Independent
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Sustainable Horticultural Land Use Opportunities for the Tararua District

Prepared for
Tararua District Council

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1.0 EXECUTIVE SUMMARY

The Tararua District Council has commissioned this project to evaluate four alternative horticultural land uses for farmers of the Tararua District, including:

- Blueberry
- Cider Apple
- Feijoa
- Hazelnut

These land uses were selected by Tararua District Council based on previous knowledge from the Go Project and the Tararua Districts strengths and vision of the future. Tararua District Council chose feijoas and hazelnuts as these were part of an earlier study and there are growers of these crops in the district. It was important to update earlier data on these two crops and explore current market opportunities. Blueberries were selected as they are a crop experiencing high growth at present. Cider apples were chosen as there are currently shortages in New Zealand and it is a growing industry. Cider apples also offer potential to support a future tourism industry if successful in much the same way as other regions have successful winery tourism.

The scope of the project was to evaluate the topography, climate, and soils of the Tararua District and determine whether the alternative land use options were environmentally and economically sustainable. In particular, these permanent crops can have much lower carbon footprints, lower nitrogen leaching losses and higher margins. The report also outlines the potential markets, resource limitations and skill sets needed for each land use option.

Climate

The climate analysis revealed that altitude has a strong impact on several key climate metrics across the Tararua District. Areas with higher altitudes (particularly Eketahuna and Norsewood) recorded lower maximum, minimum and average temperatures and more days with temperatures less than 0°C, resulting in fewer Growing Degree Days (GDDs) and a shorter growing season.

In general, the average temperatures throughout the Tararua district support all the proposed land use options. Rainfall timing is a limiting factor for some of the land use options. Precipitation at flowering can inhibit flowering and pollination, ultimately leading to lower yields. Precipitation at harvest can increase incidence of fruit splitting, rots and diseases. Furthermore, rain at harvest can create situations where mechanical harvesters slip or slide on wet surfaces, causing harvesters to damage trees or trellising.

Topography and Soils

The Tararua District is large with an approximate land area of 4,364 km^2. Approximately 13% of that land is classified as LUC 1, LUC 2, or LUC 3 and is preliminarily suitable for intensive horticulture.

Soil physical properties and wetness are the primary soil limitations in the area designated for horticulture, however, with slight to moderate soil modification, most of the land area should be able to support at least one of the proposed land use options (i.e. blueberry, cider apple, feijoa, or hazelnut production). In areas where soil modification is not an option, blueberries could be grown in containers on top of the soil.

Elevation, and its impact on climate, is likely to be more of a limiting factor than physical soil properties. Elevation will dictate the air temperature, rainfall pattern and length of growing season and therefore limit land use options.

Environment

Nitrogen loss data in New Zealand is difficult to find for even the large horticultural tree or vine crops (vineyards, pipfruit and kiwifruit). Most of the work done to date in reference to these crops is modelling in either the Overseer or SPASMO modelling systems. Modelling shows common ranges of nitrogen loss of 2kg N/ha/year up to 25 kg N/ha/year. With good environmental management, all systems are expected to leach under 20kg nitrogen/ha/year. This is low relative to current losses modelled for dairy farm systems in the Tararua district. Most high value horticulture is placed on flat land, and in this case the risk of phosphorus runoff is minor.

Economics

All the land use options are economically viable if well managed. The gross margins are very sensitive to yield and return $/kg fruit. Low yields combined with poor quality fruit will result in a significantly lower gross margin. These gross margins are example systems which will change depending on the limitations for a specific location and the management of the farm system.

Table 1.1- Financial Summary of Model Farms

Crop	Gross Margin ($/ha)	Development Cost ($/ha)	Breakeven (No. Years)
Blueberry	$51,710	$281,130	11
Cider Apple	$14,510	$35,000	8
Feijoa	$10,038	$22,500	9
Hazelnut	$12,898	$35,000	11

Markets

There are currently no established markets within the Tararua District for the proposed land use options. Local markets (e.g. farmers markets and local retail outlets) will need to be developed.

There are domestic and export markets established for all the land use options. The processing facilities for these markets lie outside of the Tararua District, and to take advantage of the these, a shipping and distribution network needs to be set up.

Resource Limitations

All the proposed land use options have the similar resource limitations including:

- Poor availability and supply of plant material
- Absence of consultancy support and local grower networks
- Lack of harvesting resources (both contract pickers and mechanized harvesters)
- No local processing facilities

Skill Sets

Each land use option will require a manger with fruit production experience, an interest in learning and troubleshooting, and most importantly, a passion for horticultural production. Specifically, a manager will need a range of skills including fruit tree husbandry, plant nutrition and irrigation knowledge, plant pest and disease knowledge, and experience in staff and contractor management.

Blueberry Summary

Blueberries will grow in the Tararua under weather protection. Some areas that are warmer micro-climates with less flowering and harvest time rainfall may gain acceptable levels of production with field grown blueberries, however, the year to year risk of losing a crop means that growing plants in raised beds/containers and under tunnel house is the preferred option for the Tararua.

Irrigation will be required, and it is advisable to connect to a fertigation system so that each container gets the precise amount of water and nutrition is requires.

Flat land will be necessary, but the soil type can be anything not prone to surface ponding if growing in raised containers. Nutrient losses will be able to be managed to near 0 kg N/ha/year in this system, while in field grown systems, losses will be able to be carefully managed down to the same range as apples at 3 to 24kg N/ha/year.

Undercover blueberries are a profitable option but require the availability of large amounts of capital to set up.

Land area required is lower than other crop options in this study to make a functioning business. A small blueberry operation could be set up with just 5ha of land, where the manager is also a hands-on farm worker. Very small operations of 1 to 2ha can be viable in the same way, and the manager might only work part time on the blueberry operation.

Main resource limitations include access to plants and varieties, people skilled in growing the fruit, harvest labour and postharvest facilities to pack and store the fruit.

Table 1.2- Blueberry Summary Table

Crop	Blueberry
Temp / GDD	Mean summer temp 15 to 26°C
Frost	Protect from flowering to -2°C. Frosts from flowering below -3°C unsuitable.
Frost free period	>160 days
Winter Chill	800 to 1200 hours. Less than 700 unsuitable.
Flowering time	Varies depending on cultivar and climate from August to November
Harvest time	December to March
Rainfall	Annual 800 to1000mm. Rain at flowering and harvest an issue
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat (indoor) to undulating (field grown) 0 - 7°
Soil depth	>60cm best. <40cm not suitable. Container = no restriction
Soil type	Fertile, well drained acidic soil. This can be in containers
Avoid	Standing water, pH above 5
Nitrogen loss if well managed	N loss 3 to 24kg/ha, or nearing 0 undercover
Fert timing	Mid Sep to Dec
Water requirement	Needs irrigation. 330 to 350mm/year and 80 to 90mm/month estimated for Tararua
Market modelled	80% fresh export, 15% fresh local, 5% process
Supply chain end budgeted	Fresh harvested, graded, packed in punnets, domestic transport. No coolstore costs included
Harvest	Hand harvested
Labour needs	High
Land area required	2ha to 30+ha
Gross margin and sensitivity	$51,710 per ha. If price average is $15.50/kg, $75,897/ha.
Development Costs	$281,130/ha in model plus coolstorage, machinery and automated irrigation control
Breakeven (model)	11 years. Potential for upside on price

Cider Apple Summary

Cider apples will grow in the Tararua district in the warmer and drier areas of Woodville, Pahiatua and Dannevirke. In these areas, they will need good frost protection, shelter belts and specific attention needs to be paid to rainfall at the flowering time of the variety chosen. Lack of pollination due to rain, disease being spread by water and wet soils dropping flowers are all risks of growing apples in the Tararua District.

Well drained soils are important, whether naturally or tile drained to 1m depth. Apple trees are good at accessing water, and roots go deep, so water for irrigation may only be necessary when young. This avoids the need to install a permanent irrigation system. However, consented water should be available to irrigate trees in hot summers when roots are still shallow.

Flat to mildly rolling land will be usable and soils should be 70cm or more in depth. Avoid very heavy clay soils or pans, and soils that stay saturated into spring.

Nutrient losses were modelled on Overseer and with management focus can be reduced to 10 to 20kg N/ha/year.

Cider apples will always complete with export over-run fruit in New Zealand, however there is demand from cider makers to have access to cider-specific varieties. The gross margin is attractive but could easily be eaten into by extra costs of coolstorage of fruit, or longer transport distances.

Land area required for a cider apple orchard at a minimum is defined by the need for volume support a machine harvester. Export apple orchards in Hawke's Bay can operate at 10ha, with a manager who also works on hands-on jobs. However, a cider apple orchard in the Tararua will need 30-40 ha to cover costs of machine harvesting equipment, and in this case can hire a full-time manager and one orchard worker on the property.

Main resource limitations include access to plants and varieties, people skilled in growing the fruit, machine harvesting equipment and distance to storage facilities.

Table 1.3- Cider Apple Summary Table

Crop	Cider Apple
Temp / GDD	>800 GDD
Frost	Protect at flowering to 0°C. Fruit damaged below -1.5°C.
Winter Chill	1200 to 1500 hours below 7°C
Flowering time	October
Harvest time	March-May
Rainfall	Compare to Nelson 270mm average Sept- Nov rainfall. Less rain at flower better
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat to mild rolling 0 - 10°
Soil depth	>70cm ideal. >50cm not suitable
Soil type	Moderate to well drained
Avoid	Dense soils with high clay content, standing water
Nitrogen loss if well managed	Tararua modelled N loss 15 to 17kg/ha
Fert timing	Postharvest (March to April) or foliar
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	100% NZ process for craft level ciders
Supply chain end budgeted	Fresh apples freighted to Hawke's Bay, no processing or storage costs
Harvest	Machine harvested
Labour needs	Low- Moderate
Land area required	10ha to 30+ha
Gross margin and sensitivity	$14,510 per ha. If 50t/ha and $0.35/kg, $8,210/ha.
Development Costs	$35,000/ha in model, plus frost protection and shelter belts which vary widely in cost could increase to $50,000.
Breakeven (model)	8 years. Unlikely to achieve higher yields, prices constrained by export over-run

Feijoa Summary

Feijoas already are grown in the Tararua District for export and local production. They are frost hardy, have a later flowering than many other fruit crops and tolerate a wide range of climates throughout New Zealand. Harvest timing is expected to be in April-May, later than warmer growing districts, which could present a market supply opportunity. They are wind tolerant but in Tararua's windy climate shelter will be required, especially if aiming for export markets where wind rub is an issue.

Feijoas will benefit from flatter land with moderate to well drained soils. More sloped land restricts trellising and machinery access, but systems can be tailored to work on undulating or mildly rolling country (0-10°). Feijoas grow on a wide range of soil types, but heavy clays with standing water present should be avoided. Light, stony sands should also be avoided, especially if there will be no permanent irrigation system installed. Soils should ideally be 60cm in depth or greater.

Nitrogen losses are likely to be able to be kept between 10 and 20kg N/ha/year with careful fertiliser application management. Timing of fertiliser application is in spring.

It is advisable to have a water consent available to provide water when trees are young, and for very dry years. Overall, feijoas are reasonably drought tolerant.

The local fresh market for feijoa is at capacity currently, and the opportunities for feijoa are process or export systems. The orchard set up will be targeted to one or the other market. The orchard model is for process which has a lower gross margin than export, but which can have a very low capital set up. One of the drawcards for feijoa is also the ease of management.

Land area required for a process feijoa orchard at a minimum is defined by the need for volume to support a machine harvester. A feijoa orchard in the Tararua will need 30ha to cover costs of machine harvesting equipment, and in this case can hire a full-time worker on the property.

Main resource limitations include people skilled in growing the fruit, machine harvesting equipment and postharvest, processing or storage facilities.

Table 1.4- Feijoa Summary Table

Crop	Feijoa
Temp / GDD	Wide range of temperate climates.
Frost	Frost tolerant. Winter down to -10°C. During season, -1.5°C.
Frost free period	n.d. Frost protection from Oct-May to -1.5°C
Winter Chill	200 hours below 7°C
Flowering time	November-December
Harvest time	April-May, 4-6 weeks later than warmer districts
Rainfall	Moderate, 750 to 1000mm. Low humidity harvest
Wind	Require shelter-live shelter belts
Slope	Flat to mild rolling 0 - 10°
Soil depth	>60cm ideal. >40cm not suitable
Soil type	Moderate to well drained
Avoid	Dense soils with high clay content, standing water
Nitrogen loss if well managed	Likely 10 to 20kg/ha/year
Fert timing	Spring, mainly Nov-Dec
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	NZ process or fresh export market
Supply chain end budgeted	Machine harvested and freighted to Hawke's Bay, no storage or processing
Harvest	Machine modelled. Other options are touch picked or catch-nets for export
Labour needs	Low for process. Otherwise extra workers just for harvest
Land area required	10ha to 30+ha
Gross margin and sensitivity	$10,038 per ha. If price is $1.00/kg, $14,032/ha.
Development Costs	$22,500/ha in model, plus frost protection, other machinery and shelter belts
Breakeven (model)	9 years. Unlikely to get price upside unless supplying non-commodity processor

Hazelnut Summary

Hazelnuts will grow well in Tararua as long as they have adequate shelter, soil moisture and lower rainfall at harvest. Rain at harvest time in the Tararua as researched in the climate section of this report, indicated that Eketahuna and Norsewood will be less suitable than the other main centres analysed.

Soils for hazelnut production should be flat or slightly sloping to accommodate harvest machinery. They should be 60cm deep or more, with high water holding capacities. Dense poorly structured soils or standing water should be avoided.
Nitrogen requirements to form protein in the nut are higher than other crops in this study, and it is estimated that with good nutrient management nitrogen losses should be 15 to 25kg N/ha/year. Irrigation is not costed in the model but may be required, perhaps instead of tile drainage depending on soil characteristics.

Tararua hazelnut production will struggle to be price competitive with imports, so will likely target smaller boutique markets and will need strong branding. Hazelnuts are slower to reach mature production than other crops, but once they do reach maturity, they will continue producing for many years with minimal labour requirement.

Land area required is 30 ha based on having enough scale to have a machine harvester. Smaller land areas of 10 ha are estimated to be viable to have 1 full time labour unit focussed on the crop.

Resource restrictions include tree availability, skills and advice around growing the crop, machine harvest equipment, contract drying facilities and processing facilities.

Table 1.5- Hazelnut Summary Table

Crop	Hazelnut
Temp / GDD	Mild summers below 30°C and cool winters to -10°C
Frost	Very frost tolerant. Flowers tolerate temperatures to -8°C.
Frost free period	n.d. Not the most important factor for Hazelnut
Winter Chill	600 to 1200 hours
Flowering time	Female flowers open June - September
Harvest time	Late Feb to early April
Rainfall	800 to 1000mm, evenly distributed but less over harvest
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat to mild rolling 0 - 10°
Soil depth	>60cm ideal. >40cm not suitable
Soil type	Fertile loam with high water holding capacity to mitigate drought
Avoid	Soils with poor structure, standing water, low water holding capacity
Nitrogen loss if well managed	Likely 15 to 25kg/ha/year
Fert timing	Little and often through growing season
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	High quality nuts for fresh local and export market
Supply chain end budgeted	Harvested and hung to dry in a barn, no cost added for storage materials
Harvest	Machine harvested
Labour needs	Low, 2 permanents for 30ha, one manger one worker. Extras for pruning.
Land area required	10ha to 30+ha
Gross margin and sensitivity	$12,898 per ha. At 3.5 t/ha and $9.50/kg, $19,405/ha
Development Costs	$35,000/ha in model, plus other machinery and shelter belts
Breakeven (model)	11 years. Likely to be able to achieve upside on yield and price

2.0 INTRODUCTION

The Tararua District Council has commissioned this project to evaluate several alternative horticultural land uses for farmers of the Tararua District. This project is intended to be an introduction to these crop options, from which landowners can investigate further those they have interest in with reference to their land resource, accessible capital, lifestyle values and passions.

