Weaving resilience into our farming landscapes with native forestry

INTRODUCTION

Intensification of pastoral farming, and in particular dairying, is a feature in many of our productive landscapes. This intensification is occurring on hill country where steep slopes and riparian zones are often occupied by regenerating shrubland and forest less suited to growth of good quality pasture.

The prevailing attitude with farmers is that while clearing of these regenerating stands will not improve pasture production, they are a hindrance to stock management and do not have any inherent economic value. However, the work of Tāne's Tree Trust and specifically the Northland Tōtara Working Group indicates that native forest, both by managing existing regeneration and by planting further stands, can be integrated with existing pastoral land use to provide economic and environmental benefits.

With input from DairyNZ and Northland Regional Council, a dairy farm near Titoki in central Northland, northwest of Whangarei, was selected as a study area. The typical hill country dairy farm comprised up to one hundred hectares of pasture with areas of regenerating native forest dominated by tōtara. Tōtara, which is relatively unpalatable, have naturally regenerated on less productive steep hillsides and along riparian areas in the presence of grazing (Bergin 2001).

The farm presented excellent opportunities to inspire and demonstrate to farmers how regenerating stands of native forest dominated by tōtara, can be managed for future sustainable timber production and yet also address water-quality issues to meet increasing expectations of the dairy industry such as the Fonterra Clean Streams Accord.

This study is funded by Reconnecting Northland over three years with support from Tāne's Tree Trust, Northland Regional Council, New Zealand Landcare Trust, Ministry for Primary Industries, and Taratahi Agricultural Training Centre.

THE NORTHLAND PROJECT

This project on a Northland hill country pastoral farm, typical of increasing intensification of hill country farming in many regions of New Zealand, provided the opportunity to link many different aspects relevant to sustainable land management and to address some of the concerns raised by the Parliamentary Commissioner for the Environment.

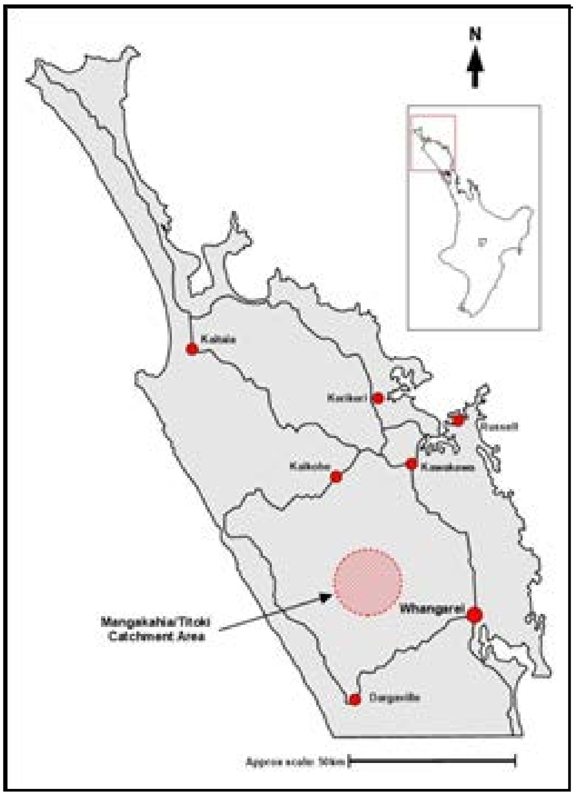
The farm is located in the Mangakahia River catchment which covers about 800 square kilometres of central Northland, bounded by the Tutamoe Range in the west and the Wairua River catchment in the east. It has the largest and most rapid flood discharge of any catchment in the Northern Wairoa system.

Objectives of the Study

The overall aim is to promote the benefits of managing native forestry integrated as a multi-purpose asset for improved land use practices within existing pastoral farming landscapes. The specific objectives were to:

- Demonstrate practical on-farm restoration and management of existing native regenerating forest leading to water quality and biodiversity improvements;
- Extend native forest cover on marginal steep hill country slopes and along fenced riparian zones by planting;
- Establish trials evaluating a range of silvicultural treatments to improve growth rates and timber quality for the pole and semi-mature tōtara stands within a pastoral farm setting;
- Quantify changes in ground cover and understorey biodiversity of managed stands including the influence of excluding grazing stock and increased light levels from thinning operations;
- Monitor potential improvement in water quality in the sub-catchment due to management of forest;
- Test the development of a Sustainable Management Plan for selective harvesting of merchantable timber from stands on a working dairy farm.

In collaboration with the landowner, and initially the Northland Taratahi Agricultural Training Centre, demonstration trials were set up and monitored over an initial 3-year period.



The Northland Project located on a farm within the Mangakahia River catchment, Northern Wairoa River system, central Northland.

