HARVESTING TECHNICAL NOTE

HTN15-06
2023

Future Opportunities: A Novel Forest Harvesting System

Summary

A novel harvesting concept was developed to stimulate thinking and challenge convention in the way that forests are harvested. The novel harvesting system proposes primary processing of timber products undertaken from the standing tree. An approach such as this eliminates the need to fell and extract stems and logs. All bark and waste products remain at the stump, fertilising the forest soil. New forest roads, tracks and landings are not required because the processed timber products are flown to the nearest existing road, with zero soil disturbance. The Unmanned Aerial Vehicle (UAV) harvesting system still requires a pilot and ground crew support, so people continue to have jobs in the forest – but the machines do the heavy work and humans do the planning and control. The aim is to minimise environmental impacts (no soil disturbance), increase biodiversity (continuous cover mixed age forests), reduce costs (eliminating roading and ground based extraction expenses), and improve worker safety and wellness.

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Introduction

This work is part of a project in New Job Design, a component of the Human Factors of Automation objective in the 'Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age' Primary Growth Partnership (FGR, 2018). The aim is to explore opportunities afforded by new technology designed to improve safety, reduce workload, and create new jobs while reducing environmental impact. Scion's Human Factors group leads this work and engages specialist expertise when appropriate.

Normal clearfell forest harvesting operations are expensive because they require sophisticated machinery, very skilled staff, supporting networks of roads, culverts, and landings. The roads must be maintained to a standard suitable for all weather access for heavy vehicles such as trucks, loaders and haulers.

Figure 1: Clearfell harvesting operation in steep terrain

Harvesting Economic Costs

Analysis of current harvesting costs (Hall, 2022) indicates terrain has a significant impact on costs (Table 1). Steep terrain requires hauler extraction and associated roading to gain access for equipment.

Table 1: Per tonne cost estimate of the elements of silvicultural and harvesting for three for easy, steep, and very steep terrain.

	Easy	Steep	Very steep
Grow	$30.00	$35.00	$40.00
Road	$3.70	$5.00	$9.40
Landing	$0.30	$0.51	$1.05
Logging	$24.00	$32.00	$42.00
Transport	$16.00	$22.00	$33.00
Total	**$74.00**	**$94.51**	**$125.45**

Establishment and growing is a fixed cost that is difficult to reduce. However, the novel forest system presented in this report could dramatically alter the costs for roading, landing construction and logging.

Harvesting Environmental Costs

The environmental costs of harvesting are considerable (e.g., Baillie, 2010). Soil is disturbed to build roads to access the site and soil is moved and compacted to construct landings. The natural flow of water is altered by earthworks and culverts must be constructed to channel water across roads. Clearfell harvesting results in the complete removal of vegetation from the land and exposes the soil to direct impact of rainfall. Mass mobilisation sometimes occurs with soil and forest debris flowing downhill into streams. The result is silted rivers, debris flows downstream and poor public perception of forestry.

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Novel Harvesting System

The Unmanned Aerial Vehicle (UAV) harvesting system does not require roads, landings, or earthworks to be created because all machinery is bought to the site by air. Similarly, all products are removed from the site by air to the nearest established road. The plan is to have human operators controlling much of the process. In this way forestry employees form a workforce who know and understand the forest, are available for firefighting, and act as a local community connection to the forest. People are also on site for repair and maintenance tasks. An animation of the proposed system can be found on YouTube (Parker & Hooper, 2022).

Feasibility

At first sight, the concept appears futuristic and unobtainable. Yet many of the elements of the system already exist. AirForestry (a startup in Sweden) have developed a large prototype tree felling and extraction UAV for production thinning operations. It is still in proof-of-concept stage, but significant effort is being devoted to developing a working system. AirForestry have also developed a delimbing and felling head which is carried by the heavy-lift UAV (Figure 2).

Figure 2: AirForestry delimbing & felling head

The only major engineering component missing is a processing head that can cut forest products, such as boards, from a standing tree. The processing head will require sophisticated engineering to cut and remove forest products from the standing tree.

Selective harvest systems for radiata pine forests exist and are profitable (Bloomberg, 2019). In conventional clearfell forestry systems, all the trees are harvested and sold over a short period. In continuous cover forestry systems, harvesting occurs continuously, and revenue is constant over time.

