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Takahuri Whenua: Approaches to Systems and Land Use Change to Reduce GHG Emissions

Prepared for NZ Agricultural Greenhouse Gas Research Centre

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Authors:
Phil Journeaux, AgFirst
Tanira Kingi, TKL
John-Paul Praat, Peter Handford, Conrad Lloyd-Bird, Groundtruth Ltd
Sandy Scarrow, Sophie Twigley, Fruition Horticulture
Reina Tamepo, Scion

Takahuri Whenua (*The Changing Land*) is part of the NZ Agricultural Greenhouse Gas Research Centre Māori Research Programme

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1.0 EXECUTIVE SUMMARY

This project focuses on three Māori Collectives, and investigates:

(i) The impact on greenhouse gas emissions, farm profitability, and nitrogen leaching levels at an individual farm level for six farms within each Collective;

(ii) The opportunity to operate the farms at a Collective level to enhance greenhouse gas emission reductions while maintaining or improving profitability; and

(iii) The opportunity to operate at a pan-Collective level to further achieve the goals of reduced greenhouse gas emissions/maintenance of business profitability.

This report concentrates on the first objective, namely the modelling at the individual farm level.

The three Collectives were:

(i) Tuwharetoa Farming Collective (Central North Island/Taupo) – sheep & beef farms

(ii) Te Arawa Arataua (Bay of Plenty/Rotorua) – dairy farms

(iii) Whāngārā Partnership (East Coast) – sheep & beef farms

All the individual farms were visited, and discussions held with Governance and management as to greenhouse gas issues, likely scenarios to be modelled, and best opportunities within the farm as to land use change.

The modelling involved three distinct aspects; farm system change, land use change into forestry, and land use change into either arable cropping or permanent horticulture.

The details of the modelling for each farm are outlined in the report. A summary of the results are:

1.1 Farm System Change

Most of the modelling was around reducing stock numbers (to reduce dry matter eaten). Reducing stocking rate on its own will certainly reduce greenhouse gas emissions, but usually at a significant cost to the farm business. For many of the farms, reducing stocking rate while improving the productivity of the remaining animals achieved both a reduction in greenhouse gases (in the order of 3-8%) while maintaining or improving financial returns. For some farms the improvement in productivity still resulted in a reduction in farm profitability, albeit much less than if no productivity improvement had occurred.

For the dairy farms, scenarios modelled involved reductions or elimination of bought-in supplementary feed or nitrogen fertiliser, both of which adds additional dry matter into the system and therefore boosts greenhouse gas emissions. The degree to which the removal of these factors from the farm system impacts on greenhouse gas emissions and farm profitability depends on the amount of the input, the proportion it makes up of total dry matter consumed, and the relative difference between marginal revenue versus marginal cost. The results therefore vary widely between the farms.

1.2 Forestry

For the project, three forestry regimes were included in the modelling:

(i) Production pines

(ii) Production other exotic softwood (cypress); and

(iii) Indigenous forestry planted as a permanent forest for carbon sequestration

For each of these regimes an annuity was developed, based on a 5% discount rate (current Government discount rate) for each farm, along with a carbon sequestration level based on "averaging" for the two production regimes, and on a permanent forest regime for the indigenous forest.

For each farm, approximately 10% of the current effective area was assumed to be planted, on the lessor (pasture) productive areas, based on a LUC analysis. This meant that the stock unit reduction on most farms (to allow for the forestry) was less than 10%.

The impact of the forestry was:

(i) Greenhouse gas emissions on the remaining pastoral area often increased, given an effective increase in the stocking rate.

(ii) Net emissions at the farm level decreased significantly given the offsetting nature of the sequestration by the trees.

(iii) Financially the forestry had a greater proportional impact on the dairy farms (ignoring the value of carbon).

(iv) The pine regime had the greatest positive impact financially due to its higher returns, with the indigenous forest having the least positive financial impact.

1.3 Horticulture

An assessment was made following the farm visit as to possible crops that could be grown, both arable and permanent horticulture, based on a variety of factors, e.g. soil type, climate, water availability, etc., as discussed in the report.

At this stage the emphasis was on whether the crop could be grown; other vital factors, such as whether a value chain existed, was not considered. Although such issues would be crucial to whether the crop would be grown, that is a matter for further investigation.

The end result was a suggestion on a range of possible crops, and a firmer recommendation for one arable crop and one permanent horticultural crop for each farm. These were then modelled within the farm system, under the assumption that (a) they would again take land out of the existing effective area; and (b) would be on the best land and would therefore have a directly proportional impact on stocking rate.

Generally, horticultural land has a much lower greenhouse gas emission profile relative to pastoral farming. Changing land use into horticulture means that the total farm emission profile effectively averages down. The overall impact depends therefore on the proportion of land taken out of pastoral farming – while there is some variation between the farms, often the reduction in greenhouse gas emissions was in the order of 5%. The impact on farm profitability tended to be strongly positive, given the greater profitability of the horticultural crop.

The other consideration was the impact on nitrogen leaching. The arable crop (assumed to be either oats or peas), often resulted in a slight increase in nitrogen leaching, which, for farms operating in a nitrogen-capped catchment, e.g. Taupo, would be quite crucial.

1.4 Impact of Carbon Levy

The intent is that from 2025, farmers will pay a carbon levy based on their emissions, with the general formula of A + B – C, where:

- A = price of methane
- B = price of nitrous oxide + CO_2 from nitrogen fertiliser; and
- C = value of carbon sequestration

Inasmuch as the separate price for methane is yet to be announced, a simple calculation on the amount of the levy was made based on a single assumed price in 2025 ($85/T$CO_2$e) and 2030 ($138/TCO_2e), accompanied by an assumption on the free allocation in each of those years (95% in 2025, 90% in 2030).

The outcome of this was:

(i) The average reduction in EBITDA for the dairy farms in 2025 was 1%, and 4% in 2030. For the sheep & beef farms the figures were 5-7% in 2025 and 17-24% in 2030. At the 2030 level, the sheep & beef farms will struggle to meet this.

(ii) The value of the carbon sequestration from the forestry planting showed through, with all farms showing a negative effect, i.e. the sequestration was greater than the levy. Within this, again the pines showed the greatest benefit.

2.0 BACKGROUND

This project builds on the previous six years' work that focused on modelling individual Māori dairy and livestock farms to develop mitigation and land use change scenarios to reduce Greenhouse Gas (GHG) emissions while minimising the economic impact on the farm businesses.

The project takes an integrated land use approach to the future of agribusiness. It provides an early high-level examination of how properties may be able to undertake land use changes that better align land use with land capability. There is potential for carefully planned land use changes to introduce forestry to lower production pastural areas, and to include areas of intensive horticulture where high quality soils and suitable climate are present. An integrated land use approach may offer opportunity for greater economic and environmental resilience, while also reducing greenhouse gas emissions.

This project focuses on three Māori Collectives, where a Collective is defined as:

1. A group of Māori farming entities that include governance structures under the 1993 Te Ture Whenua Māori Act (1993) that have formally established themselves under an administration structure (e.g. incorporated society).

2. A group of Māori farming entities that include governance structures established under Post Settlement Governance Entities (PSGEs) resulting from a Treaty of Waitangi settlement. These structures might include – limited liability companies, limited partnerships or other structures owned by a PSGE and like 1 above have formally established themselves under an administration structure (e.g. incorporated society).

3. A group of farms or farm entities that are in an informal collective arrangement that may be considering establishing a formally recognised collective.

2.1 The Collective Framework

The development of Collective Framework specifically designed for Māori farming groups and collectives is seen as a more effective structure for the assessment of mitigation options and land use change scenarios than the single case farm approach. Scaling up from single farm entities and single farms to reach a wider group of entities has been recognised as a limitation to the methodology. The proposed Collective Framework will adapt the single case farm methodology to a group of farms that are connected by common whakapapa linkages.

The Collective Framework involved modelling and presenting alternative systems and land use change options to the governance groups for up to six individual farms within three collectives (18 farms in total). This will be followed by group discussions among all of the governance and management teams of the modelled farms in the collective. These multi-farm discussions underpin the collective approach.

The project will test the proposition that the whanaungatanga (tribal connections) that bind the members of collectives goes beyond the farm business and encapsulates the community and environmental (kaitiakitanga) obligations of the trustees/committee members (te hunga tiaki). This community and environmental responsibility will underpin the development of the collective approach that draws on tikanga Māori imperatives in communication, agricultural technology adoption and extension.

Working with collectives is likely to increase the adoption and uptake of the single farm modelling approach that has been developed over the last six years. While it follows similar industry approaches that use monitor or model farms as an extension focal point for farmers to engage with scientists or technologists on innovations and new ideas, the proposed collective approach differs in one significant aspect: Decision-making on technology adoption/systems or land use change is made by a governance group (trustees, committee or board of directors) in consultation with a management team (farm manager, sharemilker, consultants/advisors, accountants etc.), and this governance group represents the aspirations of many hundreds and or often thousands of owners or tribal members. The complexity of this decision-making structure requires the development of a more comprehensive framework that encapsulates these complexities. This complexity also requires significant face to face interaction and communication between the research team, the farm governance and management teams and the collectives.

Note: This report only covers the initial modelling work carried out on each of the Collective's six farms.

2.2 The Collectives

The three collectives involved in the study are:

Tuwharetoa Farming Collective (Central North Island/Taupo) – sheep & beef farms:

- Puketapu 3A }
- Ohaukura No 3 } Tuatahi Farming Partnership
- Wakarawa Trust
- Waihi Pukawa Trust
- Rangiatea Station
- Taurewa Station

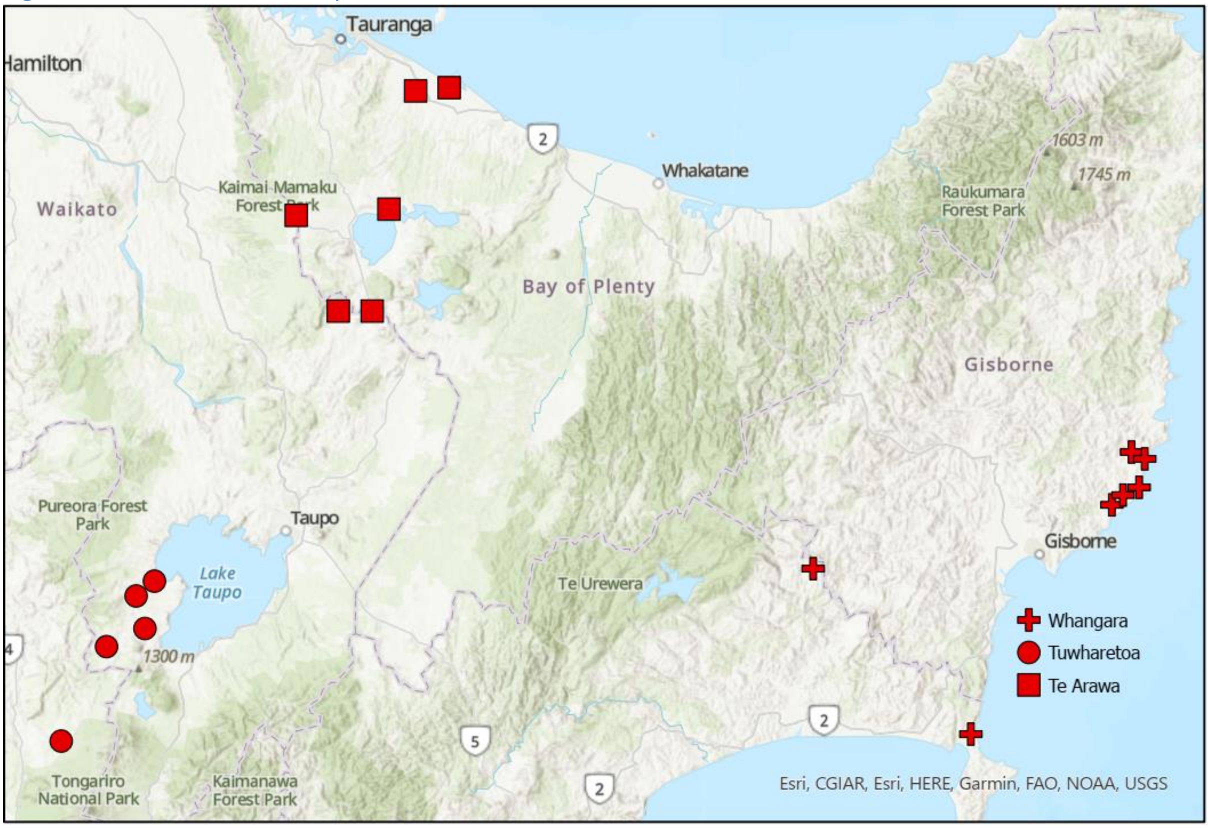
Te Arawa Arataua (Bay of Plenty/Rotorua) – dairy farms:

- Te Arawa Management Ltd
- Waipupumahana A1B2
- Tumunui Trust
- Maraeroa Oturoa 2B
- Waerenga Incorporation
- Otukawa

Whāngārā Partnership (East Coast) – sheep & beef farms:

- Rototahi
- Puatai
- Pakarae
- Whāngārā B5/Whitiwhiti
- Tongataha
- Pa Nui

Figure 1: Location of Case Study Farms



3.0 OBJECTIVES

The project focuses on three main areas:

1. Demonstrating the application of the 10-point methodology developed in phases 1-3 of the wider programme.

2. Developing a communication and extension framework where the methodology can be demonstrated on individual Māori farms and Māori collectives to inform, educate and motivate farm entities to explore and adopt the methodology to reduce on-farm agricultural GHGs through changes in farm systems design and land use diversification.

3. Building the capacity of the collectives and entities to develop a GHG mitigation framework that will enable Māori farmers and landowners to respond to environmental policy restrictions while also meeting the expectations of their owner communities

The overarching aim of the programme is to develop a GHG mitigation framework for Māori agribusiness entities (farmers, forest owners, horticulturists and landowners) that produces scenarios to reduce GHG (and freshwater) emissions while clarifying the socio-economic impacts of these scenarios.

Additionally, the project aims to understand how working with collectives can build on the knowledge and awareness of the Primary Sector Climate Change Commitment (He Waka Eke Noa) to develop practical experience in developing mitigation and land use change scenarios.

The programme is underpinned by nga ahuatanga Māori and kaupapa Māori research approaches that includes adherence to cultural tikanga (protocols) and kawa (rules) of the collectives and case farms.

4.0 METHODOLOGY

The methodology involved:

(i) Preliminary discussions with key members of the Collectives to seek their agreement to participate in the project.

(ii) Meeting with each Collective and providing a presentation on climate change and greenhouse gas issues, along with a discussion on what the project would involve.

(iii) Visiting each farm to again discuss the project with the Governance Board of the farm and collect relevant information on the farm to enable the modelling to be undertaken. The discussion also involved discussion on any farm system scenario's they would like modelled, as well as thoughts on land use change into forestry and/or horticulture.

(iv) The modelling was then carried out, initially with the three aspects - farm system forestry, horticulture, done in isolation, and then combined into different systems within the farm. Spatial mapping of the proposed land use changes was also done, to provide a visual outline of potential changes.

For each of the scenarios the GHG emissions, farm profitability, nitrogen leaching, and any carbon offsets were calculated, so as to illustrate the implications of the different scenarios.

The next step, outside of this report, is to visit each farm individually to report on and discuss the modelling outcomes, followed by a meeting of the Collective, to discuss the implications at a Collective level.

4.1 Farm Systems Modelling

All of the farms were set up in Farmax[1] to establish the base farm system, and the profitability of this. For the purposes of the analysis, a three year average milksolids payout and meat schedules were used in order to give a more "averaged" calculation of the farm's Earnings before Interest, Tax, Depreciation and Amortisation (EBITDA). This was done to give a more representative indication of farm profitability, given payouts and schedules rise and fall, and to better fit with the annuities or forestry (also calculated on a three year average log prices) and horticulture.

These payouts/schedules were:

Table 1: 3-year average prices ($/kg; 2018/19 – 2020/21)

Milksolids	Lamb	Bull Beef	Prime Beef	Venison
$7.01	$7.52	$5.31	$5.48	$8.02

[1] Farm system model: www.farmax.co.nz

Once the base farms were set up, they were also developed in OverseerFM[2], so as to calculate the GHG emissions (not withstanding that Farmax also calculates GHG emissions) and nitrogen leaching figure.

The exception to this were the Tuwharetoa farms, all of whom had Overseer files, which then formed the base of setting them up in Farmax.

The various scenarios were then modelled in Farmax to determine the physical and financial impact, with the data again transferred into OverseerFM to determine the impact on GHG emissions and nitrogen leaching.

4.2 Forestry Modelling

Retiring pastoral areas to forestry reduces the cost of GHG emissions to the farm business in two ways. Firstly, through the annual sale of carbon credits arising from the growth of new (post-1989) forests and secondly, by potentially displacing livestock from the farming operation. In this project both aspects are included in the modelling. The farm emissions profile was not directly impacted by carbon sequestrated by new forests on the farm. However, income from the sale of carbon credits was allocated to pay the emissions tax. Two prices were used for this either $85/NZU in 2025 or $138/NZU in 2030. The quantum of NZUs available for sale was determined by the proposed new forest area and forest type.

4.2.1 Carbon sequestration

Sequestration of carbon in forests occurs through photosynthesis by trees taking CO_2 from the atmosphere and moisture and nutrients through their roots to build cellulose and other biological materials, particularly in their woody stems. Sequestration or storage occurs while a forest is growing on a site that previously did not have forest, such as a pasture site. Eventually a forest will grow to its maximum biomass and be cycling carbon – so will cease to sequester more carbon from the atmosphere. Forest offsets provide an interim measure while we move away from burning fossil fuels.

The New Zealand Emissions Trading Scheme (ETS) facilitates the registration of land with new forests and provides the mechanism to account for gains and losses of carbon stored in a forest via "Look-up tables".

4.2.2 Forest types

Three types of forest have been included in the analysis of integrated land use for each of the 18 farms of this study. Table 4.2.1 describes the forest types along with the average sequestration rate. Note that default average age for Radiata Pine is 16 years and for Cypress (exotic softwood) is 22 years. Sequestration for native has been averaged over 50 years which is the current extent of the Look-up tables.

[2] Nutrient balance model: www.overseer.org.nz

Table 2: Forest type and average carbon sequestration rate.

Forest Type	Description	Average sequestration tonnes CO_2e/ha/year to average age (age, total tonnes/ha)
Radiata Pine	Structural or framing regime, thinned at age 10, clearfell at age 28	Taupo 22.1 (16, 354) BOP 20.8 (16, 333) Gisborne 25.6 (16, 410) Hawkes Bay 24.9 (16, 398) Southern NI
Special purpose timber species	Cypress example, pruned and thinned, clearfell at age 35	All regions 12.8 (22, 283)
Native Forest	Plant mix of native species, control pest weeds and animals, not harvested for 50 years	All regions 6.5 (50, 323)

Radiata Pine is low risk, relatively simple to manage, has established markets with known returns and achieves a high sequestration rate. Special purpose timber species such as Cypress, an exotic softwood, adds diversification into high value timbers which don't require preservative for some uses. Some of these species are more suited to long term continuous cover forest management. However, in comparison to Radiata Pine the management and markets are less well known, they are more expensive to establish and achieve only medium carbon sequestration rate. A framing regime was chosen for Radiata as this was the simplest and most cost-effective option. A clear-wood regime was chosen for Cypress in order to maximise the returns from higher value timber. Native forests create improved biodiversity and protection of water quality, are the least able to cope with weeds and have a low carbon sequestration rate. Any potential for very long term sustained yield timber production from native forests is not included. The mix of forest types on a farm will depend on landowner preference and site suitability.

4.2.3 Locating proposed new forest

An initial set of maps were prepared for each farm from existing spatial data. A full set included farm boundary, aerial image, paddock boundaries, land use capability (LUC) and land use classification 2016 or "LUCNA". The latter provides information to estimate the eligibility of land for entry into the NZETS. Farms varied in the availability of spatial data. For example, for some farms only national scale (1:50,000) LUC was available while others had been mapped at a farm scale, mostly by LandVision Ltd. Locations for new forests were suggested by the management team at four of the 18 farms. Where none was suggested, locations were proposed by Groundtruth Ltd on the basis of minimising the opportunity cost of lost pastoral production, access for harvest, protection of waterways and where possible, enhancement of farm management through new roading infrastructure and simplifying movement of livestock. The quantity of foregone pastoral production (available DM/ha/year) was estimated based on LUC and LUCNA data and categorised as either Low, Medium or High in relation to the average DM consumption derived by the Farmax model for each farm. Where farm scale LUC was available, location of forestry and assessment of livestock production forgone from pasture was more accurate than where only national scale LUC was available (see Figures 5-6 for comparison of national and farm scale LUC mapping). Table 2 summarises the area proposed for new forest, LUC and pasture production category and carbon region by farm.

4.2.4 Key cost and return assumptions

Key costs for new forests include costs of forest establishment, silviculture, follow up weed control, enrichment planting, harvest and roading as appropriate for each forest type at each site. Establishment and growing costs are summarised in Table 4.2.2. More detail on cost assumptions can be found in Section 7.1. Where harvest revenues are expected, yield tables were generated for each farm site. Timber yield and log grade mix for Radiata Pine was calculated using Forecaster Calculator (Ver 1.0.4.81). These were reduced by 20% to allow for uncertainties in actual production from these sites. For Cypress, the alternative, special purpose forest softwood species used for modelling, yield and log grade mix was estimated from Groundtruth Ltd experience and industry reports.

Harvest cost was based on the proportion of the site estimated to be suited to either ground based (skidder/tracked) or hauler harvesting. This approximately related to land up to 15° slope, over 15° and over about 20° slope respectively. Roading cost was based on estimates of the distance of formed road requiring upgrade, new road required on easy, moderate or difficult terrain. Table 7.1.2 details the roading distances and proportion of harvest type by farm.

Three year rolling average log prices for Radiata Pine were used from the Ministry of Primary Industry December 2021 report. Composite prices were derived in relation to log product mix percentages. For Cypress, the lower values of the range were used from values quoted in the farm forestry market report from Laurie Forestry. Current prices are used throughout the analysis.

The gross harvest return per hectare was calculated from yield, mix of log grades and mill gate or export prices. A broad estimate of 50% to domestic processing, 50% to export port was used for cost calculations. From this harvest, roading, transport and marketing costs were deducted based on log volume harvested per ha (m^3). This provided a net harvest return per hectare. This figure, also known as "stumpage", is the net return to the landowner from harvest. This has been calculated for pine and special purpose species (Cypress). Table 3 summarises the range in yield for Radiata Pine and the range in stumpage for Radiata Pine and Cypress. Where options involve forestry with a timber income, the situation with and without carbon income has been modelled.

Table 3: Effect of forest type on growing costs, yield and stumpage.

Forest Type	Establishment costs $/ha Year 1 (stems/ha (sph))	Growing costs $/ha (Yrs 1 to 11)	Yield (m^3/ha)	Stumpage ($/ha range)
Radiata Pine	$2,000 (1000 sph)	$850	554 - 770	$18,134 – $45,059
Cypress (SPS)	$2,870 (800 sph)	$4,600	500	$37,701 - $39,638
Native Forest	$8,000 (1600 + sph)*	$5,000	n/a	n/a

* In addition, about 300 sph of other forest species are planted later for enhancement
n/a = not applicable

4.2.5 Economic analysis

Two key performance Indicators were derived for each forest type at each farm. These were the Net Present Value (NPV) and Equivalent Annual Annuity. The NPV is the value of the cash flow if a 5% annual discount rate is applied to all future costs and revenue. This is effectively the amount that could be paid for land at the start of the project while still obtaining a 5% return on investment, and is also referred to as the Land Expectation Value (LEV). The Equivalent Annual Annuity is the payment that would need to be made over the rotation length to give an equivalent NPV. This is one way of considering a per hectare return from forestry that is spread over a long time period - for comparison with EBITDA from livestock operations where returns are calculated over a relatively very short term. Note that an average cashflow which is the cash flow average per year over the rotation period would be higher on an annual basis but does not take account of the time value of money as no discount rate is applied to future income.

Economic analysis was carried out for three carbon values. Either $85/NZU, $138/NZU or without carbon income.

4.3 Horticultural Modelling

Part of the purpose of visiting each farm was to assess the potential for arable and/or horticultural crops. Criteria were set for whether the land would be suitable for horticultural development relative to landform and the characteristics of the soil. Other factors, such as elevation also are considered, although is not used to exclude a property from this project.

Areas of the property identified as suited for horticulture have the following characteristics:

- Soil texture: silt loam, sandy loam, loam or loamy sand (in the topsoil 15 cm).
- Potential rooting depth: minimum one metre.
- Drainage Class: well-drained - Profile readily available water (0-100 cm): moderate (greater or equal to 50 mm).
- No point exceeding 15 degree slope.
- No land shall be facing 45 degrees either side of South (southeast to southwest).

Based on these criteria, areas in each farm were identified suitable for horticultural production. This estimated area could increase as small gullies and steep areas can be smoothed out by careful contouring.

4.3.1 Crop Options

Crops were considered based on various attributes, listed below. There is also a need to investigate other aspects with respect to horticultural development. These include:

- The desire for the community to have this level of intensive horticulture.
- The capacity of the community to manage intensive horticultural crops that require continuous input.
- The potential to grow crops as a cash crops while other areas of land are developed into perennial crops, e.g. passionfruit prior to planting kiwifruit.

- The legality of growing the crop, e.g. marijuana and hemp.

Those crops selected for further consideration will need to undergo detailed evaluation regarding crop production programmes, crop suitability for more specific sites, financial calculations for establishing and growing the crop and analysis of their marketing and likely income.

4.3.2 Description of Attributes Used in the Crop Considerations

There are many aspects to consider when making recommendations on crop options. These are listed below and then summarised in (Table 4). Appendix 9 provides more detail on these attributes.

- Climate
- Soils and landform
- Environmental considerations
- Time to first production, time to full production and productive lifespan
- Estimated establishment costs
- Crop storage attributes
- Size of industry, stage of industry development and recent trends
- Product types
- Export or domestic focus
- Marketing infrastructure
- Industry structure
- Level of growers "hands on" management required
- Production infrastructure
- Scalability
- Barriers to entry
- Level of labour required and peak labour period
- Biosecurity issues
- Pest and disease considerations

4.3.3 Reasons for Discounting a Crop

There are a number of crops that landowners might have considered as suitable for their block that we have discounted. Reasons for discounting a crop include productive reasons and crop and industry characteristics. For example, a crop that requires a significant duration of chilling during the winter or that performs poorly during humid summer may not be suited to some sites but suited to others. Similarly, the detrimental effect of regular cultivation on relatively fragile soils is the reason many vegetable crops were discounted, as these may require cultivation multiple times each year. This is particularly important for perennial crops such as asparagus where cultivation occurs mostly between the rows for weed control and to form beds annually.

Sometimes these factors are able to be addressed for a specific crop, for example with varieties that require limited chilling or within a niche operation using refrigeration to provide chilling of containerised plants. We have not included these activities unless they are well established technologies or widely available, proven low-chill varieties.

Industry characteristics may include factors such as the product being a long-storing international commodity (e.g. olives for oil), so there is limited opportunity for niche production from Aotearoa/New Zealand.

Based on all of these considerations 10 crops have been recommended as options for these sites. Table 4 summarises their characteristics and then detailed discussion on each crop is provided. While not all of these crops have been modelled for their Greenhouse Gas emissions, the similarity of the cropping systems suggests emissions calculated for the perennial tree and vine crops and the arable crops could be applied to similar crop types not modelled but discussed in the report.

Within the discussion is comment about the financial performance of the crop. This financial discussion included very generalised development costs and estimates of annual income and growing costs. From this is generated a Net Present Value (NPV). The NPV is a way in which options with different income streams, over different periods of time, can be compared. The larger the NPV, the better off, economically, the investor is. The calculations uses a 5% discount rate and extends the cashflows over 20 years, where appropriate. There are some crops (e.g. kiwifruit and avocados) that produce an income stream past this time period.

