A PRACTICAL GUIDE TO MANAGING TŌTARA ON PRIVATE LAND

By Paul Quinlan

A Practical Guide to Managing Tōtara on Private Land. Written by Paul Quinlan.

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Online resources include three videos; Form-pruning tōtara for timber production on private land, Freestyle silviculture in naturally regenerating tōtara forests on private land, and, Harvesting tōtara – trialing small-scale, low-impact methods.

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NATIVE FORESTS FOR OUR FUTURE
Hereherea te Wao-nui-a-Tāne

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The New Zealand Indigenous Tree Bulletin No. 1: *Tōtara - Establishment, growth, and management*, by David Bergin, was published in 2003. It is based on his PhD thesis and comprehensively covers topics ranging from seed collection, propagation, planting, growth rates, and timber. Furthermore, it highlighted the phenomenal natural regeneration of tōtara in many regions. This provided the necessary science-based platform to encourage renewed investigation into the potential of the species to be planted and managed for both timber and non-timber values.

In 2017, Philip Simpson's consummate book on tōtara - *Tōtara a Natural and Cultural History*, was published. It is a feat unlikely to be bettered and provides an enduring treasure in anyone's bookshelf. It delivers, as its title promises, a rich and complete history. And I defer to it on all such matters. It provides essential perspective as we contemplate the future management of tōtara for multiple values. Simpson stresses the need for conservation, but without closing the door on some sustainable management for cultural purposes, including some timber production. In doing so, he leaves room for complementary efforts, ideas, and visions for the future of the species in Aotearoa. The following is my contribution in that regard.

As the carefully chosen title states, this is to be a *practical guide* and is about *management* of the species on private land. It tries to add to the excellent publications acknowledged above, by focussing on the topics of silvicultural management for timber production and harvesting. The following chapters contain practical information and advice based on my experience with these aspects. It focusses on forest management and leaves milling, timber properties and processing outside of the scope for now. Nevertheless, it is important to point out that studies confirm valuable timber can be produced even from relatively young planted or regenerated tōtara trees.

This guide is specific to private land, including Maori land, because on such lands, the breadth of management objectives and priorities may include many continuums ranging from conservation values, right through to areas where timber production is a major focus. And this guide unashamedly provides considerable information on the latter. There are several reasons for this. Managing tōtara for some timber production will be of interest to many readers, and unlike other topics, this information is not available from other sources. Furthermore, it is considered that timber value could be an effective vehicle to incentivise the planting and management of tōtara forests – for multiple purposes and benefits – on private land.

However, it is important to state that this is certainly not part of any wider agenda for timber production within conservation areas. Nor should it be taken as an inference that timber values should always take priority in privately owned forests.

There can be many subtle gradations and weightings of management objectives applied even within and across very small areas of forest on private land. This complicates management decisions. Deciding exactly what to do where, and to what extent, can be difficult. It will be shaped by the interplays between many factors, from the features of the site to personal preferences, perspectives, and even ideologies. However, all forests require active management, even those where conservation is the main objective, and I contend that in many situations management to enhance timber production potential is largely compatible with the maintenance of the many non-timber values within a forest.

Where tensions do exist between non-timber values and management for productive purposes, the owner or forest manager will have to decide what is most appropriate in their situation. And that may vary across micro-spatial scales within each forest. The features, characteristics, opportunities, and restraints present within native forests often vary within very short distances – even a tree length or two. Appropriate management plans and practices should respond to this richness and be accommodating of multiple forest values to protect and even enhance them where possible. The potential to do so, is one of the main advantages of indigenous forestry. This multivalent approach is likely to result in a sophisticated mosaic-like pattern of land use and forest management practices rather than an extensive, simplistic, single-purpose approach to management of a native forest area.

For reasons mentioned above, the content of this practical guide unashamedly presumes that timber production is a management objective and major topic of interest. Indeed, it dominates the content of the following chapters on:

- Planting and establishment,
- Pruning,
- Thinning, and
- Harvesting.

In practice, forest managers can and should apply this advice in a differentiated way to suit their unique situations and varyingly weighted management objectives across and within each forest.

The rest of this introductory chapter will attempt to place the management of tōtara forests on private land within a broader contextual perspective on land use options and issues. This may help readers refine their own thoughts and positions - especially on the controversial matter of harvesting native trees. Hopefully this will assist with deliberations and decisions on land use and management possibilities and especially where tōtara forests may fit in. It will also outline a vision and potential role for tōtara forestry.

In the beginning...

Simpson's book outlines the Māori creation story and how the tōtara was the first big tree created by Tāne. He also contends Māori legends concerning the whakapapa of tōtara, can be metaphors, and "... the vehicle through which attitudes to the forest (and to life in general) were shaped." As an example, he relates the story of Rātā, the atua of travel, cutting down the tōtara tree which turns out to be a story that teaches the need to respect the forest for its products.

Finding and discussing additional meanings and truths in myths is part of their value. I see a parallel here with the ecological role of tōtara, as one of our few native pioneer tree species, often creating the initial tall forest canopy and a structure within which other smaller trees and shrubs can dwell.

And the tōtara that Rātā cut down kept resurrecting itself – is it stretching things too far to relate this to the regenerative capacity of the species? Regardless of any such spurious interpretations, the legendary status and role of tōtara is irrefutable and needs to be acknowledged.

Land uses and forestry inevitably reflect our cultural values. Fortunately, these can and do change. As Simpson contends, myths can shape our attitudes and practices. The lesson to respect Tāne's forest is still relevant and can still help shape our attitudes and approaches to native forestry in Aotearoa, now and into the future.

Edward Beattie saying a karakia before a harvest as part of the Tōtara Industry Pilot project.

Weaving native forests into our working lands

The challenge of encouraging native afforestation

Back in 2001, Morgan Williams, as the Parliamentary Commissioner for the Environment (PCE), challenged us to find ways to 'weave' more native plants back into our working lands. This reflected the recognition that

"Native plants... are a key to maintaining the ecological health of New Zealand's lands and waters, which underpin the country's social and economic well-being. Reintroducing native plants into working landscapes will also play a role in strengthening New Zealand's 'sense of place', and achieving desired biodiversity outcomes."

Twenty years later, in 2021, He Pou a Rangi – the Climate Change Commission of New Zealand recognised that native forests not only sequester carbon but provide multiple co-benefits, including cultural, biodiversity, erosion control and water quality benefits. And, consequently, it recommended[1] a comprehensive national programme to incentivise the establishment (by planting and natural reversion) of 300,000ha of new native forests. However, it recognised that that would be an ambitious challenge noting:

"...there are currently limited incentives for landowners to change less-productive farmland to native forests".

It also mentioned the need to protect and manage pre-1990 native forests (existing native forest areas that are ineligible for carbon credits through the Emissions Trading Scheme).

Pointing out possible ways to enable the large scale of reforestation needed, the Climate Change Commission's report stated that;

"In some places, if managed appropriately, there is also potential for new native forests to be selectively harvested to provide high-value timber and non-wood forests products, while still being considered 'permanent"[2].

However, the *"barriers to the expansion of native plants on private land"* that Morgan Williams identified, remain. These were:

- a lack of markets for the range of services and products sustainably managed native plants can provide;
- limited research and knowledge to support the ecologically sustainable management of native plants on private land; and,
- individuals and organisations holding entrenched positions about the use of native plants rather than undertaking to explore the issues through open and informed debate.

With that 2001 paper, Morgan Williams aimed to "stimulate thinking and to encourage debate about the uses and services native plants can provide and how this valuable resource should be managed."

The wide array of ecosystem services, benefits, and values that native forests can provide has been well established. And it is widely recognised that native forest cover would be an elegant way to address the pressing environmental crises of our times – being the freshwater, biodiversity, and climate-change crises. The need and urgency to find effective ways to encourage the 'weaving' of more multi-functional native forest into our working lands, and to protect and better manage the areas of existing native forest on private land, is now acute.

"Establishing more native forest cover is a panacea for our environmental problems."

[1] Ināia tonu nei: a low emissions future for Aotearoa Advice to the New Zealand Government on its first three emissions budgets and direction for its emissions reduction plan 2022 – 2025

[2] He Pou a Rangi the Climate Change Commission. Ināia tonu nei: a low emissions future for Aotearoa, Chapter 18.2, paragraph 27, on page 318.

Naturally regenerated tōtara stands on private land can be managed for multiple purposes – some sustainable timber production and all the environmental benefits that come along with native forest cover.

Weaving more native forest into the rural production zones will be a challenge. However, it is not only important for environmental reasons, but also for landscape character and 'sense of place'. We want native forest to also be a relevant part of our everyday working lives and landscapes.

Native forestry as an appropriate land use option

Successfully integrating more native forest into the rural production landscape, and sustainably managing and enhancing what is already there, will be a significant challenge. Native forest cover will need to take on many different forms and functions. In this context, continuous cover native forestry has a potential role to play. This is not to say that timber production should be a management objective for all areas. But in some places, it might present a way to help make native forest cover a viable land use option on private land. However, greater acceptance of native forestry as a legitimate and appropriate land use activity will still be needed to realise this potential. And this will need to be reflected in policy, regulations, and public opinion.

Fortunately, we already have some good examples of continuous cover and sustainable indigenous forestry in New Zealand such as John and Rosalie Wardle's Woodside Forest in Canterbury, and the Tōtara Industry Pilot project in Northland. These show that it is possible to implement low-impact sustainable native forest management within our working landscapes.

Part 3A of the Forests Act permits some legal harvesting from native forest areas on private land but requires this to be done on a sustainable basis.

"Nature-based forestry is 'a blend between art, culture, and science'. Forests are managed on a continuous cover basis, for multiple values – including timber production where appropriate"

The emphasis should be on management of a whole and healthy natural ecosystem and where timber production is only one objective to be managed in a compatible way with the many other cultural, environmental, and recreational values in each part of a forest. Generally, this means working with natural regeneration, mixed species, mixed ages, and no clear-felling. This is largely congruent with a Te Ao Māori view – and some of us see scope to build on this to create a new forestry model for Aotearoa. One that regenerates not just the environment, but also a more appropriate relationship between people and nature, land use and kaitiakitanga. This is an aspirational vision.

The tōtara opportunity

Naturally regenerating tōtara presents an opportunity to realise the sustainable native forestry vision described above. This potential was highlighted by Dr David Bergin's work and has been developed and refined over the years by the Northland Tōtara Working Group (NTWG): https://www.tanestrees.org.nz/about-us/northland-totara-working-group-ntwg

The practicalities and business case for a new native timber industry – based on sustainably managing tōtara on private land, have been confirmed by the Tōtara Industry Pilot (TIP) project. The reasons to support and promote development of such an industry are also well articulated on the TIP website: https://www.totaraindustry.co.nz

In short, it is considered that a sustainable tōtara timber industry – unlike the native logging of the past – would not only encourage the proliferation and management of regenerating tōtara but would also encourage the planting of significant new areas of forest – as a complement to natural reversion.

While cutting down trees to encourage more native forest may seem counter-intuitive, it is based on the understanding of how markets drive rural land use changes – or reinforce undesirable ones. The key premise is that achieving large-scale native forest cover on private land will need the support of markets to become a viable land-use option. If it can become a rational investment or land use option, then it will happen. Morgan Williams called this re-engineering of the production system "Growing for Good" in a later PCE publication with that title.

"The premise is that markets can support appropriate land uses. Engineering that outcome is the challenge."

Markets drive land use changes. Getting markets to support native forest cover as a viable land use option will be essential for native reforestation at a significant scale.

Advanced regeneration and scale

To realise this vision with its ideal landscape outcome, a suitable tōtara timber industry needs to be developed to bring native forestry as a land use into existence and support it. This is no small feat. Fortunately, the significant areas of existing natural regeneration on private land provide a springboard. Unlike other alternative forestry species, which struggle to have sufficient scale and potential continuity of supply to attract a strong market interest, the advanced regrowth of tōtara on farms has a natural advantage. It is not a case of having to wait 80 years for planted forests to reach a harvestable stage. A level of sustainable harvesting can commence now to build market awareness and value. A modestly sized tōtara timber industry could start now.

"We don't need to plant and wait 80 years. Naturally regenerated trees mean a sustainable tōtara timber industry could start now."

Planted tōtara stands have the potential to be the complement to this natural resource. A sustainable tōtara timber industry would give landowners greater confidence to plant and manage more too.

83 years was the average age of the tōtara trees harvested as part of the Tōtara Industry Pilot project. Advanced natural regeneration on some farms could enable a sustainable industry to start now.

Fear of regulations and lack of financial incentives often results in clearances of reverting indigenous vegetation even on steep, marginal farmland. In this case, many pole-sized tōtara amongst the kanuka were just right for pruning up, but have instead been cleared and burnt. The regeneration process will start again.

Forest Ecologist, Dejan Firm from Scion, discusses growth rings of tōtara with Furne Patuwai at Northpine, Waipu.

Good prospects for the species

Te Taitokerau Maori Forestry Incorporated have indicated that they wish to be the entity to progress this tōtara opportunity, at least in the Northland region. For landowners interested in realising any timber value from their regenerated forests, or interested in establishing new tōtara dominant forests, this should be encouraging. Some coordination and or collective management for industry development would be an advantage.

There appears to be good prospects for native forestry based around the management of tōtara on private land.

Similar prospects would exist for some of our beech species in certain regions.

Monocultures verses nature-based forestry

Tāne's Tree Trust fields many inquiries from landowners interested in establishing plantations of tōtara. Generally, the trust promotes mixed-species continuous cover forestry as a more sophisticated form of forestry. However, it would be inconsistent to be too purist about it and treat plantation forestry with native species as being somehow illegitimate while plantation forestry with exotics is acceptable. Therefore, prescriptions for monocultural tōtara plantations have also been included as valid management options in the chapters of this guide.

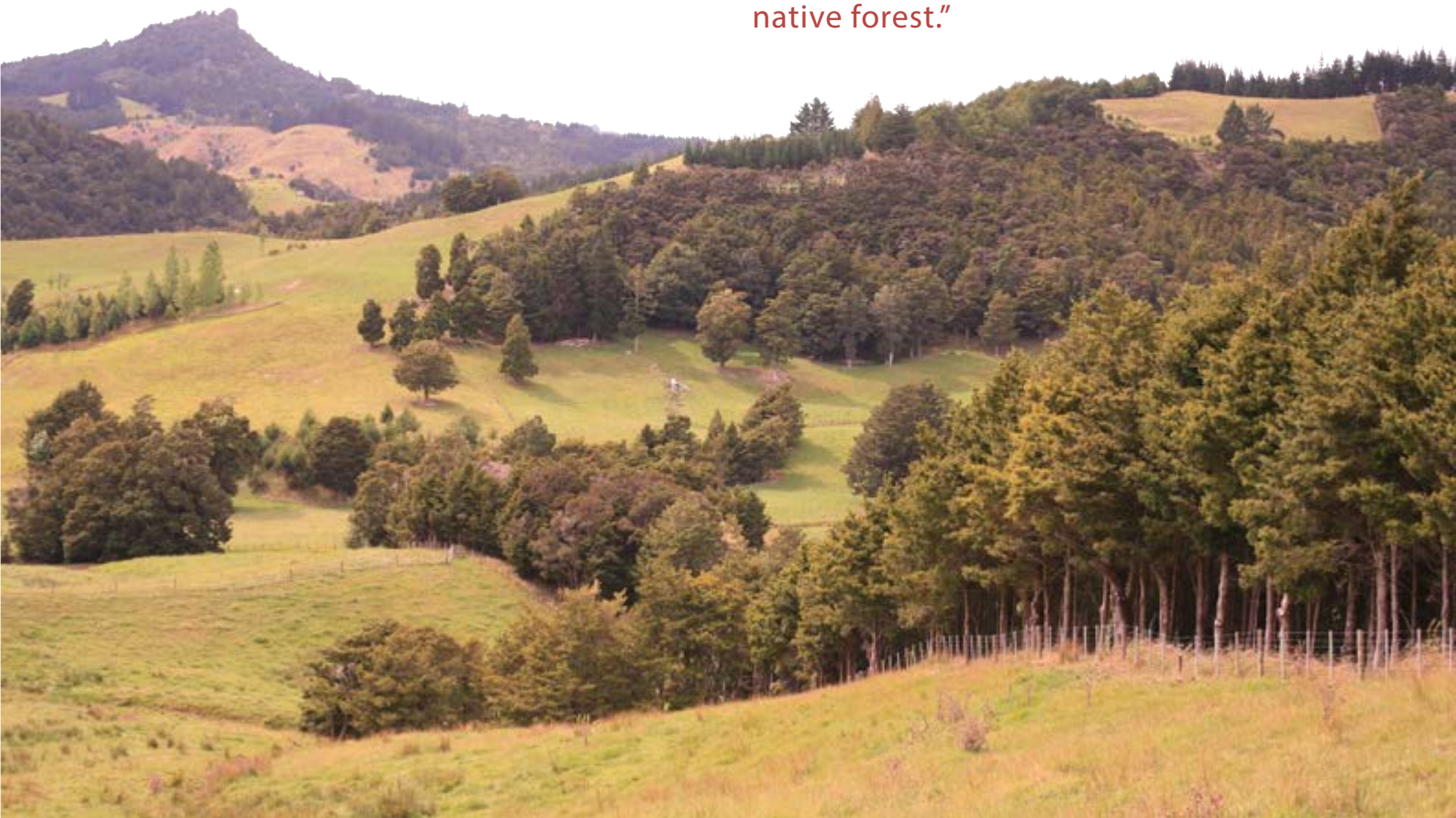
This is consistent with the idea introduced further above that weaving more native forest into the production landscape will need to take on many forms. Continuums or gradients from more to less natural forest structures, characteristics, and management will exist. Furthermore, native forests are enduring elements in the landscape. Management ideas can and probably will change over time. I believe it should be possible to transition a native plantation to near-natural/continuous cover forestry. Indeed, significant structural changes often occur with natural forest establishment and through long-term successional processes. Many stands of naturally regenerated tōtara on farms have developed with near mono-cultural plantation characteristics. Encouraging more native afforestation is the priority at this point, refining the management prescriptions and options will be a continual exercise.

Trail-blazer roles for tōtara (and beech)

As intimated above, the characteristics of a forest during the establishment phase will be different to the potential climax community of a sustainable mature forest. Pioneer tree species like tōtara and beech are useful for successful forest establishment. Tōtara plantations can provide the first canopy and forest structure or framework to support an increasing diversity of other indigenous forest species – especially the more exposure sensitive broadleaf plant species. In this way, tōtara can be seen as a species with an important role in our country's native reforestation ambitions – perhaps echoing the creation story of Tāne's forest.

There is another trailblazer role too. While many other species also have worthy timber attributes and potential – it is probably wise to first prove success with the most promising native timber species – tōtara and beeches. If we cannot make native forestry work with these species, then the likelihood of success with other native tree species is even more remote. But if successful, other native timber species may ride on the coattails of a sustainable tōtara and or beech timber industry. So, while the focussed emphasis on tōtara - a single species - may seem unbalanced, its potential role as a trailblazer for diverse native forests and native forestry generally, is part of the reason for it.

"Timber value may be a useful vehicle to encourage the sustainable management of naturally regenerating tōtara forests and the planting of more areas in native forest."



The aspirational vision

An interwoven world

Imagine an idyllic rural production landscape. One where native forest is an ingrained and prominent feature, forming an extensive web. The many tracts of native forest and wetlands are interconnected with corridors of native bush along riparian margins, and in the steep gullies within pasture or plantation forests, and as shelterbelts defining each paddock or field. In this picture, native forest would occupy all the sensitive areas of the land, like the connective grouting of a mosaic pattern, a local vegetative matrix within which other land uses are nestled – a filter to our waterways and harbours. Native forest would be an inextricable and defining feature of the local landscape character.

Moreover, this web of native forest would also be a familiar part of our everyday working lives. Not just to look at, passively, from a distance, as something that we are alien to, and too scared to touch. But rather as something we know because we have nurtured it, tended it, worked in it. It is in our view. We know how it smells, how it sounds, and what work still needs doing and where.

These areas of bush would also help support our existence on the land, the timber would adorn our houses, we would build with it, treasure it, and take pleasure in the memories created by all these activities, and these connections to place, people, and our cultural heritages. Native forest would be a natural part of any rural scene when we imagine the future.

Peter Berg, chairman of Tāne's Tree Trust, tirelessly promotes all the values of native forests. Photo: @AlistairGuthrie/ ©PureAdvantage #OTātouNgāhere

Importantly, we would be proud of the sustainable management and environmental improvements that result from it - our kaitiakitanga and continuing efforts to learn and understand it. This increasing matrix of native forest would be an integral part of the local economy and an example of the type of regenerative 'nature-based' land use solution that was needed for the twenty-first century.

The local co-op would help advise and organise planting, silviculture, planning, harvests, sales, and research. It would ensure the native forest resource is sustainably managed at a landscape catchment level, not just for continuity of timber supply and marketing scale, but also for job continuity and the environmental benefits and enhancements. Local forestry advisors would help landowners with management plans and scope opportunities for further plantings and/or to encourage natural reversion.

Young people would be trained in the complexities of multi-purpose native forest management, both for timber and non-timber values, benefits, and products. Tōtara would be a key timber species in many places. Low-impact harvesting and continuous cover forestry would become standard practice and native forestry would be considered normal forestry. Local people would be doing the work, getting the benefits, but also facing the responsibilities.

Management practices would be adapted and refined in response to research learnings. And long-term monitoring would show continued improvements in the water-quality of local streams and harbours, resilience in indigenous biodiversity, and effective mitigation of climate-change problems...

Imagine that.

Realising the potential for tōtara on private land

What is needed to achieve the idyll painted above? The barriers identified by Morgan Williams can be refined more specifically for tōtara as:

- Lack of incentives – There is a need for timber and non-timber markets/industry development to support sustainable native forestry as a viable land use option.
- Limited knowledge - Research, monitoring, and adaptive management approaches to guide new sustainable forest management practices are needed.
- Conducive regulations - Effective controls to ensure sufficient protection and sustainability credentials, without becoming onerous disincentives.
- Public support and understanding.
- Some coordinated management, processing, and marketing to enable the many small forest areas to gain the advantages of a significant cumulative scale.
- An industry model with business plans and practices that are fit for the twenty-first century.

The Northland Tōtara Working Group

In 2005, Helen Moodie of the New Zealand Landcare Trust, and Dr David Bergin of Tāne's Tree Trust formed the Northland Tōtara Working Group (NTWG). It represented a range of stakeholders from landowners interested in the potential to manage regenerating tōtara on their land, to government agencies involved with promoting sustainable land management outcomes.

The NTWG set five broad objectives:

- Quantify the resource of naturally regenerating tōtara on private land.
- Demonstrate the growth response of naturally-regenerating and planted tōtara to silvicultural treatment (thinning and pruning).
- Determine wood qualities and potential uses of farm-grown trees.
- Investigate the feasibility of developing a supply-chain from resource to market.
- Identify and overcome hindrances and disincentives to sustainable management of naturally-regenerating and plantation tōtara.

The group has completed many projects aimed at addressing these objectives. So far all projects have concluded with encouraging results.

Mostly the projects have been funded by the Ministry for Primary Industries through the Sustainable Farming Fund, but with support from many other organisations too. Slow but incremental progress on all the objectives has been made. The results of the various projects are available via the 'Resources' tab of the NTWG pages on the Tāne's Tree Trust website – including the chapters and videos of this practical guide. However, there is still considerable work to do to realise the potential that the Northland tōtara opportunity presents. This will be ongoing and includes submissions and discussion with authorities on the regulatory issues.

Membership

A database of NTWG stakeholders is kept, including landowners with an interest in managing tōtara on their land. It is not exclusive to Northland. Latest developments and project results are sent out in NTWG newsletters to people on the NTWG mailing list. Membership is free. Anyone, throughout the country, who is interested in managing tōtara, is encouraged to join – Click here for the new membership page: https://www.tanestrees.org.nz/about-us/northland-totara-working-group-ntwg/join-ntwg

Taking it nationwide

Tōtara is a common species throughout the country, and its regeneration is observed in many regions. Ultimately, the Northland Tōtara Working Group may be superseded or develop into a more formal group – perhaps as a nationwide tōtara growers association, or the basis of co-op, to represent a tōtara industry's interests.

Cumulative resource scale

Regenerating tōtara on private land comprises many small areas, with a sporadic distribution pattern across many different properties. Few if any properties by themselves have sufficient scale of tōtara resource to offer commercial scale of supply and product continuity to market. Yet, cumulatively, the collective tōtara forest areas - over hundreds of individual properties - amount to a significantly scaled resource. For example, it is estimated[1] that on private land in the Northland region, over 200,000ha of native forest cover, contains tōtara at various stocking rates. Of that, around 30,000ha is estimated to be tōtara dominant forest and potentially available for sustainable management under Part 3A of the Forests Act.

[1] Estimates figures derived from NTWG work by Chris Kennedy in 2007 and later refined by the Ministry for Primary Industries. Excludes all conservation land, council land (e.g., esplanade strips), and QEII covenanted areas.

The cumulative scale of this resource is a significant advantage for the development of a tōtara timber industry and markets for the timber. However, capitalising on this advantage will necessitate some form of coordination of the collective resource. This also brings other opportunities for benefits such as training, permanent jobs, local work continuity, and accreditation etc. Naturally, there are also associated risks. It is imperative that any coordinating entity has the right ethical foundation to develop an appropriate business operation that ensures the long-term management outcomes live up to the potential – i.e., the idealistic vision, presented further above.

Potential to be a model example

The ingredients are all there to create a new and exemplary model for a primary industry – one based on sustainable long-term management of native forests for multiple values and benefits. Native forestry is arguably one the best opportunities to create the type of regenerative primary industry that answers Morgan Williams' call in *'Growing for Good'*.

In this context, I would be extremely disappointed if a twentieth-century styled tōtara industry results. That would squander the opportunity to prove to ourselves that, as species, as a nation, as a community, and as individuals, that we can put the relationship right between culture and nature. In contrast, what is needed is a truly sustainable and regenerative primary industry, with intergenerational perspective and values. Making it work with native forestry, particularly tōtara and beech, is the opportunity to find and guide the way – to create a forestry model that brings hope for the future.

Doing it

Bringing about a new tōtara timber industry will still require the convergence of many things. A mob of issues still need mustering through the gate. A sustainable supply chain needs to be engineered. That involves all the matters outlined further above, including public opinion, market acceptance, and more conducive regulations. It is a slow process. However, we have been making steady progress by keeping our sights on the long-term goal.

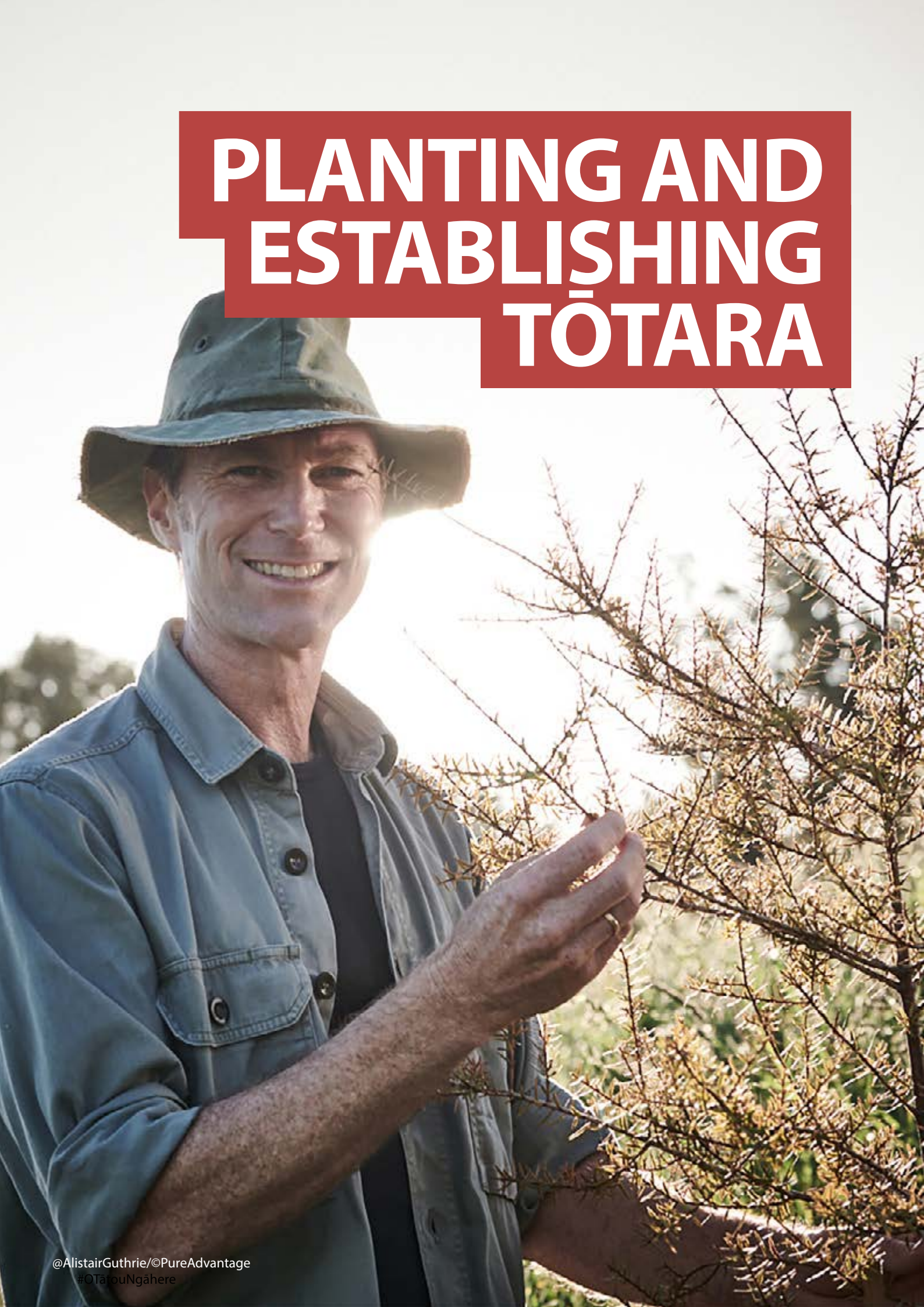
While it is important to have lofty aspirational goals, and for people to be working on the many aspects required to enable them to happen, ultimately, these ideas need to be put in to practice. Someone needs to start doing it – in the forest. This is where this practical guide to managing tōtara on private land comes in.

The advice presented in this guide will not be perfect. It is based on the limited experiences to date, observations, and doses of opinion. Management prescriptions will inevitably be revised and improved upon over time. Nevertheless, I hope that it provides inspiration and enough useful information to give people the confidence to take a spade, pruning loppers, or chainsaw, and to get out there and start doing it.

Whatungarongaro te tangata, toitū te whenua

As people disappear from sight, the land remains

PLANTING AND ESTABLISHING TŌTARA



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PLANTING AND ESTABLISHING TŌTARA

Why plant tōtara for timber?

Rākau Rangatira

Tōtara is revered in Aotearoa, New Zealand. For Maori it is the leading Rākau Rangatira, the first big tree created by Tāne. It is a species that grows throughout the country and has iconic status based largely on respect for the attributes of its timber and the cultural heritages associated with its use - and its abuse.

These days it is one of the most widely planted native canopy-tree species. This probably reflects the ease of seed collection, propagation, and that it generally has good survival rates and reasonable growth across a range of site conditions. It is also one of our few native pioneer tree species, tolerating more open light conditions and fresh mineral soils. These are natural advantages that make it suitable for early inclusion in reforestation projects. And, when people are thinking about possible future native timber options, natural durability is often a priority attribute – and in that respect, tōtara is one of the kings.

"Tōtara is an iconic native tree species. It is revered for its timber attributes and cultural heritage values."

"Tōtara has excellent potential to be managed as a high-value native timber species."

Dr. David Bergin

The preeminent forestry scientist David Bergin did his PHD thesis on the growth and management of planted and naturally-regenerating stands of *Podocarpus tōtara* D. Don.

A popular choice

In recent years, native reforestation has been encouraged through schemes such as the One Billion Trees programme. This recognises that native forests can be an elegant way to address some of the most pressing issues of our times – the biodiversity, freshwater, and climate-change crises, as well as providing an array of other environmental services along with natural landscape and cultural values. However, for many people, adding some potential productive timber value to this suite of benefits makes perfect sense. Diversifying our country's production forests in terms of forest type and species is considered one way to weave environmental resilience into our working landscapes – particularly with native forest.

