HARVESTING TECHNICAL NOTE
HTN

Date:

Harvestline: a versatile cable hauler for small forest growers

Summary

Profitable harvesting on steep, difficult-to-access terrain has always been a challenge for small forest growers. Many small forests have been established in these types of sites with the hope of generating a reasonable return on investment. Small forest owners often have a single age class forest, therefore dictating a one-off opportunity to harvest when market conditions align.

Traditional harvesting systems used in small forests on steep land are generally large fixed or swing-yarder tower machines with accompanying specialised supporting equipment. These systems bring high set-up and production costs for the forest owner, making the harvest of some stands uneconomic or marginal.

Forme Consulting Group recently studied an increasingly available alternative system - a lower capital cost, smaller and more versatile excavator-based Harvestline machine. Although individual haul size is smaller than with larger machines, the Harvestline provides other benefits. These include the ability to achieve reasonable production through quicker access and quicker set-up and re-positioning, all contributing to an increased number of haul cycles achievable in a normal workday.

Our work study confirms that, in the typical scenario we studied, this type of smaller and more versatile cable hauling system can be economic as well as potentially conferring environmental and health and safety benefits.

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Introduction

Many small forests established in New Zealand during 1990s planting boom are located on steep, difficult country, often isolated from any main internal access routes.

Owners wishing to make a profit from these stands are now facing dilemmas associated with finding harvesting crews with the right mix of equipment and operating knowledge to extract and transport harvested logs from these properties at reasonable cost.

The transport, set-up, and operations associated with large, highly productive harvesting equipment commonly seen in large corporate forests are neither effective nor desirable in most small forests, and alternative solutions are required.

Generally, this means scaled down and less productive harvest crew set-up and configurations. Finding a harvesting crew with lighter, smaller, multi-purpose and highly mobile plant and equipment becomes the dominant consideration rather than a crew with the ability to pull large volumes of wood in the shortest possible time.

This requires a step change in harvesting attitude – we must move away from the belief that large single task machines common in highly productive harvesting systems always produce the better outcomes.

Small excavator-based yarders have been active in New Zealand for a number of years. A review of literature provides only limited information on application and performance of these adaptable yarders, particularly effective in smaller constrained harvest settings.

A survey in 2018 identified 21 such machines (Visser & Harrill 2018) up from 6 in 2012._Abeyratne, 2021 noted the manufacture of 60 machines by Electrical Machinery & Services Ltd (EMS) in Rotorua to that point and concluded the Harvestline system as very capable over a variety of distances, piece size and terrain.

The EMS website states:

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"The Harvestline is marketed as an innovative cable logging system that allows efficient log extraction and quick line shifts in hard-to-access areas and tight landings where the logistics of moving in a large yarder or tower are challenging.

The system is designed using leading computer aided design software and assembled using high-quality components to provide safe and superior performance."

Koszman & Evans, 2018, noted the main benefits of the use of such machines to be improved safety performance and more efficient harvesting operations.

Current numbers in use in New Zealand are unknown but likely to be increasing all the time.

This Technical Note reports on observations and outcomes of a three-day study of a *Harvestline*™ system in DG Glenn's harvesting crew working in Pan Pac forests in the Hawkes Bay. It seeks to expand on existing knowledge to encourage greater interest in these systems.

Forest Stand Details

Fig 1. Harvestline logging setting.

The Harvestline was selected to complete the harvest of a stand deemed unsuitable for larger scale equipment used in the wider compartment. The stand was located adjacent to a public road, wet swampy areas and broken with short unevenly dispersed gully systems where ability to optimise a more highly productive crew wasn't possible.

The part-stand was typical of the type likely to be encountered in small forest grower scenarios.

Stand Data

Species	*Pinus radiata*
Age	29
Spha	329
Stem size	2.5 t
Vol/ha	810 t

Note: As provided by Pan Pac.

Harvestline System

The system employed during the study consisted of a Komatsu PC400LC excavator-based Harvestline machine equipped with a Hawkeye motorised carriage as the main extraction machine, a John Deere 909KH harvester used mainly for felling, clearing the landing chute and stem processing, a Caterpillar 330D excavator loader used for further shovelling of logs from processing to load-out position and truck loading and an older Caterpillar tail anchor machine.

Fig 2. Harvestline set-up and supporting equipment.

A three-man crew operated the system.

Out priority for data collection was extraction cycles of the Harvestline although some complementary data was collected for the processor as it cleared the chute, removed branches, and undertook limited cut-to-length tasks. The operation was functioning as a stem system, with 18-metre stems being transported from the landing, allowing a smaller landing size and minimal processing on the skid site.