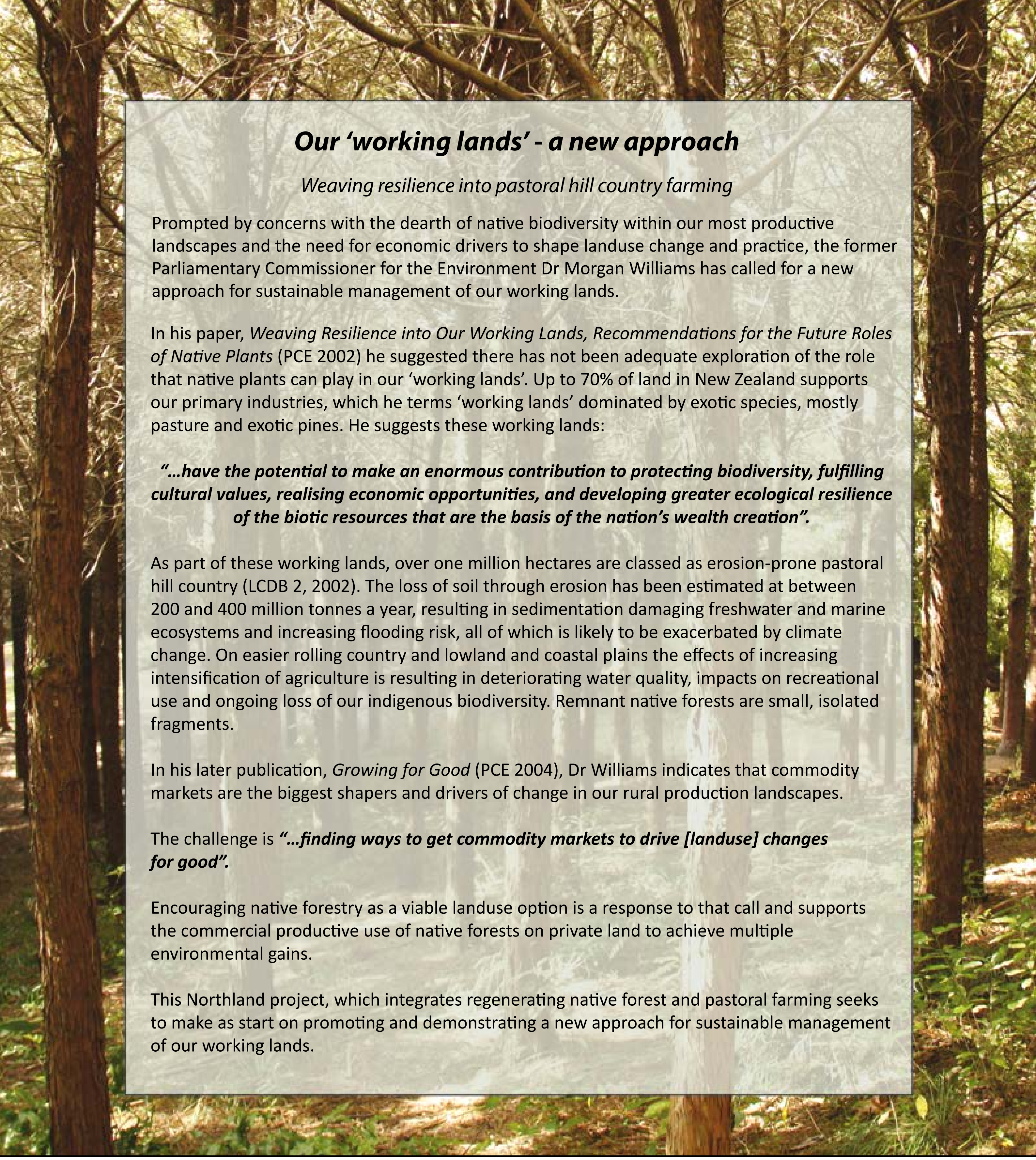
Landuse practices evaluated and demonstrated as part of this farm study included:

1. Developing and extending a native timber resource;
2. Securing an approved management plan for sustainable production of timber;
3. Enhancing indigenous biodiversity;
4. Improving soil conservation and water quality;
5. Enhancing landscape and amenity values; and
6. Improving farm management such as focusing grazing on better sites.

Fencing and managing such forest stands will decrease soil erosion from steep hill faces and decrease nutrient runoff into watercourses. Demonstrating this on this training farm also brought unique opportunities to influence farmers, both young and old.

Site characteristics

One gully catchment contained within the rolling hill-country part of the farm was the focus area. This comprised existing stands of naturally regenerated tōtara in a gully, and an open grassed area of 0.5 ha in rank grass on steep slopes and along the riparian zone. A total area of 6 ha of steep slopes, gully and riparian zones had been fenced-off.



Our 'working lands' - a new approach

Weaving resilience into pastoral hill country farming

Prompted by concerns with the dearth of native biodiversity within our most productive landscapes and the need for economic drivers to shape landuse change and practice, the former Parliamentary Commissioner for the Environment Dr Morgan Williams has called for a new approach for sustainable management of our working lands.