The Productivity Commission completed a report in 2018 recommending the government incentivise diversification of land use towards horticulture and cropping as part of a strategy for a low-emissions economy. Meanwhile, the climate is changing, with projections for warmer average temperatures, less rainfall on the east coast in summer, and more extreme weather events. The first two may come as opportunities for the Tararua District, while the latter will be an issue across the country and the globe. NZ also has a strong national drive for improved water quality which has been set in law by the National Policy Statement for Freshwater Management (2014). This forces regional councils to set water quality and quantity limits and enforce these.

Environmental limits may be tough for some animal-based land uses to adhere to. Alternative land uses can bring benefits such as lower environmental impacts, higher economic profitability, higher permanent labour requirements and agriculture and horticulture related tourism. The outcome of all this is several strong drivers for land use change or diversification. The next barrier is the learning and culture change it will take for farmers to be successful if they want to make a diversification decision. The Tararua District Council sought to provide information on a range of potential diversification options in order to facilitate the thought process with landowners. Initially, many crops were to be studied, and this was narrowed down to four based on perceived likelihood of success for the farmers and the regional benefits the industry could provide.

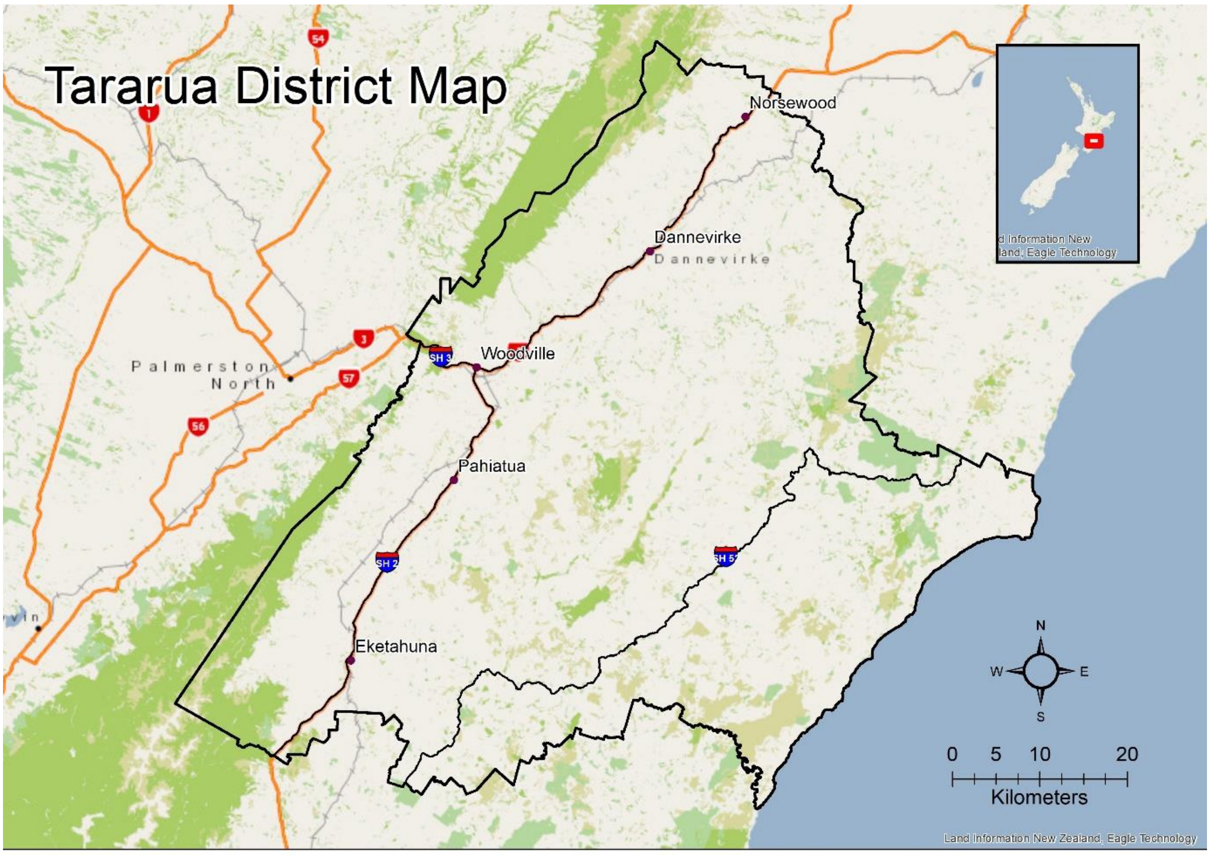
Land uses studied in this report include:

- Feijoa
- Blueberry
- Cider apple
- Hazelnut

Feijoas already have examples of being grown successfully in the Tararua District, and the potential is there for Tararua to become a feijoa industry hub. Blueberries can be grown under cover, and both feijoa and blueberry can be added flavours to a cider industry. Cider apples are in demand across the country from boutique brewers, and Tararua cider apples could be used to make cider within the district and allow Tararua to attract visitors on the Classic NZ Wine Trail to stay in the region and add cider tasting to their activities. Hazelnuts handle coder and wetter climates than many other horticultural crops. All are permanent crops which would help farmers meet their environmental limits, improve local water quality, attract people to the region and improve the livelihoods of Tararua communities.

The Tararua District is located between the Hawke's Bay and the Wairarapa regions of the North Island's east coast (Figure 1). On the East of the Tararua ranges, the valley in which State Highway 2 (SH2) is situated features large tracts of flatter land. Another line of hills used predominantly for sheep and beef farming and forestry runs to the east coast. The rainfall gradient is generally higher near the large Tararua Ranges and lower towards the east coast. Small areas of flat land lie around the river valleys of the east coast, but these are too small to present major opportunities for the district. The higher rainfall, flat land area in the SH2 valley was in forest for a long time before being cleared and is currently used for dairy. This flatter area of land is the focus of this report.

Table 2.1- Map of the Tararua District



The high rainfall and wind levels in the Tararua District present horticultural challenges, but these can be overcome with the right crop and the right mitigations such as shelter belts. Tararua's position as a horticultural supplier is close to the transport hub of Palmerston North, and there is opportunity to supply Wellington and Hawke's Bay direct too.

Environmental issues are a key concern for the farmers of Tararua, with nitrogen leaching loss caps and improved environmental management having new focus in New Zealand communities and governing bodies. The National Policy Statement for Freshwater

Management 2014 (NPSFM) requires the Horizons Regional Council to set targets and limits for water quantity and quality, which they did within the One Plan. This is affecting many farmers in the Tararua District, who are facing regulatory restrictions on how they can farm. The government also proposed action on agricultural emissions in 2019, and this will be then next pressure on farmers to reduce their carbon emissions. Horticultural systems have potential to lower the impact the land is having on waterways and greenhouse gasses and can be an attractive option to land users having trouble reaching their environmental objectives.

Horticulture as an industry is booming throughout New Zealand currently, driven by export apples, kiwifruit and a burgeoning avocado and cherry industry, to name a few. The profit potential of horticultural land uses is greater than dairy or sheep and beef systems, along with bringing in more labour units per hectare, as well as support industry and supply chain to the area. This is important for Tararua District, because the district population has increased between the 2013 and 2019 censuses. Horticulture also has potential to create a higher level of tourism, which brings money and jobs to the region.

The question for the district is: Do any of these four land use options have the potential to take off in areas suitable for horticulture, and can these options help farmers meet environmental challenges, increase profitability and attract more people and supporting businesses to the Tararua District over the next 10 to 30 years?

The answer is yes, there is potential for this, but it will not be easy, and it will need passionate and motivated individuals to take the first steps and set up a commercially successful business before others will follow suit. It will also need excellent marketing, whether this is to convince buyer companies to take this first step, or whether it is forming a local vertically integrated business selling their own Tararua branded products. Our rural people have demonstrated this ability throughout NZ history, and it can be done again in the Tararua District.

Previous work that feeds into this project includes the Tararua District Council 'Go Project', an in-depth study on land use conducted by the council 10 years ago. The aim of the 'Go Project' study was to discover alternative land use options for farms in the region, particularly areas which are underutilised in terms of growing potential. Thirty-seven highly detailed maps were produced, showing district-wide annual rainfall, crop options and optimal planting areas for high-yield, high-return crops which would work for the Tararua District. These included, among others, hazelnuts, saffron, feijoa, flax and Mānuka.

The current report aims to deepen understanding of potential in the region for four crops of interest, updating our understanding, or completing a full new study of them.

A climatic analysis of the region was undertaken, and a soils analysis summarised from the data already collected under the 'Go Project'. The report then is divided into sections by crop, which relate climatic, soil and production requirements back to the weather and soil summary data. Each crop section also includes information on:

- Environmental sustainability
- Financials
- Markets and trends
- Labour needs

3.0 CLIMATE ANALYSIS

In order to assess the feasibility of growing cider apples, blueberries, feijoas, and hazelnuts across the Tararua District, an analysis of the local climate and weather events was undertaken. Metrics that directly impact horticultural production were assessed based on 10-year averages from 2009 to 2018, including:

- Maximum, minimum and average daily and monthly air temperature
- Growing Degree Days (GDD)
- Frost Free Period (FFP)
- Annual precipitation
- Chilling Units (CU)

In the Tararua District, weather data was collected and analysed for Dannevirke, Eketahuna, Norsewood, Pahiatua and Woodville. These localities were chosen because they had the largest areas of flat land that were suitable for horticultural production and they also provided a wide range of topographical situations. The data from the Tararua District weather stations was compared to Hastings, a well-established horticultural region.

Most of the weather data was accessed from NIWA's National Climate Database (CliFlo)[1]; however, incomplete datasets were supplemented with NIWA's Virtual Climate Station Network (VCSN)[2].

3.1 Air Temperature

Maximum, minimum and average air temperatures greatly impact the productivity of horticultural crops.

Maximum daily temperatures (both absolute and average) directly impact photosynthetic production. For example, blueberry plants will not undergo photosynthesis if maximum daily temperatures exceed 30°C and this is important because photosynthesis drives plant growth and fruit quality. Maximum daily temperature is also a component of Growing Degree Days (GDD), a heat index used to predict plant growth and development and fruit maturation.

[1] https://cliflo.niwa.co.nz
[2] https://data.niwa.co.nz/#/home

Minimum daily temperatures (both absolute and average) can also impact photosynthetic production. Furthermore, temperatures below 0°C can result in plant and flower senescence, impacting final fruit yield and quality. Minimum daily temperature is also a component of GDD and is the basis for determining the length of the growing season.

The Tararua District has a moderate climate like the Hastings in terms of average maximum, minimum and daily temperature, with slightly lower long term maximums that bring the average down from 15.9°C in Hastings to a range of 14.4°C to 15.6°C through the Tararua District (Table 3.1).

The analysis revealed that altitude has a strong impact on several key climate metrics across the Tararua District. For example, the weather station at Norsewood recorded lower maximum, minimum and average temperatures (Tables 3.1 and 3.2) and more days with temperatures less than 0°C (Table 3.3) when compared with other towns in the study, resulting in fewer GDDs (Table 3.4), and a shorter growing season.

Table 3.1. Average Temperatures during the growing season (1 October - 31 April) at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Maximum (°C)	Minimum (°C)	Daily Average (°C)
Dannevirke	20.2	10.1	15.1
Eketahuna	20.1	9.9	15.0
Norsewood	19.5	9.3	14.4
Pahiatua	20.5	10.5	15.5
Woodville	20.6	10.5	15.6
Hastings	21.5	10.3	15.9

Absolute maximum temperature is lower at all Tararua sites when compared to Hastings (Table 3.2). The average number of days above 30°C is 3 days or less in the Tararua District and this lower maximum temperature can be an advantage for growing some fruit crops. For example, at temperatures higher than 35°C, hazelnut trees stop producing carbohydrates which could result smaller nuts, negatively impacting yield. Climate change in the region is predicted to increase temperatures by between 0.7°C and 1.1°C by 2040, which brings the average temperature very close to Hastings for many areas of the Tararua District.

Table 3.2. Absolute maximum and minimum temperatures, and number of days above 30°C and below 0°C during the growing season (1 October - 30 April) at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Absolute Maximum (°C)	No. Days Above 30°C	Absolute Minimum (°C)	No. Days Below 0°C
Dannevirke	31.1	3	-1.5	6
Eketahuna	30.6	2	-1.3	12
Norsewood	30.4	2	-2.0	10
Pahiatua	31.1	3	-1.0	8
Woodville	31.5	3	-1.2	9
Hastings	36.4	55	-1.2	11

The first autumn frosts typically occur around the 1st of May for most of the Tararua District, except for Norsewood, which can have frosts as early as mid-April. Woodville's first frosts can be a little later due to the proximity to the Manawatu Gorge. Westerly winds coming through the gorge keep the air at the surface well mixed with relatively warmer air from higher in the atmosphere, resulting in fewer frosts.

Areas of the Tararua District that are higher in elevation also have the greatest number of late frosts. For example, both Norsewood and Eketahuna have more incidences of frost in October and November than the other towns in this analysis (Table 3). This is important because late spring frosts are more likely to have detrimental effects on horticultural production (e.g. bud damage, flower senescence, and fruit damage).

In general, frosts colder than -3°C are hard to manage with conventional frost fans unless a heat source is used alongside the frost fan. In Central Otago, where frosts are regularly below -3°C, overhead sprinklers are used.

Higher frost incidence and absolute minimum temperatures colder than -3°C in the cooler areas of the district will narrow land use options and require a higher level of frost protection.

Table 3.3. Total incidence of temperatures below 0°C and absolute minimum temperature during flowering at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Sep		Oct		Nov	
	(No. days < 0°C)	Min. Temp. (°C)	(No. days < 0°C)	Min. Temp. (°C)	(No. days < 0°C)	Min. Temp. (°C)
Dannevirke	12	-2.2	7	-1.5	2	-1.1
Eketahuna	18	-3.0	10	-1.3	4	-0.7
Norsewood	21	-2.1	10	-2.0	4	-1.7
Pahiatua	10	-2.6	6	-1.0	3	-0.4
Woodville	10	-2.6	6	-1.2	4	-0.7
Hastings	15	-2.3	4	-1.2	2	-0.4

3.2 Growing Degree Days (GDD)

Growing Degree Days, a heat index, is a means of characterising climate for predicting the crop suitability of a region. Growing Degree Days can also be used to predict when a crop will reach maturity. For most of the lowland areas in the district, the GDD values are between 1000 and 1100 (Table 3.4). In the northern part of the district, between Norsewood and Dannevirke, the values are around 900. The climate stations with the highest GDD are Pahiatua and Woodville, with approximately 1200 GDD.

Table 3.4 shows maximum, minimum and the upper and lower quartile GDDs over the growing season for the 10-year period from 2009-2018. Dividing the data into quartiles is a useful way to quantify the year to year variability. The GDD ranges across the district are enough to support all the proposed land use options (Table 3.4).

It should be noted that areas with lower GDDs will take longer to bring a crop to full maturity when compared to an area with higher GDDs. Essentially, areas with lower GDD will have less time to size and mature the fruit on the tree.

Table 3.4. Average, Minimum, Lower Quartile, Median, Upper Quartile, and Maximum GDD (base 10°C) during the growing season (1 Oct - 30 Apr) at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Average	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Dannevirke	1116	944	1037	1155	1198	1254
Eketahuna	1085	922	1026	1081	1166	1243
Norsewood	975	809	901	1018	1050	1112
Pahiatua	1190	1031	1129	1194	1268	1340
Woodville	1207	1035	1140	1219	1282	1379
Hastings	1259	1076	1157	1254	1340	1466

3.3 Frost Free Period (FFP)

The length of the growing season is typically determined by the number of consecutive days without frost; this is the time between the last spring frost and the first frost in the autumn. For this report, the frost-free periods are given for the number of consecutive days with a minimum air temperature above both 0°C and -1°C.

Frosts are more prevalent in the areas of higher elevation (i.e. Norsewood and Eketahuna) where the air temperature is cooler (Tables 3.1, 3.2, 3.3). In general, the length of growing season is acceptable across the district for all the land use options. However, Norsewood has the lowest FFP and it will be necessary for growers in these areas to choose crops or varieties that better tolerate low temperatures.