Table 1. Harvestline specifications.

SPECIFICATIONS/FEATURES - HARVESTLINE SYSTEM	
MODULAR DESOGN FOR INSTALLATION ON ANY >30tonne EXCAVATOR	
Weight excluding ropes	7650 kg
Main rope capacity	500 m
Haulback rope capacity	1000 m
Strawline rope capacity	1000 m
Minimum excavator power requirement	220 kw
Minimum hydraulic flow requirement	500 lpm @ 50 bar
Mast height	11.5 m
Effective yarding distance	400 m
Rope spec	19 mm 6x31 lwrc
HAWKEYE CARRIAGE	
Air cooled Kohler Twin Cylinder Engine	18 kw
Versatile rope connection points	
3 HD industrial digital cameras	
360^0 grapple rotation	
Integral LED lighting system	
3 grapple design options	

Note: Standard specifications from product brochures.

Study approach

Time studies were carried out on the activities of the Harvestline machine. Frequent work elements observed were out-haul, grapple, and in-haul. Associated information collected was distance travelled by the Hawkeye motorised carriage both in and out, and the number of stems hauled during each cycle. Number of stems in turn were defined as a stem (butt log) or a piece to enable calculation of haul size. Complementary information was collected on the processor to verify haul size data and to provide indication of work content involved in clearing the chute and processing.

Non- frequent elements were numerous and included machine reposition, line reposition, tail-hold machine reposition and aborted cycles due to breakage, stem loss, haul jamming e.g. behind stump and ground jamming particularly where deflection was minimal.

Weather was a mix of hot and dry through to wet and murky conditions. Wet conditions in particular provided challenges to the operator due to in-built cameras on the carriage either not working or compromised by poor visibility.

Setting topography provided challenges later in the study when lack of deflection required more machine and line repositioning to enable physical performance and minimal soil disturbance during extraction.

The prime objective of the time studies was to determine Harvestline cycle times and therefore enable production performance to be estimated within the harvesting system.

Production data presentation

Data presented in tables below follow a simple work study approach. These represent activity at the studied site and are therefore specific to that site.

Harvestline

The cycle of extraction follows a normalised pattern as with any motorised carriage/cable system. Repetitive elements observed and recorded were:

Out-haul – the carriage is returned empty into the felled stand to retrieve next stem(s). Variable is distance.

Grapple – Upon arrival at next stem the grapple is deployed, and the stem(s) manoeuvred and secured to commence in-haul. Variable is the number of pieces (stems and bits).

In-haul – Stem(s) are cabled to the drop site in the chute of the Harvestline. Variable is distance and number of pieces (stems and bits).

Drop – Grapple releases logs. For this study drop time was unmeasurable, merely the push of a button.

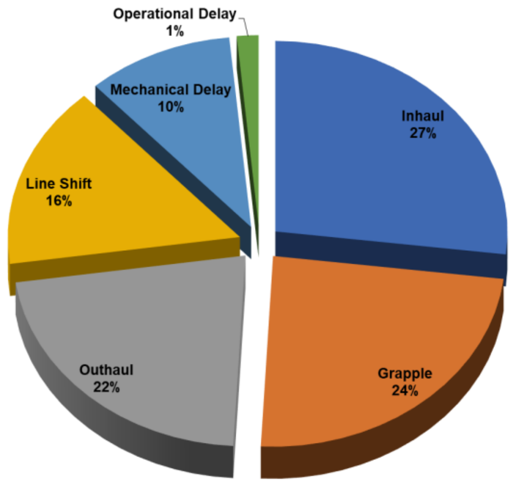

Fig 3. Basic data presentation, Harvestline utilisation

Fig 3 shows that approximately 75% of available time was engaged in productive log haulage. The remainder was predominantly line shift activity where the Harvestline machine and/or the backline anchor machine were repositioned for start of a new extraction line. Mechanical delays were largely related to issues with rope breakage and carriage operation, normally expected with this type of operation.

Table 2. Basic data presentation, Harvestline repetitive elements.

150 metres haul distance	
Element	**std.time/haul (mins)**
Out-haul	0.728
Grapple	0.870
In-haul	0.859
Drop	0.000
Ave/cycle	**2.457**

Out-haul / In-haul Times

Simple carriage travel time regression analysis was undertaken, and results are below:

Out-haul = .003 (dist) + .2783

In-haul = .0038 (dist) + .2892

Generally, out-haul times will not be affected by terrain as speed is determined by carriage line speed. On the other hand, in-haul times will be affected by degree of lift affecting passage of logs and their drag over the terrain.