In his paper, *Weaving Resilience into Our Working Lands, Recommendations for the Future Roles of Native Plants* (PCE 2002) he suggested there has not been adequate exploration of the role that native plants can play in our 'working lands'. Up to 70% of land in New Zealand supports our primary industries, which he terms 'working lands' dominated by exotic species, mostly pasture and exotic pines. He suggests these working lands:

"…have the potential to make an enormous contribution to protecting biodiversity, fulfilling cultural values, realising economic opportunities, and developing greater ecological resilience of the biotic resources that are the basis of the nation's wealth creation".

As part of these working lands, over one million hectares are classed as erosion-prone pastoral hill country (LCDB 2, 2002). The loss of soil through erosion has been estimated at between 200 and 400 million tonnes a year, resulting in sedimentation damaging freshwater and marine ecosystems and increasing flooding risk, all of which is likely to be exacerbated by climate change. On easier rolling country and lowland and coastal plains the effects of increasing intensification of agriculture is resulting in deteriorating water quality, impacts on recreational use and ongoing loss of our indigenous biodiversity. Remnant native forests are small, isolated fragments.

In his later publication, *Growing for Good* (PCE 2004), Dr Williams indicates that commodity markets are the biggest shapers and drivers of change in our rural production landscapes.

The challenge is ***"…finding ways to get commodity markets to drive [landuse] changes for good".***

Encouraging native forestry as a viable landuse option is a response to that call and supports the commercial productive use of native forests on private land to achieve multiple environmental gains.

This Northland project, which integrates regenerating native forest and pastoral farming seeks to make as start on promoting and demonstrating a new approach for sustainable management of our working lands.

The study area

The study area is set within 80 ha of steep to rolling hill country that is part of a 200 ha dairy farm near Titoki, central Northland, where there are numerous regenerating stands of native forest dominated mostly by tōtara, a pattern typical of many pastoral farming areas in Northland (Figure 1). Most of the activity for this project has focused on a small gully catchment comprising steep slopes, gully and riparian zones with an extensive cover of regenerating tōtara where silvicultural trials, and biodiversity and water quality monitoring has occurred. A total of 6 ha of forest and small areas of rank grass had been fenced off.

