# Low-volume selective harvesting of farm tōtara – a practical trial

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## Abstract

This paper looks at whether low-cost and farm-based harvest equipment is a viable option for small-volume selective harvesting of farm tōtara. It also asks when the cost of transporting heavy machinery to site makes harvesting small volumes uneconomic, could European-style harvesting methods work in New Zealand? A practical trial in Northland provides some of the answers to these questions.


Figure 1: Trialling low-cost small machinery for selective harvesting of regenerated tōtara on a Northland farm

## Regenerating tōtara – a regional opportunity

Tōtara grows prolifically in Northland. A significant resource of naturally regenerated tōtara already exists in the region (Kennedy, 2007), especially on farms and previously cleared scrubland. This presents a practical opportunity to integrate native forest into the rural production landscape and to develop a sustainable native forest industry based on continuous cover forestry practices (Quinlan, 2013). Although it is an untended resource, many farms have naturally regenerated trees that are of millable size or will be within a few decades.

The summary report (Dunningham et al., 2020) of the 2020 Tōtara Industry Pilot (TIP) project highlighted scope to develop a regional wood and wood products industry based on the sustainable management of this second-growth tōtara resource (see www.totaraindustry.co.nz). Importantly, it is not a case of planting and waiting 80 years. The advanced regeneration present on many farms provides the opportunity to start with some sustainable harvesting now. Tāne's Tree Trust, the Northland Tōtara Working Group and the TIP project are working on making this a viable land use option.

Pāmu (Landcorp Farming Ltd) has supported the Northland tōtara projects for many years. Gordon Williams, Environment Manager: Ngāhere (Forestry) for this state-owned company, sees the enhancement and careful management of their native forests as part of their stewardship role. The company is keen to explore and develop sustainable land use options that fit with this responsibility.

Funding this small-scale sustainable harvest of tōtara is part of that effort.

## Objectives

The objectives were to:

- Test the feasibility of using low-cost farm-based extraction machinery for small-volume selective harvesting

- Commence active management in the forest by using harvest as a silvicultural intervention (i.e. applying a production-thinning approach)
- Test the viability of milling the logs on-site using a portable bandsaw mill and sell the timber
- Demonstrate continuous cover forestry practice.

The results suggest that small-scale selective harvesting is both practical and viable.

## Forest location and establishment history

The forest comprises naturally regenerated tōtara on the company's Takou Bay Dairy unit, just north of Kerikeri in Northland. Typical of many pastoral landscapes the native vegetation is located in moderately steep gullies, and in this case the terrain is also very rocky – factors that made it unsuitable for pastoral use. Nevertheless, the predominance of tōtara reflects a lengthy history of livestock grazing during the early reestablishment and growth of the forest. The result is a dense stand of mixed-age trees.

The largest trees (40–75 cm diameter breast height (DBH)) are thought to be up to about 130 years old and are surrounded by younger pole-sized trees (10–40 cm DBH) at a stocking of up to 3,000 stems/ha.

## Forest characteristics

This is an untended forest. The dominant trees have large crowns and good diameter growth, but short boles and many large branches. In contrast, the trees with the best form for milling are usually crowded, have narrow and competing crowns and suppressed growth rates. Many of the pole-sized trees have an unhealthy height to stem-diameter ratio and probably insufficient green crown for a viable future. However, amongst this dense forest of stems there are many tōtara trees and poles with excellent form and the potential to develop into high-quality timber trees if released from competition.

Silvicultural trials (Bergin & Kimberley, 2009; Quinlan et al., 2013) by the Northland Tōtara Working Group have demonstrated that significant growth and productivity increases result from thinning dense stands of naturally regenerated tōtara.

## Sustainable harvest rate

On this property, 27.7 ha of secondary native forest is subject to a Sustainable Forest Management (SFM) Plan prepared under provisions in the Forests Act 1949. This SFM Plan provides for an annual harvest of 8.6 $m^3$ of tōtara, equating to a harvest rate of only 0.3 $m^3$/ha/yr. However, an Annual Logging Plan (ALP) for 30 $m^3$ of tōtara logs, allowing up to 3.5 years' annual harvest, was approved by Te Uru Rākau – The New Zealand Forest Service. The low annual harvest rate reflects the fact that most of the forest area comprises young pole-sized trees (i.e. $<$30 cm DBH) not yet at merchantable size. The harvest rate will be reviewed in the future as the forest matures.