Table 3. Basic data presentation, Harvestline non-repetitive elements.

Element	std.time/haul (mins)
Mechanical delay	0.306
Operational delay	0.045
Line shift	0.466
Ave/cycle	**0.817**

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In our analysis, delay and line shift times reflect total time engaged in these activities divided by the number of completed haul cycles completed. Again, these are as observed in the study area but could be used as a guide for similar operations.

Haul size estimation

High-level yield and stem data per ha were used to estimate mean tree size as 2.5 tonnes. Our observations strongly suggest that tree size has limited impact on in-haul times. In-haul cycle times can be adversely affected by such things as tree shape, grappling position on the stem and very obviously deflection and other impediments on the slope such as tree stumps, banks etc.

Further analysis of stem and bit data has enabled the calculation an estimated mean haul size as follows:

Table 4. Haul size calculation, Harvestline.

Haul size calculation	
No. drags	350
No. total pieces extracted	359
No. stems (butt logs) extracted	235
No. bits extracted	124
Total volume extracted @2.5 tonnes	587.5
Average haul size (tonnes)	**1.68**

Production Work Value

Basic data contained in Tables 2, 3 and 4 were used to construct estimated production levels for the Harvestline.

Table 5. Extrapolation of basic data to daily production – Harvestline.

Target calculation	
Element	**Mins/cycle**
Out-haul	0.728
Grapple	0.870
In-haul	0.859
Line shift	0.466
Mechanical delay	0.306
Operational delay	0.045
Total cycle time	3.274
Plus allowances @ 31.8%	4.315
Cycles per 480 min day	111.236
Tonnes/day @ 1.68 tonnes per haul	**186.877**

Discussion - Harvestline production

We do not intend to quantify optimum crew production as this depends on numerous variables including setting characteristics, log shovelling distance from the Harvestline chute to load-out stack, crew allocation of duties to include truck loading, number of trucks loaded per day, variability in tree size etc. Rather, maximum crew production will normally be determined by the controlling cycle that in this case is the Harvestline, i.e., around 190 tonnes/day at 150m haul distance and 2.5 tonne stem size.

While this is lower than optimum for a larger machine like a swing yarder or well-performing ground-based crew (frequently aiming for 300 tonnes/day plus), the ability for the Harvestline to pull this sort of daily volume while also minimising the need for additional hauler pads or roading could offset the lower production. The removal or lengthy set up times relating to rigging etc possibly means the Harvestline would be able to pull this sort of volume more consistently over more varied terrain than other systems.

Subsequent discussion with Pan Pac's harvesting manager suggests a longer-term production average for the observed crew configuration of around 227 tonnes/day. This of course represents a wider span of all factors that influence production but may be a fairer estimate for similar system setup.

Machine costing - Harvestline

Indicative daily crew operating costs of this Harvestline system were estimated using commonly used machine costing methodology. Costing of forestry equipment is reliant on individual and specific operator preferences and circumstances and therefore resultant methodologies can provide a variety of daily cost outcomes. For this we have adopted the following:

"Business Management for Logging, 3rd edition 2020", Future Forests Research (BMOL).

This is an updated version of the costing handbook for loggers first produced by the NZ Logging Research Association in 1981 and subsequently reviewed three times by the Blackburne Group, Chartered Accountants. This has been used to calculate indicative machine and crew daily rate costs.

"Informe Harvesting 2022" and daily rate estimates, based on an independent survey of harvesting equipment, vehicles, labour, overheads, by Forme Consulting Group Limited.

This publication, particularly the capital cost survey data, has been used to estimate investment requirements for the equipment used on site. More detailed comparative analysis, unreported, has been done to ensure benchmark and relativity to the BMOL Harvestline cost estimate only.

Fig 4. Harvestline mounted on Komatsu PC400LC.

Table 6. Key cost inputs.

Harvestline basic cost inputs	
Purchase price	$1,200,000
Power (kw)	270
Annual hours	1400
Life (hours)	20000
Fuel (litre)	$2.40
Interest (debt)	12%
Interest (equity)	6%
Risk	1.50%

Table 7. Indicative Harvestline annual machinery costs – BMOL.