Table 4: Crop Attributes - Summary

	Potential Crop									
	Tree Crops				Vine Crops		Vegetable Crops	Berryfruit	Arable Crops	
Attribute	Avocados	Apples	Macadamias	Chestnuts	Kiwifruit	Wine Grapes	Annual Vegetables	Blueberries	Oats	Peas
Suited to Climate and Landform	Suited	Suited	Well suited	Well suited	Well suited	Well suited	Well suited	Well suited	Well suited	Well suited
Environmental Considerations	Perennial Crop	Perennial Crop	Perennial Crop	Perennial Crop	Perennial Crop	Perennial Crop	Intensive Cultivation	Perennial Crop	Soil carbon accumulation	Nitrogen fixing
Time to First Production	3 - 5 years	2 years	5 - 12 years	3 - 5 years	4 years (Green) 3 years (Gold3)	2 years	1 year	1 year indoors 3 years outdoors	1 year	1 year
Time to Full Production	5 - 8 years	6 years	10 - 15 years	10 - 15 years	7 years (Green) 6 years (Gold3)	4 years	Annual crop	6 years	Annual crop	Annual crop
Expected Productive Lifespan	20 - 30+ years	20 - 30 + years	25 - 35 years	100+ years	30 - 50+ years	50+ years	N/A	20+ years	N/A	N/A
Estimated Annual Gross Margin ($/ha)	Moderate	High (licenced varieties)	Moderate	Moderate	Moderate (Green) High (Gold3)	Moderate	Variable	Moderate	Variable	Variable
Estimated Establishment Costs ($/ha)	Moderate (plants, shelter, maybe irrigation)	High (plants, structures, shelter, irrigation and licence for protected varieties)	Moderate (plants, shelter, maybe irrigation)	Moderate (plants, shelter, maybe irrigation)	High (plants, structures, shelter, irrigation and licence for Gold3)	High (plants, structures, shelter and irrigation)	Variable	Moderate	Variable	Variable
Crop Storage Attributes	Medium - weeks. Can store on the tree by delaying harvest. Stores well. Limited time for international shipping.	Long - months	Nuts collected within 3 days of nut fall. Air dried nuts can be stored in shell for several months	Nuts collected daily to avoid degradation of nut quality Air dried nuts can be stored in shell for several months	Long - months	Long - years	Variable	Medium - weeks	Variable	Variable
Size of Industry (rounded to nearest 50 ha)	3,950 ha and increasing	10,400 ha and increasing	200 ha planted	150 ha planted	12,900 ha and increasing	39,950 ha and increasing	45,450 ha	750 ha and increasing	2,800 ha (2018)	4,100 ha

Stage of Industry Development	Mature	Mature	Emerging	Emerging	Mature	Mature	Mature	Mature	Mature	Mature
Produce Types	Fresh fruit, oil and pulp	Fresh and juice	Fresh and processed	Fresh and processed	Fresh	Processed (wine)	Fresh, processed and frozen	Fresh and frozen	Processed	Frozen
Recent Industry Trends	Significant growth in Northland and Taranaki	Increasing production. Fast moving cultivars trends in the industry.	Increasing interest in "healthy fats"	Increasing interest in "healthy fats"	Growth in Gold3 market Release of Red19	Interest in low alcohol wines	Reducing land availability in traditional areas	Large developments under cover	Alternative milks	Plant based proteins
Export or Domestic Market Focus	Both	Both	Domestic	Domestic - import substitution	Export	Both	Both	Export and domestic	Domestic	Both
Marketing Infrastructure	Developed	Developed	Cottage	Cottage	Developed	Developed	Developed	Developed	Undeveloped for milk	
Structure of Industry	Avocado Industry Council and registered with HEA	Apples and Pears NZ and registered with HEA	New Zealand Macadamia Society, www.macadamia.co.nz	New Zealand Chestnut Council and registered with HEA	New Zealand Kiwifruit Marketing Board (aka Zespri)	New Zealand Winegrowers	Horticulture New Zealand and various industry bodies	Blueberries New Zealand Miro LP Ltd	Foundation for Arable Research	Foundation for Arable Research
Level of Grower "Hands-on" Management	Moderate	Minimal	Moderate	Moderate	Minimal	Minimal	High	Moderate	Moderate	Moderate
Production Infrastructure	Well developed	Well developed	Undeveloped	Undeveloped	Developed	Developed	Developed in Whānagārā	Developed in some areas	Undeveloped in these regions	Developed in Whanagara
Scalability	Scalable - local market currently undersupplied at times	Highly scalable	Limited scalability from small base	Highly scalable if investment is applied to processing the nut into high-end export products	Highly scalable	Highly scalable	Highly scalable	Scalable	Scalable	Scalable
Barriers to Entry	None	Licence for PVR varieties	None	None	None for Green Licence costs and access for Gold 3	None	None	None	None	None
Level of Labour Required	Moderate	Moderate	Low - moderate	Low - moderate	High	High	High	High	Low	Low
Peak Labour Period	Harvest - July through to January	Harvest - autumn	Harvest - winter	Harvest - autumn	Canopy management June - February and Harvest March - June	Harvest - autumn	Planting and Harvest	Harvest - spring and summer	Harvest - autumn	Harvest - autumn

Biosecurity Issues	Typical	Typical	Typical - Guava moth may be problematic	Typical - though currently NZ is free of pest and diseases that are impacting significantly on international production	Psa had significant impact with other pests and diseases on the horizon. Kiwifruit Vine Health managing risk with government	Typical	Typical	Typical	Wild oats	Pea weevil incursion
Pest and Disease Considerations	Spray programme maintains good control of major pests and diseases. Common root rots need to be controlled.	Spray programme maintains good control of major pests and diseases	Very few pests or diseases of this crop presently	Spray programme maintains good control of major pests and diseases. Small scale of industry can result in limited control options. Highly suited to organic production.	Spray programme maintains good control of major pests and diseases. Zespri interested in growing organic category	Spray programme maintains good control of major pests and diseases	Rotation of crop family and types reduces incidence of reoccurring diseases	Spray programme maintains good control of major pests and diseases. Small scale of industry can result in limited control options	Spray programme maintains good control of major pests and diseases.	Spray programme maintains good control of major pests and diseases.

There is more detailed discussion on the individual crops in Appendix 9, Section 9.2

4.3.4 *Crops Recommended for the Various Trust Properties*

Based on this analysis described above, a recommendation of two crops has been made for each of the properties, one a permanent crop and the other an annual crop that may be considered in crop rotations within the overall farming system.

Table 5: Recommended crops

Trust Name	Recommended Crops
Tūwharetoa Collective	
Rangiatea Station	Chestnuts
	Oats
Tuatahi Partnership	Chestnuts
	Oats
Waihi Pukawa	Chestnuts
	Oats
Whakarawa	Chestnuts
	Oats
Taurewa	Chestnuts
	Oats
Te Arawa Collective	
Maraeroa	Chestnuts
	Oats
Otukawa	Chestnuts
	Oats
Te Arawa Management Ltd	Gold Kiwifruit
	Oats
Waerenga	Chestnuts
	Oats
Waipupumahana A1B2	Chestnuts
	Oats
Tumunui	Chestnuts
	Oats
Whāngārā Farms	
Pa Nui	Gold Kiwifruit/Macadamias
	Peas
B5/Whitiwhiti	Gold Kiwifruit
	Peas
Pakarae	Macadamias
	Peas
Rototahi	Macadamias/Grapes
	Peas
Tongatahi	Chestnuts/Macadamias
	Peas
Puatahi	Macadamias
	Peas

These were used as the basis for the modelling. If other similar crops were preferred by the farms, then (a) the GHG implications would be very similar; but (b) the financial impact would differ.

4.4 Spatial Mapping

Spatial maps were also produced for most of the farms (depending on whether source data was available). These included:

- Soil type by soil order
- Land capability class
- Growing degree days
- Land cover
- Slope
- Land use
- Annual sunshine hours
- Rainfall

All of which were used as a source of information when deciding on possible crops, and where any crops and forestry could be located on the farms.

Examples of such mapping are:

Figure 2: Rangiatea Station: LUC

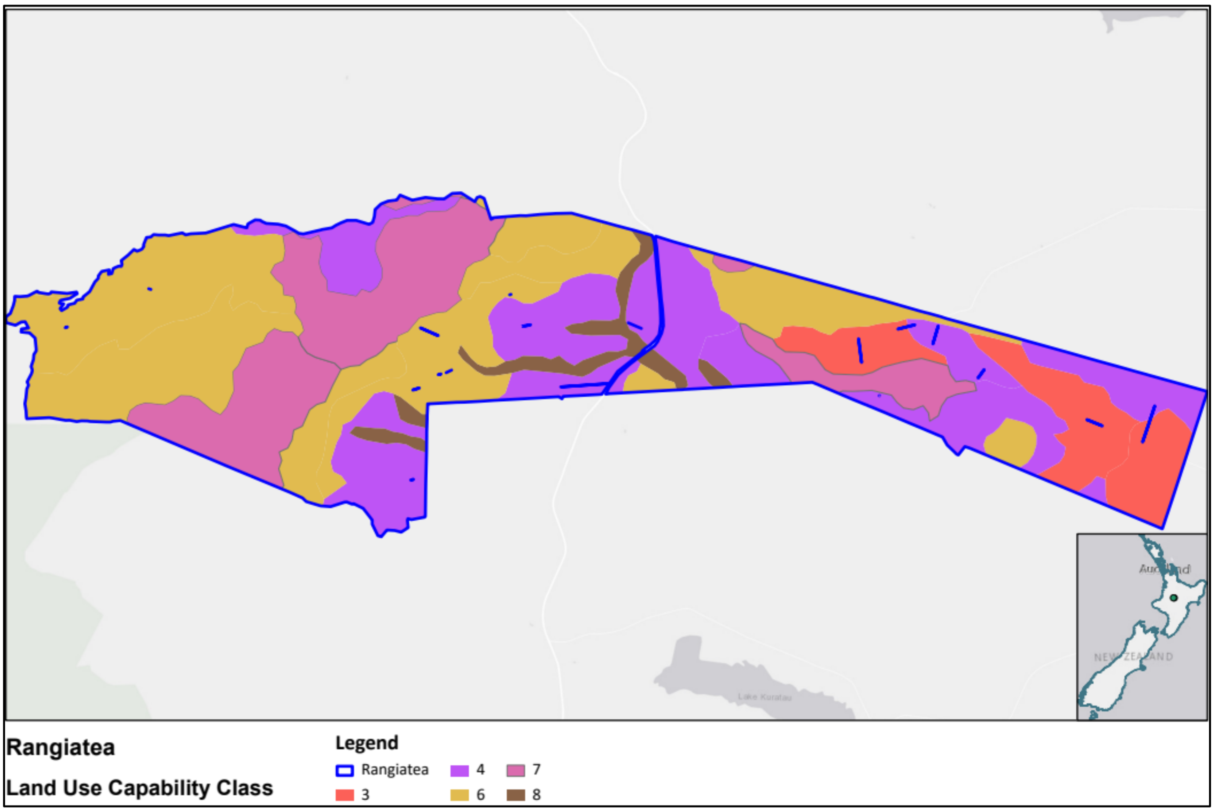


Figure 3: Waerenga Land Cover

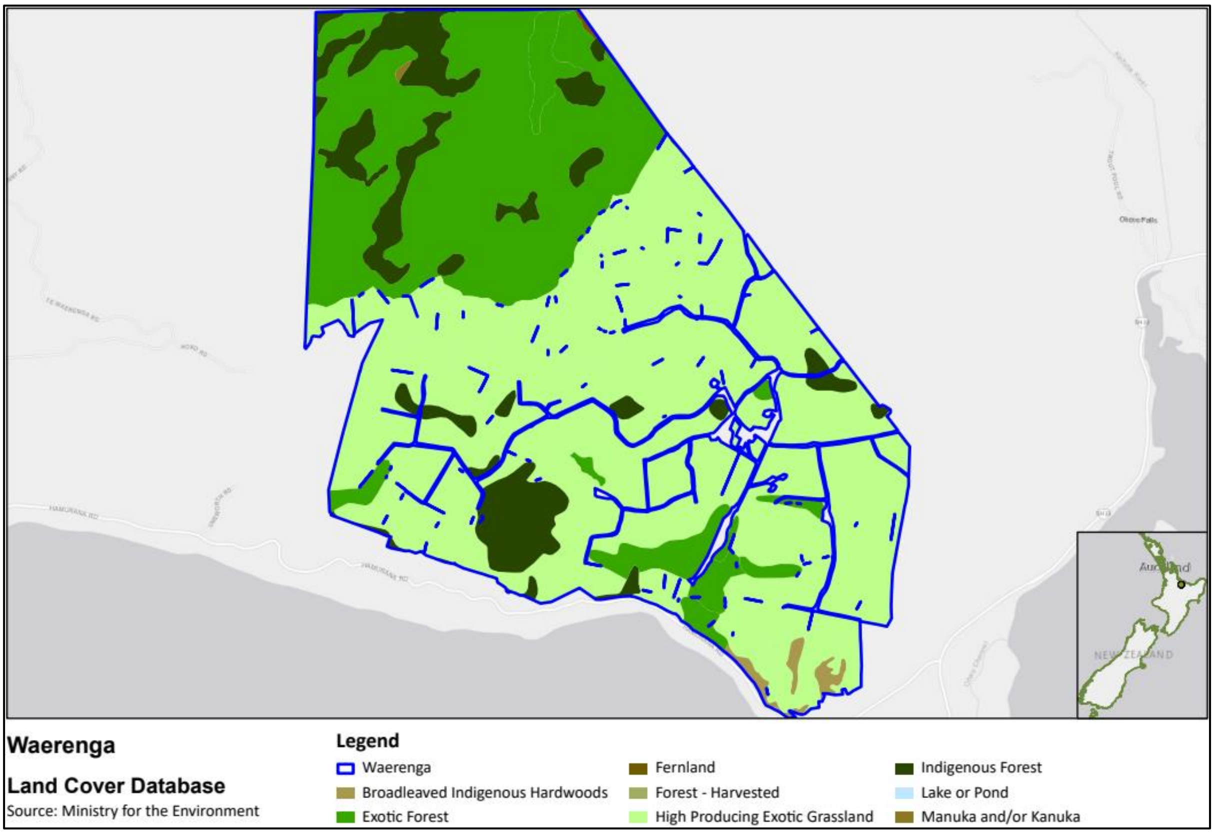
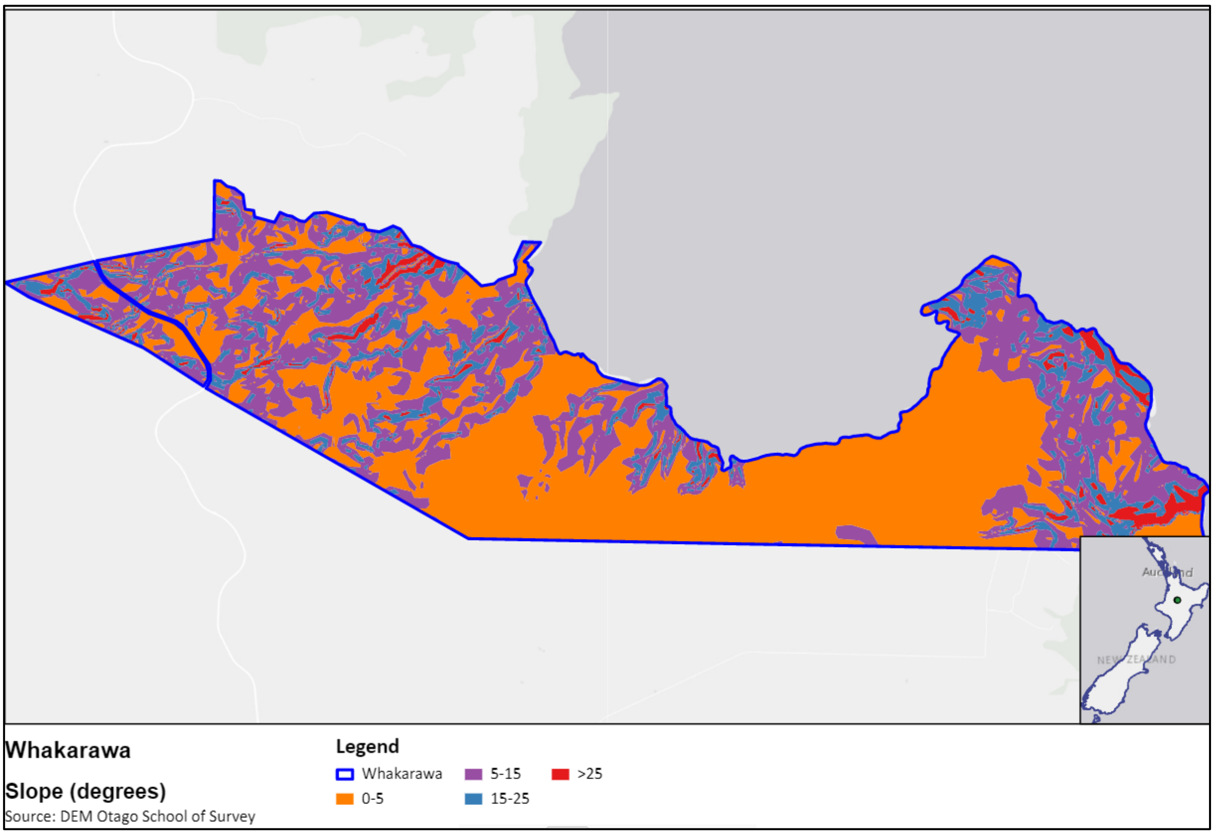


Figure 4: Whakarawa: Slope



The following is an example of available data and maps generated in relation to forestry (example is Tuatahi Partnership, Tuwharetoa Collective).

Figure 5: Property and paddock boundaries

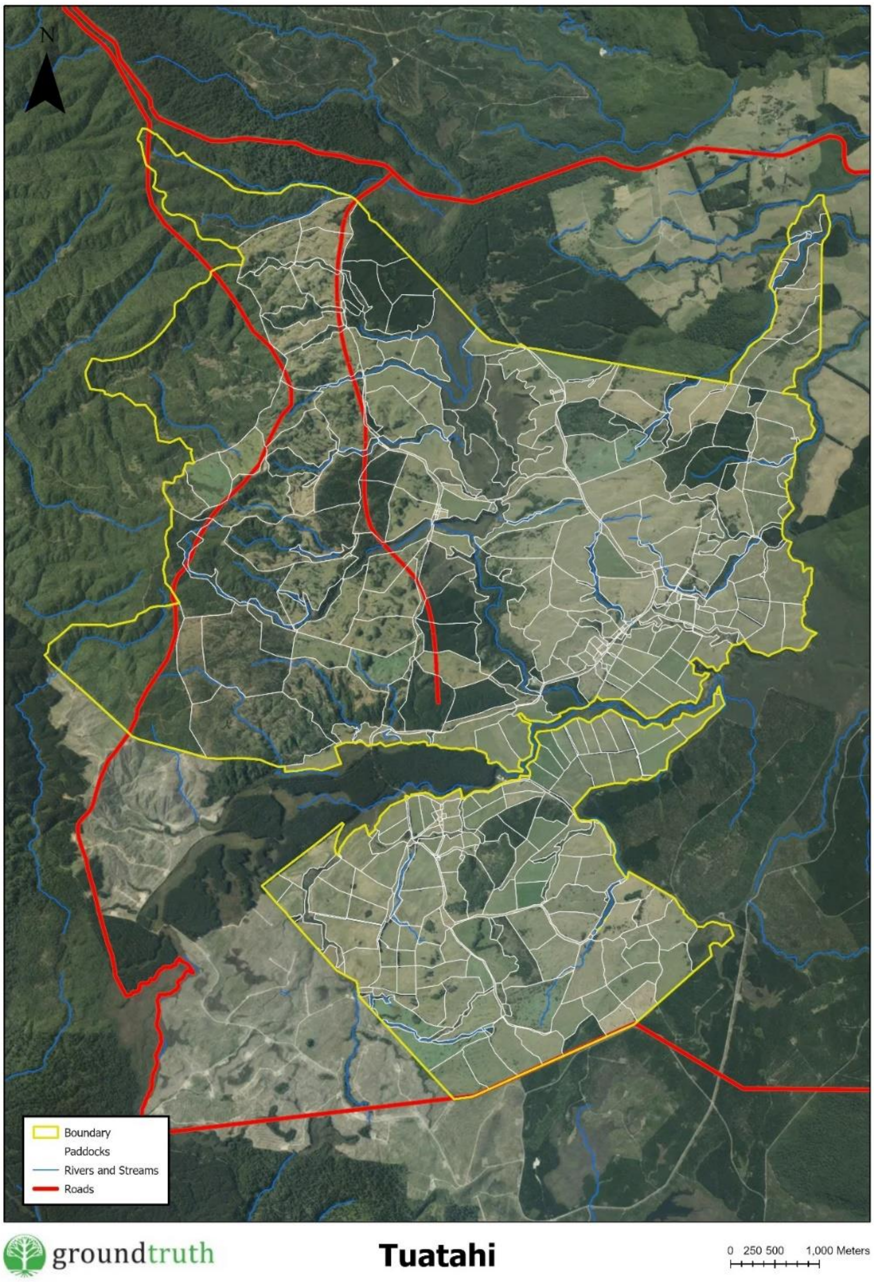


Figure 6: Land Use Capability

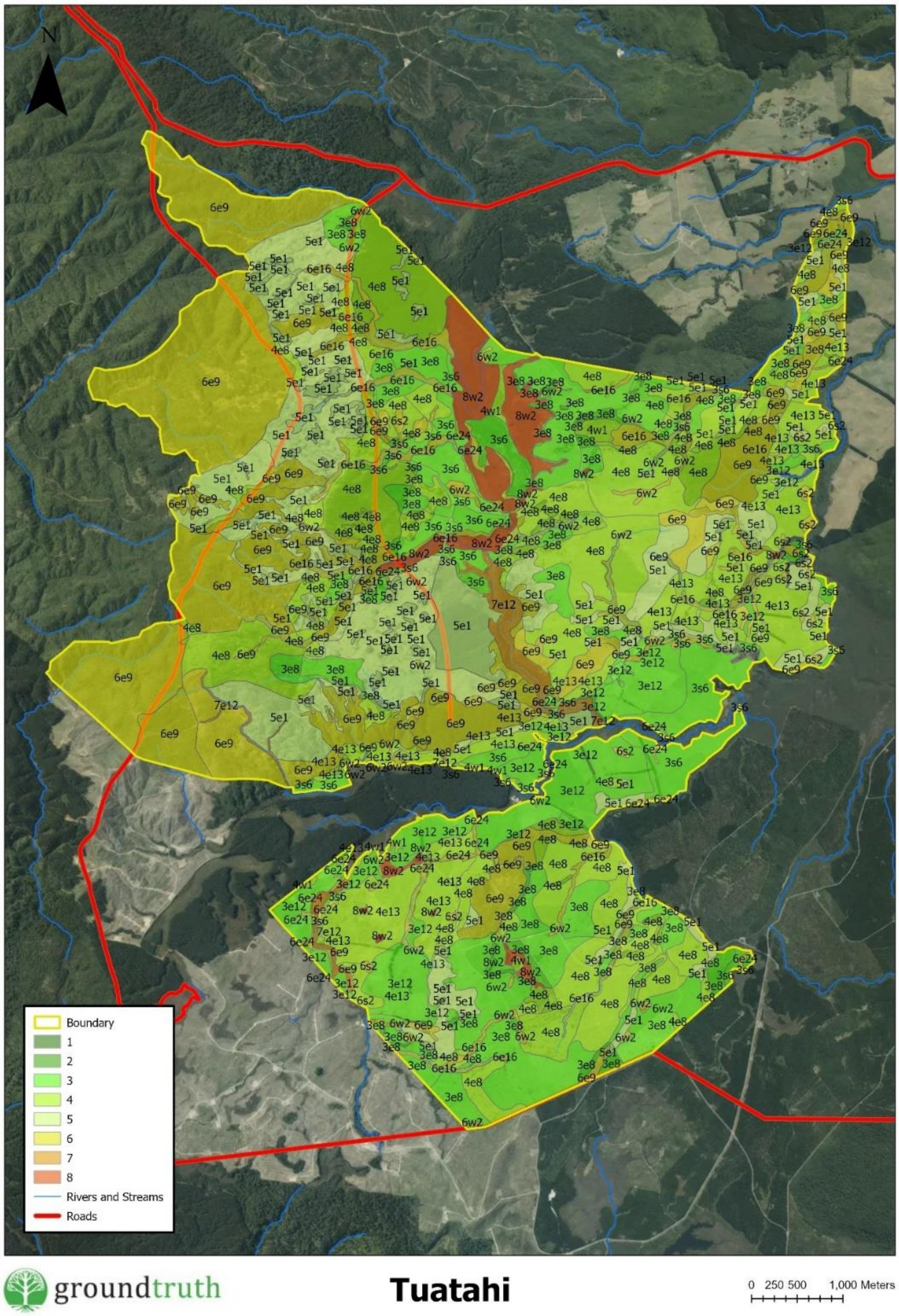
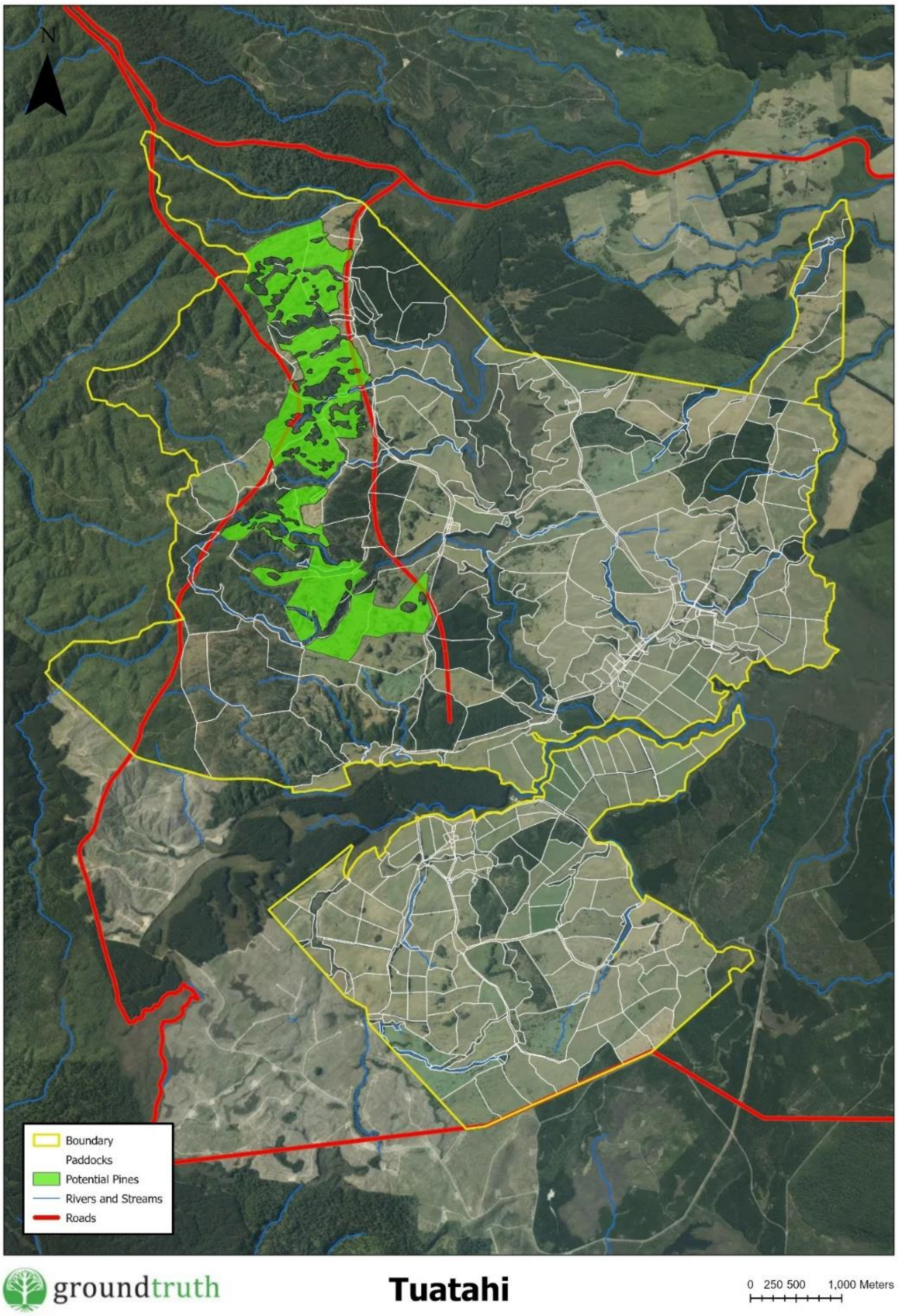


Figure 7: Location of proposed new forest



5.0 RESULTS

The modelling was based on the current effective areas of the farms; any land use change was therefore taken out of this effective area. There is also no value of carbon included, either as a cost to the farm or a return to the forestry scenarios - this is covered in Section 6. Some farms had existing areas of forestry, both production, with some in the ETS, and native. These have been ignored within this analysis.