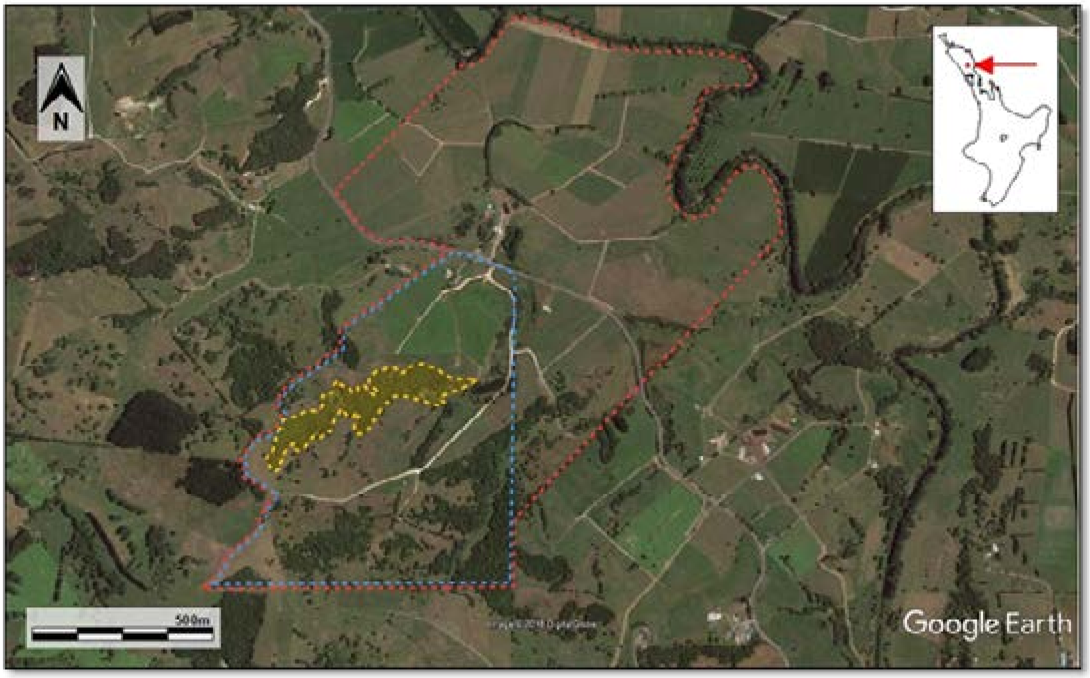


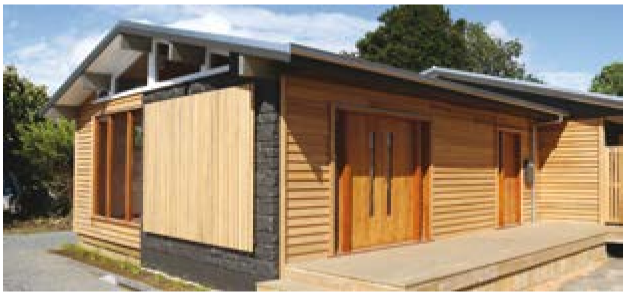
Figure 1: *The 80 ha study area (blue line) comprising steep to rolling hill country that is part of a 200 ha dairy farm, near Titoki, central Northland (red line). The area shown in yellow is the 6 ha sub catchment of steep slopes, gully and riparian zones with an extensive cover of regenerating tōtara-dominant forest which is the focus of silvicultural trials, and biodiversity and water quality monitoring.*

MANAGING FARM TŌTARA STANDS FOR TIMBER

Forest management focussed on boosting growth rates and timber quality of the regenerating tōtara-dominant stands to provide a high-value future timber resource. This involved thinning trials focusing on dense pole stands comprising trees with stem diameters of 10 - 30cm.

Silvicultural trials

Following Ellis and Hayes (1997), eight Permanent Sample Plots (PSPs) up to 400 m^2 each were established as paired plots to compare differences between forest areas that had been managed (thinned) and areas that had not (controls) (Figure 2). A thinning intensity schedule based on a Stand Density Index for naturally regenerating tōtara developed by the Northland Tōtara Working Group was used to guide the level of thinning needed, determined by basal area of the stands (Quinlan et al. 2014).



Managed stands of tōtara have the potential to become a significant regional timber resource. These offices in Kerikeri have weatherboards and joinery of milled farm tōtara.

Influenced by natural variation in stem density, species composition, tree size and form, the level of thinning aimed at maintaining a reasonably consistent stocking. Although dominated by tōtara, other native canopy tree species such as the occasional matai (*Prumnopitys taxifolia*) and the more prolific tanekaha (*Phyllocladus trichomanoides*) were retained wherever practical.

Stocking within the thinned plots (616 stems/ha) was on average close to one-quarter of that in the unthinned control stands (2242 stems/ha). No mortality occurred in either thinned plots or controls in the first year after thinning (Table 1).

Pruning of residual crop trees was undertaken in thinned plots, removing multiple leaders and larger steeply angled branches to at least 4 m above ground. Height of branch pruning was determined by tree size, with the aim of retaining at least one third of the green crown.

All stems within each plot were measured for diameter at breast height (DBH at 1.4 m above ground) down to understorey saplings with a DBH 2.5 cm at establishment and one and two years later. Heights of selected canopy trees and a sample of understorey trees and shrubs were also measured. Stem form was assessed for canopy trees, noting multiple leaders, major stem distortions such as breakages or rot, and incidence of coarse lower branching.

Figure 2: *The 6 ha study area (within the yellow line) where eight Permanent Sample Plots (PSPs) were established as paired plots with and without thinning and grazing (red plots - 7 circular, 1 rectanglar). RECCE, seedling and biodiversity plots were also established within the PSPs. The blue plots are part of the Sustainable Forest Management Plan plots and green area are the planted sites (refer later sections).*

Mean stocking of control plots within the unthinned tōtara pole stands was 2242 stems/ha (left) compared to the plots in the thinned stands that had been reduced to a mean stocking of 616 stems/ha (right). The level of thinning and selection of stems was largely guided by the Stand Density Index (SDI) schedule developed for thinning tōtara stands.

Growth response to thinning

A summary of stand stocking, basal area, mean DBH and mean height two years after establishment of the trial is shown in Table 1 with mean annual increment (MAI) of diameter in Table 2.

Table 1: Mean characteristics of thinned and unthinned tōtara stands at start of the trial (2015) and two years later (2017).

Treatment	Stocking (stems/ha)	Basal area (m^2/ha)		Mean DBH (cm)		Mean height (m)	
		2015	2017	2015	2017	2015	2017
Unthinned	2242	52.0	53.7	19.3	19.6	14.2	14.7
Thinned	616	26.2	27.8	23.9	24.5	15.8	16.4

Table 2: Mean annual increments (MAI) for DBH and height in thinned and unthinned stands with standard errors. Both unadjusted DBH increment and adjusted DBH increment are shown (accounts for any bias in growth rates that may occur due to size and dominance of any tree).

	DBH MAI (cm)	Adjusted DBH MAI (cm)	Height MAI (m)
Unthinned	0.136 ± 0.024	0.142 ± 0.008	0.20 ± 0.03
Thinned	0.345 ± 0.027	0.294 ± 0.015	0.28 ± 0.04**

**Increase in DBH growth between unthinned and thinned plots is statistically highly significant (p=0.0030).

Two years after thinning, there is a significantly increased diameter growth rate of residual trees in the thinned stands (2.9 mm MAI) compared with unthinned control stands (1.4 mm MAI). The deliberate selection of better formed trees and additional management through pruning the stand has substantially improved these managed stands from a timber growing perspective. Based on the experiences of previous silviculture trials in Northland (e.g. Quinlan et al. 2014), it is expected that this significant boost in tree growth due to management will continue, if not increase.

