Assessments of a Winch-Assisted John Deere Harvester and Forwarder

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Peter Dyson, Researcher, Fibre Supply

Vladimir Strimbu, Researcher, Fibre Supply

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ABSTRACT

The productivity, utilization, and operator working techniques of a winch-assisted forwarder and harvester were assessed over five months. Anchoring techniques, wire rope inspection methods, and environmental and terrain factors affecting productivity were documented.

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REVIEWERS

Matt Campbell, FPInnovations Coordinator, Forest Management Group, Canadian Forest Products Ltd.

Christian Volk, Principal, Volk-trans Canada Ltd.

Jim Hunt, Research Leader, Fibre Supply, FPInnovations

CONTACT

Peter Dyson
Forest Operations
604-222-5635
peter.dyson@fpinnovations.ca

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1. INTRODUCTION

Conventional steep slope harvesting methods that use hand falling and cable extraction are well established and have been in use for years. However, these methods are hazardous and, in stands with small stem volume, productivity is often low. Harvesting machines equipped with winch-assist technology offer potentially improved safety and higher productivity compared to conventional systems. European-manufactured winch-assisted harvesters and forwarders have been used for many years in Europe and South America and have recently been introduced to the Pacific Northwest. An on-board winch provides traction assistance, enabling the machines to operate safely and efficiently on steep slopes.

A B.C. logging contractor is using a European-manufactured John Deere harvester and forwarder equipped with a Haas winch system. This report presents the findings from a five-month assessment of the machines' productivities and describes the operating techniques.

2. OBJECTIVES

The specific objectives of this study are to:

- Determine harvester and forwarder productivity and utilization rates.
- Describe operator working techniques, including:
  - Anchoring methods
  - Wire rope inspection
  - Winch deployment
- Document advantages and disadvantages of the system.

3. STUDY METHODOLOGY

The harvester and forwarder were assessed from September 2016 to January 2017. MultiDATs[1] were installed on the machines to measure shift-level productivity and utilization rate. Researchers periodically visited the harvest sites to document operating conditions, discuss operating procedures with the machine operators, and to conduct detailed timing of the harvester and forwarder. The cooperating company provided harvest volume data from its weigh scale system.

4. SITE AND EQUIPMENT DESCRIPTIONS

Four sites were included in the study near Clearwater, B.C. Sites1, 2, and 4 were clearcut, while the harvest prescription at Site 3 required leaving all Western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). At Site 1, all Douglas-fir (*Pseudotsuga menziesii*) with a diameter at breast height (DBH) greater than 72 cm were not harvested. Sites 1, 2, and 4 were on steep ground with slopes ranging from 30% to 80%. However, at Site 3, the terrain was relatively flat with only a small area of the block with slopes over 30%. Table 1 summarizes stand and stem volume from timber cruise data.

[1] A MultiDAT is a data logger developed by FPInnovations that records machine working time and GPS location.

Table 1. Timber cruise stand and stem volume

	Site			
	1	2	3	4
Volume (m^3/ha)	266	271	282	183
Average stem volume (m^3)	0.61	0.44	0.25	0.35
Average DBH (cm)	31	30	22	25
Average slope (%)	43	63	27	42
Species composition by volume (%)				
Douglas-fir	57	0	15	61
White spruce	19	66	9	0
Lodgepole pine	14	10	76	14
Balsam fir	10	22	0	23
Western hemlock, western redcedar	0	2	0	2

Logs were processed to primary lengths of 3.75, 4.4, 5.0 and 6.2 m.

Harvester and forwarder

Trees were felled and processed with a John Deere 1470 E six-wheeled harvester equipped with a H290 harvesting head (Figure 1). Processed stems were forwarded to the roadside with a John Deere 1910 E forwarder (Figure 2). The equipment was manufactured in Europe and imported to Canada by the harvesting contractor. Steel guarding had to be installed around the harvester and forwarder cabs to meet WorkSafeBC regulations (Figure 3).

Figure 1. John Deere 1470 E harvester.

Figure 2. John Deere 1910 E forwarder.

Figure 3. Guarding on harvester cab.