Table 3.5. Average growing degree days (GDD), rainfall, evapotranspiration (ET) during the growing season (1 Oct - 30 Apr), and annual Chill Units and Frost-free Period (FFP) at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Rainfall (mm)	ET (mm)	GDD (base 10°C)	Chill Units (Hours)	FFP_0* (No. Days >0°C)	FFP_1** (No. Days >1°C)
Dannevirke	532	758	1107	2360	231	261
Eketahuna	782	728	1075	NA	220	253
Norsewood	756	744	970	2683	135	244
Pahiatua	642	751	1180	2182	229	270
Woodville	620	757	1197	1744	227	271
Hastings	336	765	1253	1571	222	264

* Consecutive frost-free days above 0°C

** Consecutive frost-free days above -1°C

3.4 Chilling Units (CU)

Winter chilling is the period of cold weather that many crops require during their winter rest period, prior to commencing new growth in spring. Typically, the most effective chilling temperatures are between about 3°C and 7°C. Conditions colder than freezing do not assist chilling, and at temperatures above 15°C, the chilling process is reversed.

Typically, chill unit calculations are made from air temperatures recorded at least once an hour, although reasonably reliable chill estimates can be made from daily maximum and minimum temperatures.

There are various methods to calculate chill units, however, a count of the number of hours between 0°C and 7°C is most common in New Zealand.

Chill unit accumulation increases with elevation across the district. Horticultural crops have different chilling requirements; therefore, growers must choose an appropriate crop-variety combination to ensure chill requirements are met. For example, blueberry shrubs have different chilling requirements depending on cultivar. High bush blueberries require at least 800 hours of chilling, however, rabbiteye blueberries require less than 600 hours of chilling. All the sites assessed across the district meet the chilling requirement for the evaluated land use options.

3.5 Annual Precipitation

The quantity of water a horticultural crop requires varies with soil type, the age of the plant, the amount of fruit produced, the presence of competitive weeds, and humidity. Low precipitation can result in water stress, leading to reduced carbohydrate production, poor fruit set, low fruit quality, and diminished yields. Excessive precipitation can increase plant vigour, which in turn can increase incidence of plant diseases and reduce fruit quality.

The annual rainfall is relatively high over the district, so lack of water is less of a risk in this climate than excessive water. Supplemental irrigation will still be needed at key phenological stages and over the summer to combat drought periods (Table 3.5).

Rainfall timing is a limiting factor for some of the land use options. Precipitation at flowering can inhibit flowering and pollination, ultimately leading to lower yields. Precipitation at harvest can increase incidence of fruit splitting, rots and diseases. Furthermore, rain at harvest can create situations where mechanical harvesters slip or slide on wet surfaces, causing harvesters to damage trees or trellising. Rainfall over flowering and harvest are higher in areas of higher elevation (i.e. Norsewood and Eketahuna) (Table 3.6).

Table 3.6. Average rainfall (mm) at flowering and harvest at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Rain at flowering (Sept - Nov)	Rain at harvest (Mar - May)
Dannevirke	275	171
Eketahuna	418	242
Norsewood	410	254
Pahiatua	344	187
Woodville	329	179
Hastings	135	138
Nelson*	270	330

*A comparison is added here with Nelson data, because Nelson is a key horticultural growing area for apples, where rainfall is much higher than Hastings.

Table 3.7 below shows maximum, minimum and the upper and lower quartile rainfall over the growing season for the 10-year period from 2009-2018. This table reveals that rainfall in the Tararua district is relatively stable from year to year and that the mean rainfall figure is not hiding 5 years of drought and 5 years of excessive rainfall.

Table 3.7. Average, Minimum, Lower Quartile, Median, Upper Quartile, and Maximum rainfall (mm) during the growing season (1 Oct - 30 Apr) at several locations in the Tararua District over a ten-year period (2009-2018).

Weather Station	Average	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Dannevirke	532	368	428	506	633	787
Eketahuna	782	585	685	737	884	1035
Norsewood	756	548	603	754	857	1139
Pahiatua	642	478	558	602	732	835
Woodville	620	440	547	555	727	843
Hastings	336	226	265	329	373	528

4.0 SOILS AND LAND USE CAPABILITY

4.1 Introduction

This section provides maps and data illustrating the topography and soil properties of the Tararua District. Specifically, the single factor maps in this section will focus on the areas of the district that are suitable for intensive horticulture.

Landscape topography, climate and soil properties all show obvious spatial variability across the Tararua District. Visualizing these differences through maps will help determine appropriate potential land uses for different areas within the Tararua District.

This section provides interpretation of the data, including maps, in terms of land suitability for blueberries, cider apples, feijoas and hazelnuts.

Land Suitability

The Land Use Capability[3] (LUC) system has been used since the early 1950s to help achieve sustainable land development and management. The LUC system has two key components:
Land Resource Inventory (LRI) – Assessment of physical land features
LUC Classification – Using the LRI, land is categorised into 8 classes according to long-term capability to sustain one or more productive uses.
For this project, horticultural land suitability was determined by using LUC less than 4 (Figure 4.1), and a slope classification less than 3 (Figure 4.2).

Land Use Capabilities are described as:

LUC Class code	*Description*
1	Land with virtually no limitations for arable use and suitable for cultivated crops, pasture or forestry
2	Land with slight limitations for arable use and suitable for cultivated crops, pasture or forestry
3	Land with moderate limitations for arable use, but suitable for cultivated crops, pasture or forestry
4	Land with moderate limitations for arable use, but suitable for occasional cropping, pasture or forestry
5	High producing land unsuitable for arable use, but only slight limitations for pastoral or forestry use
6	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest
7	Non-arable land with severe limitations to use under perennial vegetation such as pasture or forest
8	Land with very severe to extreme limitations or hazards that make it unsuitable for cropping, pasture or forestry

[3] https://www.landcareresearch.co.nz/__data/assets/pdf_file/0017/50048/luc_handbook.pdf

The Tararua District has a wide range of LUCs (Table 4.1). Approximately 54,163 hectares, nearly 20% of the land area of the Tararua District, is suitable for the proposed land use options (Table 4.1) according to the simple LUC and slope rules implemented.

Figure 4.1. Tararua District Land Use Capabilities (LUC). Data from: https://lris.scinfo.org.nz.

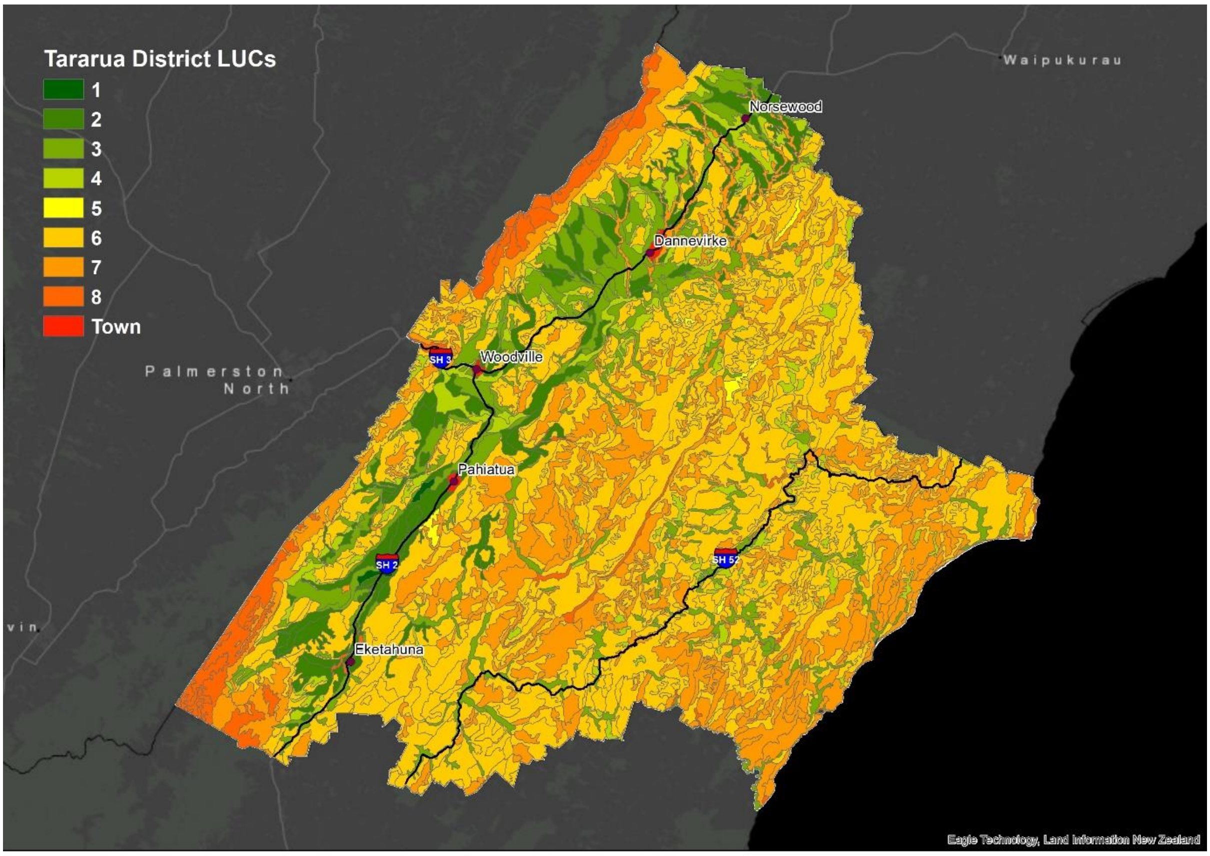


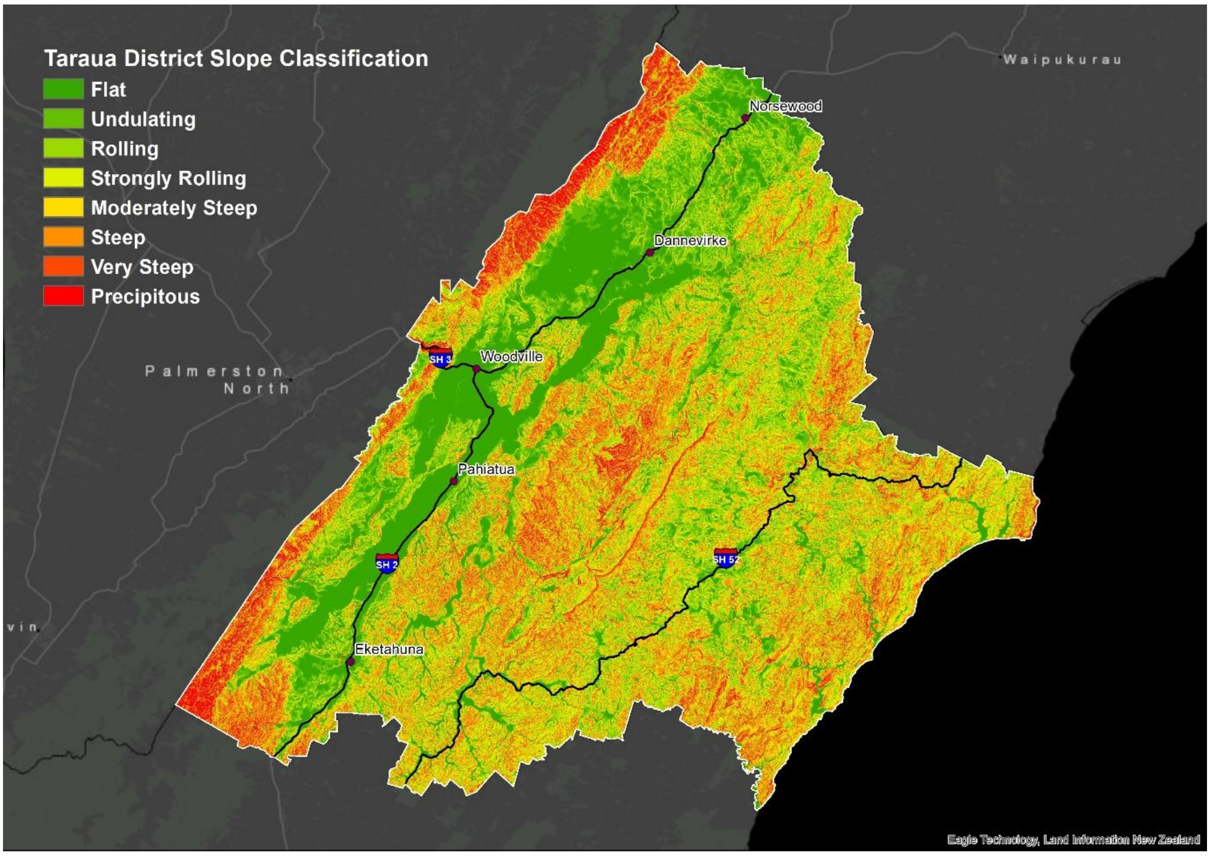
Table 4.1. LUC designations for the Tararua District.

LUC	Area (ha)	Percent of Total
1	549	0.1%
2	31,368	7.2%
3	46,348	10.6%
4	22,246	5.1%
5	1,375	0.3%
6	211,106	48.4%
7	105,481	24.2%
8	16,859	3.9%
Town	889	0.2%
Grand Total	**436,221**	**100%**

Slope Classes are described as:

Item code	*Class description*	*Class range*
A	Flat to gently undulating	0–3°
B	Undulating	4–7°
C	Rolling	8–15°
D	Strongly rolling	16–20°
E	Moderately steep	21–25°
F	Steep	26–35°
G	Very steep	>35° (36–42°)
H	Precipitous	(>42°)

Figure 4.2. Tararua District Slope Classification. Data derived from a 25-meter DEM from: https://lris.scinfo.org.nz.



LUCs are further broken down into subclasses. The LUC subclass is a subcategory of the LUC Class that defines the main physical limitation or hazard that might limit land use.

The four limitations are:

LUC subclass modifier	*Description*
e	**Erosion** – where susceptibility to erosion is the dominant limitation
w	**Soil Wetness** – where high water table, slow internal drainage, and/or flooding is the dominant limitation
s	**Soil Physical** – where the dominant limitation is in the rooting zone (e.g. shallow soil, low water holding capacity, stoniness, low fertility, salinity or toxicity)
c	**Climate** – where climate is the dominant limitation (e.g. summer drought, excessive rainfall, unseasonal/frequent frost, and strong winds).

The land suitable for intensive horticulture in the Tararua District has all four limitations (Figure 4.3). Soil Physical and Soil Wetness make up approximately 82% of the total limitations, while erosion and climate contribute the remaining 18% (Table 4.2). Note that soil physical limitations can class soil as unsuitable for horticulture when you can get around these limitations and be successful, for example planting blueberries in pots above the shallow soil, or soils like the Hastings Gimblett Gravels which are world class soils for grape vines.

Figure 4.3 Limitations of land designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.