INCREASING BIODIVERSITY IN TŌTARA STANDS

Quantifying change in biodiversity

Several methods were used to quantify changes in biodiversity comparing managed stands with those that were not thinned and/or grazed with sub-plots established within each PSP (Figure 2). These included:

1. **RECCE plots** – long term changes in stand structure using the standard Reconnaissance Plot method based on Hurst and Allen (2007);
2. **Seedlings plots** – 2 m diameter subplots to assess regeneration of woody seedling and saplings by species; and
3. **Ground cover** – 1 m diameter plots to compare change in ground cover vegetation between thinned and unthinned treatments over time.

Biodiversity plots compare development of understorey and ground cover vegetation within regenerated tōtara forest where no silvicultural management has occurred (left) and where thinning was carried out 12 months earlier (right) to boost tree growth as a future timber production forest. Livestock grazing was excluded from both areas.

Thinning boosts biodiversity

While changes in overall stand structure based on RECCE plots will take a decade or more to become apparent, thinning stands and excluding stock resulted in an immediate increase in biodiversity. Species richness was higher in thinned plots compared to unthinned plots. Although not statistically significant due to highly variable sites, mean stocking of hangehange (*Geniostoma ligustrifolium*) and putaputaweta (*Carpodetus serratus*) in thinned stands was double that compared to unthinned stands and four times higher for other species (Table 3).

Table 3: Mean stocking of seedlings (stems per hectare) in thinned and unthinned control stands of understorey native species.

	Total	*Coprosma rhamnoides*	Hangehange	Putaputaweta	Other species
Control	93,300	79,800	9,700	2,200	1,600
Thinned	111,800	81,400	19,100	4,200	7,100

Similarly, there was a trend of increased numbers of woody species regenerating in fenced areas compared with grazed sites, though these differences were not significant (Table 4). There was a particularly large increase in stock-palatable species in the fenced plots.

Table 4: Mean stocking of seedlings (stems per hectare) in fenced and unfenced (grazed) stands of understorey natives species.

	Total	*Coprosma rhamnoides*	Hangehange	Putaputaweta	Other species
Unfenced	87,100	67,200	19,100	800	0
Fenced	107,700	85,000	12,900	4,000	5,800

The unfenced plots not only had reduced ground cover but where seedlings had survived, they were severely stunted by grazing. There was a significant difference in ground cover due to silviculture with more herbaceous species and woody debris and less litter/bare soil under thinned stands compared with unthinned stands (Table 5). Given sufficient time, fenced plots are likely to show increasing diversity and faster height growth of seedlings.

Table 5: Mean cover score of vegetation types between thinned and unthinned control stands. Statistical significance is indicated as follows: ns - no significant difference; * - p<0.05; ** - p<0.01.

	Shrub hardwood	Fern	Grass/ sedge	Herb	Non-vascular	Litter/ bare	Woody debris	Total veg
Control	1.61	0.88	0.98	0.91	2.36	4.75	0.71	2.14
Thinned	2.28	1.16	1.17	1.81	1.91	3.12	2.69	3.21
Significance	ns	ns	ns	**	ns	**	*	ns

Cover class scores: 1 = < 1%, 2 = 1-5 %, 3 = 6-25%, 4 = 26-50%, 5 = 51-75%, 6 = 76-100%

Development of understory vegetation is apparent one year after thinning and excluding livestock. In contrast, the grazed and unthinned stands in the background have little understory development.

Biodiversity gains

Thinning and exclusion of stock have substantially boosted the abundance of understorey vegetation within these naturally regenerating tōtara-dominant stands. This is likely to be a result of increased light levels on the forest floor. Development of understorey vegetation has been observed elsewhere in tōtara stands that have been thinned from 2000 down to 600 stems per ha.

A survey of the indigenous biodiversity values within grazed tōtara dominant forest areas has found that while abundance is low, there is a surprising number of native species present. Although these stands appear almost mono-cultural, a survey by David Norton and Laura Young recorded 89 native species within the forest areas on the study farm. They suggest that this will only increase in time, especially if grazing is excluded and pests are managed (Young & Norton 2017).

EXTENDING NATIVE FOREST

View across to the gully to part of a steep face with forest gaps that were in-filled with additional planting. Poorly formed existing trees were ring-barked to allow space for planted seedlings as they develop.

Although the 80 ha hill country part of the farm had over 13 ha of regenerating native forest, there are areas of steep erosion-prone hill sides and riparian zones in poor quality pasture with scattered blackberry, gorse and regenerating tōtara trees that would benefit from retiring from grazing. Typically, most farms will have such areas that are difficult to keep in high quality pasture, difficult for stock movement and require constant control of brush weeds.

