



Excavator Yarders for New Zealand

Summary

TECHNOLOGY WATCH is a biannual report outlining research and technology developments that are occurring outside the FFR Harvesting Programme, frequently from overseas. This report focusses on the need for wider uptake of lower cost cable yarders such as excavator-based yarders suitable for small scale steep forests. It has been forecast that in the near future a large proportion of the annual plantation harvest will be sourced from farm-based woodlots and small forests. These small forests are likely to include short steep slopes and poor road access. There are also similar areas in many larger plantation forests. Excavator yarders are ideally suited for extracting trees from this type of terrain, they are simple to operate, and are less capital intensive than larger cable yarders. The features and availability of a range of excavator yarders, suitable for New Zealand, are presented.

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INTRODUCTION

Smaller scale forest owners (those owning less than 1000 hectares) made up 30% of the national plantation forest estate in 2014 ^[1]. Recent forecasts indicate that the potential harvest volumes available from these small-scale owners' forests could increase from 7 million cubic metres per year to over 14 million by 2023 ^[2]. This increase is expected to be mainly driven by harvesting from the Southern North Island, East Coast, Marlborough, and Otago/Southland regions. This in turn means that the national annual harvest could increase to 35 million cubic metres through to the mid-2030s.

Despite this potential wood availability, the economics of harvesting will drive the decision as to whether these forests are harvested. Harvesting costs are a critical component affecting the economics of forestry. These costs include roading and landing construction, harvest planning, harvesting operations and log transport within and outside the forest. In New Zealand the average cable logging rate has steadily increased over the last five years from \$32.40 per tonne in 2009 to \$37.50 per tonne in 2015 ^[3] due to increasing labour and machinery costs.

Over the same period log prices have remained relatively static, resulting in reduced returns for owners of steep country forests. If the cost of harvesting continues to increase at the same rate and log prices remain static many forests will be uneconomic to harvest in the near future, particularly small, steep terrain forests remote from mills or ports. Scenario analysis has determined that some small forests in remote locations may either be harvested and not replanted, or not harvested at all. For example, one analysis of small blocks in the Whanganui region suggested that 5-10% of the blocks might never be harvested ^[4]. A more recent analysis indicated that 6-9% of small forest blocks would be uneconomic to

harvest. These blocks are spread around the country and, mostly due to remoteness, may not be harvested at all. As expected, the terrain of the forest block, access to major roads and distance to port or mill had a strong influence on forest profitability ^[5].

The combination of increased wood availability, small forests, remote locations and steep terrain means that harvesting systems must be carefully matched to these conditions to avoid high cost harvest access and harvesting. Such a low cost harvesting system could have the following characteristics:

- Mobile, multi-function machines for yarding, processing and loading logs
- Reduced labour component
- Ability to move log products both off-road to where highway trucks can access the wood and off-highway to a point where more efficient secondary transport can be employed (such as HPMV trucks or rail).



Figure 1. Jewell Timbermast'r dual winch yarder with mast assembly and Acme slack pulling carriage (Source: Jewell).



HARVESTING TECHNOLOGY WATCH

HTW-017
November 2016

Excavator yarders (also known as Yarder-Loaders or 'Yoaders' in North America) provide some of the above requirements and are well suited for extraction and processing and/or loading in the above conditions. They can run a variety of cable rigging configurations such as highlead, scab skyline and shotgun systems as well as operate rope grapples, grapple carriages and slack-pulling carriages (Figure 1). They are suited to relatively low production operations working on roadsides. The mass of the base machine and support of the boom as an outrigger allow for excavator-based yarders to operate without guylines, a major advantage in terms of space requirement and set-up. Labour costs are also lower than other yarder types as excavator yarder-based logging systems can be run by a smaller crew than larger yarders.



Figure 2. Jewell Model HL25 Dual Winch Yarder Log Loader
(Source: Paladinattachments.com)

Excavator yarders can be produced as single, two or three drum machines. Tower height can vary, as can the choice of grapple, bucket or processor head. Location of the drums and the tower itself can also vary (Figure 2). Some European excavator yarders favour drum location at the base of the tower, which is connected to the end of the boom. The excavator is then used as a single function machine (Figure 3).

A recent study in Norway^[6] examined the desired features for selecting an appropriate excavator yarder to meet Norwegian forestry conditions. A hierarchical preference process determined that the yarder should be:

- Based on a medium-sized tracked excavator (25 tonnes)

- Have a rear-mounted double drum winch
- Feature a tower mounted as an extension to the arm or stick
- Have an operating range of at least 500m.