Work by the Northland Tōtara Working Group and others has demonstrated that tōtara has excellent potential to be managed for timber production. It responds well to silvicultural treatments, such as pruning and thinning, and the timber, even from relatively young trees, is an excellent softwood timber suitable for many interior applications and uses.

Tōtara is considered one of the most promising native tree species for timber production purposes. New tōtara forests can be planted and managed as even-aged plantations, or as continuous cover forests for selective harvesting, or as part of a more natural mix of native forest species.

Resource scale and future timber demand

Scale is another reason to plant tōtara. A significant resource of naturally regenerated tōtara already exists on private land in Northland and other regions. This natural resource has commercial scale and could provide the potential continuity of supply that is essential to develop markets for a sustainable tōtara timber industry. Planted tōtara forests should benefit from this confidence and be a complement to the extensive existing regenerating forest resource. Few other alternative timber species have this advantage of commercial scale and continuity. The more people that plant and create tōtara forests, the better the chances that a strong tōtara timber market and industry will develop.

"Tōtara is one of the most popular choices for native tree planting – and the more that are planted, the better the chances that a strong market for the timber develops."

Monocultures and mixed species

For many reasons it appears that tōtara has been considered one of the safer bets when planting with long-term native timber production in mind. While there are some advantages with single-species plantations, diversity is a sound strategy for spreading risk. Moreover, non-timber values, such as biodiversity and natural character, are likely to be much higher in diverse, mixed-species native forests, rather than mono-cultural native plantations. Planting also brings the opportunity to create and support the many non-timber values also associated with mixed native forests.

Nevertheless, the forest of the early establishment phase will not be the same as the enduring forest after 80 years or more. Ferns and other native plants will likely establish themselves naturally as conditions change under the canopy and will increasingly support shade-tolerant and exposure-sensitive plants that wouldn't have survived if they had been planted out in the open from the start.

Role in establishing native forestry

Tōtara, as a pioneer tree species might be useful, in places, to help create the first emergent forest canopy within which a more diverse native forest will inevitably develop or can be supplemented by under-planting later. Some low-impact selective harvesting could even be a way of helping to transition a tōtara dominant forest into a more diverse native forest - within a couple of centuries.

Native forest establishment involves very long timeframes and processes of species succession. On many sites, tōtara is a species well-suited for inclusion and strong representation in the mix of early canopy tree species. Given its attributes and its mana, it is only natural for tōtara to take a leading role in native afforestation. Perhaps this echoes Maori creation stories where tōtara provides the space for other life to thrive.

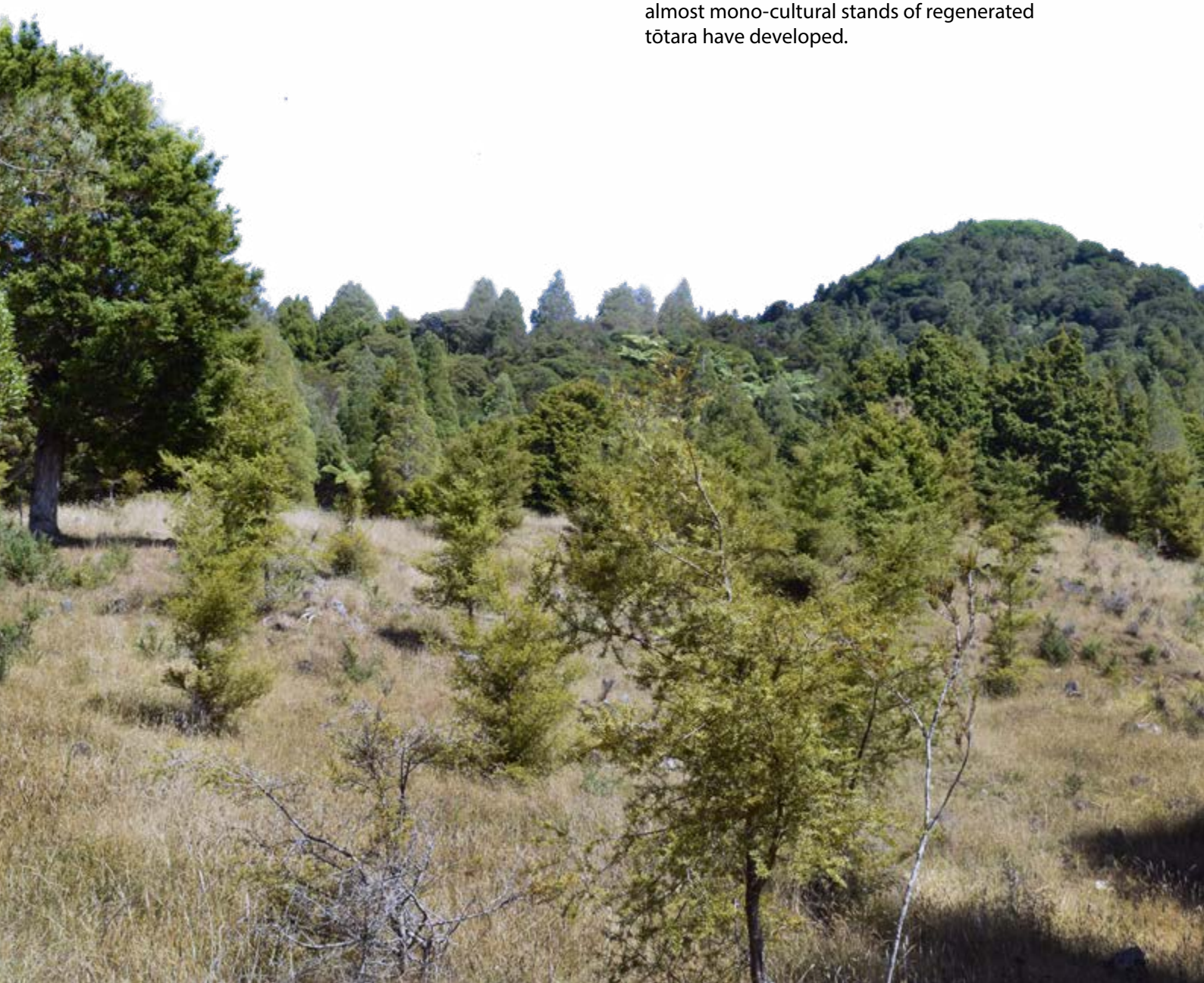
"Given its attributes and mana, it is only natural for tōtara to take a leading role in native afforestation."

Working with natural regeneration

The ability of tōtara to naturally regenerate is one of the most remarkable features of the species today. In some regions, such as Northland, regeneration of the species is especially prolific. Clearly planting is not the only way to establish a tōtara forest. Indeed, in respect to large-scale native reforestation, and particularly tōtara forests, I suggest that natural regeneration is the much 'bigger fish'. The key role of planting is to complement it by adding more forest area.

"Natural regeneration is the 'big fish' of large-scale native forestry."

Ecologically, tōtara is a pioneer tree species. It is well suited to colonising disturbed environments, such as what we have created through bush clearances and farming. It sets seed from a young age and the seeds are widely spread by birds and germinate easily. Moreover, it seems to be enjoying the warming climate. But perhaps its greatest advantage is its relative resistance to grazing by livestock. Tōtara is often the dominant native canopy tree species in areas of second-growth forest and scrub regrowth on farms. This reflects the influence of livestock browsing which modifies the species composition of regenerating vegetation. It has become one of our most prolific native tree species in highly modified pastoral landscapes nationwide. In some pastoral areas, almost mono-cultural stands of regenerated tōtara have developed.



Just like gorse and tea-tree, tōtara can naturally regenerate within a pastoral environment, especially on rough pastoral hill country. Birds spread the seeds across the landscape and grazing helps release the tōtara from competing vegetation. Kahikatea is often also present, but to a much lesser extent.

Grazing can even help naturally regenerating seedlings to establish.

Tōtara are well suited for integration into the pastoral environment. They tend to colonise steep slopes with poor pasture – arguably the areas that should be in trees anyway.

At low stocking rates, the first trees to establish will be heavily branched and with no merchantable timber bole. Such trees provide livestock shelter and amenity value but have no timber value. Photo: Helen Moodie

Scope to manage natural regeneration

Given the demonstrable ability of the species to regenerate, the critical question is whether we can deliberately encourage and manage this natural process to establish new tōtara forests suitable for timber production – without planting? Certainly, the work of Dr David Bergin and the Northland Tōtara Working Group, shows the scope to apply silviculture (pruning and thinning) to the areas of dense tōtara saplings and pole-sized trees. But those dense pole-stands and trees, with boles suitable for timber production, are only a small proportion of the natural population. The bulk of the naturally regenerated resource is dominated by branchy trees with little or no merchantable timber volume.

Establishment pattern in open areas

A typical pattern of establishment in opens areas is that the older trees, the first to colonise, develop a coarse branchy growth habit, often with multiple leaders, and no merchantable timber volume. However, these provide the seed source and bird-perches, for consequential waves of colonisation that start to infill the areas immediately around and in between these parent trees. As the stocking rate increases, so too does the effect of side-shade and competition, which produces young saplings and poles with increasingly better form for timber production purposes. This infilling continues until a dense and closed canopy is formed and there is insufficient light reaching the ground for further regeneration of tōtara.

Ultimately, natural regeneration tends to result in a fully stocked forest comprising trees with a range of ages and highly variable form. The poorest-formed trees are usually the oldest and biggest and dominate the stands. Dense stands will progressively self-thin, but unfortunately the better-formed trees will often be suppressed by the poorer-formed ones with the bigger crowns. Of course, there is scope to intervene and manipulate this structure through thinning and pruning – to direct the growth onto the better-formed trees so they become the dominant trees (see the chapters on pruning and thinning).

Open pastoral areas between scattered trees can infill with dense stands of saplings – up to 60,000 stems/ha

Establishment in scrub and bush

Tōtara regenerating amongst scrub and bush will tend to have much better form for timber production. However, shade and competition from ferns and shrub hardwoods will often significantly inhibit levels of tōtara regeneration. Even where seed sources are present, areas of second-growth native forest may have a relatively low stocking of tōtara, especially if there is no history of livestock influence. In contrast, tōtara abundance does seem to have a relationship with a history of farming. Presumably where cattle have had access and kept the ferns, shrubs, and herbaceous weeds in check, tōtara and other podocarps have had enough light and freedom from competition to become established. Without grazing, a mixed-species native forest develops.

Even without any silvicultural management, naturally regenerated pole-stands can develop into tōtara forests that are well-stocked with well-formed trees and high volumes of merchantable timber. However, growth rates could be significantly improved with some active management (see chapters on pruning and thinning).

Severe competition between stems in dense thickets or stands of tōtara saplings will encourage the development of tall straight stems, but significantly slows the growth rate.

Encouraging natural regeneration

In areas where a seed source is present and natural regeneration is evident, there may be opportunities to establish areas of tōtara forest without actively planting. However, this is likely to be a slow process over a couple of decades or more. Conducive land management practices may include:

- Allow natural reversion with gorse, and kanuka.
- Refrain from slashing or burning the area.
- Continue light periodic grazing (if that is an option) but avoid intensive mob-stocking or feeding-out, or standing-off, in that area.
- Spray to control thick gorse, bracken, blackberry, shrub hardwood and herbaceous weeds. (N.B. – see section on herbicide resistance).
- Manage the vegetation cover to ensure that it is not inhibiting successful colonisation and growth of tōtara seedlings through excessive shade and competition.
- Protect from fire.

"The advantage of natural regeneration is cost. No planting, no fencing, no releasing is needed to establish the trees"

Managing natural regeneration for timber production purposes

Unless dense thickets of tōtara develop (>6000 stems/ha), some form-pruning will be needed and later some thinning. See the video on form-pruning tōtara for timber production: https://vimeo.com/580207222

Images following show a small fringe of regenerating tōtara encroaching on a paddock on a dairy-farm runoff block. Gorse developing amongst it was killed off by herbicide spray, which also killed the black tree ferns (see section on herbicide resistance). This left a monoculture of tōtara on the rough pasture with a stocking rate equivalent to 2800 stems/ha. No planting, no releasing, and no fencing was necessary to establish this stand. Form-pruning and later thinning should see it develop as a woodlot with excellent timber production potential.

Frequent (3-5 yearly) form-pruning should be carried out to improve the form of saplings and poles (see chapter on form-pruning tōtara). Such silviculture will help maximise the productive potential of the developing stand.

These young tōtara naturally established amongst gorse and kanuka within a paddock. Herbicide applications killed off the gorse and kanuka and have left the tōtara. If the landowner refrains from clearing these trees, they could be managed to become a tōtara woodlot, but would need a lot of form-pruning.

Regenerating tōtara saplings and poles establishing at the edge of the paddock can be form-pruned and managed to ensure they develop sawlog potential in the future.

These regenerating tōtara have encroached into a paddock on a dairy-farm runoff block. Herbicide spraying has left a monoculture of tōtara at a stocking rate of 2800 stems/ha. No planting, no releasing, and no fencing was necessary to establish this stand. Continued form-pruning and later thinning should see it develop as a woodlot with excellent timber production potential.

Regenerating tōtara can often be integrated with other land uses such as pastoral farming or production forestry. Many small areas will cumulatively amount to a significantly-scaled resource.

"The disadvantages with natural regeneration are that it is slow, inconsistent, and legal restrictions in the Forests Act apply."

Any native forest established by natural processes, such as described above, will be subject to the restrictions of Part 3A of the Forests Act. This is the case even for tōtara forests that have regenerated on previously cleared land, and as a result of conscious management decisions, such as encouraging and assisting natural reversion. The implications of this are set out and discussed further below in the next section.

Naturally regenerated tōtara on a farm in Northland.
Photo: Michael Bergin

Planning a tōtara forest

There are many excellent publications covering the importance of planning native plantings and the steps involved. In general, the same content and processes will be applicable to tōtara forests so it is not all replicated here. However, it is worth emphasising the following:

- **Site suitability:** Make sure you match species choice to the site. Tōtara do not like wet feet! And although tolerant of a range of soil types and conditions, on some sites, they simply won't thrive.

- **Work with natural regeneration as much as possible:** Planting is expensive. So use planting strategically to start-off the processes of natural regeneration where needed, and to work with and complement existing native vegetation where present. Plant close to existing bush and/or create corridors and linkages to existing remnants.

- **Local examples and advice:** Seek out local knowledge and experience and learn from local examples. Also, be aware of other local initiatives and projects such as pest control and plantings, that your plantings might link or contribute to (e.g., wildlife corridors/riparian connections).

- **Funding support:** Check with regional councils, Government agencies (e.g., Te Uru Rākau), and other organisations (such as Trees That Count) or local projects (e.g., Kaipara Moana Remediation project) for possible assistance with planning, technical advice, or funding to lessen the costs.

- **Staging:** Stage large planting projects and start with small-scale trial plantings to learn about any unique site conditions or issues, and to spread your risk (e.g., severe droughts after planting).

- **Pre-ordering:** Pre-order plant stocks from nurseries well in advance (1-2 years for manuka, 2-3 years for tōtara) – especially if eco-sourcing, and ensure plants are up to specifications at the time of planting. Pre-ordering should also get the best prices.

- **Tracks, Tracks, Tracks:** Accessibility is important for establishment and maintenance - but it is essential for harvesting! Experienced foresters stress the need for and value of tracks. These are best formed before planting and should be suitable for large 4WD tractors or skidders. Ian Barton's handbook on continuous cover forestry, states that an effective network of roads, tracks, and skid trails will occupy 6 - 8 % of the total forest area.

  With present technology, helicopter-logging is probably too expensive for young tōtara plantations. Therefore, track lay out should facilitate practical ground-based harvesting. The effective reach of a tractor-mounted forestry winch is probably around 35 – 50m (max. 70m) depending on terrain and machinery used. Skidding tracks should aim to be no more than 70m apart – 100m maximum.

  Ideally tracks should only have gentle gradients and follow along a contour. However, in steep country they might be restricted to ridges, spurs, and gully floors. Management objectives for inaccessible areas should be weighted towards conservation values.

- **Allow for mortality:** There will inevitably be some losses of planted tōtara in the first few years after planting – on average of up to 20%. So allow budget for blanking (replacement of failures).

Forest mapping

Mapping is an important tool in developing a forest management plan. Mapping your tōtara forests areas is likely to be useful for other purposes too (e.g., as integral parts of a Farm Environment Plan).

Furthermore, on many sites, planted tōtara may be complemented by areas of *naturally* regenerating tōtara – or native reversion. Differentiating planted tōtara forest from areas of naturally established native forest may be difficult to accurately map. However, the implications of the Forests Act, and potential maps and rules in District Plans (e.g., Significant Natural Areas (SNAs)), make it important to do so. Therefore, accurate mapping of the land and potential tōtara forest areas is recommended as part of the initial planning stage.

Tōtara forests provide habitat for many other native and exotic species - in this case the climbing white rata. Photo: Michael Bergin

Ian Brennan and Trisha Wren established an excellent network of tracks ahead of planting areas of native forestry that will be managed under a continuous cover canopy system. Photo: Ian Brennan

The Forests Act

Planted vs natural forests

The Forests Act is relevant to those planting native forests in the following ways:

- It differentiates between areas of planted indigenous forest and naturally established indigenous forest. Different rules apply at the time of harvest.
- Planted indigenous forests can be certified as such, to exempt them from the sustainable management requirements that naturally established native forests are subject to.

Therefore, for most native forest planters, involvement with Part 3A of the Forests Act will only be the mapping and certifying of their planted forest areas, and then again with some record-keeping, at the time of harvest and milling. These are not onerous requirements, and Te Uru Rākau charge no fees to certify planted forests.

"Get your planted tōtara forests certified as 'Planted Indigenous Forest' by Te Uru Rākau – The New Zealand Forest Service."

Planted native forests may be clear-felled

Essentially, as far as the Forests Act is concerned, planted indigenous forests may be treated like exotic woodlots, and could be clear-felled at the time of harvest, if the owner wishes. Retaining this freedom is strongly recommended – even if it is never utilised. Owners may still choose to manage their planted forests under a continuous cover forestry system instead – when harvest time comes.

This contrasts markedly with all naturally established forest areas. Part 3A of the Forests Act applies to the harvesting of native forests. And Sustainable Forest Management Permits or Plans dictate allowable harvest volumes and forest protection measures. There are also significant costs and lengthy processing times involved.

An issue for landowners planting native forest may be mapping out what is classed as already indigenous forest area. It is likely to include reverting scrub regrowth and regenerating native plants on land that has previously been cleared or is still in pastoral use. Advice from Te Uru Rākau forestry advisors will be necessary.

"Mapping out areas of existing indigenous forest – including scrub regrowth will be necessary."

Contact Te Uru Rākau – The New Zealand Forest Service to register your planted indigenous forests: https://www.mpi.govt.nz/dmsdocument/54-Planted-indigenous-forest-certificate-Application-form

Other legal disincentives

Fear of legal impediments and not being allowed to harvest, has been a disincentive for many landowners contemplating planting native forest, and especially for allowing natural reversion. Getting planted indigenous forest areas certified by Te Uru Rākau will limit potential encumbrances from the Forests Act. However, other regulations such as District Plan rules relating to Significant Natural Areas (SNAs) may still apply. Certification will not guarantee total freedom or rights to harvest in the future. Nevertheless, it is a clear registration of an interest to do so, and strongly recommended.

Given the long timeframes involved between the planting and harvesting of native forests, let's hope that issues with the regulatory frameworks are well resolved when the time comes. In the meanwhile, don't let it put you off planting and managing native forests in all their forms.

"The trees still grow despite daft regulations – hopefully there is time to sort any silly rules between planting and harvest."

Planting regimes for tōtara

Best practice for native forest establishment is set out in the Tane's Tree Trust Handbook: https://www.tanestrees.org.nz/resources/publications/

These follow the orthodox approach of interplanting canopy tree species, such as tōtara, within and amongst a protective 'nurse cover' of native plants and shrub hardwoods. In sheltered and mild Northland sites, tōtara are often planted out at the same time as the nurse species. But on harsher sites, such as exposed coastal areas, or in colder regions, the interplanting of the canopy trees is often delayed a year or more until the nurse is established enough to provide some protective shelter.

The nurse species

For most sites and situations, it is recommended that tōtara are interplanted within a 'nurse cover' of native shrub and small-tree species to provide surrounding shelter from the elements and to help suppress grass and weed competition, enhance biodiversity, attract birds, and feed bees etc., and for natural aesthetic character.

Function of a nurse for timber crops

For timber production purposes, the nurse cover also needs to draw the tōtara stems up tall and straight, by providing some lateral shade and competition to discourage the tōtara from developing heavy side branches. Ideally the nurse cover should provide some light overhead canopy competition to reduce the tendency of the tōtara stems to fork and develop more than one single leader or tip.

A trial at Tapapakanga Regional Park in South Auckland planted tōtara at the medium-high stocking rate of 2.0 x 2.0m spacings (i.e., 2500 stems/ha) but without a nurse. Evaluations more than 30 years later show that it did not result in a stand of well-formed trees for timber production purposes.

An effective nurse cover will improve the form of the tōtara and reduce the need and cost of pruning – which is expensive. It should also increase the height of the tree's bole – which ultimately is the length of usable log. However, if the nurse cover is too dominant and over-tops the tōtara with heavy shade, then the growth of the tōtara will be significantly slowed – possibly for decades. Naturally, a fine balance between enough competition and too much is what is wanted but that is certainly not easy to achieve. An ineffective nurse is an unnecessary expense.

The choice of nurse species is an important decision.

"The nurse cover has a critical role in improving the form of the tōtara."

Manuka as a nurse species

In recent years manuka has been a popular choice. It is usually one of the cheapest native plants, quick-growing and quick to plant, tough, and tolerant of a wide range of site conditions, and at little risk from accidental livestock browse, or pests. Many people have planted manuka with the hope of some income from the manuka honey industry but have still interplanted tōtara for the option of some timber value in the longer-term and for when the manuka is succeeded by taller vegetation.

Other features of manuka as a nurse are that it doesn't grow too tall or persist and live too long. Once above the height of a manuka canopy, typically 3-5metres, tōtara will quickly dominate and suppress the nurse.

However, at that stage, the adjacent planted tōtara will provide the only competition between the tōtara crowns. The big question is whether that will be sufficient competition to encourage them to form good quality top-logs, and limit forking and the development of heavily branched crowns? If not, the result will be a forest of relatively short-boled tōtara trees with large, unusable crowns. But in such instances, at least the short butt logs should fatten quickly, reducing the time to first harvest opportunities.

If using manuka as the nurse cover species, interplanting the tōtara at a medium stocking rate (>1250 stems/ha) is probably the best bet to influence the length of merchantable log (i.e., encourage the formation of usable top logs). And hopefully, provide enough choices for effective thinning.

Kanuka

In contrast to manuka, kanuka can grow relatively tall (12-18m) and persist in the secondary forest for a century or more.

It has not been as popular as manuka for use as nurse species. This probably reflects factors such as availability, price, and that kanuka is less tolerant of some site conditions. It also has the potential to develop a taller nurse canopy cover and dominate and compete with the emergent tōtara for a much longer time. This overtopping and prolonged competition is likely to significantly slow the growth rates of tōtara seedlings, saplings, and small poles. Furthermore, branches and stems from competing kanuka may damage or deform the stems of the developing tōtara if they rub against them or cause them to lean. Nevertheless, some of the best-formed young tōtara trees and forests have regenerated naturally through a predominantly kanuka nurse cover.

Indeed, tōtara is naturally more commonly associated with kanuka than with manuka. This begs the question whether we should be following nature's examples and be using kanuka as the natural nurse for tōtara? Unfortunately, there is little research to guide us on this matter. Observations and experience with naturally regenerated tōtara forests confirm that tall-boled and lightly branched tōtara poles and trees often develop through a kanuka dominated cover. However, the growth rates of tōtara within natural stands are usually significantly slowed by the competition and overhead shading.

Nevertheless, using kanuka as a nurse cover may suit situations where little or no pruning is intended and minimising the growing time to reach a harvestable diameter is not priority. Also, fewer nurse plants per hectare may be needed. Unfortunately, we are not aware of trials comparing the long-term differences between using manuka or kanuka as a nurse for tōtara intended for timber production, nor the optimal stocking rates and spacings for planting. It would be good to have research guidance on these matters.

Kanuka may be a good option for those wanting a low-cost regime, and intending on minimal management, but still hoping to ultimately produce some trees with excellent form for high-value timber in the long-term – and don't care if it takes a long time.

Mixed native species nurse

For greater biodiversity and more natural aesthetic values, the option of using a mix of locally appropriate native colonising species as a nurse is recommended. Pick a range of plants naturally found in similar habitats in the local area and known to have good survival rates when planted in open and exposed conditions.

Try to match the nurse plant species to suit micro-site conditions, hopefully improving survival rates and the resilience of the plantings to extreme weather events and conditions.

While a mixed-species nurse has many benefits, it can involve greater unit costs per plant compared to manuka.

How many to plant and at what spacing?

Tōtara plantations are notorious for developing trees with poor form for timber production. However, as many natural stands attest, the species is very capable of producing tall, high-volume, high-value timber trees. We just need to learn how to achieve the same.

Most tōtara plantations do not produce well-formed timber trees. Planted tōtara often have forked stems, spike-branches, multiple leaders, heavy branching, low stature, and short boles. Frustratingly, even planting tōtara at medium-high densities (e.g., 2.0 – 3.0m spacings) will not ensure well-formed trees result. Some form-pruning is likely to be necessary to enhance potential timber values. Medium-high density plantings will also need thinning at some point but have better chances of achieving a well-stocked stand of good quality trees. The more trees to choose from the better.

Unfortunately, there is no one single planting prescription. Essentially, there are trade-off decisions to make. Some of the pros and cons are discussed here.

Trade-offs

Planting at lower initial stocking rates (numbers of plants per hectare – expressed as stems/ha), means less outlay costs for plants, and less cost for planting, but it is likely to mean a longer maintenance period before canopy closure (when the crowns of the plants join and shade out the grass and many weeds in the understory). This may mean an extra couple of years of releasing from weeds during establishment.

Low density planting may initially be cheaper, but then require more pruning which is expensive, and will likely result in a stand that is under-stocked with merchantable trees and/or quality timber volume.

Thinning is a much more cost-effective silvicultural intervention than pruning. But relying on thinning requires having sufficient good trees to choose from. The more the better.

Higher stocking rates have more silvicultural management options to maximise timber yield and quality. However, sometimes high stocking rates of nurse plants, while initially helping displace weeds, can in themselves start to require some controlling if they overly dominate the tōtara. This would involve thinning or cutting of branches to create or maintain light wells for the tōtara. For example, Ian Brennan at Te Miro in the Waikato, finds that tarata, (lemonwood, Pittosporum eugenoides), is too vigorous and produces dense shade, which often deforms or suppresses tōtara when planted in a 2500 stems/ha regime.

Matching site conditions with your capacity and objectives

Growing conditions, weeds, and species performance will vary from site to site and region to region. Local knowledge and examples can be invaluable assistance when deciding on a planting prescription. Native afforestation is a costly long-term commitment, so it is worth trying to match the planting plan to your funds, capacity, and enthusiasm for silvicultural work.

"Most tōtara plantations do not produce well-formed timber trees – even when planted at medium densities."

More detailed information is set out in the Tane's Tree Trust Handbook, particularly chapter 8.2, and free to view and download here: https://www.tanestrees.org.nz/site/assets/files/1069/8_2_planting_patterns_and_density_for_natives_on_open_sites.pdf

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Target stocking rates at harvest time

Analysis work by Mark Kimberley based on Stand Density Index, suggests aiming for a stocking of 400 pruned crop-trees per hectare of tōtara when their mean diameter at breast height is 40cm. However, this target stocking rate progressively reduces as the mean diameter increases – as set out in the table 1.

Dense stands of naturally regenerated tōtara often have stocking rates exceeding 3000 stems/ha. Many trees have excellent form, and the stands can be heavily thinned so that they are fully-stocked with only the well-formed trees. In comparison, many planted stands may struggle to achieve a full stocking of premium quality trees.

Table 1. Target stocking rate in relation to mean diameter and/or at target harvest diameter:

Mean DBH* and/or target harvest diameter (cm)	Target stocking rate (stems/ha)	Approx. mean spacing** (m)
25	550	4.2
40	400	5.0
50	275	6.0
60	120-200	7.0- 9.0

* Quadratic mean DBH

** N.B. – Mean tree spacing is a guide only and does not need to be rigidly applied. Overall stocking per hectare is more important than even distances between trees.

However, attaining full stockings of good-quality timber trees may be difficult. Therefore, planting many times the numbers required and then selective and progressive thinning/harvests to attain the target stocking rates is recommended. Having plenty of trees to choose from is essential.

Recommended planting regimes for tōtara

Medium density regimes aim to strike a balance between the trade-offs discussed above. A medium density regime is set out below. It has plant spacings that are conducive to systematic thinning, silviculture, and selective harvests, while aiming to attain a full stocking of merchantable stems in the developing forest for timber production.

Note – the distances between trees and rows are horizontal distances – i.e., as if in plan view, rather than angled to follow the slope of the land.

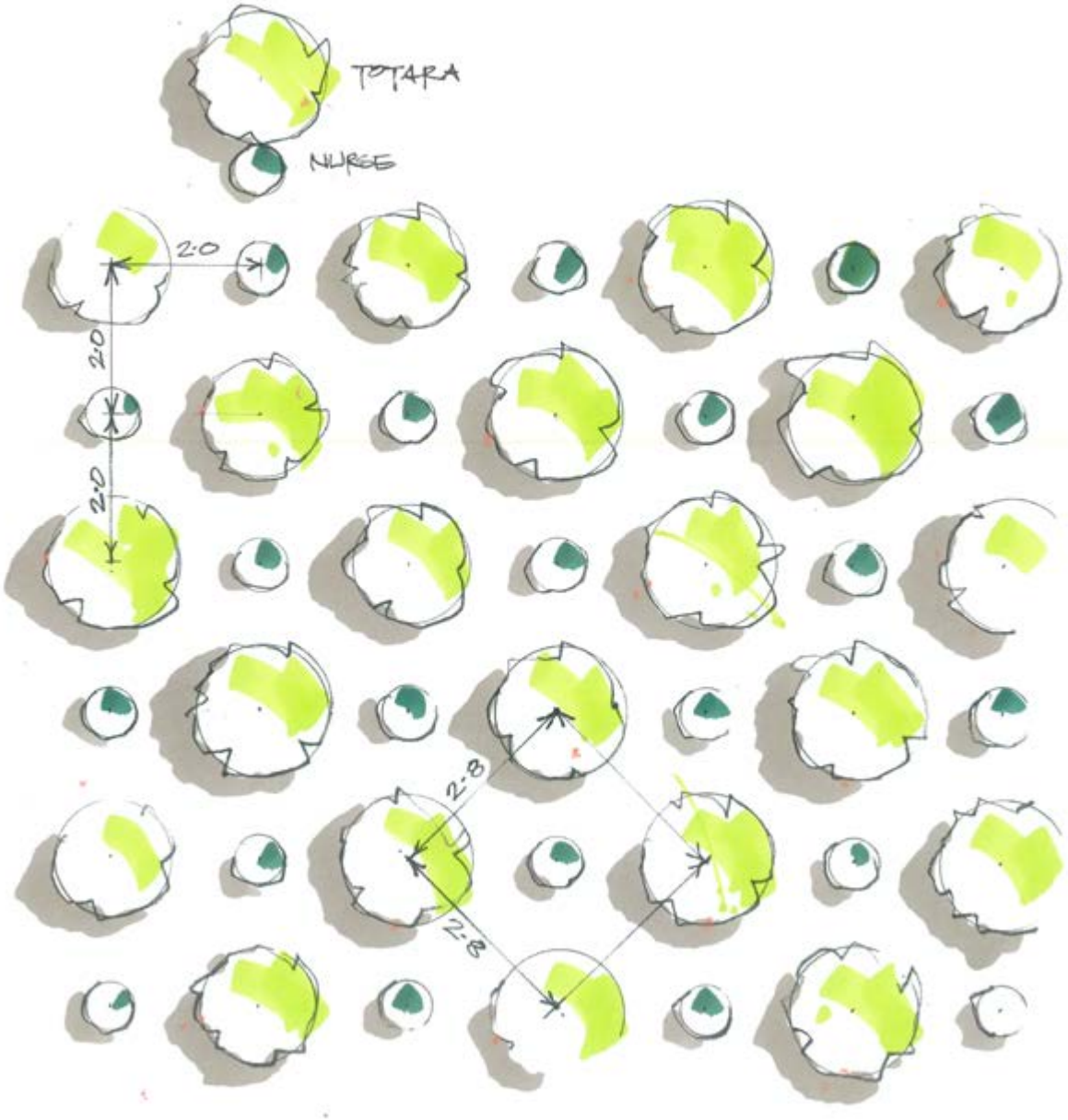
Medium density planting at 2500 stems/ha

Total stocking:	2500 stems/ha (50% tōtara/50% nurse)
Number of tōtara:	1250/ha
Number of nurse:	1250/ha
Distance between rows:	2.0m alternating nurse/tōtara along each row and staggered rows.
Distance between trees along each row:	2.0m
Set out tips:	Plant the nurse species in a 2.8m grid pattern and then interplant the tōtara in the centres of each grid (also at 2.8m centres between the tōtara).