5.1 Tuwharetoa Farming Collective

A range of scenarios were run for these sheep, beef, and (in many cases) deer farms:

Table 6: Farm Scenarios for Tuwharetoa

Base	Base Farm
Reduce stock numbers by 10%	All stock reduced down 10%. No change in animal performance
Reduce stock numbers by 10% Increase Productivity	All stock down 10%. Lambing % up 5- 3%, 2th by 10%. Lamb CW up 1 kg. Big steers CW up 10-15kg, Deer up 2-3kgCW
Swap breeding beef herd for finishing bulls	All beef animals sold. Replaced with buying in weaner bulls (Oct/Nov), finishing them as R2 year olds, average CW 310-320kg
Swap breeding beef herd for finishing prime beef	All beef animals sold. Replaced with buying in weaner steers (Oct/Nov), finishing them as R2 year olds, average CW 310kg
Plant forest - Pines	The impact on the farms varied - a key assumption was that the forest was planted on poorer quality pastureland, & hence the impact on stock numbers was not directly linear. Area planted in forest was ~10% of effective area. For most farms, stock numbers were reduced by 5-6%.
Plant forest - Other Exotic Softwood	
Plant forest - Natives	
Cropping - 100ha Oats	The crop was grown on the best land, so the reduction in stock numbers was directly proportional to the area cropped relative to total effective area.
Horticulture - 40ha Chestnuts	Similar to the cropping scenario - the orchard was based on the best land available, and stock numbers again reduced proportional to the area relative to total effective area.
Additional scenario for Rangiatea: Reduce stock numbers by 10% Run Bull Beef	All stock reduced 10%. Remove Beef breeding herd, replace with finishing 800 bulls - sell 20-24 months @ 310kg CW
Additional scenario for Wahi Pukawa: Reduce Breeding Ewes 20%, Increase Lambing to 160%, + increase Carcass Weights	Breeding ewes/Hoggets reduced 20%. Lambing lifted to 160%. Lamb CW+2kg. Beef CW + 15-40kg

Table 7: Tuwharetoa Scenario Results by Farm

Tuatahi	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Stocking rate (SU/ha pastoral area)	Gross CO_2e pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% change from Base model	EBITDA ($ effective ha/yr)	% change from Base model
Base	2,921.0		9.2	2.8	1.8		19		$191	
Reduce stock numbers by 10%	2,921.0	0	8.3	2.6	1.7	-7%	19	0%	$109	-43%
Reduce stock numbers by 10% Increase Productivity	2,921.0	0	8.6	2.7	1.7	-4%	19	0%	$194	2%
Swap breeding beef herd for finishing bulls	2,921.0	0	9.3	2.8	1.7	-2%	19	0%	$275	44%
Swap breeding beef herd for finishing prime beef	2,921.0	0	9	2.7	1.7	-5%	19	0%	$256	34%
Plant 294ha forest - Pines	2,627.0	294	10.4	3.0	0.6	-69%	18	-5%	$200	5%
Plant 294ha forest - Other Exotic Softwood	2,627.0	294	10.4	3.0	1.0	-42%	18	-5%	$183	-4%
Plant 294ha forest - Natives	2,627.0	294	10.4	3.0	1.4	-23%	18	-5%	$96	-50%
Cropping - 100ha Oats	2,821.0	100	9.9	2.9	1.8	0%	20	5%	$208	9%
Horticulture - 40ha Chestnuts	2,881.0	40	9.7	2.9	1.8	0%	19	0%	$319	67%
Rangiatea										
Base	1,631.7		13.0	5.1	2.2		17		$173	
Reduce stock numbers by 10%	1,631.7	0	11.7	4.6	2.0	-10%	16	-6%	$143	-18%
Reduce stock numbers by 10% Increase Productivity	1,631.7	0	11.9	5.0	2.1	-2%	16	-6%	$165	-5%
Swap breeding beef herd for finishing bulls	1,631.7	0	13.1	5.4	2.3	6%	17	0%	$264	52%
Swap breeding beef herd for finishing prime beef	1,631.7	0	12.7	5.0	2.1	-2%	17	0%	$245	41%
Reduce stock numbers by 10% Run Bull Beef	1,631.7	0	11.9	5.1	2.1	-2%	17	0%	$234	35%
Plant 162ha forest - Pines	1,469.7	162	14.4	5.0	1.0	-55%	16	-6%	$161	-7%
Plant 162ha forest - Other Exotic Softwood	1,469.7	162	14.4	5.0	1.4	-37%	16	-6%	$158	-9%
Plant 162ha forest - Natives	1,469.7	162	14.4	5.0	1.6	-25%	16	-6%	$120	-31%
Cropping - 100ha Oats	1,531.7	100	13.9	5.1	2.0	-7%	19	12%	$176	2%
Horticulture - 40ha Chestnuts	1,591.7	40	13.9	5.1	2.1	-4%	17	0%	$267	54%

Taurewa	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Stocking rate (SU/ha pastoral area)	Gross $CO_{2}e$ pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% change from Base model	EBITDA ($ effective ha/yr)	% change from Base model
Base	2,615.0	0	9.4	3.0	3.0		26		$321	
Reduce stock numbers by 10%	2,615.0	0	8.5	2.7	2.7	-10%	24	-8%	$289	-10%
Reduce stock numbers by 10% Increase Productivity	2,615.0	0	9	2.8	2.8	-6%	25	-4%	$373	16%
Swap breeding beef herd for finishing bulls	2,615.0	0	9.1	3.0	3.0	1%	26	0%	$338	5%
Swap breeding beef herd for finishing prime beef	2,615.0	0	9.1	2.5	2.5	-15%	24	-8%	$210	-35%
Plant 263ha forest - Pines	2,352.0	263	11	3.2	0.6	-79%	25	-4%	$361	12%
Plant 263ha forest - Other Exotic Softwood	2,352.0	263	11	3.2	1.7	-42%	25	-4%	$338	5%
Plant 263ha forest - Natives	2,352.0	263	11	3.2	2.3	-23%	25	-4%	$241	-25%
Cropping - 100ha Oats	2,515.0	100	10.3	3.0	2.9	-2%	29	12%	$340	6%
Horticulture - 40ha Chestnuts	2,575.0	40	10.3	3.0	3.0	0%	27	4%	$469	46%
Wahi Pukawa										
Base	2,742.1	0	10.3	4.3	2.8		23		$351	
Reduce stock numbers by 10%	2,742.1	0	9.2	3.9	2.6	-9%	22	-4%	$297	-15%
Reduce stock numbers by 10% Increase Productivity	2,742.1	0	9.6	4.0	2.6	-8%	22	-4%	$334	-5%
Reduce Breeding Ewes 20%, Increase Lambing to 160%, + CWs	2,742.1	0	9.8	4.2	2.7	-3%	23	0%	$379	8%
Plant 287ha forest - Pines	2,455.1	287	11.4	4.7	1.3	-53%	23	0%	$398	13%
Plant 287ha forest - Other Exotic Softwood	2,455.1	287	11.4	4.7	1.9	-31%	23	0%	$379	8%
Plant 287ha forest - Natives	2,455.1	287	11.4	4.7	2.4	-17%	23	0%	$316	-10%
Cropping - 100ha Oats	2,642.1	100	10.5	4.4	2.8	0%	25	9%	$368	5%
Horticulture - 40ha Chestnuts	2,702.1	40	10.5	4.4	2.8	1%	24	4%	$444	26%

Whakarawa	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Stocking rate (SU/ha pastoral area)	Gross $CO_{2}e$ pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% change from Base model	EBITDA ($ effective ha/yr)	% change from Base model
Base	1,208.6	0	9.7	3.5	1.7		10		$108	
Reduce stock numbers by 10%	1,208.6	0	8.7	3.1	1.5	-10%	10	0%	$84	-22%
Reduce stock numbers by 10% Incr Productivity	1,208.6	0	9.6	3.4	1.7	-1%	10	0%	$118	9%
Plant 119ha forest - Pines	1,089.6	119	10.8	3.7	0.6	-67%	10	0%	$119	10%
Plant 119ha forest - Exotics	1,089.6	119	10.8	3.7	1.0	-40%	10	0%	$107	-1%
Plant 119ha forest - Native	1,089.6	119	10.8	3.7	1.3	-22%	10	0%	$66	-39%
Cropping - 100ha Oats	1,108.6	100	10.5	3.7	1.6	-3%	13	30%	$108	0%
Horticulture - 40ha Chestnuts	1,168.6	40	10	3.5	1.6	-3%	11	10%	$255	135%

Note:

(i) With the exception of Taurewa, the remaining farms are within the Taupo catchment and therefore subject to the nitrogen leaching cap within that catchment, which means the farms are very sensitive to any change in nitrogen leaching levels.

(ii) For the “Oats” scenario, it was assumed that the oats were grown as a base for oat milk production, at an assumed GM/ha of $500. The current GM/ha for Oats in this region is -$60/ha.

5.2 Te Arawa Arataua

The scenarios modelled for these dairy farms were:

Table 8: Farm Scenarios for Te Arawa

Base model	Base farm system
Reduce SR 10%, no improvement in productivity	Stock reduced 10%, no improvement in per cow production
Reduce SR 10%, Increase per cow production	Stock reduced 10%, per cow production increased within existing feed available
Remove 50% of nitrogen fertiliser applied to pasture	50% of applied nitrogen fertiliser removed
No Bought-in Supplement	All bought-in supplements removed
Replace Palm Kernel/High protein supplement with Maize Silage	Any high protein supplement was replaced with maize silage
Forestry - pines	Approximately 10% of the farm planted in forestry. Assumption this was on the poorer part of the farm; stock reduced by 7-12%
Forestry - other exotic softwood	
Forestry - natives	
Horticulture - 10 ha in either Chestnuts or Kiwifruit	10ha of horticulture planted on the best area of land. Cows reduced by ~5%
Cropping - plant 10ha in oats	Scenarios run for Otukawa and TAML only - 10ha planted in oats on best land

Table 9: Te Arawa Scenario Results by Farm

Otukawa	Pastoral Area (ha)	Area planted in Forestry or Horticulture (ha)	Cows Wintered 1 July (head)	Stocking rate (Cows/ha pastoral area)	Milksolids/peak cow (kgMS)	Net CO_2e over pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% Change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base model	155.1	0	549	3.5	343	13.1	13.1		37		$4,973	
Reduce SR 10%, no improvement in productivity	155.1	0	494	3.2	342	11.8	11.8	-10%	33	-11%	$4,143	-17%
Reduce SR 10%, Increase per cow production	155.1	0	494	3.2	382	12.5	12.5	-4%	35	-5%	$4,976	0%
1/2 Nitrogen	155.1	0	532	3.4	350	12.6	12.6	-3%	34	-8%	$4,931	-1%
No Bought-in Supplement	155.1	0	505	3.3	345	12.3	12.3	-6%	37	0%	$4,927	-1%
Replace Palm Kernel with Maize Silage	155.1	0	549	3.5	343	13.1	13.1	0%	36	-3%	$4,971	0%
Forestry - plant 15 ha in pines	140.1	15	494	3.5	354	12.9	9.6	-26%	32	-14%	$4,554	-8%
Forestry - plant 15 ha in other exotic softwood	140.1	15	494	3.5	354	12.9	10.4	-20%	32	-14%	$4,502	-9%
Forestry - plant 15 ha in natives	140.1	15	494	3.5	354	12.9	11.0	-16%	32	-14%	$4,419	-11%
Horticulture - 10 ha Kiwifruit	145.1	10	516	3.6	343	13.2	12.3	-6%	35	-5%	$12,032	142%
Cropping - 10 ha Oats	145.1	10	516	3.6	343	13.1	12.2	-6%	36	-3%	$4,887	-2%
Waerenga												
Base model	570.5	0	1,094	1.9	307	8.5	4.4		29		$2,241	
Reduce SR 10%, no improvement in productivity	570.5	0	984	1.7	308	7.8	4.1	-8%	27	-7%	$1,831	-18%
Reduce SR 10%, Increase per cow production	570.5	0	984	1.7	372	8.3	4.3	-3%	28	-3%	$2,457	10%
1/2 Nitrogen	570.5	0	1,061	1.9	308	8.2	4.2	-4%	27	-7%	$2,183	-3%
No Bought-in Supplement	570.5	0	962	1.7	308	7.9	4.1	-7%	28	-3%	$2,331	4%
Replace Palm Kernel with Maize Silage	570.5	0	1,094	1.9	308	8.7	4.5	2%	28	-3%	$2,234	0%
Forestry - plant 56 ha in pines	514.5	56	1,050	2.0	308	9.1	3.2	-27%	28	-3%	$2,218	-1%
Forestry - plant 56 ha in other exotic softwood	514.5	56	1,050	2.0	308	9.1	3.6	-18%	28	-3%	$2,185	-3%
Forestry - plant 56 ha in natives	514.5	56	1,050	2.0	308	9.1	3.9	-11%	28	-3%	$2,101	-6%
Horticulture - 10 ha Chestnuts	560.5	10	1,072	1.9	308	8.5	4.3	-2%	29	0%	$2,282	2%

Waipupumahana	Pastoral Area (ha)	Area planted in Forestry or Horticulture (ha)	Cows Wintered 1 July (head)	Stocking rate (Cows/ha pastoral area)	Milksolids/peak cow (kgMS)	Net CO_2e over pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% Change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base model	200	0	552	2.8	404	9.0	9.0		55		$4,124	
Reduce SR 10%, no improvement in productivity	200	0	497	2.5	405	8.2	8.2	-10%	50	-9%	$3,529	-14%
Reduce SR 10%, Increase per cow production	200	0	497	2.5	455	8.6	8.6	-4%	52	-5%	$4,329	5%
1/2 Nitrogen	200	0	524	2.6	404	8.3	8.3	-8%	49	-11%	$3,914	-5%
No Bought-in Supplement	200	0	497	2.5	404	8.2	8.2	-9%	51	-7%	$3,718	-10%
Replace Palm Kernel with Maize Silage	200	0	552	2.8	404	9.0	9.0	0%	53	-4%	$4,035	-2%
Forestry - plant 18 ha in pines	182	18	524	2.9	405	9.4	6.7	-26%	53	-4%	$3,932	-5%
Forestry - plant 18 ha in other exotic softwood	182	18	524	2.9	405	9.4	7.4	-18%	53	-4%	$3,907	-5%
Forestry - plant 18 ha in natives	182	18	524	2.9	405	9.4	8.0	-11%	53	-4%	$3,831	-7%
Horticulture - 10 ha Chestnuts	190	10	524	2.8	406	9.1	8.6	-4%	55	0%	$4,326	5%
Te Arawa Management Ltd												
Base (New Farm)	154	0	580	3.8	314	11.4	11.4		36		$3,247	
Reduce SR 10%, no improvement in productivity	154	0	522	3.4	314	10.4	10.4	-9%	33	-8%	$2,706	-17%
Reduce SR 10%, Increase per cow production	154	0	522	3.4	314	10.9	10.9	-5%	34	-6%	$3,373	4%
1/2 Nitrogen	154	0	551	3.6	347	10.5	10.5	-8%	29	-19%	$3,173	-2%
No Bought-in Supplement	154	0	493	3.2	314	10.2	10.2	-11%	35	-3%	$3,049	-6%
Replace Hi Protein supplements with Maize Silage	154	0	580	3.8	314	11.5	11.5	1%	32	-11%	$3,278	1%
Forestry - plant 14 ha in pines	140	14	557	4.0	315	12.3	9.3	-19%	36	0%	$3,201	-1%
Forestry - plant 14 ha in other exotic softwood	140	14	557	4.0	315	12.3	10.0	-12%	36	0%	$3,153	-3%
Forestry - plant 14 ha in natives	140	14	557	4.0	315	12.3	10.6	-7%	36	0%	$3,074	-5%
Horticulture - 10 ha Kiwifruit	144	10	545	3.8	315	11.6	10.9	-5%	35	-3%	$10,517	224%
Cropping - 10 ha Oats	144	10	545	3.8	315	11.7	10.9	-4%	36	0%	$3,036	-6%

Note:

The Te Arawa Management Ltd farm was 169 ha in total, but this was to be reduced down to 154 ha – the modelling carried out was based on this "new" farm.

Maraeroa Oturoa 2B	Pastoral Area (ha)	Area planted in Forestry or Horticulture (ha)	Cows Wintered 1 July (head)	Stocking rate (Cows/ha pastoral area)	Milksolids/peak cow (kgMS)	Net CO_{2e} over pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% Change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base model	278	0	703	2.5	312	9.7	7.5		60		$2,236	
Reduce SR 10%, no improvement in productivity	278	0	632	2.3	312	8.8	6.8	-9%	55	-8%	$1,786	-20%
Reduce SR 10%, Increase per cow production	278	0	632	2.3	367	9.5	7.3	-2%	58	-3%	$2,666	19%
1/2 Nitrogen	278	0	682	2.5	312	9.1	7.0	-6%	54	-10%	$2,182	-2%
No Bought-in Supplement	278	0	632	2.3	312	8.8	6.8	-9%	59	-2%	$2,338	5%
Replace Palm Kernel with Maize Silage	278	0	703	2.5	312	9.7	7.5	0%	59	-2%	$2,235	0%
Forestry - plant 33 ha in pines	245	33	654	2.7	313	10.4	5.2	-31%	59	-2%	$2,109	-6%
Forestry - plant 33 ha in other exotic softwood	245	33	654	2.7	313	10.4	5.9	-21%	59	-2%	$2,075	-7%
Forestry - plant 33 ha in natives	245	33	654	2.7	313	10.4	6.5	-13%	59	-2%	$1,972	-12%
Horticulture - 10 ha Chestnuts	268	10	682	2.5	313	9.8	7.3	-2%	61	2%	$2,425	8%

	Dairy Area (ha)	Area planted in Forestry or Horticulture (ha)	Cows Wintered 1 July (head)	Stocking rate (Cows/ha pastoral area)	Milksolids/peak cow (kgMS)	Deer Area (ha)	Breeding Hinds Wintered	Deer SU/ha	Net CO_{2e} over pastoral area (T/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	(kg N/ha/yr)	% Change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Tumunui North															
Base (Dairy + Deer)	550		920	1.7	320	100	470	10.1	2.6	2.6		25		$1,080	
Reduce SR 10%, no improvement in productivity (Dairy + Deer)	550		828	1.5	321	100	423	9.1	2.4	2.4	-9%	22	-12%	$794	-26%
Reduce SR 10%, Increase productivity (Dairy + Deer)	550		828	1.5	380	100	423	9.2	2.5	2.5	-5%	23	-8%	$1,309	21%
Plant 140 ha forestry - pines	550	140	920	1.7	320	100	470	10.1	2.6	-1.6	-173%	20	-19%	$941	-13%
Plant 140 ha forestry - other exotic softwood	550	140	920	1.7	320	100	470	10.1	2.6	-0.1	-107%	20	-19%	$869	-20%
Plant 140 ha forestry - natives	550	140	920	1.7	320	100	470	10.1	2.6	1.0	-54%	20	-19%	$723	-33%
Dairy 1/2 Nitrogen + Base Deer	550		911	1.7	320	100	470	10.1	2.5	2.1	-3%	23	-8%	$926	-14%
Dairy No Bought-in Supplement + Base Deer	550		874	1.6	321	100	470	10.1	2.5	2.0	-4%	24	-4%	$844	-22%
Dairy Replace Palm Kernel with Maize Silage + Base Deer	550		920	1.7	320	100	470	10.1	2.6	2.1	0%	24	-4%	$878	-19%
Horticulture - 10ha Chestnuts on dairy unit + Base Deer	540	10	902	1.7	320	100	470	10.1	2.6	2.5	-2%	24	-4%	$1,203	11%

Note:
The original Tumunui North farm was 790 ha effective. In discussion with the owners, they indicated they were planning to alter this into a 550 ha dairy farm, 100 ha deer farm, and plant 140 ha into forestry. It is this latter configuration which has been modelled.

5.3 Whāngārā Farms Ltd

The scenarios modelled for these sheep & beef farms were:

Table 10: Farm Scenarios for Whāngārā Farms

Base	Base farm system
Reduce SR 10%	Reduce stock numbers by 10%, with no improvement in per animal performance. Remove nitrogen fertiliser
Reduce Sr 10% Increase productivity	Reduce stock numbers by 10% and increase per animal performance; lambing % up 5%, calving up4%, Lamb CW increased by 1-1.5kg, cattle CW increased by 5-15kg
Replace Breeding cows with finishing bulls	Take out all breeding cattle replace with finishing bulls; buy in yearlings, finish at 20-22 months at ~350kg CW
Reduce Ewes 20%, Increase lambing % to 160	Tongataha only: Reduce breeding ewes by 20%, increase lambing to 160%, increase lamb CW by 2kg
Plant forest - pines	Plant approximately 10% of the effective area in forest - only the poorer (Class 7 land)
Plant forest - Other exotic softwood	
Plant forest - natives	
Cropping - peas	Plant ~50ha in arable crop - peas
Horticulture - kiwifruit, macadamias, grapes, chestnuts	Plant 20ha in horticulture - type depending on the farm.

Table 11: Whāngārā Scenario Results by Farm

B5 Whitwhiti	Pastoral Area (ha)	Area Planted in Forestry or Horticulture (ha)	Stocking rate (pastoral area)	Gross CO_2e pastoral area (t/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base	3,222	0	11.5	4.1	4.1		$740	
Reduce SR 10%	3,222	0	10.6	3.7	3.7	-10%	$751	2%
Reduce Sr 10% Increase productivity	3,222	0	11	3.9	3.9	-6%	$806	9%
Replace Breeding cows with finishing bulls	3,222	0	11.2	4.0	4.0	-3%	$839	13%
Plant 186 ha forest - pines	3,036	186	12	4.5	2.7	-34%	$761	3%
Plant 186 ha forest - Other exotic softwood	3,036	186	12	4.5	3.5	-16%	$742	0%
Plant 186 ha forest - natives	3,036	186	12	4.5	3.8	-7%	$693	-6%
Cropping - 100ha peas	3,122	100	11.5	4.2	4.1	-1%	$782	6%
Horticulture - 20ha gold kiwifruit	3,202	20	11.6	4.1	4.1	-1%	$1,326	79%
Pakarae								
Base	1,431	0	9	3.3	3.3		$397	
Reduce SR 10%	1,431	0	8.1	2.8	2.8	-15%	$380	-4%
Reduce Sr 10% Increase productivity	1,431	0	8.5	2.9	2.9	-11%	$490	23%
Replace Breeding cows with finishing bulls	1,431	0	9	3.2	3.2	-2%	$549	38%
Plant 217 ha forest - pines	1,214	217	9.6	3.5	-0.3	-110%	$403	2%
Plant 217 ha forest - Other exotic softwood	1,214	217	9.6	3.5	1.6	-52%	$371	-6%
Plant 217 ha forest - natives	1,214	217	9.6	3.5	2.6	-23%	$240	-40%
Horticulture - 20ha macadamias	1,411	20	0	3.3	3.3	-1%	$554	39%

Puatai	Pastoral Area (ha)	Area Planted in Forestry or Horticulture (ha)	Stocking rate (pastoral area)	Gross $CO_{2}e$ pastoral area (t/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base	487	0	12.6	5.0	5.0		$492	
Reduce SR 10%	487	0	11.5	4.2	4.2	-17%	$511	4%
Reduce Sr 10% Increase productivity	487	0	12.6	5.0	5.0	0%	$516	5%
Plant45 ha forest - pines	442	45	13.5	5.4	3.0	-40%	$493	0%
Plant 45 ha forest - Other exotic softwood	442	45	13.5	5.4	4.2	-17%	$468	-5%
Plant 45 ha forest - natives	442	45	13.5	5.4	4.8	-5%	$390	-21%
Cropping - 50ha peas	437	50	12.8	5.1	5.1	2%	$570	16%
Horticulture - 20ha macadamias	467	20	12.6	5.0	5.0	0%	$922	87%
Rototahi								
Base	737	0	12.4	4.7	4.7		$248	
Reduce SR 10%	737	0	11.3	4.0	4.0	-14%	$240	-3%
Reduce Sr 10% Increase productivity	737	0	11.7	4.2	4.2	-10%	$345	39%
Replace Breeding cows with finishing bulls	737	0	12.4	4.6	4.6	-1%	$414	67%
Plant 82 ha forest - pines	655	82	13.4	4.8	2.0	-57%	$251	1%
Plant 82 ha forest - Other exotic softwood	655	82	13.4	4.8	3.4	-27%	$218	-12%
Plant 82 ha forest - natives	655	82	13.4	4.8	4.1	-12%	$123	-50%
Cropping - 50ha peas	687	50	12.8	4.7	4.7	0%	$319	29%
Horticulture - 50ha grapes	717	20	12.8	4.7	4.6	-1%	$420	69%

Tongataha	Pastoral Area (ha)	Area Planted in Forestry or Horticulture (ha)	Stocking rate (pastoral area)	Gross $CO_{2}e$ pastoral area (t/ha)	Total property net CO_{2e} (T/ha)	Total GHG % change from Base	EBITDA ($ effective ha/yr)	% change from Base model
Base	1,252	0	11.9	4.2	4.2		$416	
Reduce SR 10%	1,252	0	10.6	3.7	3.7	-12%	$376	-10%
Reduce Sr 10% Increase productivity	1,252	0	11.1	3.9	3.9	-7%	$497	19%
Reduce Ewes 20%, Incr lambing % to 160	1,252	0	11.5	4.0	4.0	-5%	$692	66%
Replace Breeding cows with finishing bulls	1,252	0	11.8	4.2	4.2	0%	$324	-22%
Plant 63 ha forest - pines	1,189	63	11.9	4.2	2.9	-30%	$403	-3%
Plant 63 ha forest - Other exotic softwood	1,189	63	11.9	4.2	3.6	-14%	$399	-4%
Plant 63 ha forest - natives	1,189	63	11.9	4.2	3.9	-7%	$356	-14%
Cropping - 50ha peas	1,202	50	11.7	4.1	4.1	-1%	$454	9%
Horticulture - 20 ha Chestnuts	1,232	20	11.7	4.1	4.1	-1%	$552	33%
Pa Nui								
Base	620	0	18.2	6.1	6.1		$152	
Reduce SR 10%	620	0	16.5	5.4	5.4	-11%	$144	-5%
Reduce Sr 10% Increase productivity	620	0	17.6	5.8	5.8	-5%	$160	5%
Replace Breeding cows with finishing bulls	620	0	17.8	5.9	5.9	-3%	$242	59%
Plant 164 ha forest - pines	456	164	19.3	6.4	-0.2	-103%	$164	8%
Plant 164 ha forest - Other exotic softwood	456	164	19.3	6.4	3.0	-50%	$132	-13%
Plant 164 ha forest - natives	456	164	19.3	6.4	4.7	-23%	-$95	-163%
Cropping - 40 ha peas	580	40	17.9	6.0	6.0	-2%	$240	58%
Horticulture - 20 ha Macadamias	600	20	17.9	6.0	6.0	-2%	$524	245%

6.0 CARBON INCOME AND LEVY

The current government action is to price on-farm GHG emissions from 2025. He Waka Eke Noa, the Government/Industry/Iwi group, is working towards what that pricing mechanism will be, and have proposed two options for the pricing regime:

(i) An on-farm option, whereby farmers would calculate their net emissions and pay the levy accordingly; or

(ii) A Processor-level Hybrid regime, whereby the Processors would collect the levy when product was processed, and farmers could enter into an Emissions Management Contract (EMC) whereby they would submit a return showing how they had reduced GHG emissions, and/or sequestered carbon.

The general formula for determining the levy is: A + B – C, where:

- A = the price of methane
- B = the price of nitrous oxide + CO_2 from nitrogen fertiliser
- C = the amount of carbon sequestered by forestry

Currently the price for methane is yet to be set, as is the value of carbon sequestrated, under He Waka Eke Noa rules.

For the purposes of this report, a simplistic example of the cost of the levy is shown below, assuming a standard price across all emissions and sequestration, and an assumed free allocation.

Table 12: Carbon price and Free Allocation Assumptions

	2025	2030
Carbon Price ($/T CO_2e)	$85	$138
Assumed Free Allocation Percentage	95%	90%

The calculation also illustrates the value of carbon sequestration by the forestry scenarios used; in the previous analysis (Tables 7-12) the price of carbon has not been incorporated in either the cost to the farm via the EBIDTA calculation, or in the value of the forestry annuity used. The value of carbon to the farm was based on the average sequestration rate. As can be seen in Tables 13-15 below, the value of the forestry sequestration has a major impact in (a) improving the profitability of the farming business; and (b) lessening the cost of the carbon levy. In the analysis, it was assumed that all the carbon credits were sold in that year. In reality, it is likely the farm would sell enough credits to cover the cost of the levy and bank the rest for later years.

The other issue that arises is between the two sectors - while emissions from dairy farms are greater per hectare, total emissions from sheep & beef farms are higher due to their greater size (at a national level the average sheep & beef farm is five times bigger than the average dairy farm).

This means that the total levy from sheep & beef farms is higher, which is then compounded as the profitability of sheep & beef farms is lower, often by a factor of 4-5, meaning the levy as a proportion of farm profit is also higher on sheep & beef farms.

As can be seen in Tables 13 and 15, the levy as a proportion of farm EBITDA for the sheep and beef farms were 5-7% in 2025 and 17-24% in 2030, compared to 1% in 2025 and 4% in 2030 for the dairy farms (Table 14)[3].

This has implications for the sheep & beef farms, as by 2030 the carbon levy will be starting to have a significant impact on overall farm profitability.

[3] Excluding the forestry scenarios

Table 13: Impact of Carbon Levy: Tuwharetoa farms

	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Carbon Levy 2025, Carbon Price ($/T CO_2e) $85, Free Allocation 95%	Carbon Levy 2030, Carbon Price ($/T CO_2e) $138, Free Allocation 90%	Forestry Credit 2025	Forestry Credit 2030	Net Levy* 2025	Net Levy* 2030	Levy as a % of total EBITDA 2025	Levy as a % of total EBITDA 2030	EBITDA/ha** 2025	EBITDA/ha** 2030	% change relative to base 2025	% change relative to base 2030
Tuatahi															
Base	2,921	0	8,285	$35,212	$114,336			$35,212	$114,336	6%	20%	$179	$152		
Reduce stock numbers by 10%	2,921	0	7,690	$32,684	$106,128			$32,684	$106,128	10%	33%	$98	$73	-45%	-52%
Reduce stock numbers by 10% Increase Productivity	2,921	0	7,960	$33,830	$109,848			$33,830	$109,848	6%	19%	$183	$157	2%	3%
Swap breeding beef herd for finishing bulls	2,921	0	8,095	$34,403	$111,707			$34,403	$111,707	4%	14%	$263	$236	47%	56%
Swap breeding beef herd for finishing prime beef	2,921	0	7,890	$33,534	$108,886			$33,534	$108,886	4%	15%	$245	$219	37%	44%
Plant 294ha forest - Pines	2,627	294	7,937	$33,731	$109,527	$552,279	$896,641	-$518,548	-$787,114	-89%	-134%	$378	$470	111%	209%
Plant 294ha forest - Other Exotic Softwood	2,627	294	7,937	$33,731	$109,527	$319,872	$519,322	-$286,141	-$409,795	-54%	-77%	$281	$323	57%	113%
Plant 294ha forest - Natives	2,627	294	7,937	$33,731	$109,527	$162,435	$263,718	-$128,704	-$154,191	-46%	-55%	$140	$148	-22%	-2%
Cropping - 100ha Oats	2,821	100	8,282	$35,200	$114,297			$35,200	$114,297	6%	19%	$196	$169	10%	11%
Horticulture - 40ha Chestnuts	2,881	40	8,239	$35,015	$113,695			$35,015	$113,695	4%	12%	$307	$280	72%	85%
Rangiatea															
Base	1,632	0	8,369	$35,682	$115,862			$35,682	$115,862	13%	41%	$152	$102		
Reduce stock numbers by 10%	1,632	0	7,571	$32,176	$104,477			$32,176	$104,477	14%	45%	$123	$79	-19%	-23%
Reduce stock numbers by 10% Increase Productivity	1,632	0	8,232	$34,987	$113,604			$34,987	$113,604	13%	42%	$144	$96	-5%	-6%
Swap breeding beef herd for finishing bulls	1,632	0	8,870	$37,699	$122,412			$37,699	$122,412	9%	28%	$241	$189	59%	85%
Swap breeding beef herd for finishing prime beef	1,632	0	8,201	$34,856	$113,179			$34,856	$113,179	9%	28%	$224	$176	48%	72%
Reduce stock numbers by 10% Run Bull Beef	1,632	0	8,251	$35,068	$113,869			$35,068	$113,869	9%	30%	$213	$164	40%	60%
Plant 162ha forest - Pines	1,470	162	7,329	$31,146	$101,134	$304,317	$494,068	-$273,171	-$392,933	-104%	-150%	$328	$402	116%	292%
Plant 162ha forest - Other Exotic Softwood	1,470	162	7,329	$31,146	$101,134	$176,256	$286,157	-$145,110	-$185,023	-56%	-72%	$247	$271	63%	165%
Plant 162ha forest - Natives	1,470	162	7,329	$31,146	$101,134	$89,505	$145,314	-$58,359	-$44,180	-30%	-23%	$156	$147	3%	44%
Cropping - 100ha Oats	1,532	100	7,767	$33,009	$107,183			$33,009	$107,183	11%	37%	$156	$110	3%	8%
Horticulture - 40ha Chestnuts	1,592	40	8,059	$34,251	$111,216			$34,251	$111,216	8%	25%	$246	$199	63%	95%

*A negative net levy means there is income from carbon sequestered

**EBITDA/ha is the EBITDA from the farm less the carbon levy, plus any income from forestry carbon, divided by pastoral area + forestry/horticultural area. These can be compared with the EBITDA/ha figures shown in Tables 7-12.