Indicative Harvestline annual costs (BMOL)	
Depreciation	$62,068
Interest/risk	$92,522
Insurance	$22,566
R&M	$43,475
Fuel	$95,658
Oil	$19,132
Rigging	$37,602
Total/annum	$373,022
Total/day (220 days)	$1,696

Fig 5. View down the extraction corridor.

Crew costing

To complement the machinery costing we have constructed a crew costing similar to that observed during on-site studies. Table 8 captures the additional cost items upon which we have based our total crew cost.

Table 8. Daily crew cost components.

Daily crew cost components cost/day BMOL	
Harvestline	$1,696
Processor	$2,440
Excavator loader	$1,401
Vehicles	$561
Tailhold	$174
Labour	$1,410
Operating	$649
Powersaws	$110
Overheads	$127
Profit	857
Total	**$9,425**

Note: Costings based on 8.5 hours/day, 220 workdays /annum

Operation indicative costs

Table 9 provides details of the operation's indicative costs/tonne and how this varies depending on the volume harvested per day.

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Table 9. Operation indicative cost/tonne (150-metre haul distance, 2.5 tonne stem size.

tonnes per day	tonnes p.a.	RATE $ per tonne
166	36609	56.64
168	37016	56.02
170	37423	55.41
172	37830	54.81
174	38236	54.23
176	38643	53.66
178	39050	53.10
179	39457	52.55
181	39864	52.01
183	40270	51.49
185	40677	50.97
187	41084	50.47
189	41491	49.97
190	41897	49.49
192	42304	49.01
194	42711	48.55
196	43118	48.09
198	43524	47.64
200	43931	47.20
202	44338	46.77
203	44745	46.34

Note: For longer term production based on Pan Pac experience this equates to approximately $41.50/tonne.

System balance

As noted earlier we have not attempted to optimise workloads between the Harvestline and supporting machinery. Study outcomes represent the operation as observed and optimal production will be influenced in a number of ways, for example:

- Incorporation of the tree-felling cycle, in this case undertaken by the processor.
- Improvements in tree placement and layout by the processor in the cutover to facilitate more efficient grappling.
- Optimising deflection and Harvestline/tailhold machinery placement within available haul line length.
- Managing truck loading, re-allocation of truck loading tasks and processing/chute clearance duties between the processor and loader.
- More or less frequent line changes, to optimise the line corridor over butt ends of stems.

Fig 6. View down the extraction corridor from inside Harvestline cab.

Potential for greater use of Harvestline systems for small forest stands

Engaging a contractor equipped with a Harvestline to undertake small woodlot harvesting makes good sense where woodlots are located in difficult country with engineering and extraction challenges which were not foreseen when stands were initially planted.

Some of the pros and cons of the Harvestline are discussed in greater detail below:

Pros:

1. Favourable capital cost compared to specialised swing yarder options that may require 2 ½ - 3 times initial investment.
2. The Harvestline, mounted on a suitable excavator base, has all the advantages of a normal excavator machine for road transport to and from the forest location.
3. Construction of higher standard access roads can normally be avoided - unlike when using more specialised and much larger cable hauling machines.
4. System set-up and dismantling is much more time efficient than specialised cable hauling systems. The need for tower anchoring is

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avoided, giving savings in time and hauler pad space.

5. Ability to undertake quick line shifts, by relocating the Harvestline or paired tailhold machine, offers significant time saving advantages.
6. Quick set-up and repositioning coupled with quick cycle rotation speeds means maximising the haul size of each cycle is less important.
7. Focus on quick cycle turnaround enables better management of haul weights particularly in areas where deflection is limited, and risk of stem snagging is high.
8. Selection of supporting grappling configurations and equipment choice is high, giving flexibility to crews.

Cons:

1. Size and configuration of the Harvestline will compromise ability to comfortably manage larger stems.
2. Tower height restricts ability to achieve desired deflection however in many cases this can be countered by ability to quickly reposition the Harvestline and undertake line shifts.

Conclusion

This Technical Note aims to inform small forest growers of one option available when considering selecting a crew for harvesting forest stands in difficult locations. Smaller, more mobile and versatile machines are likely to be a better fit than the larger, more specialised machines often found in high-production forest operations. Smaller, versatile machines may also be more cost effective and help to address the rapidly escalating costs of harvesting small forest stands.

The Harvestline is well-suited to small, difficult-to-harvest situations, particularly when supported by specific Harvestline planning, management and operator skills, training and experience.

Our study shows that reasonable production and cost is attainable, with other site and crew benefits, often overlooked and unmeasured, such as environmental and safety benefits enabled through use of equipment such as the Harvestline.

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