FUTURE FORESTS RESEARCH

HARVESTING TECHNICAL NOTE

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Improving Yarding Productivity Using Tension Monitors

Summary

Tension monitors in cable yarding have traditionally been used to ensure safe operation. A tension monitor can also be a very powerful tool to help optimise the productivity of the yarding process when used in conjunction with daily production information such as payload and cycle times. This study explored and documented such opportunities by providing operator feedback from two different operations. Both crews found the short production study and the alternatives discussed to be useful in helping them better understand their operating techniques and how they affected their productivity. The crews felt that the tension monitors provided them with assurance that they were operating safely and were able to use operating techniques they would otherwise not have tried. When the tension monitors were used in conjunction with a production control chart, the crews were able to see the effects of alternative techniques tried, and their influence on productivity within a few cycles, improving their control over the operation.

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Introduction

Cable logging unit production costs (in $/m³) in New Zealand are 50% greater than ground-based harvesting (Visser 2015). This is because of a lower rate of productivity, combined with more expensive machinery and larger crew size. The preferred ways to improve unit production costs are either to increase productivity (m³/hr) or reduce operating costs ($/hr), or a combination of both. Increasing productivity and reducing costs has been one of the main objectives of the FFR Steep Land Harvesting Programme.

In order to make improvements in either costs or productivity, one has to be able to establish current performance of the system/process and be able to work out what is physically feasible and economically viable. On a short term (daily or weekly basis) most loggers are more able to change their operating practices than make changes in investment of equipment or personnel.

One way to control production is to set a production standard, commonly called a “target”. Many loggers draw on past experience to set production targets for a given harvest setting. However, production estimates based on experience and good judgement are not always accurate, or are sometimes correct but for the wrong reasons (Conway 1982). Supporting documentation such as daily production records in similar conditions can help set accurate production targets (Visser *et al.* 2000).

If daily information is graphed in a “production control chart” one can monitor the operation and determine an acceptable tolerance level for deviation from the standard productivity (Figure 1). However, some crews keep records associated with each cycle in cable yarding, which introduces the opportunity to create a production control chart over a shorter time scale. For example, if productivity was monitored at the cycle level, the feedback time to the crew/manager could be reduced, allowing for faster response when productivity drops below the tolerable level.

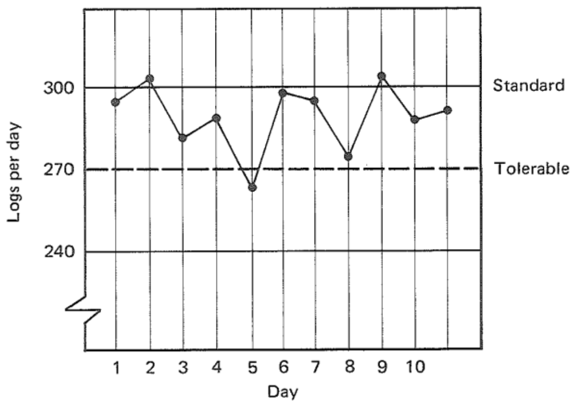

Figure 1: Example of production control chart for cable logging (Conway 1982).

Since one measure of productivity is volume produced per hour, improving yarder extraction productivity can involve either increasing the payload transported or decreasing the time it takes to transport the payload (cycle time). Therefore there is often a trade-off between the two values. Optimisation is defined as the process of finding the “best available” values to make the best or most effective use of a situation or resource (to meet the objective).

For example, using Figure 2 it can be seen that a 6-tonne payload cycle taking 9 minutes to extract results in productivity of 40 tonnes per hour. But if cycle time can be shortened by 2 minutes per cycle by reducing the average payload down to 5 tonnes, then

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productivity is increased to over 42 tonnes per hour and there is a lower loading on the system overall. Alternatively if a larger payload of 7 tonnes takes a slightly longer cycle time of 10 minutes productivity will also increase to 42 tonnes per hour (Figure 2).

