NEW HARVESTING INNOVATIONS TO IMPROVE HEALTH AND SAFETY*

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Timber harvesting continues to be expensive, difficult and dangerous work. This is especially true in steep terrain where planning and managing successful harvesting operation is challenging due to the terrain conditions. While harvesting operation on flat or rolling slopes can be largely mechanised, steep terrain harvesting is still typically characterised by manual tasks such as felling and setting-chokers for cable yarding. This paper highlights both machinery innovation, as well as innovative practices that are improving the safety of the workforce. Examples include using the newly developed cable-assist machinery to extend the operating range of ground-based operations onto steeper slopes. Specifically, cable assist machines are now felling and pre-bunching on steep slopes. Combining this with the new motorised grappled carriages, operating on standard live skyline systems, the felled trees can be extracted without the need for choker-setters making it a fully mechanised system. For cable yarding systems still using choker-setters, remote control of the yarder eliminates the risks associated with poor communication. New GIS based cable planning software not only asses feasibility, but also allows a level of integration between the various tasks, with felled trees being bunched along pre-determined corridors for ease of extraction.

Keywords: harvesting, silviculture, safety, equipment.
Parole chiave: utilizzazioni forestali, selvicoltura, sicurezza, attrezzatura.

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1. Introduction

Forestry is, and will always be, a great place to work. Despite many positive changes, most countries practicing commercial forestry still have unacceptably high incident and accident rates associated with forestry work. Opportunities to mechanise have been extensively realised on flat to rolling terrain. Mechanisation has also lead to greater levels of automation, with the machines being a platform for technology such as on-board computers and geo-referencing systems. However, harvesting on steep terrain still requires higher levels of manual, or motor manual input. Cable yarding extraction requires motor-manual felling of the trees, and choker-setters are required to attach the rigging to the felled trees. These two work activities account for the majority of fatalities. A number of opportunities are being developed to increase the level of mechanisation on steep terrain. Italy has led the way in design and implementation of remote controlled yarders, but other countries taking a lead in developing cable assist harvesters and extraction machines.
In terms of silviculture, while ‘near to nature’ forestry practices are becoming ever more popular in Europe, they are not without implication if the resource is to be used commercially. Adding silvicultural complexity increases both cost and safety risk for the harvesting crews. To date, harvesting crews are expected to manage safety within a defined forestry task (‘harvest prescription’). Some of these risks can be mitigated by new mechanised or even robotic, harvest systems. However, constructively working together with the silvicultural specialist should ensure that harvesting practices not only remain safe, but also economically viable.

2. Extending ground-based system range

Ground-based harvesting systems are typically more productive and cost-effective than cable or aerial systems (Visser, 2012). Steep slopes create an operating limit for ground-based machines, although that limit is often not well defined. Forestry machines working on steep slopes typically lose traction before they are close to their static roll-over limit (Visser, 2013a), so both terrain slope and soil strength must be taken into account. A cable can be used to assist the traction capability of a machine and thereby extend the operating range. Cable-assisted harvesting machines are not new; in Europe they have been most commonly used for forwarders but are now also available for harvesting machines. However, New Zealand conditions include very steep (more than 50 per cent is common) and unstable terrain (geologically young and often highly erodible), in combination with relatively large tree size (more than three cubic metres is common), which has required larger felling machines than were commercially available. The ClimbMAX Steep Slope Harvester (Fig. 1), developed by Nigel Kelly and Trinder Engineering with the support of

FFR, is an example of a machine that meets these requirements.
This is a 43 tonne purpose-built machine which integrates the winch system into the chassis. With development work that included research and testing, it is now fully commercialised with units sold in both New Zealand and Canada.
It complements other cable-assisted systems that are being developed based around purpose-built self-levelling steep terrain harvesters that are tethered to an uphill anchor machine (typically a bulldozer) that both houses and powers the cable winch (Fig. 2). With the largest risk of serious harm injury associated with motor-manual felling on steep terrain, a number of New Zealand forestry companies are actively encouraging their logging contractors to adopt these mechanised felling/bunching/shovelling systems that can work on very steep slopes.
A comprehensive research project looking at a range of forestry machines working on 'typical' terrain established that most exceeded the safety guidelines of 30 per cent slope for rubber tyred and 40 per cent for tracked machines (Berkett and Visser, 2012). Machine operators typically do not measure actual machine slope, or predict the slopes they might be exposed to when they harvest a block. Interpine Forestry has developed an on-board navigation application, HarvestNav, that provides the operator of any steep slope harvesting machine with information on harvest area terrain.