Haas winch system

The harvester and forwarder were equipped with a Haas winch (Figure 4). A hydraulic system powers a “winch disk” which provides tension to the wire rope. The winch drum is for cable storage and does not provide tension to the wire rope. A tension of 300 kg is maintained on the wire rope as it spools on the drum which promotes good line spooling. The drum holds 400 m of 14 mm wire rope. A monitor in the cab displays wire rope tension and length of cable in use and length remaining on the drum. A camera mounted above the winch drum and a display screen in the cab provides the operator with live monitoring of the winch drum. The winch is enclosed in a box mounted on the back of the harvester (Figure 5). The box tilting range is up to 80°. The forwarder winch is mounted underneath the rear of the trailer.

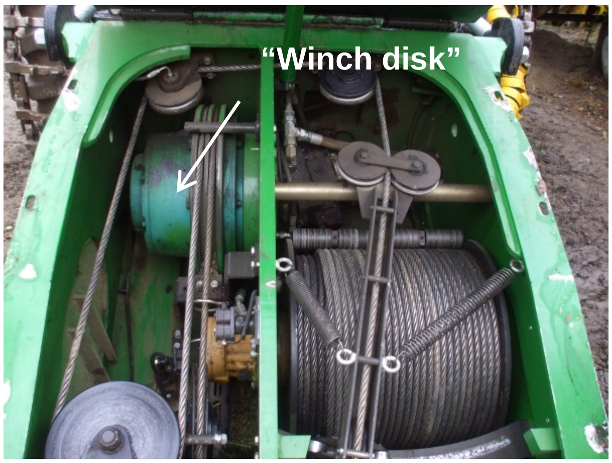

Figure 4. Haas winch.

Figure 5. Haas winch housing box.

At the end of the study, there were 841 and 1,100 hours on the wire rope for the harvester and forwarder, respectively. Both operators felt the wire rope on their machine was in good condition. Wire rope longevity is highly variable. If it is well maintained and not abused, it could last up to 2,000 hours. However, 1,200 -1,500 hours is the average expected life.[2] At the start of shift, the operator checks the wire rope at the anchor hook connection, as this is the most likely location for wear (Figure 6). About every two weeks, the entire length of wire rope is laid out on a road and visually checked.

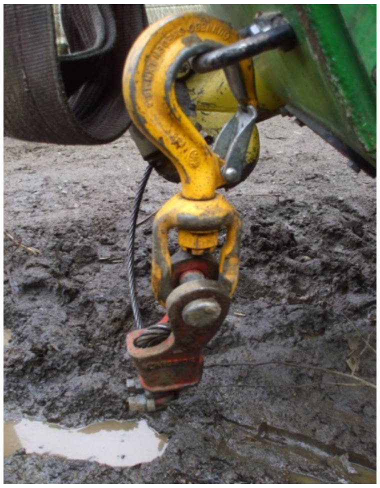

Figure 6. Winch anchor hook.

5. RESULTS

Harvester productivity

Shift-level utilization and productivity

Harvester productivity and utilization for the four sites are summarized in Table 2. The consolidated utilization from the four sites was 65%. Utilization was lower at Site 3 (61%) and Site 4 (56%) compared to Site 1 (75%) and Site 2 (74%). Utilization at Site 3 was affected by a three-day mechanical breakdown and at Site 2 by days when the machine was scheduled to work but did not because of operator absence or mechanical breakdowns.

The expected trend of increased productivity (m^3/PMH) as piece volume increased was found at three of the four sites. However, at Site 2, productivity was the lowest (14.1 m^3/PMH) but the average piece volume was the second largest at 0.44 m^3/stem. The lower productivity, at Site 2, was attributed to most of the site having been harvested many years earlier except the very steep areas which were left unharvested. These steep areas were challenging to harvest and reduced harvester productivity.

[2] Personal communication Klaus Herzog developer of the Herzog winch.

Additionally, there were pockets of isolated timber and the site had been developed for a different harvesting system, which further contributed to the lower productivity. Most of Site 3 had relatively flat terrain with slopes less than 30%, so the winch-assist on the harvester was used sparingly. However, the operator had to leave the hemlock and cedar stems standing, which reduced felling and processing productivity compared to clearcutting, which was the harvest prescription for the other sites.

Table 2. Harvester shift-level summary

	Site				
	1	**2**	**3**	**4**	**All sites**
Average shift length (h)	10	10	10	10	10
Productive machine hours (PMH)	68	77	149	85	379
Scheduled machine hours (SMH)	90	102	244	152	588
Scaled volume [3] (m^3)	2212	1076	3400	2244	8933
Utilization (PMH/SMH) (%)	75	74	61	56	64
Average stem volume (m^3)	0.61	0.44	0.25	0.35	0.34
Productivity					
m^3/SMH	24.6	10.5	13.9	14.7	15.3
m^3/PMH	32.7	14.1	22.8	26.4	23.6

[3] Scaled volume used for analyzing productivity, not the total block volume.

