HARVESTING TECHNICAL NOTE

SMG-TN01
2021

Valtra Tractors: A forwarding solution for small forest growers

Summary

Harvesting of small forest blocks located in areas with difficult access can be a nightmare for all concerned. Physical and economic constraints often result in growers receiving marginal or no return for their investment in growing their forest stand. Finding a suitable, cost-effective harvesting system to adopt in these situations is often challenging and confusing for forest owners and harvesting contractors alike.

The machines commonly used in forest harvesting can struggle to achieve acceptable production levels in woodlot situations and harvesting costs tend to increase as a result, sometimes well beyond what was predicted. Problems can also occur with damage to farm paddocks, tracks and raceways by the large, heavy machines used in forest harvesting.

Adapted farm tractors provide one viable alternative to commonly used forest harvesting systems 'Valtra' is one brand of farm tractor for which a range of forestry adaptations are available. An adapted Valtra tractor can operate as a forwarder for part of the harvesting operation; the same tractor can also undertake site remediation following harvest. Studies have been completed on a Valtra forwarding tractor currently operating in small forest blocks in the North Island.

John Schrider and Jack Palmer, Forme Consulting Group Ltd

INTRODUCTION

The use of forwarding systems for transporting logs from the bush to a load-out site has had mixed success in New Zealand throughout the years.

Traditional extraction systems, using either ground-based or cable hauling systems, where logs are accumulated at a bush landing site for further processing and load-out, have prevailed.

A literature review provides insights into forwarder and bush truck extraction equipment and system development over the years, most of which have not been adopted as common practice in the New Zealand forest sector. Those that have been successful have tended to work well in niche operating and in specific conditions in the forest.

The forest planting boom in the 1990s resulted in the establishment of many small woodlots, owned by smaller investors and farmers. These woodlots are now at, or approaching, the end of their first rotation and are due for harvest.

Many of these stands are not well located in relation to access to public roads and markets. This means innovative decision making and tight operational control if growers are to receive decent returns on their investment in forestry.

High capital cost of conventional harvesting equipment, lack of economies of scale, long distances to markets, and lack of relevant experience amongst harvest planners and harvesting contractors are some of the challenges facing woodlot owners. An added challenge on farms is maintaining day-to-day farming operations while harvesting is on-going.

A recent introduction to the small forest harvesting sector in New Zealand is the Valtra series of agricultural tractors. A Valtra T174 model attached to a locally designed and fabricated PTO-driven log trailer is in operation in Seaview Logging's farm woodlot harvesting operations.

The tractor set-up is unique in that the tractor's ground speed power take-off is connected to the trailer which allows the trailer wheels to be driven via a gearbox and diffs. A conventional 'dragged' trailer would simply be incapable of operating on any wet ground or slopes with large loads, even in the summer months.

In addition to this, the forest-specific cab is appropriately guarded and recognised as falling-object protective structure FOPS compliant.

Studies were undertaken and supporting information collected over 3 days in early June 2020 in a range of weather conditions to gain an understanding of the capabilities of this equipment combination.

Harvesting System

The system employed by Seaview Logging Ltd consisted of the Valtra tractor/forwarder, a Tigercat

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph.: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

855 leveller equipped with a Satco felling head for felling and processing in the bush, a Komatsu PC200 for shovelling and loading in the bush and a Hitachi excavator loader for truck loading at the landing. All machines aside from the tractor are older machines, bought second-hand, recognising their very low daily productive hours and the need to maintain control of costs.

The crew consists of the owner who operates, loads, and unloads the tractor and the Tigercat operator who controls the bush operations including hand-felling as required. A third part-time crew member undertakes tree felling e.g., on fence lines, and other tasks as required.

The forest stand was located approximately 1.5km from the log accumulation and load-out site near the front of the farm property. As is common with many small woodlots, no inventory data were available to record stand age, tree size and grade outturn.

Disruption to harvesting operations from day-to day-farm operations was minimal with only stock movements and opening and shutting gates by the tractor operator causing any delays.

Figure 1: A fully-laden trailer is extracted across a farm paddock and onto a race.

Study approach

Time studies were carried out on the tractor cycle only. Elements, consisting of return haul unloaded, load, hauling loaded, and unload, were recorded. The focus was on operational time. Delays, although recorded, were excluded from any data analysis. Associated actions e.g., securing and releasing load securing strops, have been incorporated in load and unload times.

The extraction haul route consisted of bare paddock running, farm stock raceway and formed and metalled milk tanker road surfaces, all of which were then further segregated by broad slope categories, in this case, +/- 5 degrees and +/- 10 degrees.