## Harvesting

Contractor, Li Legler, was engaged to do the harvest using a 45-horsepower agricultural tractor mounted with a PTO-driven forestry winch (a Fransgard brand winch with a 4-tonne maximum pull capacity).

While this type of extraction equipment is commonly used in many European forests, even by their standards the plant used here would be considered relatively light. Therefore, on the moderately steep and rocky terrain, it was expected to be a fair test and a valuable comparison to the heavy machinery and experienced forestry crews used in the larger-scale harvests conducted by the TIP project.

It was also an opportunity to compare costs between milling on-site with a portable bandsaw mill (a LT40 Woodmizer) with the costs of transport and milling by a commercial pine mill, as was done by the TIP project.

## Forest management approach

A production-thinning approach was adopted for this harvest. As noted, harvesting is also a silvicultural intervention to improve the mid- and long-term timber production potential of the future crop trees within the stand. Some further complementary thinning to waste is also intended.

Improving the species diversity within the forest is another management objective. Other native species are present and regenerating within the tōtara dominant forest. Ironically, harvest is seen as an opportunity to influence the character and composition of the forest towards a more 'natural' mixed-species, mixed-age native forest in the future, including shade-tolerant hardwoods.

## Harvest tree selection

The methodology used was to 'thin from below', identifying and marking-up the trees and poles with the best potential to develop into high-quality timber trees. At roughly 4 m spacing (625 stems/ha), these 'crop trees' are intended to become the frame of the developing forest and needed to have some thinning around them. Potentially harvestable trees above 30 cm DBH, which were competing with the better formed 'crop trees', were identified for removal and with most having larger (but shorter) knotty boles.

This approach was a single-tree selection process, with the focus on removing poorer (but still merchantable) trees from the forest to the benefit of the crop trees left to grow on.

## Two forest size-classes/types

In terms of size-class, there were two forest types. The first was a heavily stocked pole-stand where the mean DBH was approximately 18–20 cm, and the production thinning involved removing 10 trees with 30–45 cm DBHs. The second involved selecting 10 trees

Table 1: Cost of felling and extraction by log volume

| Stratum | No. trees harvested (no. logs) | Mean DBH of trees (cm) | Mean log length | Mean log volume | Log volume extracted ($m^3$) | Harvest contractor costs* | Harvest rate $/m³ |
|---|---|---|---|---|---|---|---|
| Pole-stand | 10 trees (11 logs) | 36.6 cm (30–45 cm range) | 5.8 m | 0.57 $m^3$ | 6.32 $m^3$ | $1,200 (1 day) | $190/$m^3$ |
| Merch. forest | 10 trees (11 logs) | 44.4 cm (30–71 cm range) | 5.7 m | 0.85 $m^3$ | 9.4 $m^3$ | $1,200 (1 day) | $128/$m^3$ |
| **Total harvest** | **20 trees (22 logs)** | **40.5 cm** | **5.7 m** | **0.71 $m^3$** | **15.72 $m^3$** | **$2,400 (2 days)** | **$153/$m^3$** |

* Note: This cost only covers the contractor's provision of a two-man crew for site induction/establishment, felling and extraction to the paddock where a portable sawmill could mill the trees. It does not include the forest manager's role in preparing the ALP, tree selection, measurement and record-keeping etc

from scattered groups of larger merchantable trees (30–75 cm DBH). These forest types have been separated in Table 1 and are referred to as 'Pole-stand' and 'Merch. forest' strata.

Naturally, harvesting smaller logs from the pole-stand area was less efficient for volume recovered for extraction time and costs. Also, two of the 10 trees harvested from the pole-stand area involved difficult extractions from over 50 m into the bush and from the other side of a gully. Harvesting these two trees required significantly more time to extract (2 hours) than that for the other eight (3.5 hours).

## Range of log sizes

A total of 22 separate logs were extracted (20 butt logs and two top logs). The harvested trees had trunks with DBHs ranging from 30.3 to 71 cm DBH, and their individual merchantable log volumes from only 0.285 $m^3$, up to 2.18 $m^3$. The mean was 40.5 cm DBH, with a 5.7 m log and 0.71 $m^3$ merchantable log volume.