3. Mechanisation of cable yarder extraction

Most cable yarding rigging configurations in New Zealand still require the use of choker-setters to attach chokers to the felled trees for extraction (Harrill and Visser, 2012). Next to tree fallers, choker-setters have the second highest risk of serious harm injury. The use of grapples on cable yarding systems eliminates the need for choker-setters to work on the steep slopes.
The use of a mechanical grapple, typically coupled with a swing yarder, has been around for a long time. The design of a 'grapple restraint' to help control the movement of the grapple and improve its productivity shows that existing systems can always be improved upon (Evanson and Brown, 2012). However, the mechanical grapple system is typically limited to terrain with good deflection, short extraction distances and good piece size.
Swing yarders are versatile, powerful and fast, but they are also expensive to purchase and operate. Two-thirds of New Zealand yarders are tower yarders (Visser, 2013b), which are not well configured for running skyline/mechanical grapple carriages. With improved control features, a powered grapple carriage can operate successfully on the existing tower yarders. Two types of powered grapple carriages alternatives are now working in New Zealand as shown in Figure 3. The Falcon Forestry Claw is a two-tonne carriage housing an internal engine that powers the grapple.
A comprehensive study, including scenarios of extracting motorised manually-felled stems and machine-felled stems (pre-bunched), showed that signifycant improvement in productivity can be achieved when working with an excavator/shovel in the cut-over that 'feeds' the stems directly into the grapple (McFadzean and Visser, 2013). The second carriage is the Alpine which was developed in South Africa, but modified for New Zealand conditions. It is hydraulically-powered so relies on accumulated hydraulic pressure to operate the grapple. The advantage of a hydraulically grapple is reduced carriage weight, with the disadvantage of needing to accumulate hydraulic pressure before the grapple can be actuated. One disadvantage of the grapple carriage extraction system is that due to visibility limitations the operator can have difficulty in picking up stems. Traditionally this limitation is overcome by using a 'spotter'. This is a worker who places themselves along the harvest corridor where they are able to see the grapple and the stems to be extracted, and provides feedback to the yarder operator on carriage control commands through a walkie-talkie. Although using a spotter is effective, it does not meet the objective of fully mechanising the system. An idea has been developed to use camera technology to provide the yarder operator with good visual information to assist in the grappling phase.

4. Cable planning and performance monitoring

Most forestry companies actively use GIS, not just as mapping software but extensively as an information management system. It therefore makes sense to create harvest plans in this environment, especially for cable logging operations where terrain information is critical to successful layout of landing locations, setting boundaries and cable corridors.
The Cable Harvest Planning System (CHPS) has been developed to work in the ArcGIS environment - see www.cableharvesting.com - and integrates the fundamental calculations that determine payload with the capability of various machines and rigging configurations. It allows the harvest planner to select their preferred system, and then by identifying landing locations automates the calculation on physical feasibility with regard to both corridor distance and payload limits as shown in Figure 4.
Considerable work has been completed to improve our understanding of skyline tension/deflection/payload relationships. These mathematical relationships are often accurate for standing skyline with fully suspended loads, but they are invariably quite inaccurate for the live-skyline partial suspension scenarios that are most common for large-scale cable yarder operations. Rigging configurations such as North Bend are not included in most analyses packages, and little is known about the new generation of motorised carriages and their effect on skyline tension.
Extensive tension monitoring of various rigging configurations have highlighted the importance of not relying on just mid-span deflection/tension/payload, which is typically the design calculation for most software programmes.
Operational tension monitoring can be used for both immediate operator feedback with regard to both safety

and payload optimising and improving our understanding of the effect of different configurations on actual skyline tension. The one aspect not fully explored is to feed this information back into our cable planning software algorithms to more accurately predict cable tensions, and therefore allow for more advanced payload planning.