				Carbon Levy											
				2025	2030										
				Carbon Price ($/T CO_2e)											
				$85	$138	Forestry Credit		Net Levy		Levy as a % of total EBITDA		EBITDA/ha		% change relative to base	
	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Free Allocation		2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
Taurewa				95%	90%										
Base	2,615	0	7,727	$32,841	$106,637			$32,841	$106,637	4%	13%	$309	$280		
Reduce stock numbers by 10%	2,615	0	6,964	$29,596	$96,100			$29,596	$96,100	4%	13%	$278	$252	-10%	-10%
Reduce stock numbers by 10% Incr Productivity	2,615	0	7,244	$30,785	$99,961			$30,785	$99,961	3%	10%	$361	$335	17%	19%
Swap breeding beef herd for finishing bulls	2,615	0	7,837	$33,308	$108,153			$33,308	$108,153	4%	12%	$325	$297	5%	6%
Swap breeding beef herd for finishing prime beef	2,615	0	6,587	$27,996	$90,903			$27,996	$90,903	5%	17%	$200	$176	-35%	-37%
Plant 263ha forest - Pines	2,352	263	7,468	$31,741	$103,064	$556,640	$903,721	-$524,899	-$800,656	-56%	-85%	$562	$667	82%	138%
Plant 263ha forest - Other Exotic Softwood	2,352	263	7,468	$31,741	$103,064	$286,144	$464,563	-$254,403	-$361,499	-29%	-41%	$436	$477	41%	70%
Plant 263ha forest - Natives	2,352	263	7,468	$31,741	$103,064	$145,308	$235,911	-$113,567	-$132,847	-18%	-21%	$285	$292	-8%	4%
Cropping - 100ha Oats	2,515	100	7,607	$32,330	$104,977			$32,330	$104,977	4%	12%	$328	$300	6%	7%
Horticulture - 40ha Chestnuts	2,575	40	7,725	$32,830	$106,601			$32,830	$106,601	3%	9%	$456	$428	48%	53%
Wahi Pukawa															
Base	2,742	0	11,804	$50,168	$162,900			$50,168	$162,900	5%	17%	$333	$292		
Reduce stock numbers by 10%	2,742	0	10,684	$45,407	$147,440			$45,407	$147,440	6%	18%	$281	$243	-16%	-17%
Reduce stock numbers by 10% Incr Productivity	2,742	0	10,868	$46,189	$149,978			$46,189	$149,978	5%	16%	$317	$279	-5%	-4%
Reduce Breeding Ewes 20%, Incr Lambing to 160%, + CWs	2,742	0	11,478	$48,783	$158,400			$48,783	$158,400	5%	15%	$362	$322	9%	10%
Plant 287ha forest - Pines	2,455	287	11,620	$49,387	$160,362	$539,130	$875,293	-$489,743	-$714,931	-45%	-66%	$576	$658	73%	126%
Plant 287ha forest - Other Exotic Softwood	2,455	287	11,620	$49,387	$160,362	$312,256	$506,957	-$262,869	-$346,595	-25%	-33%	$475	$506	43%	73%
Plant 287ha forest - Natives	2,455	287	11,620	$49,387	$160,362	$158,568	$257,439	-$109,181	-$97,077	-13%	-11%	$355	$351	7%	20%
Cropping - 100ha Oats	2,642	100	11,754	$49,955	$162,207			$49,955	$162,207	5%	16%	$350	$309	5%	6%
Horticulture - 40ha Chestnuts	2,702	40	11,867	$50,435	$163,765			$50,435	$163,765	4%	13%	$426	$384	28%	32%
Whakarawa															
Base	1,209	0	4,200	$17,850	$57,961			$17,850	$57,961	14%	44%	$93	$60		
Reduce stock numbers by 10%	1,209	0	3,781	$16,067	$52,172			$16,067	$52,172	16%	51%	$71	$41	-24%	-32%
Reduce stock numbers by 10% Incr Productivity	1,209	0	4,145	$17,615	$57,198			$17,615	$57,198	12%	40%	$103	$71	11%	17%
Plant 119ha forest - Pines	1,090	119	4,029	$17,124	$55,604	$223,542	$362,926	-$206,417	-$307,323	-144%	-214%	$290	$373	210%	520%
Plant 119ha forest - Exotics	1,090	119	4,029	$17,124	$55,604	$129,472	$210,202	-$112,348	-$154,598	-87%	-120%	$200	$234	114%	289%
Plant 119ha forest - Native	1,090	119	4,029	$17,124	$55,604	$65,748	$106,743	-$48,623	-$51,139	-61%	-64%	$106	$108	14%	80%
Cropping - 100ha Oats	1,109	100	4,074	$17,316	$56,228			$17,316	$56,228	13%	43%	$94	$62	1%	3%
Horticulture - 40ha Chestnuts	1,169	40	4,054	$17,231	$55,950			$17,231	$55,950	6%	18%	$240	$208	157%	246%

Table 14: Impact of Carbon Levy: Te Arawa farms

				Carbon Levy		Forestry Credit		Net Levy		Levy as a % of total EBITDA		EBITDA/ha (net of levy)		% change relative to base	
				2025	2030										
				Carbon Price ($/T CO_2e)											
				$85	$138										
	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Free Allocation		2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
Otukawa				95%	90%										
Base model	155.1	0	2,027	$8,613	$27,966			$8,613	$27,966	1%	4%	$4,917	$4,793		
Reduce SR 10%, no improvement in productivity	155.1	0	1,829	$7,774	$25,244			$7,774	$25,244	1%	4%	$4,093	$3,980	-17%	-17%
Reduce SR 10%, Increase per cow production	155.1	0	1,935	$8,226	$26,710			$8,226	$26,710	1%	3%	$4,923	$4,804	0%	0%
1/2 Nitrogen	155.1	0	1,960	$8,329	$27,046			$8,329	$27,046	1%	4%	$4,877	$4,756	-1%	-1%
No Bought-in Supplement	155.1	0	1,912	$8,126	$26,384			$8,126	$26,384	1%	3%	$4,875	$4,757	-1%	-1%
Replace Palm Kernel with Maize Silage	155.1	0	2,027	$8,614	$27,970			$8,614	$27,970	1%	4%	$4,916	$4,791	0%	0%
Forestry - plant 15 ha in pines	140.1	15	1,806	$7,677	$24,927	$26,520	$43,056	-$18,843	-$18,129	-3%	-3%	$4,675	$4,671	-5%	-3%
Forestry - plant 15 ha in other exotic softwood	140.1	15	1,806	$7,677	$24,927	$16,320	$26,496	-$8,643	-$1,569	-1%	0%	$4,558	$4,513	-7%	-6%
Forestry - plant 15 ha in natives	140.1	15	1,806	$7,677	$24,927	$8,288	$13,455	-$611	$11,472	0%	2%	$4,423	$4,345	-10%	-9%
Horticulture - 10 ha Kiwifruit	145.1	10	1,909	$8,112	$26,342			$8,112	$26,342	0%	1%	$11,979	$11,862	144%	148%
Cropping - 10 ha Oats	145.1	10	1,899	$8,069	$26,200			$8,069	$26,200	1%	3%	$4,835	$4,718	-2%	-2%
Waerenga															
Base model	570.5	0	4,855	$20,635	$67,004			$20,635	$67,004	2%	5%	$2,205	$2,124		
Reduce SR 10%, no improvement in productivity	570.5	0	4,450	$18,913	$61,413			$18,913	$61,413	2%	6%	$1,798	$1,724	-18%	-19%
Reduce SR 10%, Increase per cow production	570.5	0	4,730	$20,103	$65,277			$20,103	$65,277	1%	5%	$2,422	$2,342	10%	10%
1/2 Nitrogen	570.5	0	4,659	$19,800	$64,292			$19,800	$64,292	2%	5%	$2,149	$2,071	-3%	-3%
No Bought-in Supplement	570.5	0	4,525	$19,231	$62,443			$19,231	$62,443	1%	5%	$2,297	$2,222	4%	5%
Replace Palm Kernel with Maize Silage	570.5	0	4,944	$21,013	$68,231			$21,013	$68,231	2%	5%	$2,197	$2,115	0%	0%
Forestry - plant 56 ha in pines	514.5	56	4,701	$19,977	$64,867	$99,008	$160,742	-$79,031	-$95,875	-6%	-8%	$2,356	$2,386	7%	12%
Forestry - plant 56 ha in other exotic softwood	514.5	56	4,701	$19,977	$64,867	$60,928	$98,918	-$40,951	-$34,051	-3%	-3%	$2,257	$2,245	2%	6%
Forestry - plant 56 ha in natives	514.5	56	4,701	$19,977	$64,867	$30,940	$50,232	-$10,963	$14,635	-1%	1%	$2,120	$2,075	-4%	-2%
Horticulture - 10 ha Chestnuts	560.5	10	4,773	$20,285	$65,867			$20,285	$65,867	2%	5%	$2,247	$2,167	2%	2%
Waipupumahana															
Base model	200	0	1,803	$7,664	$24,887			$7,664	$24,887	1%	3%	$4,086	$4,000		
Reduce SR 10%, no improvement in productivity	200	0	1,631	$6,931	$22,505			$6,931	$22,505	1%	3%	$3,494	$3,416	-14%	-15%
Reduce SR 10%, Increase per cow production	200	0	1,725	$7,331	$23,805			$7,331	$23,805	1%	3%	$4,292	$4,210	5%	5%
1/2 Nitrogen	200	0	1,659	$7,051	$22,894			$7,051	$22,894	1%	3%	$3,879	$3,800	-5%	-5%
No Bought-in Supplement	200	0	1,643	$6,984	$22,679			$6,984	$22,679	1%	3%	$3,683	$3,605	-10%	-10%
Replace Palm Kernel with Maize Silage	200	0	1,804	$7,666	$24,892			$7,666	$24,892	1%	3%	$3,996	$3,910	-2%	-2%
Forestry - plant 18 ha in pines	182	18	1,718	$7,301	$23,706	$31,824	$51,667	-$24,523	-$27,962	-3%	-4%	$4,055	$4,072	-1%	2%
Forestry - plant 18 ha in other exotic softwood	182	18	1,718	$7,301	$23,706	$19,584	$31,795	-$12,283	-$8,090	-2%	-1%	$3,968	$3,947	-3%	-1%
Forestry - plant 18 ha in natives	182	18	1,718	$7,301	$23,706	$9,945	$16,146	-$2,644	$7,560	0%	1%	$3,844	$3,793	-6%	-5%
Horticulture - 10 ha Chestnuts	190	10	1,728	$7,344	$23,846			$7,344	$23,846	1%	3%	$4,289	$4,207	5%	5%

				Carbon Levy											
				2025	2030										
				Carbon Price ($/T CO_2e)											
				$85	$138	Forestry Credit		Net Levy*		Levy as a % of total EBITDA		EBITDA/ha (net of levy)		% change relative to base	
	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Free Allocation		2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
Te Arawa Management Ltd				95%	90%										
Base (New Farm)	154	0	1,761	$7,484	$24,302			$7,484	$24,302	1%	5%	$3,198	$3,089		
Reduce SR 10%, no improvement in productivity	154	0	1,604	$6,815	$22,130			$6,815	$22,130	2%	5%	$2,662	$2,563	-17%	-17%
Reduce SR 10%, Increase per cow production	154	0	1,676	$7,123	$23,129			$7,123	$23,129	1%	4%	$3,327	$3,223	4%	4%
1/2 Nitrogen	154	0	1,612	$6,852	$22,249			$6,852	$22,249	1%	5%	$3,128	$3,028	-2%	-2%
No Bought-in Supplement	154	0	1,573	$6,684	$21,703			$6,684	$21,703	1%	5%	$3,005	$2,908	-6%	-6%
Replace Hi Protein supplements with Maize Silage	154	0	1,775	$7,542	$24,489			$7,542	$24,489	1%	5%	$3,229	$3,119	1%	1%
Forestry - plant 14 ha in pines	140	14	1,723	$7,323	$23,779	$24,752	$40,186	-$17,429	-$16,407	-4%	-3%	$3,314	$3,308	4%	7%
Forestry - plant 14 ha in other exotic softwood	140	14	1,723	$7,323	$23,779	$15,232	$24,730	-$7,909	-$951	-2%	0%	$3,205	$3,159	0%	2%
Forestry - plant 14 ha in natives	140	14	1,723	$7,323	$23,779	$7,735	$12,558	-$412	$11,221	0%	2%	$3,077	$3,002	-4%	-3%
Horticulture - 10 ha Kiwifruit	144	10	1,676	$7,124	$23,133			$7,124	$23,133	0%	1%	$10,471	$10,367	227%	236%
Cropping - 10 ha Oats	144	10	1,683	$7,152	$23,224			$7,152	$23,224	2%	5%	$2,990	$2,886	-7%	-7%
Maraeroa Oturoa 2B															
Base model	278	0	2,683	$11,404	$37,028			$11,404	$37,028	2%	6%	$2,195	$2,103		
Reduce SR 10%, no improvement in productivity	278	0	2,451	$10,415	$33,817			$10,415	$33,817	2%	7%	$1,749	$1,664	-20%	-21%
Reduce SR 10%, Increase per cow production	278	0	2,635	$11,201	$36,369			$11,201	$36,369	2%	5%	$2,626	$2,536	20%	21%
1/2 Nitrogen	278	0	2,517	$10,696	$34,729			$10,696	$34,729	2%	6%	$2,143	$2,057	-2%	-2%
No Bought-in Supplement	278	0	2,450	$10,413	$33,812			$10,413	$33,812	2%	5%	$2,300	$2,216	5%	5%
Replace Palm Kernel with Maize Silage	278	0	2,683	$11,403	$37,028			$11,403	$37,028	2%	6%	$2,194	$2,102	0%	0%
Forestry - plant 33 ha in pines	245	33	2,541	$10,798	$35,061	$58,344	$94,723	-$47,546	-$59,662	-8%	-10%	$2,280	$2,324	4%	10%
Forestry - plant 33 ha in other exotic softwood	245	33	2,541	$10,798	$35,061	$35,904	$58,291	-$25,106	-$23,230	-4%	-4%	$2,166	$2,159	-1%	3%
Forestry - plant 33 ha in natives	245	33	2,541	$10,798	$35,061	$18,233	$29,601	-$7,435	$5,460	-1%	1%	$1,999	$1,953	-9%	-7%
Horticulture - 10 ha Chestnuts	268	10	2,621	$11,138	$36,166			$11,138	$36,166	2%	5%	$2,385	$2,295	9%	9%
Tumunui North															
Base	550	0	1,422	$6,044	$19,626			$6,044	$19,626	1%	3%	$1,265	$1,241		
Reduce SR 10%, no improvement in productivity (Dairy + Deer)	550	0	1,300	$5,525	$17,941			$5,525	$17,941	1%	3%	$929	$906	-27%	-27%
Reduce SR 10%, Increase productivity (Dairy + Deer)	550	0	1,354	$5,755	$18,687			$5,755	$18,687	1%	2%	$1,536	$1,513	21%	22%
Plant 140 ha forestry - pines	550	140	1,422	$6,044	$19,626	$247,520	$401,856	-$241,476	-$382,230	-32%	-51%	$1,427	$1,631	13%	31%
Plant 140 ha forestry - other exotic softwood	550	140	1,422	$6,044	$19,626	$152,320	$247,296	-$146,276	-$227,670	-21%	-33%	$1,207	$1,325	-5%	7%
Plant 140 ha forestry - natives	550	140	1,422	$6,044	$19,626	$77,350	$125,580	-$71,306	-$105,954	-12%	-19%	$932	$982	-26%	-21%
Dairy 1/2 Nitrogen + Base Deer	550	0	1,374	$5,839	$18,958			$5,839	$18,958	1%	3%	$1,084	$1,060	-14%	-15%
Dairy No Bought-in Supplement + Base Deer	550	0	1,370	$5,823	$18,909			$5,823	$18,909	1%	3%	$986	$963	-22%	-22%
Dairy Replace Palm Kernel with Maize Silage + Base Deer	550	0	1,422	$6,044	$19,626			$6,044	$19,626	1%	3%	$1,027	$1,002	-19%	-19%
Horticulture - 10ha Chestnuts on dairy unit + Base Deer	540	10	1,395	$5,927	$19,246			$5,927	$19,246	1%	2%	$1,411	$1,386	11%	12%

*A negative net levy means there is income from carbon sequestered

Table 15: Impact of Carbon Levy: Whāngārā farms

				Carbon Levy											
				2025	2030										
				Carbon Price ($/T CO2e)											
				$85	$138	Forestry Credit		Net Levy		Levy as a % of total EBITDA		EBITDA/ha (net of levy)		% change relative to base	
	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Free Allocation		2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
B5 Whitwhiti				95%	90%										
Base	3,222	0	13,307	$56,554	$183,635			$56,554	$183,635	2%	8%	$722	$683		
Reduce SR 10%	3,222	0	11,986	$50,940	$165,405			$50,940	$165,405	2%	7%	$735	$700	2%	3%
Reduce Sr 10% Increase productivity	3,222	0	12,501	$53,131	$172,519			$53,131	$172,519	2%	7%	$789	$752	9%	10%
Replace Breeding cows with finishing bulls	3,222	0	12,920	$54,911	$178,299			$54,911	$178,299	2%	7%	$822	$783	14%	15%
Plant 186 ha forest - pines	3,036	186	13,565	$57,650	$187,192	$404,736	$657,101	-$347,086	-$469,909	-14%	-19%	$869	$907	20%	33%
Plant 186 ha forest - Other exotic softwood	3,036	186	13,565	$57,650	$187,192	$202,368	$328,550	-$144,718	-$141,359	-6%	-6%	$787	$786	9%	15%
Plant 186 ha forest - natives	3,036	186	13,565	$57,650	$187,192	$102,765	$166,842	-$45,115	$20,350	-2%	1%	$707	$687	-2%	1%
Cropping - 100ha peas	3,122	100	13,114	$55,733	$180,967			$55,733	$180,967	2%	7%	$764	$725	6%	6%
Horticulture - 20ha gold kiwifruit	3,202	20	13,178	$56,006	$181,856			$56,006	$181,856	1%	4%	$1,309	$1,269	81%	86%
Pakarae															
Base	1,431	0	4,722	$20,070	$65,168			$20,070	$65,168	4%	11%	$383	$352		
Reduce SR 10%	1,431	0	4,035	$17,151	$55,689			$17,151	$55,689	3%	10%	$368	$341	-4%	-3%
Reduce Sr 10% Increase productivity	1,431	0	4,193	$17,820	$57,861			$17,820	$57,861	3%	8%	$477	$449	25%	28%
Replace Breeding cows with finishing bulls	1,431	0	4,608	$19,583	$63,588			$19,583	$63,588	2%	8%	$535	$504	40%	43%
Plant 217 ha forest - pines	1,214	217	4,298	$18,265	$59,306	$472,192	$766,618	-$453,927	-$707,311	-79%	-123%	$721	$898	88%	155%
Plant 217 ha forest - Other exotic softwood	1,214	217	4,298	$18,265	$59,306	$236,096	$383,309	-$217,831	-$324,002	-41%	-61%	$524	$598	37%	70%
Plant 217 ha forest - natives	1,214	217	4,298	$18,265	$59,306	$119,893	$194,649	-$101,628	-$135,343	-30%	-39%	$311	$335	-19%	-5%
Horticulture - 20ha macadamias	1,411	20	4,628	$19,669	$63,868			$19,669	$63,868	2%	8%	$540	$510	41%	45%
Puatai															
Base	487	0	2,450	$10,411	$33,805			$10,411	$33,805	4%	14%	$471	$423		
Reduce SR 10%	487	0	2,045	$8,693	$28,227			$8,693	$28,227	3%	11%	$493	$453	5%	7%
Reduce Sr 10% Increase productivity	487	0	2,445	$10,390	$33,737			$10,390	$33,737	4%	13%	$495	$447	5%	6%
Plant45 ha forest - pines	442	45	2,378	$10,106	$32,816	$97,920	$158,976	-$87,814	-$126,160	-37%	-53%	$674	$752	43%	78%
Plant 45 ha forest - Other exotic softwood	442	45	2,378	$10,106	$32,816	$48,960	$79,488	-$38,854	-$46,672	-17%	-20%	$548	$564	16%	33%
Plant 45 ha forest - natives	442	45	2,378	$10,106	$32,816	$24,863	$40,365	-$14,756	-$7,549	-8%	-4%	$420	$405	-11%	-4%
Cropping - 50ha peas	437	50	2,237	$9,509	$30,877			$9,509	$30,877	3%	11%	$551	$507	17%	20%
Horticulture - 20ha macadamias	467	20	2,354	$10,003	$32,481			$10,003	$32,481	2%	7%	$901	$855	91%	102%

				Carbon Levy											
				2025	2030										
				Carbon Price ($/T CO2e)											
				$85	$138	Forestry Credit		Net Levy		Levy as a % of total EBITDA		EBITDA/ha (net of levy)		% change relative to base	
	Pastoral Area (ha)	Forest/ Horticulture Area (ha)	Total T CO_2e/Pastoral area	Free Allocation		2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
Rototahi				95%	90%										
Base	737	0	3,442	$14,628	$47,497			$14,628	$47,497	8%	26%	$229	$184		
Reduce SR 10%	737	0	2,963	$12,592	$40,886			$12,592	$40,886	7%	23%	$223	$185	-2%	1%
Reduce Sr 10% Increase productivity	737	0	3,110	$13,218	$42,920			$13,218	$42,920	5%	17%	$327	$287	43%	56%
Replace Breeding cows with finishing bulls	737	0	3,412	$14,502	$47,090			$14,502	$47,090	5%	15%	$394	$350	72%	90%
Plant 82 ha forest - pines	655	82	3,170	$13,473	$43,749	$178,432	$289,690	-$164,959	-$245,941	-89%	-133%	$474	$584	108%	218%
Plant 82 ha forest - Other exotic softwood	655	82	3,170	$13,473	$43,749	$89,216	$144,845	-$75,743	-$101,096	-47%	-63%	$321	$355	40%	93%
Plant 82 ha forest - natives	655	82	3,170	$13,473	$43,749	$45,305	$73,554	-$31,832	-$29,805	-35%	-33%	$166	$164	-27%	-11%
Cropping - 50ha peas	687	50	3,195	$13,577	$44,085			$13,577	$44,085	6%	19%	$301	$259	32%	41%
Horticulture - 50ha grapes	717	20	3,334	$14,170	$46,010			$14,170	$46,010	5%	15%	$400	$357	75%	94%
Tongataha															
Base	1,252	0	5,233	$22,242	$72,220			$22,242	$72,220	4%	14%	$399	$359		
Reduce SR 10%	1,252	0	4,582	$19,475	$63,236			$19,475	$63,236	4%	13%	$361	$326	-9%	-9%
Reduce Sr 10% Increase productivity	1,252	0	4,870	$20,699	$67,210			$20,699	$67,210	3%	11%	$480	$443	20%	24%
Reduce Ewes 20%, Incr lambing % to 160	1,252	0	4,983	$21,178	$68,765			$21,178	$68,765	2%	8%	$675	$637	69%	78%
Replace Breeding cows with finishing bulls	1,252	0	5,208	$22,135	$71,875			$22,135	$71,875	5%	18%	$307	$267	-23%	-26%
Plant 63 ha forest - pines	1,189	63	5,018	$21,325	$69,243	$137,088	$222,566	-$115,763	-$153,324	-23%	-30%	$496	$526	24%	47%
Plant 63 ha forest - Other exotic softwood	1,189	63	5,018	$21,325	$69,243	$68,544	$111,283	-$47,219	-$42,041	-9%	-8%	$437	$433	10%	21%
Plant 63 ha forest - natives	1,189	63	5,018	$21,325	$69,243	$34,808	$56,511	-$13,483	$12,732	-3%	3%	$367	$346	-8%	-3%
Cropping - 50ha peas	1,202	50	4,964	$21,098	$68,507			$21,098	$68,507	4%	12%	$437	$399	10%	11%
Horticulture - 20 ha Chestnuts	1,232	20	5,088	$21,625	$70,217			$21,625	$70,217	3%	10%	$535	$496	34%	38%
Pa Nui															
Base	620	0	3,776	$16,047	$52,106			$16,047	$52,106	17%	55%	$126	$68		
Reduce SR 10%	620	0	3,373	$14,334	$46,545			$14,334	$46,545	16%	52%	$121	$69	-4%	1%
Reduce Sr 10% Increase productivity	620	0	3,602	$15,309	$49,710			$15,309	$49,710	15%	50%	$135	$80	7%	18%
Replace Breeding cows with finishing bulls	620	0	3,658	$15,547	$50,480			$15,547	$50,480	10%	34%	$217	$161	72%	137%
Plant 164 ha forest - pines	456	164	2,928	$12,442	$40,400	$347,106	$563,537	-$334,664	-$523,137	-330%	-516%	$703	$1,007	457%	1381%
Plant 164 ha forest - Other exotic softwood	456	164	2,928	$12,442	$40,400	$178,432	$289,690	-$165,990	-$249,290	-203%	-305%	$400	$534	217%	685%
Plant 164 ha forest - natives	456	164	2,928	$12,442	$40,400	$90,610	$147,108	-$78,168	-$106,708	-133%	-181%	$31	$77	-75%	13%
Cropping - 40 ha peas	580	40	3,468	$14,741	$47,864			$14,741	$47,864	10%	32%	$216	$163	71%	139%
Horticulture - 20 ha Macadamias	600	20	3,588	$15,249	$49,514			$15,249	$49,514	5%	15%	$500	$445	296%	554%

7.0 DISCUSSION

The modelling exercise has thrown up a range of possible responses to reducing and/or offsetting GHG emissions.

7.1 Farm System Change

The three key drivers of biological emissions at a farm level are:

» Amount of dry matter (DM) eaten
» Level of protein in the diet
» Amount of nitrogen fertiliser applied

The alternative farm systems modelled were therefore analysing ways of reducing the above while maintaining the financial viability of the farm. In most instances this came down to reducing stocking rates (to reduce DM eaten), and then improving the productivity of the remaining animals in order to maintain the viability of the business.

As the modelling shows, simply reducing stocking rate will certainly reduce GHG emissions, but at a cost (often significant) to the farm business. Improving the productivity of the remaining animals then means something of a trade-off, so as to achieve this increase the stock then need to eat more dry matter. But in most cases, it can maintain, if not improve, the financial returns to the farm.

The other important factor to remember is that if a farm is following a "reduce stocking rate/improve productivity" strategy, then:

(a) Farm management has to improve, especially grazing management, in order to maintain the quality of the pasture; and

(b) It is likely to take several years (often 5-10) to achieve the improvement in productivity.

Altering protein levels in the diet essentially comes down to the type of supplement being fed, given that it is very difficult to manipulate protein levels in pasture. In this respect this strategy is generally much more applicable in the dairy sector rather than the sheep & beef sector, given the limited amounts of supplements fed on most sheep & beef farms.

The degree to which switching from a high to a low protein feed affects the GHG emissions depends very much on the level of supplement being fed relative to the proportion of pasture in the diet. At high levels of supplementary feeding switching protein levels can have some effect on N_2O emission, but at moderate to low levels of supplement feeding the effect is relatively small.

The other aspect of feeding supplements is of course that it is adding additional DM into the system, and hence generating further GHG emissions. Removing supplements from the system will reduce GHG emissions, but again can come at a cost to the business, depending on the cost of the supplement relative to payout; if the marginal revenue (MR) from the supplement is less than the marginal cost (MC), then reducing the level of feeding will reduce GHG emissions while improving profit, and vice-versa – if MR>MC, then reducing the level of supplement will reduce both GHG emissions and farm profit.

The issue with nitrogen fertiliser is somewhat similar – essentially it is used to boost pasture growth and is therefore adding more DM into the system. The impact of a reduction in nitrogen fertiliser application involves two factors:

(a) The overall impact depends on the amount of nitrogen fertiliser used; the dairy sector uses significantly more nitrogen fertiliser than the sheep & beef sector, and therefore the impact of reducing nitrogen fertiliser is greater on dairy farms [The dairy sector uses 67% of nitrogen fertiliser, the sheep & beef sector uses 25%[4]].

