Retiring Farmland into Ngahere

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Funded by Our Land and Water Science Challenge 2022

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Executive Summary

The purpose of this report, and information video: https://youtu.be/p8KHO4W--5E will introduce successful low-cost native planting methods which can be used as an educational resource for landowners, agribusiness and forestry advisors, regional councils and native forest restoration projects. Its application has the potential to reduce the cost of ngahere (native bush) establishment by some $20,000 per ha. This equates to a potential saving of $10 billion if even just half of the 1,000,000 hectares identified as highly erodible pastoral land were planted back into native forest using this method.

Many landowners across Aotearoa have a desire to restore significant areas of marginal pastoral land back into native bush (ngahere). We wish to offer a technique known as the Tīmata Method which has been shown to significantly reduce challenges associated with affordability, supply of trees and labour, while retaining the ecological end economic benefit of establishing ngahere.

The fundamental principles of the Tīmata Method are:

- careful land preparation,
- use of easily propagated native nursery crop species,
- cultivation of plants in small-size containers known as "forestry-grade"
- fewer trees per hectare than conventional guidelines

Deployed as a whole, the Tīmata Method lowers cost and makes more efficient use of time and labour resource.

The concepts were derived from a government-funded Primary Growth Partnership which set out to determine the ideal methods for establishment of mānuka plantations. The project began in 2011 and which resulted in the formation of a company called Mānuka Farming NZ, which now advises landowners on ways to implement the data collected by the project. Over 3,000 ha of mānuka plantations have now been planted across NZ using these techniques.

In addition to the use of cost-effective forestry-grade seedlings, the Tīmata Method generally recommends that plants are set no closer than 2m x 2m apart (2,500 stems per ha). This is less dense, and therefore less costly, than recommendations made by many nurseries. 2m spacings are recommended on most sites; however, 3m spacings could be contemplated on fertile, easy contour sites which may adjoin a critical source area or wetland.

The principal species used for ngahere restoration will depend on individual location conditions but will normally comprise at least 70% mānuka and/or kānuka. These are known as "nursery crops" in that their natural role in native ecosystems is to provide a fertile base for a range of larger and longer-lived species which will eventually emerge and rise through the mānuka and kānuka. To assist in this natural process of regeneration, a mix of other coloniser species are also used, particularly those which will attract and support bird life.

The Tīmata Method which in Māori translates to begin, start, kick-off or commence - initiates the natural processes that are known to restore ngahere. Full regeneration of complex ngahere ecosystems may take 100 years or more to arise; the Tīmata Method thereby practices Te Ao Māori principles of long-term thinking. The guiding philosophy is to harness the healing powers of Papatuanuku (Earth Mother) to protect the whenua and awa, attract manu (birds) and simply to allow natural reversion to mature ngahere to occur over time, rather than forcing rapid change on the land.

The method is best suited for retirement of marginal (and often uneconomic) pastoral land, such as steep, erosion-prone sideling's, riparian strips and wetland buffer zones. Mānuka, kānuka and other species may qualify land for enrolment in the Emissions Trading Scheme, which can offer a source of passive income.

2022 establishment costs in the Bay of Plenty using this method were approximately $2.20 per plant, which covered pre-plant spot spray, plants and planting. This equates to a cost of $2,811 per ha at (3m spacings - 1,111 plants per ha) or $6,050 per ha at (2m spacings – 2,500 plants per ha). This compares to a conventional large grade/high density cost of $30,222 per ha ($6.80 per plant at 1.5m spacings or 4,444 plants per ha)

An integrated weed and animal pest control program should be undertaken over the site and peripheral areas both prior to and after planting (this should apply to all forms of native retirement irrespective of planting method). Weed control costs using the Tīmata Method may be higher than those required when using high-density/high-cost planting. If properly carried out, such post-planting costs until canopy closure should total no more than $5,000 per hectare, which is a small fraction of the $20,000+ per hectare (conventional method) saved in plant costs when using the lower-density Tīmata Method.

Canopy closure can take a little longer than high-density (high cost) planting and is normally achieved within 5-8 years.

It is advisable to use higher-grade plants on more challenging sites such as cut-over pine and Kikuyu pasture, but it is considered unnecessary and wasteful to plant at a higher density than 2,500 stems per hectare irrespective of plant grade.

It is recommended that introduction of succession broadleaf, podocarp and conifer trees is deferred until the nursery crop is well established (3-5 years+) and they are planted in strategic groves (at 100 to 200 trees per hectare)

Eco-sourcing of native plant seed is encouraged to maintain historical flora characteristics and assist plant establishment and performance

Recommendations

1. The Tīmata method is adopted more widely across Aotearoa for broadscale restoration of marginal pastoral land into ngahere.
2. Further research is undertaken related to application and improvements to the method (with variances) on particular landscapes including the development of site-specific best practice establishment manuals.
3. Further research and investment is undertaken to fill knowledge gaps and develop decision support tools for mapping and species placement – as outlined in this paper.
4. A high-level strategic plan is developed to restore the priority ecological areas of NZ landscapes back into ngahere and wetland. Identification of such would preclude planting of these sites into exotic trees for carbon.
5. The plan in 4 should incorporate an integrated weed and animal pest management program with guidelines that can be applied regionally, at catchment scale and at farm scale. The recommendations in Simon Upton's Space Invaders report should be adopted as the starting point for development of an integrated weed management program.
6. Existing and new exotic forests (both production and carbon) are subject to strict environmental covenants relating to planting into native of ecologically enhancing areas and weed and animal pest control.
7. Government provide increased and ongoing support for the education and training of local, catchment based labour trained to the level of forestry cadets, multi-skilled to undertake planting of trees (both native and exotic), weed and animal pest control, eco-sourcing of seed and nursery work.

Acknowledgements

Given the short time frame of developing this resource and its purpose being for landowners and Agri professionals, we recognise it cannot serve all purposes for all parties: the primary focus in preparation of this report has been to capture the observations and learnings of the past 12 years related to mānuka plantation establishment, along with recent learnings on more widespread sites where plantings have occurred from 2016-2022.

It is hoped that the introduction to a wider audience of the lower cost Tīmata method of native forest establishment may assist the faster and more economical uptake of broadscale repurposing of marginal pastoral land into ngahere. The expectation is that the method can be further refined over time particularly when combined with the knowledge and assistance of Tane's Tree Trust (TTT), Manaaki Whenua - Landcare Research (MWLR), Scion and Mānuka Farming NZ. The authors are most grateful to the following reviewers and assistance over the seven months of developing the case study sites which captures learnings from the past two decades. Multiple individuals (Rick Burke & Jan Loney) and agencies BOPRC and HBRC have contributed to learnings at Pukekauri Farm and Lake Tutira . Contributors with experience at Tutira include James Powrie and Barry Poole. Farmers (Ao Marama Farms) and others in the Wai-Kokopu Catchment group along with the authors, who have current trial sites. The following reviewers offered valuable recommendations on the document, and future development of the resource include Rob McGowan (Rongoa Maori Practitioner and Trustee Tane's Tree Trust), Brodie Davis (Project Parore), Stephanie Versteeg (Kaipara Moana Remediation), Doug MacCredie (Forester & Landowner), Tanira Kingi (Maori Agribusiness & Landowner), Manu Caddie (Landowner, Maori Agribusiness), Te Kapunga Dewes (Forester), David Bergin (Tanes Tree Trust), Wally Lee (Maori Agribusiness), Jane le Guay (Te Uru Rakau), Ted Ries and Oliver Coutts (Balanced Forestry), Gordon Williams, (Pamu), Robin Simcock (Manaaki Whenua – Landcare Research).

Videography by Tim Firkin (filmmaker), and photography contributed to the report is from Hannah Fromont and Geoff Reid.

Background/Context

In 2022, politicians expressed their will to incentivise [1] one million hectares of land to be restored into native bush in Aotearoa. Policy development is underway to enhance this behavioural change. Most of this is steep, erosion prone hill country but also includes riparian margins and reinstatement of wetlands - 90% of which have disappeared through pastoral farming development.

Market requirements[2] and central government policy changes[3] means New Zealand now needs to significantly increase the rate of tree planting on its marginal land. There is broad support from public to incentivise landowners to retire significant areas of the vulnerable pastoral land in New Zealand for reasons of biodiversity enhancement and soil protection into native.

To date, native restoration of land has been sporadic with planting projects by landowners encouraged by Central Government and Regional Councils providing funding assistance and access to service providers for plants and planting. Limitations on Regional Council resources means that they generally take a low risk/low input/high-cost approach to planting which can be achieved by planting using a high density- high grade tree (PB3+)[4] approach to gain quick canopy closure with the aim to minimise ongoing management - particularly weed control. The cost of planting using this method in 2022 would be approximately $30,000 per hectare ($6.80 per plant X 4,444+ plants per ha). We refer to this method as the **conventional method.**

The metrics of planting one million hectares using the conventional method are that at least 4.4 billion plants would be required at a cost of $30 billion. The propagating, growing on, distributing and planting of 4.4 billion plants presents a significant challenge let alone funding the exorbitant cost per hectare of this method.

Most of the land by far requiring change of land use is located on dry stock farms where existing profit margins are modest and cash reserves low meaning that for most landowners contemplating broadscale retirement into ngahere, the $30,000+ per hectare (high density/PB3 approach) planting cost is prohibitive. ***If this ambition is to be realised, then the establishment cost must reduce.***

Note: the planting cost the authors refer to in this paper is the cost of pre-plant spot spray, the plants (including blanking) and the planting. Costs relating to weed and animal pest control, earthworks, fencing, release and succession tree infill are in addition to this (Refer table 1)

Decision making is influenced by the suitability of land for exotic plantations. In many cases, the plantation of pine will only cost $2,000 per hectare to plant with a carbon sequestration earning potential that is three times more.

This paper outlines a planting method which at $6,000 per hectare (based on current costs) is more affordable. This low-cost method has been named "Tīmata" which in Māori translates to begin, start, kick-off or commence. The method has been shown to also significantly reduce challenges associated

[1] Hon Stuart Nash – Tanes Tree Conference refer 7.15 min of this link: https://vimeo.com/774900716

[2] Tesco's warning to NZ (19/12/2022) https://www.stuff.co.nz/business/farming/130784599/tescos-warning-to-new-zealand-farmers

[3] Pricing agricultural emissions: Report under section 215 of the Climate Change Response Act 2002. 21 Dec 2022.Freshwater Regulations, RMA reform, Regional Plan Changes, Three Waters, Freshwater Farm plans + Te Mana o Te Wai, Health and Safety Law, Animal Welfare Law, NPS Biodiversity and the recognition of SNAs,

[4]. The number on a PB bag signifies the volume which is measured in pints of soil they hold PB 3 120mm high x 120mm diameter equivalent to 2Ltrs of soil

with supply of trees and labour, while retaining the ecological end economic benefit of establishing *ngahere.*

The fundamental principles of the Tīmata Method are use of easily propagated and planted nursery crop species, cultivation of plants in small-size (120ml) containers known as "forestry-grade" and fewer trees per hectare than conventional guidelines. Deployed as a whole, the Tīmata Method lowers cost and makes more efficient use of time and labour resource.