Automated control systems have long been a feature of the new yarders produced in Europe, but this new technology is now also being developed and retrofitted into the existing larger yarders. Active Equipment of Rotorua has released the ACDAT system that integrates tension monitoring, GPS tracking of the carriage, production monitoring and remote control camera all onto a touch-screen that is designed to be retrofitted into the yarder cab - see www.activeequipment.co.nz. Another example is the Brightwater PLC Air Control system which, in addition to tension monitoring, provides the opportunity to optimise the yarder/winch system performance by selecting the type of rigging system that is used (grapple, carriage or scab) - see www.brightwater.co.nz. This makes it easier to change between configurations.

5. Future opportunities

There has been a very positive synergy between the applied forest operations research work carried out in New Zealand and the implementation of innovations through both equipment development and application by industry. The focus on mechanisation and modernisation of steep terrain harvesting systems is showing potential for significantly improving both productivity and safety.

The new developments presented in this paper each provide an opportunity for improvement, but there remains a greater potential when integrating these individual components into an effective combined ‘advanced steep terrain harvesting system’.

Using the GIS-based cable harvest planning software to identify both cable corridors and payload potential, this geo-referenced information could be uploaded into a cable-assisted felling machine application which shows exactly where and how to bunch the felled timber for most effective mechanised extraction using the grapple carriage systems.

The on-board yarder monitoring system can then ensure that the productive potential is achieved safely. This data, which includes payload and tensions, can then be analysed and used for future updates of the harvest planning approach.

*Note

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Figure 1. ClimbMAX felling machine with winch integrated into chassis.

Figure 2. Purpose-built self-levelling harvester (right) being cable-assisted by the winch mounted on the dozer (left).

Figure 3. Motorised grapple carriages – Falcon Forestry Claw with internal motor (left) and hydraulically powered Alpine (right).

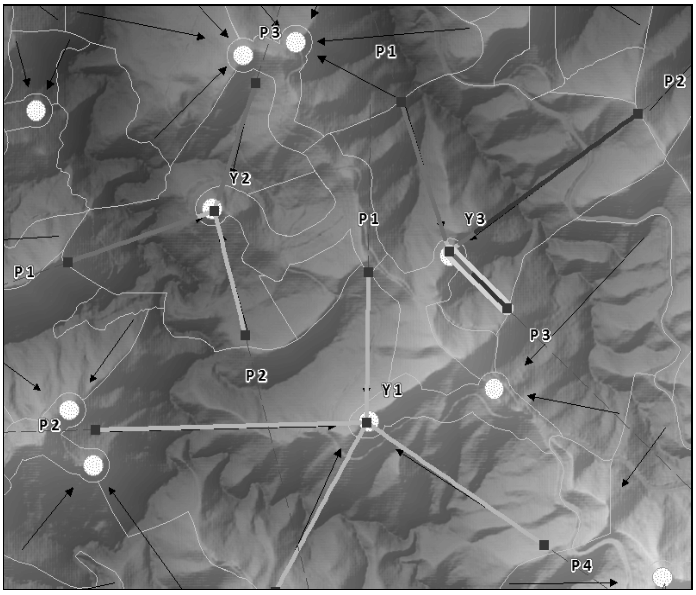

Figure 4. Example of the CHPS map interface which allows the harvest planner to identify landing locations and corridors. Corridor colours are used to denote payload limit ranges.