Figure 3. Valentini V550 on a Liebherr R914B-2 excavator
(Source: Valentini)

Background to Excavator Yarders

Excavator yarders are not a new idea. Skurdahl in 1990 described an excavator yarder concept as a response to the need for efficient and environmentally acceptable logging systems in the U.S.^[7] This style of machine was intended to be multi-functional – to yard, clear the chute and also to load trucks. Specifications quoted included a bare drum line pull of 11.35 tonnes and a line speed of 7.1 m/sec.

The productivity of excavator yarders was described in a report in 1995 by the Logging Industry Research Organisation^[8]. An excavator yarder in a highlead logging in New Zealand was evaluated in a two-day study (115 cycles). The system's suitability to short, steep settings where the use of conventional ground-based systems was unacceptably hazardous or might cause excessive soil disturbance was noted. In 1.7 m³ trees and an average haul distance of 78m, an estimated volume of 415m³ was extracted over two days (using chokers). This machine, owned by Dewes Contracting Ltd, is still working today.

In 2004 a study in the U.S. reported the productivity of two dual-drum excavator yarder systems using Allied W400 winches, working in thinning operations^[9]. One of the yarders was a CAT 315-L and the other a converted Timbco T425. Crew size was 2-3 workers (excluding felling). One of the yarders was used within the stand and trees were two-staged by skidder to a landing. Both



HARVESTING TECHNOLOGY WATCH

HTW-017
November 2016

yarders used live skylines and gravity return Christy carriages. Both machines showed quick skyline shifts (less than 30 min each). The authors concluded that the yarders were suited to logging environmentally sensitive sites at haul distances of less than 100 m.

In 2011, researchers presenting a paper to the FORMEC Conference^[10] noted that there were more than 400 excavator yarders with double drum winches in Japan. In New Zealand a survey of yarders in 2012 identified only nine excavator yarders working in New Zealand^[11]. These yarders comprised only 3% of the total number of yarders in New Zealand at the time.

Renewed interest in excavator yarders has lately been seen in New Zealand. Electrical and Machinery Services Ltd (E.M.S.) of Rotorua^[12], is the manufacturer of the Harvestline excavator-based yarder (Figure 4). E.M.S. has confirmed orders in 2016 for four machines (Chris Hancock, E.M.S., pers. comm.).



Figure 4. EMS Harvestline double drum yarder

Priceright Parts and Machinery Ltd in Rotorua^[13] has also built an excavator-mounted winch system from a converted 28 tonne Doosan 280LC-3 excavator with dual Allied WH411Y winches (Figure 5). The winches have bare drum line pull of 12.9 tonnes and line speed of 3.0 m/sec. The machine is currently uphill yarding with a Christy carriage (Peter Edwards, Priceright Ltd., pers. comm.). The Allied WH411Y system is a very simple cost effective shotgun yarding system for uphill yarding out to a maximum distance of 300 metres. A downhill yarding system is also in development.

Variations of excavator yarder design also include “Tong throwers”^[14], where a single drum excavator yarder “throws” either a grapple or choker rigging up to 100 metres.



Figure 5. Priceright double drum conversion of Doosan 28 tonne excavator base with Allied winches

Multi-function Machines

Excavator yarders can also be equipped with processor heads rather than buckets or grapples, extending the concept of multi-function machines. This combination was demonstrated in a study of a wheeled excavator-based integrated yarder-processor^[15]. The excavator yarder studied was developed by Zöggeler Forsttechnik in Austria (Figure 6).



Figure 6. Zoeggeler Yarder-Processor
(Source: <http://www.zoeggeler.at/>)



HARVESTING TECHNOLOGY WATCH

HTW-017
November 2016

The Zöggeler^[16] three-drum, wheeled excavator yarder-processor had three in-line winch drums mounted on the excavator boom of a 21 tonne Doosan DX210W wheeled excavator. Each winch was fitted with auto-tensioning. The Zöggeler ZBH58 processor was designed to enable both processing and loading functions. The yarder-processor alternately operated a running skyline then processed the extracted stems in a clearfelling operation in central Norway. Productivity was restricted by the small tree size (0.27 m³), the faller/breaker-out productivity, and the inability to yard and process at the same time. It was suggested that processing only take place during felling activity.