(b) Inasmuch as nitrogen fertiliser is often the cheapest form of supplementary feed, its removal usually has an adverse impact on farm profitability.

Note that within the modelling, any removal of nitrogen fertiliser was that applied to pasture. No reduction was made in nitrogen fertiliser applied to crops, given that would usually adversely affect the yield.

7.2 Forestry

Forestry is the key tool in providing an offset, in that the carbon sequestered by the forest is then used to offset GHG emissions from the farm.

Within this analysis, the assumption was to plant around 10% of the effective area of the farm into forestry, usually on the less (pasture) productive areas as identified via the LUC mapping.

The profitability of forestry is very site-specific; the annuities calculated for the pine forest often had a reasonable input into the profitability of the sheep & beef farms, but much less so for the dairy farms. In many respects the addition of some forestry can materially assist the financial viability of many sheep & beef farms and strengthen their overall business. The assumption used was that the pines and the Cypress were planted as production forest, whereas the natives were planted for carbon.

As can be seen from the tables, the sequestration input from pines was greatest, followed by the other exotic species (Cypress), followed by natives. This then has a direct correlation as to their value in offsetting farm emissions, and consequently in offsetting the cost of the carbon level. While under the Zero Carbon Act farmers cannot directly offset methane emissions via forestry, this is readily circumvented by calculating the levy cost in dollars.

Another key aspect to remember is the advent of the "averaging" scheme on 1 January 2023. This allows foresters to claim credits in the first rotation, without having to pay these back at harvest. But this does confer a limited time span in which carbon credits can be claimed; 16 years for pines, 22 years for exotic softwoods, which means that if farmers want to continue to claim carbon credits as an offset, then further forestry needs to be planted. A key aspect of

[4] NZ Fertiliser Association statistics

forestry, from a carbon perspective, is that it provides a window of time before, hopefully, other more permanent technologies can be developed and introduced.

The natives were planted as a permanent forest; while annual sequestration levels are low relative to the other species, they can be claimed for a considerable time.

As noted, the forests were located on the less (pastoral) productive areas on the farms, which had several consequences:

- The reduction in stock numbers was not linear – usually much less than the 10% of area planted.
- This meant that the stocking rate on the remaining (better) pastoral land increased.
- Which meant that the GHG emissions from the pastoral area actually increased in line with the increased stocking rate.
- But were more than offset by the forestry sequestration.

Farmers who have carried out such land use change experience a positive impact on farm profitability due to an increase in per head livestock performance and a decrease in management costs for weed control, infrastructure maintenance and labour associated with land that carried less stock. Quinn et al. (2007)[5] reported that an integrated land use approach offered the opportunity for greater economic and environmental resilience. Where forests are established on appropriate areas of the farm and farm systems analysis shows a positive impact of economics, additional benefits will also accrue.

Additional benefits of forestry

In addition to providing carbon sequestration for income or greenhouse gas emissions offset, forestry can provide a range of co-benefits to the farm operation including:

- Soil and water protection
- Income diversification
- Climate resilience
- Increased biodiversity
- Shade and shelter
- Increased subdivision

Integration of forestry into a farming business has long been an opportunity for farmers. Some of the hurdles to involvement in forestry have been capital investment, new skills required and potential loss of pasture and livestock production. Careful integration of forestry onto appropriate land types within a farming operation can overcome many of these barriers. The combination of opportunities around earning of carbon income in the relatively short term and

[5] J.M. Quinn, J.M. Dodd M.B., Thorrold B.S. 2007: Whatawhata Catchment Management Project: the story so far. Proceedings of the New Zealand Grassland Association 69: 229–233.

increased pressure on landowners to reduce erosion, nitrogen leaching risks to water ways, and improved biodiversity, may further the attraction of forestry to some landowners.

7.3 Horticulture

The advantage of horticulture from a GHG aspect is that emissions are generally very low (relative to pastoral farming), and usually only N_2O generated by nitrogen fertiliser use.

A degree of land use change into horticulture on a farm, therefore, means that the total GHG emissions are averaged down relative to that of the pastoral operation.

The other key aspect of horticulture is that it is often (much) more profitable than pastoral farming, although also generally more of a risky enterprise.

The main issues around horticulture though, are requirements that have very little to do with GHG emissions:

(i) Good quality land, of flat to easy slope.

(ii) Access to water for irrigation, often in significant quantities.

(iii) Access to labour; skilled labour to manage the operation as well as "mass" labour for harvesting.

(iv) Often high capital requirement for development.

(v) Access to a value chain which can process, store, transport, market the crop.

Within the analysis, a range of crops have been considered, mainly around the physical characteristics of the farm in question. The other issues around water, labour and value chain need much further analysis to determine whether the crop in question is viable or not.

The other aspect is the integration of the horticultural enterprise within the farm system. For arable cropping, this could mean using a cash crop as part of an ongoing regrassing regime, or regular cropping on a particular portion of the farm involving a crop – regrass – crop – regrass type rotation. Which in turn would involve a degree of "system" change for the rest of the farm in order to incorporate such a cropping system in order to utilise the area when not in a cash crop.

For permanent horticultural crops such as kiwifruit, chestnuts, macadamias, these are specialised operations, which to all intents and purposes would be separate to the pastoral side of the farm business.

8.0 APPENDIX ONE: FORESTRY

Assumptions used in generating a cash flow for the different options are described below.

- Establishment Cost: this is the cost of seedlings/plants, their planting and any pre plant or post plant spot releasing.

- Silviculture year 5-11: For exotic forests pruning and operations after planting costs have been included, follow up weed and animal pest control. A 15% supervision fee has been added to establishment and silvicultural (growing) costs.

- Weed and animal pest control and enrichment planting: year 1-3: For native forest follow up weed and animal pest control along with enrichment planting have been included.

- Management fee: An annual management fee of $100/ha is also costed to cover aspects such as insurance, health, weed and pest inspections, weed and pest control, track maintenance and fire protection (dams).

- Transport cost was determined by distance from the farm to identified local processing sites or ports. The multiplier of $/tonne km was either $0.3, $0.25 or $0.2 for 0-75 km, 76 to 150 km or 151 to 250 km respectively.

- A management/marketing fee of $3.50/m^3 and a contingency (e.g. RMA) fee of $1.00/m^3 was included as part of the harvest cost.

Along with transport cost, roading and harvest costs have a large impact on the profitability and are especially site specific. Table 16 describes the breakdown of roading and harvest cost in relation to slope of the forest site.

Table 16: Effect of slope on harvest and roading cost

Roading	Slope Category	Description	Cost
	Easy	Upgrade of formed farm tracks	$25,000/km
	Medium	New Road on flat to rolling	$50,000/km
	Difficult	New Road on Hill	$100,000/km
	Temporary Bridge	Removable water way crossing	$5,000/crossing
Harvest			
	Ground based flat	Suitable for rubber tyre wheeled machine flat to rolling (up to 15° slope)	$35/m^3
	Ground based rolling	More difficult terrain, may require tracked machine (over 15° slope)	$45/m^3
	Hauler	Requires a Hauler	$60/m^3

The size, land use capability, current pasture production, on-farm roading distance and difficulty, harvest method, number of bridges and the region for carbon look-up tables varied among the 18 farms studied. These site-specific factors are summarised in Table 17.

Table 17: Summary of proposed forest areas and assumption details by farm

Collective Property	Proposed New Forest (ha)	LUC (map scale)	Pasture production category low, medium or high	Estimated Roading Difficulty (km) Easy, moderate, high	Harvest Type (%) Wheeled, Tracked, Hauler	Bridges	Carbon Region
Tuwharetoa							
Rangiatea	162	6 (nat'l)	Low	4.5, 0, 1.1	100, 0, 0		Waikato/Taupo
Waihi Pukawa	287	7e 7 (nat'l)	50% Low 50% Medium	3.3, 1.9, 0	40, 40, 20	1	Waikato/Taupo
Tauwera	263	6 (nat'l)	Medium	2.5, 0, 0	100, 0, 0	1	Hawkes Bay/Sth Nth Is
Tuatahi P/shp	294	5e1 (farm)	Low	3.7, 1.0, 0.5	30, 50, 20	2	Waikato/Taupo
Whakarawa	119	8e2, 7e7 (farm)	Low	4.8, 0, 0.7	0, 100, 0		Waikato/Taupo
Te Arawa							
Otukawa	15	3w1 (nat'l)	Medium	0.5, 0, 0	100, 0, 0		Bay of Plenty
Te Arawa Mngmt Ltd (TAML)	14	3 dominant, with 6 (nat'l)	Medium	0.3, 0, 0	100, 0, 0		Bay of Plenty
Waerenga	56	6 (nat'l)	Low	1.0, 0.7, 0	0, 100, 0		Bay of Plenty
Tumunui	149	6 or 7 (nat'l)	Low	2.5, 1.0, 0	80, 20, 0	1	Bay of Plenty
Waipupumahana	18	6e17 (nat'l)	Low	0, 0.8, 0	0, 100, 0		Bay of Plenty
Maraeroa Oturoa	33	4 (natl'l)	Medium	0.5, 0, 0	100, 0, 0		Bay of Plenty
Whāngārā							
B5 + Whitiwhiti	186	7e1, 7e21, 7e3,	Low	0, 3.1, 1.3	0, 0, 100		Gisborne
Rototahi	82	6e16,7e15	Low	0, 1.0, 1.0	0, 40, 60		Gisborne
Pakarae	217	7e1, 7e3	Low	0, 2.0. 1.5	0, 0, 100		Gisborne
Puatai	45	7e15 dominant	Low	0, 0.6, 0.7	0, 30, 70		Gisborne
Tongataha	63	7e9, 6e1	Low	2.0, 0, 0.7	0, 30, 70		Gisborne
Pa Nui	164	7 dominant with 6 & 5	Low	0, 1.0, 1.5	0, 25 75		Hawkes Bay/Sth Nth Is

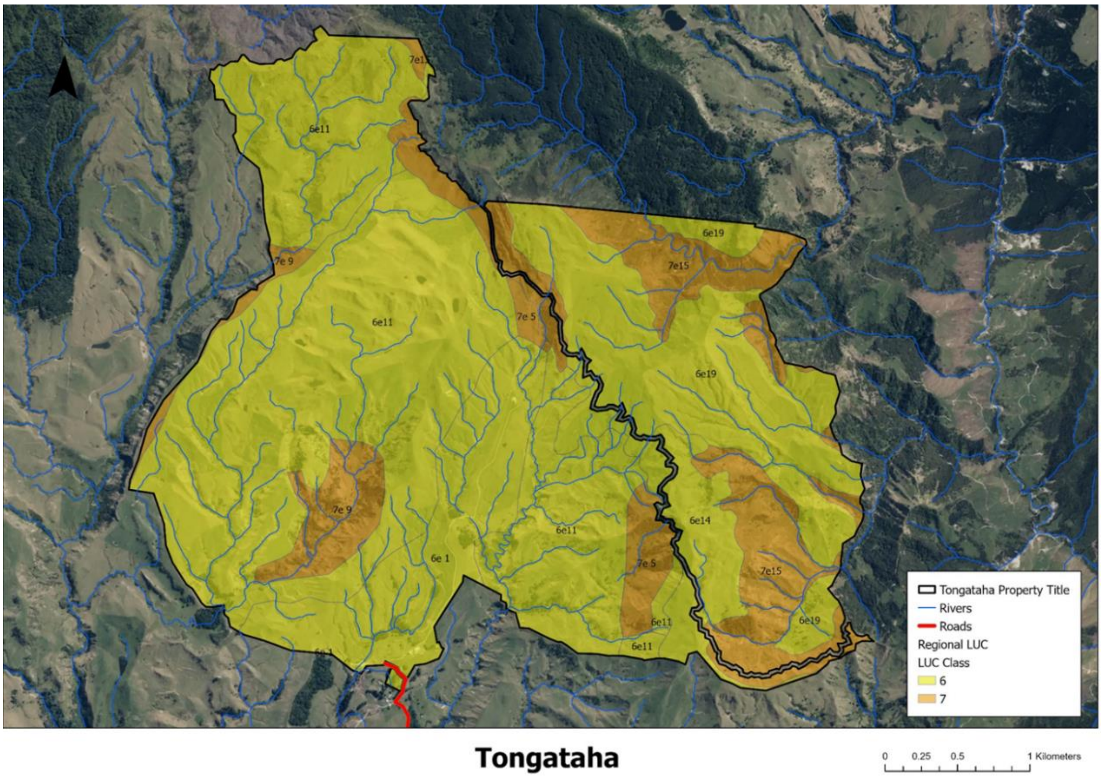
Table 18: Example cashflow (radiata pine, Tuatahi Partnership)

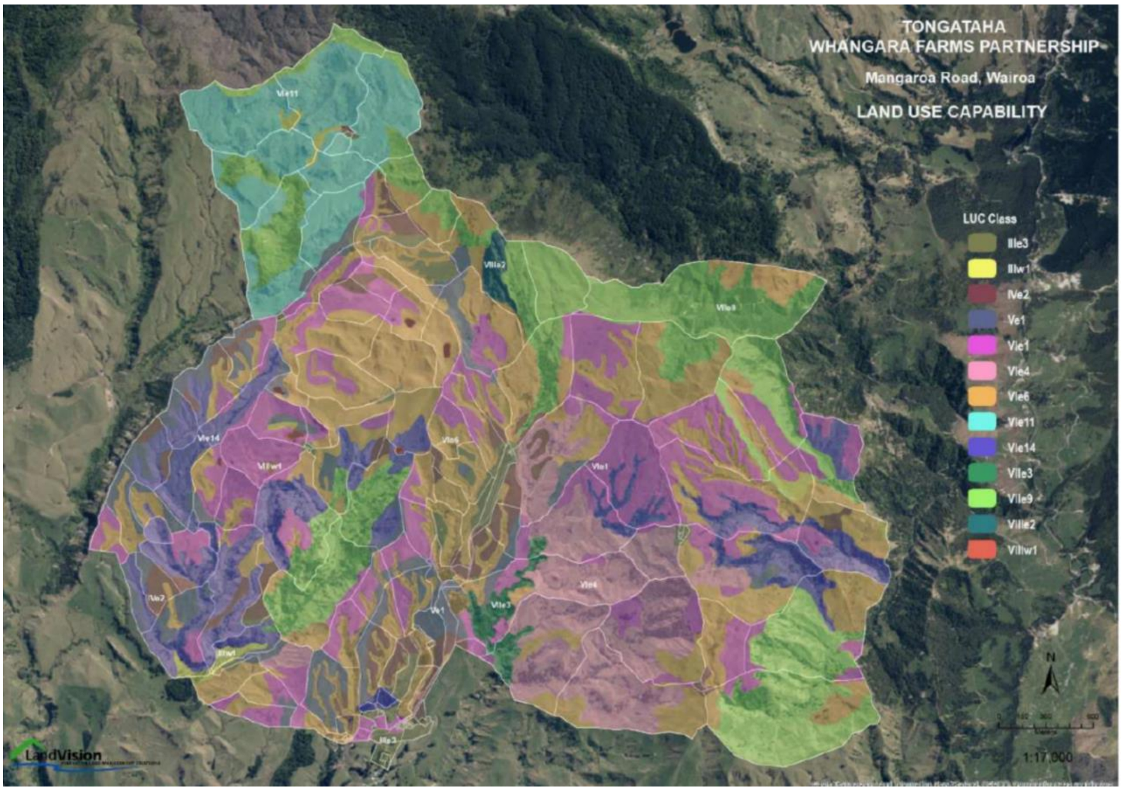
Cash Flow																						
Forest type	Pinus radiata	**Forest Area**	294	ha																		
Management	Structural	**Forest**	Tuatahi Partnership																			
						Cash flow year																
	Operation	**Description**	**$/ha**	**Total $**	**year**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Land preparation costs	Aerial weed contro	$400/ha	$100	$0	0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Planting costs	Tree stocks	1000 sph $0.60	$600	$176,400	0	$176,400	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Planting	$0.70/seedling	$700	$205,800	0	$205,800	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Release	$0.70/spot	$700	$205,800	0	$205,800	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Silviculture costs	Prune 1		$0	$0	6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Prune 2		$0	$0	7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Prune 3		$0	$0	9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Thin 1		$850	$249,900	9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$249,900	$0	$0	$0	$0	$0	$0	$0
	Thin 2		$0	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Operations management	Management	15% of operation cost	15%	$125,685		$88,200	$0	$0	$0	$0	$0	$0	$0	$0	$37,485	$0	$0	$0	$0	$0	$0	$0
Management costs		includes management, insurance etc	$80	$23,520	all	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520
						$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	Total costs					$699,720	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$310,905	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520
Harvest revenue	yes	Net stumpage. See stumpage calculation	$24,423	$7,180,469	28	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Carbon revenue	yes	ETS Tables					16229	105487	162288	730296	1014300	1379448	1095444	770868	486864	852012	1014300	1217160	1257732	1379448	1420020	1460592
Total revenue	Total revenue					$0	$16,229	$105,487	$162,288	$730,296	$1,014,300	$1,379,448	$1,095,444	$770,868	$486,864	$852,012	$1,014,300	$1,217,160	$1,257,732	$1,379,448	$1,420,020	$1,460,592
Cash flow						-$699,720	-$7,291	$81,967	$138,768	$706,776	$990,780	$1,355,928	$1,071,924	$747,348	$175,959	$828,492	$990,780	$1,193,640	$1,234,212	$1,355,928	$1,396,500	$1,437,072

12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520	$23,520
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,180,469
1217160	1257732	1379448	1420020	1460592	0	0	0	0	0	0	0	0	0	0	0	0
$1,217,160	$1,257,732	$1,379,448	$1,420,020	$1,460,592	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,180,469
$1,193,640	$1,234,212	$1,355,928	$1,396,500	$1,437,072	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	-$23,520	$7,156,949

While land use capability can be a useful guide in making land use change decisions, there is limited information available at a farm scale, and which differs markedly from the national-level data available.

Figure 8: Comparison of national (top) and farm scale (bottom) of Land use Capability





9.0 APPENDIX TWO: HORTICULTURAL CROPS

More detail is provided on the considerations for choosing, or not, a horticultural crop and then discussion on the crops chosen.

9.1.1 Climate

The three regions that form this project include Whenua Māori Trusts in the area of Tūwharetoa, Te Arawa and Whangarā. The sites range from warm coastal sites to those that could almost be described as alpine. The range in elevation impacts significantly on the climatic conditions experienced and hence the suitability of some crops. Furthermore, some crops which may produce well in one site may be impacted by cooler temperatures or lack of chill.

Climatic data collected for this report is taken from the closest reliable regional weather station and will not reflect the exact microclimate of the land parcels under consideration but provides background to the region's general climate and the effect of this on crop production. Weather details for Te Puke (and sometimes Tauranga) and Rotorua are provided to represent the Te Arawa sites as the two areas are so different.

Table 19: Overall Climate Summary

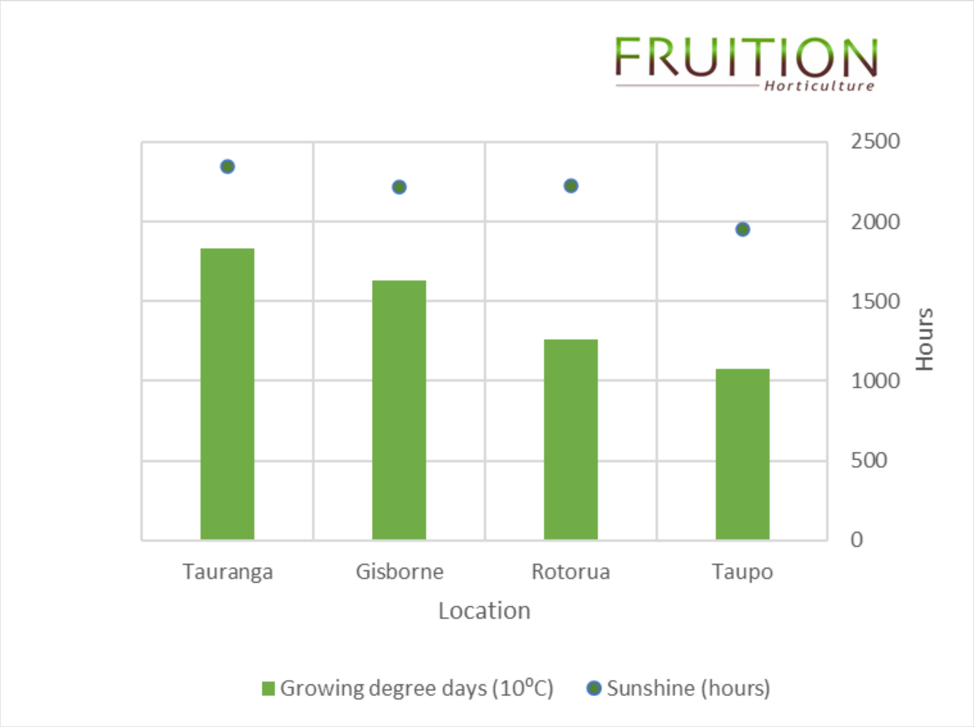
Criteria	Taupō	Rotorua	Tauranga	Gisborne
Overall conditions	Warm and temperate Significant rainfall	Warm and temperate Significant rainfall	Marine east coast warm summer climate	Warm and temperate
Average annual temperature	10.9°C	12.8°C	15°C	13.9
Warmest Month	Feb - 16.1°C	Feb - 17.8°C	Feb - 20°C	Jan - 18.7oC
Coolest Month	July - 6.1°C	July - 7.6°C	July - 10°C	July - 9.3°C
Average annual rainfall	960mm	1,353mm	1,642mm	987mm
Wettest Month	July - 96mm	Jul - 135mm	June - 169mm	July - 131mm
Driest Month	Mar - 65mm	Nov - 74mm	Nov - 102mm	Dec - 57mm
Prevailing Wind	Westerly with some NE and SE influences	Northeasterly	Westerly	Northwesterly
Altitude data was collected from	396masl	287masl	4masl	4masl
Köppen Classification[6]	Cfb	Cfb	Cfb	Cfb

All of the locations in the study area are classified as Cfb. This means it is considered a temperate climate, with a warm summer and without a dry season.

[6] The Köppen climate classification system is one of the most widely used classification systems for the climate. It works based on three levels of classification. The 1st level breaks climate into five major levels: A – Tropical, B – Arid, C – Temperate, D – Cold and D – Polar. Next, the 2nd level accounts for rainfall, further classifying based on dryness. The 3rd and last levels then account for temperature and if seasons are hot or cold.

Growing conditions are impacted by sunshine hours and warmth. Growing Degree Days (GDD_{10}) is a measure of the number of hours that is experienced above 10°C. Figure 9 provides a comparison of the relative warmth and the level of sunshine experienced in the locations. Taupo and Rotorua are much cooler and Taupo experiences fewer sunshine hours. These two indicators will impact on the crops that can be grown.

Figure 9: Comparison of Indicators of Growing Conditions



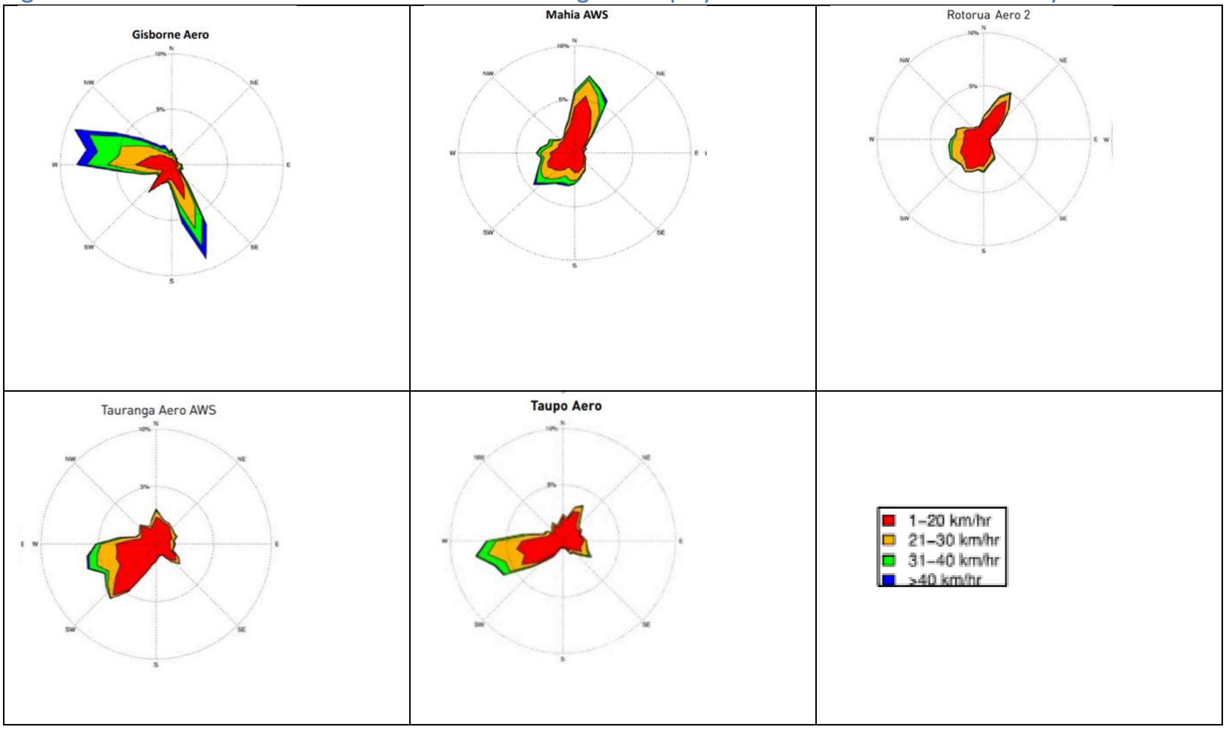
Winter chilling is important for some deciduous crops to achieve a good bud burst and return bloom. Untimely chilling can result in crop loss. While management (e.g. bud burst enhancing sprays and frost protection) can mitigate these impacts, various crops will be included or excluded based on these two factors.

Both Taupō and Gisborne are much drier than the Waiariki locations. It is likely however that irrigation would be required to support crops at establishment and during extended dry spells.

The National Institute of Water and Atmospheric Research (NIWA) use wind roses as a pictorial representation of wind ground speed and direction. They help to understand prevailing winds and intensities in different areas all over New Zealand. Northerly and westerly airflows are common across the region but are greatly affected in specific locations by the topography of the land.

Figure 2 compares wind speed and direction data from various monitoring sites around the region. Gisborne is clearly the windiest of the locations in the study. Manaia, where one of the Trust farms is located experiences a different wind pattern again. Both Tauranga and Taupō experience relatively settled wind conditions with the prevailing wind from the west.

Figure 10: Wind roses from various locations in the regions display the wind direction and intensity



9.1.2 Soils and Landform

The criteria set for whether the land would be suitable for horticultural development describe aspects of landform and the characteristics of the soil. Other factors, such as elevation also are considered, though in this case not used to exclude a property from this project. The criteria are as follows:

Shall have the following characteristics:

» Soil texture: silt loam, sandy loam, loam or loamy sand (in the topsoil 15 cm).

» Potential rooting depth: minimum one metre.

» Drainage Class: well-drained - Profile readily available water (0 - 100 cm): moderate (greater or equal to 50 mm).

» No point exceeding 15-degree slope.

» No land shall be facing 45 degrees either side of South (southeast to southwest).

Based on these criteria, areas in each farm were identified as land suitable for horticultural production. This estimated area could increase as small gullies and steep areas can be smoothed out by careful contouring.

Soil compositions makes a critical difference to the overall production abilities of many crops. New Zealand's soil types vary significantly, as does the soil types within individual land blocks. This summary of soils aims to provide an overview of regional soil types within the three regions of interest, Gisborne/East Coast, Taupō/Turangi and BOP, which has been split into

Maketu and Rotorua based soils. These will not directly reflect the soil of individual blocks but can give a background into the suitability of horticulture within each general region.

Soils in the Tūwharetoa region are dominated by soils with gravelly, sandy textures which allow for rooting depths of greater than 100 cm, excess water to rapidly drain, and no physical barriers to root development. They often can store medium-to-high quantities of plant-available water without waterlogging, allowing for adequate aeration in the root zone. These are all excellent attributes for growing, but consequently, they often have low fertility and require careful nutrient and water management to prevent leaching events.

The Gisborne/East Coast region has a range of soils with nearer the city centre being primarily "brown" soils, transitioning into "recent" soils further up the coastline. Gisborne soils have also been significantly impacted by silt deposited in flooding events. These may not have been described in the literature and will need to be considered on-site.

Bay of Plenty has a very wide range of soils, many of which are highly suited to horticulture. The well drained brown and pumice soils based along the coastline, and further into the centre of the North Island, as indicated in the Soil Map of New Zealand below, are often well draining and have suited soil properties for a range of horticultural crops including avocados and kiwifruit.

Soil types can directly affect the growth of roots, accessibility to water and nutrients and the overall cropping ability of each plant. Rooting barriers can reduce the access of plants to further nutrients and soil water reserves. Drainage also impacts on the water accessibility for plants, poorly drained areas can significantly impact the incidence of diseases and root rot. Many plants including those such as avocados, passionfruit and asparagus dislike having "wet feet". In many cases the suitability of soils can outweigh many other suited factors in horticulture. Movement into housed and potted plant options and earthworks allows for a wider range of areas to now be suited to horticulture, however quality soils remain as one of the most critical components in profitable horticulture.