This medium density plantation regime suits those aiming for good timber production potential and multiple management options. Thinning will be necessary as the stand develops (aiming for 400 premium, pruned trees, per hectare, by the time the mean diameter at breast height is 40cm).

Planting the nurse a couple of years before the tōtara should be considered for exposed or tough sites where the nurse needs to provide early shelter.

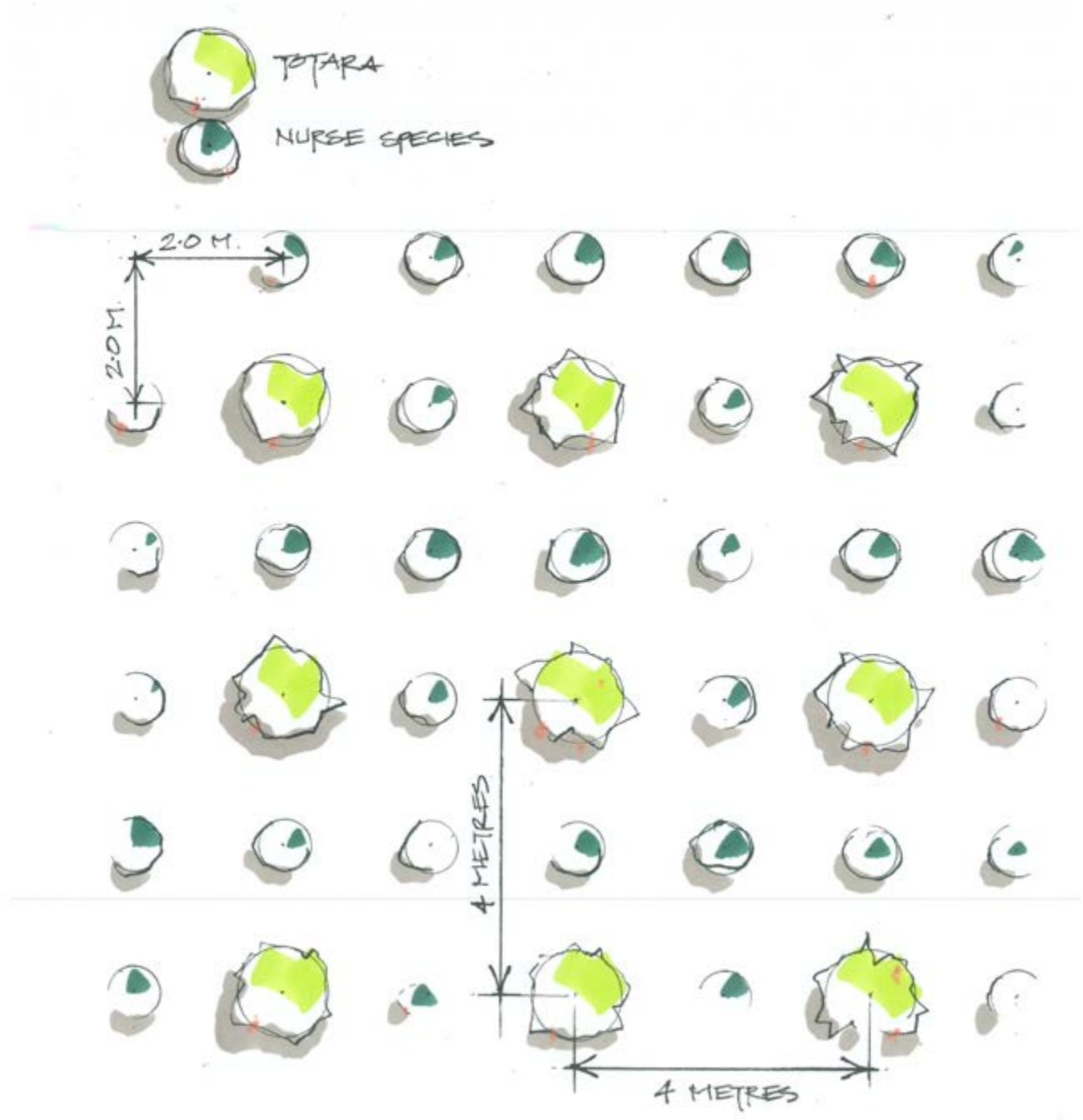
Form-pruning will still be needed to improve the quality and volume of merchantable tōtara timber. And it is still unknown whether this regime, with manuka as a nurse, will produce high quality top-logs.



Medium-low density at 2500 stems/ha

Total stocking:	2500 stems/ha (25% tōtara/75% nurse)
Number of tōtara:	625/ha
Number of nurse:	1875/ha
Distance between rows:	2.0m
Distance between trees along each row:	2.0m
Set out tips:	Plant the tōtara in a 4.0m grid pattern and then interplant the nurse species to complete a 2.0m x 2.0m fully planted grid pattern.

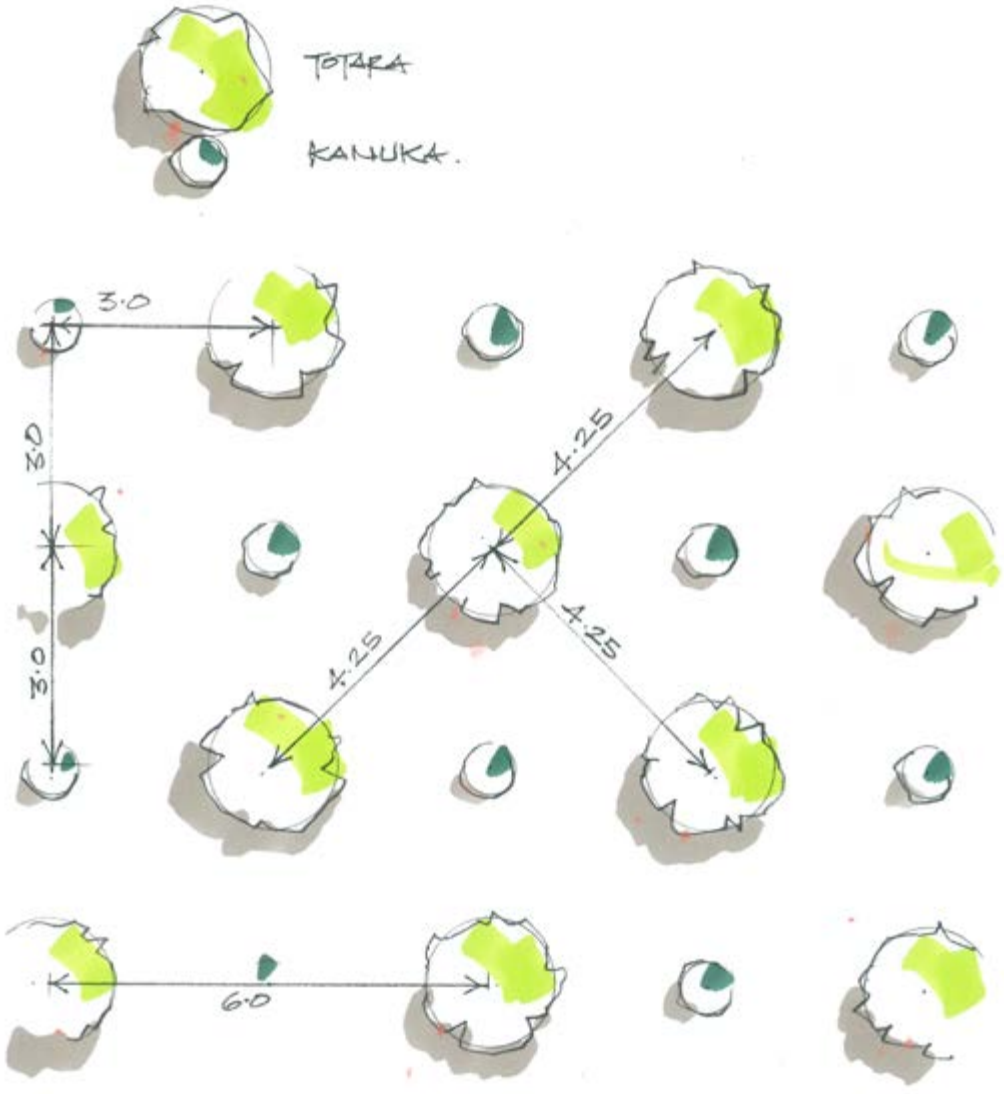
This regime suits mixed-species native forest plantings and tougher sites where establishing a thick protective nurse cover is important, and where expensive large-grade tōtara are used. However, with such a low stocking of tōtara, form-pruning will be needed, and there will be fewer choices for thinning operations. The resultant stand may not be fully stocked with well-formed timber trees.



Low-density at 1110 stems/ha

Total stocking:	1110 stems/ha (50% tōtara/50% Kanuka)
Number of tōtara:	555/ha
Number of Kanuka:	555/ha
Distance between rows:	3.0m
Distance between trees along each row:	Distance between plants along each row: 3.0m (alternating species: kanuka, tōtara, kanuka...)
Set out tips:	Plant the Kanuka in a 4.25m grid pattern and then interplant the tōtara in an offset grid pattern also at 4.25m centres.

This regime is untested. It is inspired by observations of a common natural forest succession – i.e., tōtara under a tall nurse canopy of kanuka. It might suit those seeking to minimise establishment and management costs, and where slow growth of tōtara is acceptable. Potentially well-formed tōtara trees could form amongst the kanuka, but at such a low planting density, the stand is unlikely to be fully stocked with quality timber trees when poorly-formed trees are thinned out. However, some minimum-input European forestry systems consider producing as few as 20-40 tall, large-diameter, premium-quality trees per hectare, to be a success. And the trees may be 180 –240 years old.



High density plantings at 4,444+ stems/ha

Dense natural stands of tōtara can produce many trees with excellent form for timber production. However, these have typically developed as thickets with extremely high stocking rates. Planting at a minimum of 4,444 stems/ha (i.e., a maximum of 1.5m spacings) would be needed to try to replicate that effect – and 1.0m spacings, or less (i.e., 10,000+ stems/ha), would be better. Of course, planting at such densities is extremely expensive and likely to be cost prohibitive for most situations.

In some parts of Northland, tōtara can be planted at high density without an accompanying nurse species. However, presently the high cost of tōtara seedlings that are large enough to plant out, precludes this from being a viable establishment option at any significant scale. While pruning costs could be minimised, or maybe even avoided, several thinning operations would still be required for effective timber production.

Medium-high density tōtara plantation at 1.5 -1.8m spacings without an accompanying 'nurse'. Even at this stocking rate form-pruning will be needed in order to have enough well-formed and vigorous trees to be optimally stocked after thinning.

Tōtara planted in Northland at around 4,000 stems/ha without an accompanying nurse species. All trees are looking healthy, but some form-pruning will still be required to maximise crop-tree stocking options.

Interplanting tōtara within an existing nurse

Interplanting tōtara within an existing cover of scrub, such as kanuka, may be an option on some sites.

However, site conditions may not be conducive to underplanting tōtara at medium or high stocking rates or in a regular grid layout pattern. Opportunities may be patchy rather than uniform. In such instances, planting along lines cut through the scrub, within gaps in the canopy, or creating some light-wells in taller vegetation may be necessary to get good growth rates. This is a lot of work. And maintenance of over-head canopy gaps may be needed to ensure survival and/or reasonable growth performance. Tōtara will not grow well in heavy shade.

If planting within larger canopy gaps, consider planting tōtara in groups at high density and expect to thin them later to select the best trees.

Planting into existing native vegetation

Note – If planting within a native scrub cover, the area will be classed as *indigenous* forest, and any harvesting will be subject to the provisions of the Forests Act (i.e., Part 3a) – if it is still relevant come harvest time!

That would effectively prohibit clear-fell harvesting but allow for low-impact selective harvests and close to nature forest management. Considering the long timeframes involved, the future legal situation is a gamble. Other regulation such as Significant Natural Areas (SNAs) may also apply. Checking with the regional and district plan maps is recommended. And well-documenting any supplementary planting within existing native cover is advised.

Planting specifications

The following sets out a basic specification. This may be used as part of a contract agreement with nurseries and contract planters, or as a guide for landowners doing the planting themselves.

Pre-plant site preparation

For sites that are being retired from grazing and are dominated by pasture, there are two options:

- Either
  a) **Herbicide spray option** - A herbicide spray application (blanket sprayed over problem weeds, or as spot-sprayed 1metre squares in clean pasture areas – N.B., use spray marker dye to ensure coverage and assist with consistent spacing). N.B. - If herbicide is used, ensure it is applied sufficiently well in advance of planting, so that the target vegetation is brown and dying, to avoid problems with any residues in the soil affecting planted seedlings. Or
  b) **Non-spray option** - Graze as hard as possible with livestock immediately before the planting date if that is an option. Otherwise, mulch the site, or chip weeds with a spade to clear around each plant spot.

Planting season

- Plant in the winter season only, no earlier than mid-May and no later than 20th August, unless unique site conditions dictate otherwise. Delay planting during dry periods until it has rained and the ground is moist.

Planting stock

- All plants are to be top-quality nursery stock, true to type and form (e.g., not cultivars), free of pests and diseases, and hardened–off well to cope with exposed open site conditions. The root-ball must be developed enough to hold the potting mix together when removed from the containers. **Inferior, root-bound, or otherwise ill-thrifty stock should be rejected and not planted.** Plants shall meet or exceed the specified grades. N.B. - It is best to check quality, seedling size and grade of stock at the nursery before delivery, and modify orders to reject any lines that do not meet planting specifications.

Grade and size of plants

- Best practice recommendations are that tōtara plant stock should be at least 2 years-old, a minimum of 50cm high above the potted soil level and have a minimum stem diameter of 4mm at 3-5cm above the root collar (N.B.- most plants will need to be in a PB 2 sized planter bag, or equivalent, to achieve these specifications, although sometimes attained in large volume trays).

  N.B. – using smaller grade and younger planting stock is subject to higher risk of failures and a longer maintenance period.

- Manuka and kanuka plant stock may be less than two years old and in 5-7cm pots or trays with individual cell dimensions not less than 50mm x 50mm x 100mm deep. (N.B.- stock in Hillson root-trainers are not recommended). Manuka plants must have been trimmed in the nursery, so they are not tall and leggy, but instead have stiff upright stems, and plenty of green bushy foliage. Plant heights above potted soil level should be between 30-55cm. Tall leggy seedlings with foliage restricted to only the top third of the plant height are to be rejected.

- Size and grades of nurse plant species other than manuka and kanuka, will vary according to species. But generally, most shrub hardwoods will need to be in PB 1.5, 2, or 3 grades (i.e., 1.0 - 1.8 litre bags or equivalent).

Transport, delivery, and storage of plants

- Ideally plant material will be planted on the day of delivery. If this is not possible, the Contractor/Owner must protect the unplanted plants from sun or drying winds. Plants that cannot be planted on delivery need to be kept in a sheltered and shady location, and well-watered.

Set out of plants

- Plants are to be accurately laid out and planted according to the spacings and patterns in the selected planting prescription/regime to meet the specified number of plants per hectare. However, where obstacles, such as rocks, watercourses, roots, or stumps, make that impractical, then a suitable location close nearby should be used instead.

Planting method

- Professional planting tools and methods shall be used. See video: How to plant native seedlings at scale: https://www.tanestrees.org.nz/resources/videos/
- Plant holes are to be well cultivated and at least 100mm larger in all directions than required to accommodate the root-ball of the plants, and the surrounding soil structure well fractured by levering actions of the planting spade to a minimum depth of 350mm.
- Plants seedlings so the base of the stem (top of the root ball) is at 3-5cm below level of surrounding ground to reduce loss of moisture from exposed potting mix and to ensure plants have sufficient anchorage to reduce socketing in high winds after planting. The backfilled soil shall be firmed by foot so that the plant is stable and wind firm, and large air pockets are removed, but avoiding excessive compaction.
- Plant protectors, weed mats, spray-guards, and fertilisers are considered unnecessary on most sites except dryland areas and where rabbits are a problem.

Healthy 1-year-old tōtara seedlings produced by the Te Kotahitanga e Mahi Kaha Trust in Kaikohe.

Locator stakes

- All tōtara should have a bamboo marker stake (1.5m long 14mm diameter). The purpose is not to stake the tree, but to help with visually finding the seedling for subsequent releasing and maintenance if overtopped or hidden by weeds. Consistent location of the stake, placed within 100mm on the uphill side of the seedlings, is recommended.

Monitoring

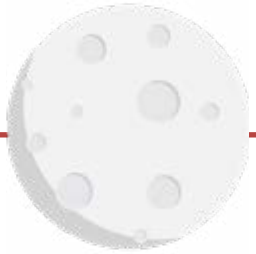
- Monitor the plantings within the first week of planting. Then schedule regular 3-4 monthly monitoring visits - at least in early spring, mid-summer, and early autumn for the first 3 years. Then at least each spring thereafter.

Maintenance

- Release seedlings by spraying/ chipping/ hand weeding, or trampling around them as necessary. Expect 2 -3 release sprays, or 3-4 hand-releases each year for 3 years, or up to 5 years or more on particularly weedy sites. In addition to releasing, spray out any woody weeds annually for 4-5 years and then as required until canopy closure.

Blanking

- Replace all failures in the following planting season.



Maramataka

Based on the *maramataka* of Ngāti Miro in the Whangaroa area, rongoā practitioner Thomas Hawtin, suggests the best time to plant tōtara trees is Hoata (2 days after the new moon), and for the following three days to *Tamatea a Ngana*. However, planting could still be carried out for up to seven days if need be, up to *Tamawharu,* which is two nights before the full moon (*ōturu*).

Releasing – weed control

Herbicides

Anecdotal evidence suggests tōtara has some resistance to a range of herbicides commonly used in agriculture and forestry. These include Metsulfuron-methyl, Terbuthylazine, and Triclopyr for gorse and brush weeds, and Haloxyfop for grasses. In Northland, tōtara surviving the aerial spraying of gorse has frequently been observed. And small preliminary trial results suggest that the apparent herbicide tolerance of the species certainly warrants further exploration. Understanding and utilising this herbicide resistance could make establishing tōtara less costly and more successful in the future.

In Northland, naturally regenerated tōtara is often seen surviving aerial applications of herbicide over gorse and scrub.

Tōtara seedlings needed releasing from gorse one year following planting. A small sample of tōtara were spot-sprayed with Metsulfuron-methyl at label-rates for gorse (and with penetrant) using a knapsack sprayer. The gorse died, and most of the tōtara showed some visible signs of ill-health, but nine months following the treatment, all tōtara were still alive.

Six months after an aerial spray application of Metsulfuron-methyl, the gorse and kanuka and black tree ferns (tall trunks) have died, but the naturally regenerated tōtara appears to be surviving, although with some 'burnt tips'.

A spray trial of Metsulfuron-methyl over 1 year old potted tōtara seedlings, tested a full label-rate, a half label-rate, and an unsprayed control group for comparison. Ill-health was observed amongst the seedlings subjected to the full label-rate spray dose and their height growth was also affected. However, 14 months following the treatment, the survival rate was still 100%.

Presently, there are insufficient trial results to be recommending the spraying of release herbicides directly over tōtara seedlings (other than perhaps Haloxyfop for the control of grasses). Nevertheless, the indications to date should give confidence that with careful knapsack application of the chemicals mentioned above, that tries to avoid directly spraying the tōtara seedlings, there may be relatively little risk of killing them by minor accidental contact such as from wind-drift etc.

Furthermore, herbicide releasing of tōtara in areas afflicted with problem weed species such as Kahili Ginger (*Hedychium gardnerianum*), that can only be controlled with Metsulfuron-methyl, may be possible.

However, at this stage, only very careful use of the above-mentioned herbicides is advised. Mixes at lower than recommended label-rates may still provide an effective release from weed competition while reducing the chances of tōtara suffering adverse health effects. It is not known if observed damage - the browning-off of the growing tips - will increase the likelihood of tōtara developing heavy branching and multiple-leaders. And the effect on seedling health from repetitive applications has not been tested.

"Keep a look out for results from further trials exploring herbicide release options for tōtara seedlings."

Grazing as a releasing method

As discussed in Section 2, in many situations tōtara demonstrates high resistance to livestock browsing. This remarkable attribute opens the possibility of utilising controlled-grazing as a method of releasing tōtara from competing pasture grasses and other palatable vegetation. However, anecdotal experiences reveal mixed success.

David Bergin relates how sheep on a lifestyle block in Rotorua quickly ate and killed freshly planted nursery raised tōtara seedlings. And even in Northland, where tōtara often regenerate freely in paddocks grazed by sheep, beef, dairy cows, horses, even where feral goats are present, damage from browsing, rubbing, and trampling is usually observed on some of the tōtara seedlings and saplings.

In contrast, there are also instances where livestock have either had deliberate or unintentional access to young tōtara plantations without a net deleterious effect. In some cases, the loss and/or damage to a small proportion of the seedlings caused by the livestock, has arguably been balanced by the benefit of releasing the other seedlings. For example, a one-off release-grazing in a 5ha plantation of 3-year-old planted tōtara seedlings was tested on a Northland farm. The seedlings were in danger of being smothered by rank kikuyu grass. 600 ewes spent 4 days on one half of the block, and 85 angus cows on the other. The sheep made little impact on the kikuyu grass and so were followed by the cattle for another 3 days. Around 40% of the seedlings around the livestock camps showed signs of browse, However, no damage was observed on tōtara seedlings further away from the obvious stock camping areas.

Grazing as a desperate method of releasing to salvage a 5-ha plantation of 3-year-old planted tōtara seedlings from the smothering effects of kikuyu grass on a Northland farm was tested. Only the seedlings around the livestock camp areas were browsed (top), but those further away from the camps were not (above). Photos 3-weeks after stock removed.

So, what are the critical factors involved with release grazing? Unfortunately, there is no research guidance, but the following observations have been made:

- Fresh nursery-raised seedlings are likely to be palatable to livestock and may be completely killed by grazing.
- Hardened-off seedlings (e.g., 1 year or more after planting out) have a better chance of surviving grazing, although the fresh growing tips are still likely to be browsed.
- Livestock that are familiar with naturally regenerating tōtara, are less likely to browse tōtara.
- Younger livestock and pets are a greater risk to tōtara seedlings (possibly out of curiosity).
- Seedlings protected from trampling (e.g., next to fences, rocks, and other vegetation) are more likely to survive.
- Damage to seedlings is concentrated around livestock camp areas.
- As seedlings become saplings (i.e., taller than 1.4m) the risk of damage from browsing and trampling reduces.
- Sheep, cattle, horses, and goats do not appear to ring-bark established tōtara trees. Although some trees are targeted for rubbing against.
- Palatable plants amongst the tōtara will be at risk with any grazing.
- Manuka and kanuka as a nurse species are generally more stock resistant than tōtara.

Suggestions

If trialing the use of livestock as a release method the following suggestions are offered:

1. Use manuka or kanuka as an accompanying nurse species.
2. Avoid grazing in the early years of seedling establishment.
3. Use older livestock and preferably stock that are already familiar with tōtara.
4. Carefully monitor the behaviour of the livestock and remove them as soon as they have eaten their fill and camp - before they get bored and curious.
5. Trial frequent, short-duration grazing intervals to start with.

This 2-year-old tōtara seedling was planted into pasture behind a single hot-wire, but still well within reach of livestock (horses, cows and calves). One year after planting, it has survived unscathed and without any releasing.

A successful tall screen hedge of tōtara (approx. 12 years old) resulted from 25-35cm seedlings being densely planted directly into a paddock grazed by horses, cows, and calves without any protection. Proximity to an existing fence prevented trampling, but otherwise, no fencing, no livestock exclusion and no spray-releasing or any other post-planting maintenance occurred. This suggests scope to explore unconventional options for establishing native forest on farms in Northland.

Seedlings were planted close to the fence to prevent trampling, but otherwise not protected from grazing. However, the livestock were familiar with naturally regenerating tōtara in their paddocks.

Cost of establishment

Planting will usually be the quickest way to establish a tōtara forest, and in areas without natural regeneration, it is the only way. However, the high cost of establishing native forests is a significant disincentive and limiting factor. Good information on the costs of various options is essential in the decision-making and planning process. Indicative cost estimates for the four planting prescriptions/options outlined in section 4 are set out below. However, these figures should only be used as a guide for average site conditions and costs in 2022. Actual prices, costs and site requirements may vary significantly.

Table: 2 includes the following assumptions/unit costs:

- $ 450/ha pre-plant site preparation (herbicide spray).
- The lower figures given in the cost estimate range relate to using 1 year old seedling stock at the price of $1.85 + GST from the nursery. The higher figures of each range relate to 2-year-old tōtara seedlings in PB 2 or equivalent grades at the price of $6.00 + GST each, at the nursery.

  (N.B. - best practice recommendations are still to use top-quality PB 2 plant stock).
- Plant costs of manuka is $1.50 and $2.00 for kanuka.
- Set out and planting costs of $2 per plant for PB2 grades, and $1.50 for smaller tōtara grades, and manuka and kanuka.
- A bamboo marker stake is used beside each tōtara at a cost of 30 cents including stake.
- Tōtara are released three times per annum, and manuka and kanuka twice, for the first two years and then tōtara are released twice in the third year, but manuka only once. Release spot-sprays are costed at $0.25 each unit.

Exclusions: No costs for the following items are included in the above figures: fencing, plant delivery from the nursery, blanking (replacement of failures), fertiliser or plant protectors, mulch mats or other products, or ongoing woody weed control in addition to spray release around the seedlings, nor ongoing maintenance beyond year three.

Table 2. Indicative estimates of comparative costs (per hectare) to plant and establish tōtara using 4 different planting regimes, in 2022.

Prescription /option (Stems/ha)	Number of tōtara (stems/ ha)	Number of nurse (stems/ha)	Total cost including 3 years releasing*
Medium (2500)	1250	1250 (manuka)	$12,500 – 19,000
Medium-low (2500)	625	1875 (manuka)	$11,500 – 14,900
Low density (1110)	555	555 (kanuka)	$6,250 – 8,800
High density (4444+)	4444+	0	$25,600 – 45,700+

*Lower figures of each range relate to 1-year-old tōtara seedling stock at the price of $1.85 + GST from the nursery. The higher figures relate to 2-year-old tōtara seedlings in PB 2 grades, or equivalent, at the price of $6.00 + GST each, at the nursery.

Small vs large grades of tōtara

Research to date confirms that survival rates are usually higher if larger grade tōtara plants are used. However, the rising costs of PB 2 plants and the higher cost of planting, make the option of cheaper but smaller and younger seedlings attractive to some landowners. There are anecdotes of successful plantings that have used smaller grade tōtara (e.g., in T-28 and even TS-48 tray sizes), and more recently, nurseries that have managed to grow tōtara seedlings to a height of 30-50cm in a single year. Pressure to perfect the production and planting of smaller, younger, and cheaper seedlings is expected to continue.

Using smaller grade tōtara seedlings may be a lower-cost establishment option on some sites. However, it is associated with higher risk of failure and mortality due to factors such as unseasonal droughts, poor releasing and weed control, damage by animals, and severe frost or wind exposure. Moreover, smaller plant stocks will require a longer period of post-planting releasing and care. Therefore, small seedlings are not recommended for difficult or harsh sites and conditions. If in doubt, try a small-scale trial first.

Conclusions

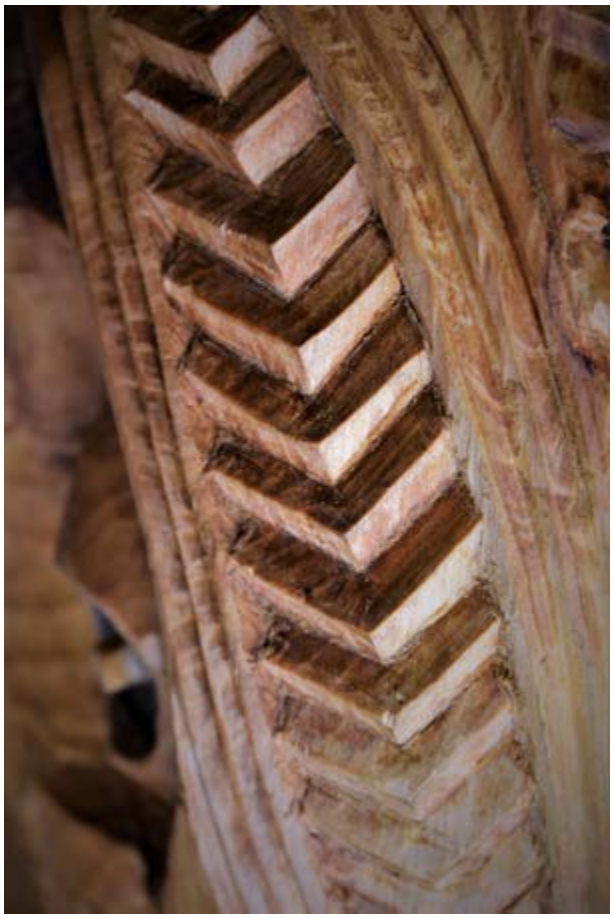
Tōtara is an iconic native timber species well suited to silviculture and sustainable management for multiple values, including timber production. Tōtara has remarkable natural attributes. These include easy seed collection and germination, tolerance of a wide range of sites and drought conditions, high survival rates, quick growth and the ability to naturally regenerate, even apparent resistance to some herbicides and livestock grazing. It is no wonder that it is starting to be viewed as something of a wonder-species with a significant role to play in our indigenous forestry aspirations.

Tōtara is also one of the most popular choices for planted native timber trees in new forests.

Planted tōtara forests will complement a significant resource of naturally regenerating tōtara forests developing on private land in several regions of the country. The cumulative scale and potential supply continuity of the combined natural and planted tōtara resource should encourage the development of a sustainable industry and a strong market for tōtara timber. The more planted the better – as far as timber value is concerned.

But planting a native forest is never just about timber, or any single value. It is always aspirational and regenerative. Tōtara has an important role to play in creating new native forests that provide the space for other life and values to grow and thrive.

And enjoyment can be part of that too. Enjoy creating a vision, enjoy the planning, and enjoy watching it grow.



Whakairo rākau tōtara - a work in progress by Mark Howard, Kaeo.

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PRUNING TŌTARA

PRUNING TŌTARA

Introduction – why prune tōtara?

Tōtara are capable of growing very tall with long, straight, and branch-free trunks (boles). So why do we prune? Is it even necessary? Before getting into the technical how-to details, this section will first discuss some of the more theoretical questions around the actual need, value, and role for pruning in managed tōtara forests.

The late indigenous silviculturist, Owen Lewis, liked to quote an overseas arboriculturist who provocatively stated something like: "Pruning should only be done with a stout stick" – conjuring up images of knocking off dead branches within a thick and dark wood. Of course, he was not recommending sticks as the most suitable tool, but rather putting pruning within the larger context of silvicultural management and making the point that other management factors such as stocking-rate, shade, and the timing of thinning etc., may make pruning unnecessary – or at least help minimise the task.

Pruning is only one way to influence the growth-form of a tree and should be considered as part of a suite of silvicultural management options and practices. Therefore, it is useful to understand why and when we should prune.

Timber as an objective?

Apart from minor incidental reasons to prune, such as to maintain access ways, visibility, or for aesthetics, pruning is mostly relevant to timber production. More specifically, it is a way to increase the potential value of the timber within a sawlog, by increasing the yield of branch/knot-free timber, called clearwood. Clearwood timber usually has a much stronger or wider market demand and commands a premium price. But such pruning is only relevant if your management objectives include maximising potential timber value from a tree or forest, and if the young tree's form is not naturally developing a branch-free bole. It also assumes that clearwood logs will be more valuable - come harvest time.

Pruning by forest management

Ideally, pruning to optimise potential timber quality and volume would not be necessary. In established natural forests, many tōtara develop tall branch-free boles without any pruning at all. Such trees grow up within a tall forest structure that encourages them to keep self-selecting a single, dominant leader, and to naturally shut down and abscise their redundant, shaded, lower branches, to produce tall, clean boles, and lightly branched top-logs. Yet, even in such tall forest environments, not all trees will develop a perfectly formed stem – at least not perfect to the eyes of a sawmiller. However, the aberrations are greatly exacerbated in naturally regenerated (second-growth) or plantation-grown stands because they lack a tall overhead canopy to 'draw-up' the young tōtara stems straight and true.