Costs

Costs vary, depending on whether a new or used base machine is chosen. Another factor is the drum configuration. A used 35 tonne base machine Harvestline has been quoted at approximately \$500,000^[17]. The cost of converting a 28 tonne Doosan excavator to a two drum yarder using Allied winches was between \$120,000 and \$150,000 (Peter Edwards, Priceright Ltd., pers. comm.). The quoted price for a Jewell installed dual-winch TimberMast'r system (ex-Jewell facility) is \$191,500 (Matt Hall, pers. comm.). The cost of the Alpine Shovel Yarder ASY 500-LS two drum winch set with live skyline valve bank is \$350,000, which includes shipment to New Zealand and fitment. All these quoted costs are considerably lower than that of conventional towers and swing yarders.

RESULTS OF REVIEW

Excavator yarder productivity was reviewed using information sourced from New Zealand-based manufacturers and the websites of international manufacturers. Twelve different manufacturers of excavator yarder equipment were identified. The information is summarised in Table 1. Key features of these machines were:

- Tower construction, location and height
- Winches – number and location. In addition, winch specifications can be specific to the task and preferences of the purchaser.
- Yarding Distance
- Carriages
- Accessories – bucket, grapple or processor head.

Tower Height

Most machine manufacturers do not specify tower height but there is definitely variation. Tower attachment design varies with location on the boom or stick. One

manufacturer which does not use a tower system – the Pierce Pacific conversion^[18] has sheaves located at the end of the extended boom and stick (Figure 7).



Figure 7. Pierce Pacific Yarder conversion
(Source: Pierce Pacific website.

Both Herzog Forsttechnik AG^[19] of Switzerland and Valentini of Italy^[20] produce machines with towers located at the end of the boom and the stick has been removed (Figure 8). These machines are single function yarders. A factor is the overall weight of the yarder, which must fit suitable requirements of the transporter (low-loader) and possibly bridge specifications during transport between forests.



Figure 8: Herzog Grizzly 400 Yarder combines European skyline crane technology with the excavator yarder system

Winches

The main overseas suppliers of winches for excavator yarders were Pullmaster TWG^[21,22] and Allied Winch^[23].



HARVESTING TECHNOLOGY WATCH

HTW-017
November 2016

Some manufacturers such as EMS make their own winches to the customer's specifications.

The two main attributes of winches are line pull (tonnes) and line speed (m/sec). These values can relate to the torque applied from a bare drum, mid-drum or full drum. At bare drum the line pull is greatest and line speed is at minimum. Mainline and haulback drums are either hydraulically or mechanically interlocked (by gears or chain). Some winch systems introduce gearing to increase line speed. Winch performance is largely dependent on flow and pressure of hydraulic pumps used. Winch drums are designed to operate with given hydraulic flow rates and pressures. Information indicates that with higher flow rates and pressures, higher line pull and line speed is possible [23].

A description of HL25 Pullmaster planetary winches [21, 22] describes main and haulback winches as being set up for low speed/high torque for heavy drags, and high speed/low torque for smaller loads. In reverse, these drums operate at high speed. The same drum configuration can be used for a skyline, if required. A straw line drum is included in most setups. For example, based on 231 litres/min and 3800psi (26.2 MPa), a No. 4 size Pullmaster HL25 winch in high speed mode, mid-drum using 11mm ($\frac{7}{16}$ inch) rope has 1.62 tonnes line pull and 4.9 m/sec line speed. In low speed mode, the same drum has 7.47 tonnes line pull and only 1.1 m/sec line speed.

Winch information for the current Pullmaster HL25-7-86-1 (rapid reverse/two-speed forward) winch does not give mid-drum specifications but a bare-drum specification of 11.34 tonnes line pull in slow speed mode is noted. This model comes with an over-running clutch (sprag clutch) and multi-disc brake.

The Allied WH411Y [23] series winch relies on a sprag clutch for braking, which allows free movement in one direction, but a degree of braking in the opposite direction. Bare drum line pull and line speed specifications are similar to the HL25.

Custom designed winches have their advantages. This is illustrated by an EMS [12] winch design that offers 13 tonne line pull at mid-drum with 5000 psi maximum hydraulic pressure (35MPa).

Models of the Alpine Shovel Yarder suitable for New Zealand include the twin drum hydraulically interlocked 16 tonne kitset or the twin drum mechanical/hydraulic interlocked 16 tonne kitset. Additionally, a skyline drum

is also available which is able to be fitted to the standard double drum kitset.

Yarding Distance

Buyers of excavator yarders can specify the winch design and drum capacity. Most drums are set up for haul distances out to about 300 m. Longer distances are possible using extensions. Rope sizes do not exceed 19mm ($\frac{3}{4}$ inch) and many run 11mm ($\frac{7}{16}$ inch) ropes.

The advantage of a custom drum set is also noted in terms of drum capacity. The Alpine Shovel Yarder [24], for example, is quoted at drum capacities of 550 m of 22 mm rope (Figure 9).