Tīmata vs. Conventional Cost Comparison

Comparative Native Planting Costs (2022 pricing)					
			Tīmata Forestry Grade	Tīmata Forestry Grade	High Density PB3
Plant Spacing:					
- Metres Between Plants			3.0	2.0	1.5
- Metres Between Rows			3.0	2.0	1.5
Plants per ha			1,111	2,500	4,444
Blanking %			15%	10%	0%
Blanking Plants			167	250	-
Total Plants			**1,278**	**2,750**	**4,444**
Planting Cost Metrics					
Preplant Spot Spray*		$ Per plant	$ 0.50	$ 0.50	$ 0.50
Plant		$ Per plant	$ 1.00	$ 1.00	$ 3.80
Planting		$ Per plant	$ 0.70	$ 0.70	$ 2.50
Total		**$ Per plant**	**$ 2.20**	**$ 2.20**	**$ 6.80**
Total Planting Cost per Hectare			**$ 2,811**	**$ 6,050**	**$ 30,222**

Table 1: Cost Comparison based on 2022 actuals, for Tīmata Method versus Conventional High-Density Method (Refer to Appendix 4 for example full 2022 budget costing in the Bay of Plenty)5

Te Ao Māori Concept

The Tīmata method of restoring land into ngahere by replicating and enhancing the natural reversion process would appear to fit well with te Ao Māori principles which is reflected in the whakatauki – "Whatu ngarongaro he tangata toitu he whenua" (man disappears but the land remains).

More expensive methods seek to accelerate regrowth by immediately blanketing the land with a wide mix of species, whereas the Tīmata Method simply kick starts the natural reversion process and lets nature take its course.

Full regeneration of complex *ngahere* ecosystems may take 100 years or more to arise; the Tīmata Method incorporates Te Ao Māori principles of long-term thinking. The guiding philosophy is to harness the healing powers of *Papatuanuku* (Earth Mother) to protect the whenua and *awa*, attract *manu* (birds) and simply to allow natural reversion to mature ngahere to occur over time.

It is important to understand that native forest is roughly 10x that of human age. In human terms:
- a 10-year ngahere is only 1 year old
- a 100-year ngahere is barely a teenager
- a 600-year ngahere is due for the pension

[5] Note: The costs outlined in this paper are likely to increase significantly in 2023 and beyond due to inflationary pressures and labour shortages which means the disparity between methods becomes even more pronounced.

Proof of Papatuanuku's natural healing powers is demonstrated on naturally regenerating sites all over Aotearoa:

- The first stage of reversion from pasture to native is commonly seen in the appearance of seedling mānuka or kānuka which farmers classically have called scrub. If fenced off from livestock, this nursery crop of scrub forms a healing cover over the land for other residual native plants to take hold and habitat for birds or manu to introduce seed of other species.
- The mānuka and kānuka which start out as a mass of seedlings seem to naturally thin themselves to a spatial distance of around 2-3 metres which at the 30–50-year stage allows diffused light into the understory which encourages growth of other coloniser species and eventually second and third tier broadleaf, conifer and podocarp tree species.
- In the final stages the tall succession trees assert their dominance – magnificent examples of which can be seen at the likes of Pureora Forest in the King Country.

In the words of Rob McGowan (MBE) "The land knows how to heal itself. What's really happened is that we have disrupted the landscape so much that it takes a while to get those natural processes of coming back to life happening."

Describing the Tīmata method

Primary Growth Partnership Beginnings

Tīmata concepts are derived from a government-funded Primary Growth Partnership project which commenced in 2011 known as Mānuka Research Partnership Ltd (MRPL) which set out to determine the ideal methods for establishment of mānuka plantations.

This took place on over 400ha at various locations around NZ to test the feasibility of economically establishing mānuka plantations for high UMF honey production as an alternate land use to farming steep erosion prone land. A key element to the project was, that to reduce establishment costs, the trial plots were planted using pine forestry methods which included planting small sized forestry grade mānuka at a low density of 1,100 stems per hectare.

One of the largest trial sites was at Lake Tutira in northern Hawkes Bay where 130ha of mānuka was planted in 2012 on challenging, steep northerly facing class 6E and 7E land. The film resource includes footage of the site 10 years on, and interviews with key parties involved with the planting. Mānuka establishment at Tutira in the main has been good with canopy closure complete over most of the area. Tree establishment has been weaker on steep rock seams where there is little or no topsoil. Inspection of the site shows clear evidence of natural regeneration taking place into kānuka, mahoe, native fern and other species. Unfortunately, the reversion process under this plantation has been retarded due to the allowance of stock grazing under the original nursery crop. Ideally the plantation should have had stock excluded to allow full natural reversion

Mike Marden previously of Manaaki Whenua - Landcare Research (MWLR) examined the Tutira site six years after planting, to access "the potential effectiveness of low-density plantings of mānuka as an erosion mitigation strategy in steep lands"[6] His report records that "the timing (years after planting) to attain canopy closure and root occupancy, if stands of mānuka were to remain fully stocked, varies between landforms and would likely occur between 6.5 and 9 years after planting. However, variable rates in planting density, and of plant mortality, resulting in under-stocking would significantly delay this timing, particularly on landslide-affected slopes."

Had the site been retired for ngahere establishment, kānuka should have been planted as a more naturally occurring and suited nurse crop. It follows that canopy closure and root occupancy would more than likely be earlier than the 6.5-to-9-year range if kānuka had have planted at a higher stocking of 2,500 stems/ha (2m spacings). MWLR have advised that they are currently undertaking research on root system of kānuka for modelling purposes which possibly may have a different soil stabilising form and profile to mānuka.
The MRPL project was completed in 2018 and involved Massey University as the research provider who documented mānuka plantation establishment and growth across various sites.[7] [8] [9] [10]

[6] Potential effectiveness of low-density plantings of mānuka (*Leptospermum scoparium*) as an erosion mitigation strategy in steep lands, northern Hawke's Bay, New Zealand (Marden. M, Lambie,S. Phillips, C.) NZJour Forestry Science 2019
[7] Phenotypic description of Mānuka wild varieties (Gaucer.G, &Olsen,M.)
[8] Elizabeth M. Nickless, Christopher W. N. Anderson, Georgie Hamilton, Jonathan M. Stephens & Jason Wargent (2016): Soil nfluences on plant growth, floral density and nectar yield in three cultivars of mānuka (Leptospermum scoparium), New Zealand Journal of Botany, DOI: 10.1080
[9] Mānuka – a viable alternative land use for New Zealand's hill country? Angus J. McPherson NZ Jour Forestry 2016. V61 (3) & Spacing for Mānuka Seedlings*Angus McPherson (Trees for Bees Farm Planting Adviser) and James McPherson (Department of Electronics, University of Otago)*
[10] A review of research on the erosion control effectiveness of naturally reverting mānuka (*Leptospermum scoparium*) and kānuka (*Kunzea ericoides* complex): implications for erosion mitigation of space-planted mānuka on marginal hill country (Marden M & Phillips,C) Landcare Research: LC2280.

MRPL commercialised their learnings by forming Mānuka Farming NZ, which now advises landowners on mānuka plantation establishment for high UMF honey production. Over 3,000 ha of mānuka plantations have now been planted across NZ using this methodology and knowledge. The same principles have essentially been applied to Tīmata plant procurement, land preparation and planting.

Refinement of the Tīmata method

Learnings from the PGP project prompted some of the persons involved to adopt the method for general native land retirement which progressively have been modified to include kānuka and additional bird loving coloniser species to assist the natural reversion process.

A good example of this can be found at 300ha Pukekauri Farm in the Bay of Plenty which began its environmental restoration program in 1995. The Bay of Plenty Regional Council played an important role advising on protection planting and providing subsidising planting costs. The farm is situated at the top of Te Mania catchment bounding the Kaimai DOC estate. The main farm environmental issue 27 years ago was soil erosion causing considerable sedimentation damage to Te Mania awa and estuary. This led to Pukekauri implementing a Land Environment Plan (LEP) (Appendix 3) across the property where riparian margins, wetland and unproductive grazing land have been progressively retired from grazing concentrating pastoral farming on its best land. Since 2016 a further 25 ha of critical source areas, riparian and steep erosion prone pasture has been retired with forestry grade nursery crop species. Accumulation of sediment in Te Mania estuary has now stabilised because of restoration works on Pukekauri and adjoining properties under the Project Parore catchment program.

Initial 2016 plantings were 100% mānuka at 1,100 stems per ha (3mx3m spacings) for native buffer zones adjoining reinstated wetlands. A steep gully area was also retired in 2018 using the same method. Wetland plants were planted in low-lying areas. Strategic groves of bird attracting colonisers such as karamu (coprosma), mahoe (whiteywood), makomako (wineberry), tarata (lemonwood pittosporum), whauwhaupaku (fivefinger), ti kouka(cabbage tree) harakeke (flax) were added as PB3 plants around 3 years later. Some shade loving species such as kawakawa were also included but these were planted on in shady areas under well-formed mānuka.

More erosion prone LUC 6e land was repurposed into native from 2020 onwards. Planting density however was increased to 2,500 stems per ha (2mx2m spacings) given the more challenging nature of these sites. The planting mix was also modified to include kānuka which was a naturally occurring species particularly on the drier ridges. Other bird attracting colonisers were also added to the mix to avoid the cost of introducing them later. Experienced forestry contractors were engaged to carry out the pre-plant spot spray and planting. The plants were delivered packed into forestry boxes either as mānuka or kānuka with the other colonisers mixed. This enabled the planters to be directed as to plant placement according to species. Good ATV tracks assisted this process.

The growth progression from planting forestry grade at Pukekauri has been quite dramatic and on the older 3mx3m plantings has achieved canopy closure within 6 years.

Figure 1: Newly planted 3-month-old forestry grade mānuka

Figure 2: One year old plantings

A one-year-old Tīmata mix planted on a 1.4ha erosion prone area in 2021 with no release undertaken. Most of the kānuka was planted on the ridges and drier areas and mānuka in the cooler wetter areas.

Figure 3: Two-year-old plantings

13.7ha of steep erosion prone pasture at 300m altitude planted in 2020 at mainly 2m spacings (2,500 stems per ha) using the Tīmata nursery crop mix. The plantings on this steep northerly slope were challenged with drought and around 10% blanking was required.

Figure 4: Three-year-old plantings

These mānuka trees at 2m spacings have done particularly well adjoining an existing native bush area.

Figure 5: Four-year-old plantings

A mānuka nursery crop planted into this steep gully area in 2018 at 3m spacings. Some parts of this area were challenged by gorse which the mānuka has grown through after it was cut back with scrub-saws 2 years after planting. Other bird loving nursery species such as karamu, makomako and mahoe were added in 2021. Groves of succession trees are to be planted in the next 2 years.

Figure 6: Five-year-old plantings

A mānuka nursery crop planted into a critical source area in 2017 at 3m spacings which now has canopy closure. Three metre spacings can be contemplated for mānuka in these fertile, moist sites. Other small plantings of coloniser species have been introduced as well as kahikatea, pukatea, maire tawaki, rimu, totara, puriri and kamahi.

A mānuka nursery crop planted in 2016 at 3m spacings which now has canopy closure. This is a former critical source area now retired into a wetland. The mānuka trees in this example were planted into kikuyu pasture with no chemical release but 3 hand releases.