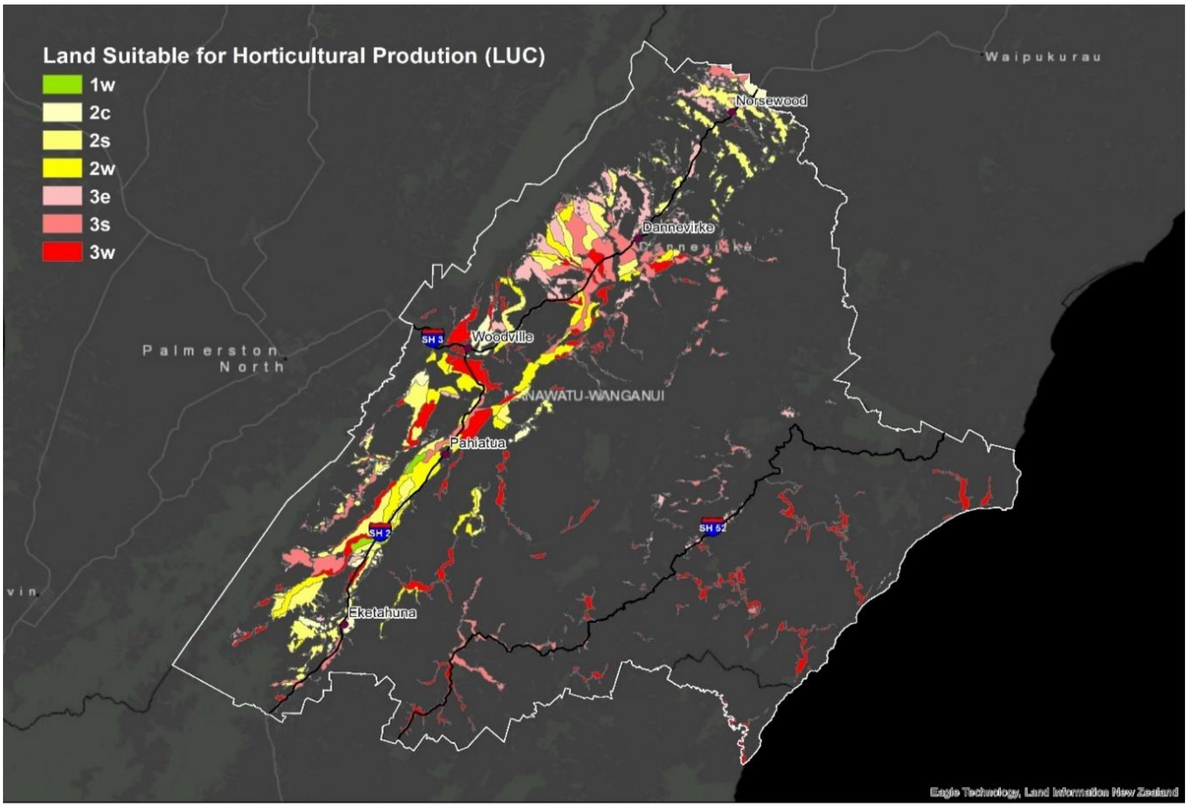


Table 4.2. LUC limitations for land that is suitable for intensive horticulture in Tararua District.

LUC Subclass	Limitations	Area (ha)	Percent of Total
E	Erosion	7,587	13.2%
W	Soil Wetness	21,853	38.1%
S	Soil Physical	25,281	44.0%
C	Climate	2,676	4.7%
Grand Total		**57,396**	**100.0%**

The erosion, wetness and soil limitations are inherent properties and characteristics that define the soils of the Tararua District, while elevation impacts the climate limitation. The LUC subclass limitations will be discussed further below in terms of soil properties and elevation.

4.2 Tararua Soils & Soil Properties

The Tararua District has 28 different soil classifications (soil groups), while the land designated for horticultural production has 17 different soil classifications (Figure 4.4). Six soil classifications make up 92% of soils in the horticultural area (Table 4.3).

Soil orders can be used to generalise soil classes and underpinning soil properties (e.g. soil draining and rooting depth). Brown soils make up 45% of the horticultural soil, with Gley, Allophanic, and Recent soils making up the remaining 30%, 14%, and 11%, respectively.

Figure 4.4. Soil classification for area designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.

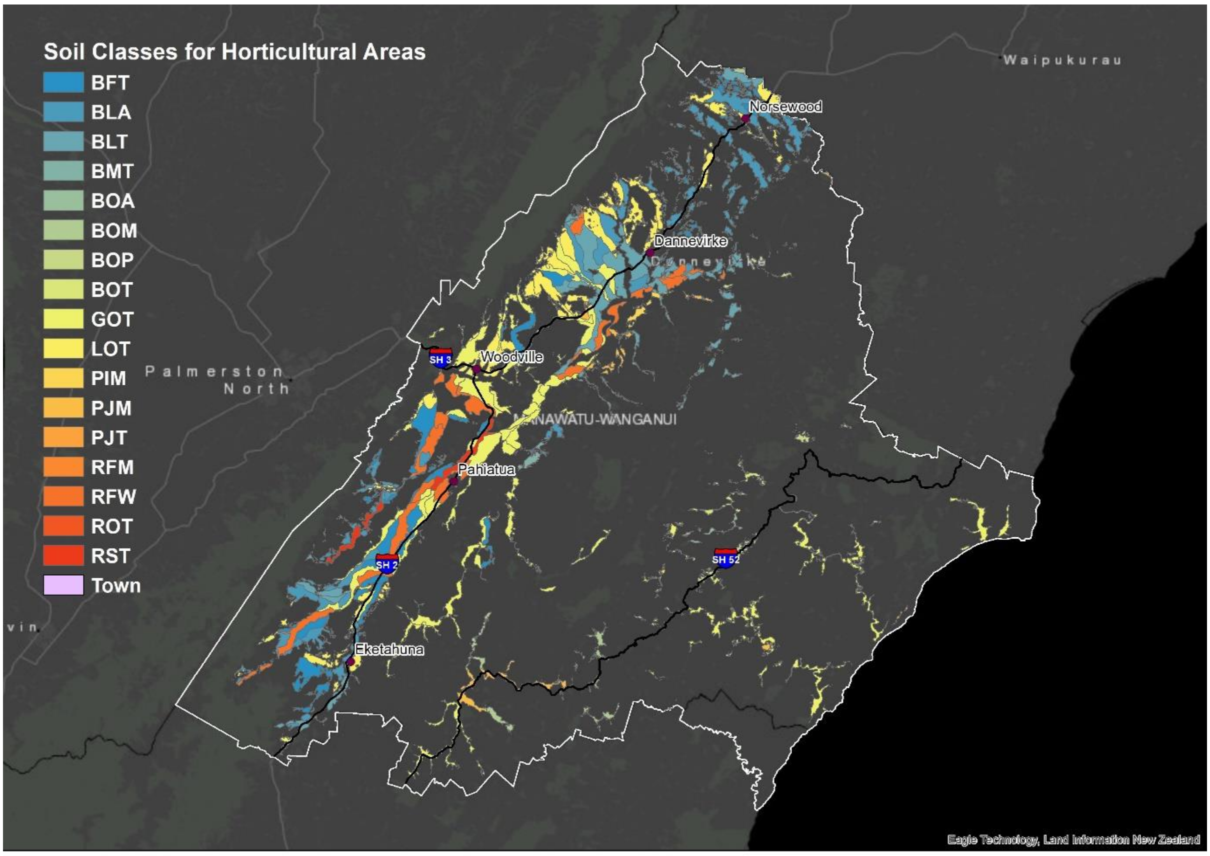


Table 4.3. Largest NZ Soil Classes (hectares) for land that is suitable for intensive horticulture.

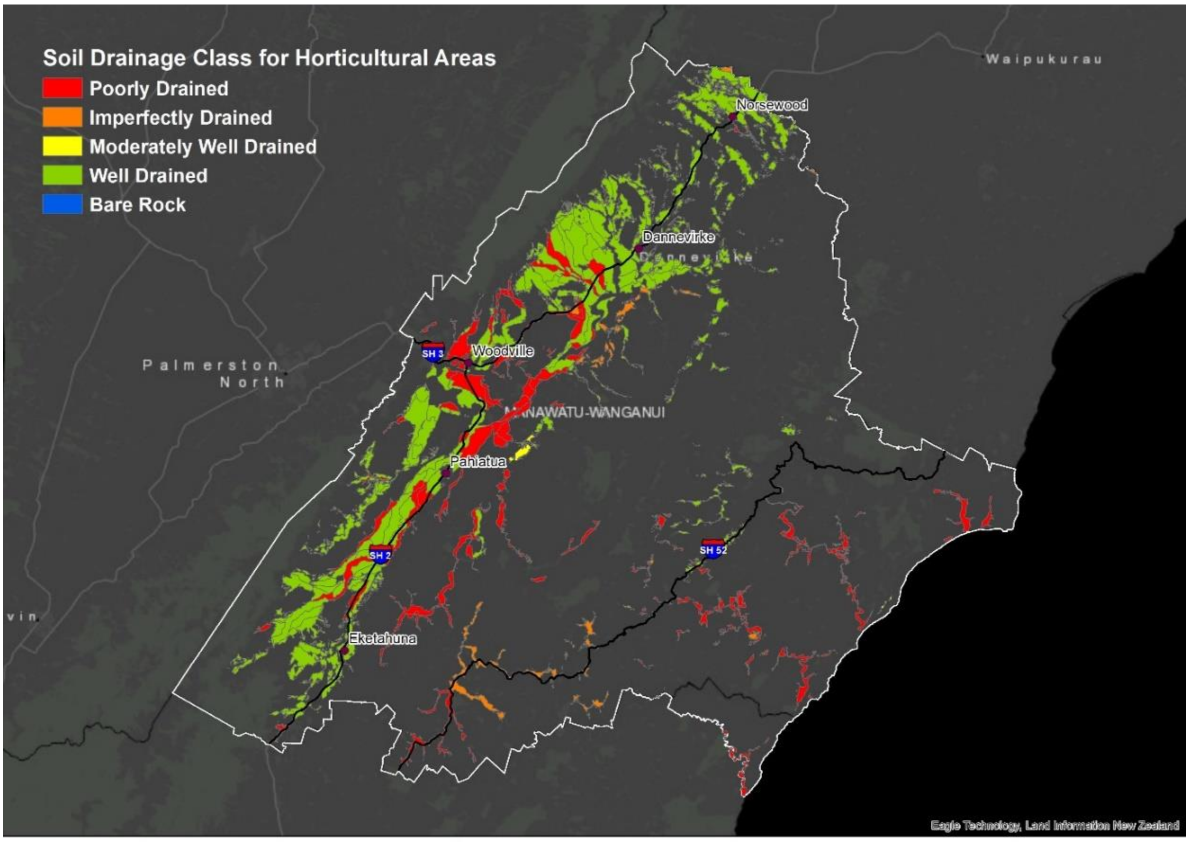
Soil Class	Soil Order	Area (ha)	Percent of Total
GOT	Gley Soil	15454	27%
BLA	Brown	9252	16%
LOT	Allophanic	7684	13%
BLT	Brown	7216	13%
BFT	Brown	6776	12%
RFW	Recent	5925	10%
Total		**52307**	**92%**

4.2.1 Soil Drainage

Soil drainage classes indicate the rate at which excess water drains from the soil and the time soil moisture is above field capacity (soil capacity is the amount of soil moisture or water content held in the soil after excess water has drained away). Drainage classes provide an indication of the likely wetness of the soil and its aeration constraints. This is important because plant roots need oxygen as well as water and available nutrients. If the soil does not drain away excess water quickly, plant roots can be killed. An example of this is a tree crop on a deep Gley soil that has a water table sitting at 30 cm through early spring, which only disappears in December each year. This restricts plant feeder roots to only the top 30cm during spring, which is an extremely important period for nutrient uptake in many crops. Once December comes, the roots might begin to explore downwards but will not be deep enough come January to deal well with drought. The solution to this problem is to install artificial drainage, which creates channels to more quickly expel excess water.

Brown, Allophanic, and Recent soils are described as being well drained, while Gley soils are described as being poorly drained (Figure 4.4). The land use options evaluated for this report are not well adapted to wetness. Therefore, artificial drainage should be installed, particularly for production on Gley soils.

Figure 4.5. Soil drainage class for area designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.

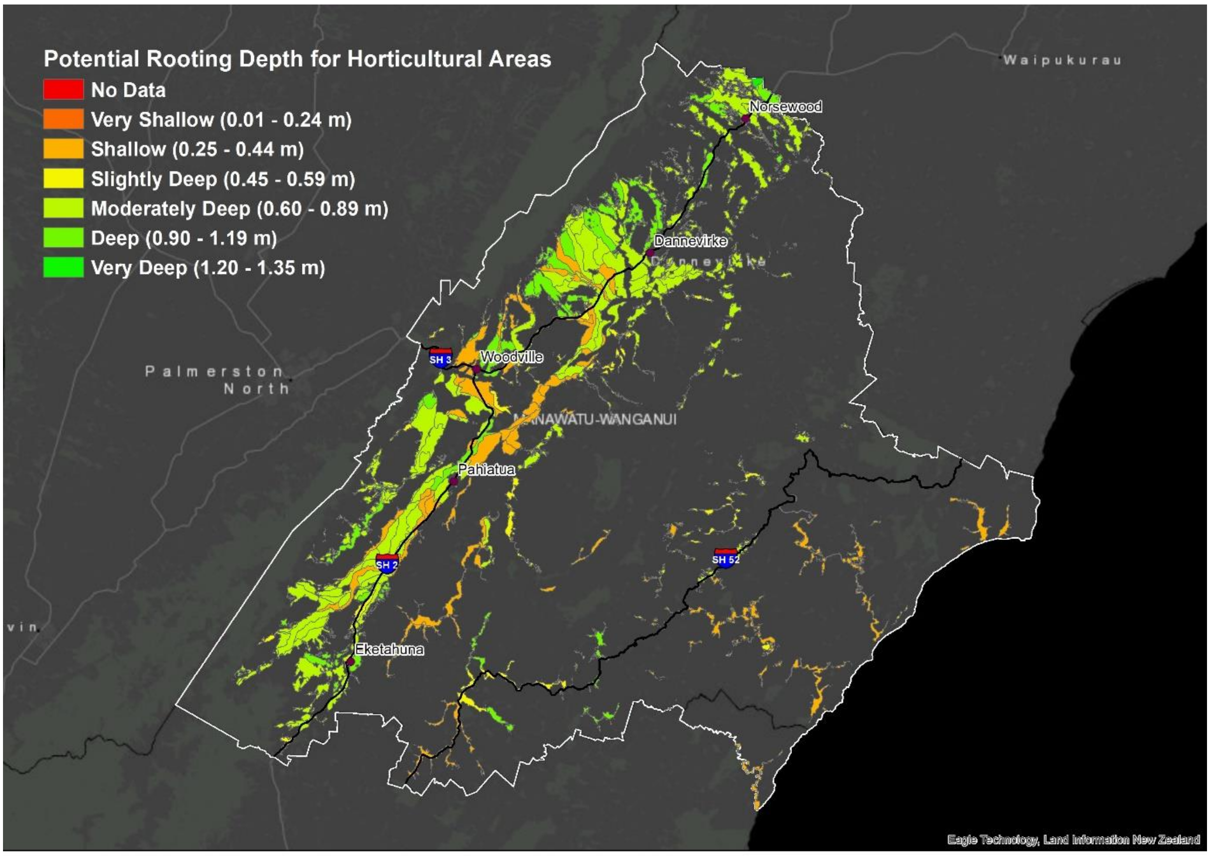


4.2.2 *Potential Rooting Depth*

Potential rooting depth is the depth to a soil layer that may physically or chemically impede root extension. It is the depth of soil that can be potentially exploited by the rooting systems of most crops, providing a medium for root development, and water and nutrient uptake. Soil characteristics known to influence root development are aeration, water retention, and compaction.

Brown, Allophanic, and Recent soils are described as have good rooting depth (Figure 4.6). Gley soil potential rooting depth is limited by poor aeration. Even after drainage, root extension may be limited in some soil horizons.

Figure 4.6. Potential rooting depth for area designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.



4.2.3 Available Water

Readily available water is the amount of water readily available to plant roots within the potential rooting depth. The amount of readily available water for plant growth is important in low rainfall areas or where rainfall is variable and helps determine irrigation frequency.

Allophanic and Recent soils have moderate readily available water; however, both Brown and Gley soils have low readily available water (Figure 4.7). All the land use options will require irrigation during the plant establishment phase, regardless of soil readily available water. Crops grown in Brown and Gley soils will likely need irrigation post crop establishment.

4.2.4 Erosion Risk

Soil class can have an impact on erodibility. Erodibility depends on soil parameters such as texture, structure and internal soil drainage. Soil class in the designated horticultural areas has no obvious correlation with erodibility (Figure 4.8).

Stream bank erosion is the most prevalent type of erosion in the areas designated for horticulture (Table 4.4). This should be easy to manage by having a large buffer area between the stream bank and production site.

Figure 4.7. Readily available plant water for areas designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.