Soils that are most suited to horticultural production are:

- Soil texture: silt loam, sandy loam, loam, clay loam or loamy sand (in the topsoil 15 cm).

- Potential rooting depth: 50 cm - over 1m. The required profile of this varies significantly between crops. For example, peas rooting depth is much lower than that of established kiwifruit.

- Drainage Class: well-drained - Profile readily available water (0-100 cm): moderate (greater or equal to 50 mm) or could be drained to at least 100 cm. Over draining soils can produce risks during droughts; however, lack of drainage causes significant issues in root growth and disease incidence. Imperfectly drained soils that are improved with drainage can also become suited for horticulture.

- Soil structure: should lend itself to aeration and root penetration.

Gisborne / East Coast General

As noted, the Gisborne/East Coast region has a range of soils with nearer the city centre being primarily "brown" soils, transitioning into "recent" soils further up the coastline. Gisborne soils have also been significantly impacted by silt deposited in flooding events. These may not have been described in the literature and will need to be considered on-site.

Brown soils are composed of equal amounts of silt, sand and clay giving them a loamy texture and providing excellent drainage and fertility, these will generally be highly suited to horticulture. There is a generally stable topsoil and can often contain high levels of soil organisms.

Recent soils are generally weakly developed and occur frequently in New Zealand on alluvial floodplains, steep sloped and areas with young volcanic ash. These soils will generally have a high plant-availability water capacity and a deep rooting zone. This makes them suited to several horticultural crops.

The suitability of soil types throughout the region means that horticulture production is common, especially within the Poverty Bay flats which is a large area of well-draining fertile soils. The Trusts in the collective are not located in these traditional flats, they are more based in hill country on the East Coast/Whāngārā area.

The East Cape in general is made up of a range of Typic Orthic soils (Typic Orthic Brown Soil, Typic Orthic Allophanic and Typic Orthic Allophanic). These are generally made of layers of silt loam and silt clay loam-based soils, with some also containing layers of sandy loam and loamy sand layers.

The most typical soils of the East Cape include:

- Kiore Hill Soil: on hill country. Some of these indicate poor drainage. Top layer of silt loam with mudstone. Tends to be fertile with some limitations of erosion in intensive agriculture. This would be suited to some horticultural crops including annual and established.

- Kopuawhara Loamy Sand: Locally these can be classed as imperfectly drained, however earthworks can help aid the drainage of these. The topsoil layer is made of black friable loamy sands, followed by further layers of mixed sandy loams. These soils are generally found on high terraces. Some subsoils would be suited to limited horticulture, however other heavier subsoils can be very poorly drained.

- Oruataiaka Hill Soil: as a result of extensive erosion these soils have a very stony profile. Topsoil layers of dark greyish-brown silt loams often have gravel, with deeper levels also having weathered greywackle gravels throughout.

- Waiherere Silt Loam: This is a common soil on the flood plains of major rivers in the Gisborne Plains and Tolaga Bay. This soil is highly suited to horticulture and has no rooting barriers and is well drained. The topsoil of friable silt loams makes this a highly suited soil. This occurs more in Waipaoa, Makaraka and Matawhero areas.

- Whakawai Hill Soil: this is generally found on the rolling to hilly areas of the east cape. In areas of high rainfall these soils are strongly leached. Derived from banded sandstones and siltstones means that the properties of the soil are between that of mudstone and sandstone. Many of the poorer sandstone areas of the Gisborne East Cape area are considered poor soils with low production. There are however large variations within this soil type.

Many areas of Gisborne/East Coast have well drained and fertile soils that are well suited to a large range of horticulture crops. As previously mentioned, the recent and brown soils, that generally make up the area, are suited to a range of crops. Some of the subsoils are poorly drained and much of the hill country is heavily susceptible to erosion risks. Overall, many soil types are suited to both arable and established crops, those with weak structure will need to be cautious in approaches to soil management during production.

Taupō/Turangi

Soils in the Taupō region are all formed from tephra, primarily pumice. Orthic Pumice soils dominate the area. There are also pockets of organic soils, which have developed from wetland areas and have an often-thick layer of organic material over pumice. Fluvial systems have also created alluvial soil types.

While there is some variation within soil families, most Orthic Pumice soils have potentially unlimited rooting depths and ample aeration in the root zone. They have large macropores which allows for quick drainage of excess water but are also able to store reasonable volumes of plant-available water. Consequently, they can be leached and have poor fertility, which should be carefully accounted for in any irrigation or nutrient management plans. They often have low structural integrity when disturbed, but a high resistance to compaction, which has made the area a popular choice for dry stock.

Some of the more common soil types found in the collective area are:

- Oruanui Sand/Rangipo soil: This Podzolic Orthic Pumice soil is widespread in Northern Taupō and a similar soil in the Southern part occurs, Rangipo soils, which are distinguished by a thin layer of Ngauruhoe tephra. Developed beneath podocarp forests, they are also on the acidic side. They are characterised by a black, friable topsoil layer and reddish-brown to brown sandy subsoil layers with fine pumice lapilli. They have a high capacity to hold plant-available water, but rapidly drain excess water.

- Taupō Sand: This is an Immature Orthic Pumice soil which is most commonly found in areas of lower rainfall on rolling hillside areas. They are characterised by thin topsoils and B horizons. This soil has a medium ability to hold plant-available water and can be prone to summer drought.

- Tihoi Loamy Sand: This is a Humose Orthic Podzol soil which is formed beneath podocarp forest over top of tephras at higher elevations in rolling to hilly areas. They tend to be acidic as a result of this and are characterised by a noticeably light, whitish-coloured horizon beneath the topsoil which is the result of leaching.

- Waipahihi Sand/Turangi Soils: This Immature Orthic Pumice soil is often found through valley floors, this soil developed from eroded pumice hillsides with a thin layer of Ngauruhoe tephra. It has no obstructions to rooting depths and has a medium capacity for holding plant-available water and can be prone to summer drought.

- Kaingaroa Sand: This is a Welded Impeded Pumice soil which is characterised by shallow topsoils and a brittle, welded subsoil layer that restricts water movement and plant roots. They have a low water-holding capacity and poor fertility.

Bay of Plenty

Bay of Plenty has a very wide range of soils in which many are highly suited to horticulture. The well drained brown and pumice soils based along the coastline, and further into the centre of the North Island, as indicated in the Soil Map of New Zealand below, are often well draining and have suited soil properties for a range of horticultural crops including avocados and kiwifruit.

The most typical soils of the Bay of Plenty include:

- Mamaku Sandy Loam: this soil predominantly occurs on the Mamaku Plateau. This is formed from very thin Kaharoa and Taupo Tephra on Mamaku. Bleached layers and red subsoils can be common within this profile. There is strong leaching properties within this soil, but high levels of phosphate retention. The top layer is made up of black sandy loam, followed by a brown loamy sand. Main current uses include forestry, sheep and beef and deer.

- Opouriao Silt Loam: Topsoil of this soil type is made up of black silt loams with a brown fine sandy loam following this, then followed by a silt loam layer. The soil is formed from alluvium and has a good natural fertility and drainage. This mainly occurs on the Ōpōtiki and Rangitaiki Plains. This soil can be suited to horticulture or cropping.

- Papamoa Loamy Sand: this soil is derived from windblown sand with small amounts of tephra. Popular for winter grazing and recreational/urban use. Excessive draining of the sand-based soils make this soil type susceptible to excessive draining and low nutrients.

- Paroa Silt Loam: derived from tephra alluvium and peat. This is a poorly drained soil which can become moderately well drained with artificial drainage implemented. A high water table effects the drainage of the soil. A topsoil of a dark brown silt loam with coarse sand is above another layer of dark silt loam buried by layering. Very dark peat layers can be found deeper in the soil.

- Rotomahana Loam: The topsoil is a very dark brown friable loam, followed by a friable silt loam with weakly developed soil structure, followed by silt loams and sandy loams. This soil was formed during the 1886 Tarawera eruption, its youth is reflected in the thin topsoils. This is less suited to intensive cropping due to the susceptibility to compaction.

- Te Puke Sandy Loam: this has a topsoil of a black friable sandy loam, followed by a brown sandy loam and a friable coarse sandy loam. This can be and is commonly utilised for cropping and orcharding, crops such as kiwifruit and citrus. There are no rooting barriers, and the soil is free draining with high water storage. These are positive aspects for horticulture.

The collective included in Te Arawa spans over a large area of the Bay of Plenty, for this reason the comments have also been made considering the areas of Maketu and Rotorua, due to the large area between the sites and the variations in soils.

Rotorua

Rotorua is classed as recent and pumice soils. Pumice soils will generally be well drained, however those with high proportions of pumice can create over draining and become an issue for some soil types. Many classes of pumice soil can be suited to horticulture.

Recent soils are generally weakly developed and occur frequently in New Zealand on alluvial floodplains, steep sloped and areas with young volcanic ash. These soils will generally have a high plant-availability water capacity and a deep rooting ability. This makes them suited to several horticultural crops.

Maketu

Maketu is classed as organic soils, this is due to the proximity to estuary and swamp land along the coastline of the area. It is predominantly poorly drained in many areas of Maketu due to the low-lying nature of much of the land. Higher areas of Maketu show much promise and are made up of a range of allophonic sandy loams and some pumice-based soils. These can be highly suited to horticulture as they are often well drained.

For this reason, the majority of the soils suitable to horticultural cropping are located in the higher areas of Maketu, with a correlation between the metres above sea level and proximity to the water table. This means that many of the areas nearer the coast in Maketu are limited due to where the water table is sitting within the soil profile.

9.1.3 Environmental Considerations

Protection of soil from erosion and degradation is a key environmental consideration. Soils of steeper land and soils with weak structure, such as young river-plains and volcanic-origin soils are particularly susceptible to erosion and damage. Similarly, crops where regular cultivation is required are more likely to degrade soil due to the negative impact of cultivation on soil structure and bare soil surfaces being more exposed to rain and wind erosion. Most annual crops require regular cultivation. Crops that do not require cultivation or are long-lived perennial crops where cultivation is used rarely or only at establishment are inherently more protective of the soil.

Crops can be grown in ways that help to contain environmental impacts, and this should be an aim of production systems used for any crops established. For example, by providing routes for run-off of rainfall that slow down water movement to avoid scouring of the land and direct the run-off to suitable destinations.

Application of fertiliser is another area where environmental impacts are a consideration. Some crops require greater nutrient inputs than other crops, which increases potential for adverse environmental effects, particularly given unpredictability of rainfall over any given period. Horticultural nutrient impacts are generally contained by banding or broadcasting fertilisers at appropriate times, and by absence of animal urine patches, which concentrate urine-sourced nitrogen to a small area of ground.

9.1.4 Time to First Production, Time to Full Production, Productive Lifespan

These characteristics of a crop provide a picture of the relative lifespan of the crop, as these can differ widely. For example, an annual crop planted at the most suitable season for the variety may be producing within a couple of months from planting and several annual crops may be able to be grown in the same land over a 12-month period. Other crops may have an extended juvenile non-producing period of up to 10 years but then continue to produce, all things being equal, for many decades. There are crops in-between with passionfruit and tamarillos being among them. These crops have a relatively short juvenile period of 18-30 months but after 2-4 years producing the plant declines in yield and plant health until it becomes uneconomic.

9.1.5 Estimated Annual Gross Margin

The gross margin is the annual income at maturity less the annual direct costs, so not allowing for overheads, capital spending and other non-annual costs. These are produced for each crop and provide a broad means to compare financial prospects, at maturity, between different crops.

9.1.6 Estimated Establishment Costs

Generalised establishment costs have been provided to show a broad comparison of the initial investment required between crops. Major areas of establishment costs are listed - for example plants, support structures, shelter, irrigation. Establishment costs vary widely between crops and also between sites and with property scale. For example, headworks are a significant component of costs for an irrigation system, but a larger sized planting would be a more efficient use of headworks with sufficient capacity. Obviously, a more detailed establishment budget would be required to take into account site specific considerations.

9.1.7 Crop Storage Attributes

Some crops are able to be stored for long durations and others have a limited storage life. Some crops are harvested mature but not ripe and others will not ripen further after harvest so must be picked at their optimum time. Development of technologies for storage and selection of crop varieties with known storage characteristics varies considerably between crops. For example, persimmons have a known temperature coupled with packaging that modifies the gas-atmosphere around the fruit, enabling sea-freighting to markets in Asia.

9.1.8 Size of Industry, Stage of Industry Development and Recent Industry Trends

The industry size is an estimate of the planted area within New Zealand. New Zealand's largest scale perennial horticultural crops are wine grapes at over 39,950 hectares, followed by kiwifruit at around 12,900 hectares, apples at 10,400 hectares and avocados at 3,950 hectares. Vegetable areas are more variable as many are annual crops, with the largest areas used for potatoes (~10,400 ha), squash (~6,500 ha), onions (~5,300 ha), sweetcorn (4,650 ha,) peas (~4,100 ha), and brassicas (~2,900 ha).

Many crops have much smaller national areas, being under 250 hectares for example for feijoas, tamarillos, persimmons, passionfruit, macadamias, chestnuts, silverbeet, cucumbers, garlic and capsicum. For these crops the impact on supply, and hence price, of developing a large area must be considered.

Industry development should also be considered. A mature industry is one in which there is co-ordinated effort into research, product protocols, market development and industry structure or administration. An immature industry has limited provision of these things, whether or not the industry is young in age. Emerging is used as the descriptor when there is current activity to provide these activities, often within a relatively young industry.

'Recent industry trends' included to enrich the picture of the industry potential and progression. For example, an industry that is increasing in area, whether initially larger or smaller, indicates confidence or enthusiasm within the industry. The recent trends for non-dairy 'milk' products and plant-based proteins are factors worthy of consideration. While the infrastructure to support the processing of these products is not yet present, the scale of this land use change could result in collective effort to develop this infrastructure, including markets.

9.1.9 Produce Types

The dominant produce type, particularly whether fresh or processed, gives an indication of the product diversity. Fresh horticultural products often have the highest product value. Processed products have increased storability and may require specialist equipment for processing. Processed products are more likely to face significant international competition.

9.1.10 Export or domestic market focus

Some crops focus on export markets and there is little value in the non-export product sold on the domestic or processing market. Others have a significant domestic market in both volume and value. The domestic market may be an important outlet for produce that does not meet the quality standards for exporting. The concept of import substitution is also a consideration. For example, alternative nut-milks present an opportunity for substitution of almond milk imports.

9.1.11 Marketing Infrastructure

These are discussed as 'developed', 'poorly developed' and 'cottage'. Developed is generally where there is access into key international markets and organisations actively marketing the produce on the growers' behalf. Poorly developed is where there is a lower level of these activities. 'Cottage' is used where growers tend to be their own marketer and/or processor including organising direct sales and attending markets and so on where there is limited option for other ways to market their crops.

9.1.12 Industry Structure

An industry may have a formal organisation such as a growers' association. There are several legislative options that can be used to influence industry structure. An industry may establish a Commodity Levy to fund specific industry activities such as research and market development if they meet the requirements to establish this levy. The levy becomes compulsory if it is granted under the legislation. There is also the Horticulture Export Authority legislation. Product groups that elect to use this legislation have an ability for some co-ordination such as licencing of exporters and development of grade standards and a marketing plan. The kiwifruit industry is an exception in this regard with specific legislation that underpins the right for Zespri to market New Zealand kiwifruit internationally with minor exceptions. This legislation is strongly supported by growers.

9.1.13 Level of Grower 'Hands On' Management Required/Production Infrastructure

These two attributes are linked. A high level of hands-on management by growers is required for crops where there is limited infrastructure such as contract or skilled labour, equipment and facilities, or where there is limited generally known production techniques or information. Production infrastructure may be available from one crop for use in another crop. For example, shelter trimming machines work across a range of crops; cool stores established for one crop may be available at certain times of year for another crop. For some industries, the level of "hands-on" management can be extremely low; there are skilled contractors and managers locally who are able to undertake all the key activities in a timely manner.

9.1.14 Scalability

Many horticultural crops in New Zealand are relatively small-scale and niche. The domestic market is limited in size and therefore sensitive to increases in volume, particularly where the crop is harvested over a short period so an increase in volume would intensify peak volumes. Similarly, crops with a limited diversity of export markets, whether due to market access, storage-life or market development, are not readily scalable. The comments on scalability are from consideration of these factors.

9.1.15 Barriers to Entry

Some crops have formal barriers to entry. These can be legal, for example a licence may be required to grow a proprietary variety, with Gold3 kiwifruit being an example of this. In the assessment, only legal barriers have been considered, not informal barriers such as a high cost of establishment.

9.1.16 Level of Labour Required and Peak Labour Period

The level of labour required is assessed as low, moderate or high. For almost all crops, the most labour-intensive period is harvest, and usual timing of the harvest period is indicated in the discussion. The intensity of the harvest labour requirement depends on whether the crop must be picked at a particular time or whether there is an ability to hold the crop on the plants; the means of harvest and so on. Other labour-intensive activities are pruning, which may be required at several stages of the growing season, and thinning. Timing of many activities, for example pest and disease control, and pollination, is critical but these are not necessarily labour-intensive activities.

9.1.17 Biosecurity Issues

Biosecurity issues can include pests and diseases new to the area or to Aotearoa/New Zealand. All crops are at risk of new pests and diseases and impacts may be severe. Impacts range from survival of the plants, reduction in production or quality of the crop, or access to markets. All these impacts can cause significant issues for a crop and industry.

9.1.18 Pest and Disease Considerations

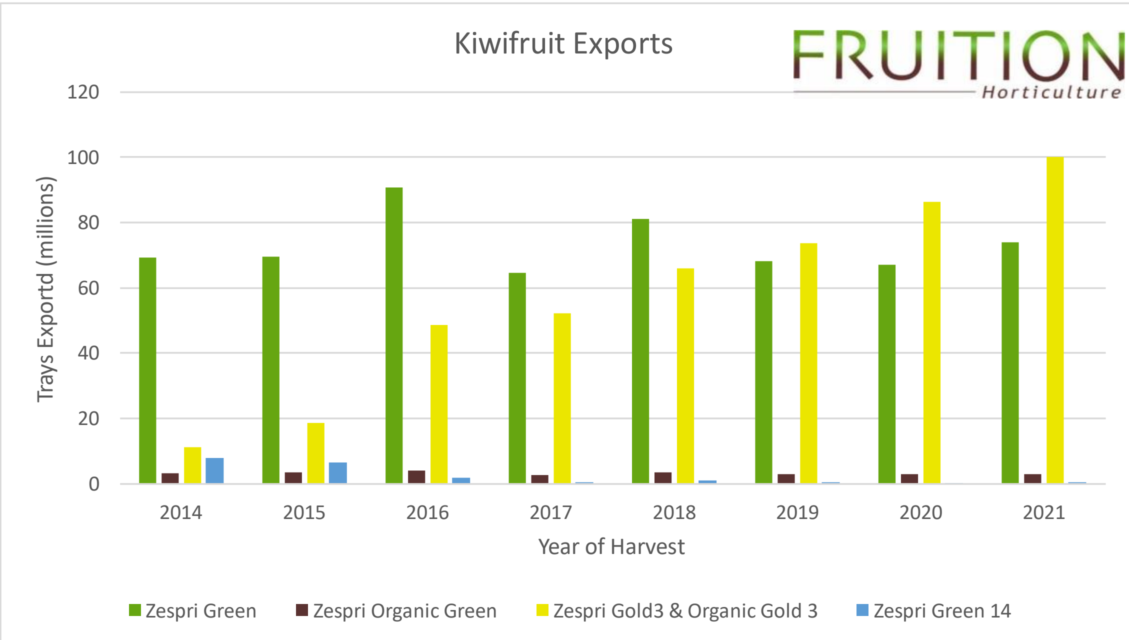
Noted are particular pest or disease considerations. For smaller industries the range of controls available is limited because the investment in research and regulatory processes to gain a product label claim are not justified by the market potential of control products. Crops that have a large international scale are more likely to have a wider range of controls available for these same commercial reasons.

9.2 Individual Crop Discussion

9.2.1 Kiwifruit

Kiwifruit is marketed by Zespri under a special 'single-desk' structure, that is largely supported by industry. Kiwifruit production within New Zealand is predominantly made up of green kiwifruit (Hayward variety) and gold kiwifruit production (Gold3 or G3 variety). These varieties are also grown, in smaller proportions, in organic systems as opposed to conventional production. Green kiwifruit has been the backbone of the New Zealand industry with gold production outstripping green production for the first time in 2019. Historical volumes of fruit exported from New Zealand are presented Figure 11. The Green14 variety referred to in the graph is no longer available to grow. Zespri have recently commercialised a red variety (R19) marketed as 'Ruby Red'. The first harvest from commercial developments is occurring this season.

Figure 11: Kiwifruit Exports



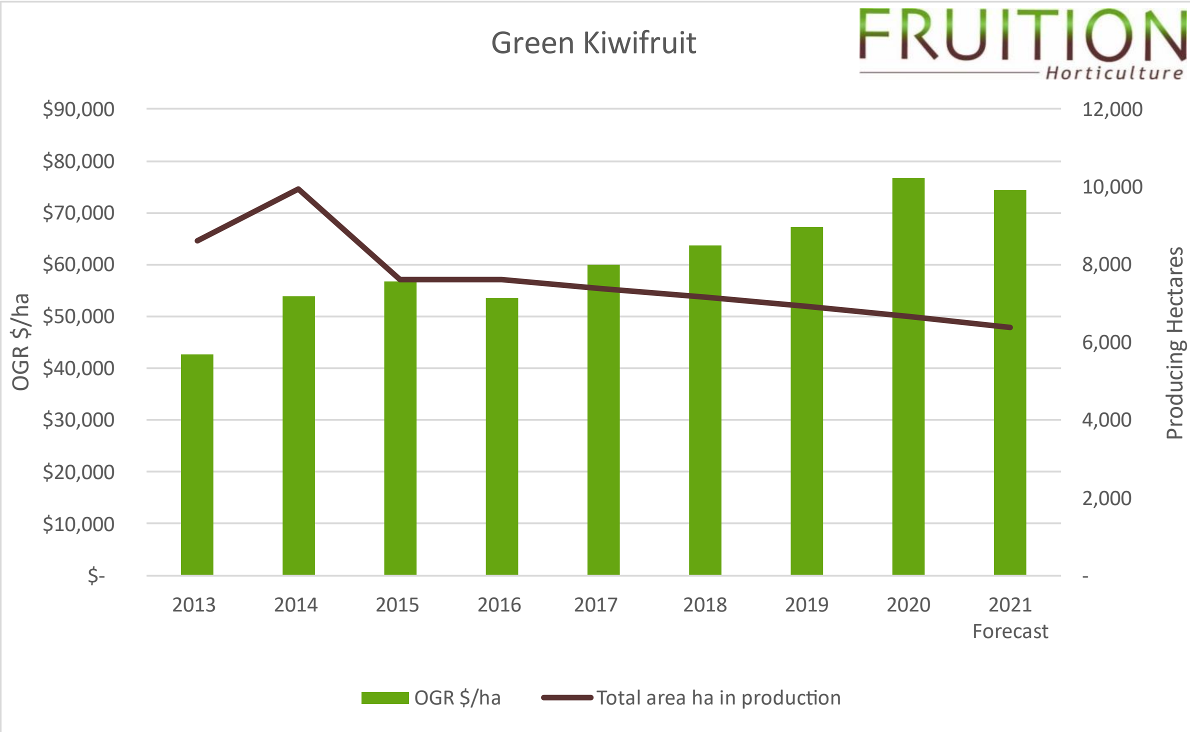
➢ *Hayward – ZESPRI™ Green*

This is the traditional green fruit that has been grown, predominantly in the Bay of Plenty, for decades. Here are some key points about green kiwifruit:

- The green Hayward variety is not protected with a Plant Variety Right (PVR) and therefore Zespri is unable to control domestic or international production.
- The OGR, or 'orchard gate return' on green kiwifruit can be influenced by incentive payments, such as KiwiStart (early harvest incentive) or storage incentives. Many Gisborne and Maketu orchards meet this early harvest incentive.
- The average yields of green kiwifruit are increasing, along with the average OGR per tray, and per hectare, but there are still significant fluctuations from season to season.
- Conversion of green orchards to Gold3 (Sun Gold) is helping lift green returns as production plateaus and more of the fruit is able to be directed to the higher returning markets as displayed in Figure 12.
- Zespri aims to keep the OGR/ha for green kiwifruit over $60,000 (subject to seasonal factors). The most recent Zespri Outlook report indicates a per tray range of between $6.50 and $8.50 over the next five years, higher that the recent average, reflecting the reduced production[7].
- Production is impacted by the level of winter chill. Production levels in warmer climates can be uneconomic. Due to the fruits need for temperatures below 7^{o}C over a period of time in order to produce good volumes of flowers.
- The incoming regulation change decision to phase out hydrogen cyanamide (Hi-Cane) will heavily impact the ability to profitably grow Green kiwifruit for many New Zealand growers. Hi-Cane is a chemical used to promote uniform budbreak and flowering in kiwifruit vines. This helps to produce a more reliable crop.

[7] https://canopy.zespri.com/EN/industry/pubs/outlook/Documents/2022-Outlook.pdf

Figure 12: The trends in the OGR per ha and total hectares in production for Hayward kiwifruit



- *Gold3 – ZESPRI™ Sun Gold*

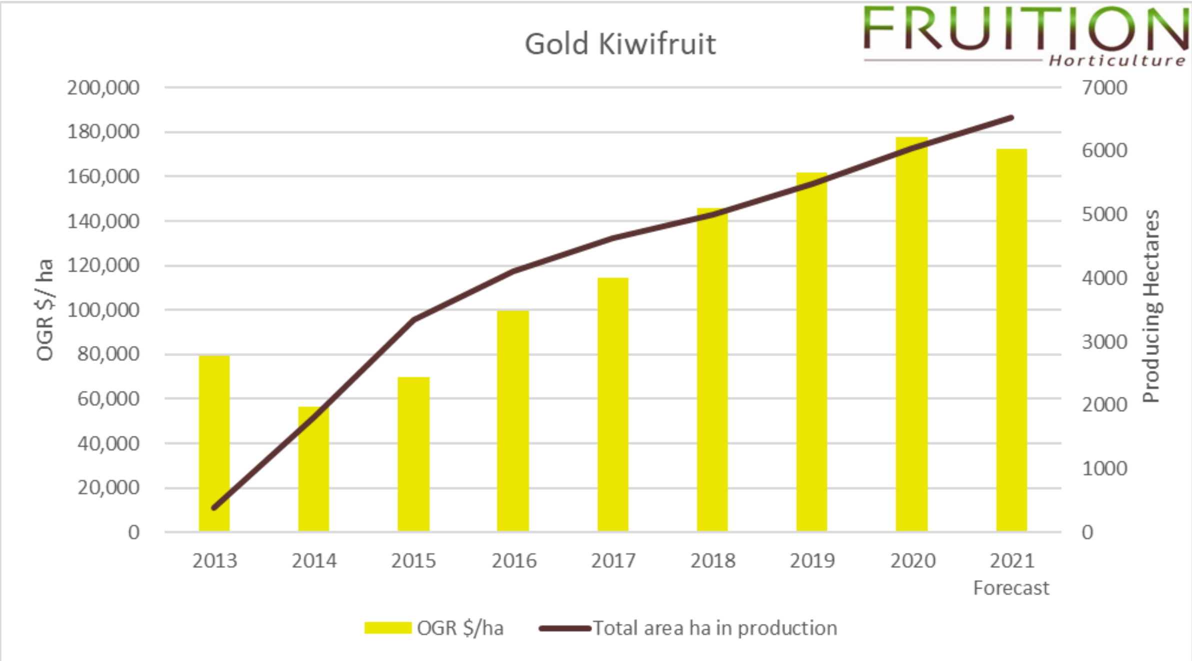
  Gold3, marketed as 'SunGold' is a Zespri-owned variety, and growers must be licenced for the area they have in the variety. Some key points are outlined below:

  » Increasing area in production, due particularly to conversion from Psa-affected Hort16A gold kiwifruit since 2012 and also conversion from green kiwifruit, as seen in Figure 13.

  » Yields for Gold3 are typically higher than those for Hayward.

  » Gold3 produce high average OGR per tray and OGR per hectare despite increased area in production, as also seen in Figure 13. Zespri's Outlook document of December 2021 predicts a range for OGR/hectare of over $120,000.

Figure 13: The trends in the OGR per ha and total hectares in production for Gold kiwifruit



Gold3 requires a licence from Zespri to produce and can be purchased through a tender process. Previously Zespri has released 700 hectares of Gold3 licence and a further 50 hectares of organic Gold licence annually. This season Zespri will only be selling 350 hectares of Gold3 licence and is releasing no organic gold licence.