Figure 7: Six-year-old plantings

Natural reversion is evident amongst the older 5- and 6-year mānuka with seedlings of mahoe, kawakawa, karamu, hangehange and rewarewa are now starting to emerge under the canopy. Other small plantings of coloniser species have been introduced as well as groves of kahikatea (white pine), pukatea, maire tawaki, rimu, totara, kauri, puriri, porokaiwhiri(pigeonwood) and kamahi.

Figure 8: A kauri planted in year 3 after mānuka established, growing through the six-year canopy

Note some trees were planted at the same time as the nursery crop. These trees struggled for the first few years until the mānuka became well established. The same species of trees such as kauri and rimu planted 3 years later have grown much faster.

Wider Adoption

Plantings using the Tīmata method are now being applied in other areas around NZ. Plant ordering and distribution agents are able to bulk up and allocate orders to propagation and wholesale nurseries, supervise nursery contract performance and organise supply chain arrangements for delivery.

The Tīmata method is particularly suitable for broadscale retirement of steep pastoral land but also riparian and wetland margins using professional forestry preparation and planting methods.

Community Catchment Groups reliant on public funding such as Wai Kokopu, King Country River Care and Project Parore are applying the process with landowners wishing to restore their landscapes. Wai Kokopu Inc. for example has obtained funding from Community Trusts - Bay Trust and TECT with a target of repurposing 150 hectares per annum of steep erosion prone pastoral land (>26 degree). The more cost effective Tīmata method is a way of stretching the funding to help achieve their objective. A real hurdle to farmers undertaking land use change is having the time to organise planting on top already stretched resources carrying out day to day farming operations. Recognising this, Wai Kokopu have employed skilled advisors who are offering free works co-ordination services to assist farmers with professional pre-plant land preparation, planting and follow up management. Pre-planting land assessment and preparation are a priority to co-fund. Bulk orders of trees are done 8-10 months ahead to ensure lowest cost, dependable supply, and professional planters are booked in 6-8 months ahead.

The cost of native tree establishment is substantially reduced due to efficiencies gained by incorporating proven pine planting practices and use of forestry grade plants. An experienced planter is likely to be able to plant up to 1,000 forestry grade plants per day (a similar output to the planting of pine seedlings), compared to only around 200 PB3 plants per day resulting in not only better labour utilisation but a significant reduction in planted cost from of around $6.80 per plant for a PB3 to $2.20 per plant for forestry grade. Over 68,000 trees were planted for Wai Kokopu, Pongakawa, Bay of Plenty in 2022 by 23 forestry workers in just 3.5 days. This planting of 27.5ha critical source areas and steep erosion prone slopes was spread over 9 separate properties. https://vimeo.com/manage/videos/749345750

Coloniser Mix

The species used to kick start ngahere establishment will be specific to each location and site but will normally comprise at least 70% mānuka and/or kānuka. These are known as “nursery crops” in that their natural role in native ecosystems is to create a habitat for a range of larger and longer-lived succession species which will eventually emerge and take hold. To assist in this natural process of regeneration, a mix of other coloniser species are also used, particularly those which will attract and support bird life.

A typical Tīmata planting mix for a dry site might be 50% kānuka, 20% mānuka and 30% bird loving species whereas cooler and/or wetter sites would change to around 50% mānuka and 20% kānuka. The higher proportions of mānuka or kānuka also reduce the risk of loss due to browsing damage from pests with their selection depending on what is likely to naturally found on a particular site.

The bird loving tree mix will vary according to the site but is likely to include species such as karamu, mahoe, makomako, whauwhaupaku, tarata, kohuhu, koromiko, ti kouka and harakeke. Strategic planting of tree lucerne (tagasaste) could also be considered.

The placement of coloniser species should reflect not only what is common for the location but also where plants are likely to perform best according to the topography of the site. On site organisation of planting boxes, good track access and direction to planters can achieve this.

Eco-sourcing of plant seed is encouraged to maintain local flora characteristics and assist plant establishment and performance.

Plant Specifications

Typical plant specifications include:

- Minimum above ground seedling height of 30cm
- Root collar diameter of 3mm
- Seedlings grown in Lannen 64FD container trays or equivalent
- Root density in plugs to such that plugs hold together during lifting, transport and handling for planting
- Seedlings packed and delivered in corrugated cardboard or returnable plastic boxes at 75-100 seedlings per carton

It may be useful to the planters if during packing, nurseries are able to mix the bird loving species. This could be 3 species per box and depending on the extra charge may be cost effective towards saving planting costs.

Plant delivery to the site is normally the day before planting with seedlings targeted to be planted within 48 hours of delivery. If planting is delayed the seedlings can store for up to 6 days in a chiller or cool, protected shed or shady site.

Planning and Preparation Guidelines

Detail regarding Tīmata method preparation and planning is very site specific and professional native forestry establishment advice should be sought including requirements relating to weed and animal pest control. There are also very good resources available on the subject that can be found at TTT and MWLR[11]

A sound piece of advice for landowners beginning the process of native planting is to ***"start small, learn what works best for your land and expand from there"***. Preparation and planning in general terms should involve the following:

The year before planting:

- Organising funding
- Weed and animal pest control
- Ordering of plants
- Arranging contractors
- Fencing and earthworks including tracking

The year of planting:

- Weed and animal pest control
- May/June/July – Pre-plant spot spray
- July/Aug/Sep – Plant
- Oct/Nov – Release

[11] Improving resilience of native New Zealand woody seedlings to drought (mpi.govt.nz) - section 4 – Five Steps to Restoration Success.

The years after planting:

- Further blanking if required
- Further release if required
- Weed monitoring and control – ground based knapsack. Canopy closure and 1.5m height are critical milestones for weed control – subsequent maintenance is reduced to shade tolerant weeds and canopy light-wells or gaps.[12]
- Animal pest monitoring and control
- Introduction of succession trees – normally 3-5 years after planting, plant in groves at 100-200 stems per ha

Note other options and factors to consider are:

- Helicopter pre-plant desiccation instead of pre-plant spot spray
- Screef[13] planting – if not wanting to use chemicals. This is more expensive but can achieve satisfactory results
- No chemical release but hand release where grass is smothering plants
- Timing of planting will vary according to location. Early planting increases the risk of frost particularly to leafy plants. Root growth is also minimal until ground temperatures start to increase. Later planting in September poses greater risk of mortality on drought prone sites.
- Care should also be taken when using residual herbicides. Inexperienced contractors can easily over apply chemical which can result in plant chemical burn or loss.
- Incorporating "green" firebreaks into the planting plan as mānuka and kānuka are flammable native species

Plant Spacing and Plant Grade

In addition to the use of forestry-grade seedlings which forestry contractors can plant at a rate of up to 1,000 stems per day; the Tīmata Method generally recommends that plants are set no closer than 2m x 2m apart (2,500 stems per ha). This is less dense, and therefore less costly, than recommendations made by many nurseries. Whilst 2m spacings are recommended on most sites, 3m spacings could be contemplated on fertile, easy contour sites which may adjoin a critical source area or wetland.

Well managed forestry grade planting at these densities can be expected to achieve canopy closure within 5-8 years of planting. Scion has undertaken replicated field trials measuring the growth performance of various species in different container[14] sizes. This trial is showing promising results on authors property at a Tauranga Direct Road (Hamurana) location. (Planted 2020, video 2022: https://vimeo.com/manage/videos/778685881)

[12] Personal Communication – 13 Dec 2022: Robin Simcock, MWLR,

[13] Screef is a word used in the tree planting world, specifically Western Canada, to mean to clear a space using a shovel to expose mineral soil in order to plant a pine or spruce seedling.

[14] Field testing of forestry and alternative container types for native tree species. An analysis of seedling performance across 6 sites. Ford.C, Lloyd. A, Klinger,S. Feb 2022, Scion.

Figure 9: Showing the Allepot (different sizes) Trial – 2 years growth, Tauranga Direct Road: Hamurana.(2022)

The conventional low risk/low input/high-cost approach to planting has been to crowd in high grade (PB3+) trees to gain quick canopy closure with the aim to minimise ongoing management particularly weed control. Whilst this approach lessens weed incursion it does not exclude infestation of weeds such as taiwanese cherry, woolly nightshade, barberry and japanese honeysuckle which birds can disburse from peripheral areas. The need for regular, ongoing weed control irrespective of planting regime is required to avoid this.

A further observation of 10 year and older high-density plantings at 1.0 to 1.5-meter spacings is dieback due to the stress of overcrowding. The dieback is from ground level up to just below a solid top canopy with lack of understory light resulting in bare, potentially erosion prone soil with retarded seedling development.

Figure 10: Example of 12-year-old riparian planting dieback

Figure 10 is taken at Pukekauri Farm where trees have been planted at 1.5 metre spacings. Bird life and ecology appears adversely affected also. Lovers of rakau would probably describe this practice as cruel – not unlike packing a family of 15 into a three-bedroom house with a fridge of food to feed five. The ngahere will grow past this stage over time, however this stagnation post-canopy closure may last 20 years or more [15]It seems illogical to plant species such as Tarata into a 1.5m growth gap when if given space and time has the capacity to develop a ground level wingspan of well over 3 metres.

Figure 11: Three-year-old tarata tree with a 2m+ wingspan amongst 3m spaced mānuka

Whilst it may be advisable to use higher-grade plants on more challenging sites such as cut-over pine and kikuyu pasture, it is generally considered unnecessary to plant at a higher density than 2,500 stems per hectare irrespective of plant grade.

[15] Scion & Turu Rakau Native Tree Establishment Workshop> Facilitating Natural Woody Vegetation: Simcock R, Fergus,A & Rufaut.

Proponents justify the planting of high grade (PB3+) plants at close spacings for not only minimising weed control but reducing the requirements for plant release and blanking (plant replacement) due to mortality following planting. We are unaware of any cost/benefit studies between this approach and the Tīmata method. However, we do know that MRPL adopted low density planting of forestry grade mānuka as being the most economical way of establishing broadscale mānuka plantations. At Pukekauri Farm for example no chemical release is carried out and the requirement for blanking has been low.

Feedback from others using the Tīmata method is that additional costs for release, blanking and follow-up weed control on the very worst sites are unlikely to exceed $5,000 per hectare. Based on this worst-case scenario the $11,000 maximum cost of the Tīmata method is still only 37% of a $30,000 per hectare high-grade/high-density planting cost which unrealistically assumes zero additional post planting costs for release, blanking and follow-up weed control.

Chasing canopy closure as soon as possible for weed and soil erosion control using the conventional method needs to be weighed against the advantages of the Tīmata method where potentially five times the area can be planted at the same cost whilst achieving for the same long-term outcome.

Other Lower Cost Options

Variations to the Tīmata method that require consideration/evaluation include:

- Planting 100% mānuka and/or kānuka and allowing time for natural introduction of other native species - worthwhile considering if the site is adjoining existing ngahere
- Planting 100% mānuka and/or kānuka followed by planting of strategic groves of bird loving coloniser species after 2-3 years
- Incorporating naturally occurring gorse/broom as a nursery crop in conjunction with mānuka/kānuka and other colonisers
- Oversowing mānuka and kānuka seed
- Higher density forestry grade planting on slow growth and extremely weedy sites ref Tawapou Conservation Trust 2022: revegetation growth Robyn Simcock, MWLR
- Totara included as a nursery crop in Northland - ref TTT

These variations and others are being practiced and evaluated in different parts of NZ with the approach customised according to the specific challenges and attributes of the site.