Tōtara is a light-demanding tree species and does not naturally have strong apical dominance (a natural growth habit characterised by a single dominant growing tip, or leader, even in open field conditions). Indeed, in open-grown situations, or in high light conditions, tōtara tend to branch heavily and develop large, spreading, and multi-leadered crowns. Many will do so from near ground level, others as soon as they get above any adjacent vegetation. If inter-planted with manuka this may be only a few metres high, or higher if inter-planted with naturally taller growing kanuka.

While it is impractical to avert or remedy all potential timber defects from the whole stem – at some point the stem will need to branch out into a spreading crown - it is possible to influence the form of the lower stem sections to improve the number, lengths, volume, and timber value, of the potential sawlogs. As far as possible, this should be done indirectly by managing the structure and density of the stand (e.g., by planting tōtara at high-stocking rates, or planting within a 'nurse' canopy of early successional hardwood species like manuka or kanuka or delaying thinning to retain some side competition from adjacent trees that also providing some shade on the lower stem etc.).

Pruning is very labour intensive and costly, and that effort is required well in advance of any potential return on that investment. It may not be a good economic investment. Therefore, any practical options to reduce the effort and cost of pruning makes sense.

"Pruning is very expensive – so, as far as possible, try to minimise the need for pruning by managing the forest structure."

Strategically then, it is wise to try and minimise the need for, or use of pruning, through management of the forest structure, wherever those options exist. Naturally, there are balances to find. Maintaining a higher stocking of trees and delaying thinning may reduce the need for pruning, but also reduces the growth rates of the individual trees.

Pruning a practical intervention

Even in highly stocked plantations, where heavy side-branching may be reduced, defects such forking and/or development of steeply-angled branches trying to compete with the main stem are still common. When the latter, sometimes referred to as 'spike-branches', are eventually out-competed and begin to naturally die-back, they can leave large unattractive knots in the timber, or even small pockets of deadwood or rot. Such defects, as with large knots, significantly devalue any timber recovered from such sections of log. Therefore, for many planted and naturally regenerating tōtara forests, pruning is a relevant and useful management option if timber production is an objective.

"While pruning can increase the timber value of the forest, the economic viability of pruning is not known".

Indeed, in sparsely stocked developing forests, without the advantages of an existing and tall forest structure, pruning may be the only practical option to manipulate the form of the future harvest trees. Fortunately, it can be very effective.

Pruning can even 'salvage' a situation. It is often possible to create a stem with clear potential to develop into a good-quality timber tree, where otherwise only a poorly formed tree with little or no sawlog volume at all would have developed. Even tōtara trees growing in open conditions can often be pruned to achieve a 4+m clear bole.

While pruning can create and add significant sawlog volume and value to your future forest. The economic viability of pruning operations is not known. Timing and technique are important factors along with site specific variables such as growth-rates, stocking, and practical harvest/extraction options etc.

Potential health issues

Pruning is an unnatural act to modify the form of individual trees to better fit to our management objectives. It is quite a severe intervention that often drastically reduces the amount of foliage (which is where the tree's energy is produced) and leaves open wounds on the tree trunk that can take years to heal over and potentially exposes the tree to entry of insects and pathogens. As with most attempts to 'correct' or 'improve' nature, it is probably not without some risk of making some ignorant presumptions or creating some surprises in the future. The milling of pruned logs in the future may yet reveal hidden issues resulting from past pruning such as pockets of rot, fungal attack/discolouration or insect damage, or long-term health effects that we are presently unaware of, or underestimate.

Notwithstanding that, field observations and silvicultural trials to date suggest that tōtara trees are very amenable to timely pruning and survive even severe pruning treatments. Observations to date do not indicate widespread or serious issues resulting from best practice pruning operations. In contrast, poor practices and extreme pruning that creates large wounds, may result in internal defects and localised discoloration of the timber.

Pruning only adds value if done well and before the individual stem reaches a certain diameter. This will be covered in detail further on, but it means there is a limited window of opportunity for pruning tōtara to enhance potential timber value; and pruning outside of that window is probably a waste of effort. Therefore, timing is a critical factor.

"Tōtara respond well to pruning - and survive even severe pruning treatments. But if pruning is not well targeted, well timed, and well executed, it could be a wasted effort – or worse, even damage the tree."

Summary

- Pruning can be an effective intervention to influence the form of young developing trees, increasing the volume and value of potentially recoverable logs and timber.
- There is only a limited time in the tree's development for pruning to be effective.
- Pruning is labour-intensive and costly. The economic viability of pruning is not known.
- While tōtara appear to survive and heal well from pruning wounds, any long-term ill-effects from large pruning wounds are unknown.
- Managing the structure of a forest to minimise the need for pruning is wise.
- If pruning is not well targeted, well timed, and well executed, it could be a wasted effort – or worse, damage the tree.

The rest of this chapter covers key concepts and practical details relevant to pruning tōtara trees.

Key concepts

Pruning tōtara is not as simple as pruning pine trees. There is not a single prescription or formula. It involves applying a complex mix of varying concepts, strategies, and approaches, and to trees that will often vary significantly in their individual characteristics and according to their location within a stand.

Farm-foresters experienced and skilled at pruning tree species such as blackwoods will find many parallels with pruning tōtara. They may find tōtara comparatively better behaved, with slower growth and less time pressure. However, those trying to manage sparsely stocked and highly variable naturally regenerated stands of tōtara, will find many complicated and confounding trees to deal with.

Some key concepts, that may help the pruner to make appropriate decisions in the field, include:

- Understanding DOS (Diameter Over Stubs)
- Form-pruning rather than straight 'lifts'
- 'Top-down and bottom-up, and tweak in-between' – a practical approach
- Sooner the better and little and often
- Select the best trees - and not too many!
- Consider each tree individually and within its immediate and its future context
- Flexibility rather than rigid prescriptions
- Prune with a realistic programme in mind

These concepts are applicable to both planted and naturally grown tōtara and are explained and discussed in more detail below.

DOS

DOS– Diameter over [pruned] stubs. This is a practical term that relates to one of the most critical concepts of pruning. It is essential for forest managers and field workers alike, to understand the purpose of this parameter (i.e., minimising the defect core, and ensuring sufficient recoverable clearwood, etc.). And to apply this in the field, to avoid wasting your time and effort unproductively pruning trees that should not be pruned or creating a timber defect where a green knot would have been preferrable.

DOS is a term that is comprehensively explained on other websites (e.g., Best Practice Guidelines for Silvicultural Pruning 2005 (pages 8 & 10), and on the NZFFA website (see Useful links). If unfamiliar with DOS please look it up before reading on.

"Understanding DOS is essential – It will help select the individual trees to prune and the appropriate timing of pruning operations and help decide which branches to prune at each visit."

See section 7, page 25, and video (see Useful links) for recommendations on maximum DOS figures and how to apply in the field.

A diameter tape is handy to check stem diameter and the DOS.

Form-pruning

This idea prioritises pruning decisions and actions that will result in the development of a single, tall, straight tree bole, rather than just pruning all branches from the bottom up, sequentially in stages, often called lifts. Form-pruning is important to maximise log length. In contrast, pruning tōtara in a series of straight-lifts (as is done with pine trees), especially trees growing in relatively open conditions, will tend to promote heavy branching and multiple leaders in the crown – resulting in short-boled trees with poor top logs – or none at all with useable timber.

Form-pruning targets major potential defects such forking of the main stem, steeply angled branches that may compete with the main leader, and heavy branches that may create large knots that would significantly down-grade the timber. It does not target small branches, especially not those that come out at near horizontal angles from the trunk – as many of these will not develop into large branches and will either naturally die-back or stay as small-diameter branches once shaded as the tree grows in height. Small tight knots in timber are acceptable for structural and dressing grade timber. Keep in mind that not all timber has to be knot-free. And 'green knots' (i.e., knots from live branches) are preferrable to having pruning stub defects in the timber.

Form-pruning aims to maximise potential merchantable log length and sawlog volume rather than just creating clearwood butt logs. Trees in developing young forests will tend to have short butt logs and heavily branched poor-quality top logs – or no merchantable top log. Therefore, form-pruning is important to try and raise the mean bole-length or height of the developing forest. This will significantly increase the total merchantable log volume within the forest at time of harvest.

Form-pruning stems <10-12 cm diameter should target forks, competing leaders, steeply angled, and heavy branches. Small branches, especially ones that come out near horizontally from the stem, can be left to help the tree recover and can be removed later before the target maximum DOS is exceeded.

Two severe form-prunings of this tree up to 2010 (left) created a single straight trunk, and once the crown of the tree had recovered, it was clear-pruned to 4.5m before the maximum DOS exceeded 20cm – as shown 11 years later in 2021 (right), with the same 2.4m ladder for scale.

Top-down and bottom-up, and tweak in-between.

This phrase tries to encapsulate a hierarchy or sequence of pruning priorities and actions. See photos below and **Pruning Tōtara for Timber** video (see Useful links). It hints at the need to consider and apply multiple strategies to achieve a balanced outcome to suit the individual tree. It also tries to avert the problem of one action causing an undesirable growth response somewhere else (e.g., a bottom-up lift encouraging heavy branching and competing leaders in the remaining crown resulting in only a short bole).

Pruning may need to apply a mix of actions variously weighted to suit the individual tree. This will often be a mix of form-pruning that works from 'the top down' (or as high up as is practicable), then a bottom-up clearwood 'lift' executed just in time to avoid an excessive DOS, and then some preventative surgery on the heavy and steeply angled residual branches that are likely to cause problems in future. The latter can be done by removing full branches, or alternatively, to keep more green-crown (foliage), just by cutting the tips off potential problem branches to discourage their continued vigorous growth, known as 'tipping'.

The overall severity of the pruning is usually limited only by concerns to retain sufficient green-crown for tree health, recovery, and maintenance of its growth rates. Do not remove more than two-thirds of the foliage. Many guides recommend not more than one-third, and that is ideal, but necessitates more frequent pruning visits. And some trees simply require more off to salvage the situation.

The pole-sized tōtara tree (bottom left), had previously had some basic form-pruning when it was a sapling. Nevertheless, growing in open conditions it had once again developed several competing leaders and many steeply-angled heavy branches, and with a DBH of 17cm. The image (bottom right), shows the same tree (from a different angle) following pruning which addressed the top of the tree first, then the steeply-angled branches, then a bottom up 'lift' to ensure the DOS was kept below 20cm and then some of the remaining heavy branches were 'tipped' (shortened by about one third), to reduce their vigour, but retain sufficient foliage. This utilised the 'top down, bottom up, and tweak in the middle' approach. Growth in the leader will be promoted. And as the tree recovers, conventional bottom-up lifts will easily create a 6m clear-pruned bole with a maximum DOS well less than 20cm.

Sooner the better and little and often.

Small young tōtara respond well to form-pruning. Smaller pruning wounds heal faster and with less adverse effects on tree growth. It is better to avert the need for large pruning wounds in the future by nipping potential problems in the bud as soon as they can be identified.

Form-pruning can start with secateurs on small saplings and should continue with loppers influencing the form of the top of the developing pole/tree as far as can be safely reached from ladders.

Useful illustrations of form-pruning and advice is provided in the book: **Blackwood – a Handbook for growers and users,** by Ian Nicholas and Ian Brown, 2002, (pages 50-60). It is available free to view and download on from the NZFFA website (see Useful links).

Tōtara often have multiple young branches contending to be the main leader. Helping the sapling or tree make an early choice often results in rapid formation of another metre or so of trunk height. This has sometimes been called 'leader-training' (see Usefull links). A few strategic snips at an indecisive growing tuft and the first 3 to 4 metres of bole can often be set in train. 'Tipping' branches that could develop into problems later on, can reduce their vigour and encourage the growth into your selected leader.

"Leader-training at the saplings stage can be very effective form-pruning".

Don't be too concerned about floppy, arched-over top leaders. They will straighten up by themselves as the tree grows.

Early intervention allows for a focus on leader-training and form-pruning first, with plenty of time to follow-up later with bottom-up lifts to remove side branches before the DOS becomes too large.

Frequent small interventions are better than a severe pruning that removes a greater proportion of the foliage. More frequently staged pruning enables much better manipulation of the tree's form and lessens the risk of significantly slowing the tree's growth-rate or vigour. However, that risk needs to be weighed against the risk of not getting back in time to do the necessary further pruning and the missing the windows of opportunity to control the DOS.

It can be difficult to decide how much to take off at each visit. A realistic silvicultural management plan is required to inform such pruning decisions. Be aware that the stem diameter of vigorous trees may increase by around 6mm – 1cm each year. This potential growth rate should be kept in mind when deciding which branches to remove to keep the DOS below your target.

Form-pruning wounds on vigorous saplings heal very quickly. There are two hardly noticeable pruning scars on the stem above left, and one on the stem above right.

Select the best trees - and not too many!

How many to prune?

The ideal final crop stocking rate of any forestry species is often a matter of debate between foresters. And unfortunately, there is presently little tōtara-specific research or case studies to inform the topic for our purposes. Ideas on prospective markets, log value and end uses will affect the target harvest diameters, which in turn effect stocking rates. Moreover, growth rates and the economics of carrying the costs of planting, pruning, and thinning until harvest time, will also shape forest management prescriptions, such as how many trees to prune. And of course, there will be significant differences between plantation clear-fell regimes and single-stem selection systems in naturally regenerated stands.

For plantation-grown tōtara a thinning schedule developed by the Northland Tōtara Working Group (refer to the chapter on thinning) suggests pruning up to a maximum final stocking of 400 fully pruned trees per hectare. This seeks to maximise sawlog stocking and volume productivity. In contrast, European close to nature forestry systems that use single-stem selection approaches, typically only prune up to around 150 trees per hectare. The long rotation lengths put the focus on creating and maintaining high-value, large-diameter trees, and minimising costly silvicultural interventions.

Table: 1 (in Section: 7) sets out a guide on the maximum final number of pruned trees in plantation situations, for various target harvest diameters and DOS values. Up to 400 pruned trees/ha is a target for optimal performance from plantations.

However, finishing up with around 300 well-pruned trees/ha will still be an excellent outcome for most forests. It allows more leeway with maximum DOS, develops plenty of potential crop trees, and retains flexibility for future forest management options, and avoids pruning far too many trees.

"400 pruned trees/ha with a maximum DOS of 16.5cm is a target for optimal performance."

"However, 300 pruned trees/ha with a 20cm maximum DOS, would still be an excellent outcome for most forests."

However, in less homogenous natural stands, it may be hard to find so many good potential crop trees to prune. The forest owner should not be discouraged. Forests with a lower stocking of potential harvest trees can still be wonderful native forests with some high-value timber production potential. Indeed, a more diverse and natural, mixed-species, native forest will be the objective of many forest owners.

Tree selection - vigour or form?

Selecting the right trees to prune is critical. Only the potential harvest trees should be pruned. These should be vigorous, well-formed, and well-spaced.

European forestry practices usually place priority on vigour (expressed as crown dominance) as the selection criterion, then form, and then spacing. However, particularly, in naturally regenerated tōtara forests, the trees with the most dominant crowns and vigour, often have the poorest form. Typically, they were established first and developed large crowns with poor trunk form in open conditions. Often it is later cohorts, growing in gaps and competing with each other, that have the best form. Selecting these better-formed subdominant or even supressed trees to prune in such situations is often the only option. This will need to be followed by a thinning operation to prevent the pruned trees being dominated by adjacent trees.

In plantations, tree selection may not be so clear, especially where a vigorous tree could be 'salvaged' by pruning to develop a good butt log. The question is whether any adjacent and better-formed subdominant tree will pick-up its growth-rate if given the chance? Again, we lack specific research to answer that question at present.

Silvicultural trials by the Northland Tōtara Working Group, indicate that the mean growth rate of the residual trees increases following a thinning intervention. However, that research did not compare the individual growth-rate responses of dominant, sub-dominant and supressed trees. The forest manager will often need to decide on whether vigour or form should be given priority when selecting tōtara trees to prune. Spreading the risk may be wise at this stage.

Specific defects that should preclude a tree from selection are covered in Section: 7 - General Specifications and Frequently Asked Questions.

Consider each tree individually and within its immediate and future context.

Pruning should be considered part of comprehensive silviculture applied at a micro-spatial level. Every visit to a tree is an opportunity to address both obvious problems and to avert foreseeable issues. The tree's form will have a direct relationship to its immediate context. For example, in some cases, pruning of the surrounding vegetation may also be useful to create an overhead light-gap or to free the tree from branches or fronds from neighbouring trees or ferns that are rubbing against the stem and/or damaging the growing leader (often a cause of forking). Or localised weed control or releasing from competition may be a timely additional task for hand, loppers and pruning saw - while the pruner is there.

"Tree form has a relationship to its immediate surroundings – present and future".

Flexibility rather than rigid prescriptions.

Following on from the point above, the most appropriate pruning intervention may vary from tree to tree. In contrast to pine plantations, it is unlikely that basic pruning prescriptions such as pruning to a specified height above ground or up to a minimum diameter of the trunk, will result in the best outcome. Spacing in natural stands will also be uneven. Therefore, the pruner of tōtara needs to be aware of a range pruning strategies and options and have the flexibility to make the decisions on what approaches to apply and to what extent, on an individual tree basis.

In many instances a variously weighted mix of approaches (such as the 'top-down, bottom-up, and tweak in-between' approach) will be appropriate. But in more homogenous natural pole-stands or dense plantations, more of a conventional bottom-up lift approach may be more applicable. And in sparsely stocked areas, severe corrective tree surgery may be necessary to salvage some merchantable sawlog potential from a poor tree where no other candidates are present.

"The pruner needs to assess each tree individually and apply a flexible mix of approaches and actions".

Prune with a realistic programme in mind.

Pruning is hard work, time consuming, and a significant early cost. Financial and/or time restraints may affect pruning actions. Also, the opportunities to usefully prune a tree or forest, are limited by parameters such as trunk diameter, branch size and tree form. Furthermore, there may be practical limitations such as access difficulties due to weeds such as blackberry or gorse. Then there are difficult decisions to make, such as how much to prune off at one time? Moreover, only completing a partial pruning (e.g., not achieving a useful clear bole length, or not maintaining a tight DOS) may mean previous pruning efforts are wasted. These matters highlight the need for pruning to be part a realistic silvicultural programme or plan.

Strategic match to site and resources

The form-quality and total area of the forest, its accessibility, and the forest owner's capacity and resources to either do the work themselves or pay for a contractor, are all significant factors that will affect pruning operations. With severely limited time or resources pruning efforts should be directed to the best existing trees spread over the most accessible areas of the forest. If greater investment is possible, then intensive silviculture that aims to develop a forest that is fully stocked with potential harvest trees, even with potential for production-thinning, could be considered. However, the reality is that there is almost no limit to the amount of silvicultural effort that could be applied to a developing forest. Therefore, it is useful to have some framework or plan that helps limit the work and decide how many trees to prune and how severely to prune them.

Know when you likely to return

For many native forest owners, pruning may be done in their spare-time on an opportunistic basis – e.g., when the time is available, and the mood takes them. However, even on that basis, it is useful to have an idea on when a return visit to that tree or part of the forest is realistic. Such a rough programme of intent will help make critical decisions such as how much to take off in one go. For instance, if the expectation is that a repeat visit is unlikely within the next 10 years, then it may be wise to choose between form-pruning to create a tall bole, or alternatively, at least securing a shorter clearwood butt log in a single pruning action.

In contrast, if more frequent periodic visits are anticipated, then a more restrained, staged, and strategic manipulation of the tree form, to develop a tall and clear-pruned bole could be applied.

Pruning every 3-5 years is ideal.

"It is easy to underestimate the time and effort involved with intensive pruning and to overestimate the likely enthusiasm for it when the time comes".

Predict diameter growth to manage DOS

Managing the maximum target DOS is usually the key driver for any pruning programme. To assist with this, knowing, or predicting, the growth rates of your vigorous trees can be a useful guide. In northern regions, on good growing sites, the diameter of the trunks of the vigorous tōtara may be growing around 6mm to 10mm diameter each year.

This can be used as guide on when a return visit will be necessary. For example, if the target maximum DOS is 15cm, but monitoring shows a mean unpruned trunk diameter of 10cm, then a pruning operation should be planned within 5 years, before the stem diameter gets too close to 15cm. But if a 20cm maximum DOS is targeted, then the next prune should be scheduled within 10years.

Monitoring the growth rate of your forest will help guide pruning to manage DOS.

Suggested pruning schedule for tōtara plantations

Ideally pruning is started early and done 'little and often' and as much as necessary. DOS is the critical driver of pruning programmes. However, many people will want guidance on what the minimum requirements might be. Of course, that will depend on the site and many other factors. Nevertheless, the following is an example of a practical pruning schedule based on good growth rates and targeting 400 pruned trees with a 50cm target harvest diameter.

First Prune

When: Approx. age 5-8 years, mean DBH 3-5cm, height around 1.5 - 2.5m.

What: Leader-training and basic form-pruning only.

Amount: Up to 600 stems/ha (4metres average spacing).

Second Prune

When: Approx. age 12-15years, mean DBH* 9-12cm, height around 4-5m.

What: Leader-training and form-pruning, and clear-prune from ground-up only where stem dia. exceeds 12cm. Target max. DOS 16.5cm**.

Amount: Up to 550 stems/ha (around 4.2m average spacing between pruned trees).

Third Prune (3-5 years later)

When: Approx. age 15-25, mean DBH* 13-15cm, height around 5-8m.

What: Form-pruning to secure a straight trunk (targeting a 4.5-6.5m potential butt log) and clear-prune only where stem dia. exceeds 12cm. Target max. DOS 16.5cm**.

Amount: Up to a maximum of 400 stems/ha.

Fourth Prune (final)

When: Approx. age 20-35, mean DBH* <20cm, height around 9-12m.

What: Clear prune to secure a clearwood butt log (target 4.5-6.5m pruned height). Max. DOS 16.5cm**.

Amount: Up to a maximum of 400 stems/ha if the max. DOS is kept below 16.5cm. Otherwise, refer to Table 3 (page 81) for recommended maximum final stocking of pruned trees according to maximum DOS values.

*Mean DBH of vigorous/dominant potential future harvest trees only – ignore the suppressed trees.

**Target max. DOS of 16.5cm is for a target harvest diameter of 50cm DBH. If it is impractical to keep max. DOS below 16.5cm, record the max DOS value in the silvicultural records. Note - It will change the target harvest diameter and the recommended final stocking of pruned trees (See Table 3, page 81).

Equipment

This section lists an array of equipment and tools useful for pruning tōtara. The list varies slightly from the standard equipment used in plantation forestry. The main differences are that pruning ladders need to be of a type that does not damage/bruise the bark of the tree. Additional 'steps' (e.g., Timbersaws' Unistep) are not recommended due to the risk of bark damage. Jack saws (e.g., Timbersaws' Bushmate) are not as practical or versatile as arborist-style pruning saws (e.g., Silky Saws) due to the bulkiness of their frames. Epicormic knives are not necessary because epicormic shoots are not so often encountered that a dedicated tool is warranted when a saw or loppers will make do.

Health and safety

All tools and equipment should be bought from a reputable forestry supplier and all products should be intended and certified for commercial forestry use. The use and maintenance of all tools and equipment should follow the current best practice Safety and Health standards or advice for silviculture as is set out in relevant industry guidelines, and Approved Codes of Practice documents (see Useful links). The matters of health and safety are not covered thoroughly in this manual – the reader shall be responsible to inform themselves on the most up-to-date advice.

Pruning ladders should be of a type that does not damage the bark of the tree with the 'V' shape structure at the working platform.

A webbing belt can keep the hard metal of the 'V' from contacting the bark.

Minimum pruning tools and equipment

Personal preferences and, for plantations, the stage and height of forest growth, will affect the range of tools required. But for mixed-age, mixed-size, natural regeneration and continuous cover forestry, the following list is a suggested minimum range of tools.

Minimum Tools:

- ☐ **Pruning loppers**
  e.g., Timbersaws Prun-off Lopper, plus holster
- ☐ **Pruning saw - arborist style**
  e.g., Silky Saw, model: Gomtaro, with sheath
- ☐ **Eye protection**
  either safety glasses or mesh goggles
- ☐ **Pruning ladder 2.2 – 2.4m**
  enables pruning up to around 4.3- 4.5m (i.e., a 4.2m log)
- ☐ **Pruning ladder 4.0 -4.2m**
  if high pruning is intended (4.3 – 6.5m)
- ☐ **Forestry pruning harness**
  fall Prevention Device, if high pruning - (e.g., Timbersaws Body-belt 1.1m chain lanyard)
- ☐ **Diameter tape**
  to apply/check/record DOS

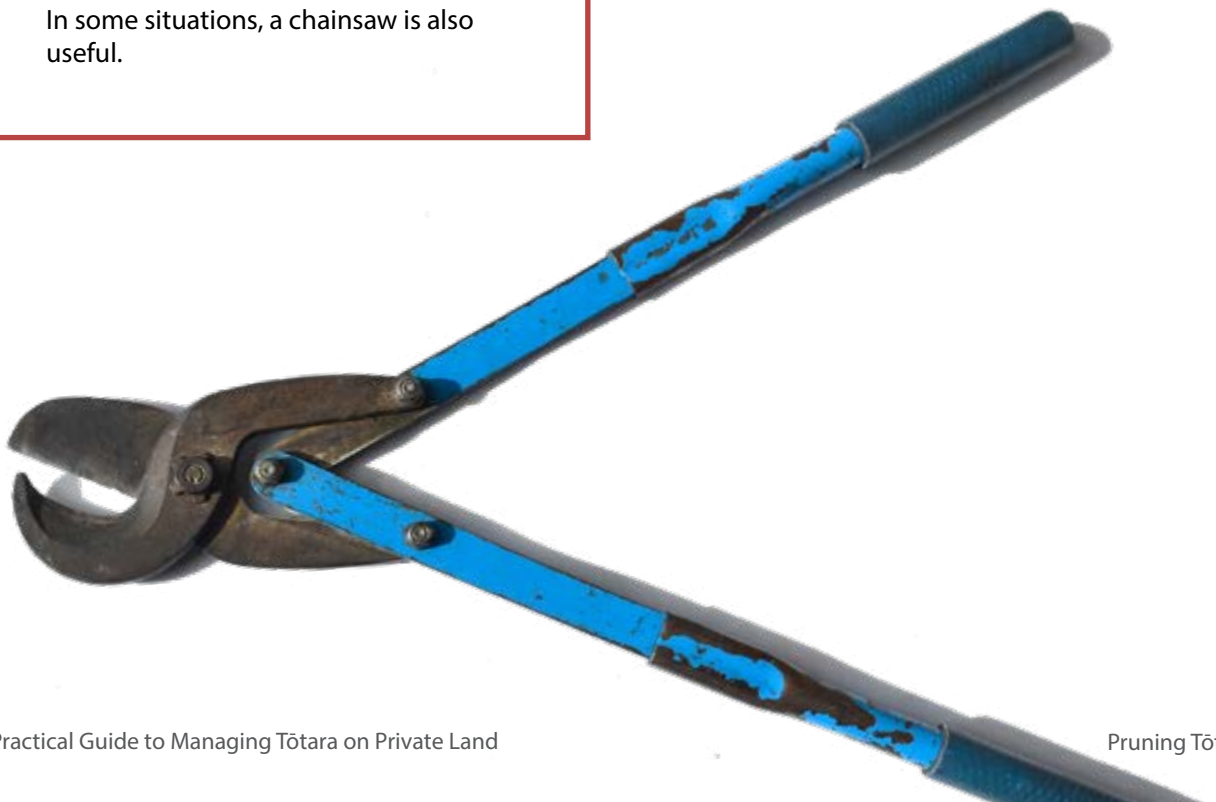
In some situations, a chainsaw is also useful.

Comments on using specific tools

General safety, user instructions, Approved Codes of Practice, and standard maintenance etc. is not covered here. Rather a selection of comments relevant to the use of specific tools for the pruning of tōtara are offered below.

Loppers

- Loppers are quick and energy efficient pruning tools.
- They are designed to be used with only one side of the lopper (the side with the flat head of the bolt between the opposing jaws) positioned against the trunk. Do not use loppers with the nut side against the trunk as this will damage the bark at the collar of the branch stub.
- If a branch is too large for the lopper's jaws to easily grab, then use the pruning saw instead.
- Shortening a heavy branch before the final pruning cut can help ensure a smoother cut face results.
- Loppers do not leave as smooth a stub cut as a saw.



Pruning saws

- Pruning saws are slower than loppers, but can leave a smoother pruned stub face with may have health advantages for the tree.
- Arborists' pruning saws usually enable more accurate cutting (i.e., close to the branch collar) without leaving 'coat-hanger' branch stubs.
- Undercutting of the bark around the root collar of ALL live branches is essential to avoid tearing of the bark down the stem as the cut branch drops – which has serious health implications for tree. **Tōtara branches are prone to bark tearing! Always generously undercut all branches**!
- It is important to shorten heavy branches to avoid 'pull-wood' holes in the pruned stub face. Use a three-step cutting process; undercut at branch collar, shorten the branch, final pruning cut. When shortening, leave a 250-450mm branch stub and use an offset double-cut to avoid tearing the bark back to the trunk. (See demonstration in video)
- Sawdust in the eyes can be a problem when sawing branches above shoulder level. Eye protection should be used to alleviate this nuisance.

Pole-pruners (non-motorised)

- Pole-pruners may avoid the need for ladders or enable higher pruned heights from ground level.
- However, pole-pruners have less cutting accuracy than handsaws or loppers and it may be more difficult to execute the bark-tear prevention cuts well (i.e., undercutting).
- If using a pole-pruner the same advice as with handsaws applies concerning the need for undercutting and the shortening of heavy branches to prevent bark-tears and pull-wood.
- Motorised pole-pruners present a high risk of leaving long branch stubs ('coat hangers') or damaging the bark at the root collar or at the tree trunk.

Chainsaws

- Chainsaws are useful for severe corrective tree surgery such as removing large forks and for releasing tōtara from the adverse effects of adjacent trees and branches (e.g., branches that are interfering with the crown or rubbing against the main stem etc.).
- As with non-motorised handsaw procedures, preparatory undercuts should be made to reduce risk of bark tearing and felling cuts should all be executed further out or above where the final cut will be made (i.e., to leave a short stub that can be removed with a final tidy-up pruning cut).
- If pruning off the ground, top-handled chainsaws must be fitted with a bar guard (e.g., Timbersaws chainsaw pruning guard). N.B. - top-handled chainsaws should not be used from the ground.
- Chainsaw pruning presents a higher risk of damaging the bark of the tree around the branch collar, than non-motorised pruning tools.
- For the removal of large double leaders, a standard chainsaw without a bar guard may be necessary and to avoid damaging the residual stem, the back cut, or felling cut, may need to be angled down steeply, just off vertical, to create the hinge.
- To encourage the unwanted fork or stem to fall cleanly, a Vee scarf or a Humboldt scarf may have advantages over a standard scarf.
- The finished cut faces of the pruned stub should be angled steeply to shed water.
- Final pruning cut faces should be done with a push-stroke (i.e., using the top of chainsaw bar), because that enables good vision and control and leaves a smoother finished cut surface.
- Chainsaws can easily damage the bark collar or bark of trees and should not be used for pruning branches that can be easily done with a handsaw.
- **If a tree requires pruning with a chainsaw, it questionable whether it should be pruned at all!**

bark tearing

'pull-wood' hole

Pruning basics

This section illustrates basic technical details relevant to pruning cuts on tōtara trees.

Loppers are quick and efficient and suitable for small branches, but the cut faces of pruning stubs from loppers are never quite as smooth as can be achieved using hand saws.

Clean pruning stubs done with a hand saw, near vertical cut faces, close to the trunk, but outside the branch collar. Undercutting, and then shortening the branch to take the weight off before the final cut, has avoided any pull-wood or bark tears.

Large pruning wounds need to have smooth, clean cut faces, and be steeply angled to shed water and minimise chances of disease entry or rot before they seal over.

'Pull-wood' on the pruned stub face is caused by breakage as the branch falls. This increases the risk of pathogens entering the pruning wound. Shortening the branch first - but only after undercutting at the branch collar – relieves the weight and avoids this defect. This makes pruning with a saw a 3-step process (i.e., undercut, shorten, final pruning cut).

Tōtara are prone to bark tears when pruning branches with a saw. ALWAYS generously undercut the bark, and shorten heavy branches, to prevent tearing the bark and or breakages, or pulling wood out of the pruning stub face.