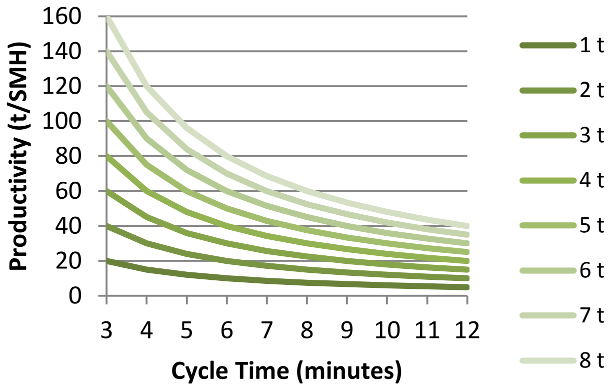

Figure 2: Productivity and the relationship with cycle time and payload.

Improvements to cable logging productivity have been studied previously in New Zealand. Visser *et al.* (1999) investigated the potential to increase payload by changing the combination of breaker-outs and strops (chokers) and the effect this had on productivity. Results indicated that there was an ideal number of strops and breaker-outs required to achieve the maximum payload, and this should be adjusted according to the payload capacity of the system along the extraction corridor. In another earlier study a three-step procedure was developed for loggers to follow, which could help increase productivity by using a simple tool for estimating payload volume (Visser and Palmer 1999).

Hartsough (1993) investigated the benefits of tension monitors and concluded that productivity improvement was one of many potential benefits. During this earlier study a tension monitor was used to give feedback to the breaker-outs to help increase payloads without overloading the skyline, as well as providing information to enable time saving techniques such as getting drags unstuck (e.g. by reducing payload to reduce cycle time). In another study Harrill & Visser (2014) recommended that industry should give serious consideration to using tension monitors to record skyline tension data along with monitoring production. Instrumented yarders are also capable of such functions (Evanson & Henderson 2009). These authors also suggested that operators could use tension monitors to learn new configurations or operating techniques and evaluate their effectiveness.

The objective of this project was to demonstrate that tension monitor data can be used by yarder operators to improve performance, including optimising productivity.

Methods

This study involved a researcher working directly with the yarder operator and crew to evaluate the operation using short production studies. Two different harvesting operations were evaluated, a Madill 071 yarder with standing skyline operated in the North Bend configuration, and a Thunderbird TMY70 yarder with a live skyline employing a Falcon Forestry Claw motorised grapple carriage in the slackline configuration.

Several steps were used in the evaluation process to identify if and where potential improvements could be made to increase productivity. First, the span was identified on a contour map and the terrain features were input into the SkylineXL payload analysis software running on a Panasonic Toughbook computer. An analysis was performed to determine the load path and maximum allowable payload, and results were used to identify which terrain point(s) limited the payload.

Secondly, a discussion with the crew identified possible techniques to improve either payload or cycle time, or both. Finally a tension monitor was used as a feedback mechanism to the yarder operator to ensure that any changes in operating practices were physically feasible and safe.

Results & Discussion

Madill 071 / North Bend

For the Madill 071 with North Bend configuration, the skyline span (275m) had good deflection (8%) and adequate rigging clearance at mid-span (Figure 3). Due to the clearance required at the edge of the landing, deflection could not be increased by lowering the skyline, and the payload limiting point occurred at mid-span, where maximum payload was calculated to be 4.9 tonnes.

Figure 3: Span from anchor to yarder for the Madill 071 crew using North Bend.

A "control" period of ten cycles was observed and plotted on a production control chart to determine where improvements could be made. In the production control chart, cycle times were reasonably consistent (between 8 and 12 minutes) but productivity varied considerably due to the variability in payload (Figure 4).