Note many sites already have a residual seed source and will easily revert to mānuka and/or kānuka if livestock are excluded. In this situation, only strategic planting of coloniser species may be required to assist this process.

Introduction of Succession Trees

There are many examples in NZ where we can see the natural reversion process over time leading to the establishment mature ngahere. It is possible that the planting of a well-managed nursery crop using the Tīmata method will imitate this process without the need for further investment for planting of broadleaf, podocarp and conifer tree species; particularly if it is adjoining or near an existing native forest which can provide the seed source for manu or birds to enhance dispersal. Note some species such as kauri, beech and kowhai require a close seed source whereas others such as puriri, kohekohe, totara and ferns can spread from quite some distance[16]

[16] Personal Communication Robin Simcock, 13 Dec 2022

If succession trees are to be introduced, it is recommended that they are planted in strategic groves (at 100 to 200 trees per hectare) and that their planting is deferred until the nursery crop is well established (3-5 years+). Delay of their planting which will encourage good tree form and provide shelter and friendly fungi for the taller trees (rakau) to thrive.

Figure 12: Larger (PB5) rimu, planted after 3 years spearing through the mānuka canopy. Fig 11b) a 3-year Puriri tree, and Fig 11c) a 3year Pukatea succession tree

The Rimu in figure 12 was planted was planted as a PB5[17] plant amongst three-year-old mānuka. It is now a three-year-old tree with a strong single stem pushing towards the top of the now six year old nursery crop canopy.

Tane's Tree Trust[18] contains good resources and advice on this subject including the concept of creating "tree seed 'islands" where bird-dispersed trees are established in suitable areas where they can be tended and if necessary, deer-fenced.

Manaaki Whenua - Landcare Research (Simcock et al 2022 report)[19] note that inclusion of nursery crop species such as makomako or kotukutuku can become gap makers in the canopy where succession trees can be planted beside or into. These semi-deciduous species which can outcompete mānuka/kānuka and are often taller than tarata or kohuhu become light wells for to accelerate the natural regeneration process.

The succession trees requiring introduction will depend on location in NZ. Their siting in the landscape must be carefully evaluated. A good way of doing this is by observing the type and siting of canopy trees that can be found in the local native forest. Further information can also be sought from a Regional Council, Manaaki Whenua - Landcare Research or Tane's Tree Trust. Again, it is important the seed for these taonga succession species is eco-sourced to maintain local flora characteristics and assist tree establishment and performance.

[17] PB5 contains 2.5 litres of soil.

[18] Tāne's Tree Trust • Native forests for our future (tanestrees.org.nz)

[19] Accelerating regeneration using canopy gap makers and seedling-friendly substrates –(Simcock, Fergus, Rufaut.2022)

Soil Biome – the Important Role of Mycorrhizae

An important factor which is often overlooked is the importance of soil biome.[20] In NZ, mānuka, kānuka and beech form ecto-mycorrhizal networks with over 100 species of fungi that facilitate water and phosphorus uptake. Ecto-mycorrhizal networks can also link root systems of different plant individuals.

Pastoral based soils are generally bacterial dominant whilst soils supporting mature native bush are fungal dominant. Planting mānuka and kānuka as an initial nursery crop to retire pastoral land assists to transition the soil to a more fungal friendly environment for other native plants.

The publication "New Zealand's Native Trees" by John Dawson and Rob Lucas describe that mānuka and kānuka "play a role in conditioning the soil because they help attract fungi. Mycorrhizae are mutually beneficial relationships which develop between certain fungi and many woody plants. The fungal partner draws soluble carbohydrates from the plant, which in turn benefits by receiving an enhanced supply of mineral ions and water, drawn from the soil by the ultra-efficient, ultra-fine feeding threads of the fungus. This relationship enhances plant growth and health; mycorrhizal plants grow better, are more resistant to diseases and pests, are more drought tolerant, and recover faster and more successfully after drought periods."

The Importance of Integrated Weed and Animal Pest Control

This section only comments on the importance of weed and animal pest control. Specific detail on different weeds and animal pests and their treatment is a specialized area that requires a separate, comprehensive information resource. Landowners undertaking native tree planting should seek professional advice and assistance.

Successful, cost-effective farm scale and catchment-scale ngahere establishment requires a strategic assessment of catchment scale weed and animal pest incursion risks followed up with an integrated weed and animal pest control program. Comprehensive pre-plant control measures should be undertaken over the site and peripheral areas prior to planting – weed and animal pest control treatment may be required for up to 2 years before the site is ready for planting. This, along with ongoing weed & pest management needs to apply ***irrespective of the planting regime***.

Control of browsing animal pests such as deer, goats, wallabies, hares, and rabbits should ideally be carried out by professional hunters. Regular surveillance is also required to identify potential recursion as even one or two deer can cause significant damage to young plants in a short space of time. Landowners should consider plant guards or spray-on repellants at planting in high-risk areas. As noted earlier, higher proportions of mānuka or kānuka in the planting mix reduce the risk of loss due to browsing damage.

A November 2021 report by Simon Upton's (Parliamentary Commissioner for the Environment) report "Space Invaders"[21] [22] describes in depth the problems and challenges NZ is facing to control native ecosystem weeds (exotic plant species that pose considerable risk to the integrity of native ecosystems). The core of the report's seven recommendations is a call for greater leadership and the need for coordinated national strategy and management of weeds across Aotearoa.

[20] Simcock et al 2022 report Page 20 3.5.3 https://www.mpi.govt.nz/dmsdocument/51274-Improving-resilience-of-native-New-Zealand-woody-seedlings-to-drought

[21] Space invaders – managing weeds that threaten native ecosystems | Parliamentary Commissioner of Environment (pce.parliament.nz)

[22] Rodríguez de Medina, J.: D Phil Thesis: 2018: Companion biota associated with Leptospermum scoparium: (mānuka; Myrtaceae).

Figure 13: Browsing damage from deer

A major concern arising from this report must be if we are already struggling to control existing ngahere weed incursion, how are we going to control weeds on newly planted forest as we relandscape Aotearoa?

This certainly underlines the importance of strategically aligned biosecurity management without which we will end up spending billions of dollars on land retirement, but then potentially be faced with the need to address vast, weed infested retirement areas requiring endless if not impossible levels of maintenance.

Figure 14: Example of weed Incursion (Japanese Honeysuckle) in high density regenerating bush

Figure 15: Exotic Honeysuckle and Weeds dominate the riparian planting zone.

The Space Invaders report profiles some of the great work being done by five community weed groups and the challenges they face. Organised local catchment focused programs which integrate weed and animal pest control with native tree planting are where the best outcomes are likely to be achieved. For this to occur it is important that these groups have access to long term funding, and they are supported by regional and national agencies (e.g.: local councils, waka Kotahi, NZ Rail) with monitored and enforceable regional weed and pest management.

Manaaki Whenua - Landcare Research emphasise that "understanding and mapping of weed ecosystem destroyers is so important and one of the most critical assessment and maintenance issues.....need to predict what weeds will dominate post-planting, and ensure wider-landscape removal of weed sources" (pers comm Simcock 2022)

The community catchment group Wai Kokopu Inc. in the Coastal Bay of Plenty has recognised that weed and animal pest control needs to be integrated into its 34,000-hectare catchment restoration plan. The planning process has involved obtaining an independent report on native ecosystem weeds within the catchment. A strategy being considered is to create weed exclusion and weed containment zones and then address dispersal corridors within the catchment. Creation of zones is a great way to engage the community, particularly containment zones around townships. The same strategy could be applied to animal pests.

Problems exist between regional Councils regarding coordination and alignment of pest management plans with agencies in their respective regions. The Space Invaders Report notes that "*While regional councils collectively aim to manage 334 plant taxa through their pest management plans, these plants are managed for a variety of reasons, not just because of their impacts on native ecosystems. Further, the lists of plants included in the final regional pest management plans that emerge reflect public and local political pressures to varying degrees, rather than the weeds that pose the greatest risks or cause the greatest harm.*"

In the Coastal BOP for example, Japanese honeysuckle is not registered on the local council list of noxious weeds when it is posing a serious problem to existing stands of native bush and incursion risk to new retirement areas. The plant is being allowed to proliferate and spread along weed dispersal corridors such as railways, and roads. Pampas Grass is also a significant threat.

Figure 16: Pampas Grass and Japanese Honeysuckle in a road corridor(Coastal Bay of Plenty).

An example of this lack of co- ordination in the Coastal Bay of Plenty is where farmers and landowners are required to control honeysuckle and other weeds such as woolly nightshade and Taiwanese cherry on covenanted retirement areas within their property when just outside the boundary on the road verge the same weeds which are an ongoing source of infestation, are proliferating.

Where native restoration is occurring on farm adjacent to exotic forestry stands, the risk of weed incursion is also potentially a significant problem. Comprehensive native ecosystem weed and animal pest control within existing and new exotic plantations needs to be incorporated into NZ's native restoration planting plan otherwise given their proximity to native forest will simply become harbours for ongoing infestation.

Figure 17: Weed incursion in Pine Forest.

The Pine Tree Debate

An observation by professional agribusiness advisors is a significant proportion of landowners[23]preference is to restore their land into permanent carbon sink native forest. This highly desirable broadscale restoration of land into ngahere however is economically challenged from the less expensive and higher carbon value option of planting pine trees.

Traditional high-cost planting methods for native restoration per hectare can't compete with the alternate of planting pine forest at a cost of $2,000 per hectare. Furthermore, the decision to plant pines becomes even more compelling when there is triple the per hectare income from carbon credits compared with native tree planting.

The reduced cost of the Tīmata method tilts the playing field a little bit more in native tree plantings favour but still requires additional economic incentives to encourage and support investment into ngahere establishment.

The tree planting comparison between pines and natives is not intended to deride the pine planting alternative, both of which have a role to play in stabilising our vulnerable landscapes, meeting New Zealand's carbon sequestration commitments and restoring ecology.

The importance of planning exotic and native tree placement in landscape design is considered paramount to optimise environmental and ecological outcomes across Aotearoa. Existing and new exotic forests (both production and carbon) require much stricter environmental covenants relating to riparian, gully and wetland setbacks, planting into native of ecologically enhancing areas and weed and pest control which hopefully will be reflected in a more rigorous NES.

[23] Pers. Comm & Experience of advisors in the Wai Kokopu Inc Society project 2020-2022

Policy Landscape and Incentives for Change

In many catchments across Aotearoa, the challenges are similar from the mountains to the sea: a loss of biodiversity accompanied by weed and pest incursion, contaminant runoff, degradation of water and the rapidly moving threat of climate volatility alongside central and regional government policy changes that are attempting to constrain these.

In Dec 2022, central government acknowledged they would incentivize on farm sequestration, including woody vegetation in riparian and critical source areas.[24] Incentives are provided for uptake of actions (practices and technologies) to reduce emissions and on-farm sequestration would be recognized, which could offset the cost of the emissions levy. While landowners may be disturbed by the pace of change[25] on how to adapt their land and people: positive solutions are emerging and while change at pace isn't always perfect, it is a start.