Tōtara can heal over large pruning wounds (e.g., left above in 2010 and right above is the same tree in 2021). However, the advantages of removing large forks and large branches need to be weighed against the risk of creating internal defects (See next two pages).

An 11cm diameter pruning stub in 2010 (left above), had been completely occluded within the trunk by 2021 (right above). However, excessive DOS, discolouration and a pocket of unsound wood have resulted at this part of the log on the side that sustained the pruning wound (see right).

A small pocket of slightly spongey wood is present on part of the pruned stub face (beneath the dark area of encased bark), and a brown discolouration of the otherwise physically sound wood beneath the pruned stub is apparent. Some discolouration of the pith of the remaining stem has also occurred. This has created a wood defect at this part of the log. Any long-term health effects on the tree or on timber quality, from such pruning wounds are unknown.

This pole-sized tōtara tree growing in open conditions (left above) had had some form-pruning in the past, but then could be pruned up to 4.5m in a conventional bottom-up lift, before the DOS became too large (right above: tree in centre view, midground, - is same tree but different viewing angle).

Tōtara trunks can easily grow right over the stubs of large forks that have been removed.

However, early indications are that rot in large, pruning wounds may sometimes result in defects at the base of the remaining trunk (See above right).

A pocket of rot in the pruned stub where a large fork was removed has resulted in brown discoloured wood within the residual trunk. It is not known whether this would have been successfully contained and 'compartmentalised' by the tree's defences, or whether it would have spread significantly further up and within the crop stem (see below).

A long section ripped through the stump reveals rot and discolouration resulting from the removal of a large fork. In contrast, on the right-hand side of the tree, a pruned stub from a small branch has been occluded over without causing any apparent ill effects (see below).

Small pruning stubs appear to heal over without causing any significant ill-health to the tree.

Pruning implementation – A checklist guide

A checklist style 'quick guide' for pruning is set out below.

Planning and preparation:

- ☐ Have a plan or idea when you will likely make a return visit (e.g., 3yrs, 5yrs, 10yrs), to guide how much to prune each tree at this visit. (N.B. – 3-5 yrs. is ideal)
- ☐ Have a final pruned stocking rate in mind (i.e., how many trees to prune per hectare – so you don't prune too many) – N.B. – this will depend on stand stocking, silvicultural system and target harvest diameters – See Table 3, page 81). It will range up to 400 stems/ha for plantations and tōtara dominant stands, but should be much less for mixed species, natural stands.
- ☐ Convert the target stocking rate to average spacing (distance between pruned trees), as a guide for practical application (this will vary according to mean tree size and stand development and likely be at least 5.0m between pruned trees – See Table 3, page 81).
- ☐ Have a target maximum DOS in mind (based on an expected minimum harvest diameter (- e.g., 16.5cm max. DOS for 50cm min target harvest diameter, or 20cm max. DOS for 60cm target harvest diameter). And take a diameter tape measure with you when pruning!

Assessing the tree:

- ☐ Select a potential crop tree, confirming that the tree has the following:
  - ☐ Good potential form, health, and vigour, and no defects (e.g., spiral grain etc.)
  - ☐ Its immediate surroundings are suitable to maintain good future growth – or can be managed to ensure continued vigour and crown development.
  - ☐ Its diameter is less than the intended maximum DOS.
  - ☐ There are no better trees in the immediate vicinity.
- ☐ Prioritise the branches to prune according to the following guide:
  - ☐ Identify and plan leader-training and form-pruning to maximise the height of a single stem starting from the top of the tree, or as high as is safe and practical to reach, and removing any forks and competing leaders, and working down the stem to remove (or tip) the steeply-angled and large-diameter branches.
  - ☐ Remove all lower branches as a bottom-up 'clear lift' where the diameter of the tree trunk is close to (within 3-4cm of) maximum DOS.
  - ☐ Estimate the future growth of the tree until the next likely visit (using a rate of 6-10mm annual diameter increase of the trunk) and remove branches where the trunk growth might exceed the specified maximum DOS in that time, and either remove or tip (shorten) heavy branches that are likely to exceed 45mm in diameter before the next pruning visit.
  - ☐ Remove the minimum amount of foliage to achieve the above. Do not remove more than two-thirds of the tree's foliage in one pruning. (N.B. – ideally limit removal to one third of the tree's foliage if possible).
- ☐ Assess and plan any actions needed around the tree such as:
  - ☐ Thinning or pruning of adjacent trees or interfering branches to ensure an overhead light gap and room for canopy development (to maintain vigour and growth rates) but also maintain some side shade (to encourage good form development).
  - ☐ Weed control around the tree– especially control of climbing vines (including the native Muehlenbeckia australis), both on the ground and in the surrounding trees.

Pruning practice

- ☐ Apply best practice pruning techniques, including:
  - ☐ **Ensure** the 'V' of the ladder does not damage the bark of the tree.
  - ☐ **ALWAYS** prune close to the stem, but outside of, and without damaging, the branch collar (i.e., where the bark wrinkles at base of the branch), and without leaving protruding branch stubs ('Coat hangers').
  - ☐ **NEVER** place loppers with the locking nut side against the tree.
  - ☐ **ALWAYS** generously undercut branches when using a pruning saw, to avoid bark tears.
  - ☐ **ALWAYS** shorten heavy branches before final pruning cut to avoid pull-wood (i.e., a 3 step process – undercut, shorten, prune).
  - ☐ **Minimise or avoid** pruning branches >45mm in diameter.
  - ☐ When pruning forks and large branches always leave steeply-angled final pruning cuts that shed water.
  - ☐ **DO NOT** prune trees that will have an excessive DOS.
  - ☐ Remove all epicormic shoots

Record keeping

- ☐ If practical, record silvicultural activities (e.g., map areas, note dates, max. DOS, mean pruned height, pruned tree numbers (stocking rate), etc.)
- ☐ Schedule the next pruning visit in 3-5 yrs.
- ☐ Consider surveying for Pruned Stand Certification (for large commercial timber plantations).

General pruning specifications for tōtara – and matters of choice

Frequently Asked Questions

The following section discusses some the common parameters relating to pruning choices and decisions to make.

Q- Is there a minimum pruned log length?

The short answer is no. But 2.7m is suggested as a practical minimum length.

While longer pruned butt logs (4.2m+) are likely to have greater market demand – because they have more possible end use applications and are more efficient to process, shorter pruned logs still have useful clearwood timber volume. Technology, such as end-matching for tongue and groove profiles, glue-laminating and finger-jointing etc. may help enable short timber lengths to be effectively used. Who can predict the future technological, processing, and market requirements concerning a minimum log length? Carvers may also find short log lengths suitable for some applications. So how short is too short? That is only answered by what we consider is practical and economic now or in the future.

John Wardle in his Woodside forest applies a minimum of 3.3m log length for his black beech. That length suits the characteristics of the forest, practical extraction, and the processing equipment he uses. If the logs are to be transported to a mill, then the trucking company may stipulate a minimum log length to fit safely between the bolsters. This may be 3.1m, otherwise short logs need to be cradled between longer log lengths. However, the use of on-site portable sawmills would remove any such transport restraints.

In the context of continuous cover forestry and silviculture that includes production thinning, it may be useful to recover a short log from a poor tree that would otherwise only be thinned to waste. It adds to the forest's productivity. If the tree has a big green crown, then short butt logs often put-on log diameter faster and reach targeted minimum harvest diameters more quickly. They also have high timber volume recovery rates due to lessened effect of natural log taper over the length.

Potential merchantable log length will be affected by the characteristics of the forest, such as stocking rate, topography, growth-rates and individual tree locations. For example, it may be unrealistic to expect to prune a long log section from a tree growing on an exposed ridge, or in open conditions.

But if we have to offer a figure, then currently, around 2.7 metres is probably a minimum pruned height. It allows for the generous docking and processing of finished timber to furnish 2.4m minimum lengths. However, for most tōtara forests, a target pruned height of 4.5m+ above the ground is a practical goal. This length strikes a nice balance between limiting the negative effects of log taper on sawn-timber recovery percentages and yet providing a common industry standard for medium length finished products at 4.2m long. Nevertheless, if a pruned height of 4.5m cannot be attained then a shorter merchantable log may still be 100% better than no merchantable log.

"For most tōtara forests, a target pruned height of 4.5m+ above the ground is a practical goal."

Q- How high to prune?

As high as you can and the tree's form permits! But generally, a good target pruning height above the ground is to accept a flexible range between 4.5 and 6.5m, determined by the tree's form attributes.

Often there is a point where such severe form-pruning would be required to continue increasing the pruned height that it is better to just accept the practical length that the tree itself determines.

Tōtara are capable of growing very tall and developing tall boles often with 8-14m of total combined length of sawlogs. In some situations, pole-sized trees in highly stocked stands will naturally have good form and be shedding their shaded lower branches. Sometimes the opportunity to prune to 8m or more will exist. However, in most cases influencing the quality of the logs above 6.5m is more about managing the forest's structure (e.g., stand stocking and timing of thinning etc.) than by ultra-high pruning. Even if the tree forks or branches heavily above a short, pruned butt log, often merchantable top logs can form in the stem sections above such defects.

Ultimately, the pruner should aim to maximise the potential pruned log length. However, in continuous cover forestry contexts this should also be thought of in relation to a harvest being used as a production thinning opportunity. The shorter-boled trees are likely to harvested first, often leaving thinner but taller-boled adjacent trees as the residual forest or creating gaps for new regeneration that can be managed to have better form. In this way, over time, and through selective harvests, the overall canopy height and mean bole-length of the developing forest could be increased. It is difficult to develop trees with tall clear boles, from a young developing forest by pruning efforts alone.

In some natural pole stands a 4.5 – 6.5+m clear pruned height can be done in one single pruning lift. Some trees would have the potential to chase a 9m pruned height.

Q- How much to take off?

Recommendations vary from not more than one-third, to not more than half of the green foliage or crown – although vigorous trees will survive having two-thirds to three-quarters of their foliage removed.

The practical answer depends on several variables, such as what form-pruning is required, and when you expect to be able to return to prune again, and how the DOS values will be effectively managed. Pruning at not more than three-to-five-year intervals is recommended. But if a timely return visit is doubtful, then it may be wise to prune to best effect assuming a one-off intervention.

Experience shows that tōtara survive severe pruning – even 'lion's tailing' – where only a tuft of foliage is left on a tall, clear-pruned stem. But that can reduce their rate of growth for several years. This is logical since the foliage is where their energy is produced, and so it is reasonable to assume that a drastic reduction in foliage is likely to reduce a tree's vigour and possibly also slow the healing of pruning wounds and reduce its resistance to pathogens. However, the latter assumptions are supposition in relation tōtara, but such effects have been observed in other tree species. And severe pruning encourages epicormic growths from the trunk.

Q- What is the maximum DOS?

Ideally the DOS should be kept as low as possible (e.g., <15cm). But for plantation tōtara forests an ideal target maximum DOS is below 16.5cm. However, a maximum DOS of up to 20cm may be more realistic in many forests - especially in naturally regenerated forests.

There is an important relationship between the target harvest diameter of a tree and its maximum DOS. The DOS should not be more than one third of the target harvest diameter. For example, if the target harvest diameter is 45cm, then the DOS should be kept less than 15cm. That means the tree stem should be well less than 15cm thick at the time of pruning. Another way of looking at it is to realise that if the tree has a DOS of 20cm at breast height, then the target harvest diameter of that tree will then need to be >60cm DBH. But if that 20cm DOS was high up on the tree's stem near the top of the log length, i.e., at the small end diameter (SED) of the log, then the SED of the log should be around 60cm before that tree is harvested. That may require the tree having a DBH of >70+cm.

Earlier harvest opportunities dramatically affect the financial economics of forestry. This incentivises management to minimise DOS and thin the stands to quickly reach harvest size.

A cross-sectional view of a tōtara log showing a pruned branch stub (lower left) at recommended maximum DOS relative to the harvested diameter (i.e., in this case, a DOS of around 15cm and log diameter around 45cm.

N.B. – a Pin knot has formed (upper right) in what should have been Clears Grade timber. This is probably the result of an epicormic shoot developing on the stem. Such Pin Knots are acceptable in Premium Grade timber (under NZS 3631:1988), but not in Clears Grade. This highlights the importance of a return visit to remove epicormic shoots.

Pruned branch stubs are sealed when the tree grows (occludes) over them. However, a structural defect in the timber remains between the face of the pruned branch stub (left) and the sealing occlusion material (right). Pruned stubs are not wanted in sawn timber products and need to be restricted to the defect core. It is better not to prune branches when the stem diameter exceeds the target maximum DOS.

Record keeping & Pruned Stand Certification

In even-aged tōtara plantations it is very important that the mean maximum DOS is measured and recorded, because the DOS value has such significant implications for log value and harvesting decisions. Certified forest inventories that confirm the DOS values following pruning operations will give any potential log purchasers confidence in the clearwood volume of the forest. This reduces their risk and should result in higher prices being obtained for the logs. It also helps the forest owner better estimate the timber values of the forest.

For large commercial tōtara plantations, owners should consider Pruned Stand Certification, by an independent forester to verify the pruning work. See NZFFA website (see Useful links).

When pruning an uneven-aged naturally regenerating forest, detailed record keeping is complicated and may be less meaningful. The pruner will need to assess the individual trees, and make a judgement call in the field on whether to prune or not. Simply identifying the pruned trees (as future harvest trees) and recording a maximum DOS that was applied across the block (e.g., 20cm), is a practical approach.

Exceptions to every rule

A 60cm target harvest diameter is certainly not unreasonable for tōtara. Many farm-tōtara well exceed that diameter within 80 to 100 years. And there will always be odd situations where trees may be expected to be kept to much larger diameters, e.g., trees holding up tracks and stream banks. The DBH of such trees might eventually exceed 90cm, so arguably, if the DOS of those trees were 30cm, there would still be plenty of recoverable clearwood timber – should they come down in storm or be harvested for any reason in the very distant future.

Once the pruning wounds have occluded over, the DOS will become a hidden secret within each stem – maybe to the saw miller's pleasure or dismay.

Q- Which trees to prune? And how many?

Pruning a tree is to select it as a potential future harvest tree. Only the right stocking of well-formed and well-spaced, vigorous trees, should be pruned. Trees with serious defects, in terms of sawlog quality, should not be pruned. However, where no better tree exists, form-pruning may be used to address some defects to create a potential sawlog where otherwise no merchantable sawlog would develop.

Defects

Standard forestry tree defects include multiple leaders, heavy branching, sweep, lean, wobble, kinks, out of round, spiral grain, bark damage, rot, and lack of vigour etc. Some trees may only have these faults to a minor degree. Acceptable limits to some of these parameters are set out in forestry publications. Some trees are not worth pruning.

Knowledge of tōtara specific log-grade categories, would help a pruner decide when a defect should preclude a tree from being pruned. However, a tōtara specific log grading system has not yet been developed.

Select for vigour or form?

In young developing tōtara forests, especially in natural stands, often the dominant trees will have poor form and/or large branches. In contrast, the slower growing sub-dominant and supressed trees often have excellent form and lower potential DOS values. It can be hard to choose between more vigorous but branchy trees, and sub-dominant but better-formed saplings and poles.

There are risks either way. Vigorous trees may have a larger DOS and larger pruning wounds which may create possible long-term tree health risks. But then vigorous trees certainly heal over pruning wounds much quicker than supressed trees do. Well-formed tōtara poles often require very little pruning, but it is unknown to what extent slower growing sub-dominant or supressed trees with small crowns, will pick-up vitality even if released from competition.

Unfortunately, we do not have tōtara specific research guidance on this matter. Spreading the risk is probably a wise approach.

Table 3. A guide on maximum final number of pruned trees, relative to maximum DOS and target harvest diameters for tōtara plantations.

Maximum DOS (cm)	Target DBH* (cm) at harvest	Recommended maximum final number of pruned trees (stems/ha)	Average spacing between pruned trees (m)
16.5	50	400	5.0
18.0	55	350	5.3
20.0	60	300	5.8

Stocking and spacing

Deciding how many trees to prune is a critical step. For plantations, or for evenly sized and well-stocked pole-stands in naturally regenerated forests, Table 3 may help guide such decisions. For practical application, the average spacings between pruned trees are also indicated in the table.

Thinning is an important complementary action to pruning. And although both pruning and thinning relate to a common final stocking rate, they are not necessarily carried out at the same time or to the same degree. Unpruned trees may be left between pruned trees and remove in staged operations as the stand develops. The details of thinning are covered in another chapter. So, it should be noted that the suggested stocking of pruned trees in Table 3, does not infer that all non-pruned trees are to be thinned immediately following pruning.

It may be useful to form-prune up to 550 stems/ha in the sapling and early pole-stand development phase (<15cm DBH), but the final number of fully pruned trees should not exceed the maximum recommended figures.

Lower-stocked natural forests

Table: 1 may be a useful guide for well-stocked plantations and naturally regenerating pole-sized stands. However, owners of naturally regenerated forests with relatively low stocking rates of well-formed trees may be heartened to know that in many European forests it is common to only identify 40-150 potential final crop trees per hectare. These 'future trees' are pruned and managed to become large-diameter, tall-boled, large-crowned, premium-quality, and extremely valuable timber trees. Such trees are often around 8-14metres apart to give them sufficient space to develop large green crowns. So, even pruning only a few dozen trees per hectare is not a ridiculous forest management option if that is what suits your forest.

If any additional trees between them are pruned for possible production-thinning, then it is essential that they have a low DOS, and sufficient diameter at harvest time to have made the pruning worthwhile.

A naturally regenerated stand of farm tōtara pruned and thinned. A circular sample plot (centre peg visible in image above), indicated an initial stand stocking of nearly 3,400 stems/ha and a mean DBH of 14.3cm. The stand stocking was reduced to 1200 stems/ha and most residual trees pruned in single lift, up to between 4m and 6.5m high. However, not all of those trees should have been pruned because many will be thinned to further reduce the stocking of the stand over time (see Table 3)

N.B. – two forked trees in the image (centre and lower right) have been ring-barked rather than felled to waste. This should reduce the chance of wind damage, and also reduce the incidence of epicormic shoots developing on the residual stems due to a sudden increase in exposure to light.

Q- How big a branch can be pruned?

Ideally, branches should be pruned before they exceed 3cm diameter at the branch collar. The smaller the branch diameter the quicker the pruning wound can heal over and seal out potential health threats to the tree. However, larger branches will often be encountered on vigorous tōtara trees that are otherwise excellent trees to prune. A practical threshold to apply is only to prune what can comfortably fit in jaws of the loppers. This may include branches up to approximately 45mm in diameter at the branch collar. However, such large pruning wounds should only be made on vigorous trees and a pruning saw would make a cleaner cut.

Pruning stubs from small branches <30mm occlude (heal and seal) over quickly.

Bigger branches and/or competing leaders and forks need to be sawn-off. While tōtara appear to heal well – even over quite large pruning wounds (e.g., up to 100mm across), larger pruning wounds, especially where a fork has been removed, will frequently go soft or crumbly with rot before the cambium and bark occludes (grows over) the wound and seals it off. Large pruning wounds/stubs that are close to vertical and drain well, appear to resist rot much better than shallow-angled wounds. The long-term effects of sealing in a pocket of rot within the tree are not known. But small pockets of rot and discolouration of the timber around such wounds have been observed.

Pruning wounds from large branches up to around 45mm diameter appear to heal cleanly on vigorously growing trees but take several years to do so.

Dry, hard, and clean pruning stubs suggest minimal danger of ill health effects on the tree resulting from pruning.

In contrast to the three images above, large pruning scars on suppressed and slow-growing trees can take more than 4-5 years to heal.

A small pocket of rot beneath a 50mm pruned branch stub has been occluded over and sealed within the tree. This branch may have been dead at the time of pruning.

To date, observations of milled timber from natural stands of farm-tōtara indicate that tōtara trees are relatively adept at 'compartmentalising' and limiting the spread of small rot defects caused by cavities from branch-dieback and injuries. However, the average age of the harvested trees was only around 85 years old. Longer term effects on trees exceeding 150 years are unknown.

Perhaps of greater significance is that the Tōtara Industry Pilot project results indicated reasonable timber volume and grade recoveries from knotty tōtara logs. The diameter of branch knots tapers down from the outside of the log to the pith and live branches do not typically have bark inclusion defects. This means that 'green knots' stay sound and intact within tōtara timber, unlike some cypresses where a bark ring around the branch knots often causes them to become loose and fall out. Again, the implications are that tōtara trees do not always need to be pruned to yield valuable timber. Indeed, the compression grain around live knots can make an attractive feature in knotty tōtara timber.

Rot from large branch removal

Field observations have revealed pockets of rot and/or discolouration of the surrounding timber, from trees where large pruning wounds have been made. This is presumed to be the result of a fungal entry via the large pruning wounds. Whether such discolouration would be contained (compartmentalised) or spread within the tree is unknown. Likewise, any long-term effects on tree health are not known.

Large pruning cuts should only be executed where there are no alternative trees in that location to prune instead, and where such pruning is necessary to create a sawlog where otherwise none would eventuate.

Similar discolouration was observed at the butt end of many freshly cut logs harvested during the Tōtara Industry Pilot project (See image following page), yet encouragingly, no corresponding defects were noted during the milling and grading of that timber. Those trees had not been pruned, but a fungal attack entering the tree via obvious and sustained damage to their roots from cattle hooves was the presumed caused. However, the discolouration fades and is much less apparent in dry lumber and is possibly mistaken for heartwood.

Although this is a very concerning observation, to date, harvests from farm-tōtara trees have not highlighted this as a serious implication for timber yield or tree health. Nor has pruning or tree wounds been clearly confirmed as the cause. Nevertheless, a precautionary approach in respect to pruning is recommended at this stage. Pruners should understand that large pruning wounds are associated with health risks for the tree and possibly timber defects too.

Tōtara survive severe pruning treatments such as removal of large forks and large branches. However, this is not without some potential effects on timber values and long-term tree health (see image below). Near vertical pruning wounds (e.g., above, bottom image) shed water and resist rot much better than flatter pruning cuts (e.g.,above, top image)

A cross-sectional disc taken 30cm above a pocket of rot at the base of a 50cm DBH tree, that had had a large fork removed around 15 years before. Dark brown discolouration of what is otherwise sound timber is apparent. The long-sectional area affected tapers to nothing within the first 1.5m of log length. This discolouration is presumed to be the result of a fungal entry via the large pruning wound. Whether it would have been contained (compartmentalised) or spread further within the tree is unknown. Likewise, any long-term effects on tree health are not known.

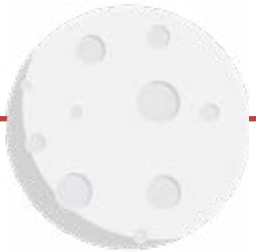
Examples of similar discolouration observed at the butt ends of large unpruned logs freshly harvested as part of the Tōtara Industry Pilot project. Fungal attack entering by sustained damage to the roots by livestock is thought to be a possible cause. Surprisingly, adverse visual or structural effects on the timber quality were not noted during milling or timber grading.

Q- Is there a correct pruning season?

At this stage, we are not aware of any problems that indicate that pruning of tōtara should be restricted to a particular time of the year.

In European forestry, it is generally recommended that pruning of live branches (except for Douglas fir) is only done between end-winter and mid-spring, or before the main growth flush. The reason is to minimise potential disease issues- especially from fungi. Dead branches can be pruned any time of the year. Presumably, this advice is based on extensive experience and possibly research. However, there are some varying recommendations, and some foresters point out that pruning wounds take an average of 4 to 5 years to heal over and therefore suggest that that makes the time of year of relatively little consequence.

More than one growth flush per year has frequently been observed on tōtara in Northland. And although growth slows during winter, it probably does not cease. Therefore, time of year for pruning may not be as significant for evergreen trees in milder climates, such as tōtara in northern regions of New Zealand. However, we are unaware of any New Zealand based, or tōtara specific research on the matter. Nevertheless, it is suggested that pruning is scheduled before the main growth spurts if practicable.



Maramataka

Based on the *maramataka* of Ngāti Miro in the Whangaroa area, rongoa practitioner Thomas Hawtin, suggests pruning should be avoided during the waxing moon phase – especially on the full moon. The best time for pruning is *Korekore* to *Tangaroa whakapau* - between the 20th - 26th night after the new moon (i.e., in the last quarter and before the new moon).

Conclusion

Technical details concerning the pruning of tōtara have been set out and summarised above and demonstrated in the associated video.

For foresters who have the privilege of managing a tall mature native forest structure, pruning will be a relatively minor part of silvicultural activities. In contrast, for developing plantations and naturally regenerating forests, the pruning of tōtara could significantly increase the future volume and value of merchantable saw logs within a forest.

However, pruning is a costly intervention and needs to be undertaken at least several decades before any potential harvest or return on the investment. This means pruning needs to be well-targeted, well-executed and well-recorded to have maximum benefit. And it is not without some associated risks. Poor timing, poor tree-selection, and poor practise, all risk it being a wasted effort or even damaging the trees. Furthermore, pruning is only one action within the context of silvicultural management of a tōtara forest. Pruning usually needs to be complemented by thinning, a topic covered in the next chapter.

All forests need active management and maintenance, and intensive silviculture is a lot of work. However, tōtara, as a species, is amenable to pruning - and often needs it, if timber production is an objective - although the economic viability of pruning tōtara is untested.

There is a lot of work but also a lot of pleasure to had in tending a developing forest, imagining it in the future, and watching it grow. This can be very rewarding and enjoyable well before harvest time. So, happy pruning. Go out and enjoy it too!

"Silviculture is a lot of work. But tending a developing forest can be extremely rewarding and enjoyable too."

Useful links

Pruning Tōtara for Timber – Video

Northland Tōtara Working Group video, featuring Paul Quinlan, produced by Ian Brennan

https://vimeo.com/580207222

DOS

Best Practice Guidelines for Silvicultural Pruning 2005 (pages 8 & 10)

https://safetree.nz/wp-content/uploads/2015/03/Silvicultural-Pruning.pdf

NZFFA leaflet – No.7 Pruning

https://www.nzffa.org.nz/farm-forestry-model/resource-centre/information-leaflets/farm-forestry-association-leaflet-series/no-7-pruning/#Defect_core_size

Illustrations and advice on form-pruning

Blackwood – a Handbook for growers and users, by Ian Nicholas and Ian Brown, 2002, (pages 50-60).

https://www.nzffa.org.nz/system/assets/1709/blackwood-a-handbook-for-growers-and-users-.pdf

Leader-training

NZFFA leaflet - Form-pruning deciduous hardwoods

https://www.nzffa.org.nz/farm-forestry-model/resource-centre/information-leaflets/farm-forestry-association-leaflet-series/form-pruning-deciduous-hardwoods/

Pruned Stand Certification – for large commercial tōtara plantations

https://www.nzffa.org.nz/farm-forestry-model/resource-centre/information-leaflets/farm-forestry-association-leaflet-series/no-9-pruning-and-pruned-stand-certification/#Pruned_stand_certification)

Safety and Health

Standards for silviculture

https://safetree.nz/wp-content/uploads/2015/03/Silvicultural-Pruning.pdf

Approved Codes of Practice documents

https://safetree.nz/wp-content/uploads/2015/02/forest-operations1.pdf

THINNING TŌTARA

THINNING TŌTARA

Why thin tōtara?

High density, slow growth, and poor form

Naturally regenerated tōtara forests typically have high stocking rates – sometimes thousands of stems per hectare – and comprise trees with wide ranging characteristics such as size, form (branchy-ness etc.), growth rates, and green crown development. Planted native forests also tend to be established with high stocking rates (often around 2500 stems/ha or more) in order to beat and supress weeds and also to utilise the advantages of competition between the stems to improve the form of the developing young trees. If such forests are left untended, some trees will dominate, others will be suppressed, and there will be fierce competition between the stems. The stands will self-thin over time – i.e., the stocking rate will decrease over time as the weaker, supressed trees, die off. This is a slow and gradual natural process that also slows the growth of the trees within the stand. Moreover, the dominant trees may not be good timber trees.

Thinning manipulates these factors.

Enhancing timber production potential

Although untended natural or planted tōtara forests can still develop into stands with some merchantable timber volume, they will tend to have sub-optimal productivity in this respect. A large portion of the forest's total annual growth increase may be going on trees with relatively poor form (i.e., have little or no merchantable sawlog volumes, or only logs of relatively low timber value, and some growth will be going into supressed trees that are likely to fail). Often the dominant trees have the poorest form. The high stocking rates also slow the average growth rate of the trees. And trees with the best form for timber production may be supressed and never realise their full potential. All this is sub-optimal for timber productivity. However, this can be changed by thinning.

Ironically, thinning involves cutting trees down to grow more and better timber. Essentially, it is about culling out the poor trees, so the better ones have more space and light to grow faster and to reach their full potential. Thinning is a practical way to direct the forest's growth into the individual trees with the best potential for timber production and increase the total productivity from the forest area.

"Thinning is the most effective silvicultural intervention to significantly influence the future sawlog volume and value of a forest."

The growth form of tōtara ranges from trees that branch from ground level with large spreading crowns, to thickets of skinny, pencil-straight trees.

Timing, intensity, and skilled execution are all significant factors that affect the relative value and benefit of any thinning. Unfortunately, without case-studies and modelling, the economic viability of thinning tōtara forests, (as opposed to doing nothing and leaving things to nature) is not known. However, it is clear that thinning can significantly affect the potential for timber production.

Silvicultural trials by the Northland Tōtara Working Group found the mean annual growth rate of individual trees more than doubles following a thinning (trunk diameter increment at breast height), and total stand productivity can be 5-fold greater than for comparable unthinned stands.

The growth rings of this tree clearly show the response to a thinning 4 years previously.

"Thinning can significantly boost growth rates of the potential crop trees"

The necessary complement to pruning

If any pruning has been done, then thinning is an essential complementary operation. Otherwise, the unpruned residual trees may dominate and suppress the pruned trees and the investment in pruning effort will be wasted.

Creating viable trees as replacements

In highly stocked tōtara plantations and natural pole-stands within regenerated forests, many young trees develop excessively tall skinny trunks and very small narrow crowns. It is doubtful whether these trees, even if released from competition by thinning or selective harvests, have sufficient vitality to 'fatten' and ever become viable timber trees. Thinning is a way of developing vigorous potential recruitments that are physically capable of filling gaps and replacing harvested trees. This is important when managing forests with a natural uneven-aged structure, (as opposed to even-aged plantations).

Stand stability

Although to-date, wind-throw in tōtara stands has not been noted as a serious problem by the Northland Tōtara Working Group, it may be an issue in other regions. In theory, trees with healthy and balanced crowns and greater trunk-diameter to tree-height ratios are more resistant to extreme wind events. Thinning is generally recognised as one way of improving the inherent stability of the trees within a stand and their resistance to wind-throw (and snow damage in regions where that is a risk). Thinning to improve stand stability may be relevant for developing tōtara plantations and natural pole-stands in some regions.

Naturally regenerated tōtara stands may have such high stocking rates that it significantly slows the growth of the trees.

Thinning increases the light levels within a stand and often leads to the development of diverse understorey. In contrast, many unthinned natural stands have a comparatively bare understorey.

Long-term stand improvement via new regeneration

Many naturally regenerated tōtara forests are dominated by large trees that occupy significant space yet have such poor form that their timber value may not increase by allowing them grow on and become even bigger trees. Indeed, it may just make them even more problematic to deal with in the future. Removing some of these trees may free up space within the forest for new regeneration that will have better potential to be managed for timber production.

Forest establishment

Sometimes early thinning operations may also be useful in native forest establishment – e.g., releasing suppressed young native trees from a dominating nurse cover, or exotic weed competition.

Biodiversity management

Timber production may not be the only forest management objective. Thinning may be a practical way to influence the species mix and biodiversity of the forest. For example, by releasing around rare or less common non-timber native tree specimens to ensure their survival and to provide them with adequate growing space within the forest. Increased light levels reaching the forest floor following a thinning operation also often results in development of the forest's understorey.

Summary

The potential benefits of thinning include:

- Enhanced timber production potential – growth directed to higher value trees
- Larger diameter harvest trees in a shorter time
- More stable stands
- Improvement of the forest structure (e.g., creating regeneration opportunities and healthy potential recruitments for canopy gaps)
- Biodiversity management (fostering mixed species, and understorey development).

Thinning is a very effective silvicultural intervention to enhance timber production potential. However, thinning is a severe manipulation of a forest's structure. Moreover, cutting a tōtara tree down is an irreversible act. Therefore, it is very important to make good decisions when undertaking such operations.

When to thin?