Detailed timing

Harvester detailed timing was conducted at Site 1 and the results are shown in Table 3 and Figure 7. Detailed timing provides detailed cycle time and short-duration detailed productivity. However, shift-level analysis provides a better estimate of longer-term productivity. At Site 1, productivity from detailed timing was very similar to productivity determined from the shift analysis, as the difference was only1.8 m^3/PMH.

Table 3. Detailed timing summary of harvester

Description	
Productive time (h)	3.2
Total cycles (no.)	162
Total stems (no.)	162
Total logs (no.)	543
Average slope (%)	39
Average stem volume (m^3)	0.61
Total volume (m^3)	98.8
Stems/cycle	1.0
Logs/cycle	3.3
Productivity	
Stems/PMH	50.7
Logs/PMH	170.0
m^3/PMH	30.9

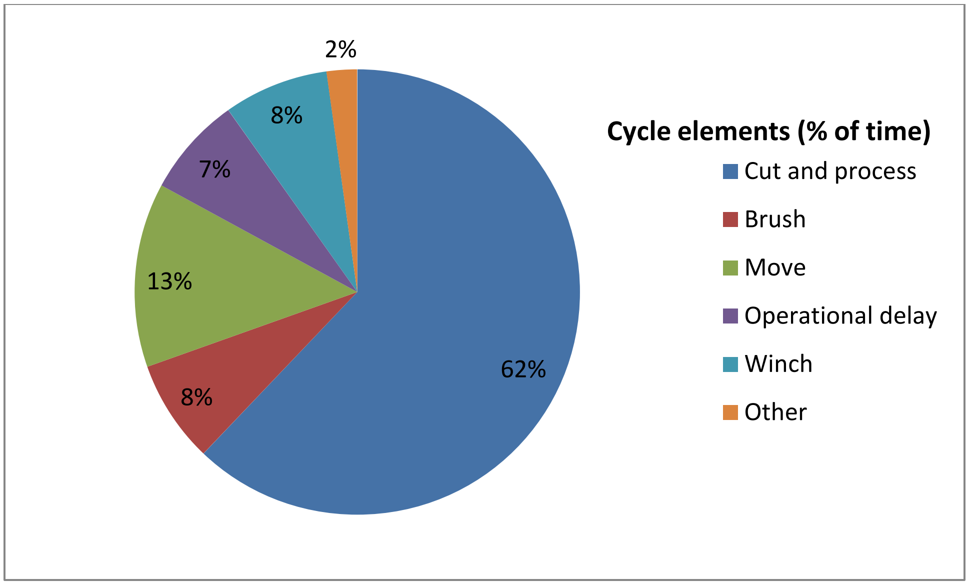

Figure 7. Harvester work cycle time elements.

Forwarder productivity

Shift level utilization and productivity

Table 4 summarizes forwarder utilization and productivity. Utilization at all four sites was very similar, ranging from 70% to 76%, and the aggregated utilization was 73%. The lower forwarder productivity at Site 3 compared to the other three sites was attributed to the same reasons that harvester productivity was lower at this site: difficult terrain, isolated timber, and a different harvesting system planned for the site.

Table 4. Forwarder shift-level summary

	Site				
	1	**2**	**3**	**4**	**All sites**
Average shift length (h)	10	10	10	10	10
Productive machine hours (PMH)	136.3	58.1	40.3	138.1	372.8
Scheduled machine hours (SMH)	195	77	57	182	511
Scaled volume[a] (m^3)	3218	914	938	2896	7966
Utilization (PMH/SMH) (%)	70	76	71	76	73
Productivity					
m^3/SMH	16.5	11.9	16.4	15.9	15.6
m^3/PMH	23.6	15.7	23.3	21.0	21.4

[a] Scaled volume used for analyzing productivity, not the total block volume.

Detailed timing

Table 5 and Figure 8 provide a summary of the forwarder productivity based on the detailed timing study conducted at Sites 1, 2, and 3. No detailed timing was done at Site 4. The aggregated detailed timing productivity for the three sites (23.4 m^3/PMH) is close to the aggregated shift-level productivity (21.4 m^3/PMH).