The prime objective of the time studies was to understand tractor travel times and speeds and evaluate any significant observations over varying surface and slope conditions. This would enable us to construct of a set of high-level time standards to predict tractor performance over a range of conditions.

While it was not possible to measure load weight, either via load cell or measurement, the number of logs for each load was counted and estimation of weights undertaken. Time studies were supplemented by UAV videography that captured full tractor running time over the length of the extraction route.

Production data presentation

Data presented in Table 1 follows a work study approach. The data represent activity at the studied site and are therefore specific to that site.

Table 1: Basic data presentation

	Direct				Indirect			
	Dist (m)	Slope	min/cycle	min/10m	Dist (m)	Slope	min/cycle	min/10m
S1 Unloaded	225	+/- 5	0.788	0.035	225	+/- 5	0.788	0.035
S2 Unloaded	450	+ 10	2.009	0.045	450	+ 10	2.009	0.045
S3 Unloaded	680	- 10	2.594	0.038	680	- 10	2.594	0.038
Position	40		1.233		40		1.233	
Load			12.507				12.507	
S3 Loaded	780	+ 10	5.836	0.075	660	+ 10	6.628	0.100
S2b Loaded					140	+ 10	1.84	0.131
S2a Loaded					120	- 10	1.035	0.086
S2 Loaded	450	- 10	2.738	0.061	450	- 10	2.738	0.061
S1 Loaded	225	+/- 5	1.195	0.053	225	+/- 5	1.195	0.053
Unload			7.211				7.211	
Total			**36.111**				**39.778**	

Note: S1 - metalled milk tanker road flat
S2 - metalled milk tanker road +/- 10^0
S3 - cow race/bare paddock

Calculated cycle times relate to two routes followed by the tractor (direct and indirect). The direct route was

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph.: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

followed on the first day only as wet weather prevented use of one section of that track for the remaining days.

Data is presented to demonstrate a simple methodology for calculating estimated production once basic cycle times are known. Machine travel times are further presented as time/10m standards that that can be applied to other route scenarios.

Table 2 provides a mechanism for additional machine and operator specific allowances. For this we have adopted a historical work study figure of 31.8%. This accounts for extra time, usually non-productive, that includes rest, contingency, and process allowances. Daily production estimates have been provided for 3 load size scenarios that represent high, average, and low trailer capacity depending on log size (length & diameter).

Table 2: Daily production estimates

Basic time (from Table 1)		36.111	39.778
Allowances	plus 31.8%	47.59	52.43
Cycles/day	480 min day	10.09	9.16
Tonnes/day	10 tonne payload	101	92
Tonnes/day	12 tonne payload	121	110
Tonnes/day	15 tonne payload	151	137

Discussion: Slope and running surface

Data were further analysed to detect any meaningful variances due to changing slope and surface conditions. Further explanation of observed extraction route sections is provided:

1. Bare open paddock with variable slope between 5° and 15° with some blade levelled classified as +10° for loaded and -10° for unloaded running.

2. Metalled farm race with variable slope between 5° and 15° with narrow gates requiring careful navigation classified as +10° for loaded and -10° for unloaded running.

3. Metalled, tanker track standard road with variable slope between 5° and 15° classified as -10° for loaded and +10° for unloaded.

4. Metalled, tanker track standard road with variable slope between -5° and +5° loaded and unloaded.

Basic time standards were developed as shown in Table 3.

Table 3: Time standards for tractor

Element	min/10m
Travel unloaded road +/- 5°	0.042
Travel unloaded road + 10°	0.045
Travel unloaded paddock/race -10°	0.053
Travel loaded paddock +10°	0.105
Travel loaded race +10°	0.137
Travel loaded road -10°	0.071
Travel loaded road +/- 5°	

Comments and Observations

1. Travel times unloaded on flat and relatively flat surfaces of any kind were consistent.
2. Travel loaded uphill was affected more by manoeuvrability constraints (narrow gateways, sharp corners) rather than surface type. Load size had minimal effect on travel speeds as once the right gear is selected the operator tended to remain in that gear at a set speed.
3. Surface condition affected ease of mobilisation from standing.
4. Travel loaded on unmetalled surfaces i.e., bare grass, was challenging on slopes above 10° – 15° in wet conditions for observed soil types.

For high level cycle time estimation, the observed data has been further summarised into broad categories as shown in Table 4.

Table 4: Time standards for tractor (consolidated)

Element (consolidated)	min/10m
Travel unloaded all surfaces +/- 10°	0.049
Travel loaded all surfaces +10°	0.108
Travel loaded all surfaces flat/-10°	0.066

Example production calculation using consolidated data.

An example production calculation is provided using 1800m extraction route consisting of 1300m uphill 10° slope and 500m downhill 10° slope (Table 5).