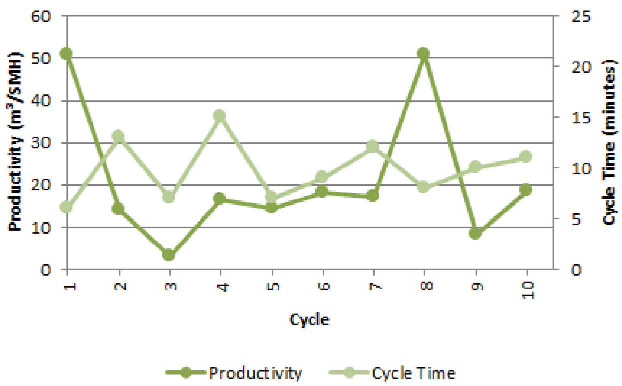

Figure 4: Production control chart for the first 10 cycles ("Control") for the crew using North Bend.

It was estimated that the average payload achieved was only approximately half of the maximum payload suggested (Figure 5). Therefore it was proposed that the crew could direct efforts towards increasing the payload and use the tension monitoring to determine whether increasing the payload was safe. Results would then determine whether the impact on the cycle time was enough to increase productivity.

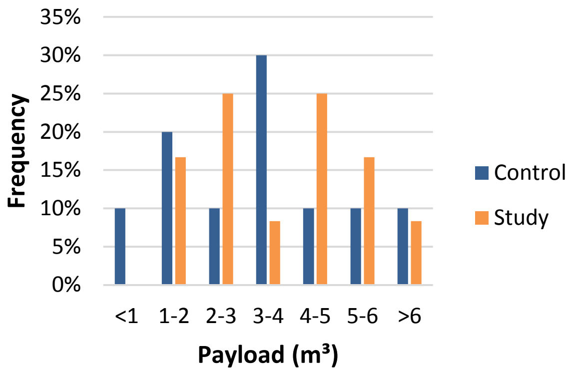

Figure 5: Histogram of payloads for the study and control periods with the crew using North Bend.

During the payload optimisation period ("Study" period in Figure 5), a higher and more consistent payload was achieved, with little change in cycle time (part A of Figure 6). Average piece size (1.7 m³) provided the potential to achieve the maximum payload but unfortunately the desired stems could not always be reached by the breaker-outs every cycle. In a couple of cycles the two breaker-outs spent excessive time trying to locate and hook-up the maximum payload, which increased the cycle time to an extent where it out-weighed the increase in payload and decreased the overall productivity (part B of Figure 6).

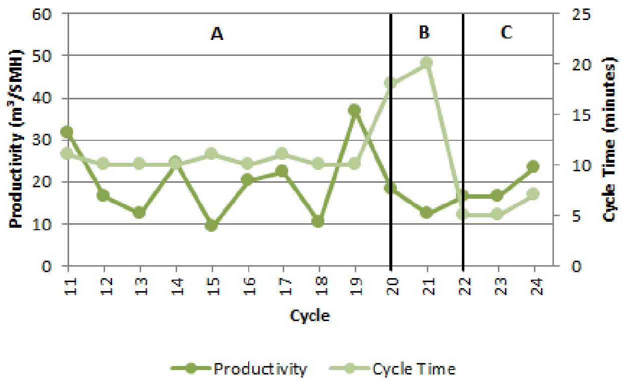

Figure 6: Production control chart for cycles 11-24 ("Study") for the crew using North Bend.

At times, few stems could be hooked on, and the payload could not be improved. So in an additional test, the crew tried to reduce cycle time by fully suspending the load during inhaul as the maximum payload (4.9 tonnes) was calculated based on full suspension. There was some reluctance to suspend loads fully, due to concerns this would overload the skyline. To determine this impact, a trial was done whereby only one stem was fully suspended across

mid-span (in cycles 22 & 23). When it was observed that the skyline was not overloaded, successively larger payloads were then transported (part C of Figure 6), and productivity increased.

The highest tension observed during this trial nearly reached the endurance limit of the wire rope (50% of breaking strength) and occurred during breakout, surprisingly with a relatively small payload (≈2 tonnes). This occurred because the stems were buried beneath other stems at mid-span. The operator was able to immediately react and prevent the tension from reaching the endurance limit by carefully monitoring the skyline tension. On three other occasions similar breakout forces generated high tensions which were just over the safe working load (SWL), 36% of breaking strength, for only a short duration (≈ 1 second).