Table 5. Forwarder detail timing summary

Description	
Productive time (h)	21.0
Total cycles (no.)	40
Total logs (no.)	2438
Total volume (m^3)	492
Average loaded distance (m)	78
Average slope (%)	40
Average cycle volume (m^3)	12.3
Productivity	
Cycles/PMH	1.9
Logs/PMH	116
m^3/PMH	23.4

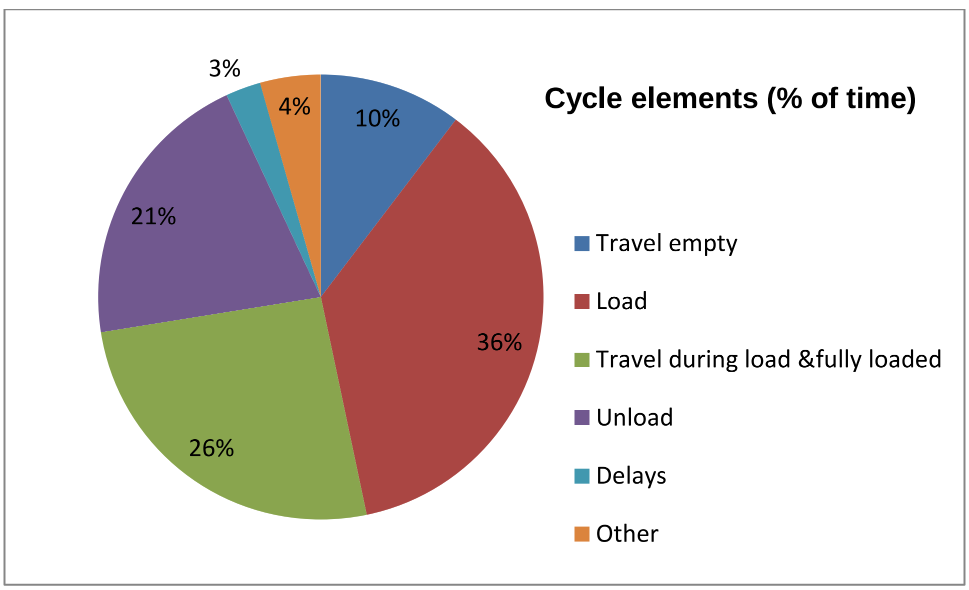

Figure 8. Forwarder work cycle time elements.

6. DISCUSSION

Influence of slope and deep snow on productivity

The harvester operator feels productivity is not affected when using the winch on slopes greater than 30% but less than 60%. He finds productivity decreases where slope exceeds 60%, and where it exceeds 80%, he feels a different harvesting system should be used.[4] Deep snow is another factor affecting the harvester's productivity. The harvester had difficulty operating in snow with a depth of 1.5 m. In one location it could not ascend a 45% slope due to snow, even with the winch-assist. Therefore, after completing a strip cutting downhill, the harvester was un-tethered from the anchor stump and then it travelled on a road back to the top of the block. It was then re-tethered to an anchor and then began cutting downhill on the next strip.

Operating on exposed rock on steep slopes is very challenging and should be avoided when possible (Figure 9). The harvester operator was able to safely and efficiently harvest these areas due to his skill and experience operating on steep slopes.

Figure 9. Steep slope with exposed rock at Site 1.

Anchoring

Stumps and trees were the primary winch anchors for the harvester and forwarder. Stumps were preferred because they did not present a potential overhead hazard. Stump or tree suitability as an anchor was tested by first attaching a sling to the selected tree or stump. Then, the wire rope was manually pulled from the winch and attached to the sling (Figure 10). The winch tension was set to 9 tonnes through a handheld winch remote control (Figure 11).

[4] Personal communication with Mirko Jansen, harvester operator.

Figure 10. Stump anchor.

Figure 11. Haas handheld winch remote control.

If the tree or stump did not move at 9 tonnes of tension, it was considered to be an acceptable anchor. The preferred species for an anchor was Douglas-fir. The operator stated other species in order of preference were pine, cedar, and spruce, He avoided using balsam and hemlock as anchors.

Available equipment was also used as anchors (Figure 12).

Figure 12. Processor used as an anchor for winch-assist equipment.

Deadman anchors were used where adequate stumps, trees, or equipment were not available. A deadman anchor was made by digging a trench 6 m long and 1.5 m deep in the roadbed. A log 5.0 m in length was placed lengthways in the trench with a cable wrapped around the log’s mid-point. The log was buried with the cable end extending above the ground which could be attached to the wire rope of the winch.