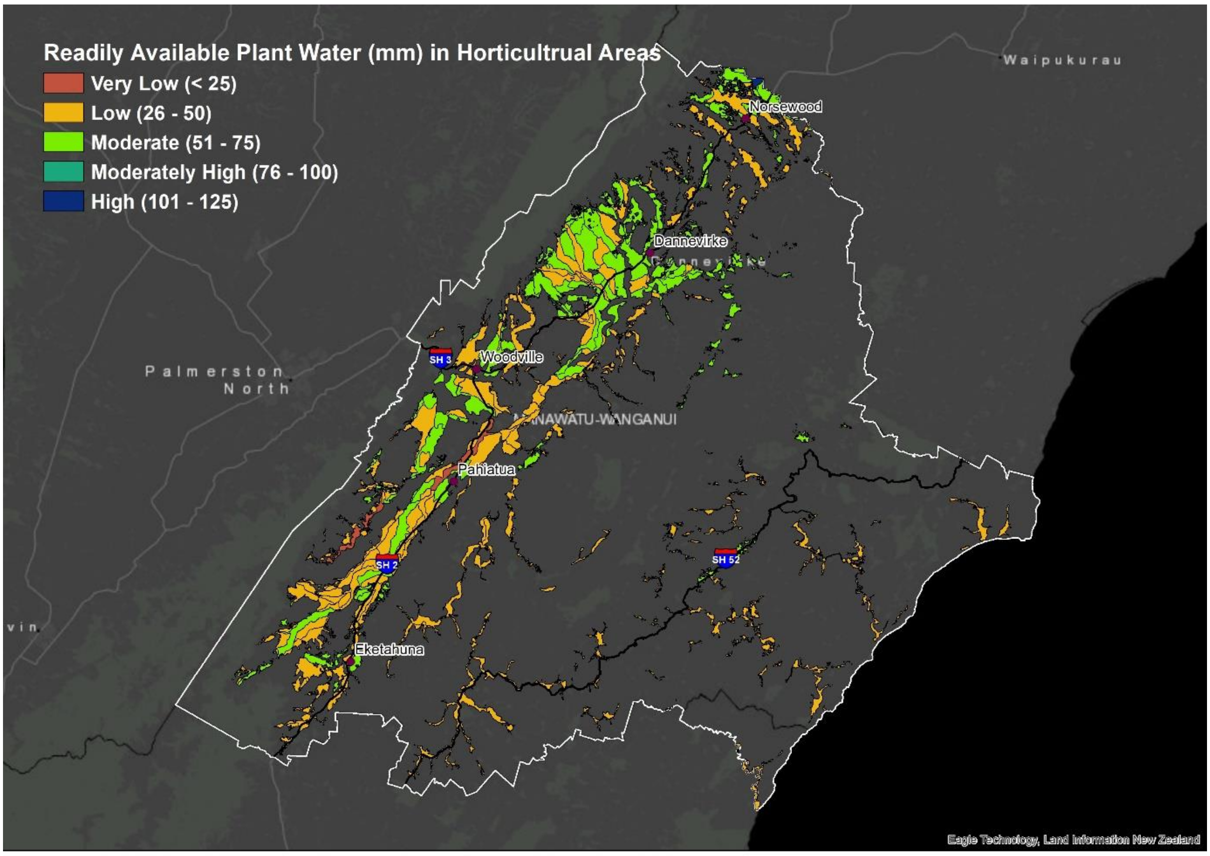
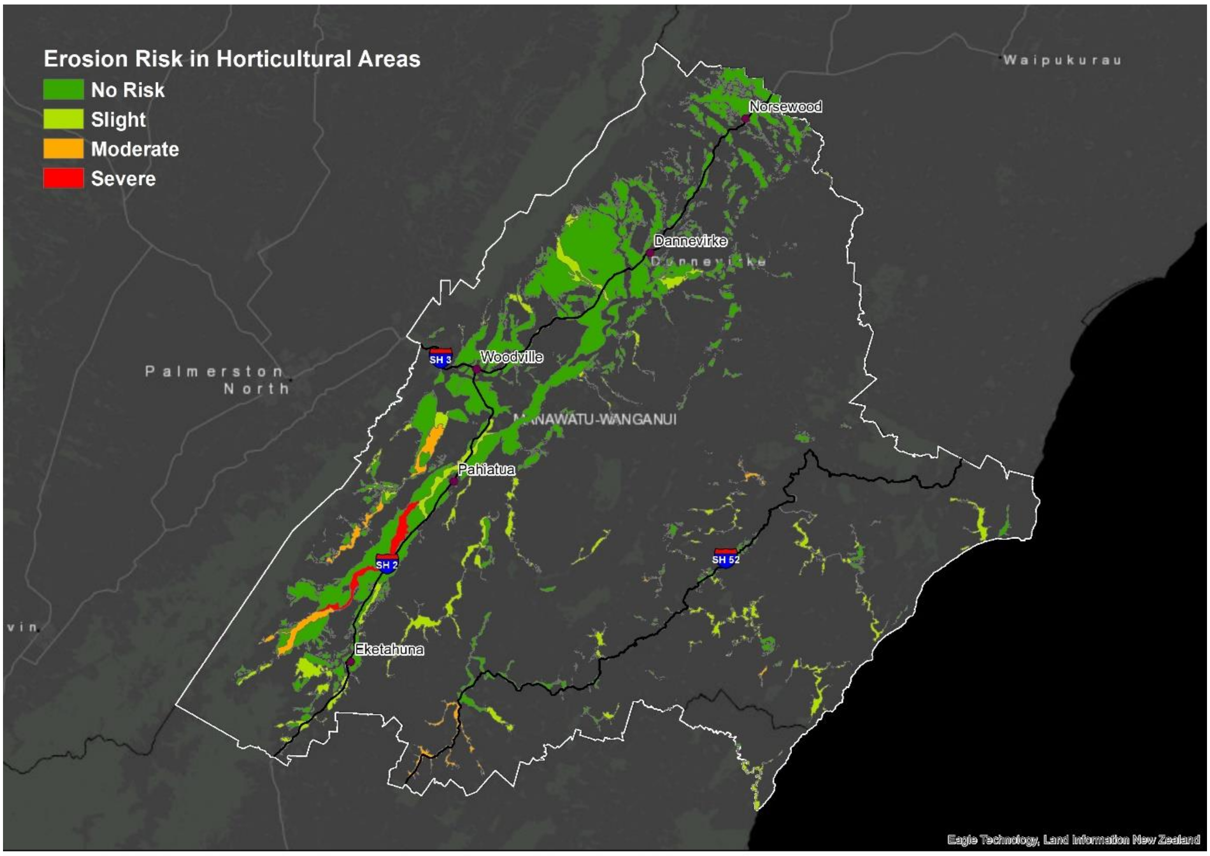


Table 4.4. Erosion Type for land that is suitable for intensive horticulture.

Erosion Code	Erosion Form	Area (ha)	Percent of Total
	None	43324	75.5%
Sb	Stream Bank	13595	23.7%
Sh	Sheet	19	0.0%
Ss	Soil Slip	458	0.8%
Grand Total		**57396**	**100.0%**

Figure 4.8. Erosion risk for areas designated for intensive horticulture. Data from: https://lris.scinfo.org.nz.



4.2.5 Elevation

Elevation can significantly impact climate and weather, and therefore horticultural production. Although elevation is not a key factor in Land Use Capability classification, elevation directly impacts air temperature, soil type, water availability, and slope, all of which are the basis for LUC designation.

The impact of elevation on the Tararua District climate was discussed in the previous 'Climate Analysis' section. There is a distinct elevation variability across the district (Figure 4.9). The elevation for the district starts at sea level at the coast and climbs to over 500 meters above sea level (MASL) at the Puketoi, Waewaepa and Tararua Ranges. Generally, the district has a low elevation and more than 50% of the district is below 250 MASL.

There are elevation differences in the area that was identified for intensive horticulture (Figure 4.10). Approximately 76% of the land suitable for horticultural production is below 250 MASL (Table 4.5). This is important because there will be higher average temperatures, resulting in more GDD and fewer air frosts. For example, Norsewood has the highest elevation at approximately 400 MASL and this area has the lowest average temperatures and GDD, highest rainfall, and the most days with temperatures below -1°C (see 'Climate Analysis' section).

Figure 4.9. Tararua District Elevation (meters above sea level). Data derived from a 25-meter DEM from: https://lris.scinfo.org.nz.

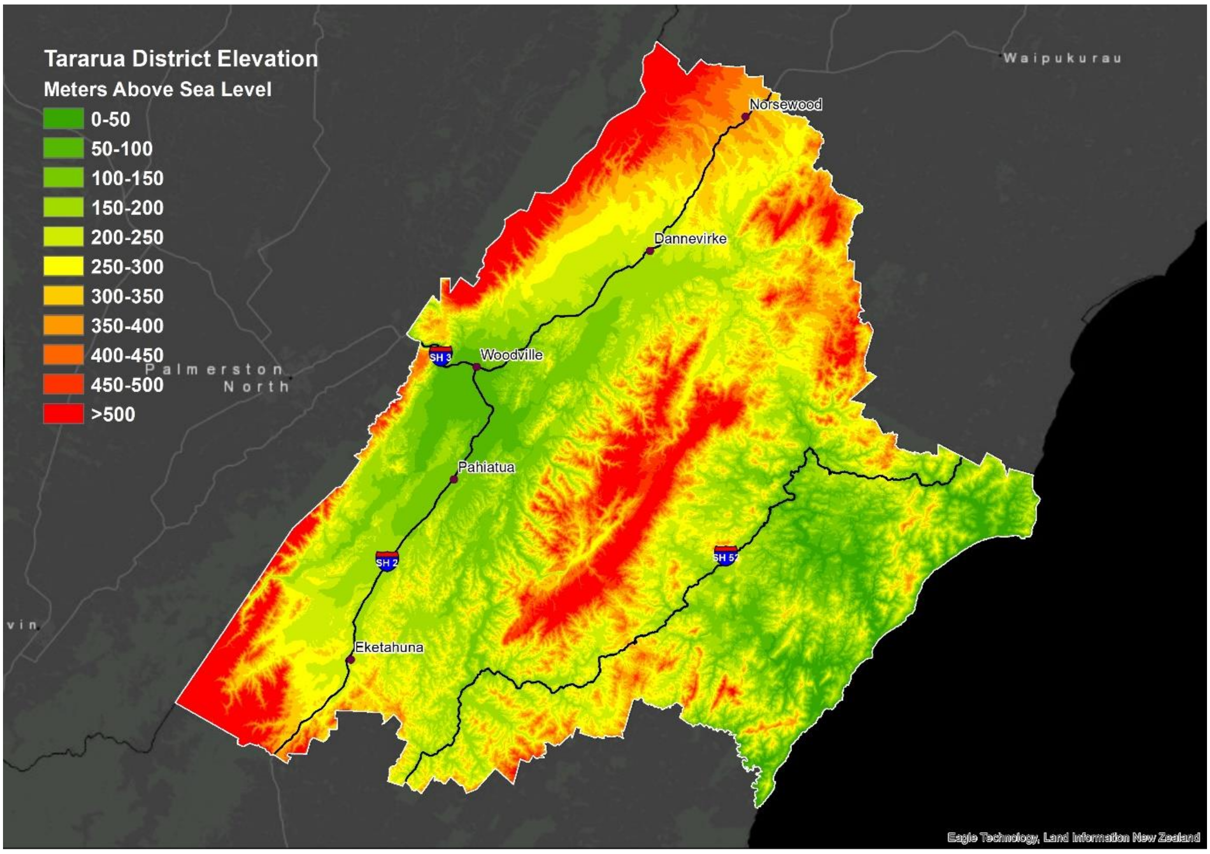
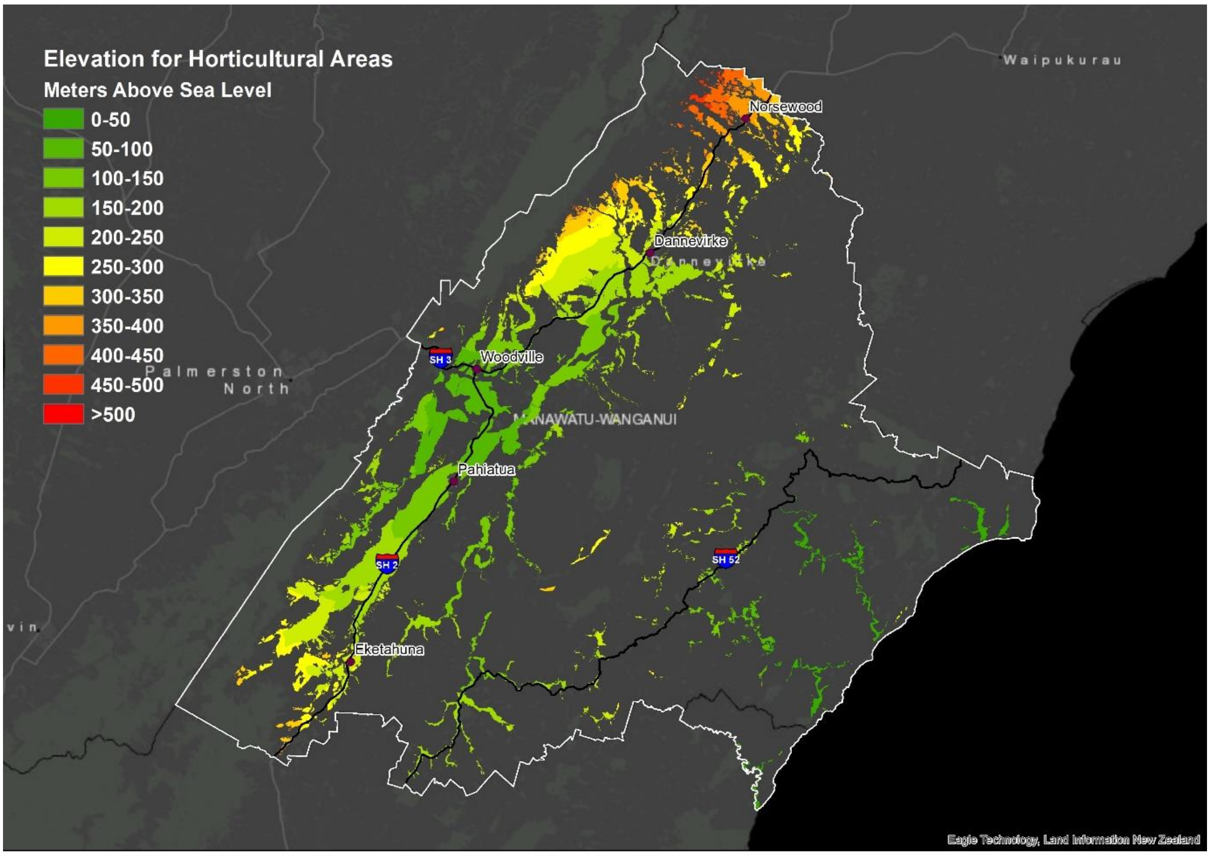


Table 4.5. Elevation (meters above sea level) for land that is suitable for intensive horticulture.

Elevation Range (MASL)			Area (ha)	Percent of Total	Cumulative %
0	-	50	2167	4%	4%
51	-	100	7209	13%	17%
101	-	150	11579	20%	37%
151	-	200	12965	23%	59%
201	-	250	9641	17%	76%
251	-	300	6811	12%	88%
301	-	350	3650	6%	94%
351	-	400	1902	3%	98%
401	-	450	1252	2%	100%
			Grand Total	**100%**	**100%**

Figure 4.10. Elevation (meters above sea level) of areas suitable for horticultural production. Data derived from a 25-meter DEM from: https://lris.scinfo.org.nz.



4.3 Conclusion

The Tararua District is large with an approximate land area of 4,364 km^2. This section has shown that approximately 13% of that land is classified as LUC 1, LUC 2, or LUC 3 and is preliminarily suitable for intensive horticulture.

Soil physical properties and wetness are the primary soil limitations in the area designated for horticulture. However, with slight to moderate soil modification, most of the land area should be able to support at least one of the proposed land use options (i.e. blueberry, cider apple, feijoa, or hazelnut production). In areas where soil modification is not an option, blueberries could be grown in containers on top of the soil.

Elevation, and its impact on climate, is likely to be more of a limiting factor than soil physical properties. Elevation will dictate the air temperature, rainfall pattern and length of growing season and therefore limit land use options.

5.0 ENVIRONMENTAL ASPECTS OF PERMANENT HORTICULTURAL CROPS

One key need in the Tararua District is to show responsible environmental management and reduce nitrogen and phosphorus loss, as well as sediment loss to waterways. Animal based agricultural systems concentrate nitrogen in urine and phosphorus in faeces, which is vulnerable to leaching from the farm system. Animals can also destabilise streambanks and create areas of risk for sediment loss.