IIdeally forests are thinned gradually, with light and frequent operations over an extended period. Frequent thinning can keep the potential crop trees growing quickly and consistently. It also allows the trees to adjust and compensate to increasing exposure to wind and light. Graduated thinning reduces the risk of wind-throw and epicormic shoots developing on the stems of trees in response to sudden exposure to more open conditions. However, in practice, thinning is often executed in only a couple of severe interventions.

This untended stand of naturally regenerated tōtara had a mean DBH of 14.4cm and a stocking of 2800 stems/ha. It was thinned to 700 stems/ha and the mean DBH of the residual trees was 19.2cm. These were then pruned to 6.5m in one lift. The delayed thinning has resulted in trees with good form, reducing silviculture costs, but has significantly slowed the growth rates of individual stems. The stand is estimated to be 50-60 years old.

First thinnings

Thinning often follows pruning, and depending on the site, and stocking, this may even be necessary during the sapling phase to prevent the unpruned trees, or a dominating nurse-crop, from supressing the pruned trees. However, there may be advantages in delaying the first thinning, or only lightly thinning, until the potential crop trees within the stand are between 7 and 12metres high, and mean DBH exceeds 12cm (ideally 15-18cm). This utilises the effect of competition between the trees within the stand to positively influence the form of the developing trees and reduces the need for pruning. It also reveals natural differences in vigour between individual trees – which is relevant to tree selection. However, it will slow the growth of the trees.

Waiting until thick undergrowth such a gorse and blackberry has started to be shaded out is another practical consideration. Ideally the lower branches of the crop trees will already have started to die-back naturally on the first 3-5m of stem height. Some dense natural pole-stands can be thinned and pruned to 4.0- 6.5m in one single operation. This significantly reduces the costs of silviculture. However, the advantages of delaying thinning like this will come at the expense of growth rate.

"There is a balance to find between maintaining diameter growth on the potential crop-tree stems and maintaining sufficient side competition to develop good tree form and minimise pruning costs."

Many forestry publications suggest that thinning should occur before the green crown is suppressed to less than a third of the tree's height (or average values of a stand). In many highly stocked natural pole-stands of tōtara, individual trees with proportionally smaller crowns are not uncommon. In such instances, tree selection becomes another difficult choice – as the trees with bigger and healthier crowns will often not be the trees with the best stem form.

Maintaining relatively high stocking rates to reduce the need for pruning makes sense. However, if thinning is delayed too long it risks creating tall skinny poles with ill thrifty crowns and potential stability problems. The ability for such 'stretched' young tōtara poles to pick-up their growth rates and become viable timber trees is not known. Some research on this matter would be helpful. However, experience with other species is that past a certain point in the pole-stand phase, even if thinned, unhealthily skinny residual poles with small crowns, will not develop into viable timber trees. Where is that point for tōtara?

Height/diameter ratio

Many European forestry publications refer to a tree height to trunk diameter ratio as a way to determine the timing of thinning operations, or whether a pole-stand has past the point of sensible intervention. The equation is:

$$\text{Height/Diameter ratio} = \frac{\text{Tree height (in cm)}}{\text{DBH* (in cm)}}$$

*DBH = Tree diameter at breast height

Example:

$$\frac{\text{1200cm (12m. Tree height)}}{\text{15.0cm (DBH)}} = 80$$

Height/Diameter ratios of 80:1 or lower are generally considered stable. Ratios between 80 -90 are considered at higher risk of wind-damage etc., and values above 90, to have little chance of becoming viable canopy trees.

Applying it to tōtara

We are unaware of any research testing these assumptions with tōtara.

The above formula would suggest that trees with a DBH of 10cm should not be more than 8m tall. Or trees with a DBH of 15cm should not be more than 12m tall. Based on practical experience with tōtara pole-stands, this seems about right. However, trees in some dense natural pole-stands exceed that recommended threshold. If the height/diameter ratio of a plantation or pole-stand is approaching the 80:1 ratio, it would be prudent to undertake a thinning operation.

"A Height/Diameter ratio of <80:1, may be a useful measure to help guide timely thinning interventions, and individual tree selection, especially in dense natural pole-stands".

A practical approach may be to measure a sample of the trees likely to be selected as 'keepers' (potential crop-trees), ignoring those likely to be culled, and ensure thinning commences well before those potential crop-trees become too skinny (i.e., their height to diameter ratio exceeds 80:1 and/or their green crowns are less than one third of their total height. This may also help decide if a tree is too skinny to keep.

Further thinnings

Subsequent thinnings need to balance the maintenance of good tree form, while promoting fast growth, and maximising the stocking of potential harvest trees. Suggested thinning schedules are set out further on. These are based on Stand Density Index (SDI) analysis work by Tane's Tree Trust and the Northland Tōtara Working Group.

These are relevant to well-stocked plantations and naturally regenerated pole-stands of tōtara. They suggest progressively reducing the stocking to 550 stems/ha before the mean DBH exceeds 25cm and then maintaining that stocking until about a 40cm DBH. This aims to maintain good growth rates, yet hopefully also encouraging the development of some top logs, and maximise the stocking at 40cm DBH to provide an earlier production thinning harvest opportunity.

However, for sparsely stocked and highly variable natural stands a different approach is needed – one based on thinning around individually selected crop trees. This is also outlined further below.

Bole height and top log development

Once a clearwood bole has been formed, the forest manager faces a choice of further thinning options. These are either to thin more heavily for maximum diameter growth on the butt log and the earliest harvest of selected potential crop trees, or to maintain a higher stocking rate in the hope of developing more merchantable top logs (i.e., any sawlogs formed above the butt log).

In young, naturally regenerated stands, and low-stocked plantations, it may be difficult to develop good top logs. The trees with the largest crowns are likely to have relatively short boles and little or no merchantable top logs. In contrast, adjacent pole-sized trees growing between the dominant trees will often have the potential to develop taller boles. This is where production thinning and continuous cover forest management practices provide opportunities to improve the forest structure in the long-term. For example, if the shorter-boled trees are removed first, either through thinning, or selective harvests (production thinning), then over time, the canopy height and mean merchantable bole-length of the forest may be gradually increased.

This untended natural pole-stand should have been thinned earlier. The height/diameter ratio well exceeded the recommended 80:1. The skinniest trees have been thinned out, and mean height diameter ratio of the residual stand is now 78:1. Hopefully this has salvaged the situation in the nick of time. Further thinning will be required as these trees fatten.

Production thinning

Early thinnings are mostly dealing with small diameter trees not large enough or worthwhile to mill. This is generally called 'thinning to waste' – as the stems and slash are usually left in the bush to rot.

But as the forest develops, or in older naturally regenerated forests, many of the trees to thin have logs just large enough to mill. If they are extracted for that purpose, or other commercial use, then that is known as 'production thinning', and in theory, such thinnings present a revenue opportunity.

Later thinnings may involve felling trees that are large enough to be milled (usually >30cm DBH).
If these are extracted from the forest it is known as production thinning.

Reducing the size of the crown before felling is an effective but time-consuming way to production thin in way that avoids damaging adjacent trees. In this case, the tree with a 51cm DBH and 4.2m long butt log yielded 0.85m3 of saw log volume, and was harvested to the advantage of taller-boled but younger trees around it.

There may be sections of millable timber and top logs even in some of rougher trees that are thinned.

In practice, the costs of extraction may outweigh the value of the logs -especially since it is the poorer-grade trees that are targeted for thinning. However, an important principle is that silviculture is expensive and therefore any opportunities to offset the costs (even only partly) should be fully explored and utilised.

"Silviculture is expensive. Therefore, any opportunities for production thinning should be fully explored and utilised if practicable."

Thinning of plantations or natural pole-stands, should not be delayed in the hope of being able to execute a production thin. However, when starting with an already regenerated natural forest, production thinning will often be an option. Selective harvests should be treated as silvicultural (thinning) interventions – i.e., targeting the removal of poorly formed trees to the benefit of the better-formed residual trees.

Usually, stems with a DBH of 30cm or greater are considered 'merchantable trees' in forest inventories under the Forests Act. However, this is an arbitrary threshold. It is possible to mill and recover merchantable timber from tōtara trees with DBHs less than 30cm. Ultimately, what is 'merchantable' and worth production thinning, will be decided by market economics at the time, or what the forest owners can find a use for.

Legal requirements

Part 3A of the Forests Act applies to any harvesting and milling of any *natural* native forests, including regenerated farm-tōtara on previously cleared land. Various provisions of the Forests Act enable the harvesting and milling of native timber. However, approvals are required before the trees are felled.

The milling of all native timber requires approval from Te Uru Rākau this includes trees harvested from planted native forests which requires a milling statement issued by Te Uru Rākau prior to milling. Contact Te Uru Rākau New Zealand Forest Service for information on this matter: https://www.mpi.govt.nz/forestry/native-indigenous-forests/

What to thin

Tōtara trees with obvious significant defects that would affect timber production should be thinned.

Serious defects include:

- **bark damage and rot**
- **misshapen or damaged crowns**
- **forking/multiple leaders with no potential merchantable log sections**
- **excessive heavy branching**
- **unstable trees and poles with ill-thrifty crowns**

Standard criteria to assess acceptable limits (tolerances) to some other common defects in tree form are set out in some forestry publications.

Such defects include:

- **trunks that have sweep, leans and kinks etc.**
- **spiral grain (noticeable in the bark pattern)**
- **large diameter branches**

Weak, stunted and misshapen tōtara saplings in the understories may also be removed, although this is unlikely to boost growth rates of the dominant and codominant trees.

Other species

Unless ecological values or environmental management objectives suggest otherwise, other common species such tree ferns and kanuka, should be thinned if they are significantly supressing the growth rates or deforming potential crop trees, or inhibiting natural regeneration.

Weeds

Woody weed species should also be felled during any thinning operation. Ideally their freshly cut stumps should also be swabbed with herbicide (e.g., the gel called 'Vigilant' – with picloram as an active ingredient). Slash from thinned trees can make access for weed control difficult, therefore, it best to cut and poison woody weeds before felling trees on them.

What not to thin

Native trees should not be thinned where they are holding up stream banks, or on steep scarps, or providing valuable environmental service. Maintaining or fostering a mix of forest species is likely to be an important management objective for most native forests. Therefore, thinning must consider the potential effects on species diversity within the forest. Care needs to be taken to ensure that the falling of thinned trees will not damage valuable non-timber species in the process. In situations where damage appears possible, ringbarking may be a better option than felling.

Wildlife values and safety may also be relevant if larger trees are involved. For example, hollow trunks should be checked for signs of bat or bird roosts, or kiwi burrows at the base - and unsound or multi-leadered trees can be very hazardous to fell. It is desirable to include some non-merchantable trees and tree species within any native forests for many environmental and ecological reasons, and for natural character and amenity values.

How many to thin?

Two approaches

Some areas of naturally regenerated tōtara forest have very plantation-like characteristics. They can be almost monocultures of tōtara and be relatively consistent in terms of tree size – especially in the pole-stand phase (i.e., mean DBH of 10-30cm). Such natural pole-stands can be thinned and managed like even-aged plantations. In contrast, other areas of natural forest have more variable attributes and require a far more flexible approach to silviculture - one that is suited to uneven-aged, variably stocked, and often mixed species within a more natural forest structure. Therefore, two differing approaches to thinning are outlined below.

One approach involves thinning schedules that can be applied to plantations and well-stocked natural pole-stands, the other simply applies some criteria of when to thin around individually selected trees without specifying a particular stocking rate – just working with what you have got.

Because of the variable nature of many forests, both approaches might be usefully applied to different areas within the same forest. Such 'free-style silviculture' will be particularly relevant to naturally regenerated forests and Close-to-Nature forestry practice. For video (see Useful links).

Once potential crop trees have formed an acceptable bole, thin around them so they have space to develop large, healthy crowns, to drive growth.

1. Variable thinning in natural regeneration

This practice is typically adopted in Close-to-Nature, continuous cover forestry situations. It works with what nature has provided and involves individually selecting potential crop trees (sometimes called 'future trees' or 'frame trees'). These potential crop trees must be free of defects, healthy, with vigorous crowns, and capable of developing a suitable bole. They might be pruned, but otherwise their form and growth rate is managed by thinning when needed.

Once a good bole has been developed, the emphasis is developing large and healthy green crowns to optimise the diameter growth of their trunks. The criterion is simple: thin trees when their crowns start competing with the crowns of better-formed potential crop trees – i.e., when their branches touch

"Once a tree has formed a good bole, thin the trees around it when their crowns start to compete – i.e., when their branches touch".

This approach develops high-value, large-diameter trees, as quickly as possible, and with the least cost. It tends to result in lower final stocking rates than plantations systems that seek to optimise volume. In many European forests practising Close-to-Nature forestry, typically less than 150 'Future trees' are selected per hectare, and ultimately, after a series of production thinning harvests, they may end up with only 30-80 large-diameter, but very high-value trees/ha. Therefore, forest owners should not be discouraged if their forest appears to have poor stocking of potential crop trees. Work with what is there and thin to improve the forest for the future.

"Work with the forest you have and thin to improve it for the future."

Obvious cull-trees – trees with defects, can be thinned to free up space for new regeneration that can be managed to have better form and timber potential. Ring-barking non-merchantable trees can be a practical way to do this (see the section on ringbarking further below).

Some thinned trees will be small and thinned to waste. Others might be large enough to harvest as production thinnings. These should not have been pruned because there is unlikely to be sufficient clearwood outside the pruning stubs to have made the pruning a benefit (unless the diameter of the thinned trees exceeds about 45cm).

Note, that harvesting in natural indigenous forests is subject to the Forests Act, and Sustainable Forest Management Permits or Plans will require a nature-based approach to forest management.

"Free-style silviculture suits close-to-nature forestry"

In summary, prescriptive thinning schedules are not applicable to highly variable areas of natural forest. Individual trees should be selected as crop trees, or potential crop trees. Once they have developed a merchantable bole, thinning around them, to keep their crowns free, will optimise their growth. A variable thinning approach is well suited to managing mixed species, uneven-aged forests for multiple objectives.

See Freestyle silviculture video.

2. Thinning schedules for tōtara plantations

In contrast to the variable natural forest situation described above, more systematic, and prescribed approaches to thinning could be applied to plantations of tōtara and areas of well-stocked pole-stand within natural forests.

Two thinning schedules are set out below. One is a more aggressive *prune and thin* regime, the other a more conservative and/or *unpruned* regime. They are both based on analysis of Stand Density Index (SDI), developed by the Northland Tōtara Working Group, as a practical basis to guide thinning intensities.

Both regimes seek to quickly achieve a site occupancy of 550 stems/ha with a mean trunk diameter at breast height (DBH) of 40cm. This maximises the opportunity for production thinning from this point onwards. From 50cm DBH a clear-fell harvest would be an option or continued selective harvesting.

The 400 *Pruned Regime* anticipates the harvest of up to 400 pruned trees/ha at a DBH of 50cm, or the progressive selective harvesting of those stems. The more aggressive thinning schedule of this regime aims to quickly grow the trees to a production thinning size of 40cm DBH. However, this may mean intensive pruning is required to maintain good tree form in the early stand development phase – and pruning is a significant cost.

In comparison, the *Conservative/Unpruned Regime* retains higher stocking rates up to a mean DBH of 25cm. This hopes to produce trees with better natural form and thereby either reducing or avoiding the costs of pruning. However, comparatively, it is also likely to slow growth rates in the early development phase.

"Aim to progressively reduce plantations to 550 trees/ha before the mean DBH exceeds 25cm".

Silvicultural prescriptions are always a matter of debate and personal choice. Popular schedules are refined and evolve over time and may still need adapting for site-specific use. The following schedules are not presented as the perfect prescriptions. They reflect a best attempt based on current research and considerations. Therefore, they are only offered as possible guides and may be revised in the future.

Implications for thinning of planted tōtara forests

Native forests are typically planted with a total stocking rate of between 2220-4440 stems/ha including the nurse species, but with the canopy-tree species interplanted at only 625 to 1250 stems/ha amongst the nurse cover. So, although early competition from the nurse or weeds may occur, competition between the canopy-trees species is unlikely to be significantly affecting growth rates until their mean DBH exceeds about 15cm, or 20-25cm, depending on the stocking rate they were planted at.

Therefore, the tables above suggest that apart from minor thinning work (e.g., - just enough to ensure that any pruned trees, or potential crop trees, are not being supressed or deformed by nurse species or non-crop trees), the thinning will mostly only involve the cutting of the nurse and weed species until the canopy tree species exceed at least 15-20cm DBH. This seems to support establishing tōtara plantations with nurse species that will be succeeded and shaded out and will not require physical removal by thinning.

Table 4. 400 Pruned regime: (For production thinning of up to 150/ha unpruned trees starting at 40cm DBH, and then a clearwood harvest of up to 400/ha pruned trees from 50cm DBH)

DBH* cm	**Stocking** (after thinning) **Stems/ha**	**Approx. mean spacing*** m.**	**Action**
10	2100	2.2	Light release from nurse/weeds as required
15	1100	3.0	Thin to waste
25	550	4.2	Thin to waste
40	400	5.0	Production harvest of up to 150 unpruned trees (leaving up to 400 residual pruned trees)
50**	275	6.0	Harvest all 400 pruned trees - or leave 275 & continue production-thinning/selective harvests...
60	120-200	7.0- 9.0	Harvest all 275 trees – or leave 120- 200 and continue selective harvesting…

* Quadratic mean DBH

** N.B. – Harvest pruned trees from 50cm DBH if max. DOS does not exceed 16.5cm.
Otherwise target harvest diameter at 3x max. DOS value (e.g., 60cm harvest diameter for 20cm max. DOS)

*** N.B. – Mean tree spacing is a guide only and does not need to be rigidly applied.
Overall stocking per hectare is more important than even distances between trees.

Table 5. Conservative/unpruned regime:
(Production thinning/harvests of up to 550 unpruned trees starting from 40cm DBH)

DBH* cm	**Stocking** (after thinning) **Stems/ha**	**Approx. mean spacing*** m.**	**Action**
10	3,300	1.75	Light release from nurse?
15	2,000	2.2	Thin to waste
20	1250	2.8	Thin to waste
25	550	4.2	Thin to waste
40	400	5.0	Start of production harvesting up to of 150 trees (leaving 400 residual trees)
50	275	6.0	Harvest all 400 trees - or leave 275 & continue production-thinning/selective harvests...
60	120-200	7.0- 9.0	Harvest all 275 trees – or leave 120-200 and continue selective harvesting…

* Quadratic mean DBH

** N.B. – Mean tree spacing is a guide only and does not need to be rigidly applied.
Overall stocking per hectare is more important than even distances between trees.

Ringbarking

Ringbarking can be a useful alternative to felling trees that are difficult or dangerous and/or likely to damage valuable adjacent trees or understorey if felled to waste. Other advantages include a slower exposure of the remaining trees to the increasing levels of light and wind than would occur if they were felled. This reduces the risk of windthrow and epicormic growths on the stems of residual crop trees. However, ringbarked trees become hazardous to be around until they have eventually fallen.

Stand improvement

Ringbarking is particularly useful in naturally regenerated stands where large-crowned, and poorly formed trees, with no merchantable timber value, often dominant and suppress adjacent but better-formed younger trees. Thinning by ringbarking can divert the growth to the better-formed supressed trees and help regenerate a forest with better potential for timber production. See Freestyle silviculture video.

A pattern often seen in regenerated tōtara forests is a ring of pole-sized trees with reasonable form struggling to compete around the drip line of a large, heavily branched, and poorly formed, dominant tree. The larger branchy tree was probably established earlier and in more open conditions. It may even have been the parent tree. In such instances, ringbarking the large, poorly formed tree, enables the area it occupied to infill with new regeneration of seedlings and saplings that can be managed to have better form for timber production, and/or for increased species diversity within the forest. In many cases, the canopy gap created by ringbarked tree will be an ideal environment for new regeneration to naturally develop with good stem form.

"Ringbarking can be a quick and effective way to manipulate the structure of the forest – but it creates a hazard for many years".

Ringbarking is a quick and useful alternative to felling in some situations. Ringbarked trees usually take a couple of years to die and then slowly disintegrate over about a decade.

The disintegrating carcass of a ringbarked tree within a circle of better-formed poles. If it had been left, the poorly formed tree would have dominated this space.

The decaying tree (right of centre) was ringbarked approx. 12 years ago. It had dominated the canopy at the time and supressed the surrounding young trees in this area. However, now the growth is going into the adjacent well-formed and pruned trees, and more diverse regeneration is occurring in the gap. The decaying trunk has been a nesting site for kingfishers over many years.

A new tōtara sapling growing against a ringbarked stem. Regeneration within this canopy gap could be managed to have better form than the tree it is replacing.

Method

Trees with a short section of single trunk, can be ringbarked with a chainsaw. Two parallel horizontal cuts should be made between 100 and 200mm apart, around knee height, and deep enough to ensure the sapwood layer is severed (usually 60 to 150mm deep depending on the size of the tree and its crown). When the tree is actively growing, and the 'sap is flowing', the band of bark between the cuts can be easily levered off with the plug spanner from the chainsaw belt.

Safety hazards with ringbarking

Multi-stemmed trees that branch from ground level may be too impracticable and dangerous to ringbark. At all times ensure only safe and responsible practices are implemented. Ringbarked trees will often take a couple of years to die and a decade or more to disintegrate or fall. It will be hazardous to be within two tree lengths of ringbarked trees until they have fallen to ground. Warn any forest users of the hazard and suspend all forest activities in the vicinity of ringbarked trees as long as the hazard exists. Never attempt to fell a ringbarked tree.

Two parallel cuts through the sapwood band and removal of the bark will ensure a successful ringbarking.

Planning of thinning operations

Surveying the forest before thinning

For naturally regenerated tōtara forests, thinning will mostly be a case of responding to what is found at a micro-spatial and individual tree level. This contrasts with even-aged plantations and areas of relatively consistent pole-stands of regenerating tōtara. For the latter, a decision on when to thin in such areas should be guided by a forest inventory – involving at least the measurement of the mean DBH and stocking of the forest, (ideally also the height/diameter ratio). And how much to thin should be guided by a thinning schedule (such as one of the schedules offered above).

Forest inventory

Forest inventory is a quite a specialised task. For large plantations it may be best to be conducted by a professional forester. However, some farm-foresters will have the basic knowledge, equipment, and skills to make suitable assessments themselves. And there are publications[1] that could guide forest owners and managers on how to survey their forests to determine values such as mean DBH, DOS, tree height, and stocking etc. Mean DBH and stocking are critical values needed to apply a thinning schedule.

It is also useful to be able to do some quick sample plots in the field when conducting thinning operations to check/calibrate work in progress or to respond to variation within the forest (see Quick Sample Plots under Practical Tips further below).

[1] For example: Bergin, D. 2009: Assessing regenerating tōtara on the farm. A preliminary guide for landowners in Northland. Contract Report for the Northland Regional Council (Envirolink 516-NLRC). Contract Report (unpubl.). Scion, Rotorua. 27p.

Forest inventory is needed to determine mean diameter at breast height (DBH) and stocking rates, to guide and check thinning.

Health & safety

Thinning is chainsaw work and dangerous. Moreover, tree felling is a notifiable activity (to Worksafe NZ) and thinning for forestry purposes will mean the forest is defined as a Work Place. Responsibility lies with the forest owner and manager to inform themselves of any and all relevant Acts, regulations, Approved Codes of Practice etc., and to ensure that they are applied and complied with.

The topic of health and safety management is highlighted here as an essential matter to be considered and addressed in the planning and carrying out of any thinning work; however comprehensive coverage of the matter is not attempted here.

Useful information may be found on the following websites and links:

Work Safe:

https://www.worksafe.govt.nz/topic-and-industry/agriculture/tree-work-on-farms/managing-a-safe-and-healthy-small-forest-harvest

NZ Farm Forestry Association:

https://www.nzffa.org.nz/farm-forestry-model/the-essentials/health-and-safety/small-scale-forestry-safety-guidelines

Regulatory impediments

Queen Elizabeth II National Trust, or other bush protection covenants, may preclude thinning within covenanted forest areas.

Regional and District Plans may also have rules that could affect thinning activities within bush on private land – especially if the forest area is mapped as a Significant Natural Area (SNA) or other designation such as an Outstanding Landscape Area etc. The planning maps and rules should be checked when planning a thinning operation, and if necessary, a phone call to the duty planner at your local council should give definitive advice at no cost.

Thinning under part 3A of the Forests Act

Planted indigenous forests are not subject to the Sustainable Forest Management requirements of part 3A of the Forests Act. And thinning to waste in a natural forest does not trigger the involvement part 3A of the of the Forests Act. A Sustainable Forest Management (SFM) Permit or SFM Plan is not required to undertake thinning unless the thinned trees will be milled.

In native forests that are already subject to a SFM Plan under part 3A of the Forests Act, thinning may be specifically provided for. However, such silviculture will still need to at least maintain the starting range of forest's species and natural amenities. This will be easy in many of the highly modified and often almost mono-cultural tōtara stands that have regenerated on farmland. Thinning is likely to help an understory to develop and enhance species diversity in those forest types. However, in more diverse and natural forests, the effects of thinning on species composition and forest structure will need careful consideration. Retaining non-commercial native species for biodiversity and natural values is important.

Trees with trunk diameters of 30cm and above, may be classified as 'merchantable' under part 3A of the Forests Act. Depending on the specifics of your SFM Plan, any thinned merchantable volume may need to be accounted for as harvested volume.

Practical tips

The following practical tips may be useful.

Dos and Don'ts

Do:

- **Delay** thinning until weeds and lower branches start to die off and enable access.
- **Schedule** thinning before the green crowns of potential crop trees are supressed (i.e., less than one third of tree height).
- **Prune** before thinning.
- **Apply and obtain** legal approval (e.g., SFM Plan under the Forests Act) before felling trees if production thinning.
- **Notify** Worksafe that tree felling work will be done.
- **Assess and mark-up** trees before picking up the chainsaw! Mark-up the trees to stay.
- **Gradually reduce stocking** over multiple thinning operations to reduce risk of wind throw.
- **Start** felling at the bottom of hills and directional-fell trees into gaps.
- **Free** the trunks of remaining trees from hang-ups, and slash from felled stems especially if under tension.
- **Cut woody weed species** at the same time.
- **Consider** if ringbarking instead of felling would be appropriate and advantageous.
- **Be flexible** and respond to localised natural variation and values within the forest.

Don't:

- **Don't** apply recommended tree spacing too rigidly. The overall stocking per/ha is more important than even spacing between trees.
- **Don't** leave slash in watercourses.
- **Don't poison** cull tōtara trees - because they may be 'root-grafted' to adjacent tōtara trees.
- **Don't work alone** - but ensure workers are always at least two tree lengths apart when felling.

Quick sample plots

5.64m radius plots

In areas of highly stocked regeneration, sample plots with a 5.64m radius are easy to apply in the field. These can be useful to quickly get a rough indication to check stocking rates. A measuring tape can be tied to a sapling or stake (an electric fence standard is ideal) and used as temporary 'plot centre'. Holding the tape near horizontal, can usually avoid needing to adjust the radius to account for the slope of the ground. A count of the relevant stems within a 5.64m radius can be easily converted to a per hectare stocking rate simply by multiplying the number of stems within the plot by 100 (– e.g., 15 stems in plot equates to 1,500 stems/ha). However, if there are less than 5 or 6 stems in the plot, then a larger radius should be used to get a more accurate estimate.

See Freestyle silviculture video.

Conclusion

Thinning can be a very effective silvicultural intervention to enhance the timber production potential of a tōtara forest. Its purpose is to promote quick growth of the potential high-value crop trees, at their maximum stocking, while maintaining just enough competition from other trees to encourage the development of tall boles on the crop trees. It can also help manage other forest values such as stand stability, species diversity and composition.

Various criteria have been outlined above to help decide when, and to what degree, thinning should be carried out. For planted tōtara forests and areas of natural regeneration that have a plantation-like structure, the two thinning schedules based on recent tōtara research using a Stand Density Index approach, may be useful guides to thinning for timber production. For highly variable natural forests, thinning must work with what is there, but it is also an opportunity to initiate new regeneration and 'renovate' areas of poor-quality forest.

Thinning should always be carried out with all relevant management objectives in mind and be flexibly applied in response to localised variations, features, and competing values within a forest. It needs to be well considered, well planned, and safely executed. However, if done well, thinning will significantly enhance a forest's potential for timber production and other values. It is usually the most effective silvicultural intervention. However, the economic case for thinning tōtara forests has not been evaluated.

Thinning is hard physical work, but it can also be gratifying work too. You get to see some instant effect for your effort, as well as the pleasure of observing the more gradual changes that it sets in train. Go on - sharpen your chain!

"And remember, not every tree should be thinned or culled from the forest just because it may be unsuitable for timber production!"

Useful links

The Forests Act

For information on harvesting and milling of any natural native forests contact Te Uru Rākau New Zealand Forest Service.

https://www.mpi.govt.nz/forestry/native-indigenous-forests

Videos

Freestyle silviculture in naturally regenerating tōtara forests on private land

Harvesting tōtara – trialing small-scale, low[1] impact methods

https://www.tanestrees.org.nz/resources/videos/

Safety and Health

Work Safe:

https://www.worksafe.govt.nz/topic-and-industry/agriculture/tree-work-on-farms/managing-a-safe-and-healthy-small-forest-harvest/

NZ Farm Forestry Association:

https://www.nzffa.org.nz/farm-forestry-model/the-essentials/health-and-safety/small-scale-forestry-safety-guidelines/

HARVESTING TŌTARA

HARVESTING TŌTARA

Introduction – is harvesting tōtara okay today?

Legendary and divine status

Tōtara – A natural and cultural history is the title of the consummate book on tōtara by Philip Simpson. As the title indicates, tōtara is a legendary pillar of our environment and cultures. The book relates how for Māori, tōtara has divine status as the first big tree created by Tāne following the separation of Ranginui and Papatūānuku and how it is deeply interwoven through a wealth of cultural traditions and part of our combined cultural heritages. It also relates how tōtara is associated with the big win for the conservation movement, with the treetop sit-in protests saving tōtara stands at Pureora, which ultimately led to the end of native logging on state-owned land.

Nowadays it would be sacrilege for anyone to suggest a return of logging to the public conservation estate. And, thankfully, this protected status is unchallengeable.

Others would go further and contend that a sustainable native timber industry will do more to encourage the planting and management of more native forest in our primary production landscapes.

Contemporary views on harvesting

With all this hallowed background it is no wonder that many people ask if you are even still allowed to cut down tōtara anymore? The short answer is yes – but only on private land, (and the various legal processes will be outlined further on). But really, the first question should be is it even appropriate to still be harvesting tōtara today?

In the final statement of Philip Simpson's book, he sets out a plea for the conservation of tōtara, however, it also states his 'support for the development of a sustainable timber industry based on second growth [i.e., the forest resource regenerating on previously cleared or logged land and new planted forests]'. This may recognise that, in some situations, sustainable harvesting can be compatible with conservation, at least at a landscape scale. Or perhaps it just affirms the valuable cultural connections to the forest that come with some continued ability to use native timber.

Actions an expression of values

Either way, **appropriateness** of any harvesting depends on a range of considerations sensitive to both the site and the wider landscape context - and ultimately, at the individual tree level. It is a question of far more than just legalities because forests, especially native forests, are always far more than just wood. Our actions and forestry practices inevitably reflect and express our attitudes, values, and relationship to nature. In many instances, yes, harvesting tōtara and other natives will be okay. However, such decisions and actions should always be made with full reverence, cognisant of the mistakes of the past, and considerate of present and future generations.

Harvest is an opportunity to demonstrate that we can do things right. It can express both restraint and respect.

The legal situation

Fortunately, there are legal provisions under the Forests Act 1949 to enable the harvesting and milling of native trees on private land. Several other sets of legislation may also apply to the actual harvesting operation. These include the Resource Management Act 1991 (RMA), the Health and Safety at Work Act 2015, and the Forest and Rural Fires Act 1977. And there may be others.

While some aspects of the current regulations are commented on in this section, no attempt to comprehensively cover all relevant legal and regulatory aspects will be made here. Responsibility lies with the readers to inform and update themselves on all legal matters. And this chapter will not replicate what can be found out from the official channels such as the content and process of preparing a Sustainable Forest Management Plan and Permit applications, etc. Nevertheless, a brief outline, some useful links, and some specific comments on the current legal situation are offered below.

Main contacts for advice on rules and regulation include:

The Forests Act

For official information and advice on all matters to do with the legalities, provisions, and processes of harvesting and milling timber from indigenous forests and trees – planted or natural, contact:

Te Uru Rākau New Zealand Forest Service: https://www.mpi.govt.nz/forestry/native-indigenous-forests

The email address of the Indigenous Forestry Team is: indigenous.forestry@mpi.govt.nz

Useful downloadable resources on this website include guides on how to estimate and measure merchantable volumes of trees and logs for indigenous species.