Figure 9: Alpine Shovel Yarder on Cat 3360 base machine.

The HL25 and WH411Y model winches have capacity for around 300m of rope whereas the Harvestline brochure quotes a capacity of 526m of 19mm ($\frac{3}{4}$ inch) rope for a front main/rear main drum and 907m for the haulback. This gives an effective maximum haul distance of 350m.

Carriages

Many excavator yarders are two drum machines. This usually limits the rigging systems that can be used. Two drum machines can shotgun effectively in uphill logging using Christy carriages as well as run a scab skyline system. The Alpine Grapple carriage [24] was designed for a two-drum system and Jewell machines have been pictured running Acme motorised slackpulling carriages. A three-drum configuration enables the yarder to use a conventional Johnson-type grapple or a dropline type carriage.



HARVESTING TECHNOLOGY WATCH

HTW-017
November 2016

Table 1. Internet-sourced information on Excavator Yarders

Manufacturer	Base	Attachments	Winches	Winch location	Mast	Notes
Timberpro	Self-levelling	Foot, Processor head (SP761 LF)	Single, auxilliary winch	Rear boom	None	Timberpro TL735-B. Winch 12 tonne capacity 50m 1/2 inch cable.
EMS	Tracked	Bucket or grapple	2, 3 drums EMS manufactured	base engine flat	Stick tower extension	Three drum machine can run a Johnson grapple.
Jewell	Tracked	bucket or grapple	Dual Pullmaster HL25 2 speed inhaul	Boom	Stick tower extension	Timbermast'r dual winch yarder with mast
Zoggeler	Wheeled	Processor (Zoggeler) Loading capable	2, 3 drum yarder	Boom	Boom attachment	250m haul distance, 11mm rope mechanical slackpulling carriage
Logfisher	Tracked	bucket or grapple	Single	Boom rear	Boom extension	30-50m haul distance, manual outhaul
Komatsu	Tracked	Bucket/live heel	Two	Boom rear	Stick tower extension	PC 300 operating weight 37,600 kg
Hin-Tech	Tracked	Grapple (30T machine)	Two, with disc brakes. Sauer danfoss motors.	base engine angled	Stick tower extension	Urus 111 300 Uni T model. 320m of 13mm mainline. 6T breakout power.
Alpine	Tracked	Bucket/grapple	Single, dual Alpine manufactured.	base engine angled	Stick tower extension	Alpine Shovel Yarder. Haulback/skyline 550m 22mm rope, Mainline 550m 22mm rope.
A and B Services	Tracked	Bucket/grapple	Two.	base engine flat	Stick tower extension	EX350
Priceright	Tracked	Grapple	Dual Allied WH411Y	base engine flat	Stick tower extension	28t Doosan excavator.
Herzog	Tracked	Stick replacements (bucket/grapple/ processor)	Two	Base of tower	Stick replacement	Grizzly 400-Yarder. 400m HD - 11mm main rope. 3 drum optional. Remote controlled.
Waldbedarf Forstmaschinen	Tracked	Processor head (Waratah 622)	Two, three	Rear engine Rear boom	Stick tower extension	315m skyline 18mm rope haulback 345m 14mm rope.
Pierce Pacific	Tracked	Grapple/live heel	Two	Turntable	Boom and stick	11.3 Tonne linepull in low gear at 42m/min 672m of 22mm rope (no. 5 drum).

Accessories / Attachments

The location of the tower will dictate the kind of attachment used. Three main attachments are possible – bucket, grapple or processor. Log grapples may be incorporated with a live or fixed heel. Some attachments may enable both grapple and processor operation. A multi-function approach will increase the utilisation of the machine and, with a processor, reduce the numbers of crew in the operation, but extraction will probably be the excavator-yarder's main function. Excavator yarders cannot yard and process simultaneously. Both buckets and live heels are used to anchor the stick during yarding (Figure 10).



**Figure 10: European excavator yarder from Waldbedarf Forstmaschinen & Zubehör [25]
[Source: <http://www.yarder.eu/index.html>].**



CONCLUSION

A variety of excavator-yarder designs are available, including those with processor heads. However, machines with processor heads cannot simultaneously process and yard.

Costs of conversions vary between \$150,000 and \$350,000, excluding the cost of rope and rigging. Excavator bases may be used or new. Processor costs are in addition to conversion cost.

The capital cost and flexibility of excavator yarders make them suitable for short haul distance, steep slope logging in difficult to reach areas or where it may be uneconomic to use larger tower yarders or swing yarders.

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