It is expected that this smaller amount of licence release will continue in coming seasons, this is due to continual revision of market conditions, demand projections each year and concerns regarding the illegal planting of Gold3 in China now thought to be over 12,000 hectares. It is difficult to project the exact tender price for 2022, however it is expected to increase significantly on previous years due to this lowered supply and the current buoyancy of development in the industry. Our development budgets have used a price of $800,000. It should be noted that:

» In the 2021 tender, the median price paid for licence, exclusive of GST, was $550,000

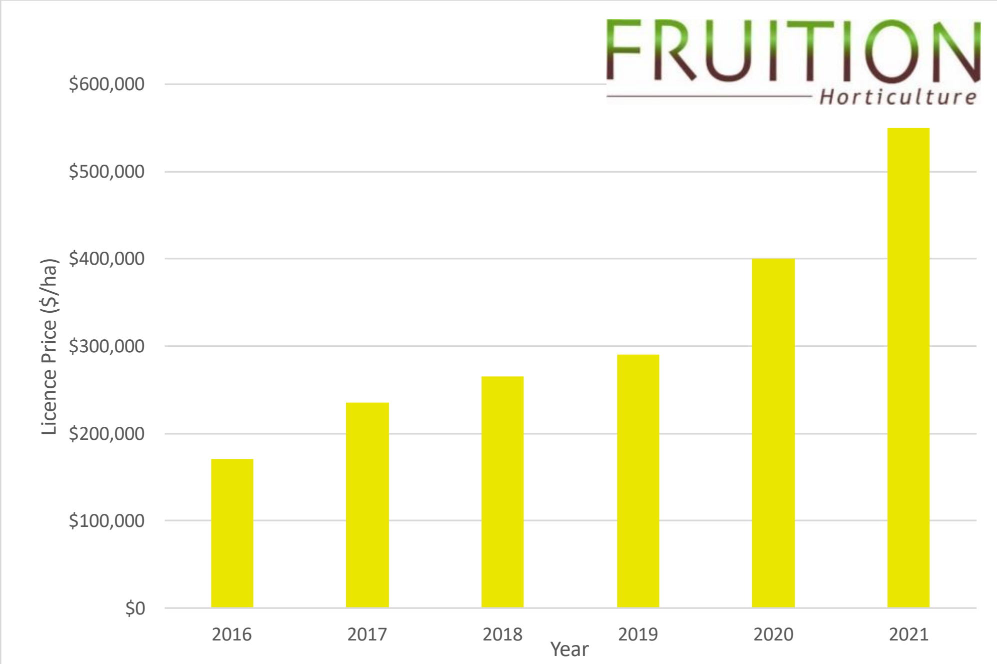
» The full offering of 700 hectares of licence was sold, and demand exceeded the hectares of licence that was made available.

» Many growers and large investors missed out on licence this year, this may mean the price growers are prepared to pay will increase significantly in the next tender round. Tenders may be as high as up to $1,000,000 per hectare, however, they are very difficult to predict in the coming season.

» Zespri is carefully managing the release of licence to match with market growth. The Zespri Board meets in October 2021 to confirm the future plans for licence release but has already commit to another round of licence for 2022.

» The Plant Variety Right (PVR) on Gold3 licence does expire around 2035, which will remove legal protection for the variety, although commercial protection such as branding, and trademarking can continue.

Figure 14: Gold Kiwifruit License Cost



- *Red Kiwifruit – ZESPRI™ Ruby Red*
  In 2019 Zespri announced the commercialisation of a red variety to be marketed as "Ruby Red". It is considered to be more difficult to grow than either of the other commercial varieties. The crop has been sold commercially for coming up to two season now and many trialists have claimed that it shows great promise. Asian markets have especially shown strong demand for the fruit during trial seasons.

Figure 15: Recently released red kiwifruit variety

This variety is still very early on in terms of grower knowledge and production area. With the third season of commercial sales occurring this season there will be 350 hectares of licence available again this year for this cultivar. It is not recommended by us for first time growers. Investment in licence is expected to increase this season, with the previous seasons licence selling for just under $75,000/ha median price.

Kiwifruit are grown as grafted plants and are graft compatible with other kiwifruit varieties. This allows for choice of the most suitable rootstock and scion (graft which grows into fruiting part of vines) as different varieties offer different attributes. It also means that vines can be cut over and grafted with new varieties once they are developed. For example, Hayward green kiwifruit can be cut off and the Gold3 kiwifruit can be grafted onto the rootstock, this is also the case with the new Red19 variety.

Site Selection

Kiwifruit is best suited to well-drained fertile soils with a soil pH of 6.0 to 6.5. Kiwifruit do not tolerate 'wet feet' or poorly drained soils.

They do best in places with sheltered spots with good levels of winter chilling but also a high amount of growing degree days and sunshine hours. Evenly spread year-round rainfall is also ideal, but with not too many wet days over the pollination period in October/November. Kiwifruit is sensitive to late-spring and early-autumn frosts as this is during critical growing periods. Their need for relatively warm sites makes site elevation an issue as the higher in elevation the cooler the site, for this reason we don't recommend kiwifruit be planted in sites above 200 meters about sea level.

Establishment requirements

The coastal areas considered for production in Gisborne and Maketu have a prevalence of wind during the season, this can have a large impact on kiwifruit quality, vine stresses and reject rates. Lines of natural shelters could be established a few years before planting or artificial shelter can be used to generate immediate barriers to the wind but at a higher cost. A mix of both natural and artificial would be preferable. The financial analysis below has included provision for overhead shelter netting as well as to reduce wind speed, eliminate wind turbulence and reduce the risk of damage from hail and storm events. However, this may not be necessary at all locations.

Figure 16: Netting over the top of the orchard reduces damage from strong gusty winds and hail. Sourced from NZKGI Kiwifruit Book 2019.

Figure 17: Artificial wind breaks provides instant shelter and maximizes the productive land area. Sourced from NZKGI Kiwifruit Book 2019.

Kiwifruit is grown using a pergola structure, with rows typically running north to south. Vine footprints or the size of the bay are generally tending towards 15-20 m^2 nowadays, though older set ups had larger footprints of 30 m^2. Kiwifruit have male and female vines, both of which are needed for successful pollination of the female flowers to produce fruit. There are many different layouts that can be used in reference to the male to female placements within an orchard. Some orchards grow their males in rows as strip males, while other orchards place their males spread out in a grid.

Generally, around 80-90% of the suitable area will be planted. The remaining area is used for the loading bay, shed and facilities, water storage, driveways, headlands, and shelters.

An irrigation system with sprinklers is typically used for the dual purposes of irrigation and frost protection. Weeds need to be controlled effectively to help the vines establish quickly, and fertiliser and compost would need to be applied.

For a stand-alone orchard, at least 5 canopy hectares is needed in order to attract labour, especially in more isolated areas.

Orchard Management

Young vines will need to be trained to establish canopy cover, usually through stringing for Gold. Gold vines take 4-5 years to mature and reach full production but can crop in year 3 from grafting or planting the grafted plant. The canopy needs to be manged to ensure high quality fruiting wood gets laid down every year during pruning, and replacement fruiting wood is grown and nurtured throughout the year, as well as producing high quality fruit. Fruit must reach grade standards in terms of dry matter (an indication of eating taste), sugars, and colour of the flesh or seeds before it is cleared for picking. Once harvested, fruit will need to be transported to a packhouse, potentially taken to a local packhouse, for grading and packing.

Ongoing jobs such as fertiliser spreading, weed control and crop protection sprays can be undertaken by contractors, or the equipment could be purchased, this would only be recommended for a large-scale venture. This can be a better choice, as it the assures that activities and jobs get completed on time (for example copper sprays need to be applied before and after a heavy rainfall event to reduce to spread of a disease called Psa).

Pollination is critical, as without it, no fruit will be produced. Specially prepared beehives need to be brought into the orchard over the short flowering window to facilitate pollination. Reliable beekeepers will need to be found for the orchards. Additional pollen can be sprayed onto the canopy, but honeybees are still required to move this pollen around to the flowers.

Water Requirements

Though kiwifruit can survive without additional irrigation, it is recommended to increase resilience against season-to-season fluctuations in rainfall and long-term impacts of climate change. Irrigation can be used to support young vines to become established faster and supports fruit set and larger fruit sizes. Maximum water needs over the peak of summer could be as much 60 m^3 per hectare per day.

Labour Requirements

There are many significant labour requirements for kiwifruit during the kiwifruit seasonal cycle, with harvest (March to June) as the most labour intensive on orchards and in packhouses. This relies on unskilled seasonal labour for picking, but also requires some skilled positions like managers and tractor and truck drivers. There are year-round requirements for a smaller level of skilled labour for activities such as winter pruning (June-August), flower bud thinning (October), summer canopy management and fruit thinning (December-February). Employees or contractors are needed for ongoing activities such as orchard spraying, weed control, mowing and mulching, shelter trimming and other general maintenance and repair. Overall, one full time worker is needed for every 2 hectares of kiwifruit[8]. An orchard manager is responsible for organising all these activities to happen at the right time. There are a range of kiwifruit management companies that will manage the system from season to season, usually an orchard manager can look after 40 to 60 hectares of kiwifruit.

Potential Production Volumes and Returns

We would predict that average yields at full production would be around 15,000 trays/ha for Gold3. This could fluctuate as much as 2,000 trays/ha up or down depending on seasonal variations. These yields will change between the Whāngārā and Maketu based farms. The current financials are based off of a Maketu farm analysis.

Financial analysis below has taken into consideration many of the production and typical development costs needed for kiwifruit production. We have included sufficient budget to cover the construction of irrigation infrastructure on orchards, water storage and frost protection. The establishment costs also include provisions for extensive shelter, though this may not be required in all locations. Please note that some blocks need some additional preparation work (for example, clearing trees, digging of open drains, laying gravel roads) which is not included in the development costs stated below.

Table 20: Financial Analysis of Kiwifruit Production

Financial Criteria	*Gold Kiwifruit*
Yield at full production (export trays/ha)	15,000
Years to Full Production	5
Price per tray	$11.00
Development Costs ($/ha) - excluding land but including licence cost	$1,025,000
Total Income (OGR/ha) at Full Production	$165,000
Growing Costs ($/ha)	$49,300
Gross Margin ($/ha)	$115,700
Net Present Value (NPV)	-$191,950
Internal Rate of Return	2%

[8] New Zealand Kiwifruit Labour Shortage, New Zealand Kiwifruit Growers Incorporated. July 2018

Industry, Markets and Partnerships

In New Zealand Zespri works with 2,800 growers and a further 1,500 growers internationally, providing lots of technical expertise and advice. This gives them the ability to source the highest-quality kiwifruit and deliver these through the supply chain to the market and distributing their profits with the growers who own shares within Zespri. Zespri has a very strong brand identity, especially in the Asian markets which are fuelling a lot of the growth in the industry.

Other associations advocate on behalf of growers, including New Zealand Kiwifruit Growers Incorporated (NZKGI), and Kiwifruit New Zealand. There is also a range of packhouse and orchard management companies and contractors which support growers and manage orchards. Most of these are based in the Bay of Plenty but are looking to expand into other non-traditional kiwifruit growing areas. Poverty Bay is beginning to see a large presence of kiwifruit in the Poverty Bay flats area, with large developments increasing.

In terms of investment, packhouses such as Eastpack, Apata and Seeka are keen to help develop and manage orchards. Other investment syndicates such as MyFarm are also seeking orchard development opportunities. Ministry for Primary Industries (MPI) offers some different pathways to funding and co-investment opportunities, which can be seen on their website. (Funding and rural support | MPI | NZ Government).

9.2.2 Oats

Oats are traditionally grown in New Zealand for human and stock consumption but also in crop rotations to improve soil quality. While the financial modelling in this report focuses on oats for their traditional uses, there is the potential for value add using the oats for products such as oat milk, an alternative to dairy milk, and also a substitute for alternative milks currently imported into New Zealand.

Oats will be sown in April and harvested by October or November. Combine harvesters will remove the heads of the oats which will then be separated and processed into rolled oats. Oats are an annual rotation crop which will need to be planted as part of a rotation system, this reduces the incidence of wild oats, grassy weeds, and breaks the cycle of family specific diseases. The majority of growers will use pasture production and other fodder forage crops or potatoes between oat crops. Identification of multiple areas for rotation need to be planned before planting.

Figure 18: White oats in field (source: newsroom.co.nz)

Climatic Requirements

Oats are predominantly grown in cool temperate areas. The most common cultivars being Armstrong and L5 oat cultivars for white oat production. The majority of the world's oats are produced in the Northern Hemisphere between 40 and 60 degrees, however there is also successful and strong oat growing areas within many Southern Hemisphere regions. The areas considered in this project lie just outside of this latitude at around 38 degrees South.

Oats can adapt to growing in a range of soil types however a well-drained soil with a pH between 5 and 6 produce the most successful yields. Despite being a cool-weather crop oats should be positioned in full sun. Light frosts can be tolerated, however heavy frosts below -15°C can kill the plant. It is unlikely that these low temperatures would be experienced in even the coolest of sites during the growing season.

The nitrogen fixing that occurs in soil from oat growing makes them an attractive rotation crop for farmers to grow in pasture systems. Oats can increase organic matter of soil or be grown in rotation with slower-growing legumes. Many farming systems therefore use oats as a forage crop or to increase the suitability of soils for future crops rather than production for sale to market.

Management and Labour Requirements

The majority of the labour requirement is during harvesting, sowing and tilling of the soil. This work is all undertaken by skilled machinery operators on specialist equipment. Having access to skilled labour and the correct equipment for these roles is important in producing high yields. Pre establishment activities such as seed bed preparation to reduce competition from fast growing weeds is also critical. Because the annual crop must be rotated with a number of other crops throughout the year, management input is also needed to decide what crops will be used in rotation with the oat crop and also consider the labour and management requirements for those identified crops. It is likely that an oat crop will fit well within these farming systems as a part of the pasture renewal programme.

Pests and Diseases

Oats for rolled oats production will require specialist input for the control of pests and diseases in the crop. There is a need for continuous monitoring throughout the season to determine the presence of cereal pests or diseases and to act on this monitoring in a timely manner.

Wild oats are a large issue in many cereal crops, and these cannot be distinguished from the crop oats during the vegetative stage. These can significantly impact final crop quality and competition for resources, continual efforts should be made to reduce the seed bank of these within the soil. Wild oats can be difficult to control with herbicides.

Oats are affected by a range of diseases that affect many cereal crops including stem rust, barley yellow dwarf virus, leaf rust and speckled leaf blotch. These diseases affect vegetative growth and therefore reduce overall yield and quality of final products. Fungicides can reduce the incidence of many of these diseases, however the use of crop rotation is most effective in reducing the risk of many of the cereal specific diseases.

Several pests including aphids, slugs, African black beetles and wheat bugs often reduce the quality and quantity of crops if left uncontrolled. Some also act as carriers of serious diseases and viruses. Insecticides can be used to control these as well as cultural practices such as rotations of crops.

Water Requirements

Oats can be and often are grown without supplementary irrigation. Oat production will continue even with low soil water reserves, however studies have found that oat plants increase, to a certain threshold, in production as the water access of the plant also increases. This in turn means that production can be hindered by low rainfall, however most producers can adequately produce without irrigation.

Potential Production Volumes and Values

Volumes of rolled oat production in New Zealand varies significantly throughout the country. Some Southland producers, due to the pairing of suited cultivars with soils, are able to produce up to 10 tonnes of rolled oats per hectare, up from previous levels of approximately 5.8 tonnes/ha.

Increased value for rolled oats could be further processed into oat milk. Further information on oat milk production is provided below. The financials here show analysis of oat production to be used for rolled oats, rather than oat milk.

Table 21: Financial Analysis of Oat Production

Financial Criteria	*Oats*
Yield at full production (kg/ha)	7,000
Total Income at Full Production ($)	$2,800
Growing Costs ($/ha)	$2,860
Gross Margin ($/ha)	-$60

Industry, Markets and Partnerships

Oat production in New Zealand is centralised around the Canterbury and Southland regions, with Southland producing the highest oat yield per hectare in the world. Due to the large areas of flat open plains, climatic suitability with cool temperatures, access to facilities and scale within the area oats are a popular crop. The majority of North Island producers concentrate on oats as a forage crop in pasture systems, utilised during times of seasonal pasture shortages, rather than food grade rolled oat production.

The Foundation for Arable Research is a levy funded organisation that undertakes research and advocates on behalf of all arable crop growers in New Zealand.

New Zealand's only major processor of rolled oats is Harraways Ltd who sell rolled oats for porridge and other further processed and flavoured products. Harraways have processed oats in New Zealand since 1867. The company processes rolled oats for their own products but also distribute to a wide range of companies making other products containing rolled oats, such as oat milk and muesli bars.

The majority of Harraways current source of oats are from South Island areas such as Otago and Southland where there are intensive facilities, knowledge and scale of the industry in the area. The suited conditions also means that majority of South Island growers will be able to produce premium yields compared to the North Island. Harraways oats are supplied by Otago, Southland and Gore growers. These are split between Dunedin and Gore based miller operations.

Oats are used for human consumption through products such as rolled oats, muesli bars, breads, biscuits, and infant foods. As well as the fast-growing industry of using oats as a dairy alternative to produce milks, ice creams and yoghurts.

The oat milk consumption in New Zealand and Australia has increased by 270% in the year 2020 alone. With an increase in demand for alternative milks there is an opportunity for future development of both local supply chains and more profitable oat production in New Zealand. A number of New Zealand oat milk producers already exist. This includes Boring Oat Milk and Otis's Oat Milk. There is a high proportion of supermarket shelf space held by large scale Australian producers also such as Sanitarium and All Good Oat Milk.

Unprocessed oats receive much lower market values compared to processed oat products. For those outside of the optimal growing areas for oats financial viability is marginal when compared to other land uses, due to the need for high yields for a viable return. The option of increasing product price by value add is another way to produce positive financial return. Oat milk is one of these options.

Alternative milks have been praised for their health benefits, but the makeup of alternative milks varies significantly. Many do not match the protein or calcium levels of dairy milk and concerns of nutritional values have been raised. Oat milk is similar to the composition of dairy milk in terms of energy and calcium but not protein.

The water requirements for oat production to make oat milk, compared to traditional dairy milk and alternative almond or soy milks, makes it a more popular product amongst consumers as it is relatively low. The environmental impact of water consumption, and high environmental impacts, especially highlighted by the mass production of almonds in California, has created a group of consumers wanting to shift from almond milk as a dairy alternative. Between the years of 2018 and 2020 oat milk surpassed the sales of almond and soy milk in many countries, not only due to growing environmental and ethical production concerns but also increased awareness and availability of the product.

9.2.3 Chestnuts

Chestnuts are grown on large trees. The nuts have been commercially produced around the world for millennia with records of the chestnut being grown around the Mediterranean for at least 3,000 years.

The New Zealand chestnut industry is small, with very few commercial producers. A large majority of production occurs in Waikato, Bay of Plenty and Auckland. Due to the hardiness of the crop, there is the ability to successfully grow chestnuts in most areas of New Zealand.

Chestnuts can be sold fresh or processed into a range of products. Processed products include beer, flour, baby food and pastes. Chestnut flesh was at one time the baby food of choice in Asia until the pest and disease load in the chestnut trees in Asia resulted in high levels of pesticides being used. The potential of producing a pesticide free, even organic, baby food for export to Asia is there, but limited by capital to develop the processing plant. Currently the pests and diseases causing problems overseas are not in New Zealand. Once chestnuts have fallen from the tree they need to be gathered promptly and then stored appropriately by either chilling or freezing. The chestnut tree can also be harvested as a timber product and/or coppiced and used as stock food. Furthermore, cattle and other grazing animals can graze the grass under the trees. Pork sold from pigs grazing under chestnuts sells for very high prices in Europe.

Currently there are around 140 hectares of chestnuts producing approximately 350 tonnes of fresh nuts annually in New Zealand. The value of all processed nut exports (including hazelnuts, walnuts, macadamias, and other nuts) from New Zealand is around $9.3 million annually.

The analysis in this report has only gone to the point of selling the nuts in shell (NIS). The processing options for chestnuts are considerable. The nut, once separated from its burr and shell, can be processed into a range of products including puree, a gluten free flour, chestnut water and milk, beer, and sugared confectionary as examples. There is the opportunity to produce these nuts in sufficient scale in the regions of focus to justify the development of the processing plant. Obviously, further feasibility analysis on this is necessary.

General requirements

Chestnuts will grow well in a range of climate and soils and are much hardier than many other cropping options. Being deciduous trees, they are tolerant of frosts and suited to New Zealand's temperate climate. It is reported they tolerate frosts of up to -6^{o}C even in spring when young growth is very tender. Due to the large nature of the trees, once well-established there is little need for large amounts of artificial shelter or support. However, on-going pruning is a key part of maintaining well managed production areas.

Figure 19: Chestnuts near harvest. (Source: NZlife.co.nz)

Establishment requirements

Chestnuts are planted in rows of around 4.5 m with 3 m between the plants. As the trees grow, the plant density is reduced to maximise the fruiting area of the tree. The orchard must be set out with thought to placement of pollinator varieties. This selection of the varieties is dependent on the chosen cultivar as the main nut crop and the time that the pollinator sheds pollen in the particular location. This may require some experimentation in the location.

Weed control around the young trees is critical for their successful establishment. Reducing weed competition for establishing trees provides stronger establishment and a more managed production system.

Water requirements

Chestnuts are relatively tolerant of dry soils. Though irrigation during the first two seasons would be useful during the establishment of trees, it is not considered essential. Initial irrigation can help with successful production especially in areas prone to drought such as Whāngārā when the trees are coming out of dormancy. Once fully established it is highly unlikely that they will require any irrigation systems due to the tree roots being large and accessing soil moisture deep in the soil profile.

Labour requirements

The main requirement for labour is at harvest. The orchard floor needs to be cleared prior to harvest and nuts must be collected from the ground, using simple mechanical harvesters, every two to three days.

Other labour requirements include the tree management and removal to optimise the fruiting canopy of the trees. This work is similar to that done in apples using hydra ladders and chainsaws. The only difference is in the need to totally remove the tree stump when trees are removed to reduce the risk of root rot diseases infecting the remaining trees.

The maintenance of orchards throughout the season is low until harvest. Labour for orchard maintenance will be required throughout the season for pruning, mowing and the monitoring and control of pest and diseases.

The labour required to develop and manage a Chestnut orchard is not significant but the specialist knowledge on Chestnut growing is not readily available and would need to be contracted in. The budget includes expenditure on consultancy. There is a requirement for occasional crop sprays, pruning and training of the trees but otherwise harvest is the only other high time demand when the nuts need to be collected every second day to reduce degradation of nut quality. There are machines able to do this using either sweeping or vacuum technology.

Potential production volumes and values

A recent, but undated sheet from the New Zealand Chestnut Council specifies some of the prices achieved for these process products ranging from \$3/kg for fresh nuts to \$200/kg plus for chestnut confectionary. The financial model produced assumes a mature yield of 7.5 tonne per hectare of chestnuts. These are sold NIS for \$2.50.

There has been a large shift in recent years from fresh exports of chestnuts to frozen and value-added products such as chestnut flours and chestnut crumbs. Inclusion of this would significantly alter the financial outcomes of chestnut production.

Table 22: Financial Analysis of Chestnuts Production

Financial Criteria	*Chestnuts*
Development Costs ($/ha)	$35,275
Yield at full production (kg/ha)	7,500
Years to Full Production	10
Total Income at Full Production ($)	$18,750
Growing Costs ($/ha)	$8,900
Gross Margin ($/ha)	$9,285
Net Present Value (NPV)	$34,000
Internal Rate of Return	7%

Partnerships

The New Zealand Chestnut Council (NZCC) is a council which aims to encourage, promote and advance New Zealand's Chestnut Industry. This also includes the promotion of sale and consumption, with large amounts of work being done to push the opportunities in international markets and further processing of chestnuts. This council includes members who are very passionate about this crop and now hold patents for processing technology. These enthusiastic individuals are constrained by capital. Further analysis of these processing options could see potential to extract significantly higher returns from a plantation of chestnuts.

9.2.4 Macadamias

The macadamia industry is relatively small with only an estimated 200 hectares in production. The nut can either be sold as "Nut in Shell" (NIS) or removed from its hard nut, dried and processed into a multitude of products.

With recent focus on quality fats and oils, there is an increasing demand for macadamia and other nuts. Currently New Zealand imports more macadamias than it produces. Any increase in production can substitute the imported product.

A local grower, Vanessa Hayes of Torere Macadamias, has recently been successful in obtaining government funding through the Primary Growth Fund to support a 10-year growth strategy to develop the industry. This strategy includes focus on plant breeding, nut recovery, pest control and grower support. The project includes a facility to process and dry nuts in Torere.

The recent incursion of the Guava Moth may cause issues with macadamias.

General requirements

Macadamias require a frost free, warm, coastal site. They also have a need for free draining soils. The climate around Gisborne and Maketu is well suited to macadamia production though the soils may prove problematic. Macadamias are unsuited to the higher elevation sites in Te

Arawa and Tūwharetoa. Cool winds can impact on production, so shelter is required though Macadamia trees themselves can provide this shelter.

Establishment requirements

Trees can be planted in rows spaced at around 4.5 m apart and 2.25 m within the row or 1,000 trees per hectare. There is no requirement for tree supports so establishment costs are relatively low, mostly plants and planting. Plants are available through Torere Macadamias where Vanessa Hayes has over the years selected plants that are well suited to the location and are apparently high yielding. External natural shelter is recommended and may be a macadamia cultivar that is useful for pollination.

Water requirements

Irrigation is likely to be required to support the crop over the height of summer.

Labour requirements

Nuts drop from April through to December depending on variety. It is estimated that a for a 4 hectare block, the harvesting of these nuts can be done mechanically by one person. A minimal amount of labour will be required to manage tree shape and tree density. This activity could be timed to coincide with the low labour demand periods within the kiwifruit and pipfruit industries.

Potential production volumes and values

A mature macadamia orchard should produce around 5 tonne per hectare of nuts by year 10. Good tree management, nutrition and pest and disease control should see the trees continue to produce at this level for many years. The price received for the Nut in Shell (NIS) has increased in recent years with growers able to budget on around $5.00 per kilogram, depending on quality. The value of the processed nut rises considerably with the raw kernel selling for around $45 per kilogram and further processing resulting in income of $90 per kilogram. The recovery of kernel from NIS is typically around 33%.

The financial modelling for this location has produced the following results.

Table 23: Financial Analysis of Macadamia Production

Financial Criteria	*Macadamias*
Development Costs ($/ha)	$65,200
Yield at full production (kg/ha)	5,000
Years to Full Production	10
Income ($/kg)	$5.00
Total Income at Full Production ($)	$25,000
Growing Costs ($/ha)	$13,150
Gross Margin ($/ha)	$11,850
Net Present Value (NPV)	$30,400
IRR (%)	6%

Partnerships

There is a New Zealand Macadamia Society that represents growers and processors of macadamias. The society runs field days and facilitates research on issues of concern to macadamia growers. Locally, the knowledge and experience gained from the growing of macadamias by Vanessa Hayes and Rod Husband of Torere Macadamias is a significant asset.

9.2.5 Apples

The pipfruit industry has recovered, having experienced some very difficult times with falling returns and climatic and disease pressure reducing yields and increasing costs. This struggle appears to be over with grower returns and export value increasing significantly. The Ministry for Primary Industries (MPI) report a positive picture for pipfruit production with export volumes increasing, supplying an export market with strong demand from Europe and Asia. The 2021 Situation and Outlook for Primary Industries report forecasts apple and pear exports values to exceed $1 billion by 2023. New plantings continue in New Zealand and total planting in pipfruit has increased to 10,400 hectares, up from the 8,500 hectares in the previous decade.

Gisborne is a minor region for apple production. Local market apples have been grown there over recent decades because it is an early maturing region. This advantage has waned with the introduction of new, very early maturing varieties that are grown elsewhere.

More recently, apples are being grown for export in Gisborne. In particular, the protected T&G variety, Envy^{TM} is proving well adapted to Gisborne conditions. Producers of other Intellectual Property (IP) varieties like Rockit have recently decided to expand into Gisborne and permit production there.

The Gisborne climate appears suitable for growing apples although influences on fruit size and colour for new varieties are uncertain. In a comparison of meteorological data over a number of seasons:

- Apples require winter chill to produce flowers and break dormancy uniformly. This is measured by the accumulation of cool temperatures (ideally 4-7°C) over winter. Chill accumulation, using the Richardson model over all years and meteorological sites, was similar between the Gisborne and Hawke's Bay although there was a non-significant trend for Hawke's Bay to accumulate more chill units than Gisborne (647 versus 603),
- Hot summer temperatures can sunburn apples. The Gisborne region average maximum temperature of the January to March summer months was significantly warmer than Hawke's Bay by 0.8°C when all sites and years were considered (25.8 versus 25.0).
- Cool nights approaching harvest assist with apple colour development. The Gisborne region average minimum temperature of the January to March summer months was also significantly warmer than Hawke's Bay by 0.8°C when all sites and years were considered (14.1 versus 13.3). Colour development in Gisborne is likely to be adversely affected compared with more southern locations.
- Spring frosts can damage flowers or young fruitlets. The incidence of damaging spring frosts in Gisborne appears to be negligible compared with Hawke's Bay. The lowest

temperature recorded from September to November at four weather stations over three years was -0.9 degrees at Kaimoe in September 2015. This was the only occasion that a 'below freezing' temperature was recorded.

However, in this comparison of climatic data, there were larger differences between different locations within each region (Hawke's Bay and Gisborne) than between the regions themselves such as coastal compared with inland locations. There was also more year-to-year variation than overall regional variation.

Disease pressure

Warmer and wetter weather may also increase disease pressure and influence fruit finish:

- Black spot – quite widespread in Envy. Industry is unsure whether the main cause is higher disease pressure or prevalence of new, inexperienced growers.
- Russet – also widespread in Envy, and again further data would be needed to discover whether the underlying cause is from poor agrichemical use or application, or higher environmental russet pressure in Gisborne.

Suitability of soils

The silty relatively free draining soils near the river channels are deep and rich in plant available nutrients. A moderately low pH between 4.5 - 5.7 can be expected in these soils and may require adjustment prior to development, though recent silts deposited by flooding may be of higher pH. Cation exchange capacity (CEC) is in the medium/high category. These would be the preferred soils in the Poverty Bay Flats.

In general, the soils further from the rivers and closer to the hill boundaries have a higher clay content. pH remains similar with some of these soils trending towards neutral (pH 6). CEC increases in the soils with higher clay content, placing it firmly in the high category. The availability of these cations to the plants however is decreased due to the clays ability to retain rather than release cations. These soils would require drainage prior to development to ensure aeration and drainage of the rootzone. There is a risk of compaction, pugging, and anoxic conditions with soils of this type.