Resource Management Act

Regarding the RMA and potentially relevant local rules and consent processes, refer to the maps and relevant sections of your respective district and regional plans. Official advice from a duty planner at your respective district/ regional Council is usually provided free of charge.

Safety and Health

In relation to Health & Safety matters, please check your obligations with WorkSafe - Mahi Haumaru Aotearoa: https://www.worksafe.govt.nz

Tree felling is a notifiable work. And the WorkSafe website has information, links, and downloads, on many aspects of 'Tree Work' including planning and managing small harvests and safe manual tree felling etc. Some relevant Approved Codes of Practice (ACOPs) are also available. These include:

- Safety and Health in Forest Operations: https://www.worksafe.govt.nz/topic-and-industry/forestry/safety-and-health-in-forest-operations
- Safety and Health in Arboriculture: https://www.worksafe.govt.nz/topic-and-industry/forestry/health-and-safety-in-the-arboriculture-industry/safety-and-health-in-arboriculture

The Forests Act

The purpose of Part 3A of the Forests Act "is to promote the sustainable forest management of indigenous forest land". However, planted, as opposed to naturally established native forests, are treated differently under the Forests Act.

Planted native forests are exempt from the sustainability requirements of the Forests Act

In short, planted indigenous forests are not required to be harvested sustainably under the Forests Act. In other words, they can be clear-felled just like an exotic woodlot - if the owners choose to do so. Indeed, owners can have their planted native forests certified by Te Uru Rākau, as Planted Indigenous Forests. This will exempt those planted forest areas from being subject to the sustainable management requirements of the Act that otherwise apply to indigenous forests on private land.

However, there are still some obligations for record keeping, etc., to ensure that the timber is legally milled, so it can be legally sold. The milling of any native timber involves the Forests Act even from planted indigenous forests.

"Planted tōtara forests can be harvested like exotic woodlots – but the milling of the timber still involves the Forest Act"

The relative freedom from legal encumbrances for planted native forests will be reassuring for many landowners interested in some long-term timber production. Fear of legal impediments and not being allowed to harvest, has been a disincentive for many landowners contemplating planting native forest, or allowing natural reversion.

Having your planted native forest areas certified and mapped by Te Uru Rākau as a Planted Indigenous Forest, keeps the harvesting options open. Forest owners or managers can still choose to apply continuous cover forestry practices when the time comes.

Natural forests must be sustainably managed

In contrast, harvests from non-planted native trees and forests (i.e., remnants or naturally regenerated forests/trees) are more strictly controlled by Te Uru Rākau - The New Zealand Forest Service (the division of the Ministry for Primary Industries that administers Part 3A of the Forests Act 1949).

Sustainable harvests of indigenous forests on private land are possible via Sustainable Forests Management (SFM) Permits, and SFM Plans. These allow the harvest of indigenous timber at a rate that is no greater than the forest's ability to replace the harvested timber. At the same time, the forest must retain its natural values and ability to continue to provide a full range of products and amenities in perpetuity. The management of the forest must protect the forest's flora and fauna through the control of pests and weeds, and through the maintenance of soil and water quality.

There are also some minor miscellaneous provisions in the Act for harvesting and milling small quantities but where sustainability is not a focus (e.g., salvaging dead trees, trees cleared for fence lines, or tracks, etc., or some timber for a landowner's personal use but not for sale, etc.).

Sustainable harvests under the Forests Act

Sustainable Forests Management (SFM) Permits, and SFM Plans allow:

The harvest of indigenous timber at a rate that is no greater than the forest's ability to replace the harvested timber. At the same time, the forest must retain its natural values and ability to continue to provide a full range of products and amenities in perpetuity. The management of the forest must protect the forest's flora and fauna through the control of pests and weeds, and through the maintenance of soil and water quality.

SFM Permits and SFM Plans

Generally, commercial timber harvesting from existing tōtara forests will involve a SFM Permit, or a SFM Plan. The difference between the two is that SFM Permits are simpler, cheaper, and could often be done by the landowner themselves. But they only crudely effect sustainable management. They only have a ten-year life and were really intended for one-off harvests.

In comparison, SFM Plans are more sophisticated. They require greater levels of forest inventory and more detailed forest management prescriptions based on an ecological understanding of the forest. They have a minimum term of 50 years (and can be much longer), and therefore also provide greater protection for the forest as well as enabling ongoing sustainable harvesting.

Although SFM Plans generally cost more than Permits, they should be the preferred option in most instances. They are the only provision to adequately ensure sustainable management and secure confidence in long-term sustainable timber supply. The latter should be important for the landowner and is essential for the development of a sustainable tōtara timber industry.

"SFM Plans should be preferred over SFM Permits"

Farm tōtara – a square peg in a round hole

Unfortunately, many naturally regenerated tōtara forests, particularly on farms, are an awkward fit for the SFM Plan provision of Part 3A of the Forests Act. This part of the Act applies to all native forests, but it was designed and intended for application to discrete areas of remnant native forest. The authors didn't envisage the highly modified, highly variable, sporadic, and spreading, areas of regenerating scrub and tōtara forest on previously cleared land – especially within farmland. Consequently, many tōtara forests are only awkwardly accommodated within the SFM Plan and Permit provisions of the Forests Act. Nevertheless, it can be done.

The Northland Tōtara Working Group has worked with MPI on developing and trialling templates for tōtara SFM Plans, to address those difficulties and reduce the cost and time associated with applications.

Arguably, regenerating tōtara forests on previously cleared land should have a specific provision under the Act. One that better suits the nature and characteristics of the resource. However, that would require an act of parliament to change the legislation. While that may occur one day, it doesn't seem to be a topic of political interest at present. But at least we still have some legal provisions that can be made to work – even if clunky, costly, and very time consuming.

Encouraging SFM Plans

Landowners should be encouraged to prepare and register SFM Plans over their developing tōtara forests. The benefits include securing the legal right to long-term sustainable timber harvesting. It can also help reconceptualise immature reverting scrub areas as valuable developing native forest and affirming that as the land use. This in turn, should encourage greater care, tending and protection of these areas. Furthermore, for the development of a viable tōtara timber industry, it is essential to have confidence that a commercially scaled, sustainable resource, is available and has legal market access.

The collective scale of the tōtara resource across multiple properties is a significant feature. Ultimately, SFM Plans will be the basis of any collective management/processing of the tōtara resource and its marketing, to the advantage of the landowner and industry (e.g., Co-ops etc.).

SFM Plans secure the sustainable management of native forest areas on private land. Therefore, they should be recognised as helping to fulfil obligations of appropriate environmental management, for example, as part of Farm Environment Plans and Significant Natural Areas (SNAs), etc.

"Landowners should be encouraged to prepare and register SFM Plans over their developing tōtara forests. The benefits include securing the legal right to long-term sustainable timber harvesting."

"For the development of a viable tōtara timber industry, it is essential to have confidence that a commercially scaled, sustainable resource, is available and has legal market access."

Costs of a SFM Plan

Presently there is no processing fee for a SFM Plan application. However, there are still significant costs involved, and the process takes considerable time – allow at least 6 months and more likely a year. For most landowners, a forestry consultant will be required to help prepare a SFM Plan application.

Once approved by MPI, a SFM Plan still needs to be registered on the land title/s. While some conveyancers can economically provide this service for less than $300, many people prefer to use their lawyer at greater expense. In addition, an Annual Logging Plan is also required for approval before any harvest can commence. In addition, record keeping during and after harvest is required. However, these are relatively smaller costs.

The total costs of SFM Plans vary considerably. The field inventory work is the biggest variable. The size of the forest and its characteristics will significantly affect the relative cost. It is probably unwise to try and attempt an indication of likely costs. However, two tōtara specific SFM Plans completed and registered in recent years revealed costs ranging from the equivalent of around $300/ha for a 50ha forest area, to $600/ha for a 12ha sized forest. Clearly there are economies of scale at play. But perhaps more useful information is that, in theory, the stumpage value of around three to four years' annual harvest allowance could recover the respective costs of each of those SFM Plans.

Indeed, in one case, that was done. A mean stumpage value of $200/m^3 meant that 80 m^3 of logs - nearly four year's annual harvest allowance - covered the costs of setting up the SFM Plan. Future harvests do not involve repeating that cost. However, that forest was already well-stocked with merchantable-sized trees.

In summary, there are significant expenses involved with obtaining a SFM Plan for tōtara dominant forests. And while every forest will be different, for many tōtara forests it is reasonable to expect that, in time, those costs could be recouped via income from harvests. This could even be in the first harvest via the provision to allow 'periodic harvesting' whereby up to 10 years' worth of annual harvest allowance may be harvested in a single operation.

Tax implications

Questions have been raised regarding potential tax implications arising from a SFM Plan changing what has traditionally been considered 'worthless' scrub or bush, into a forest that is accruing a valuable stock of trees. Unfortunately, we do not have any expert knowledge or advice on any potential taxation implications. Landowners should seek qualified advice on that matter.

The Resource Management Act applies via Regional and District Plans

Obtaining approvals to harvest under the Forests Act does not override any other regulations that might also apply. In particular, the Resource Management Act (RMA) also applies and might have implications for harvesting from native forests on private land. This will primarily be through the maps and rules of the respective regional and district plans. These plans need to give effect to the RMA and National Policy Statements, etc.

Therefore, it will be important to check the planning maps to establish if the forest area is within an Outstanding Landscape Area, or Significant Natural Area (SNA), or captured by any other notation to which special rules may apply. Also check general rules pertaining to indigenous vegetation within the given zone.

In some district plans, harvests of indigenous trees under the MPI approved provisions of the Forests Act have had the explicit status of "Permitted Activity". Other district's plans have simply not addressed the matter. And, unfortunately, in some districts, or within certain mapped areas, such as Significant Natural Areas (SNAs), a Restricted Discretionary Consent process is stipulated.

District plans typically have a ten year life. So, the given situation can also change with each review. Naturally, the uncertainty around this created by some district plans, and the potential extra costs and time, is a worrying disincentive for many landowners considering sustainable native forestry.

At the time of writing this chapter, a Draft National Policy Statement on Indigenous Biodiversity has been put on hold for the time being. However, such policy documents are to be given effect through regional and district plans. Requirements for those local authorities to map sensitive landscape areas such as SNAs and apply rules to protect indigenous biodiversity and the environment, may have implications for harvests under SFM Plans and Permits unless they are explicitly afforded "Permitted Activity" status. Landowners should make submissions on such matters whenever a District Plan review and consultation process occurs.

Summary of legal situation

Disincentives exist but plenty of reasons for optimism

At present there are some difficulties, significant costs, and ongoing record-keeping obligations associated with SFM Plans to enable the sustainable harvesting of tōtara from natural forests. Furthermore, there is uncertainty around potential restrictions, additional costs, and processes, imposed by district plans on the activity. The combined effect of these disincentivises native forestry for many landowners. This is a frustrating and perverse situation given that sustainable native forest management is comparably one of the most benign and desirable land uses – indeed, a land use that should be encouraged. However, it is important to keep these matters in perspective and to acknowledge that some regulation is not only inevitable, but also desirable. For it is vital that any native forest industry has robust sustainability credentials.

Ultimately, some regulation is necessary and should be a positive safeguard, to the benefit of all stakeholders in the native timber industry. However, fine-tuning and adjustment of regulatory controls is needed and likely to be a continual process of evolution.

Hopefully landowners can take a philosophical view on this and not be put off by the current imperfections of the regulatory situation. These can be worked on and changed. Government agencies are aware of many aspects that need addressing, and, importantly, policymakers are generally supportive of encouraging indigenous forestry. This augurs well for the development of a more conducive regulatory environment for native forestry generally.

With this optimistic view, perhaps landowners can take heart from knowing that their trees will keep on growing regardless of the regulatory situation at the present – the rules will have to catch up, and they can. It is reasonable to proceed and start sustainably managing native forests now. There is legal provision to do so, and public support for sustainable native forestry is likely to increase. Furthermore, many other land uses, including plantation forestry, are likely to encounter increasingly difficult regulatory controls.

Therefore, in summary:

- There are legal provisions (under Part 3A of the Forests Act) to enable the harvesting of tōtara on private land.
- Sustainable Forest Management (SFM) Plans under the Forests Act and registered on the land title are recommended to secure long-term management rights and outcomes.
- Significant costs and time are involved with obtaining a SFM Plan. However, those costs may be recovered, over time, through harvests.
- The regulatory framework maybe subject to changes in the future.
- Indications are that policymakers are becoming more supportive of native forestry in principle, and aware of the need to encourage it as a land use by creating a more conducive regulatory framework.

"Trees keep growing regardless of regulations. Sustainable management is really doing the right thing - the rules can catch-up later."

Sustainable harvesting concepts

More than just timber

The majority of tōtara harvests will involve naturally regenerated trees and forests on previous cleared land, or 'second-growth' in cut-over bush, or from remnants of older bush. The nature and characteristics of these forest types will vary hugely. Yet, they are all subject to Part 3A of the Forests Act, which promotes an ecosystems-based approach to forest management. This allows a sustainable timber yield, while at the same time requiring the protection of the forest, retention of its natural values, and the maintenance of soil and water quality.

Many tōtara forests are highly modified, such as the almost mono-cultural stands of branchy tōtara seen in paddocks on Northland farms. Nevertheless, the 'Act still applies, although its requirement to retain the forest's natural values raises many questions. What are the 'natural' values of such modified forest types? What characteristics are to be retained? A pragmatic approach is simply to aim higher than mere maintenance and instead seek to improve the ecological and other non-timber qualities to be more like a natural (less modified) native forest for that area – even if this is slightly at odds with the stipulations of the Act.

Fortunately, management criteria for a sustainable timber yield are more straight forward.

Forest inventory and harvest rates

Sustainable timber yields are determined by calculations. These are based on field measurements of sample plots from within the particular forest (known as a forest inventory). These are used to estimate the total standing volume of merchantable tōtara logs within the forest. They also provide a profile of the size-classes of the tree population (i.e., relative numbers of seedlings, poles, and trees of different sizes). Then, taking into account factors such as natural mortality, regeneration, and recruitment, etc., the forest's likely mean annual growth increment (for standing merchantable volume) is modelled. And a sustainable harvest allowance is set at a rate less than that at which the forest grows, ensuring the volume of the harvested trees will be replaced by the growth of the remaining forest.

Permanent sample plots (PSPs) should be set up within the forest to enable periodic remeasurements to prove the allowable harvest is accurately indexed to the specific forest's growth rate. PSPs also help monitor other changes within the forest over time.

While, in theory, sustainable management is all very measurable, in practice, the natural variation within natural forests makes obtaining an accurate inventory of the tree stocks very difficult. Consequently, a conservative approach to the setting of allowable harvests by Te Uru Rākau (MPI) usually results. It also highlights the reality that sustainable forest management is really a bit of blend of art and science.

Forest management systems

The Forests Act prescribes a selection-system for all podocarp tree species, based on single-stems or small groups (defined, in the MPI guidelines, as 3-5 trees). This is similar to international forest management concepts variously known as **selection forestry and irregular shelterwood systems**. These come under the broader umbrellas of terms such as **close to nature forestry, near-natural forestry, and continuous cover forestry.** Effecting sustainable management is the common objective and some key general principles include:

- The forest is permanent and for long-term, intergenerational benefit.
- Multi-purpose forest management (i.e., it is not just about timber, but all forest values).
- No large clear-fell harvest areas.
- Working with nature – adopting an ecosystems management approach (e.g., utilise the advantages of natural features and processes such as natural regeneration).
- Maintain or create a full and healthy population profile of the target tree species in all size-classes (i.e., sufficient stocks of seedlings, saplings, poles, and immature trees for selection and as 'recruitments' to replace harvested trees.
- Leave some large old trees for wildlife and habitat value.
- An adaptive management approach is necessary, based on measuring and monitoring changes and trends within the forest.

"Native forests have multiple values. They are not just about timber – it is about managing an ecosystem."

3 years after a tōtara harvest in this forest reveals abundant new puriri seedlings in the light-wells around harvested stumps.

Basic principles

More specifically, and regarding sustaining a timber yield, basic principles include:

- Harvesting at a rate no more than the forest can naturally replace itself at – or in the case of young developing forests, at a rate less than the annual net growth increment of the forest, so the timber resource increases to its optimal stocking.
- Not harvesting only the best trees. That would be 'creaming' or 'high-grading' the forest and over the long-term will rundown the quality of the forest. It would be equivalent of a farmer selling all the best breeding stock and keeping the culls.
- Treating harvest as a silvicultural intervention for stand improvement (e.g., production thinning). Where feasible, target the poorer trees for harvest and removal from the forest – leaving the better ones to grow on, to become higher-value saw logs.
- Harvest mature trees when they reach the point where keeping them longer would not greatly improve their value, and/or they are at increased risk of internal degrade from fungi, etc.

Plenterwald

The single-stem, or small group selection approach stipulated by the Forests Act, is similar to a German forest management approach that results in a mixed species, mixed age and mixed size-class forest structure known as Plenterwald. Harvests in such forests keep targeting the poorly-formed trees so, over time, the forest becomes fully stocked with well-formed, high-quality, large-diameter trees, but also has the full range of size-classes from seedlings upwards, and all in close proximity to each other. However, this selection system best suits shade-tolerant target species.

Adaptive management

Tōtara is a light-demanding, pioneer tree species. At this stage, we cannot be certain that single-stem selection systems will create sufficient light gaps to ensure long-term natural regeneration of tōtara seedlings. It could be that single-stem selection just ekes out the tōtara resource, and ultimately results in forest succession to more shade-tolerant species. Only time will tell. This highlights the importance of monitoring, modelling, and adaptive management.

If sufficient natural regeneration is not occurring, then larger disturbance areas created by the small group selection system may be needed. But, if gaps and light-wells become choked with ferns, shrubs, or weeds, then some active interventions, such as weed control, or planting, may also be required. More tōtara specific research will eventually inform on such matters and help refine recommended management systems and prescriptions. In the meanwhile, harvesting from natural forests must follow the dictates of the Forests Act – and our best efforts in appropriate stewardship.

"Work with nature and develop an intergenerational legacy".

Plantation tōtara

Planted tōtara are exempted from the sustainable management requirements of the Forests Act. They could be clear-fell harvested like an exotic woodlot. While this freedom should be kept, it is not the only management option. The forest owner might choose to harvest using a continuous cover forestry system.

This could range from clear-felling small areas or coupes at a time, to the type of single-stem or small group selection system mentioned above.

Tree selection

Wise selection of the harvest trees is probably the most critical factor to ensure truly sustainable forest management, followed by careful felling and extraction.

Harvest as silviculture

Perhaps the ideal approach to harvesting would be to treat harvest as silviculture – more specifically, as a production thinning intervention – i.e., targeting the poorest trees and leaving the best ones to grow on to increase in size and value. In theory, if that were followed, eventually, there would only be good trees left to choose from. However, in practice, there are often many poor trees with little or no sawlogs of merchantable value and targeting only the poor trees may not be economically viable. Therefore, harvest tree selections may need to include some premium grade trees with more valuable sawlogs too. Nevertheless, the emphasis still needs to be on making wise selections to ensure responsible long-term forest management.

"Harvest should be considered silviculture – it should be tending the forest."

Focus on what is left behind

What is left behind is more important than what is taken. 'Creaming' the best trees must be avoided. There is a saying: "wood only grows on trees" and good wood only grows on good timber trees. If they have been removed, then where is the wood growing and what quality will it be? Appreciable quantities of high-value heartwood are only found in old large tōtara trees. Regular harvests of high-value tōtara in the future, will rely on leaving enough good quality trees to grow on and become the premium-quality heartwood trees of the future.

"Identifying the trees to keep helps select the trees to harvest."

Identifying the premium trees to stay

European close-to-nature forestry systems typically identify those potential premium 'future trees' and harvest any trees around them if they compete with them. The future trees or frame trees are potentially high-value crop trees often grown to large-diameter veneer-grade logs. They are eventually harvested at a diameter of maximum value. Getting them to that size and quality as quick as possible is a management objective – but it may take 150-240 years!

For tōtara in Aotearoa, the equivalent may be identifying trees that have the potential to produce clear heartwood, or become premium carving logs, even waka. Identifying the best trees to stay, is one way of helping to decide which trees to harvest.

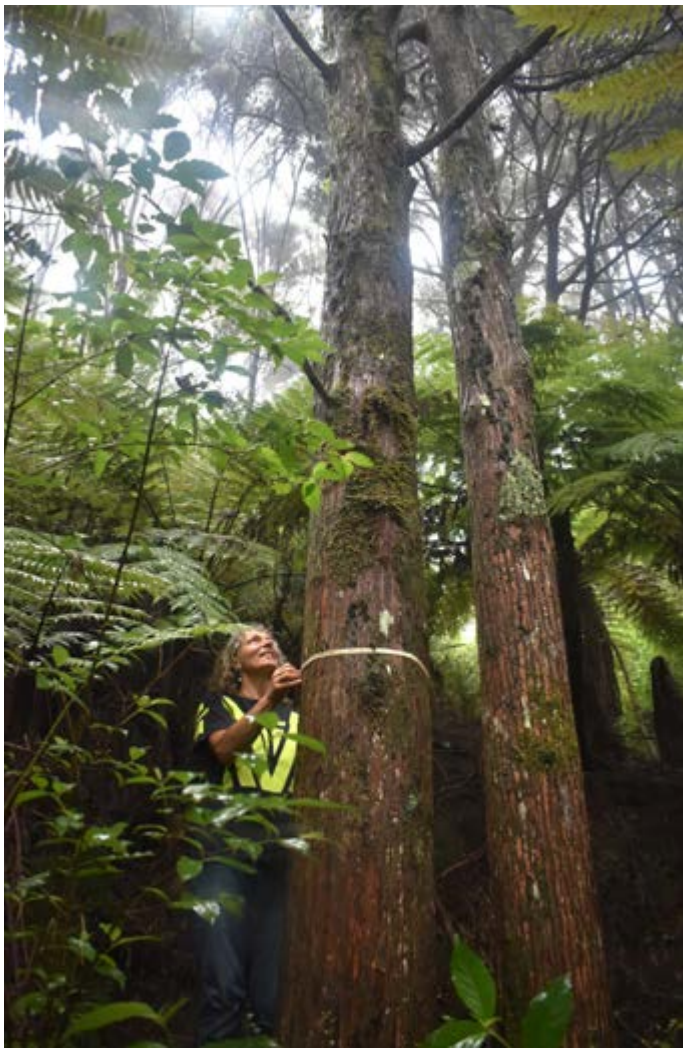
Obvious opportunities

Fortunately, it is often possible to find instances where two or more trees with reasonable quality sawlogs are located close together, and removal of one or two of them could be like thinning, and to the advantage of the ones left behind. Often the larger-diameter trees have shorter and knottier boles and large crowns, and their removal may be to the advantage of skinnier, but taller-boled trees, that if freed from competition, have the potential to develop equal or better-quality sawlogs. In such instances, appropriate selection of the harvest trees could help increase the mean bole height of the forest and ultimately increase the timber volume and value in the forest.

Two excellent trees side by side. But the tree on the right has some dead spike branches. Harvesting that tree would enable the tree on the left, which has an even better, branch-free bole, to grow larger, faster, and become even more valuable.

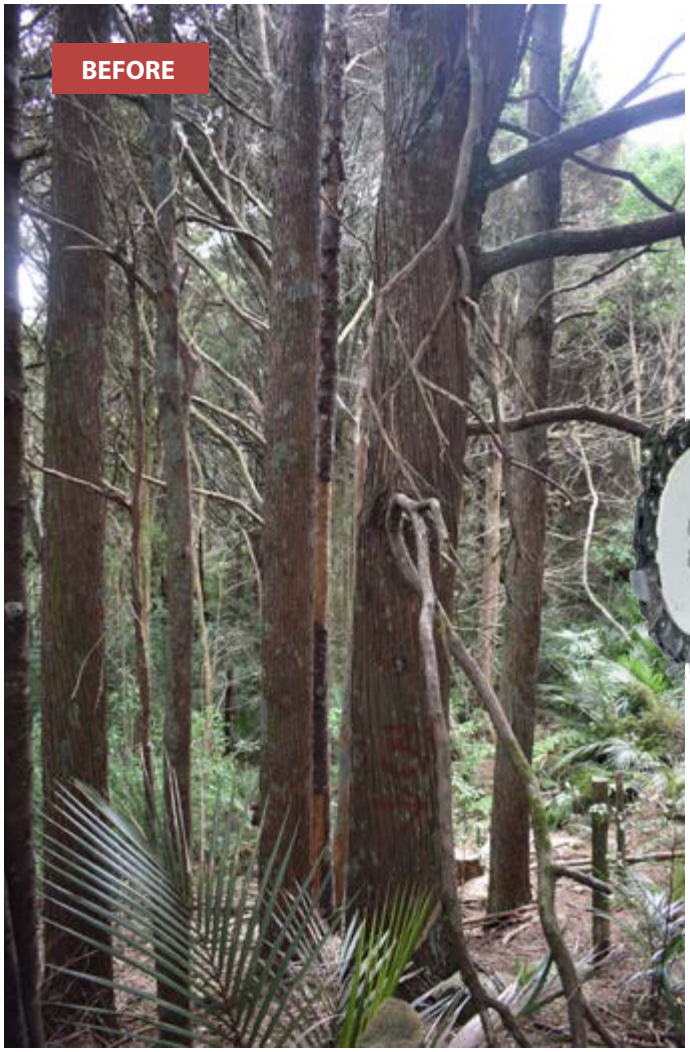
In other situations, it may be advisable to take all of a small group of trees. For example, where all the trees have some merchantable sawlog volume, but none have potential to become excellent timber trees. Or where felling one tree is likely to damage the adjacent trees, or for safety reasons.

In these instances, harvest removes trees of poor/mediocre timber-quality and creates a canopy gap within which natural regeneration might restock that area with new trees that could be managed to have better timber potential.



Right: Some harvest tree selections are easy to make. In this case, harvesting the tree with the shorter, fatter, and branchier trunk, will be to the advantage of one left behind, which has a potential to become a more valuable timber tree. It has a taller, and less branched bole, but a suppressed crown.

Below: In some areas only poor and mediocre trees are present. Leaving them to grow on will not increase their value. Harvesting such trees, as a small group, may create the opportunity for natural regeneration to replace them and restock this area with young trees that could then be managed to have better timber quality.



Left: A dense group of merchantable sized tōtara trees before harvest using a production-thinning approach.

Below: The same stand after harvest. The trees with the best form and potential to produce high-quality timber are retained. The branchier and shorter-boled trees were production-thinned (harvested). Careful extraction avoided damage to the residual trees.

Stocking rates and tree spacing

Harvests in natural forests will be a case of working with what is there. The stocking rate and tree quality will be highly variable. The practical approach is to thin around the 'future trees' that have been selected to stay, and to create sufficient space for them to develop large green crowns to promote their growth. Depending on the mean size of the trees, the average spacing, or stocking per hectare, will vary.

Residual trees with diameters at breast height of 40cm should be spaced around 5.0m apart. Larger trees require greater spacing. The 60cm diameter trees should have around 7.0 to 9.0m between them, and larger trees up to 14m. However, this should not be applied as a rigid rule. The overall stocking per hectare is more important than the exact spacing between individual trees.

Table 6. Guide to post-harvest stocking rates and tree spacing in tōtara plantations

DBH* cm	Stocking (after harvest) Stems/ha	Approx. mean spacing*** m.
25	550	4.2
30	500	4.5
40	400	5.0
50	275	6.0
60	120-200	7.0- 9.0

* Quadratic mean DBH of merchantable-sized trees

** N.B. – Harvest pruned trees from 50cm DBH if max. DOS does not exceed 16.5cm. Otherwise target harvest diameter at 3x max. DOS value (e.g., 60cm harvest diameter for 20cm max. DOS)

*** N.B. – Mean tree spacing is a guide only and does not need to be rigidly applied. Overall stocking per hectare is more important than even distances between trees.

"Harvest tree selection should be done by the forest owner or manager, not the saw miller!"

Harvesting pruned trees

If the trees have been pruned in the past, it is essential to know what the maximum DOS (Diameter over pruning stubs) was, as this dictates the minimum target harvest diameter. Generally, the target harvest diameter should be three times the DOS value. For example, if the DOS was 20cm (i.e., trees up to 20cm stem diameters were pruned), then the minimum target harvest diameter is 60cm. N.B., See the chapter on Pruning Tōtara and video: https://vimeo.com/580207222

If pruned trees are harvested before they have sufficient clear-wood over the pruned stubs, then the pruning effort will have been wasted and the timber will have defects in it that down-grade its value.

Minimum harvest tree size

For SFM Permits and Plan inventories, trees with a 30cm DBH and above, are generally considered to be of merchantable diameter, and their merchantable log volume is considered to go down to 150mm at the small end diameter. In practice, sawn timber can even be recovered from smaller diameter logs. There is no minimum size for a harvest sawlog. If you can find a market or viable use for the timber, then that will determine what is merchantable or not.

Justifying the harvest of big trees

It is also okay to harvest some big premium quality trees where there are sufficient trees in the forest that are ready to move up into that size class, and replace the volume taken. And at some point, there may be little extra value gained by keeping the tree longer. Moreover, age may increase the risk of pathogens devaluing the stem with rot or discolouration caused by fungal attack such as **Kaikaka** - that peculiar pattern of pocket heart-rot common in old-growth tōtara trees (but not a feature of timber from younger regenerated tōtara trees).

An Austrian forestry book (Handstanger, 2006) warns that a red-brown fungal discolouration of the timber is common in conifers grown on land that had previously been in pastoral use. Much of the regenerating tōtara resource is on farmland, and harvests from Northland farms have noted concerning discolourations at the butt end of large, quickly grown, second growth, tōtara logs. The source or implications of this discolouration are unknown. However, it may be that such trees are more prone to pathogens and early death. They may not have the potential to become large, old-growth trees.

Make decisions in the field

Tree selections should be made in the field – but not with a chainsaw in the hand! Unhurried, carefully considered decisions are needed. This is best done by considering each individual tree within its immediate context and imagining the future growth and structural changes of the forest. All sustainable forest management principles and objectives should be kept in mind. The 'Frame trees' to stay (potential high-quality future crop trees) should be identified not for harvest, but for protection - to grow on. Then the potential harvest trees should be identified, measured, and marked-up in a separate action before felling.

Harvesting this large, 92cm diameter tree, proved to be a good decision. A hidden pocket of heart-rot was revealed. Keeping that tree longer would not have increased its timber value. It could be felled with minimal damage, and there were plenty of regenerating trees around it to replace it, and other old moribund trees for wildlife habitat.

Harvest tree selection considerations

Tree selection is not easy. Complex interrelationships exist between trees that we don't fully understand and can't predict. In addition, conflicts may exist between some of the management objectives and competing considerations may need to be weighed. Some key considerations include:

- Retaining and improving sustainable tōtara timber production potential from the residual forest (e.g., selecting premium-quality future crop-trees to stay and grow on and creating space for them to develop large green crowns).
- Reducing the poor-quality or non-merchantable component of the forest and promoting new opportunities for regeneration that can be better managed for quality timber production (e.g., production thinning objectives)
- Keeping very large trees purely for wildlife and habitat value.
- Determining what is merchantable and viable to fell and extract.
- Practicable extraction and machinery requirements/availability.
- Target harvest diameters based on maximum DOS (Diameter over stubs)- if the trees have been pruned.
- Avoiding damage to non-target native tree/shrub species (with priority given to less common species over the more common).
- Avoiding/minimising potential damage to residual tōtara trees from falling, access and extraction.
- Ecological, environmental, and/or cultural values within the fall-zone that need protection (such as presence of rare plants, or wildlife, e.g., kiwi burrows, and bat roost trees).
- Maintenance of a protective edge to stands in respect to adverse effects of wind and light and weeds.
- Minimising risk of damage (breakage) of target tree.
- Avoiding/minimising risks to personnel health and safety, and physical and environmental property damage.
- Chances of weed ingress.
- Inclusion of merchantable tōtara trees accidentally damaged in operations in the harvest volume.

Perfecting the sustainable management of tōtara forests is likely to be a process of continual refinement. But the focus of any responsible harvest should always be on what is left behind.

"Select premium 'future trees' to stay, and harvest competing ones around them"

"Don't cream all the best trees from your forest – good timber only grows on good trees!"

Harvest season

On many soil types, extraction of tōtara logs will be practically restricted to summer and autumn, when soil conditions are hard and dry, although a network of good tracks within a forest area may extend the windows of opportunity.