Permanent horticulture is a very good option to lower the environmental impact of growing food. Permanent horticulture enables the avoidance of soil disturbance by animals or cultivation, and permanent (and often large) root systems help anchor soil. Permanent orchard systems often also mine a large rooting depth area of soil for its natural cycling of nutrients, lowering need for applied fertiliser. Applied fertiliser can be used highly efficiently as liquid foliar sprays, or as liquid fertiliser mixed with irrigation water. Solid fertiliser applied to the ground is still common but avoids the concentrating of nutrients in small patches and deficiency in others that comes with animal systems.

There is still very much a place for well managed animal-based systems, as much of the Tararua landscape is ideal for these. However, this section focusses on the environmental impact of permanent horticultural crops to give an understanding of how these systems might fit in with the current Tararua landscapes.

Environmental analyses on each crop are included in the specific crop sections.

5.1 Nitrogen

Nitrogen loss data in New Zealand is difficult to find for even the large horticultural tree or vine crops (vineyards, pipfruit and kiwifruit). Most of the work done to date in reference to these crops is modelling, in either the Overseer or SPASMO modelling systems. Modelling shows common nitrogen leaching ranges of 2kg N/ha/year up to 25 kg N/ha/year. One paper by Green et al (2010) on water and nitrogen movement under agricultural and horticultural land did measure between 10 and 15kg/ha/year lost from an apple orchard.

The difference in leaching loss is not driven by the type of woody fruit crop, but rather the soil type, rainfall and relationship between crop load and nitrogen application rate.

Nitrogen requirements vary from the establishment phase to the cropping phase. During the establishment phase, nitrogen is required to support rapid growth of roots, trunk and fruiting branches. This then gets locked up in the permanent woody structure. The period required to create this fruiting structure determines the length of the non-productive period, which is crucial in affecting the economic viability of the development.

Replacement of nitrogen is required to offset the season's growth of permanent plant structure, the harvested crop and leaching losses. In a mature orchard targeting minimal leaching losses, only the nitrogen leaving the orchard with the crop may need to be replaced annually.

Reported data for crop nitrogen removal indicates commonly grown NZ fruits contains 1 to 2kg N per tonne of crop. Citrus nitrogen content is higher at almost 3kg per tonne of crop. Most fruits are capable of luxury consumption of nitrogen, but this in many situations results in loss of fruit quality rather than increased yield. In most soils, this amount is available through the natural mineralisation of nitrogen.

Fertiliser requirements are largely driven by soil quality, particularly soil organic matter levels and rooting depth. Avoiding water logging is crucial, as anaerobic conditions create root health issues, stopping uptake of nutrients and reducing depth of soil that can be explored.

5.2 Phosphorus

Phosphorus loss is dependent on the soil type, slope, rainfall and the amount exported in the crop, and is commonly very low from orchards due to the permanent root structure stabilising the soil and minimally sloped sites. A study using SPASMO in Hawke's Bay estimated P losses from 0 to 0.4 kg P/ha/year from apples, stonefruit and kiwifruit on several soil types. However, grapes on very gravelly, extremely well drained soils with low anion storage capacity, for example the Omahu soil, did lose more phosphorus (up to 1.7kg/ha/year) when the model applied 5 kg/ha of phosphorus to the ground. In reality, phosphorus would be applied as a foliar spray or fertigated in these soil types.

Phosphorus in permanent woody fruit crops has little risk of runoff unless the crop is planted on slopes. The risk of runoff is greatest between planting and inter-row grass sward establishment. At planting, the whole orchard is cultivated, leaving soil exposed and vulnerable to wind and water erosion. Once the grass sward is established, there is an ongoing small risk of large rainfall events washing away soil from the herbicide strip, which is conventionally kept bare to reduce weed competition.

However, most high value horticulture is placed on flat land, and in this case the risk of phosphorus runoff is minor. If Olsen P is kept below 60, which it will be with all the crops covered here, then leaching loss of Dissolved Reactive Phosphorous (DRP) should be low (0 to 1 kg P/ha/year).

Most often, best practice is to work on leaf testing to determine if the crop is receiving enough phosphorus. To support this, growers generally use ground application to keep the Olsen P level of the soil between 20 and 40, coupled with well-timed foliar applications if necessary. Fertigation can also be used.

5.3 Efficiency of Uptake

All permanent woody crops allow the much more efficient methods of applying fertiliser through fertigation and foliar application rather than ground spreading solid pellets. In the higher rainfall areas of the Tararua District, uncovered crops will be limited in their use of fertigation, as there needs to be a water deficit as well as nutrient deficit in order to apply water with dissolved nutrient. Foliar applications, however, are extremely efficient, supplying nutrients when they are needed, with uptake efficiency around 80%. Foliar applications are at such low rates per ha, with such high uptake efficiency, they generally do not create any leaching losses.

6.0 BLUEBERRY

6.1 Blueberry: Background

The blueberry is a member of the heath family (Ericaceae) and is native to North America and East Asia.

There are three main types of blueberries:

1. Highbush, *Vaccinium corymbosum*
2. Lowbush, *Vaccinium angustifolium, V. myrtilloides, V. lamarkii,* and *V. vacillane*
3. Rabbiteye, *Vaccinium ashei* Reade

Lowbush varieties are important species for southern regions in the Northern Hemisphere and may be of value for the northern regions of New Zealand. However, for most areas in New Zealand, Highbush is the species that is attracting considerable interest amongst horticulturists.

Blueberry cultivars were first introduced into New Zealand nearly 70 years ago to find a suitable crop for the large areas of peat lands in the Waikato. Some of the progeny of the original six cultivars are at present being evaluated by Plant & Food Research. Further improved North American selections were imported into this country by the Ministry of Agriculture and Fisheries in 1973.

New Zealand-bred cultivars have lengthened the harvest season by up to six weeks. This has helped New Zealand producers to obtain premiums for early and late season fruit in the fresh export markets.

Currently, there are approximate 740 hectares of planted blueberries worth $21 million in domestic fresh market sales and $34.8 million in export (FOB) sales value.

There are opportunities for New Zealand blueberry producers to supply domestic and export markets. High fruit quality and high yields are necessary for profitable blueberry growing and these requirements are achievable in the Tararua District.

When planning to establish a blueberry orchard, careful consideration needs to be paid to the selection of the site, the varieties of blueberry to plant, the source and quality of water available, harvesting (including the picking labour source), marketing and distribution channels. This report focuses on the covered production of fresh blueberries for the raw, unprocessed market.

6.2 Blueberry: Soils

There are large areas in the Tararua District that are very well suited to growing blueberries as a primary crop or as part of a diversified cropping system on small holdings and larger farms.

Blueberries have more specific site and soil requirements than most other fruit horticultural crops. The sections below will outline the site requirements for high quality blueberry production.

The orchard should be flat or gently sloping Land. Slope class A is ideal, especially in covered production systems. Slope class B (4 to 7°) could be appropriate depending on production system used; however, class C slopes (8 to 15°) should be avoided because they are erodible, and difficult to cultivate and irrigate uniformly. Class B slopes allow air to drain which reduces the risk of frost injury. North-facing slopes tend to increase the risk of frost injury in spring because plants generally bloom earlier, and west-facing slopes are at the greatest risk for winter injury because they are exposed to persistent desiccating winds in winter.

Blueberries are very exacting in their soil requirements and this is particularly true for Highbush cultivars. The bulk of root growth occurs in the upper 60cm of the soil profile, therefore, a soil depth of >60 cm is most preferable. Soil depths between 40 and 60cm can still grow productive blueberries, but soil depths less than 40cm are not suitable for commercial production. Growing in containers above the soil means that soil depth is not an issue.

Field grown blueberries require a fertile, well-drained, acidic soil that has a high content of organic matter. Peatlands are the preferred soils as they are composed almost completely of organic matter and have the desirable pH level (acidity) of 3.8 to 4.5. Mineral soils that are slightly less acidic but have other correct physical attributes can be made more acid with ground sulphur or continued use of ammonium sulphate. Any soil with pH above 5 must be corrected at least six to twelve months before planting. This low pH requirement is another major reason many growers use containers where pH is more easily controlled. Blueberries have a low requirement for phosphorus and can obtain adequate amounts when soil levels are low, especially when conditions are favourable for growth of endomycorrhizal fungi (fungi which help the blueberry plant source phosphorus).

Low-lying areas with a high water table are not recommended. Blueberries do not tolerate standing water or grow well in excessively wet areas. Internal soil drainage, therefore, is a critical component of a good site. If a site is too wet for berry production, then subsoil drainage can be installed to dissipate excess water. Berries often can be grown successfully on wetter sites if they are planted on raised beds or in containers, however the soil surface should still not have standing water present.

For blueberry, recommended soils classes in the Tararua district include:

- BFT - Typic Firm Brown Soils
- BLA - Acidic Allophanic Brown Soils
- BLT - Typic Allophanic Brown Soils
- LOT - Typic Orthic Allophanic Soils
- RFW - Weathered Fluvial Recent Soils

This soils section is focussed on field grown blueberry requirements, but blueberries grown in containers on top of the soil eliminate soil limitations.

6.3 Blueberry: Climate

The primary climate factors that contribute to a successful blueberry crops are winter chill hours, moderate summer temperatures, and dry weather at harvest.

6.3.1 Frost Tolerance

Winter frosts are usually no problem to established plants.
Spring frost is an important consideration when assessing site suitability for blueberry production. Although blueberries have a chill requirement, spring frosts can kill flowers and soft new growth. Because flowering time is site dependent, the timing, severity and number of frosts create a complicated frost risk matrix. Not all flowers open at once so the likelihood of complete crop loss as a result of a single frost event is minimal.

Highly suitable sites for blueberries are those that will not experience spring frosts. However, sites that experience mild frosts during flowering (between -2 and 0°C) should also be suitable. Marginally suitable sites are those which experience more severe frosts (-2 to -3°C) during flowering, while even more frequent or severe (lower temperature) frosts will render a site unsuitable.

Early autumn frosts may damage the fruit of late-cropping varieties.

6.3.2 Chill Hours

An essential requirement for successful blueberry production is sufficient winter chill hours to successfully break dormancy. Chill hours are variety dependent. Highbush species generally have a chill requirement of between 800-1200 hours. Chill hours are the accumulated number of hours temperature is between 0°C and 7.2°C from May to August inclusive. A site with 700-800 chill hours is also suitable, however less than 700 chill hours is considered unsuitable for Highbush blueberries. Other varieties with lower chill requirements could potentially be used.

Some of the variety releases from the Plant & Food Research blueberry breeding programme require moderate to lower chill hours.

6.3.3 Temperature

Commercial blueberries require a temperate climate. The main blueberry growing areas in the northern hemisphere are characterised by:

1. Growing seasons greater than 160 days
2. Average minimum winter temperatures greater than -5°C
3. Mean monthly summer temperatures between 15-26°C
4. Maximum temperature less than 30˚C
5. Chilling greater than 1000 hours (depending on variety)

Blueberries prefer a climate with mild summer temperatures, such as a site with a mean maximum monthly temperature of 15-26°C between October and March inclusive.

Blueberries are increasingly grown under cover to allow more control over growing conditions.

6.3.4 Water Requirements

Ideal annual rainfall is 800 to 1000 mm, with rain evenly spread throughout the growing season. Locations with rainfall well distributed up until February may not require irrigation. Locations that experience prolonged periods of dry weather between November and the end of January should install irrigation, especially if the soils are free draining (sandy or stony).

Blueberry plants require approximately 25mm water per week during the growing season. Newly established plants have the most critical water needs and can be damaged by both over and under watering. Short periods (one to three weeks) without rain can stress plants severely. Irrigation during these periods is required to ensure optimum plant performance. Trickle irrigation is the most common system that growers use. Water requirements increase as the plants age, and vary due to soil type, organic matter and natural climate conditions.

A water budget done for Tararua assuming blueberries were undercover estimated that the evapotranspiration deficit would reach maximums of 80 to 90mm/month which would need replacing with irrigation.

Table 6.1 - Tararua specific blueberry water budget estimate to cover all months 2007-2018, for covered blueberries

Area	mm/year	mm/Month
Tararua	330- 350	80- 90

*Crop factor of 0.50, soil starting out dry in raised containers

Rain at flowering and harvest time is an issue. Growers in the Waikato successfully grow field blueberries in some years, but the production risk from rain at flowering is high, which means some years the crop is much lower. This is one of the main reasons covered systems would be recommended in the Tararua.

6.4 Blueberry: Environmental

6.4.1 Nutrition

In a mature field-grown blueberry orchard, it is estimated that blueberries extract 1.08 kg N per tonne of crop, and 0.26 kg of P per tonne of crop (Retamales & Hancock, 2012). If fertigation is used, leaching and runoff minimal, prunings mulched back into soil and weed uptake minimised, fertiliser application rates will near the crop removal level. However, blueberry root systems are compact and Retamales & Hancock (2012) suggest a multiplication factor for runoff, weed uptake, volatilisation and immobilisation. The lower end of the range has been used here to determine a fertigation application level for N and P on a fertile soil with high organic matter (lower value) and a sandy soil low in organic matter (higher value). This estimate assumes good weed control and management of water to prevent runoff and leaching loss.

Table 6.2 - Nutrient Removal by Blueberries and Fertigation Requirements in Field Grown Blueberries

Blueberry yield	N Removed kg/ha	P Removed kg/ha	Fertigation N kg/ha	Fertigation P kg/ha
16t/ha	17.2	4.0	40 - 66	6.0 - 12.6
20t/ha	21.6	5.2	50 - 84	8.2 - 16.4
24t/ha	26.0	6.2	60 - 100	9.8 - 19.4

Higher fertilisation inputs will be necessary for younger plants to still filling their canopy. Nitrogen fertiliser requirements at specific sites will be determined by leaf testing, with the optimum leaf concentration between 1.8% and 2.1% N (MAF, 1986). Some very fertile soils will perform best with no added nitrogen and are sensitive to excess fertility (Hanson, 2006). Timing of nitrogen application is from mid-September through early December and should be applied in the ammonium form rather than nitrate to help keep the pH low.

When applied in a solid form to the ground, nitrogen fertiliser efficiency is reduced, especially if applied in September and exposed to rainfall. MAF (1986) recommends a total of 30-40kg/ha in peat soils and 40-60kg/ha in mineral soils. Portions of this can be applied first in September/October and then again, if needed, in early December.

For phosphorus, leaf analysis should sit within the range of 0.12% to 0.4%. Ground applications of 10 to 20 kg/ha P in autumn are suggested by MAF in New Zealand (MAF, 1986).

Higher levels of fertiliser are required in covered, containerised systems because the soil does not provide as much nutrition to the plant. However, fertiliser use efficiency is higher and much easier to control.

6.4.2 Leaching loss

There have been no known leaching loss studies in New Zealand conditions on blueberries outdoors. Overseas, there have been issues in Australia (White & Santos 2018) and Canada (Saleem, 2012) with leaching losses from uncovered blueberry production. However, this is largely due to grower practice and can be improved with further research. Losses will be dependent on application rates and timing, the soil type, and yield. If the MAF (1986) recommendations above are followed, along with best practice in avoiding large rainfall events and applying 'little and often', it is likely leaching losses can be held within the same ranges as cider apples (3 to 24kg/ha/year), but if best practice is not followed, the likelihood of higher leaching losses is greater than apples due to the shallow root system of blueberry, of which just over half is contained within 300mm soil depth in most soils (Strik, 2015).

If growing blueberries under cover, one of the major risk factors for leaching losses—rainfall—is removed. Under cover systems will have permanent irrigation installed, and therefore the best way to apply nutrition is to fertigate. Well managed fertigation should result in low losses in the range of 0 to 10 kg N/ha/year. As water can be captured at the bottom of the container, losses should be able to be kept at 0kg N/ha/year.

6.5 Blueberry: Markets

6.5.1 Global

Blueberries are known to possess a range of healthy properties. They contain higher antioxidant levels than just about every other fruit and vegetable. It appears the blue pigment, anthocyanin, is the major contributor to the high antioxidant levels. Antioxidants prevent cell damage that occurs from everyday wear and tear. It is believed a diet high in antioxidants helps avoid such health problems as cancers and heart disease, as well as promoting good eyesight, urinary tract health and brain function.