The study site provided an opportunity to extend native forest cover by in-filling one of these difficult-to-manage gaps on a 0.5 ha steep slope and riparian area which the landowner did not consider worth maintaining in grazing (Figure 2).

Planting the gaps

Standard methods for planting grass sites were followed as described in Sections 7 and 8 of this handbook (TTT Technical Handbook http://www.tanestrees.org.nz/resource-centre/publications/) including:

- Grazing immediately before excluding stock;
- Herbicide spraying and scrub cutting patches of brush weeds, primarily blackberry and gorse;
- Spot-spraying grass 3 months before planting with glyphosate;
- Using good quality nursery-raised seedlings in PB3 planter bags;
- Planting a 1:1 proportion of native shrub species and native tree species at a stocking of at least 4000 stems per ha (up to 1.5m plant spacing); and
- Post-plant monitoring and maintenance, primarily controlling regrowth of brush weeds and grass around seedlings by knapsack spraying and ensuring fences remained stock proof.

The bulk of the planting comprised manuka (*Leptospermum scoparium*) as a nurse crop and tōtara as the main canopy tree. Other native canopy species were included such as harakeke (*Phormium tenax*) and ti kouka (*Cordyline australis*) on lower, moister sites and in suitably sheltered microsites, small groups of puriri (*Vitex lucens*), tanekaha (*Phyllocladus trichomanoides*), matai (*Prumnopitys taxifolia*), taraire (*Beilschmiedia tarairi*) and kauri (*Agathis australis*). In time these will become a seed source to further enhance native biodiversity within the adjacent forest areas on the farm.

Existing scattered tōtara trees and poles within the area that had developed large multi-stemmed crowns were either ring-barked or form-pruned (if they had merchantable value) to prevent them continuing to dominate the planting area. Ring-barked trees are still expected to provide some initial shelter and protection for the new plantings while they slowly disintegrate.

Planting of manuka as shelter crop at 1.5 m spacing with tōtara inter-planted at 4 m spacing.

Maintenance of planted seedlings during the first year after plating by knapsack spraying of herbicide to reduce overtopping by rank grass and regrowth of brush weeds.

Early performance

Survival of the planted tōtara and manuka seedlings across the site was over 95% two years after planting, with minimal animal browsing. Manuka were up to 1.5 m high and tōtara up to 1 m high, especially on lower slopes. Cost of planting and management of this site was $15,000 per ha, within the range of costs typical for establishing native forestry at relatively high stocking (e.g. Bergin and Gea 2007).

WATER QUALITY AND RIPARIAN MANAGEMENT

Nationwide there is considerable interest in planting natives along riparian margins to improve water quality, particularly within pastoral farming landscapes. While it is well recognised that quantifying water quality and measuring improvement due to any changes in landuse management is problematic and very long term, this project sought to establish baseline data on basic water quality within this sub-catchment.

Baseline water quality measures

Quantifiable water quality parameters were measured bi-monthly over a 3-year period from two sites, an upstream site within existing regenerated tōtara forest in the gully, and a downstream one in open farmland. The most significant change was exclusion of livestock from the 6 ha tōtara forest in the upper stream and gully although grazing continued on the surrounding rolling pastoral hill country.

Water quality measures included:

- **Hydrology and stream morphology** - channel width, depth, natural flow, floodplain connectivity, meso-habitats, bank erosion and condition;
- **Instream habitat** - substrate particle size, substrate embeddedness, organic matter abundance, shade;
- **Water chemistry** - pH, conductivity, nitrate, ammonia, phosphorous, temperature, clarity (turbidity), and faecal coliforms;
- **Macro-invertebrate Community Index (MCI)** - biological indicator of stream health based on presence or lack of macro-invertebrates, e.g., insects, worms and snails; and
- **Fish surveys** - presence of fish, exotic and native.

Monitoring

Unsurprisingly, the upstream site within the tōtara forest area overwhelming recorded better water quality and indicators of conditions for healthy stream life compared with the downstream site in open farmland. This applied to all measurable parameters except for fish. A farm dam, floodgates and a perched culvert prevent whitebait/inanga (*Galaxiid* spp.) from migrating to the apparently suitable upstream site.

Variation was recorded in many of the parameters due to seasonal changes and specific weather events as detected by the MCI monitoring (Figure 3). At times, flows ceased at the upstream site due to dry conditions. Ammonium, nitrate and phosphate levels trended downwards at both sites, although were more stable at the forested upstream site.

Kim Jones of Whitebait Connection (left) who led the water quality monitoring, with farm manager Graeme Helleur, using a sampling tube to measure water clarity.