Felling & extraction in one operation

Felling and extraction can be done together in one operation, by the same contracting crew. The advantages of this combination include having extraction machinery on-site to assist with directional felling, or the falling of difficult or dangerous trees, and hang ups, etc. Also, it enables a more accurate assessment of how feasible the extraction of each tree will be before it is cut down. And it reduces the risk of making a mess of tracks and paddocks, or having to leave fallen trees in the bush, because you couldn't get extraction machinery on site before the weather broke.

When the 'sap is down'

Traditional bushman advice was to cut native 'when the sap was down', which is generally inferred to be from mid-winter. This may have its roots in European forest practices where winter logging was preferred for several reasons. These include frozen ground and watercourses affording better access and/or protecting the soil from compaction, the bark of residual trees being less likely to be bruised off or damaged, and the avoidance of sap-stain, fungi, and insect attacks on the harvested logs, but also better-quality timber (less shrinkage when drying, etc.) even alleged better durability of the timber in service.

However, expensive harvesting machinery works year-round - even in Europe. So, presumably the superiority of timber from winter-cut trees over summer-harvested trees, is not so great as to preclude summer harvests. Nevertheless, the question remains – what is the best time to fell tōtara in New Zealand?

Winter versus summer felling?

The potential superiority of timber from winter cut tōtara, particularly for the sapwood, has not been tested. It would be good to have research to inform on the topic. It is easy to imagine that less starch and moisture in the sapwood could result in less food and harder going for fungi and insects – but that remains supposition.

Tōtara logs left lying for extended periods in the bush, or damp conditions, are susceptible to sap-stain and the two-tooth borer (*Ambeodontus tristus*) entering under the bark and tunnelling into the sapwood. It is not known if the sapwood from tōtara trees felled in winter is less susceptible, but if the bark is removed from the logs, and they are stored off the ground, then those risks also appear to be avoided. However, the catch is, that the bark does not peel easily from logs in mid-winter. In contrast, the bark does peel easily from tōtara logs 'when the sap is flowing' – presumably relating to the periods of growth, and usually through the summer.

Certainly, once milled and air-drying, neither sap-stain nor borer appear to be a risk. From experience we know that timber from tōtara trees felled in summer through to autumn, and milled within a month or so of felling, has performed very well without noticeable issues. Minimising the time between felling and milling may be an important factor, and this may be more practicable with summer harvests.

At this stage, no obvious problems resulting from summer harvesting have been observed. In warm, humid weather, black mould can develop on the surface of freshly peeled logs and freshly sawn sapwood timber. However, this does not appear to be anything more than a surface bloom without lasting effect once the timber dries. A spray with a contact fungicide (or anti-sap stain solution – e.g., AP 5, by Churton Pacific Ltd.), inhibits such mould growth. Otherwise, protecting freshly sawn timber from overnight dew, with some roofing iron, will generally avoid the issue.

The larvae of the Two-toothed borer (*Ambeodontus tristus*) can get in under the bark of logs left lying for extended periods in the bush – especially if in damp conditions. However, this does not happen if the bark is removed, or once the log is milled. The larvae feed on starch in the cambium under the bark and then eventually tunnel into the sapwood to pupate.

Tōtara logs stored for extended periods before milling should be debarked and stored off the ground to avoid damage to the timber by the Two-tooth borer and/or, risk of sap-stain. A spray coating of a contact fungicide (e.g., AP5 by Churton Pacific Ltd.), will inhibit mould growth on the surface of the log.

Tōtara logs store best without their bark and in dry locations, with good air flow – preferably off the ground.

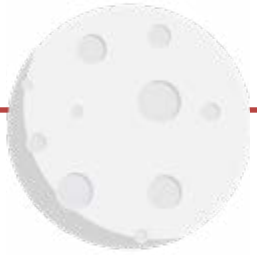
Lunar cycles and Maramataka

There are many cultural traditions concerning the felling of trees for wood use according to seasons and even monthly lunar cycles. Some go back 2000 years or more. Interestingly, many of these traditions generally align to support the felling of trees in mid-winter and in a waning moon phase.

Some European research (Zürcher, E. 1999) purports inexplicable but measurable differences in some physical timber properties between samples of Norway Spruce felled before the full moon, compared to those felled before the new moon (i.e., during a waning moon phase) – with the latter considered to have slightly better properties for construction purposes.

Surprisingly, there seems to be little research investigation of these phenomena even though it is conceivable that there may be some market interest in it. Indeed, an internet search reveals some businesses marketing "moon wood" as a feature and point of difference.

Māori cultural protocols are very relevant to the harvest and use of tōtara in Aotearoa. Where possible harvests should continue local maramataka (Māori lunar calendar) traditions.



Maramataka

Based on the *maramataka* of Ngāti Miro in the Whangaroa area, rongoā practitioner Thomas Hawtin, suggests the best time to fell trees for timber harvest is *Rākaunui* and *Rākautohi* – which are 2-3 nights after the full moon, and otherwise during the waning moon phase.

Planning a tōtara harvest operation

Management

There is a lot involved with planning and managing even a small forest harvest. There are obligations on the forest owner/manager to ensure such things as health and safety are appropriately being managed, and many other aspects need to be well coordinated in advance.

Some useful website links for guidance include:

- Te Uru Rākau: https://www.canopy.govt.nz/harvest-forest/harvest-land/plans/
- NZ Farm Forestry: https://www.nzffa.org.nz/farm-forestry-model/
- WorkSafe NZ: https://www.worksafe.govt.nz/topic-and-industry/forestry/
- Safetree: https://safetree.nz

Engaging a professional forest manager

Many landowners would find engaging a professional forest manager the easiest and safest option. However, the cost of engaging a consultant to plan and manage a small-scale native forest harvest will be disproportionately high for the small volumes involved. Few professional forest managers have expertise and experience with selective tōtara harvests or indigenous forest management. Nevertheless, professional forest managers will be well-versed and up to date on generic matters such as health and safety, standard contract documentation, and may know suitable contractors, etc.

Site visits essential

It is essential for the prospective contractors to visit the forest with the forest owner/manager to properly discuss and scope the harvest works.

Contracts

Written contracts with harvest contractors are important for any timber harvest. These should cover the responsibilities and expectations of both parties, timeframes, insurance requirements, payments, etc., and also the many 'what if' scenarios – e.g., damage to property, cleaning up slash, weather caused expenses or delays. Standard template documents may be able to be adapted.

Specific contract details or conditions for tōtara harvests should include the requirements and expectations for low-impact harvest outcomes and avoiding damage to the residual forest and infrastructure. However, defining and evaluating such matters is difficult. How far is a contractor expected to go to avoid potential damage or minimise impacts? This needs to be made explicitly clear. Involvement of the forest owner/manager in the contractor's pre-pricing site visit, and the detailed harvest planning, are ways of addressing this. However, authority and responsibilities for matters such as health and safety, must not become confused or blurred through owner/forest manager's involvement or giving directions on site during harvest operations.

Payment system

Paying contractors for harvest and extraction based on a previously agreed lump sum price, or a value per cubic metre of recovered log volume, is the safest option financially for the forest owner. But an inherent conflict exists between the contractor's interest in efficiency and the forest owner's interest in a careful harvest that protects the residual forest and avoids or minimises damage. For example, there is no incentive for the contractor to spend extra time and care to avoid possible damage if it cost more time and effort (e.g., utilising snatch-blocks, pulling over trees, cleaning up slash, or waiting for tracks to dry, etc.), because it would be at the contractor's own expense.

On the other hand, paying the contractor at an hourly or day rate, runs the risk of an overly costly operation. In either situation, expectations of both parties need to be clearly set out and understood in the written contract agreement. Ideally, the forest owner/manager should be frequently checking the harvest is being carried out according to the contract agreement.

Costs of harvesting

Every situation is different and will need to be priced uniquely. Many factors will cause the costs to vary significantly. However, as a general indication, based on harvests of 30-100m^3 (log volume) of regenerated tōtara on Northland farms in recent years, the cost for the felling and extraction to an on-farm milling or loading site, has ranged from around \$100/m^3 to \$250/m^3 + GST (log volume). That does not include the costs of permitting, harvest planning/management, tree selection and mark-up, or any milling or loading of logs for transport off-site.

Pre-harvest planning check list:

- ☐ Current SFM Plan or Permit registered on the land title.
- ☐ Regional and District Plan rules checked.
- ☐ Potential harvest trees selected by the forest owner/manager and marked-up (numbered).
- ☐ The marked-up potential harvest trees have been individually measured and their estimated standing merchantable volumes recorded.
- ☐ Site visits with prospective harvest contractors, to scope works, discuss equipment and low-impact harvest practice/requirements, identify hazards, and confirm tree selection is practicable, etc.
- ☐ Written contract agreement with harvest contractor signed (evidence of insurances and Health and Safety Plans sighted).
- ☐ Annual Logging Plan submitted and approved by Te Uru Rākau.

Felling, marking, and measuring trees and logs

The following sets out a suggested procedure suitable for adoption in an Annual Logging Plan.

1. WorkSafe NZ shall be notified at least 48 hours prior to tree felling operations.
2. Karakia and best practice health and safety protocols shall be carried out.
3. All personnel shall be made aware of general and specific trees/ items/ values identified for protection immediately around the trees selected for harvest. And before felling, all trees, stumps, and terrain within the fall-zone shall be checked for features and values needing protection (e.g., signs of kiwi burrows, bat roosts, rare trees, natural and cultural heritage features, etc.)
4. Weed control in the fall-zone should occur before felling, if slash/fallen crowns, etc., from harvested trees may restrict access afterwards for such activities.
5. Harvest trees shall be marked (numbered) for clear identification and directional felling.
6. An estimate of standing merchantable volume shall be made before felling and kept as a record and running balance on Schedule 1 (the Tree Felling List).
7. The tree number shall be spray-marked on the stump.
8. GPS locations of each stump shall be recorded on the Harvested Tree Register sheet (Schedule 1 of an Annual Logging Plan) and kept on file.
9. The respective tree numbers shall be sprayed on the LED end of each log. The numbering system shall be: number only (#) for the butt log, #a for the first top log, #b for second top log, #c …. etc.
10. This number system shall be carried forward with subsequential operations including log-making at mill-site and for the milling records.
11. Merchantable volume of each tree shall also be accurately measured after felling and entered onto an attached Harvested Tree Register sheet. A running balance record of the actual harvested volume shall also be kept during the operation to ensure that the approved harvest volume is not exceeded.
12. Clean up of slash shall include ensuring no large branches are left hanging-up against or touching the stems of residual crop-trees or other native canopy tree species where there is a risk that they may cause injury by rubbing, rot or causing the tree to lean or deform.

Harvest contractors, machinery, and equipment

Finding the right crew and combination of machinery to selectively harvest tōtara may be difficult.

Harvest contractors

The Tōtara Industry Pilot project in Northland did not find a perfect set-up or set of machinery and skills for small-scale, low-impact, selective harvests of tōtara. Large forestry contractors had heavy machinery that was expensive to relocate, (i.e., over-size loads requiring an extra 'pilot' vehicle with warning signage to drive ahead of the transporter). And these machines were often too large to comfortably negotiate tight farm gates, tracks, and races.

Dedicated forestry crews were also unfamiliar and lacked equipment for delicate, low-impact, tree work – clear-fell efficiency and productivity are their strengths. It was difficult to even get logging contractors interested in pricing what, for them, would only be a small job with too many complications – especially if pine prices were up and their services were in demand.

In comparison, professional arborists often have the tree skills to execute sensitive low-impact tree felling but lack the suitable machinery, experience and qualifications for log extraction and loading.

Non-professional contractors lack appropriate qualifications, necessary insurances, and health and safety management systems.

There seems to be a lack of contractors with all the suitable skills, experience, and the machinery/equipment to cover the wide range of tasks required for small-scale, low-impact, selective harvesting.

Ultimately, a tōtara timber industry needs specialist harvest contractors, trained, and experienced in selection forestry under the Forests Acts, with suitable machinery and equipment. However, in the meanwhile, engaging a suitable harvest contractor may be a challenge.

Harvest machinery

Logging machinery is expensive and specialised. No one machine can do all jobs efficiently. For example, large >20-tonne grapple diggers are useful for extracting trees from accessible forest margins, and for machine assisted felling, and are needed to load logging trucks. However, they are inefficient in forwarding logs from scattered felling sites to road-accessible loading sites if any significant distances are involved.

Selective harvesting requires very careful tree-felling and low-impact extraction. Machinery should be restricted to skidding tracks and logs winched, with the use of snatch-blocks where practicable, to avoid damaging the residual trees. This is time consuming and results in low productivity in terms of time for recovered harvest volume. Furthermore, sustainable tree selection often involves harvesting trees with defects, or thinning trees with lower-quality logs and value.

Getting multiple heavy machines to site and having them clock up time just to skid out a few small and variable quality logs at a time, or load them, is not cost efficient. Therefore, preharvest planning needs to carefully consider the use of machinery, equipment, and contractor skill sets. These need to be matched to the characteristics of the individual forest (e.g., tracking, accessibility, soil conditions, tree sizes, locations, timber value, and total harvest volume).

The Tōtara Industry Pilot project trialled a range of logging machinery during its harvest operations. These included two-man harvest crews using combinations of:

- D4 TSK skidder (i.e., a 12-tonne bulldozer with winch fitted with 25-30 metres of 25-30mm wire-rope and snigging chains).
- 22-tonne grapple-digger.
- 8-wheeled forwarder.
- Logging trucks with trailer units.

Brief comments on experiences using those machines are set out below.

A D4 TSK skidder is a powerful and safe machine capable of extracting large logs and working in steep terrain.

TSK Skidder/bulldozer

These heavy, tracked machines, are designed and built for forestry purposes. They can make their own tracks, handle large, heavy logs, and turn in tight areas. However, despite their many impressive attributes they are not always the perfect machine for small scale tōtara harvests. Potential disadvantages include:

- Expensive relocation/transport to sites – need significant volumes to warrant the expense.
- Tracked machines are slow at moving logs from felling sites to loading sites. They are an expensive way to skid small logs/volumes over long distances (>250m).
- Large wire rope diameters and powerful winch capacity requires very heavy componentry such as snatch-blocks, shackles, and anchor straps for indirect pulling angles – equipment needed for low-impact extraction. Plus, they are expensive machines to have waiting around while such configurations are set up and adjusted – especially if extracting only small logs and volumes.
- Tracked machines should not enter the forest or travel over tree roots as the grouser tracks easily damage roots – especially when screwing to turn.
- Likewise, repeated travel over paddocks, farm tracks, and manoeuvring at log marshalling areas can also make a mess.

Tracked skidders are built for the job, but they are a slow and expensive way to skid a few small logs over long distances.

Grapple diggers are extremely versatile machines but tracked machines should not enter the forest. They need to stay on tracks or work from paddock edges.

Grapple diggers

Grapple-diggers are extremely versatile. They are perhaps the closest to an all-round machine for well-tracked farm-forestry sites where long skidding distances are not involved. Skilled operators can control large loads safely and avoid damage to infrastructure and the residual forest. The one machine can assist with tracking, felling, extraction, shovel logging, cleaning up slash and debris, stockpiling and loading logging trucks. However, grapple diggers also have limitations. These include:

- Expensive transport/relocation costs to get onsite (oversized and a piloted warning vehicle required).
- They are not well suited to working on steep slopes (e.g., steep paddocks and tracks) especially when wet.
- Unless fitted with a winch, they are restricted to harvesting within practical reach from tracks and paddock edges (N.B. -Tracked machines should not be allowed to enter the forest area except for on forest tracks).
- The boom arm needs greater height clearance than other machinery (from overhanging branches, etc.).
- They are slow at moving logs from the forest to loading sites if long distances are involved.
- The jaws of the grapple bruise and shred the bark from the logs during summer months. Loose bark needs to be removed if logging trucks are used. Logs are handled multiple times when 'shovelling' any distance and there is some risk of damaging the logs with rough handling, especially if trying to grab several small logs at a time.

Forwarders

The Tōtara Industry Pilot project trialled an eight-wheeled forwarder for the harvest of 100m^3 of logs from a Northland farm. Efficiently transporting logs from the forest to a log loading site or 'forwarding' is usually one of the most problematic parts of the extraction chain, but that is what these machines are made for. Their advantages include:

- Ability to efficiently transport many logs in one trip.
- Self-loading and unloading.
- Avoids dragging logs over metalled tracks (i.e., keeps logs clean of stones and debris).
- Rubber tyres minimise damage to tracks.

However, in practice, the machine used was a bit too large and too heavy for the farm situation. It had a 3.3m wide wheel-brace, which only just fitted through farm gateways without chains on its tyres. The large, rounded tyres were ill-suited for traction across soft wet paddocks – even on relatively flat gradients. This meant the forwarder was effectively limited to metaled farm tracks. Logs still had to be shovelled with the digger to suitable collection points – so, another machine is still required for extraction. As with other machinery classed as over-sized, transport to and from site is expensive (often around $2,000). Small volume harvests wouldn't justify the expense.

Many farm-tōtara harvests will involve properties with narrow access tracks, gates and uncertified (engineered) bridges/infrastructure which may limit the accessibility of large forestry forwarders.

Cost effectively forwarding logs from the forest to a loading or milling site remains one of the problematic steps in the extraction process for many tōtara harvest operations. Forestry forwarders are made for this task.

Logging trucks

Transporting logs offsite to a commercial mill or buyer can be cost effectively done with standard logging trucks and trailers units. Ideally, the loading site should be as close to the forest as possible to minimise the forwarding distances. However, trucks need a safe access road, with sufficient room to turn and unload trailers etc. They cannot use uncertified bridges or substandard farm infrastructure. A site meeting with the transport company during harvest planning is essential.

Standard forestry machines are often too large for farm infrastructure, such as tracks and gateways

Above: Logging trucks require good access roads for trucks to turn, room to stockpile logs, and a >20-tonne grapple digger to load them. Loose bark is common with tōtara and needs to be cut off before the trucks travel on public roads.

"Various combinations of harvest equipment and machinery should be explored to best suit the site and scale of the harvest"

Other harvest equipment not trialled in the Northland tōtara harvests, but of possible utility, includes:

- Mini skidder (wheeled)
- Self-loading trucks
- Agricultural tractors with PTO forestry winch attachments
- Portable winches
- Helicopters

Comments on these are set out on following page.

Mini skidder (wheeled)

Possibly a small rubber-tyred mini skidder would be quicker and nimbler for skidding logs from scattered locations around a farm than a tracked skidder. Unfortunately, the Tōtara Industry Pilot project couldn't get a contractor with such a machine to trial during the Northland harvests. Mini skidders may be the ideal machines, but they are not so common. It may be difficult to find a willing contractor with the right machinery.

Self-loading trucks

A self-loading crane-truck is the alternative to standard logging truck and trailer units. The advantage of a self-loader is that it alleviates the need for a grapple-digger. However, they usually charge a higher rate for cartage and have some limitations on log diameter, weight, and length, and less total load capacities. Nevertheless, for small-scale harvests (say less than 100m^3 of logs), a self-loading truck is likely to be a cheaper transport option than standard logging trucks that require another machine to load them.

Agricultural tractors with forestry winches

Specialised forestry winches as attachments for agricultural tractors are commonly used for harvests in many European forests. However, they have not been widely used in New Zealand. This probably reflects the fact that larger dedicated logging vehicles are usually more effective at doing the tasks required, and safer too. Productivity is a critical factor in clear-fell harvesting of exotic plantations. However, the priorities are slightly different for selective harvests from tōtara forests. Sustainable harvests using continuous cover forestry systems involve more frequent harvesting of small volumes of timber – and often from widely scattered locations. Moreover, low-impact harvesting is required. In this context, it may be time to review the potential roles for tractor-mounted forestry winches.

Unfortunately, few trials or studies have been undertaken to test the relative viability of such equipment for low-impact selective harvesting of tōtara in New Zealand. European experiences suggest that, in some situations, tractor-mounted forestry winches may find practical application here too. A film of a recent farm-tōtara harvest trialing such equipment can be seen at: https://vimeo.com/692925422.

A tractor-mounted forestry winch enabled tōtara logs to be pulled out of the bush from the paddock edge. In this case, a 45hp tractor and a winch with a 4-tonne pulling capacity, managed to extract logs up to 2.2m^3 in size, in moderately steep and rocky terrain. Some trees were located at least 50 metres from the paddock edge.

Once logs are winched to tracks or paddocks, they can then be easily skidded to a loading or milling site on the farm.

There are several brands of tractor winches with over half century of history and reputation. Such skidding winches are mounted at the back of the tractor, on the three-point linkage, and driven by the Power Take-off (PTO) shaft. Generally, they have a grader blade-like plate to act as an anchor and protect the back of the tractor and they use wire ropes and choker-chains to pull logs to the back of the tractor.

The size and pulling power of the winch needs to suit the tractor, and typically ranges from 4 to 6.5 tonnes (although up to 9-tonne winches are available). Basic units can be purchased new for around $7,000 – 11,000 +GST, and remote controls are usually an upgrade option for around $2,500. Recommended additional accessories include three sets of appropriately rated snatch-blocks, bow shackles, and tree-protectors (webbing straps).

The use of snatch-blocks with at least 50-80m of cable enables tractors to work from safe locations on tracks or paddocks and for logs to be carefully winched and pulled in different directions to avoid obstacles and damaging residual trees.

Tractor winches are useful for more than just the extraction and skidding of logs. They can assist with directional felling, dealing with dangerous trees and hang-ups. The butt plate can also be used for moving or stockpiling logs at a loading site, but a front-end loader on the tractor is an ideal complement.

Snatch blocks can be used to change the pulling direction of a winch line, to avoid obstacles or damaging other trees. They can also be used for winch-assisted directional felling.

Potential advantages of tractor-mounted skidding winches might include:

- A relatively low-cost implement that further extends the utility of an existing 4WD tractor.
- Less transport/relocation costs between properties.
- Vehicle scale suited to farm situations and infrastructure (e.g., gateways, tracks, and bridges), avoiding damage and/or need for costly upgrades.
- Could enable landowner operation (if skilled enough).
- If a portable sawmill, or self-loading trucks are used, then no log loader or other heavy machinery or transport costs required.
- Allows careful felling and extraction (use of snatch blocks, etc.) without the pressure of expensive heavy machinery clocking up hours.
- Reasonably quick skidding speeds possible and suitable for bringing in small volumes from scattered locations.
- Rubber tyres minimise damage to paddocks, metalled tracks, and tree roots.
- Suits frequent and/or opportunistic harvesting and production thinning operations (e.g., when season, weather, and soil conditions, or markets suit).

Potential disadvantages include:

- Large logs and difficult terrain could exceed the capacity of the winch and/or tractor.
- Lack of clarity in New Zealand on suitable training, qualifications, and best practice and safety requirements.
- Lack of experienced operators.

Tractor-mounted forestry winches may be suitable for small-scale regenerating tōtara forests especially where they are integrated within a pastoral farming system.

Roger May has an excellent tractor-logging set up comprising a 4WD Valtra tractor with a front-end loader and 6.5-tonne Tajfun skidding winch that can be operated from a remote controller on the belt. This enables the operator to see the log at all times.

Portable capstan winches

Portable winches could also be a useful item of equipment. With long braided polyester rope, multiple snatch blocks and webbing straps, they become versatile in awkward situations with difficult access. It is not hard to imagine their utility in directional felling, grounding hang-ups, moving obstacles, and manoeuvring logs in dense, inaccessible bush, as a complement to other skidding machinery such as a 4WD tractor.

Arborists familiar with the mechanical advantage that can be gained from pulleys and snatch-blocks will know how to double, or even triple, the effective pulling force of the winch onto the targeted load. The winch pictured below has up to 1000kg of pulling power, however, with a double snatch-block set up on the log, it easily pulled a 1 tonne log up a moderately steep incline. Accessories such as a skidding cone to reduce the chance of snagging on roots and rocks would undoubtedly also be useful.

N.B. – The working load limits of all componentry (ropes, shackles, snatch-blocks, and tree protectors, etc.) must be rated for at least double the possible pulling forces from the winch.

To have such additional equipment available 'in the toolbox', for occasional miscellaneous uses, may increase the flexibility of a harvest crew to carry out low-impact harvests.

Portable petrol-powered capstan winches may be useful for directional felling, manoeuvring logs in the bush or extracting small to medium-sized logs to skid tracks. The use of snatch blocks for mechanical advantage can greatly increase their utility well beyond their basic pulling force.

Helicopters

Heli-logging might be an option in some situations where ground extraction is not practicable or viable. It was not trialled as part of the Northland tōtara harvests. But an attempt to price it as a harvesting option for two properties, indicated it would be around 60% more expensive than quotes for ground-based extraction. However, numerous assumptions and variables were involved.

Maximum lifting weight capacities depend on the machine and varied from 1200 - 1700 kg, and the number of lifts per hour would vary depending on distances involved and skill of the support crew. Relocation costs depend on distance from the home base. Hourly operating rates were around $3,000/hr or more for larger machines. Skilful cross-cutting of logs to size in the bush and preparation of lifting strops is also necessary.

Potential advantages of heli-logging include:

- Low-impact extraction in sensitive areas.
- A practicable harvest option for areas too remote, difficult, or sensitive for ground-based extraction.
- Year-round harvesting, rather than being restricted to times when the soil conditions are dry enough.

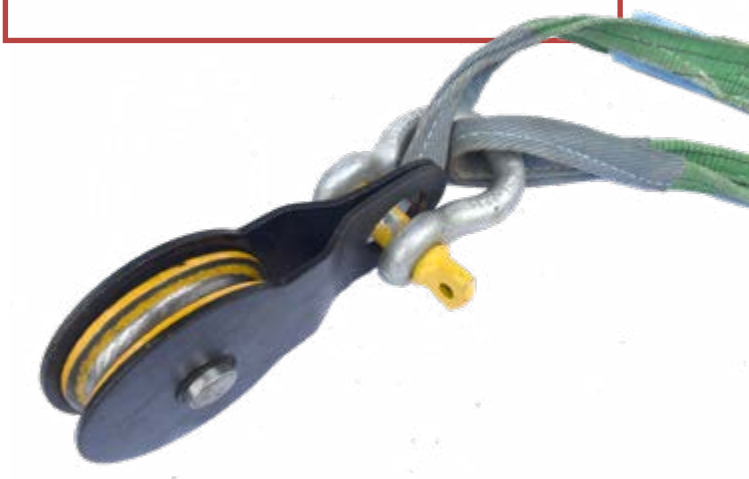
The high cost of heli-logging means it will only be relevant for very high-value logs or lumber. Chainsaw milling logs in the forest may be a way to maximise the value of each weight-limited lift.

A snatch-block on the log, with one line from the winch, the other to an anchor, doubles the force exerted on the log. A second snatch-block adds even more force on the log. In this instance a portable winch pulled a 1-tonne log up a slope and to a location accessible for a farm tractor. N.B. – Snatch-blocks, shackles and chain all rated for >8-tonne working load limits (more than three times the capacity of the winch).

Snatch blocks

Tips for use of snatch blocks:

- Insist that contractors have always at least 3 snatch blocks and 3 soft webbing tree protectors conveniently available for use.
- Ensure they are utilised wherever practicable to avoid or minimise potential damage to the remaining forest, or to increase safety.
- Always use soft, wide webbing straps to anchor snatch-blocks to trees. These 'tree protectors' must be appropriately rated to exceed the maximum working loads. Never use chains around trees that are not being harvested! Ensure that tree-protectors are carefully positioned so do not move or slip and rub the bark when under load.
- Ensure all componentry (e.g., wire rope, tree protectors, shackles, snatch-blocks) is rated to appropriately exceed the maximum working load that the winch can exert. For straight pulls, without mechanical advantage, this is generally considered to be more than double the theoretical maximum pulling force of the winch.
- Avoid using potential crop trees as anchors for snatch-blocks (unless they will also be harvested at that time). Use non-valuable trees, or harvest trees as far as is practicable for such purposes.



The ever-ingenious Li Legler, with his skidding cone fashioned out of a buoy from a mussel-farm. **Inset:** The D.I.Y. skidding cone enabled tōtara logs to be winched out of a steep and rocky gulley, from the paddock edge and with a small tractor-mounted winch. The choker-chain on the log passes through a hole in the 'nose cone' and is then hooked to the wire rope.

Skidding cones

Rather than sniping the ends of log to help avoid snagging on stumps, roots, and rocks a skidding cone fitted over the lead end of the log can be used. These have the added advantage of helping to avoid or minimise potential damage to the soil, and plant roots and bark of adjacent trees. For these reasons alone, skidding cones should probably be used wherever practicable.

Cant hooks, sappies, and hookaroons

Low impact harvesting requires avoiding damage to residual trees as far as it is safe and practical to do so. Tools such as cant hooks and long-handled hookaroons (sappies), or pickaroons, can be used to roll and manoeuvre logs to avoid the risk of winch ropes and winched logs scuffing the bark off residual trees. Contractors need to have such hand tools on-site and be prepared to stop winching and use them to avoid unnecessary damage to remaining trees. They are also useful tools to ease logs passed snags and obstacles.

Using a cant hook to roll a log to avoid damaging a sapling.

Here is link to a video that shows several techniques to effectively move large logs with a sappie/ hookaroon (unfortunately the speech is in German): https://www.youtube.com/watch?v=Qfc46I-KJMo

Tidying up

Damaged or dangerous trees and slash should be dealt with before the extraction machinery leaves the site. And stumps from harvested trees should also be cut low to the ground to minimise the chances of them becoming potential snags for future harvests.

Inevitably, harvests result in some localised areas of damage. The crowns of fallen trees may leave branches bending small saplings over, or lying under tension against the stems of other trees. For the health of the residual forest, it is good to ensure the slash is cut up and grounded so as not to impair the healthy growth of the remaining forest. Seedlings and saplings can be freed from slash that might deform their growth. It also facilitates safer and easier future access to the area for monitoring, silviculture, and weed and pest control.

There is an aesthetic and emotional aspect to it too. Tidying up after a harvest can be a pleasant task – part of respecting the forest and evaluating the effects and relative success of the harvest. It is another opportunity for weed control, pruning, and thinning, and the start of the post-harvest observation process. It is an important part of knowing and tending your changing forest.

"The focus of any responsible harvest should always be on what is left behind."

Conclusions

Tōtara is an iconic native timber species well suited to silviculture and sustainable forest management. There is a significant resource of naturally regenerating tōtara forest developing on private land in several regions of the country. Tōtara is also one of the most popular choices for planted native timber trees in new forests.

Many of these forests can be managed for multiple values, including timber production. Low-impact and sustainable management of tōtara forests can be done and has been successfully demonstrated by the Northland tōtara projects.

Tōtara is fine timber, suitable for many uses, and small markets already exists. However, to properly realise the full value, some form of co-op or coordinated management of the collective regional resources is probably required. Meanwhile, landowners are encouraged to obtain SFM Plans for their tōtara forests so that a commercially scaled supply exist. That will be essential for market development.

There are legal provisions to enable the lawful harvesting of native trees – but it is difficult, costly, and time consuming to apply them. Regulatory impediments and disincentives exist, but many policymakers are aware that sustainable native forest management is an appropriate land use that should be encouraged. The trees will keep growing while a more conducive regulatory framework can be worked on. Meanwhile, it is important that people start sustainably managing forests and develop native forestry as a viable land use option.

Perfecting the management of tōtara and native forests will be a process of continual refinement. There is a lot we don't know. There is a need for research, also training. Ultimately, a tōtara timber industry will not only create jobs, it will also reconnect people with their forests and their landscapes.

There are cultural heritages associated with bush work - some to our shame. But now we have an opportunity to demonstrate that, as a culture, we can make good the past, regenerate the forest, responsibly manage it, and find an appropriate relationship with nature. Sustainably harvesting tōtara could be participating in the creation of an inspirational example for forward-looking industries and land managers. However, realising that potential is still a challenge.

Finally, it can be okay to harvest tōtara. Whether or not it is appropriate, depends on many things. These are mostly site-specific factors and require careful decisions for each individual tree. Hopefully this chapter helps with such deliberations. Remember, forests are always more than just wood, and harvesting is an action and a record that will reflect your values. So, feel the weight of responsibility, but make sure you enjoy it too. The result should be something you can be very proud of.

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For more information on managing tōtara, see the Northland Tōtara Working Group pages on the Tane's Tree Trust website:

https://www.tanestrees.org.nz/about-us/northland-totara-working-group-ntwg/

To join the Northland Tōtara Working Group (NTWG) visit (membership is free):

https://www.tanestrees.org.nz/about-us/northland-totara-working-group-ntwg/join-ntwg/

A PRACTICAL GUIDE TO MANAGING TŌTARA ON PRIVATE LAND

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