Important technical issues need to be considered and addressed:

- A processing head that can cut sawn timber from a standing tree does not exist. It will take time and a large design and build cost to develop this device.
- Sufficient power supply to the UAV is unknown. Internal combustion engines supply more power for a lighter weight, but electric power (battery) is more environmentally desirable.
- Cost of the large UAV and processing head is unknown at this stage. With time UAVs will get bigger and more capable. In addition, there will be costs for fuelling the UAV, repairs and maintenance, and ground crew support.
- The effect of weather, particularly wind, on the UAVs ability to secure the processing head to the tree and to process and collect the sawn timber.
- Preventing warping during the drying of the boards cut from the standing tree will be a challenge.
- Value recovery from the standing tree must be competitive with conventional sawmilling. Currently, in sawmilling, approximately 45% of the volume of the tree is sold as chip for further processing and as fuel. If left in the forest the chip is not available for sale.

It is envisaged that multiple UAVs and processing heads will be working to provide sufficient productivity. Redundancy is built into the system by using multiple machines compared with one very expensive machine.

The concept is illustrated in Figure 3.

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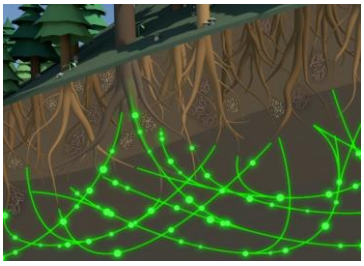
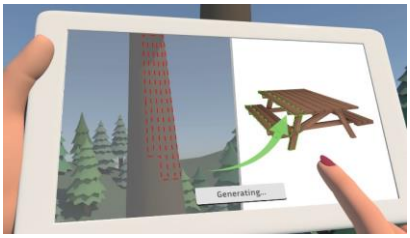
Mixed age stand



Roots interconnected.



Product selection

Decomposing stump

Selective harvesting system where mature trees are processed into products while standing. Limbs and sawdust fall to the base of the tree. No machinery touches the forest floor. Roads are not required to extract timber.

Delimbing

Transport

Processing

Drying

Figure 3: Selective harvesting system concept

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The environmental costs of the novel system should be minor because there is little ground disturbance (apart from the slash which is left on the ground). All slash and sawdust will fall in the proximity of the harvested tree adding to soil fertility. The root system of the stump and its links to adjacent trees will be undisturbed. The impact of rainfall will be ameliorated by the intact forest canopy and the bed of forestry slash.

Conclusions

A novel forest harvesting system has been presented where there is little measurable environmental impact foreseen, and the terrain will not be modified for conventional forest harvesting machine access.

It is one potential vision for the future of forestry in New Zealand that attempts to solve some of the challenges the industry faces currently. This concept has the potential to minimise environmental impacts (no soil disturbance), increase biodiversity (mixed age and mixed species forests), reduce harvesting costs (eliminating roading and ground-based extraction), and improve safety and well-being of our forestry workforce and associated communities. The concept is futuristic but possibly achievable within the next decade as the payload and operating efficiency of UAV's increases.

As part of a programme such as 'Te Mahi Ngahere i te Ao Hurihuri – Forestry Work in the Modern Age' Primary Growth Partnership which is well beyond "business as usual" it is a revolutionary concept and is subject to validation and open to challenge.

This project is part of a long-term programme, with much more to be done in terms of collaboration and partnership with sector stakeholders, researchers and innovators, and technology developers and manufacturers. Such collaboration is key to the success of the programme and will continue to guide the effective use and adoption of new technology across the forest industry to the benefit of New Zealand.

Authors' note: To see the animation of "Future Proofing Forestry" scan the QR code above, or click on the following link:
Parker, R. & Hooper, B. (2022) Future proofing forestry. YouTube:
https://www.youtube.com/watch?v=itQm2ivzZ3M&t=88s

References

AirForestry (2023)
https://www.airforestry.com/en/our-system/

Baillie B. (2010) Forest harvesting practices in and around sensitive areas: a literature review. Rotorua, New Zealand: Scion. 2010. Scion Technical Report No. S0001. 6.

Bloomberg, M. (2019) Woodside Case Study YouTube
https://www.youtube.com/watch?v=dybK8KEALe4&t=12s

Byers, A., Garrett, L., Armstrong, C., Dean, F., and Wakelin, S. (2022) Large, old pools of carbon and microbial communities are present deep in soils under a temperate planted forest, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2022-689, 2022.

FGR, (2018). Primary Growth Partnership Business Case "Te Mahi Ngahere I te Ao Hurihuri – Forestry Work in the Modern Age". Business case prepared for the Ministry for Primary Industries. Forest Growers Research Ltd, 30 September 2018.

FGR, (2019) Forest Growers Research Primary Growth Partnership Annual Plan 2019 – 2020. Forest Growers Research Ltd, 30 August 2019.

Hall, P. (2022) Harvesting cost assessment. Personal Communication.

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