements of the harvesting operation.

Harvest system productivity for New Zealand operations ranges from 80 to over 450 tonnes per day (Visser 2009). Costs associated with landing construction range typically from $4000 to $7000 per landing. Many forest companies have prescriptions depending on the type of operation or location (Twaddle 1984), but these designs are rarely definitive or benchmarked against industry practice.

For the purpose of this project it is appropriate to distinguish at least four different types of landings: 'Pad'; 'Skid'; 'Superskid'; and Central Processing Yard or 'CPY'.

Figure 1: A typical (cable yarder) skid that incorporates the extraction, processing and loading phases of the operation.

A 'pad' is a small landing usually used in a two-stage harvesting operation. The pad normally serves as the site for transferring the extracted tree stems from one to another extraction machine. A common example is a hauler pad in steep terrain where a cable yarder will be positioned on the pad to extract the trees, from which they are transferred to a ground-based machine for further extraction to a larger processing landing. Where appropriate, contractors may attempt to integrate a

Vol: 3 Number: 5
August 2010

mechanised processor onto a pad to delimb and top the trees. This aids subsequent extraction and also leaves the slash at the pad to avoid accumulation at the processing landing.

A 'Skid' is by far the most common type of landing. It will typically service just one harvesting crew and accommodate all the log processing, storage and loading functions (Figure 1).

A 'Superskid' is a processing area that services a number of smaller landings ('pads') to concentrate the log-making (processing), sorting, storage and loading activities. Multiple crews, over a larger forest area, will provide stems or logs which are often forwarded to the superskid off-road by a two-stage type machine, such as a grapple skidder or forwarder.

A 'CPY' is the largest landing type, to where stems are transported by either off-road, or on-road log or stem trucks. In the USA they may be referred to as Sort Yards (Dramm et al. 2004). CPYs are normally located close to a mill, port or rail head, and are also characterised by more automated, or sophisticated, processing capability. CPYs are still relatively uncommon in New Zealand, with just a few in use.

Figure 2: A CPY, showing the scale of the operation and the proximity to the mill.

Methods of Study

Six regions in New Zealand were visited in 2009 and 2010. We met with a series of forest supervisor from different companies and were taken to a 'typical' range of landings. During the visit to each landing the perimeter was mapped with a Garmin GPSmap 60 CSx hand-held GPS receiver. The landing was defined as any area that had been 'built', with criteria that included the removal of topsoil, or being compacted, flat and contiguous. If a road clearly went through the landing it was included in the landing area. If the road ran along the landing edge then it was excluded. Areas prepared for vehicle parking were included if they met the above criteria.

The GPS was also used to collect position points inside the landing to separate the following functional areas: extraction, processing, fleeting, stacking and loading. Position points were then downloaded into a computer and used to calculate the perimeter, the surface area, the length and width of the landings and the functional areas.

The use of a simple hand-held GPS device entailed a certain error in the positioning, normally indicated by the device itself. Given the favourable conditions encountered when mapping landings (i.e. the absence of a forest canopy), the positioning error was normally contained to 2-4 metres. A small number of landings were tested using different number of GPS points and it was found that when using more than 30 points to define the landing the area accuracy had less than 2% error.

For each of the sampled landings, forest managers were asked to provide the following data: type of operation (ground based or hauler), type of processing (manual or mechanised), type of log loader used (front-end or knuckle-boom), number of log sorts, daily productivity, and duration of harvesting operation in weeks. Data was analyses using the statistical program R, and differences reported in this paper are significant at the $p<0.05$ level.

HARVESTING TECHNICAL NOTE

Vol: 3 Number: 5
August 2010

During the survey of active landings, the type, number and tasks of all machines were noted, as well as the number of crew members and their tasks. At the same time, sketches were produced, describing the wood flow through the landing.

Using the GPS coordinates for each landing, where possible they were located on GIS digital terrain models. Average slopes were calculated for circular areas from the centre point of the landing for analyses of landing size with average slope.

Results

In total, 142 landings were measured, with 131 landings captured in 2009, the remainder in 2010. Twelve were new (un-used), 38 were in operation and 92 were recently completed. Table 1 shows the mean, 5th and 95th percentile values for each of the parameters.

Table 1: Mean, 5th and 95th percentile values for each of the parameters.

Parameter	Mean	5th Percentile	95th Percentile
Landing size (m^2)	3868	1944	7476
Weeks in Operation	4.3	1	10.5
Production (t/day)	287	150	450
Log Sorts (#)	10.2	1	15
Perimeter (m)	271	187	396
Length/Width ratio	2.12	1.1	4.0

When the data was analysed it was possible to determine other interesting characteristics:

Landing Age:
Used landings were 900 m2 larger than new, suggesting that during harvesting the crews enlarge the operating area of the landing. They may do this to make additional space for log stacks, but it will also occur as residue is pushed over the side and the landing surface is "graded" clean during the operation.