To assist adaptation at pace, central government has also provided a range of options and strategies to assist landowners to gain multiple wins, from one move[26]. There is an acknowledgement by many farmers that getting started on the journey of change is essential, and learning is a journey. Presently, New Zealand produces and exports significant volumes of food, it is uncertain whether we can produce enough of the right crops in the right places, while maintaining ambitions for both national income and profit, at the same time as improving the health of our biodiversity, land, and water. A recent study by Mc Dowell et al 2022[27] concluded that the maximum cost of the required land use change was about 1% of the primary sector's export revenues, and orders of magnitude less than the estimated savings for the health system, and that shifting productive land uses can help meet environmental targets for GHGs, N and P while saving money and improving the health of its people.

Catchment Groups, Advisors and Professional Support

Changing land use on vulnerable land parcels such as steep, erosion prone pastoral land or critical source areas; whilst implementing profitable pastoral farming system change requires careful planning for the landowner's business. Such evaluation requires from a transdisciplinary team to assess options and optimise solutions for the landowner(s).

For example, the Wai-Kokopu Catchment group spans an area of 34,000 ha from Rotorua Lakes to Pukehina – known as the Little Waihi in the Coastal Bay of Plenty. In this catchment alone, there is 6,540 hectares of steep, erodible land.[28] The assistance provided to landowners is provided from a hub of trained, farmer facing professionals that have experience in farm systems, nutrient and business, foresters, pest, biodiversity and restoration advisors. To accelerate the pace of change, lighthouse (leading) farmers share learnings with others how they altered their farm system. Refer Appendix 2.

Catchment groups are a key part of assisting the broad scale change in both pastoral farming systems and land use required across Aotearoa where landowners are being encouraged to modify their landscape and plant significant areas of marginal pastoral land into trees.

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[24] Pricing agricultural emissions: Report under section 215 of the Climate Change Response Act 2002. 21 Dec 2022.

[25] Freshwater Regulations, RMA reform, regional Plan Changes, Three Waters, Freshwater Farm plans + Te Mana o Te Wai inclusion, Health and Safety Law, Animal Welfare Law Changes (shade and reducing IWG), NPS Biodiversity and the recognition of SNAs, Biosecurity Incursions (M Bovis, PSA) and a Zoonotic Pandemic (COVID).

[26] On Farm Actions/Options – source 20 Dec: website: https://www.agmatters.nz/actions/

[27] Growing for good: producing a healthy, low greenhouse gas and water quality footprint diet in Aotearoa, New Zealand (Mc Dowell,R et al). Jour Royal Soc NZ, Oct 2022

[28] Source – Personal Communication S Dudin, catchment map (https://www.wai-kokopu.org.nz/)

Economics and Funding

Repurposing marginal land (including former wetlands) in most cases makes economic sense. There are examples on farms around NZ where such land areas have been repurposed into trees, and the total pastoral farming business profit has shown little change and, in some cases, increased from farming a reduced effective grassed area.

Add to this the benefits of carbon income, improvement in farm workability and aesthetics then the investment into ngahere starts to stack up. The authors have experienced several cases where farmland has improved market value, if well planned land use, and restoration principles have been adhered to.

Farmers, their advisors and education institutions would be fitter for the future if a more integrated land use[29] approach was applied towards the way that landholdings are managed. This approach is illustrated in Figure 18. This requires a change from traditional siloed thinking by engaging multi-disciplined pastoral farming, forestry and ecological restoration skillsets who are prepared to collaborate to optimise highest and best land use outcomes.

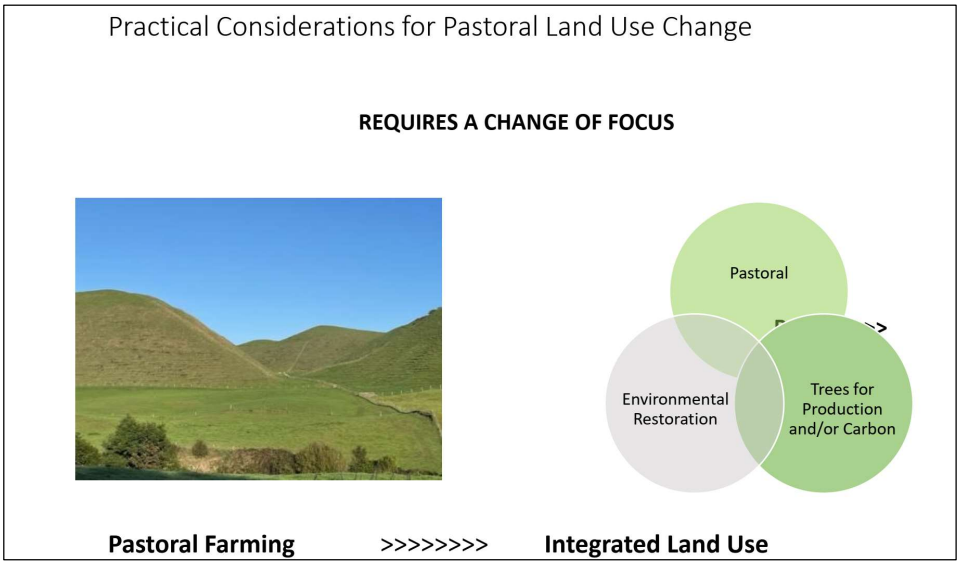


Figure 18: Typical landscape: Coastal Bay of Plenty in pasture that would be more profitable in trees.

An Ag Matters case study undertaken by AgFirst at Pukekauri Farm in 2021 Rick Burke and Jan Loney, Bay of Plenty | Ag Matters confirms this. The study as per the table below showed an improved Economic Farm Surplus per hectare along with significant environmental benefits in terms of N-loss reduction and GHG emissions.

[29] Integrated Land Use approach is where a range of farm systems become integrated, and the most appropriate land use is applied to the most appropriate land management unit, and the economics of such are also integrated in a manner that reflects best profit, and resilience, for the most appropriate land use.

Pukekauri Farm:	1998/99	2014/15	2020/21
N Leaching (kg N/ha/year)	21	19	15
Biological GHGs from the pastoral area (Tonnes CO_2-e/ha/yr.)	5.4	4.9	5.2
Net emissions, considering forestry (Tonnes CO_2-e/ha/yr.)	3.0	1.9	1.2
Total net emissions across the whole farm (Tonnes CO_2-e)	873	553	349
Economic Farm Surplus ($/ha)	$506	$969	$1,106

Table 2: Economic and Ecological progress over 2.5 decades. Case Study[30]

Note - Total enterprise profit is increased further when profitability from production trees and carbon is included.

The issue facing most farmers (particularly dry stock) is that they do not have the available spare working capital to undertake investment into tree planting. Investment into exotic trees for either harvest or carbon currently shows strong internal rate of return (IRR) investment returns in the order of 8% or more so should be able to meet bank lending criteria without the need of subsidy.

The investment however to repurpose land into ngahere is a different proposition and even under the Tīmata method, the low carbon return means it doesn't stack up from an investment point of view unless a significant portion of the planting cost is subsidised. In a range of cases, even with a 50% subsidy there is still the issue of the farmer being able fund the balance.

This is where bank funding support to assist landowners for tree planting into either natives and/or exotics is critical. The pending requirements facing farmers regarding GHG emissions, environment and water quality were obvious more than 5 years ago. It is expected that Banks have recognised this contingency and made prudent allowance to support their clients with appropriate lending products to accommodate future cashflow demands for planting. Our financial institutions support of landowners are integral to the relandscaping of Aotearoa by assisting integrated land planning and farming system change occurs which matches land use to land suitability.

To ensure the best chance of long-term success, public or private funding to assist landowners to plant either exotic or native trees should also be on the basis that an integrated weed and animal pest plan is place for the site in question along with the surrounding location or catchment area.

Labour Resources and Capacity Building

A key challenge facing the relandscaping of Aotearoa is harnessing the labour resource to undertake the demanding job of weed and animal pest control and planting. Existing forestry planters are virtually at full capacity now planting pine trees without tackling planting of ngahere and pre and post planting on the ground management.

For NZ to meet its tree planting targets we need to undertake serious capacity building of this important labour force. A good way of achieving this is through local catchment programs that target energetic, multi-skilled young people who are trained to the level of forestry cadets/workers. They are then available to undertake highly rewarding year-round employment planting trees (both native and exotic), weed and animal pest control, eco-sourcing of seed and perhaps assisting growing on nurseries (for surplus forestry grade plants and taonga succession trees).

[30] Link to Ag Matters Economic and Ecological Case study: Rick Burke and Jan Loney, Bay of Plenty | Ag Matters

Knowledge and Research Gaps

The following list comprises items that would be useful to farmers and their advisors contemplating native planting restoration. Some of this information may already exist but does not appear to be readily available:

1. A pan industry economic mapping and land-use decision support tool. Farmers, consultants and banks are struggling to evaluate & understand which specific land management units within a pastoral enterprise should be retired into exotic or natural forest cover. The main messaging around the need for retirement is the environment (sediment loss) and/or carbon with little emphasis on the economic imperative as much of this land is contributing little (and in some cases a negative) to farm profit and, therefore the business would be better if the land use changed to exotic or natural forest cover.

2. A mapping tool that identifies "must do" areas that should be planted into native forest and wetlands for ecological purposes. This should be the first step a landowner should take as part of the Land Environmental Planning process.[31]

3. More information to assist native planting, such as:
   - Comparing growth form and root development of mānuka and mānuka on erosion prone sites
   - Advice on placement of mānuka vs. kānuka across NZ locations
   - Advice on other coloniser placement and species mix across NZ locations
   - Analysing the cost/benefit of various planting densities over time in relation to soil stability, native forest health and economics
   - Analysing the cost/benefit of chemical release
   - Processes that will assist the establishment of native plant friendly mycorrhizae
   - Advice on podocarp and broadleaf tree placement and species mix across NZ locations
   - The benefits of companion planting - beneficial interactions between plants that will enhance establishment and growth but appreciate it could include the other factors you mentioned
   - The potential benefits of companion weeds in native plant establishment
   - Development of an APP for field use to assist native tree species placement at specific locations across NZ

4. Re-evaluation of the commercial potential for the use of NZ native plant products (e.g., harakeke fibre)

[31] Landowners and farmers require smart desk-top tools to assist planning and decision making as per 1&2 to reduce the demand on consultants and their cost.