## The practical harvest operation

The contractor arrived on-site with his tractor on the back of a flat-deck truck. This was backed off using ramps, and with the winch already mounted on

Figure 3: European-style forestry equipment – a 45-horsepower tractor with a PTO-driven winch on the 3-point linkage and a 4-tonne pulling capacity

the 3-point linkage was immediately operational. The tractor worked from the paddock close to the fence and did not enter the forest. No tracks were necessary.

Due to the spread of trees to be removed, only one to three trees were felled and extracted at a time before the tractor needed to be moved to a new winching position at the edge of the paddock. The wire rope was run out under the bottom wire of the old post-and-batten fence and the adjacent post staples removed, to enable the wires to be propped up so the logs could be pulled underneath and through the fence line. Minimal damage to the fence occurred, but some reinstatement (re-stapling) was necessary.

## Directional felling and winching

Competent directional felling avoided hang-ups and minimised damage to surrounding trees, although at times snatch blocks and the winch were used to fall trees in the most appropriate direction to avoid damage to the forest. Snatch blocks were used to winch logs on the least damaging path. Logs were also moved or rolled with a cant-hook to get past obstacles or trees. One potential crop tree was damaged when a log rolled while being winched, but the residual forest is well stocked with good form crop trees and, overall, a low-impact harvest was successfully executed.

## Skidding cone

Proprietary skidding cones are available that can be fitted over the end of logs up to 50 cm in diameter to facilitate easier snag-free winching of logs over rough ground and past trees. In this case, the contractor fashioned a D.I.Y. version out of a lost mussel farm buoy. It greatly simplified removal without having to snipe the end of the log.

## Capacity limits of small equipment

The steep rocky terrain was a good challenge and test for the equipment. The small-to-medium log sizes were easily handled, but the largest log (71 cm DBH, 6 m long and 2.18 $m^3$) tested the capacity of the winch. This log had to be pulled up an incline and the additional leverage of an extra snatch block was required to extract it.

## Forwarding

A portable sawmill could have milled the logs in the paddock where they were extracted to and the economic analysis further below is based on that scenario. However, in this case a mill site was already established, approximately 1.2 km away, on the same property for other milling work. Therefore, the tōtara logs were forwarded to that site instead.

This was accomplished by the contractor using the same tractor but with a different implement attached. The forestry winch was swapped out for a forklift mounted on the 3-point linkage. The forklift loaded the flat deck truck to transport the logs via the existing farm tracks.

## A demonstration of low-impact harvesting

This trial has highlighted techniques that can be applied in careful extraction operations, including:

- Directional felling, including winch-assisted felling
- The value and use of a skidding cone
- Deploying snatch blocks with tree-protectors to avoid obstacles and avoid damage to the residual forest
- Halting the winch to roll the log, or re-direct it to avoid unnecessary damage, then resuming winching

Figure 4: Ingenuity – Li Legler re-purposed a mussel farm buoy into a skidding cone

Figure 5: The D.I.Y. skidding cone proved its worth. The nose cone helped avoid snagging the logs on rocks, roots, humps and stumps, and minimised soil disturbance and damage to the forest

- A role for cant-hooks and pickaroons/sappies manoeuvring logs to avoid damage
- Scope to take simple steps to protect the bark at the base of residual trees if they are at risk from accidental contact/damage from winched logs (e.g. with branches/stone buffers).

It has also demonstrated that low-impact harvests can be done with small and relatively inexpensive farm-scale machinery and equipment. This may be very significant when dealing with small volume harvests – where the relocation costs for conventional forestry machinery and crews would be prohibitive.

A short video of the harvest operation can be viewed at: https://vimeo.com/692925422

## Cost comparison with heavy extraction machinery

Harvests by the TIP project mentioned earlier used forestry contractors with heavy machinery. However, these machines were often too large to comfortably negotiate tight farm gates, tracks and races etc without causing damage. Moreover, significant transport costs are associated in getting heavy machinery to site. In contrast, small machinery is well suited to the farm infrastructure and small volumes being removed.

The TIP project found few forestry contractors were interested in pricing small tōtara harvests. Professional arborists often had the tree skills to execute sensitive low-impact tree felling, but lacked suitable machinery and experience for log extraction and loading. Non-professional contractors lack appropriate qualifications, the necessary insurances, and health and safety management systems.