In a previous study Hartsough (1993) found similar causes of high breakout forces. He suggested that breaking out (choker setting) practices might be improved by hooking on stems such that the stem was first turned prior to being hauled in.

Thunderbird TMY70 / Falcon / Slackline

For the Thunderbird TMY70 operation, running a Falcon Forestry Claw carriage in a slackline configuration, the span (=230m distance) had very high deflection available (>25%) and satisfactory carriage clearance at mid-span (Figure 7). Therefore, payload was not limited by deflection at mid-span but by carriage clearance at the edge of the landing. Maximum payload was 13.3 tonnes.

Figure 7: Side view of span for crew using Falcon carriage. Note the surge pile beyond mid-span.

With an average tree size of 1.25 tonnes, the grapple carriage would need to accumulate more than 10 stems to achieve this payload, which was unrealistic as the grapple was not large enough and had no bunching capability. Also, to extract such large payloads successfully without over-tensioning the skyline, the carriage would have to stay close to the slope of the terrain during the inhaul portion of the cycle by executing several skyline "lifts" to avoid the carriage colliding with the ground. Each skyline lift added to the inhaul and total cycle times (and thus reduced productivity). It was observed that cycles included from one to four lifts even when small payloads (max = 5 tonnes) were extracted from the same location (such as from a large surge pile at 130 m haul distance).

Observations showed that the inhaul component of the cycle consumed the greatest amount of cycle time (32% or 0.89 minutes) followed closely by "Hook" the time taken for the carriage to grapple stems (31% or 0.86 minutes) (Figure 8). Unfortunately, when grapple yarding the operator had less control over how many stems/pieces were picked up than when using chokers. Therefore altering payload was determined to be less feasible than reducing cycle time. With smaller payloads accumulated than those allowed by the maximum deflection, an alternative method of inhaul was considered to reduce the cycle time.

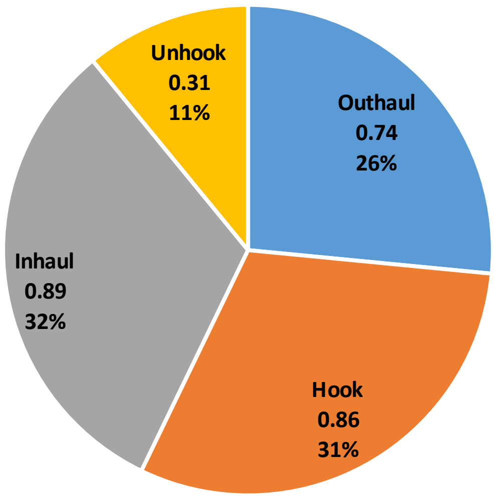

Figure 8: Observed cycle time components for Falcon Forestry Claw carriage studied.

The alternative method determined was to execute as few skyline lifts as possible during inhaul; ideally one lift high enough to satisfy carriage clearance at the edge of the landing and using the tension monitor to ensure SWL was not exceeded. The load path from

this alternative method and the maximum allowable payload were calculated in the payload analysis software. Mid-span was now determined to be the payload limiting terrain point (maximum payload 5.9 tonnes). This was closer to the maximum payload which could be grappled, or about four stems per load.

The crew attempted to execute as few lifts as possible during inhaul, but one lift was not always possible with the larger payloads. One limitation was that this yarder was not able to tension the skyline to over 18 tonnes, where SWL was 21 tonnes.

Payloads under 3 tonnes could be successfully hauled in one lift, while larger payloads required anywhere from two to four lifts. To do so safely required the operator to pay close attention to the tension monitor for the duration of inhaul (Figure 9). Each lift was found to add an extra 8 seconds to the inhaul time. Lift time was considered to be slow compared to other yarders observed operating live skylines (Harrill and Visser, 2014) due to the TMY 70 not having the capability to lift both the mainline and skyline at the same time.