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph.: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

Table 5: Example of production calculation

Element	Dist	slope	min/10m	mins
position				1.233
load				12.507
haul loaded	1300	+10	0.108	14.040
haul loaded	500	-10	0.066	3.300
unload				7.211
haul unloaded	1800	0^{o} - 10^{o}	0.049	8.820
Total basic time				47.111
Allowances	31.80%			14.981
Total cycle time				62.092
Cycles/day	480min			7.730
				Tonnes/day
10 tonne payload	10			**77.300**
12 tonne payload	12			**92.760**
15 tonne payload	15			**115.950**

Machine costing

Indicative daily costs of operating the Valtra tractor were estimated using commonly used machine costing methodology. Costing of forestry equipment is heavily reliant on individual and specific operator preferences and circumstances and therefore resultant methodologies can provide a variety of quantum outcomes. Rather than rely on any one methodology or introduce any perception of bias we have adopted two commonly known forestry equipment costing approaches:

1. "Business Management for Logging, 2nd edition 2009", Future Forests Research (FFR).

This is a later version of the costing handbook for loggers first produced by the NZ Logging Industry Research Association (LIRA) in 1981 and subsequently reviewed and updated in 1994 by LIRO and later in 2009 by FFR and the Blackburne Group, Chartered Accountants. A further revised version of this publication is due for release later in 2020.

2. "Informe Harvesting 2020" and daily rate estimates, based on an independent survey of harvesting equipment, vehicles, labour, overheads, by Forme Consulting Group Limited.

This publication, widely subscribed to by industry participants, is based on a comprehensive costing methodology originally developed by the NZ Forest Service for the management of harvesting operations during the last 20 years of the NZ Forest Service. This has been updated and refined by Forme Consulting Group over ensuing years.

For the purposes of this study a machine costing is provided that will provide a daily cost range rather than definition and discussion on the relative merits of each methodology.

One significant difference however is the flexibility within the Informe model to differentiate between the number of fixed and variable hours used for machine operation. This is important where variable (operating) hours for a harvesting machine may differ considerably from those fixed hours that require recovery of fixed costs when harvesting systems and scale constrain available working hours. To demonstrate this the cost summaries provide several iterations.

Table 6: Indicative cost structure

Key cost inputs				
Purchase price	$320,000			
Power (Kw)	140			
Standard hours	1400			
Life (yrs)	5.26			
Cost set of tyres	$29,000			
Tyre life (hrs)	$3,500			
Fuel ($/litre)	$1.20			
Interest (Debt)	8.00%			
Interest (Equity)	3.00%			
Risk	1.50%			
Indicative Annual Costs				
	BMOL		**Informe**	
Standard hours	1400	1400	1400	1400
Variable hours		1400	1000	800
Depreciation	$ 42,966	$ 43,123	$ 39,427	$ 37,579
Interest/Risk	$ 17,881	$ 14,720	$ 14,720	$ 14,720
Insurance	$ 4,335	$ 10,330	$ 10,330	$ 10,330
R&M	$ 32,224	$ 29,578	$ 26,011	$ 24,227
Fuel	$ 37,632	$ 30,317	$ 21,655	$ 17,324
Oil	$ 5,645	$ 4,843	$ 3,459	$ 2,767
Tyres	$ 11,600	$ 11,600	$ 8,286	$ 6,629
Overheads		$ 10,400	$ 10,172	$ 10,057
Total	**$ 152,283**	**$ 154,912**	**$ 134,060**	**$ 123,634**

Note 1: Individual cost components vary dependent on differing approaches to costing e.g., BMOL is based on 75% borrowed capital, Informe 70%, differing fuel consumption formulae, no overhead component (BMOL) etc.

Note 2: Variable hour costing approach is appropriate for woodlot harvesting e.g., full day operation is usually not attainable due to scale of operation i.e. fewer operators meaning machine is often idle while operator is undertaking other tasks. The operation however still needs to recover fixed costs.

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph.: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

HARVESTING TECHNICAL NOTE

SMG-TN01
2021

Tractor forwarding cost per tonne

Indicative cost per tonne for the studied operation is calculated as follows for differing machine cost scenarios.

Table 7: Indicative cost/tonne

	Indicative costs per tonne			
	BMOL	Informe		
Annual cost	$152,283	$154,912	$134,060	$123,634
Variable hours	1400	1400	1000	800
10 tonne payload	$ 8.38	$ 8.53	$ 10.33	$ 11.91
12 tonne payload	$ 6.99	$ 7.11	$ 8.61	$ 9.93
15 tonne payload	$ 5.59	$ 5.69	$ 6.89	$ 7.94

Note 3: For translation to total operation or crew cost other cost components will be added. These will include operator, other harvest system machinery and equipment, remaining personnel and associated costs. For the purposes of this report it is not intended to expand into these areas.