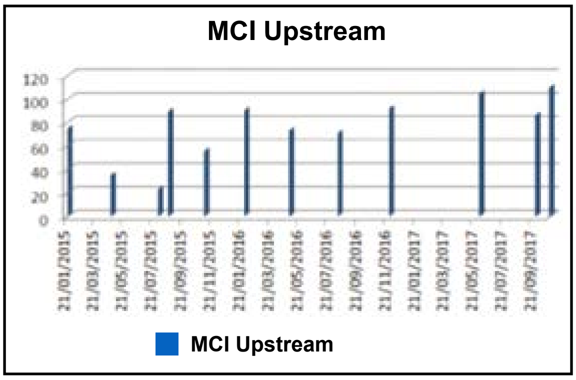


Figure: 3 – *Macro-invertebrate Community Index (MCI) results for the upstream site within the tōtara forest area. MCI scores: Excellent - clean water >120; Good - mild pollution 100-119; Fair - moderate pollution 80-99; Poor - severe pollution <80 (Boothroyd & Stark 2000)*

Harvesting under the Forest Act

The Forest Amendment Act 1993 applies to the harvesting of timber from naturally established forests on private land. The Act defines sustainable forest management as:

> *"the management of an area of indigenous forest land in a way that maintains the ability of the forest growing on that land to continue to provide a full range of products and amenities in perpetuity while retaining the forest's natural values."*

The Act provides for sustainable timber harvesting under either a Sustainable Forest Management Plan (SFM Plan) or a SFM Permit. These require continuous-cover-forestry practices whereby harvesting involves only the removal of single trees or small groups (3-5 individuals) of trees, and at a rate less than the forest's annual increment of merchantable volume. The Ministry for Primary Industries (MPI) administers the provisions of the Forest Act and processes applications from landowners where approved Sustainable Forest Management Plans or Permits are registered on the land title.

Members of the Northland Tōtara Working Group (NTWG) have found that obtaining either SFM Plans or Permits for sustainable harvests of farm tōtara on private land is costly and time consuming, and has proven to be a significant disincentive to landowners considering harvesting regenerating tōtara.

Forest inventory

As part of this project, a template produced by MPI for SFM Plan applications was trialled for this Titoki farm where 11.6 ha of tōtara forest area occurs in 11 spatially discrete stands within pastoral hill country (Figure 4). The detailed forest inventory required was undertaken using MPI-approved sampling methods and involving the establishment of fourteen 0.04 ha circular plots randomly located within mapped areas of tōtara forest.

In each plot, all canopy tree species were recorded in 10 cm DBH classes. Seedlings were also counted. DBH of all trees (≥30 cm DBH) and merchantable heights and stem form were recorded. Merchantable volumes were calculated using Mature Rimu Volume tables of Ellis (1979) as no volume table exists specifically for tōtara.

The inventory confirmed that forest composition was overwhelmingly dominated by tōtara with few other canopy tree species present, typical of most regenerating forest on farmland in Northland in the presence of grazing. The three forest types based on size-class and age were evident:

- P – pole-sized;
- W – widely-spaced poorly formed tōtara trees within a younger cohort; and
- M – merchantable-sized.

Potential for sustainable timber production

The size-class profiles within each of the stratified tōtara-dominant forest types are shown in Figure 5. Within the M forest type (merchantable-sized), excellent timber trees are present, with trunk diameters at breast height of 45-70 cm and straight, branch-free boles of 4-7 m in height. These stands also have smaller trees and poles, indicating scope for ongoing recruitment of the smaller trees to merchantable size and quality as larger trees are selectively logged over time. Where dense pole stands occur, scope exists for silvicultural management (thinning and pruning) to boost growth increments and improve potential clear-wood timber recovery, thus improving stand productivity and timber quality.

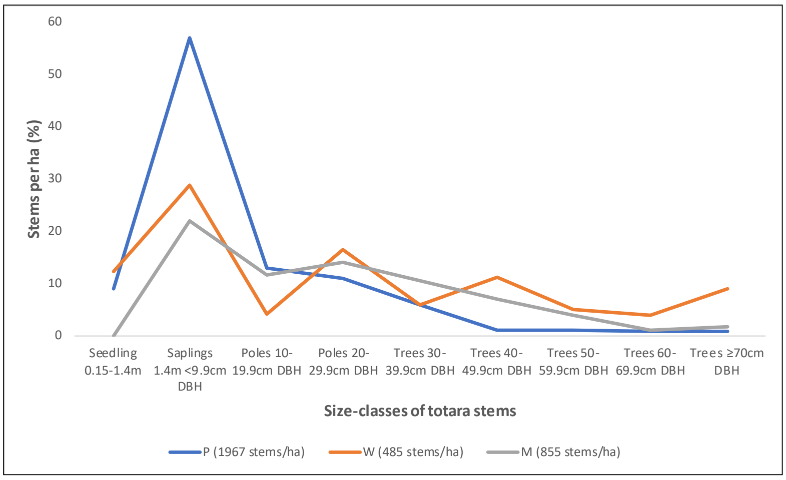


Figure 5: *Size-class profile of the three stratified tōtara forest types - poles (P), widely-spaced trees (W), merchantable-sized trees (M). All profiles show abundant sapling regeneration and potential for recruitment into larger size-classes.*