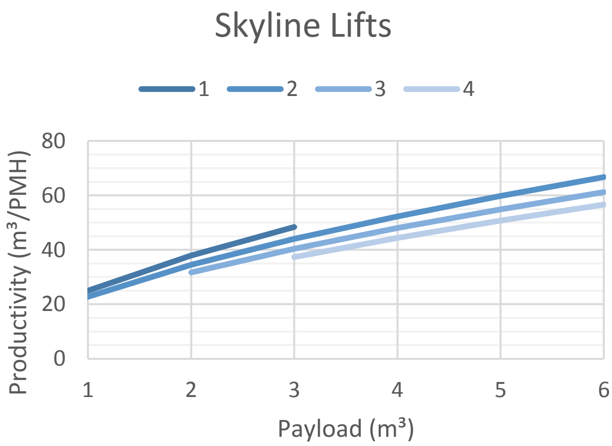

Figure 9: Relationship between productivity and payload for different number of skyline lifts (at haul distance of 130m and >25% deflection on a 230m span).

Hook time (or grapple time) was the second longest cycle component after inhaul. The cycles that were extracted from the surge pile had longer average hook times (0.98 minutes, maximum 3.5 min) than cycles that were not from the surge pile (0.37 minutes, maximum 0.5 min) even though they were extracted only a maximum of 50 metres further.

The crew used a second bulldozer (placed ≈80m away) as a mobile anchor for their haul back line to prevent rope wrap and to aid in reaching stems away from the skyline (much like a Dutchman). However, there were no stems to be picked up in the area away from the skyline, so there was no need to bridle. Placing the two dozers closer together could have reduced hook time, and this option was discussed with the crew (Figure 10).

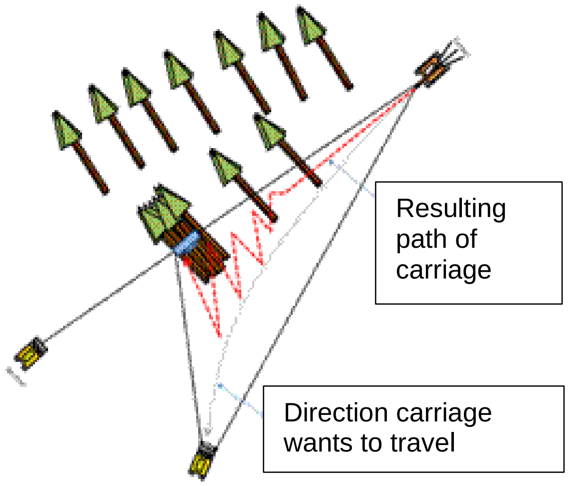

Figure 10: Effect of bridling on carriage flight path during outhaul.

Two reasons for the long grapple time were:

1) large surge piles were difficult to grapple logs from compared to bunches; and

2) difficulty in positioning the carriage due to the effect of bridling. A next logical step for the crew could be to investigate the effect of reducing bridling.

The effects of long grapple times in conjunction with relatively small payloads can be seen in cycles 13-14 and cycles 19-20 of the production control chart (Figure 11).

The crew also noted the high rate of productivity when stems were easily grappled from bunches at short distances (cycles 1-6).

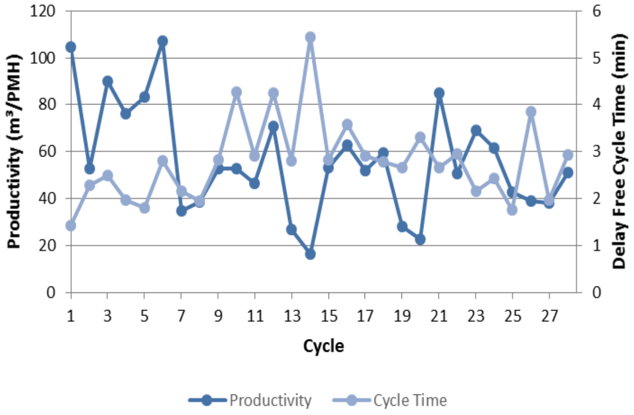

Figure 11: Production control chart for the study period with the crew using Falcon Slackline.