Potential production volumes and values

The New Zealand apple industry was deregulated in 2001. Since then, 'family orchards' have largely disappeared as a result of variable returns, increasing compliance burdens and succession issues. Corporates now dominate the industry. IP protected varieties are controlled by marketers and supply groups and tend to be the most profitable to produce. Permission to grow IP varieties is determined by their owners and come at a cost. The industry has enjoyed profitability over the past 10 or so years but prior to that, the industry was in survival mode.

There are numerous growing systems with different plant densities and differences in infrastructure costs. Development budgets are not produced by any industry body. A broad range of development costs is typical depending on requirements for water supply, frost protection, hail protection and other big-ticket items also have a big influence on development costs. More accurate costings can be determined when a specific parcel of land and orchard design are used.

The weighted average per carton equivalent (TCE) has continued to increase with the shift to the protected varieties. A weighted average of $32.50 per carton has been used in the financial modelling. This has also lifted average orchard gate returns for growers. Yields from Gisborne orchards have typically been earlier but lower due to smaller fruit size. Gisborne would be very well suited to the currently popular large-fruited varieties such as Envy, Ambrosia, Rosy Glow (Red Pink Lady) and possibly the smaller Rockit apple. The financial modelling done assumes 80% of a Hawke's Bay yield.

Table 24: Financial Analysis for Apple Production

Financial Criteria	*Apples*
Development Costs ($/ha) – excluding land but including licence costs	$200,000
Yield at full production (export cartons/ha)	2,900
Years to Full Production	6
Total Income (OGR) at Full Production ($/ha)	$94,000
Growing Costs ($/ha)	$65,000
Gross Margin ($/ha)	
Net Present Value (NPV)	$83,000
Internal Rate of Return	10.5%

Partnerships

Partnerships are well developed within the apple industry. Most independent apple growers 'join' a supply group who pack, store and market their fruit. A careful analysis of the situation in Gisborne would be required given limited availability of apple packing and storage facilities and the current need to ship fruit out of Napier Port.

The industry is represented by Apples and Pears New Zealand. An organisation that provides advocacy and contracts research on behalf of the industry.

Trees are in scarce supply and orders for trees will be required well in advance of any planting.

9.2.6 Avocados

Avocados are a crop option for the warmer, coastal sites of Whāngārā and Te Arawa.

The New Zealand avocado industry currently has over 1,800 growers with under 4,000 hectares of planted area. Avocados are a prominent horticultural crop within New Zealand and are the third largest fresh fruit export behind kiwifruit and apples. The 2020 season saw production of over 39,078 tonnes of avocados. In the 2019/20 season 65% of the value was through export grade fruit, with 33% of value in the New Zealand fresh market and 2% of value in the processed market.

Hass, being the only variety exported, is the most commonly grown avocado variety in New Zealand making up 95% of plantings. Small amounts of Reed, Gem, Fuerte, Carmen and Bacon are also grown in New Zealand, though these are planted in conjunction with Hass to assist with pollination. The increasing use of clonal rootstock allows for smaller more manageable trees as well as conferring beneficial characteristics such as tolerance of poorly drained soils. Gem and Eclipse are new varieties talked about in the industry. Gem is a Plant Variety Rights (PVR) protected cultivar which is thought, though yet unproven, to have characteristics similar to, but better than Hass. Eclipse is a new avocado variety providing opportunity in the market for growers, currently grown in Gisborne, this variety is yet to reach commercial scale. This variety is a green skinned avocado which shows much promise for filling another space in the market in the future. Details of the varieties grown in New Zealand are available on the New Zealand Avocados website.

The recent trend of profit and production increase within the New Zealand avocado industry is primarily attributed to several key factors including an increase in growers entering the industry, increased production area and increased yield of fruit produced per hectare. This upward trend in grower returns has been broken, with disappointing returns for growers in the 2021/22 marketing season. Prior to this seasonal drop there had been significant financial growth in the avocado industry including an increased value in exports over the past 20 years. The season of 2020 had an export value of $122.3 million, an increase from the previous 2019 value of $104.3 million and 4.5 times increase in value since 2000. Alongside this, the industry produced a domestic sales value of $50.6 million within the 2019/20 season. Much of this was achieved by increasing value rather than volume. The final result for this season is not yet known.

Areas of production continue to be dominated by the Bay of Plenty and Northland regions which produce a considerable share of avocados in New Zealand, but with Northland expected to eventually dominate avocado production in the future. Avocados grow well in regions of warm climates, mild winters, and fertile soils; therefore, production also occurs in areas such as Whangārei, Gisborne, Hawke's Bay and Auckland. Northland has had the most notable increase in production area and plantings in recent years, many of these current plantings are yet to mature.

Water Requirements

While as mature trees, avocados do not require irrigation, they produce more reliably with it. Irrigation is likely to be required to establish young trees over extended dry spells over the Bay of Plenty and Gisborne summer.

Potential production volumes and values

Production figures for producers change within areas of New Zealand, depending on the suitability of the growing region and specific orchards, seasonal changes, input of the grower and grower capabilities. Overall, in the 2020/21 season growers produced an average of 10.9 tonne/ha (1,980 export and local market trays), this has ranged between 5.9 tonne/ha and 11.5 tonne/ha in the past five years. The average yield in the Bay of Plenty is lower than that of the Far North and is significantly impacted by both climatic conditions and orchard management.

This year has not been a good one for New Zealand avocado growers. An oversupply of fruit in Australia has impacted significantly on grower returns. Current market analysis of export markets shows a large reliance upon the Australian marketplace, which in previous seasons has received 77% of New Zealand's overall export produce. New Zealand Avocado is currently working to further expand this demand within the Australian market, but more importantly to diversify supply into markets outside of Australia.

The current lack of market diversification is a threat to the New Zealand avocado industry. Oversupply of domestic avocados in Australia, sluggish winter demand and supply chain disruptions has seen the Australian market flooded with avocados and prices for fruit at historic lows. Until recently New Zealand were one of the only importers of avocados into Australia which is one of the highest paying avocado markets in the world. Increased worldwide plantations, including in Australia and New Zealand, caused congestion within this key market. Western Australia had a 100% increase in projected volume this season, producing over 7 million trays, with Southern Australia also doubling its production. This increase in domestic production produced a lack of opportunity for New Zealand avocados this year. This further highlights the need for New Zealand's diversification of export markets.

New Zealand's avocado industry is focused on the export market but New Zealand is also a significant market. Avocado New Zealand aims to grow New Zealand market sales to $75 million within the next five years, with domestic sales currently at just over $50 million. This is an important part of the future of New Zealand's avocado markets, with an increase in growing area and production levels, finding markets to fill is critical for continued good market returns to growers. Of the total 6.3 million trays produced in New Zealand last season 2.7 million of these were sold within the New Zealand market. This indicates how critical the retention and expansion of the domestic market is for producers, if there is to be continued increase in trays produced.

The majority of profits within the avocado industry come from high grade avocado fruit within the export and domestic markets. However, avocado oil is becoming a market space that allows for "value add" and utilisation of lower graded fruits. In the 2019/20 season New Zealand producers had a sale value of $2.6 million within the domestic market for avocado oil, and a further $9.3 million within the export market.

A major risk to developing markets is the alternate or irregular bearing of the avocado. This alternate (irregular) bearing can be minimised through effective management of crop flowers, thinning processes and reduction of crop in "on" years to allow for a larger store of carbohydrates for the coming season. This intensive pruning of trees and thinning of flowers has become a part of a typical well managed orchard system.

Table 25: Financial Analysis for Avocado Production

Financial Criteria	*Avocados*
Development Costs ($/ha) – excluding land	$73,000
Yield at full production (export cartons/ha)	2,900
Years to Full Production	6
Total Income (OGR) at Full Production ($/ha)	$29,100
Growing Costs ($/ha)	$18,980
Gross Margin ($/ha)	$10,120
Net Present Value (NPV)	-$28,600
Internal Rate of Return	3%

Labour Requirements

Avocados are unique in that much of the work done is not time critical. Fruit, for example, can hang on the trees for months and be picked when labour and/or market prices allow.

Labour cost and availability must also be considered in future with consideration not only to availability but the experience levels of workers in regions. Many avocado orchards will use dwarf rootstocks or keep trees well pruned to make activities such as flower thinning and picking easier and less labour intensive.

The main requirement of labour in avocado production is during harvest, most orchards are picked twice during the main September to March harvest period. As trees mature, traditionally the use of hydra ladders were necessary to pick fruit high up in the trees. The intensive management of the trees is intended to negate the need for hydra ladders. The harvest of avocados is unusual as it can occur over several months and, as long as the fruit has reached the desired maturity criteria, picking is timed for periods of high market prices and when the labour is available. The tree can carry two crops at a time. That is, the older mature fruit can still be on the tree when flowering and fruit set occurs. This is a useful factor if the grower wants to hold fruit to capture good prices but does have an impact on the overall carbohydrate (energy) status of the tree and can impact on the future yields.

Labour is also required for tending the trees. This is an activity that is not time critical and could be timed for periods of downtime in other crops such as the lull in activity experienced in kiwifruit. In traditional orchards, once the trees are mature, this work will include work on hydra ladders with chainsaws requiring people with specialist skill. It is expected that the smaller trees on this development would require intensive pruning without the need for hydra ladders.

Overall, the amount of people needed on the orchard at one time will fluctuate heavily from one manager on the orchard during the whole year and rising to picking gangs of any number of people depending on the desire to get the orchard harvested in a certain time period.

Partnerships

New Zealand Avocado (NZ Avocado) are representatives of the industry and describe their role as "working alongside growers to promote and advance the industry by packing the goodness of New Zealand into every slice of avocado we share with the world". The aim of NZ Avocado is to produce profit and wealth for the industry and for individual growers.

NZ Avocado has in place several rules and compliances for growers, who must register with NZ Avocado. This assures a consistent quality, food safety standard and sustainable growing strategies throughout the industry. There are currently 22 packhouses, with 14 of these being registered by the Horticultural Export Authority (HEA) to export. NZ Avocado registers exporters, including T&GGlobal, Avoco and Southern Produce. The registration process with NZ Avocado means that exporters meet guidelines of safety and quality overseen by the HEA. This helps maintain consistency and regulation of quality throughout the industry and discipline in the marketplace. Growers wishing to have their fruit exported must register with NZ Avocado each season prior to the 31st of July.

9.2.7 Blueberries

It is estimated that there are 80 growers of blueberries in New Zealand producing off 680 hectares of land. This area is rapidly expanding with large companies, including Miro Ltd Partnership (LP), and BerryCo investing in new areas of covered production. New cultivars licenced to these organisations are producing large, early berries. Miro LP is specifically targeting Māori landowners and is very buoyant about the opportunities that exist for blueberries.

Of the $80 million dollars of sales of blueberries, some 55% of it is exported. The rest is sold either as fresh or frozen product on the domestic market. New Zealand's domestic consumption of blueberries is increasing, however a large proportion of this is in the imported frozen blueberries, therefore increased production must also correlate to finding high value export opportunities.

Figure 20: Outdoor blueberry bush ready for harvesting

General requirements

Blueberries require well drained soils that are slightly acidic and an organic content of around 3%. The blueberry plant requires a sunny site but also a degree of winter chilling. It is estimated that they have a requirement of around 650 - 850 hours of temperatures below 7ºC in order to produce well. Breeding programmes have developed varieties that are less chill dependent.

Late season frosts can damage flowers and hence reduce yield. Frost protection, using overhead sprinklers, may be required. This is where the use of greenhouses, tunnelling and covered production becomes a large benefit in terms of control.

Birds will feed on blueberries and for this reason it is recommended to cover the entire block with bird proof netting in order to maximise yield.

Many covered systems grow berries at waist height which makes tasks such as pruning or picking much less labour intensive and more efficient. It is suggested that the covers of the tunnels are renewed every five years. Growing in tunnels, unless considerable attention is given to ventilation and disease management, may make the losses to *Botrytis* grey mould worse.

The tunnel house production system, while expensive to establish, results in higher returns by enabling higher quality and earlier berry production. BerryCo prefer that their suppliers grow under tunnels using this system. The increase of quality and amount of produce from this change, needs to be considered in financial terms given the heavy investment within the covered production systems.

The obvious difference between covered and conventional production of berries is the original costs of the tunnel set up. This is referred to in the financial output of blueberries within this report.

Despite the increase in production for indoor systems there are a number of attractive outdoor systems with many growers reaching high yields. An example of this was seen during the visit to the Tūwharetoa properties where a neighbour was growing outdoor blueberries for marketing through Gourmet Blueberries.

Cultivar Options

Understanding the various cultivars and which to produce is an important part of establishment in a new blueberry production system. The selected cultivars must be suited to the climate and labour availability (seasonality) of the production system. Higher altitude production will produce later fruit so this must be factored into cultivar decisions.

The two most common types of blueberries in New Zealand are the Highbush and Rabbiteye. Northern and Rabbiteye cultivars are more commonly suited to outdoor systems due to their requirement for 400 chilling hours to reach production, this makes them suited to climates with cooler winters. They are an evergreen variety with an, on average, higher yield per plant, producing much of the later season fruit within New Zealand.

Indoor systems are more suited to the production of Highbush cultivars, these make up a large amount of the early crops in New Zealand and span from as early as mid-September to mid-January. There is a range of cultivars within each of these types that are suited to harvest at different times of the season. For example, Miro Berries has ranges of the Eureka cultivar that are ready for harvest at different times of the season. Eureka Sunrise as an early season berry, Masena Eureka and First Blush as a mid-season and Eureka Sunset as a late season berry.

Production of a variation of these across the country allows for a longer season and more consistent supply of quality berries, due to the poor storage nature of the fruit. This also allows for staggering of harvest dates within individual growing systems. These cultivars have increased the harvest season by up to six weeks in New Zealand, helping to ease the seasonal effects of a labour-intensive harvest and also aiding in reaching markets at more profitable times.

Establishment requirements - outdoor production

Soil testing of the site will be necessary to determine the pH and the organic carbon content of the soil. Applications of elemental sulphur can be applied to lower soil pH. Should the organic content of the soil be too low, a cover crop of oats or something similar could be grown and cultivated in to lift the organic matter in the soil.

In areas where soils are highly suited to blueberry production but there is still a need to reduce the risk of pests and temperature variation, some growers are able to use a partly indoor system, where pots are not used but covering of the in-ground crop is used. This reduces initial costs but is only suited for some locations.

Plants are typically planted, depending on variety, at spacings of 1.2 - 2 m within the row and 3 - 3.6 m between the rows. This results in a plant density of between 1,400 and 3,300 plants per hectare.

There is a requirement for cross pollination to achieve high yields. Using a mix of suitable varieties will allow for this.

Good weed control is important, especially during the establishment phase of young plants due to the competition weeds provide for nutrients, space, and other resources. Weed control needs to be managed prior to planting.

Establishment requirements - indoor production

The establishment of covered blueberry production in pots is a highly technical enterprise that requires specialist input. Both Miro LP and BerryCo have technical specialists able to assist with this.

Water requirements

Though sensitive to waterlogging, blueberries are also sensitive to extended periods of dry. It is estimated that blueberries require between 25 - 50 mm of water per week during the growing season. This relates to 25 - 50 litres per m^2 of canopy area. The water requirement increases as the plant ages.

It is critical that accessible water is of high quality. Heightened levels of sodium chloride, boron, iron or magnesium can have an impact on production and irrigation systems. Due to the high incidence of rots, including botrytis, the use of water in fighting frosts is not recommended, therefore other methods such as heat or wind fans are preferred.

Untimely rainfall in an outdoor system during the times when the berries will have formed, right through to harvest can produce splitting in the fruit and reduce yields significantly.

Labour requirements

Aside from the labour required to establish the blueberry block, labour inputs are low outside of harvesting. The key input is for labour during harvest which can run from late spring through to April. It is assumed that 4 kg of berries can be picked by one person in an hour. Depending on the speed with which berries ripen, it may be necessary to pick berries every day. These berries need to be stored at a temperature of $1^{o}C$ within four hours of harvest. Adequate storage areas need to therefore be prepared and considered prior to the harvest season.

Typically, berries are picked first thing in the morning and then staff are shifted into the packhouse to grade and pack the fruit. Fewer staff are required to grade and pack the volume of fruit picked.

Labour is also required to thin flower buds from the young plants which is recommended for the first two years and prune the blueberry bushes. It is assumed that pruning takes 480 hours per hectare at maturity. Pruning can occur at any time during the dormant period. Some activities can be mechanised such as harvesting, but this usually produces lower yields, and reduces fruit quality, primarily due to bruising.

Access to labour throughout and during the season is a critical part of establishment consideration. With current shortages of labour in the industry and an expected continuation of this shortage for some time it is important that there are viable options for access to harvesters, pruners and maintenance staff throughout the season. Growing in an area that correlates either side of a locally popular crop is a way to help retain staff. In the Bay of Plenty, blueberry harvest sits on either side of the kiwifruit harvest meaning much of the local labour in kiwifruit harvest becomes available during the high demand times of blueberries, creating continued work.

Potential production volumes and values

It is said that volumes of fruit picked from outdoor grown blueberries can be as high as 10 tonne per hectare. The budget developed assumes 7 tonnes. Under cover the production is much higher with reported yields of 30 tonne per hectare, with a more likely average of 20 tonnes/ha. The national average for all blueberry production is between 8 and 10 tonnes. The income for the product ranges from $4/kg for frozen berries and $20/kg for fresh berries. It is estimated that only 20% of the product is sold as frozen. The budget has assumed a weighted average price of $16.00/kg.

Please note, the production of blueberries under cover is still a very new technology, the parameters of yield and growing costs particularly need to be firmed up upon over time. Furthermore, the establishment costs have been assumed using information from a personal conversation with a blueberry grower in 2020 and conversations with BerryCo in 2021. The technology is continually advancing, and the establishment cost may now be somewhat lower. The cashflow/budget allows for the replacement of the skin every five years to maintain optimal light transmission. More information on the indoor production of berries in terms of management is include later in this report.

The financial modelling for both outdoor and indoor blueberries in this location has produced the following results.

Table 26: Financial Analysis of Blueberry Production

Financial Criteria	*Blueberries - outdoors*	*Blueberries - indoors*
Development Costs ($/ha)	$165,300	$403,600
Yield at full production (kg/ha)	10,000	20,000
Years to Full Production	5 years	5 years
Income ($/kg)	$16.00	$16.00
Total Income at Full Production ($)	$120,000	$320,000
Growing Costs ($/ha)	$119,900	$300,500
Gross Margin ($/ha)	$ 55	$19,200
Net Present Value (NPV)	-$186,000	-$277,300
IRR (%)	-32%	-5%

9.2.8 Grapes

A number of the Whāngārā sites have been identified as suitable for wine grape production. Grape production in the Gisborne area has traditionally been focused on contract growing for large wine producers in other regions, most often focused on Chardonnay though other grapes also grow well in the area.

Climatic Requirements

Grapes are grown across many regions within New Zealand in both the North and South Island. The plant requires a cool period during dormancy followed by adequate heat during the summer months to produce high yields. This therefore makes grape growing more successful in areas with cool winters and hot summers. Having hot summers builds up adequate sugars in the grapes and assists in ripening and overall growth of the grapes. Cold temperatures are required during dormancy for adequate bud break in the coming season. There are a wide range of growing conditions suited to different grape cultivars. High rainfall can be beneficial to reduction in reliance upon irrigation, however large rain events in January through to March will cause grapes to split and encourage disease. Generally, areas with a hot dry summer will reduce the occurrence of this. This is typically the case for Gisborne. There are times, during periods of new growth in spring that the plant will be susceptible to frost damage, timing of frosts will need to be considered prior to plantings, or the inclusion of frost protection for the crop.

Establishment Requirements

Grapes are most suited to neutral to slightly acidic free draining soils however are tolerant to a very wide range. Free draining and stony soils can be suited to grape growing but may require irrigation if these are too free draining throughout the drier periods of the season. Wine grapes will grow on a wide range of soils depending on cultivar, with Gisborne grapes grown on a range of clay and silt loams. This range of suitability allows for establishment in a wide range of regions in New Zealand.

Grape vineyards are established in long north facing rows with approximately 2-3 metres between each row. Establishment of correct trellis systems are critical for creating structures in which the vine can grow and intercept the highest amount of radiation. Establishment will typically occur on north facing slopes but flat areas are common and preferred in many situations. Sheltered areas will reduce the impact of coastal and general wind impacts on the plants, however the majority of vineyards are able to produce effectively without added shelter.

Water Requirements

Many vineyards throughout New Zealand are able to produce without irrigation though it is likely to be needed in Gisborne. Grapes are considered a low water use crop compared to many other established crops such as kiwifruit. Research has shown that many vineyards benefit from the use of irrigation in extremely dry seasons but deficit irrigation is useful to manipulate berry quality as harvest approaches. Water access and regional water plans and consents will need to be considered.

Labour Requirements

The most labour intensive time is during harvest in autumn, with harvest generally beginning in late February through to mid-May, depending on cultivar and region. Throughout the rest of the season there are important tasks such as pruning canes and spurs, pest and disease management and general maintenance of plants and the vineyard. Increased competition for all horticultural labour means that there is now further advantage in being able to produce a vineyard of scale that will attract labour over other areas and crops.

Supply chain systems of transporting grapes and then further processing wine is an important part of grape growing. Large labour requirements are required in these roles of wine producing and marketing within the industry.

Industry and Markets

Grape production for wine in New Zealand is predominantly centralised in Marlborough with 23,000 hectares accounting for over half of the growing area in New Zealand. Hawke's Bay, Canterbury and Gisborne are also prominent growing areas, however often have lower per hectare production than that of Marlborough. Many of these specialise in different wines depending on the climate of the region. Sauvignon Blanc is by far the highest produced wine in New Zealand (326,000 tonnes) followed by Pinot Noir (34,000 tonnes) and Chardonnay (27,500 tonnes).

New Zealand Winegrowers is the national organisation for New Zealand wine growers and produces resources, research and international promotion for the industry. They are also largely involved in the sustainable production of wine within New Zealand, and the contribution of this to New Zealand's wine brand. Currently, over 96% of New Zealand's vineyard area is certified as achieving 'Sustainable Winegrowing'.

Potential Production Volumes and Values

New Zealand's wine production is reliant upon strong export markets, being worth over $1.9 billion in 2020. Wine volumes and values vary significantly between individual vineyards, both in terms of tonnes produced and the value of final product. This can make accurate financial modelling difficult. Regions and cultivars both vary significantly in tonnes produced per hectare. The dollar value paid per tonne also varies significantly between cultivars and where the grapes are sold to, for example contract growing can have a much lower return. Between cultivars there is also a range in the dollar value of different cultivars. Profitability is also determined by scale and whether growers are contract growing for the market. The below financial modelling has been undertaken for 10 hectares based in Gisborne, growing Chardonnay. This does not include machinery investment.

Table 27: Financial Analysis of Wine Grape Production

Financial Criteria	*Gisborne Vineyard Producing Chardonnay*
Development Costs ($/ha) – excluding land	$41,400
Yield at full production (t/ha)	10
Years to Full Production	5
Total Income (OGR) at Full Production ($/ha)	$20,000
Growing Costs ($/ha)	$10,200
Gross Margin ($/ha)	$9,800
Net Present Value (NPV)	$50,000
IRR (%)	5.7%

Best Management Practice (BMP) is shown to make a significant difference on the overall profit of a vineyard, indicating that management has a critical impact on overall financial outcomes.

9.2.9 Garden Peas

Peas are typically a crop grown in a rotation with other arable/vegetable crops. There is increasing interest in this crop as plant-based proteins. It is likely that there will be increasing demand for peas and other legumes as these plant protein alternatives expand in popularity.

Figure 21: Garden peas shelled

General and Climatic Requirements

Pea's development is driven by temperature, therefore potential yields are higher in cooler areas due to the slower development time producing a longer period to intercept radiation. Sowing date has a strong influence on crops yield success. Due to the yield being directly influenced by radiation, peas should be placed in areas with adequate sun, mostly impacted by the aspect of the land.

Getting fresh peas to the market quickly is critical for crop quality. Generally, this will be discussed with processors and suppliers prior to planting to ensure that the peas make it to market efficiently. Distance to the nearest processing firm needs to be considered, as well as the timing of harvest for the peas comparative to other growers in the area. Gisborne has pea processing plants but the distance from the Tūwharetoa and Te Arawa blocks would make pea production, without the establishment of new processing facilities, difficult.

Peas are a spring sown crop and can be sown from July to November, premium planting times are September and October however each seed processing company and cultivar will have variation in timing of planting. Germination can be impacted by low temperatures delaying initial growth. Generally, above temperatures above 7°C are adequate temperatures to begin growth.

There are many cultivars available dependent upon the final use in the market and growing conditions. Cultivars should be chosen to suit the soil type, climate, sowing date and pest and disease issues of the area. Local processors and seed companies will be able to advise on which is best suited to the study areas.

Peas are used regularly within a crop rotation system. Often utilised as a break crop prior to sowing of winter wheat or other arable crop options. Break crops are used to reduce incidences of pests, diseases, and weeds, improve the structure and fertility of soils, and reduce overall water use. Peas are often utilised as a very effective break crop and have been proven in some cases to be preferred over many other pasture and arable based options.

There are several management practices that will assist in improving soil quality including reducing soil compaction through controlled trafficking and avoiding driving when wet, minimum tillage practices, return crop residues where possible, and maintain grass pasture with large fine root systems. Compaction of soils can have a large impact on the root growth and effective harvesting of the peas.

Management and Labour Requirements

The majority of the labour requirements will be based around specialist machinery. A critical part of labour will be sourcing adequate machinery and machinery operators for the sowing, spraying and harvesting of the peas. This needs to be considered prior to planting, as well as the timing of harvest and availability of specialised labour during this time.

Specialist advice will be needed to determine appropriate sowing times and cultivars for the market. This will fluctuate between seasons depending on the required amounts and other areas planted, and is a critical part of planning the cropping system.

Pests and Diseases

Management of rotation crops, hygienic practices, soil sterility and application of well-timed sprays are all critical in reducing the incidence of fungi, bacteria and possible pests that could heavily reduce the pea yield. Consultation with local arable spray specialists and/or processing companies may help to determine the best timing and application of these from season to season.

Aphanomyces root rot is a disease that effects many pea crops, and includes symptoms of stunting, yellowing leaves, dye back of root systems and plant death. This disease can significantly reduce yields and survives in the soil for many years. Testing can be undertaken to determine whether an area is infected to stop planting from occurring. It is advisable that soil tests are undergone before any planting.

Peas can be very heavily affected by competition from weeds. It is critical that weed seeds are removed from the seed bed prior to planting so that the peas can have the least competition possible. Pre and post emergence control methods can be used to help create this clean seed bed.

Other common pests include aphids, slugs and leaf minors which can cause significant damage to leaves and hence yield. Aphids cause major issues in being a spreader for viruses such as PSbMV (Pea Seed-borne mosaic virus) and other mosaic viruses. This can cause reduction in plant health, quality, and yield.

A number of fungal diseases such as Ascochyta blight, Sclerotinia and downy mildew can cause significant issues within leaves and crop quality. Foliar fungicide treatments and the use of adequate crop rotations are important in containing these fungal infections. Root rots and bacterial diseases can also cause large issues with yields.

Of note in terms of pests is the pea weevil which was recently eradicated from the Wairarapa. Vigilance to ensure this pest does not re-emerge is important.

Water Requirements

Water availability has a large impact on the overall yield. Like the majority of crops access to water is critical during development stages. Soil types and management practices can have a large impact on the amount of water required. Early sowing can help to reduce the exposure to mid to late season droughts. There are more detailed descriptions of exact water requirements in the document Making Peas Pay published by the Foundation for Arable Research (FAR).

Potential Production Volumes and Values

These have been provided as estimates for garden pea growers, due to the annual nature of the crop both the volumes and the values may change significantly.

Table 28: Financial Analysis of Pea Production

Financial Criteria	*Garden Peas*
Yield at full production (kg/ha)	3,500
Total Income at Full Production ($)	$3,850
Growing Costs ($/ha)	$2,330
Gross Margin ($/ha)	$1,520

Industry, Markets and Partnerships

The New Zealand pea industry has a large presence in the Wairarapa area. The area was largely affected by the pea weevil with growing heavily restricted in the years between 2016 and 2020. Canterbury is another prominent area for pea growing within New Zealand. This is due to the highly suited flats and large areas of potential rotation crops.

Garden peas are directly contracted by processors including Talley's and Watties. These processors will provide strict guidelines of quality, yield, and timing. This can impact the decision making on farm and management due to the power that the processors have. Garden peas are often sent straight to processing and do not need storage time. This necessitates production in close proximity to the processor.

The industry is generally based around those using peas within a rotation system commonly within primarily arable crop systems or as part of an arable and pasture rotation system. This allows for growers to integrate peas into a varied system. This feature, as well as the soil benefits that peas provide, means that the industry is based on cropping and pastoral farm systems.

9.2.10 Annual Vegetable Crops

The range of annual vegetable crops is vast, therefore detailed discussion of these crops is not included in this report. Vegetable crops could be considered as a part of a crop rotation on some of the Trust farms. Large vegetable growers in Pukekohe and Levin are often looking for areas of land to lease for growing of potatoes, carrots, onions and squash. Should the lease terms be favourable, this becomes an option for these properties. Though the lease price is often lower that the potential from producing the crop internally, the risk and the necessity to develop specialist technical knowledge is reduced.

Contact

Phil Journeaux

Agricultural Economist
027 511 8161
phil.journeaux@agfirst.co.nz

AgFirst Waikato (2016) Ltd
26D Liverpool Street
PO Box 9078, Hamilton 3240, New Zealand
07 839 2683
waikato@agfirst.co.nz
www.agfirst.co.nz