Ground-based versus Cable Yarding:

Of the total, 63 % of the landings were ground-based, 27% were in cable settings. On average a ground based crew will extract 320 tons/day and cut 10 logs sorts and be on the landing 3 weeks. A cable yarding crew will extract 232 tons/day, cut 11 log sorts and operate for 6 weeks. On average a ground-based landing was 430 m2 larger than a cable landing. Yarder landings tended to be slightly more elongated (2.4 length to width ratio) than ground-based (length to width ratio = 2.0).

Manual vs Mechanized Processing:

Of the total, 47% of the landings used manual processing, and 53% mechanised processing. On average the manual processing crews operated just under one week longer at a single landing and cut 13 log sorts. Their productivity was only 26 tonnes per day less than the average mechanised processing crew. The landing shape was the same.

Front-end Loaders versus Knuckle-boom:

Of the total, 79% of the landings used knuckle-boom loaders for loading out, and 21% used front-end loaders. For the landings surveyed that were operated by front-end loaders, they handled an average of 15 log sorts, were on average 1100m2 larger, and produced 35t/day more, than landings using knuckle-boom loaders.

Regression analyses:
The best regression equation for the data is:

Landing Size (m^2) = 390 + 560 x Landing Age + 173 x No. Log Sort + 3.5 x Daily Prod.

Whereby Landing Age =0 when new; =1 when in use; and =2 when harvesting complete.

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HARVESTING TECHNICAL NOTE

Vol: 3 Number: 5
August 2010

Discussion

Comparison with previous data

In 1986 a similar study was carried out surveying landing size and other factors of 50 landings in four different regions in New Zealand (Raymond, 1987). The average landing size was 1900 m2, which is 2000 m2 less than in 2009. The upper range of landing size in the 1986 study was 4000m2, similar to the average landing size in 2009.

In 1986 there were 3 times as many landings using front-end loaders as there were knuckle-boom loaders. Landings using front-end loaders were also twice as large (approximately 1000 m2 larger). This trend has completely reversed with knuckle-boom type loaders dominating (79%) operations now, but the absolute difference in size is still about the same. In 1986 there was no discernible difference in landing size between ground-based and cable yarder.

Number of log sorts and production were two parameters that were the same in the landing size regression analyses for both studies. In 1986 the coefficients were 160 and 5 for number of log sorts and daily production respectively, and they remain very similar (the 2009 data showing them to be 173 and 3.5). This indicated that a lot of the increase in landing size can be explained by both the increase in average productivity and the number of log sorts currently being cut.

The 1986 study only measured landings in operation, so it did not record a change in landing size over time. As that study focused on four regions, it was able to establish a regional difference, and also measured stem length at the landing, which was a significant factor for yarder landing size.

Evaluation of schematic diagrams

The diagrams depicting the layout of the active operations were difficult to interpret. Attempting to differentiate between zones on the landing was also inconsistent as most areas served multiple purposes. Landing layout analyses of the schematic drawings for the live landings indicated that as landing size increased, there was a preference for using multiple rows to manage log inventory on the landing (see also Figure 1). Smaller landings typically preferred to stack around the edge of the landing.

The production through cable landings was typically more 'linear' with the cable yarder at the 'far end' and clearly separated from the landing processing and loading activities (Figure 3).

Figure 3: Arrow overlaid on acble landing showing linear flow of production.

Landings with motor-manual processing operate with clearly defined processing decks with deck placement aligned with skidder access to the landing. Many ground-based landings with mechanized processing attempt to centralise the processor to minimize subsequent fleeting distances (Figure 4).

Figure 4: Mechanised processor located more centrally on the landing to minimise fleeting distance.

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Vol: 3 Number: 5
August 2010

Evaluation of surrounding slope.

In general the steeper the surrounding slope the smaller the landing, and using 50 or 100 metre circles gave the best correlation between landing size and slope, but no statistically significant relationship was found. Surrounding slope was compounded by a 'location' factor (Figure 5). The largest landings were typically found on the lowest elevations and had the lowest surrounding slope. However large landings were also easily constructed at the top of ridges, but were characterised by quite steep slopes leading up to them. The smallest landings were found at mid-slope, on steep slopes.

Figure 5: GIS map showing landing locations. The circles shown around the landings were used to determine average surrounding slope at different radii. Note that landings on top of the hills are generally larger than those mid-slopes (Figure prepared by Hamish Berkett).

Conclusions

Landings have always been an integral part of larger scale commercial harvesting operations. They are expensive to build and their location and size is important to an efficient and safe operation. This study effectively validates the LIRO study completed in 1986 (Raymond 1987). It confirms the parameters production and number of log sorts as driving landing size, but has also added to the knowledge base by including landing use as a significant factor. A number of changes in equipment preferences, such as the trend towards mechanised processing and the current prevalence of knuckle boom grapple loaders, have also been established.

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Vol: 3 Number: 5
August 2010

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