Recommendations

- Contractor or crew boss should practice using payload analyses to set production targets and develop a production control chart for each setting.
- Crew boss should discuss with breaker-outs the potential payload and the terrain limiting points along each span.
- Breaker-outs should identify the combinations of stems and logs to achieve the desired payload determined through payload analysis (and practice estimating volume or use a tool to estimate volume).

Other Considerations

- Consider fully suspending stems when tension and deflection allow to avoid hang-ups, reduce cycle time and minimise soil disturbance.
- Reconsider use of surge piles as they may make it more difficult for both breaker-outs and grapples to accumulate pieces. Consider setting out bunches that are optimised for the payload capability in each setting.
- When required, reducing the number of skyline lifts has a positive effect on productivity, but not as great as increasing payload.
- Some yarders are more suited for live skyline applications due to their skyline tensioning capabilities, which is an important consideration when selecting a particular rigging configuration.
- When using a grapple carriage, yarder operators should avoid bridling too far, especially at the back end of the span, as it can make carriage positioning and grappling more difficult.

Conclusion

For the Madill 071 North Bend crew, after understanding the payload potential at different points along the span and the combination of pieces required to achieve it, the breaker-outs were able to increase the payload (after the control period). However, in some cases the extra time to hook logs (set chokers) outweighed the benefit. Fully suspending stems was found to be not only safe in terms of not exceeding the SWL, but also improved productivity by significantly reducing cycle time to overcome the relatively small payload.

For the TMY70 crew, which operated the Falcon carriage, there was not a great opportunity to alter payload, so they focused their efforts on understanding improvements in cycle time. Reducing the number of lifts of the skyline had a positive effect on productivity, but not as much as increasing the payload. Productivity improved when extracting from bunches rather than surge piles at short distances. The lowest rates of productivity were associated with long hook times and/or small payloads extracted from the surge pile. The crew was able to use the tension monitor to safely execute skyline lifts with varying payloads, essentially reducing the number of lifts required.

Both crews found the process of using short production studies based around the use of tension monitoring, and discussing alternative operating techniques, to be useful in helping them better understand how to improve their productivity. They were also able to make changes in techniques and see the effects within a relatively short time (i.e. within a few cycles), when using a production control chart.

The crews were observed to not only use, but to rely on, the tension monitor for nearly every cycle. Although prior to the study the crews may not have used the monitors to evaluate alternative operating techniques, they found them useful and would not have tried the alternative techniques suggested without the use of tension monitors.

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References

Conway, S. 1982. Logging Practices: Principles of Timber Harvesting Systems (revised edition). Miller Freeman Publications Inc. San Francisco. 432pp.

Evanson, T., B. Henderson. 2009. Sauer-Danfoss controllers in haulers. Harvesting Technical Note Volume 1, No. 4. Future Forests Research Ltd, Rotorua, New Zealand.

Harrill, H., and R. Visser. 2014. Rigging configurations efficiency case studies. Report No. H020. Future Forests Research Ltd. (FFR). 87pp.

Hartsough, B. 1993. Benefits of remote tension monitoring. LIRO Report 18-23. Logging Industry Research Organisation, Rotorua New Zealand. 13pp.

Visser, R., S. McMahon, T. Evanson, W. Palmer. 1999. Improving cable extraction efficiency. LIRO Report 24(16). Logging Industry Research Organisation, Rotorua New Zealand. 5pp.

Visser, R. & W. Palmer. 1999. Drag builder optimises payloads. LIRO Technical Note 51. Logging Industry Research Organisation, Rotorua New Zealand. 2pp.

Visser, R., T. Evanson, W. Palmer. 2000. Operational monitoring for evaluating work force performance. 23rd Council on Forest Engineering Annual Meeting, 11-14 September, 2000. Kelowna, British Columbia.

Visser, R. 2015. Harvesting cost and productivity benchmarking: 2014 update. Harvesting Technical Note HTN07-05. Future Forests Research Ltd. Rotorua New Zealand. 5pp.

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