Harvester operator’s operating methods

The harvester operator was very skilled and experienced. He was adept and proficient at felling, processing, sorting, and setting up neat, well-organized piles of processed logs on steep slopes. He understood the winch system and how to match winch tension to terrain conditions. The winch tension was usually set at the minimum setting necessary to provide traction, usually from 2 to 6 tonnes, but was set at the maximum, 9 tonnes, to maintain traction on very steep ground or when traction was poor. Setting the minimum required tension is good practice as it decreases wear on the winch system components and improves wire rope life. The operator found that on slopes up to 40%, where soil had good bearing and holding capacity, the traction of the harvester could be maintained without the winch.

When necessary, the operator cut some high stumps to act as a backstop for processed logs, preventing them from rolling down the hill.

The operator had the following thoughts regarding harvester and forwarder operator training:

- An operator must be skilled and knowledgeable to efficiently operate a harvester on steep ground.
- An operator should have one year of experience operating on steep slopes to be efficient and productive.
- The best way to learn how to operate a harvester is to first learn to operate a forwarder because the manual dexterity required for operating the controls is similar. Also, operating a forwarder reinforces the importance of building neat, well-sorted piles when operating the harvester.
- It would be difficult to train a buncher operator to operate a harvester because the operating techniques and controls are different between a buncher and harvester.

Comparison of a winch-assist harvester and forwarder to an alternative system

The winch-assist harvester and forwarder system offers the following advantages and disadvantages compared to grapple yarding and processing at roadside:

Advantages

- No landings required for decking and processing.
- No harvest debris at landings / roadside to pile and burn.
- High cost grapple yarding is avoided.
- Only two pieces of equipment required.
- Harvesting costs are potentially lower.
- Wheeled equipment can travel efficiently on forest roads. A lowbed may not be necessary to move equipment when travel distances between harvest sites are close.

Disadvantages

- Forwarder can only forward short logs (<8 m).
- Impractical and unproductive operating on steep slopes in deep snow (>1.5 m).
- Harvester inefficient in stands with heavy brush or understorey.
- Strong skillset required to efficiently operate a harvester on steep slopes.

7. CONCLUSIONS

Harvester productivity over the study period was 23.6 m^3/PMH and utilization was 64%. Low utilization caused by mechanical breakdown and operator time off at Site 3 (61%) and Site 4 (56%) contributed to the low overall utilization of 64%. Utilization at sites 1 and 2 was higher at 75% and 74%, respectively. Forwarder productivity was 21.4 m^3/PMH and utilization was 73%. Forwarder utilization was consistent at all four sites and ranged from 70% to 76%.

At the end of the study, there were 841 hours on the harvester wire rope and 1,100 hours on the forwarder rope. Both operators felt the wire rope was still in good condition. At the start of a shift, they checked the condition of the rope at the hook connection point. Every two weeks the entire length of wire rope was laid out on the road and visually inspected.

The harvester and forwarder did not perform well on steep slopes when the snow was deep or when the slope exceeded 80%. It is recommended that a different harvesting system be used on steep slopes in deep snow or when the slope exceeds 80%.

Stumps were the favoured anchor, although standing trees were also used. Douglas-fir was the preferred species followed by pine, cedar, and spruce. Balsam and hemlock are not recommended as they make poor anchors. Idle equipment and deadman anchors were used when stumps or trees were not available.

Compared to an alternative harvesting system of grapple yarding and processing at roadside, a winch-assisted harvester and forwarder offers potential benefits including no landings required for processing, no harvest debris accumulation at landings, and potentially lower harvesting costs as high-cost grapple yarding is not needed. Some disadvantages include the harvester being inefficient in stands with heavy brush or understorey, and the need for a skilled operator for efficient operation.

FPInnovations is continuing to assess winch-assist harvest machines. More information can be found on FPInnovations' Steep Slope Initiative website (http://steepslopeinitiative.fpinnovations.ca/).

Head Office

Pointe-Claire
570, Saint-Jean Blvd.
Pointe-Claire, QC
Canada H9R 3J9
T 514 630-4100

Vancouver
2665 East Mall
Vancouver, BC.
Canada V6T 1Z4
T 604 224-3221

Québec
319, rue Franquet
Québec, QC
Canada G1P 4R4
T 418 659-2647

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