Tractor versatility

The option of utilising a farm tractor for smaller woodlot harvesting operations comes with many additional benefits.

1. Use of forwarding machines generally avoids the need to undertake expensive road access construction. Woodlots are often small scale, inconveniently located and in difficult terrain and the Valtra provides an effective option to avoid these costs.
2. Use of tractors can avoid major disruption to farm infrastructure such as to central raceways, gateways and fences. Good manoeuvrability through such infrastructure avoids dismantling and re-building costs.
3. Impact on paddock running is very low. Illustrated ground impact on +80 slope, winter conditions (relatively dry) after 8 loaded passes. Grass regrowth completely heals impact within six weeks. The tractor configuration also caused no discernible damage to metalled central raceways and farm roads.
4. The range of attachments to extend the capability of the machine includes:

- **Front power lift with bucket** particularly useful for transport of metal to fill a pothole or cartage of heavy items such as fuel drums.
- **Front and rear winches** used to assist with felling boundary trees and ground hauling.
- **Mini tower** for running the winch rope back over the extended front power lift and extracting those hard-to-get stems.
- **Mulcher** for site rehabilitation after harvest or preparation for planting.
- **Loading crane** for attachment to the rear of the tractor or alternatively purpose-built integrated trailer and crane for loading and unloading.
- **Hydraulic blade** for tidying farm tracks or bare paddocks during and following harvest.
- **Factory forest options** including extra protected forestry fuel tank, and fully FOPS compliant cab guarding, roof protection and polycarbonate windows.

Figure 2: The system caused minimal damage to soils and vegetation.

The Valtra can operate on public sealed roads to a maximum speed of 50km/hr meaning that transport of logs to a dump site via the road and repositioning by driving between jobs is a possibility.

Conclusions

The Valtra tractor provides a cost-effective and practically viable option as part of a system for harvesting small farm woodlots. It would also complement a corporate forest owner's suite of contractor resources for tidying or completing those 'hard-to-access' parts of a forest stand that might prove uneconomic or logistically challenging for specialist equipment that might be available, but unsuitable.

While high production would not be the major determinant for selection of the machine, versatility

Forest Growers Research Ltd, PO Box 1127, Rotorua. Ph.: 07 921 1883 Email: forestgrowersresearch@fgr.nz Web: www.fgr.nz

and ability to complement other machines and equipment within a woodlot harvesting system would assist with creating the least disruption to farming operations.

The presence of smaller agricultural based machinery on a farm is also less intimidating in terms of potential for creating environmental and farm infrastructure damage and is more likely to be readily acceptable by small woodlot owners.

Notwithstanding, reasonable production rates are possible with this farm tractor configuration, particularly if the machine is able to operate unimpeded from other system machinery for example in a de-phased harvesting system.

Figure 3: Unloading the forwarder with the Hitachi excavator.

References

AGCO, Valtra Tractor T-Series, product brochure and technical specifications, www.valtra.com

Bennett, Dave: "*Two-stage logging to improve logging system performance*", NZ Logging Industry Research Organisation Report Vol.21 No. 22 1996

Byers, Jannelle and Cummins, Tina, "*A survey of North Island Woodlot Logging Contractors",* NZ LIRO Limited, Project Report PR-65, 1997

Ellegard, John, *Moving Forward - Valtra Tractor Iron Test",* NZ Logger magazine, February 2020

Forme Consulting Group Limited, "Informe Harvesting 2020 – Independent harvesting survey, equipment, accessories, vehicles, labour, overheads and daily rate estimates", January 2020

Future Forests Research Ltd, "Business Management for Logging – 2nd edition 2009".

Hall, Peter, "Two-staging to super-skids with Bell off-highway trucks", NZ LIRO Limited, Report Vol. 23 No. 8 1998

McMahon, Shane and Wylie, Neil: "*The M.A.N. 8X8 Truck*", NZ Logging Industry Research Organisation, Technical Note TN-18 June 1995

Waikato Tractors Ltd, Valtra Forest Tractor .ppt presentation and associated brochures, NZ Forest Growers Levy Trust Small Grower Harvest Initiation Workshop, Rotorua, August 2019

www.valtra.com Valtra Tractors website, general information

Acknowledgments

Support and funding for this project was provided by Forest Growers Research Limited and the New Zealand Forest Growers Levy Trust.

The ready assistance and co-operation of Graeme Saville and the team at Seaview Logging is gratefully acknowledged.

Assistance with technical and costing information also provided by Ben Peters, Waikato Tractors Ltd.