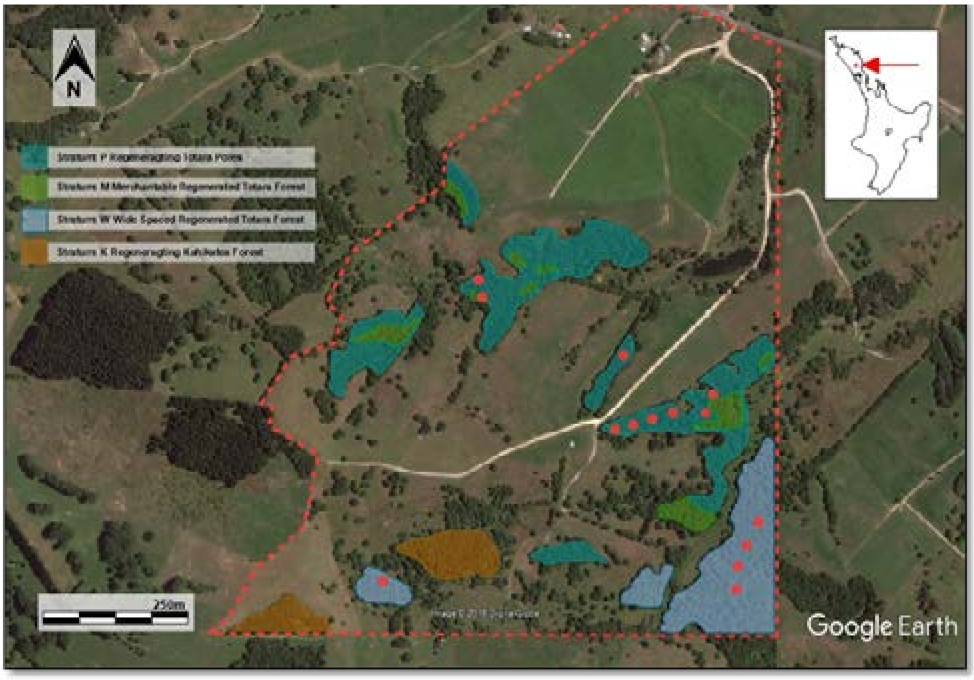


Figure 4: *The regenerated forest areas across the 80 ha hill country farm were mapped and stratified into 4 different forest types: regenerating tōtara poles (P), wide-spaced tōtara (W), merchantable tōtara (M), and kahikatea dominant (K). Only the three tōtara-dominant forest types were included in the sustainable harvest plan. Locations of the 14 randomly placed forest inventory plots required by MPI for a Sustainable Forest Management Plan are shown.*

The inventory indicated that a provisional harvest rate of 23 m^3 at 5-yearly intervals would yield a minimum of 100 m^3 of logs. At a nominal stumpage value of $135-200/$m^3$ this indicates a possible annual return to the landowner of $3,000 per annum from an area previously considered to be unproductive.

Improving the resource - a long term goal

A combination of thinning and pruning of the younger age classes and judicious selective harvesting of the larger poor form stems for timber, i.e. production thinning, will improve the quality of stands of all age classes over time. This involves a commitment to long term management to improving the saw-log quality and productivity of the stands.

CONCLUSIONS

This project has demonstrated how native forestry can be integrated within a working farm, not only providing opportunities to improve environmental outcomes but also allowing the potential development of regionally based sustainable timber production. The tōtara stands on this property are representative of many areas of 'farm-tōtara' on private land in Northland. The resource is spread in relatively small patches across multiple land-holdings. Cumulatively, these small areas are likely to amount to a significant commercial prospect. Areas of advanced regeneration would enable some sustainable harvesting and production in the region.

The development of a sustainable forest industry focusing on regenerating farm stands provides substantial biodiversity benefits that in time are likely to include improved water quality within these intensively farmed pastoral landscapes. There are early indications that active management such as fencing out stock enhances biodiversity. As indicated by Young and Norton (2017), the regenerating tōtara resource spread across the farming landscape in patches and as scattered trees provides potential connectivity and linkages for biodiversity corridors across the landscape.

The work of the Northland Tōtara Working Group, including the demonstration trials in this study, provides options for sustainably managing these stands as a long term timber resource. Placing an economic value on these regenerating forests will encourage landowners to protect and manage tōtara-dominant areas on their farms, resulting in environmental benefits both at the farm and the wider landscape level.

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A log from production thinning of a farm tõtara stand with heartwood and of sufficient size for milling.

Tãne's Tree Trust promotes the successful planting and sustainable management of New Zealand native trees and shrubs for multiple purposes.

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