Appendix 1 Feedback and Recommendations

Reviewer		Comments
Catchment Group Restorer	Initial Reaction	Re Video: Music could be more upbeat. Concepts overall area great. Ideal to stay away from too much chemical advice in video. Could be condensed (video), but great to have the key details around the process. Be good to have a more uplifting story/narrative.
	Future	While directed at landowners, as a training piece it should be shorter and under topic headings: Prep, planting, and maintenance. For landowners, I would highlight the importance for future generations. Get the Tamariki involved. Maori world view will be specific for different land holdings. More details under returns for native forestry. The benefits to water quality & soil structure should be highlighted. Suggest a library of resources with specific content to follow on from this, including different sites and a range of age groups.
Ecologist/Scientist	Initial Reaction	I have just viewed this video as requested and I am most impressed. All the key messages we are trying to get out are captured in there by those experienced in undertaking such restoration, Well done. Having Rob McGowan to introduce and close the video with his words of wisdom is fantastic.
	Content	All the key messages are well covered including nurse crops, lower forestry grades and planting practices vs higher cost options, later interplanting of larger grade key species where necessary, working with natural regeneration, need to control pest animal and key weed species, ongoing maintenance, etc...I know this is a promotional video for farmers/advisors but I am aware that there are still failures going on based on our own trials and anecdotal evidence from others across all scales of restoration planting. You would have no doubt had a few failures and that is reflected in the learnings that are mentioned such as the drier sites would probably be better planted with kānuka and mānuka prefers moister sites, south facing slopes etc...so good to hear that we all learn by trial and hopefully not too many failures. I would like to see more information supporting indications that cost of establishment is in the order of $2.5 to $3k per hectare. What does this include and just as importantly what is not included? Radiata (as I understand it) is about $2k per ha planted using a standard regime of 833 stems per ha at 40cents per pine seedling each and yet mānuka priced at $1.30 to $1.50 per unit according to your video and planted at 1100 stems per ha will only cost up to $3k per ha. I think you need to back this up with more information to support such a low establishment cost. I presume this does not include any blanking for partially failed sites, or additional planting of later successional tree species, plus what about the ongoing cost of maintaining fencing, pest animal control and weed control longer term?
		More graphs and tables (even in brief given it is a promo video) that convinces me that there is some systematic monitoring of your planting sites providing statistically significant survival and growth data to back up the success of your methods across the range of sites you are profiling. Similarly, I am very interested in what is the scope of natural regeneration that is going on to infill planted mānuka (and kānuka) areas with a wider range of species including the high forest species such as the podocarps and long-lived hardwood trees species. This requires surveys of regeneration to quantify infilling species to back up observations. We need to get serious about monitoring successes (and failures) using statistically valid but user-friendly methods that those planting (and relying on regeneration) can use to accurately report on performance of native's plantings and the role of regeneration. I really like the emphasis given to the ongoing management of planted and regenerating areas, irrespective of low- or high-density planting of natives as the invasion of 'ecosystem destroyers' (great phrase!) and shade tolerant species like ginger, ivy, climbing asparagus, Taiwanese cherry, Japanese honeysuckle etc are insidious threats to even well-established native ecosystems. Clearly landowners will require ongoing incentives (resources) to maintain any planted and naturally regenerating areas in perpetuity. DOC cannot do that for their own estate so not sure how this is going to happen on private or Maori land.
	Future Additions	I would be keen to see how planting can be used to promote regeneration over vast scales of marginal hill country as I am not convinced, particularly for dryland sites, that regeneration is going to happen in reasonable timeframes and especially where there are scarce local seed source of native shrubland and forest species. So how can your main method of planting small plugs of mānuka (and kānuka) be used to

		encourage nature to do the rest and can that be demonstrated? We have several projects underway at present where we are establishing seed islands comprising a range of the key bird and wind dispersing shrub and tree species, We are following some of these ideas with mānuka plantations on some of the Pamu sites where they are interested in incorporating seed islands amongst a matrix of planted mānuka. This will require long term monitoring including any influence of planted seed islands on natural regeneration across the wider landscape. While I am keen to promote regeneration (working with nature) as potentially the only way NZ is going see vast areas of our marginal hinterland reverting to native forest, I am a long way from being convinced about the timeframes and certainly the successional pathways that this can be achieved across a range of sites from dry to wet sites and from low to upper elevations, and with and without various exotics like gorse etc that can be effective nurses. And what is the role of planting in this successional process that would be practical along with the essential pest animal and bird predator control and selective weed control? These are big questions and need more time than I have right now to explore but interesting to contemplate how relatively low density mānuka/kānuka planting can contribute to this. In addition to an early return from mānuka honey, the role of /carbon is an obvious area to build on which is a target of our current work in promoting large scale afforestation. Again, another big topic requiring more time to ponder.
	Using this resource	Half hour is a long video but for those about to spend 1000s if not tens of 1000s of dollars on establishing natives, I think this video covers all the main issues from using experienced crews, nailing pest animals, to essential and timely maintenance. I would be happy to recommend that our organisation provides a link to this video when it becomes available and include it in our list of videos resources we have on our website that cover some of the specifics of native forest establishment and management. Given the increasing need for small sound bites required to attract the attention of most of the population, maybe a short promo video is required to entice more people to engage with this longer video. Promotion via the usual forestry and farming sector magazines and news outlets would be worthwhile with an article covering main points and an invitation to readers to download the video and watch it. The latter would benefit from more science around survival and early growth rates to add to the overall narrative of promoting mānuka plantations as a method for native forest establishment.
Maori (Agri/forestry consultant)	Key Points	A more solid context around the wide range of thoughts and methods both out there and emerging / being recognised (having been out there for ages) The need to convince, should be a bit more dissected from the intention to teach The factual tables and what not need to hit the spot better The comparison to pine planting should either be more precise, or left out altogether, the alternative would a more concise mention of typical native planting costs, vs what we are now achieving. The problem with pine (radiata) is that it's just simply a freak. Not even other exotics compare for cheapness and ease. Is it really warranted to be used as a measuring stick? For me it is , only as far as it has value as being a nurse crop, and this would mean having an indicative pine regime, around the needed thinning (probably 3 thins) to really get the understory amping. That would mean comparing the mānuka kānuka approach to a radiata regime that includes cost of plants, planting, releasing (x2), thinning (x3).
		Do we talk about other nurse crops? Do we link to other education sites that are on the same general page as us? Or would that clutter thinking. If it would clutter thinking, then do we do it anyway but re-empt the clutter with context? --- What's the thinking with the music?
Maori Agribusiness	Key Points	Great video, with practical insights from the case studies A lot of useful information on the tree or species choice, site selection, planting rates and the impact on the establishment costs Forestry grade seedling and spacing or planting density of 2m or 3m spacing and the impact on canopy closure at 5-8yrs is an important finding The point made about the high density 4-5,000 or 1.5m spacings and the cost differential with the 2-3,000 sph regimes is critical for those looking to understand native regimes

		Suggestions: The video's opening section lays out the need for the Tīmata establishment approach quite well; and it's followed up by some very good information. But the question I have is who is the target audience? Farmers who might be considering planting natives but are discouraged by the cost of establishment? If that's the audience then I would suggest that the structure of the video include several slides that show the comparisons between the Tīmata approach and alternatives with the forest system's description and cost estimates. For example, the points above are well covered in the narrative but the viewer doesn't get to any numbers in detail until the last 2 slides.
	Application for Maori farms	Another question is in relation to the introduction of Rob McGowan at the start and ending of the video – it's good. However, if you're wanting to appeal to Maori farmers, and if the video wants to demonstrate the use of matauranga or the incorporation of Te Ao Maori principles, then you may want to include Maori farms that have applied the system? Matauranga and Te Ao Maori only exist in the context of specific land and landowning groups.
	Future inclusions	The final point is that climate change impacts and the proposed on-farm carbon pricing mechanism will force farmers to look for alternative revenue streams. And so, while the video focuses on just the cost side of the alternative native establishment systems; there are farmers, particularly Maori farmers and forest owners that are looking to using exotics as a nursery crop. The main reason is to register the forest as a permanent forest with an exotic transitional nursery crop. The research behind transitional systems is untested; Scion has some work underway. But the question that farmers would ask is what the carbon sequestration curve of the Tīmata system is using 50% kānuka, 30% mānuka and 20% bird supporting species (or the formula that was given in the video…) compared to a pinus radiata nursery crop. Alternative revenue streams for hard hill country farmers is critical for the survivability of that part of the livestock sector. The statement that you could get canopy closure at 2-3m closure is interesting. But what farmers would want to know is – how does that compare to exotics at 5-8yrs? This may be a distraction to the native purists who would prefer to look at native restoration as the key objective. But a comparison with information that is verifiable would be useful.
Maori/Forester	Te Ao Maori	I don't have anything to add from a Te Ao Māori perspective. Primarily because I don't think there is one in this instructional video. That is not a bad thing in my view because land modification methods (other than fire) are generally not consistent with a traditional Māori approach. I wouldn't try to "insert" it either.
	Feedback on Content	From a critical forester perspective, if the goal is to assist or inform the decision-making framework for a land manager looking to change land use, I found the video a lacking in critical detail. This is also consistent with my evidence-based thinking. However, I understand that the target audience (Farmers?) don't necessarily need this, and the intent of the video is to change thinking not and provide ideology (I may have this wrong too?) not be prescriptive as I would want. I note there is little about how to modify the nurse crop to encourage transition to high forest, perhaps that is intentional?
		I also note that this perpetuates the negativity towards pine without validation which is also a common theme we encounter in non-evidence based, farmer centric material, so unfortunately, we couldn't use this at all. Whilst this is a pathway we would and do encourage where exotics are not "allowable" for whatever reason, what we know from evidence is that exotics offer a faster, generally cheaper, and significantly higher economic return to achieve the same outcome of native high forest.
Rongoa Maori Practitioner	Initial Feedback	The film is exceptional; very positive, very friendly, very factual and practical, and full of hope

	Future Content	It would help to have more focus on diversity. A UN report recently said that the loss of biodiversity is as great a threat to the planet's future as global warming. I'm not sure where that comment came from, but it is appropriate. Some sites, like yours at Katikati have a rich available seed source close by, but that is often not the case. A way around that maybe is to create seed islands, small areas with a lot of diversity which can provide a local seed source. I always have the birds in mind when making a planting plan. If we plant for the birds, they will do much of the work for us, and reach places we can never get a planter to.
Maori/Bus devt/Landholder	Initial Feedback	Narration is great, but I reckon having someone with a 'Māori accent' would make it much more appealing for Māori - and perhaps others. Otherwise, it's mostly/all Pākehā telling us how to re-establish indigenous plants on the whenua, which may not go down as well as a Māori narrator repeating. Depends on if the target audience is mostly Māori or Pākehā farmers I guess - probably both. Te Reo version/s would be great too - though the number of other talking heads might mean it's a little redundant given most will still be in English (unless it's dubbed.)
	Future Content	I'd be keen to see a short segment on how to decide when planting is appropriate vs letting nearby seed sources reclaim an area. What are the risks for both, how best to prepare the land for both, which species do which predators like best, which weeds are the biggest risk/benefit (e.g., gorse as nursery crop), etc. It would be great to have community presentations of the video with local experts and someone from the video available to answer questions afterwards. Maybe a bit of information for each region about sources of plants, timeframes for ordering, co-funding available, etc. Well done! It's a great resource, very practical and helpful.
Maori Landholder /Agribusiness		We need to be much more inclusive moving forward. Maori are doing a lot of good work in this area also, so balance would be good. Matauranga Maori through Maramataka. Following the moon cycles of planting and pest animal movements which have a direct connection to the moon phases. Understanding the peak movements of pest animals based on the moon phase. What does that look like and how is it implemented into the future. Good to understand the costings, established and ongoing $30,000/ha and weed/pest control. What financial support/funding is being sought long term and how will resources be allocated? How are Maori being included in any funding application moving forward? Collaboration? Great doco and shows hope for the future. Just some gaps to consider addressing so we all move together, rather than moving in isolation. As always here to support as needed and required.
Catchment Mgt/Planting - KMR	Initial Reaction + how it could help other catchments	Firstly, congrats on a very cool project! The video is really interesting with some beautiful/striking footage. Out of interest, did the PGP Project have any sites in the Kaipara ecological catchment? We are now developing projects for native planting on erodible hills particular where there is a risk of sediment delivery to waterways. Planting is at 2,500 sph and an estimated cost of ~$10-12,000/ha. However, we are an opportunity to trial some other spacings next winter, with an aim to gain and share learnings. We are currently engaging with some landowners who may be up for this. Any materials such as videos and reports coming out of your programme could be useful for this (assuming they are available as these projects are developed). Alternatively (or to complement use of your resources) I wonder if there is a mentor type arrangement that could help ensure our projects are actively informed of learnings as they are developed.
Forestry Advisor	Initial Reaction	Firstly, what a fantastic piece of work! The imagery is impressive, the messages relatable and inspirational. The presenters/narrators all come across well too. This will be a valuable resource going forward. Fantastic showcase of work done to date, the approach and the learnings that came with it. We especially appreciated the plain english/relatable approach and felt it speaks well to a farming audience. It does a good job of changing the narrative on the cost of establishing natives. We especially like how the approach encourages nature to take its course. The other aspect we discussed was how it touches on the numbers and the metrics in a really clear, understandable way, which we anticipate will go down well with the farming/landowner community.
	Future Additions	This a very inspirational video that gives a comprehensive overview. Having access to resources that assist with the "where do I start" would bode well for someone motivated to act. I'm sure you have given this some thought already. There are lots of resources out there such as Tanes Trees Trust so you don't need to reinvent the wheel. Here are some of the areas we anticipated will be of interest:

		• Some kind of methodology/how to guide for Land prep, • Pest and weed control – what are the best methods, what sprays are appropriate • Planters -how do I find planters, what do I need know about planting to assist a quality job Other areas for your consideration: Failure of natives is touched on but there is little detail given to deepen understanding. It would be good to support potential planters in their understand of the potential risks. Could be supported with an additional resource? It is clearly about retirement - there are other outcomes that landowners might be after such as harvestable crop or carbon There is little mention of regional variations in approach such as in Northland totara is almost a nurse crop.
	Using this in future	This would be a valuable resource for the TUR Advisory Service which is under establishment . The advisors will have a kete of resources they can select from to meet the needs of the landowner or situation they are in. This video would be a fantastic addition to the kete.We host a range of case studies on our Canopy Website https://www.canopy.govt.nz/ its possible this could be showcased here – would need to get approval. Thanks for the opportunity to see the video and give back some thoughts. It really is a good piece of work that is much needed – well done to all involved. We look forward to hearing your progress with it, keep in touch.
Head of Forestry-Pamu		I have just watched the video and it looks great. The message is really timely, and it is something that I have reverted to after experimenting with mixed native plantings. This should appeal to the farmers who want to establish native planting, so really good to see this being promoted. I think that pest control, pre-plant prep and post-plant management are really critical, and the costs are still going to be double that of radiata, so that does still need to be factored in. I think that it is useful for landowners to be able to see the opportunity for adding to the planting with other species over time. The video would be useful to confirm what I am doing in the circumstances, and we are working on writing up a basic planting strategy, although some flexibility is required working from Northland to Southland, with different challenges.
	Future Additions and follow up.	For riparian areas, I am using mānuka and flax as the pioneers in a basic 80:20 mix at 1100 spha, and planting seed islands of wind/bird spread species recommended by Tane's Tree Trust for each region. The seed islands are 400m2 planted at 4500 spha and at 2 per hectare, but each only amounts to an additional 140 plants. They are planted in key areas that are accessible for maintenance & alongside tracks, culvert crossings etc where the farm staff will get some pleasure out of seeing them on a regular basis. They will be managed by our environmental planting contractors and given specialist treatment. They only add marginally to the cost of establishment in the circumstances. This also enables us to complete a planting and move onto the next lot, rather than returning to plug something else in. But I'm still thinking that it would be possible over time and am already looking at planting totara into 8-year-old mānuka on a couple of places.

Appendix 2 – Case Study – A Journey to an Integrated Farm.

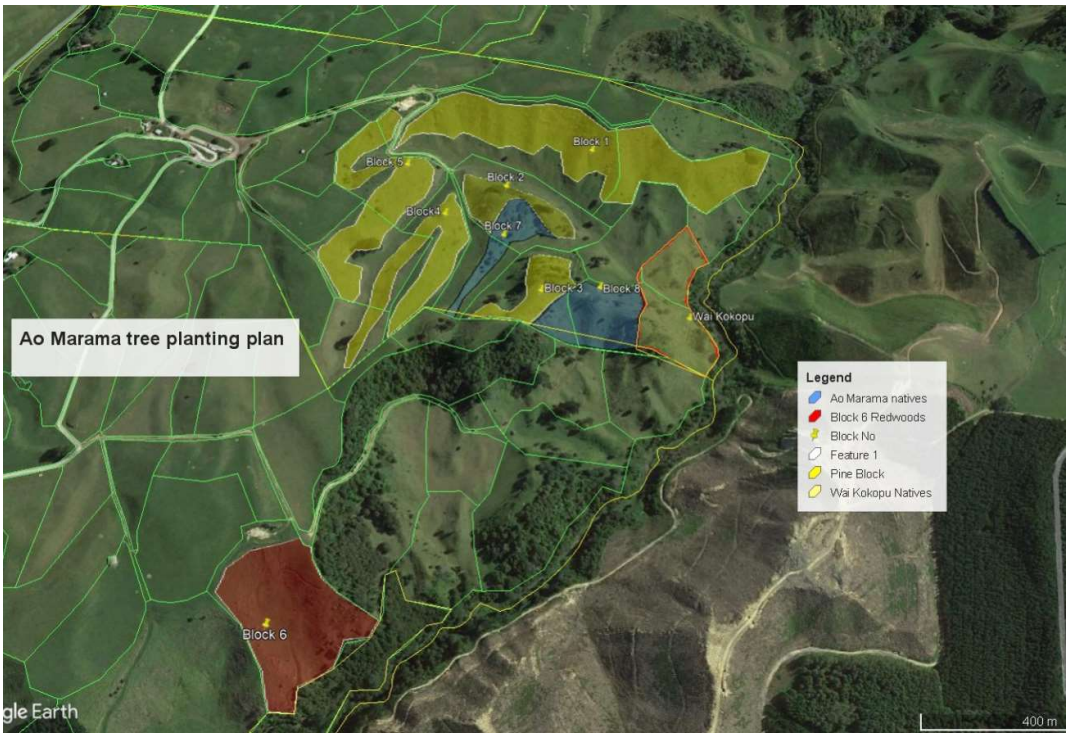
In the catchment group of Wai-Kokopu, fifteen lighthouse farmers were chosen to work alongside the farm systems team provided by MPI funding (2022). On one farm, their journey progressed over 2 years of the study, from being solely a dairy farm, on 270 ha, to a mix of forestry, native plantings, subdivision for an orchard, and a significantly reduced dairy herd.

This was assisted by a mix of tools to help them plan. This included farmax and overseer assessment on the current farm system identifying opportunities for improved profit with a lower footprint, land use capability mapping, and integrated land plan in association with a forestry consultant, and a restoration coach(for native plantings using the low cost, Tīmata method).

These farmers decided it was time to reduce intensity and review land use. While they had been raised on a dairy farm, and continued that as a career, they had also trained in science. Initially this farm had farmed deer, and the first dairy unit was 67 Hectares. The goal was to grow, maximise milk and minimise waste from the late 90s to the period 2018.

They grew the farm to over 329 Hectares with over 750 milking cows in 2020. However, following this intense period of growth, they became increasingly aware of the environmental effects, and their own personal wellbeing.

The small dairy unit was repurposed for sale for kiwifruit, and the home farm had the dairy system running at a significantly lower intensity, with half the cows. The back hill country which had historically run sheep, before dairy, and is being repurposed for a mix of exotic plantations and natives near the river boundary. The land was always difficult for people, and weed management and to keep fertile, being steep, erosion prone, class 6e land. The planting plan includes recreational pathways, exotic plantations, stock grazing the better class land to both provide fire breaks and continue to provide access ways. Over the next few years, the farm will be developed so it becomes a mix of exotic and native plantations, a dairy farm on the suitable land, and an orchard area on the highest quality land. The farm has around 2 kilometres of river boundary as well.