Blueberries are available in a range of products including fresh fruit or frozen, fruit juice, powder, wine, jams, sauces, chutneys and of course muffins, with products available from growers, at grower markets, through supermarkets and retail outlets and online.

In 2018, the majority of New Zealand blueberry value is derived from exports of fresh fruit or individually quick frozen (IQF) fruit at around $35 million compared with domestic sales of around $21 million.

The quantity of total blueberry exports (including fresh and IQF) has increased by 82 percent over the seven years to 2018. At the same time, the value of the exports increased by 140 percent. Fresh exports constitute approximately 80 percent of exports by weight, and IQF approximately 20 percent.

New Zealand's distance from overseas markets mean that fresh blueberries need to be air-freighted, putting New Zealand at a price disadvantage in those markets.

Predictions are that the export industry could be worth more than $60m by 2022.

6.5.2 Domestic

Blueberries are versatile and well suited to a variety of marketing techniques including wholesale and direct to consumer.

Blueberries may be marketed wholesale as fresh or processed products. Marketing cooperatives can be established to sell large volumes of fruit. Sales of field grown berries for processing (IQF) might be the easiest market to provide for, since some fruit quality requirements are less stringent and processed products are less perishable than fresh fruit. Processed berries can also be harvested mechanically, reducing picking costs and need for seasonal labour. However, processed blueberry prices are much lower than fresh prices, so profit margins are narrower.

Producers near large populations may find marketing directly to the consumer to be the most financially rewarding. Direct sales include farm or roadside marketing and PYO (Pick Your Own). The primary advantage of direct marketing is that retail prices are higher than wholesale. However, direct marketers must assume liability for customers, provide parking and sales facilities, and have a flair for promotion and an ability to work with people.

This model is based on fresh export sales, with smaller percentages directed to fresh local market and processing.

6.6 Blueberry: Infrastructure and Investment

The amount of infrastructure required depends on the scale being sought, the area available, the degree of sophistication that will be implemented in the orchard, whether uncovered or covered production is targeted and whether the farm's existing assets can be used or modified for use.

A small operation may be set up on one or two hectares with mowing and spraying equipment and a shed for packing and selling to the local market and perhaps to an exporter. A large operation may be set up on 50 hectares, fully enclosed with bird netting, harvesting machinery, grading and packing facilities, and with its own exporting arm.

Specialist harvest machinery may be needed. Harvesting machinery is often used to pick fruit destined for processing. Hand-picking fruit ensures top-quality fruit is selected; however, labour is one of the biggest costs for fresh market blueberries, as well as a constraint in having access to that labour.

Not all infrastructure is required immediately. Bird netting, harvesting and grading machinery may not be required until year two or three onwards, with more equipment required as fruiting reaches its peak.

Typical infrastructure required may include:

1. Tractors
2. Sprayers
3. Irrigation system
4. Shelter belts on windward side
5. Harvesting machinery (if applicable)
6. Mowing and mulching equipment
7. Bird netting/tunnel houses
8. Grading, packing, and cool storage facilities

Costs of establishing a conventional field-grown blueberry orchard vary according to how much development work (shelter, irrigation, land preparation) is required, ranging from about $30,000 per ha (established shelter, no irrigation required), up to over $100,000 per ha starting with bare undeveloped land requiring significant modification and a bird exclusion canopy.

Costs of establishing a high-density covered blueberry orchard is significant. The development costs for a covered blueberry orchard from bare undeveloped land will be approximately $280,000 per ha, including shelter belts, irrigation, land preparation, bird exclusion, and polyurethane tunnel houses.

6.6.1 Blueberry Model Farm – Capital Investment and Gross Margin

The following model is for a commercial high-density covered blueberry orchard. Early production is an important factor in economically viable production. Blueberry orchards should have a small crop in the second year after planting, with full production volume achieved in year six. Growers should plan to harvest 5 tonne/ha by year 2 and 21.5 tonnes/ha by year six. These yields have been achieved by New Zealand growers with good management in suitable environments.

Note that most new blueberry developments are tunnel house production systems, where the plants are grown on top of the ground in containers. Growing containers are beneficial as they allow the growing medium pH to be kept acidic more easily than trying to lower field soil pH. AgFirst have chosen to make the model farm a high-density tunnel house scenario to better reflect the evolving blueberry industry, and because this is considered the more viable option for the Tararua climate.

Table 6.1. Covered Blueberry Orchard Gross Margin

Blueberry Orchard	per Ha	per plant
Plants/ha	4300	
Yield (Kg)	**21,500**	**5.0**
Export Packout	80%	
Export $/kg	$15.50	$62.00
Domestic $/kg	$12.50	$9.38
Process $/kg	$2.00	$0.50
Income ($)	**$309,063**	**$71.88**
Postharvest costs	$98,900	$23.00
Levies	$710	$0.17
Orchard Gate Income ($)	**$209,453**	**$48.71**
Harvest	$96,750	$22.50
Seasonal pruning	$7,200	$1.67
Permanent wages*	$40,000	$9.30
Total labour expenses	**$143,950**	**$33.48**
Pollination	$2,000	$0.47
Weed and Pest	$1,793	$0.42
Fertiliser and lime	$7,200	$1.67
Electricity	$1,000	$0.23
Vehicles	$800	$0.19
R&M General	$400	$0.09
Sundry & general expenses	$600	$0.14
Total working expenses ($)	**$13,793**	**$3.21**
Gross Margin ($/ha)	**$51,710**	**$12.03**

Table 6.2. Covered Blueberry Orchard Development Costs.

Development Costs	$/ha
Site Establishment Costs	$33,800
Ground preparation	$5,000
Planting cost	$19,350
Trellis	$4,000
Infrastructure - Tunnels & Canopy	$186,000
Irrigation	$11,480
Plants	$21,500
Total	**$281,130**

Table 6.3. Covered Blueberry Orchard Stats

Orchard area	5 ha
Mature yield	21.5 t/ha
Time to mature yield	6 years
Operating costs covered	3 years
Breakeven	11 years

Table 6.4. Covered Blueberry Orchard Sensitivity Analysis- Gross Margin by Yield and Price

	Yield change (t/ha)					
Price Change ($/kg)		**18.5**	**20.0**	**21.5**	**23.0**	**24.5**
	$12.00	$557	$602	$647	$692	$737
	$13.50	$28,307	$30,602	$32,897	$35,192	$37,487
	$14.38	$44,494	$48,102	**$51,710**	$55,317	$58,925
	$15.50	$65,307	$70,602	$75,897	$81,192	$86,487
	$17.00	$93,057	$100,602	$108,147	$115,692	$123,237

Gross margins for well-managed covered blueberry orchards can achieve $51,710 to $108,000 per hectare. In the above model, assumed yields are 21.5 tonne/ha by year six and the average price of $14.3/kg for all fruit sold.

However, returns depend greatly on whether fruit are for the wholesale processing market or the fresh direct to consumer market. The above model is based on an 80/15/5 split between fresh export, fresh domestic, and process berries, where fresh export berries return $15.50 per kg, fresh domestic berries return $12.50 per kg, and process berries return $2.00 per kg

6.6.2 Assumptions

This blueberry orchard model was supplied by a large New Zealand grower and was adapted for this project. It is based on having a point of sale after fruit have been harvested and freighted to a buyer, where it is sold unprocessed, and the orchard does not incur storage and processing costs.

Currently there are no blueberry processors in the Tararua District and therefore growers may need to build storage facilities and/or processing facilities which would impact the gross margin. Storage is expensive and Hawke's Bay fruit growers spend about 11 cents per stored kg which could cost a mature orchard $2,000 per ha.

Site establishment costs are mainly plant royalties and containers for plants.

Establishment costs do not include costs which do not increase and decrease with every hectare. For example, the farm may have already, or many need to purchase items such as:

- Tractor
- Sprayer

- Mulcher/mower
- Equipment shed
- Automated irrigation control system that covers the entire planted area
- Shelter trees

The income figure of $14.38/kg was based on an 80/15/5 split between fresh export, fresh domestic, and process berries, where fresh export berries return $15.50 per kg, fresh domestic berries return $12.50 per kg, and process berries return $2.00 per kg and the income will vary based on variety, season and fruit size.

Most of the New Zealand blueberry crop is grown in Waikato and Bay of Plenty. Harvested fruit could be placed in containers and bins suitable for short-term storage and then transported to the final processing plant and point of sale. On-site coolstorage may be required to cool the fruit immediately after harvest before it is transported away.

Running costs like pest and disease control, fertiliser, electricity and R&M have been supplied by a Hawke's Bay blueberry grower.

6.6.3 Harvest and Harvest Machinery

Blueberry plants generally reach full production within 6 years after planting; however, partial crops may be harvested from the second year after planting. Yields on a typical blueberry site will run from second to sixth season, respectively, 5,000 to 21,5000 kg per hectare. Mature plantings are reported to yield 21,500 and up to 30,000 kg per hectare.

Blueberry plants do not ripen simultaneously throughout the fruit cluster; therefore, blueberries must be picked several times during the growing season. The harvest interval, usually 7 to 10 days, has the greatest effect on berry quality.

Manual harvesting is best for high quality fresh market fruit and it is most important for growers of blueberries to provide top quality fruit. If fruit are picked early, they will reach the maximum size and sweetness, while overly mature fruit quickly deteriorates, attracts birds and often falls to the ground.

Blueberries can be machine harvested and many growers employ both manual and mechanical methods. As the scale of operation develops in New Zealand, mechanisation will become increasingly necessary to reduce labour costs. With mechanical harvesting, some form of grading fruit would be required to sort out the different stages of fruit maturity. As an alternative to the vibrating mechanisms of the 'down the row' or 'straddle harvesters', handheld vibrating fingers are available that shake the ripe fruit from the bush on to a portable canvas catching frame. The fruit is placed in a container and sent to a cleaning unit for sorting and trash removal. Machines have been developed overseas that can be adapted to harvest both blackcurrants and blueberries. The growing of these two crops in combination has merit and would increase the usefulness of such a high cost machine.

Currently there are no known commercial harvesting contractors in New Zealand, so orchardists must either share harvesting equipment with other orchardists or invest in their own equipment.

The capital cost of harvesting equipment increases with the sophistication of the equipment and can range $20,000 for a hand-held harvester to self-propelled machines in excess of $150,000.

6.7 Blueberry: Resource Limitations

The main resource limitations in terms of blueberry production include:

1. Capital for development cots
2. Propagation wood and limited varieties
3. Free draining soils with low pH
4. Consultants and advice for blueberry husbandry and production
5. Seasonal harvest staff
6. Machine harvester
7. Postharvest processing facilities

Highbush blueberries are difficult to propagate and as a result, bud wood is limited. Waimea Nursery, one of New Zealand's largest blueberry nurseries, is not currently supplying Highbush varieties and there is at least a 12-24 month waiting list for other varieties.

Field grown blueberry developments have more physical land limitations than tunnel house blueberry development. Free draining soils with low drought risk are ideal but the amount of these available is limited in the area designated for horticulture in the Tararua District. Artificial drainage has been budgeted, however, meaning that the scope of this land use broadens into soils that have imperfect or even poor drainage. Blueberry bushes also require soils with low pH to achieve optimal production. Therefore, soil pH adjustments will need to be made 6-12 months prior to planting. Another option is growing blueberry trees in containers on top of the soil, ultimately eliminating most soil constraints.

Consultants and advice for blueberry husbandry, nursery production, and blueberry specific disease and pest issues, as well as contractors to install tile drainage and plant trees are missing from the Tararua District. That is why the manager needs to be passionate about the crop, able to research issues themselves and good at problem solving to ensure the success of an operation such as this.

Machine harvesters for blueberry production are not common in the Tararua District, though they may be found in other regions (e.g. Waikato and Canterbury).

Currently there are no blueberry processing facilities in the Tararua District and freighting berries to other districts will increase costs and requires trucking and roading facilities.

6.8 Blueberry: Skills and Labour

The manager of this operation would need to have experience in fruit growing, an interest in blueberry production, and the ability to perform research and problem solve as issues arise.

Operational and management tasks would include:

1. Directing planting with the help of a crew of farm workers in winter.
2. Mowing and weed control.
3. Plant nutrition management, including leaf and soil analysis, and fertiliser applications.
4. Irrigation monitoring, including irrigation scheduling and system maintenance.
5. Pest and disease control, including scouting, identification and spraying appropriate chemistries.
6. Harvest management, including hazelnut maturity monitoring, orchard floor preparation, and harvester operation.
7. Tree pruning to maintain tree structure and plant productivity.

A 5ha covered orchard would require one manager and four fulltime orchard workers year-round. In a smaller blueberry development, the manager would also do hands-on farm work as well as management work. There would be additional labour required for some seasonal tasks. In a mechanised harvest system, only pruning would require additional labour.

Hand-harvesting an orchard would require an additional 6 contract pickers per hectare, harvesting 6 kg fruit per hour, working 40 hrs per week over the 12-week harvest period. This would cost approximately $96,7500 per hectare. For a 5-ha orchard, an additional 30 contract pickers would be required.

Aside from hand-harvesting, pruning is the most expensive labour cost for blueberry producers. Pruning will require approximately 360 labour hours per ha (5 minutes per tree) and a 5-ha orchard would require approximately 1800 labour hours of pruning, plus management. The manager would spend the entire time monitoring pruners. As an example, to get the pruning done in 2 months, about 4 extra season workers would be needed, if they worked 40 hrs per week. Pruning can start straight after harvest (May) and finish in August or even September, so the job could also be done with just the existing permanent staff in 4 months if they worked 40 hrs per week.

6.9 Blueberry: Conclusion

Blueberries will grow in the Tararua under weather protection. Some areas that are warmer micro-climates with less flowering and harvest time rainfall may gain acceptable levels of production with field grown blueberries, however, the year to year risk of losing a crop means that growing plants in raised beds/containers and under tunnel house is the preferred option for the Tararua.

Irrigation will be required, and it is advisable to connect to a fertigation system so that each container gets the precise amount of water and nutrition is requires.

Flat land will be necessary, but the soil type can be anything not prone to surface ponding if growing in raised containers. Nutrient losses will be able to be managed to near 0 kg N/ha/year in this system, while in field grown systems, losses will be able to be carefully managed down to the same range as apples at 3 to 24kg N/ha/year.

Undercover blueberries are a profitable option but require the availability of large amounts of capital to set up.

Land area required is lower than other crop options in this study to make a functioning business. A small blueberry operation could be set up with just 5ha of land, where the manager is also a hands-on farm worker. Very small operations of 1 to 2ha can be viable in the same way, and the manager might only work part time on the blueberry operation.

Main resource limitations include access to plants and varieties, people skilled in growing the fruit, harvest labour and postharvest facilities to pack and store the fruit.

Table 6.7. Blueberry Summary Table

Crop	Blueberry
Temp / GDD	Mean summer temp 15 to 26°C
Frost	Protect from flowering to -2°C. Frosts from flowering below -3°C unsuitable.
Frost free period	>160 days
Winter Chill	800 to 1200 hours. Less than 700 unsuitable.
Flowering time	Varies depending on cultivar and climate from August to November
Harvest time	December to March
Rainfall	Annual 800 to1000mm. Rain at flowering and harvest an issue
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat (indoor) to undulating (field grown) 0 - 7°
Soil depth	>60cm best. <40cm not suitable. Container = no restriction
Soil type	Fertile, well drained acidic soil. This can be in containers
Avoid	Standing water, pH above 5
Nitrogen loss if well managed	N loss 3 to 24kg/ha, or nearing 0 undercover
Fert timing	Mid Sep to Dec
Water requirement	Needs irrigation. 330 to 350mm/year and 80 to 90mm/month estimated for Tararua
Market modelled	80% fresh export, 15% fresh local, 5% process
Supply chain end budgeted	Fresh harvested, graded, packed in punnets, domestic transport. No coolstore costs included
Harvest	Hand harvested
Labour needs	High
Land area required	2ha to 30+ha
Gross margin and sensitivity	$51,710 per ha. If price average is $15.50/kg, $75,897/ha.
Development Costs	$281,130/ha in model plus coolstorage, machinery and automated irrigation control
Breakeven (model)	11 years. Potential for upside on price

7.0 CIDER APPLE

7.1 Cider Apple: Background

Cider making is a new industry in New Zealand, but an age-old practice globally. Most cideries currently operating in New Zealand source apples from the run-off of the apple export industry. Only a few small cideries also grow their own fruit. The process grade apples that get sorted out in the export packhouse go to apple juice concentrate, dried apple, cider and many other processed products. These processed grade apples are a cheap resource, with packhouses facing the alternative of paying to dump tonnes and tonnes of fruit. Many cideries start their cider making with apple juice concentrate, made with these processing apples. This allows the cidery to steadily make cider throughout the year, rather than in one big rush after harvest.