The TIP project concluded a tōtara timber industry probably needs specialist harvest contractors, trained and experienced in selection forestry under the Forests Act, with suitable machinery and equipment for small-scale, low-impact, selective harvesting – possibly like that tested here. But is it viable?

Unfortunately, it is impossible to make a direct cost comparison. The TIP harvests involved 80–115 $m^3$ of logs in each harvest (versus the 16 $m^3$ here), and the contractors tendered prices on a cubic metre rate that included loading logging trucks and transport to the mill. At an average of \$150/$m^3$ log volume to the mill, the felling and extraction with heavy machinery is more efficient for such volumes.

However, economies of scale are clearly at play, especially with the high cost of relocating heavy machinery. A tendered price for a much smaller TIP harvest, involving only 30 $m^3$, equated to \$278/$m^3$ to the mill. Deducting a nominal figure of \$1,000 for transport (\$33/$m^3$) suggests a cost of \$245/$m^3$ for the felling, harvest and extraction. That is significantly more than the cost of this operation at \$150/$m^3$ as set out in Table 1.

## Viability of small-scale harvesting

The landowner incurred costs of around \$10,000 for the original SFM Plan over the 27.7 ha forest area, a one-off cost which enables ongoing harvests. Naturally, such set-up costs are a significant disincentive for landowners contemplating the sustainable management of their native forests. However, because it was not a cost directly incurred by this harvest operation it has not been factored into the figures below.

However, additional costs specific to this harvest include a professional forestry consultant's time to scope the harvest, meet with the landowner, contractor and farm managers, plan the harvest, prepare and submit the ALP, communicate with mana whenua, contact potential timber buyers, select, measure and mark-up the trees, record harvest volumes, reinstate fences and attend forest inspections with Ministry for Primary Industries (MPI) officers. These costs totalled around \$2,200.

While in other situations it may be possible for a landowner to undertake many or all of these tasks themselves, that does not mean these costs can be ignored. The landowner needs to put a value on their time in doing these tasks and the cost should be added to the direct costs of this harvest operation (Table 1). In this case, that makes the total cost of the harvest \$4,600.

## Total production costs

Over the harvest volume of 15.7 $m^3$, total production costs equate to \$293/$m^3$ for logs to an on-site portable milling or loading site. Portable milling costs of \$300/sawn $m^3$, and an assumed recovery of 50%, make a total production cost of \$885/$m^3$ of sawn timber. Some additional costs for stacking, filleting, storage and handling should be added to this figure – making the total production costs of the sawn timber likely to be around \$1,000/$m^3$.

## A profitable exercise

In this case, some logs were milled to order and the sawn timber sold green off-the-saw (3 $m^3$ for a price of \$2,000/$m^3$ + GST). That sale alone nearly covered the cost of the harvest and milling operation. The remaining sawn timber (estimated 4.5 $m^3$) will be sold on behalf of the landowner.

If this timber can realise a similar value, then this small-scale harvest should return around \$7,850 as profit to the landowner (i.e. around \$1,000/$m^3$ sawn timber volume or \$500/$m^3$ log volume). However, no costs associated with growing and managing these naturally regenerated trees have been factored in.

## Conclusions

The most significant conclusion from this trial is that small-scale, low-volume, selective harvesting may


Figure 6: A demonstration of production thinning and low-impact harvest. The poorer trees were removed and the best remain. This approach used selective harvest as a silvicultural intervention to improve the future timber production value of this untended natural secondary forest

be viable in farm tōtara forests. Moreover, it demonstrates that production thinning can be a practical and viable way to start managing untended natural tōtara forests for improved future timber production.

Forestry skidding winches mounted on 4WD agricultural tractors may have a useful role to play in low-volume harvesting of native forests under continuous cover forestry systems at the farm forestry scale.

This form of log extraction may be suitable where low-harvest volumes would make it uneconomical to log with standard forestry equipment, and where the forest areas are easily accessible from paddocks and tracks. However, at present, skilled contractors with such equipment are scarce and the matter of training and qualifications raises a potential health and safety issue.

This trial supports the further exploration of low-cost harvest equipment for small-volume selective harvesting of the farm tōtara resource.

Postscript: Since preparing this article the residual rough-sawn timber has been sold for $1,800/m$^3$ + GST.

## References


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