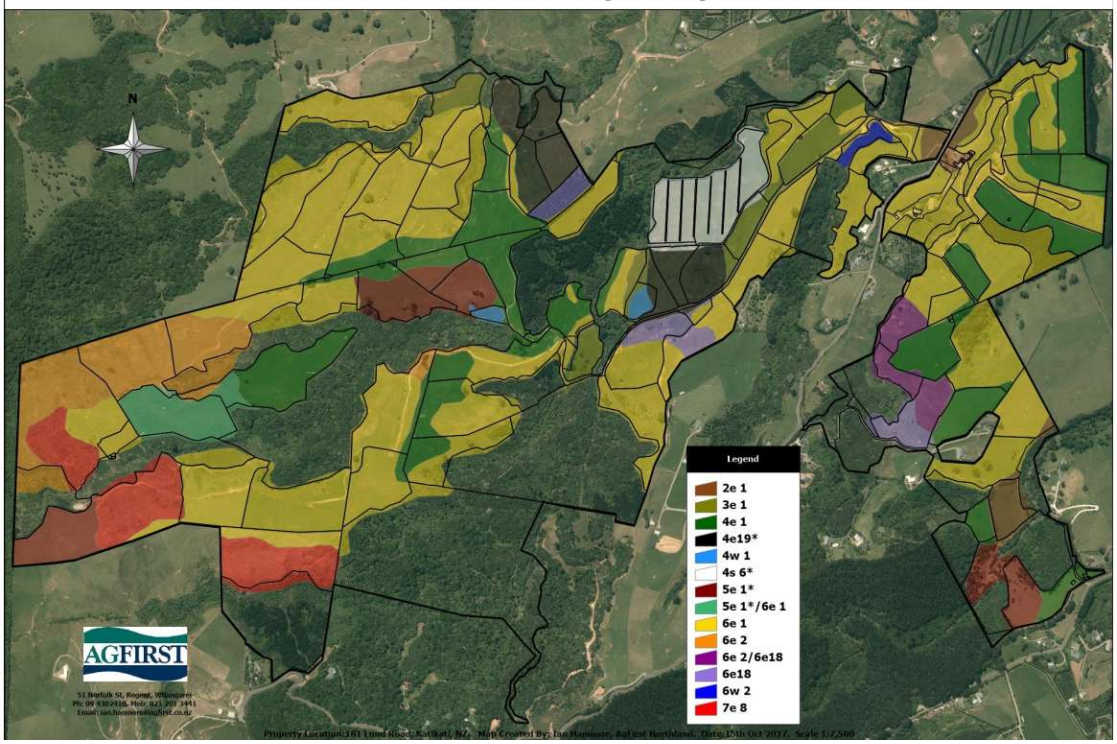

647 Pongakawa Rd - Ao Marama Farms

Appendix 3 – Pukekauri Farm map/land parcels

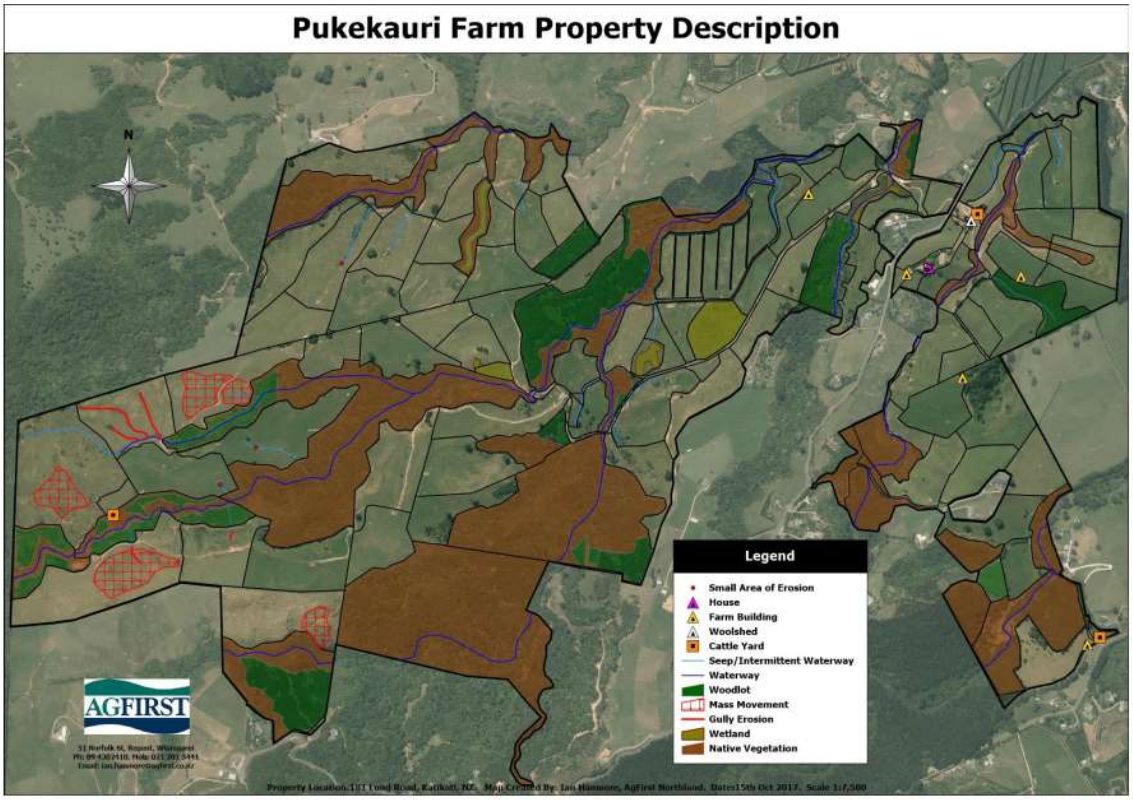
1.0 FARM SUMMARY

Feature	Farm Data
Location	181 Lund Road, Aongatete, Bay of Plenty
Enterprise	Bull finishing, dairy grazing, Suffolk sheep stud
Climate	Average annual rainfall 1500-1900mm
	Annual mean temperature 14.5^{0}c
Topography	14% Flat to rolling 26% Rolling to moderately steep 60% Moderately steep to steep
Soils	90% Volcanic tephra soils 10% Clay soils
Total Area	295ha
Total Paddock Area	182.5ha
Indigenous Vegetation	82 ha
Fenced Indigenous Vegetation	82 ha
Length of Perennial Waterways	8,755 m
Length of fenced Perennial Waterways	8,625m
Length of Ephemeral Waterways	4,197 m
Number of Wetlands	5
Number of fenced Wetlands	5

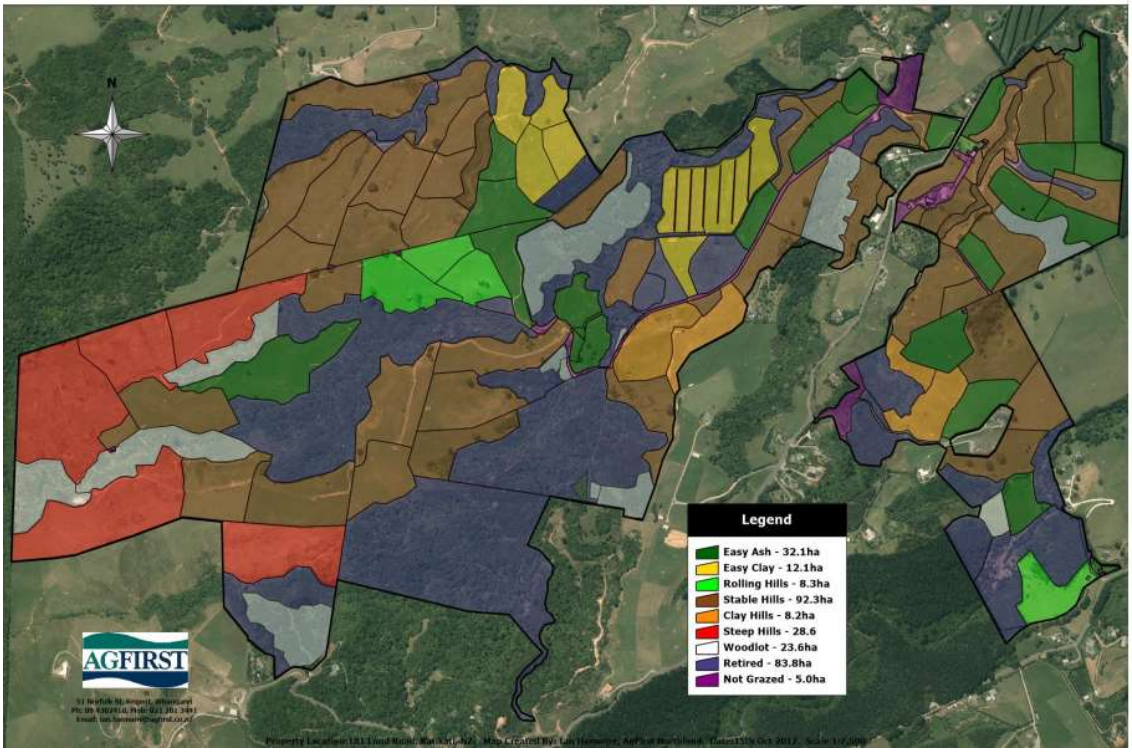
Pukekauri Farm Land Use Capability Classifications



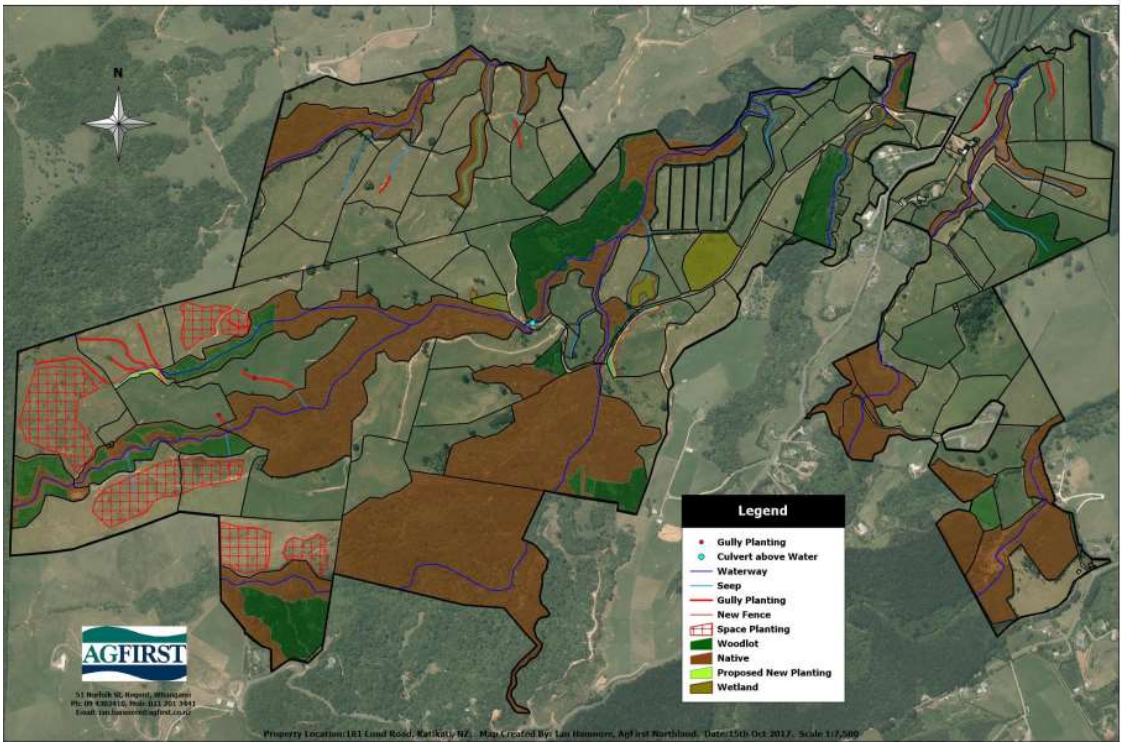
Pukekauri Farm Property Description



Pukekauri Farms Land Management Units



Pukekauri Farm Works Programme



Appendix 4 – Full costing of establishment (2022)

Comparative Native Planting Costs (2022 pricing)			Tīmata Forestry Grade	Tīmata Forestry Grade	High Density PB3
Plant Spacing:					
- Metres Between Plants			3.0	2.0	1.5
- Metres Between Rows			3.0	2.0	1.5
Plants per ha			1,111	2,500	4,444
Blanking %			15%	10%	0%
Blanking Plants			167	250	-
Total Plants			**1,278**	**2,750**	**4,444**
Planting Cost Metrics					
Preplant Spot Spray*	$ Per plant		$ 0.50	$ 0.50	$ 0.50
Plant	$ Per plant		$ 1.00	$ 1.00	$ 3.80
Planting	$ Per plant		$ 0.70	$ 0.70	$ 2.50
Total	**$ Per plant**		**$ 2.20**	**$ 2.20**	**$ 6.80**
Total Planting Cost per Hectare			**$ 2,811**	**$ 6,050**	**$ 30,222**
Release	$ Per plant		$ 0.50	$ 0.50	$ 0.50
	Cost per ha		$ 639	$ 1,375	$ 2,222
Succession Trees	Trees per ha		150	150	150
** Including Planting Labour	$ Per Tree**		$ 10.00	$ 10.00	$ 10.00
	Cost per ha		$ 1,500	$ 1,500	$ 1,500
Estimated:					
Weed Control	Cost per ha		$ 1,500	$ 1,000	$ 500
Animal Pest Control	Cost per ha		$ 1,000	$ 1,000	$ 1,000
Fencing	Cost per ha		$ 2,000	$ 2,000	$ 2,000
Earthworks			$ 500	$ 500	$ 500
TOTAL COST PER HECTARE			**$ 9,950**	**$ 13,425**	**$ 37,944**
* Ground based (Helicopter desiccation another option)					