RIASSUNTO

Innovazione delle utilizzazioni forestali per migliorare salute e sicurezza

La raccolta del legno continua ad essere un lavoro costoso, difficile e pericoloso. Questo è particolarmente vero sui terreni ripidi dove la pianificazione e la gestione delle operazioni di raccolta sono difficili a causa proprio delle condizioni del terreno. Le attività di utilizzazione forestale possono essere in buona parte meccanizzate in aree pianeggianti o su terreni poco pendenti. Al contrario, le stesse attività su terreni ripidi sono ancora tipicamente caratterizzate in gran parte da attività manuali, come l'abbattimento e l'aggancio dei tronchi nell'esbosco con gru a cavo.
Questo lavoro evidenzia le innovazioni tecnologiche, nonché le pratiche innovative che stanno migliorando la sicurezza dei lavoratori. Gli esempi riportati includono l'uso delle macchine assistite da cavi recentemente sviluppate nel settore delle utilizzazioni per estendere il raggio di azione delle macchine sui pendii più ripidi. In particolare, le machine assistite da cavi permettono oggi di operare nell'abbattimento e concentramento del materiale legnoso anche su pendii ripidi. Combinando tali machine con i nuovi carrelli motorizzati a pinza, utilizzati su particolari impianti di gru a cavo (standard live skyline systems), gli alberi o i tronchi abbattuti possono essere esboscati senza la necessità di aggancio degli stessi da personale a terra, rendendo completamente meccanizzato il lavoro di utilizzazione su terreni pendenti. Per le gru a cavo che ancora utilizzano il Sistema di aggancio dei carichi tradizionale, con personale a terra, l'impiego di sistemi di controllo remoto della stazione motrice permette di eliminare i rischi associati alle difficoltà di comunicazione tra i diversi operatori. I nuovi sistemi di pianificazione delle linee di gru a cavo, sviluppati in ambiente GIS non solo permettono di valutare la fattibilità

dell'esbosco, ma permettono anche di migliorare il livello di integrazione tra le varie fasi di lavoro, concentrando con alberi abbattuti lungo corridoi predeterminati per facilitarne l'esbosco.

REFERENCES

Amishev D., Evanson T., Raymond K., 2009 – *Felling and Bunching on Steep Terrain – A Review of the Literature.* Harvesting Technical Note HTN01-07, Rotorua, NZ: Future Forests Research Ltd.

Berkett H., Visser R., 2012 – *Measuring Slope of Forestry Machines on Steep Terrain.* Harvesting Technical Note HTN05-02, Rotorua, NZ: Future Forests Research Ltd.

Evanson T., Brown D., 2012 – *Improved Grapple Control Using a Grapple Restraint*. Harvesting Technical Note HTN10-04, Rotorua, NZ: Future Forests Research Ltd.

Harrill H., Visser R., 2012 – *Matching Rigging Configurations to Harvesting Conditions.* Harvesting Technical Note HTN04-06, Rotorua, NZ: Future Forests Research Ltd.

Harrill H., Visser R., 2014 – *Skyline Tensions and Productivity of a Motorised Grapple Carriage.* Report FFR-H015, Rotorua, NZ: Future Forests Research Ltd.

McFadzean S., Visser R., 2013 – *Falcon Forestry Claw Grapple: Productivity and Ergonomics Harvesting.* Technical Note HTN05-06, Rotorua, NZ: Future Forests Research Ltd.

Raymond K., 2010 – *Innovative Harvesting Solutions: A Step Change Harvesting Research Programme.* New Zealand Journal of Forestry, 55 (3): 4-9.

Raymond K., 2012 – *Innovation to Increase Profitability of Steep Terrain Harvesting in New Zealand.* Procee-dings of NZ Institute of Forestry Conference held in Christchurch on 1-4 July 2012.

Visser R., 2013a – *Tension Monitoring of a Cable Assisted Machine.* Harvesting Technical Note HTN05-11, Rotorua, NZ: Future Forests Research Ltd.

Visser R., 2013b – *Survey of Yarders Used in New Zealand.* Harvesting Technical Note HTN06-03, Rotorua, NZ: Future Forests Research Ltd.