However, the best apple cider is not made from the increasingly sweet export favoured apples. As New Zealand supplies more and more Asian markets, the variety mix is moving towards sweeter apples like Fuji, Pacific Queen and Envy™. There is a burgeoning craft cider market in New Zealand, and opportunities for export, but current cider makers are struggling to find a good supply of tangy cider apples with high tannin and malic acid content.

Cider apple production systems must compete on price, considering the ability of cideries to continue their current methods of making cider from sweeter export varieties. The production system therefore will need to be low input, high tonnage and machine harvested to keep costs down. Currently the largest grower of cider varieties harvests below 150 tonnes, which at 60t/ha is 2.5ha. However, the competing land use in the apple growing regions is export, which pays more, hence this is the focus of current apple growers.

7.2 Cider Apple: Soils

Flat land (slope class A) is ideal. Slope class B (4 to 7°) or even the low end of C (8-15°) in rare cases could be used in wide cider systems, depending on the ability of the tractor, sprayer and machine harvester to work on slopes. Land that is slightly sloped in a way that will enhance cold air drainage and therefore reduce frost) risk in the orchard is desirable, but North or East facing sloped would be better than south or west, due to radiation levels and the prevalent south west winds.

Preferred soils allow deep rooting, so need to be relatively free draining and be capable of withstanding heavy machinery traffic, e.g. tractors and sprayers, and machine harvesters. The heaviest traffic is in the side seasons—spring with pest and disease control and autumn with harvest. This makes orchard drainage (either natural or artificial drainage) extremely important.

For cider apples, recommended soils classes in the Tararua district include:

- BFT - Typic Firm Brown Soils
- BLA - Acidic Allophanic Brown Soils
- BLT - Typic Allophanic Brown Soils
- LOT - Typic Orthic Allophanic Soils
- RFW – Weathered Fluvial Recent Soils

The soil class GOT (Typic Orthic Gley Soils) could be used in cider apple production if artificial drainage is installed. The cost of artificial drainage has been included in the development budget.

7.3 Cider Apple: Climate

Winter chilling is required for pipfruit before they will put resources into bud development in spring. Tararua has more chill unit accumulation than Hastings and this will not be a limiting factor. Chill units can be measured in a variety of ways. The estimated requirement for hours below 7°C is 1200 to 1500 hours.

Over 1000 GDD’s would be ideal for cider apples and 800 is commonly used as a minimum level, although apples are grown in Otago with lower GDD’s than this in some years. GDD’s are not the limiting factor for growing apples in Tararua District.

Apple and pears are best grown in regions with relatively low levels of summer rainfall. Spring and summer rainfall increase the risk of disease and restricts the number of days spraying is possible. Rainfall in autumn can inhibit a grower’s ability to keep the tree under mild moisture stress coming up to harvest, to keep flavour concentrated. Rainfall through harvest can also inhibit the number of days available to harvest the crop. Nelson is a useful comparison region, as it is a key apple growing region that has a lot more rain than Hawke’s Bay. Nelson’s average October to April rainfall is 665mm, with a range of 400mm to 1070mm in the 2009 to 2018 growing seasons. The 2 years with over 1000mm were weather systems that hit during harvest and resulted in lower quality fruit those years. Nelson’s average rainfall during flowering is 270mm, and at harvest is 330mm. This indicates that Pahiatua, Woodville and Dannevirke have similar overall season rainfall, but that rainfall at flowering may be the main issue for growing apples in the Tararua area, apart from Dannevirke.

Well-drained soils will be necessary, as well as a tight program of disease management over this flowering period. Also, flowering and harvest in Central Hawke’s Bay are generally two weeks later than Hastings. It is likely that the Tararua district will be later again, perhaps 3 weeks after Hastings. Hastings full bloom dates range by variety and year, from the last week of September to the third week of October. Hence Tararua full bloom is likely to be mid-October and even into November.

High rainfall will be a limiting factor in the Tararua for cider apple production. Spring will require more spraying for disease, and the number of days bees are active for pollination will be reduced. Harvest may be inhibited by rain days, unless the harvesting machine can work in wet weather, but in all cases the average rain days during harvest are less than Nelson. Postharvest rots will increase if fruit is harvested wet, so it would need to be processed fast.

Hail and frost also injure pipfruit. Hail can be controlled with hail netting or insurance, or the risk is taken on by the grower. In a low investment cider apple situation, hail nets will likely be too expensive, and the level of insurance will be a business decision.

Frost will damage fruit below -1.5°C during the growing season. Frost is never uniform through an orchard, so frost protection is generally needed once temperatures go below 0°C. The number of days this occurs during the flowering period is higher in Tararua than Hastings, which means more nights where frost fighting must occur. The October and November frosts are most important, because bud break in Tararua will be later than Hastings. Frost protection can only protect to a certain severity. E.g. a wind machine might create a 2°C lift in temperature. In this case, a recorded -2°C frost may not damage the plant, but a more severe frost of -5°C will still damage the plant. Frost is commonly controlled with frost fans, but sprinkler systems, especially overhead sprinklers, and other heat sources can also be used. Number of frost-free days (FFDs) indicated that most of Tararua has enough FFDs to grow cider apples, and those frosts in September through November are at levels that can be controlled using frost protection and land slope.

Pipfruit crops need good protection from wind for satisfactory yield and quality. Live shelter belts are the preferred shelter for pipfruit orchards. Tararua is a windy district and sheltered microclimates should be sought for planting. Shelter belts will be necessary even within these.

7.4 Cider Apple: Environmental

7.4.1 Nutrition

Apples remove 0.6 to 1.1 kg nitrogen per tonne of fruit (MAF, 1986). The level of nitrogen in fruit depends on variety grown, for example it was found by Palmer and Drydon (2006) that the Cox Orange N content was higher than other varieties. The other factor is excessive nitrogen available for luxury uptake.

Phosphorus removed in the crop is about 0.1kg per tonne of crop (Palmer & Drydon, 2006):

Table 7.1. Nutrient Removal by an Apple Crop

Tonnage	N Removed/ha	P Removed/ha
50t/ha	30 kg	5 kg
70t/ha	42 kg	7kg
90t/ha	54 kg	9kg

In practical terms, a pre-harvest leaf test, leaf colour and history determine levels of fertiliser nitrogen applied to apple orchards. In general, a non-cider apple tree will get 0 to 50 kg N/ha/year depending on these tests. The most common application is 150 kg/ha CAN (calcium ammonium nitrate, 27% N) postharvest, generally in May. Ground nitrogen application must go on while there are significant amounts of leaf actively photosynthesising, or roots will not take it up and it will leach. On deep, fertile alluvial soils which have high natural nitrogen mineralisation, nitrogen is often not required and would be detrimental to the crop.

Phosphorus management is simpler. It is a less mobile element in soil, and annual soil testing results, usually reported as Olsen P, are used to determine if a maintenance application of P is required. Cider apple orchards would likely be recommended to sit between 25 and 35 Olsen P. Apple orchards generally do not require a phosphorus application every year. Instead, phosphorus is applied when the soil test shows Olsen P is getting into the low 20's.

Foliar nutrition is a great way of targeting the leaves with the nutrients they are lacking, and this is done in apples for both nitrogen and phosphorus along with many other nutrients in apple orchards.

7.4.2 Water

This is very dependent on the water holding capacity of the soil. A basic water balance for Tararua indicates that there is a deficit of 200 mm per year in Dannevirke, 150mm in Pahiatua and reducing to 100mm farther south in Eketahuna.

Table 7.2. Apple Water Budget to cover all months 2007-2018

Area	Mm/year	Mm/Month
Dannevirke	200	90
Pahiatua	150	85
Eketahuna	100	75

*Crop factor of 0.7, soil WHC 100mm, using 50mm before irrigating

Water will only be needed for apples in Tararua when trees are young in summer, and then in very dry spells from then, since mature trees can handle, and benefit from, some water stress. It would not be surprising to go most summers without irrigation once trees are established, but it is always advisable to have water available to irrigate if a drought hits while trees are young. Export apple orchards nowadays have irrigation, but a lower capital-intensive cider apple orchard, especially in the wetter Tararua district, might be better off without installing fixed irrigation.

To be on the conservative side, Irricalc indicated for Eketahuna that 200mm, or 2,000m3 per year would cover all but the most severe droughts (90th percentile). It indicated 40mm/week and 110 mm/month are the peak needs at this same percentile. However, Hawke's Bay is much drier with only 750mm/year and often Hawke's Bay apple orchards are fine with between 100 and 120mm/month as their consented volume.

7.4.3 Leaching Loss

Most of the information on apples in New Zealand is modelled through SPASMO and Overseer. A Nelson study by Fenermore et al (2015) applied 20kg/ha to the ground in spring, and 20kg/ha only as foliar sprays during Autumn. It resulted in between 3 kg N/ha/year and 18 kg N/ha/year leaching loss, depending on soil type. In this modelling situation, soils with faster drainage throughput (lower water holding capacity) leach more because the nitrogen is not accessible to the roots for as long before it is washed beyond the rootzone. One paper was found that measured one season of nitrate loss from two apple orchards in the Hawke's Bay, which were 10 and 15kg N/ha/year respectively (Green et al, n.d). This gives confidence that the modelling for apple orchards is in the right realm.

To determine leaching losses in the Tararua District, the Overseer model was set up in Eketahuna, Pahiatua and Dannevirke, each on a deep or moderately deep silt loam (Eketahuna on Eket_18a.1 and Pahiatua and Dannevirke on Orono_64a.1). All blocks were 70 t/ha apple blocks, with tile drains, soil moisture probe-controlled drip or sprinkler irrigation and fertiliser only applied as 150kg/ha CAN in May (postharvest). This is 41kg/ha nitrogen, banded on the tree row. The results are shown in Table 7.3.

Table 7.3. Apple Overseer Budget Results

Area	N loss per planted ha	P loss per planted ha	N loss applying CAN 1 month earlier
Dannevirke	26	0.4	14
Pahiatua	23	0.4	15
Eketahuna	23	0.4	17

Overseer calculates that much of a May application would be lost to the orchard, both in Tararua and Hawke's Bay. The reason it is done in May is that this is the first chance the grower gets after a busy harvest slows down. However, in terms of the tree, CAN applied straight after harvest would be more efficient. It is recommended that growers in Tararua plan on applying any CAN necessary in March or April, and hence plan on getting a contractor to do the spreading if they are too busy. Whether a block gets CAN spread should be based on a leaf test or nitrogen deficiency symptoms.

7.5 Cider Apple: Markets

In recent years, cider globally has had the greatest growth rate of any alcohol category. Reasons quoted are

- The advent of 'flavoured ciders' in the 1980's which add other fruit flavours over the apple base
- Increased demand for lower alcohol drinks
- Increased demand for gluten free drinks

Domestically, cider consumption has followed this trend with flavoured ciders becoming popular as a drink for the younger population, while a boutique beer and cider market has flourished. As the generation who started on the sweeter ciders age, their palate will change towards more traditional and complex ciders.

A member of the Fruit Wine and Cider Makers Association New Zealand estimated that 20,000 tonnes of apples currently go to cider production each year, and that more than 98% of this is from dessert apples.

Specialised cider makers that utilise traditional cider varieties include Peckhams in Nelson and Paynters and Zeffer in Hawke's Bay. Some grow their own supply, but it is minimal, with the largest cider grower currently under 3ha.

Many members of the cider industry that were contacted indicated that they are interested in developing a greater supply of cider apples, which would become a small section of their apple supply at first, say 5% to 15% of intake apple volume. Adding 10% of the current estimated volume of NZ apple intake volume, this equates to about 33ha of orchard assuming it produces 60 t/ha. However, companies like Zeffer Cider in Hawke's Bay have fast growth plans and the mature harvest from the orchard will be about 10 years from now. Hence Tararua growers need to think about not the current demand, but the demand in 10 years.

Tararua cider growers have the potential to supply current cideries with fresh cider apples, or supply processing companies with cider apples to either coolstore and juice on demand for cideries, or create cider apple juice concentrate, which would then be sold to cideries.

Tararua growers could also grow apples to make their own ciders and capitalise on the wine trails of the Wairarapa and the presence of the Tui Brewery, combining tourism with cider making and tasting.

The demand from cideries is for apples in the 'Bittersharp' or the "Bittersweet" cider apple category. The 'bitter' means they have high tannin content, which is key. Sweetness is available in oversupply, acid comes in the form of malic acid in apples and is desirable, but cider makers can buy malic acid to add to cider if they need. The tannin in apples, however, is hard to source in the NZ variety mix and cannot be so easily replaced.

Some examples of high tannin containing apples are

- Kingston Black
- Bisquet
- Yarlington Mill

The conversion rate differs by variety and by crushing efficiency, but the following is a rule of thumb to convert kg of apples to apple juice, to fermented cider:

Table 7.4. Apple to Cider Conversion Factor Estimate

Unit	Product	Range
1 kg	Fresh fruit	
0.7 L	Apple juice	0.5 L to 0.9 L depending on apple and crushing efficiency
0.65 L	Fermented cider	Between 90% and 95%

7.6 Cider Apple: Infrastructure and investment

Infrastructure required will include

- Tractors
- Sprayers
- Makeshift irrigation capacity to mitigate drought risk while trees are young
- Shelter belts
- Harvesting machine (both shaker and harvester, or a machine that does both)
- Apple bins
- Forklift to lift full bins
- Mowing and mulching equipment
- Ladders for pruning
- Frost protection

Cider apples should have a designated manager who is passionate about growing the fruit. It is estimated that 30 ha would support a manager and foreman, who would make use of seasonal workers for pruning. In the Tararua, the way to do this may be to have, for example, 3 farms each plant 10 ha which are within 20km of each other for machinery movement. They would combine their area and the manager would oversee all the sites and carry out most orchard tasks with the foreman. Together, the 30 ha could invest in a machine harvester.
Note that a 'working manager' can look after areas down to 20ha in apples, however the 30 ha has been used because of the scale needed to supply a machine harvester.

7.6.1 Cider Apple Model Farm – Capital Investment and Gross Margin

Table 7.5. Cider Orchard Gross Margin

Cider Apple Orchard	per Ha	per plant
Plants/ha	1250	
Yield (Kg)	**60,000**	**48**
Process Packout	100%	
Income $/kg (processing)	$0.40	
Income ($)	**$24,000**	**$19.20**
Freight to cidery	$1,200	$0.96
Coolstorage	$0	$0.00
Orchard Gate Income ($)	**$22,800**	**$18.24**
Machine harvest	$0	$0.00
Seasonal pruning	$2,500	$2.00
Permanent wages*	$3,000	$2.40
Total labour expenses	**$5,500**	**$4.40**
Weed and Pest	$1,000	$0.80
Fertiliser and lime	$200	$0.16
Electricity	$200	$0.16
Vehicles	$90	$0.07
Fuel	$100	$0.08
R&M General	$700	$0.56
Sundry	$500	$0.40
Total working expenses ($)	**$2,790**	**$2.23**
Gross Margin ($/ha)	**$14,510**	**$11.61**

*Permanent wages include one manager and one permanent worker

Table 7.6. Cider Orchard Development Costs

Development Costs	$/ha
Land Value	$0
Ground preparation	$1,000
Tile drainage 40m	$11,000
Planting Cost	$625
Tree cost	$18,750
Irrigation	$0
Machine Harvester	$4,000
Total	$35,375

**Frost protection, machinery apart from the harvester and shelter establishment not included*

Table 7.7. Cider Orchard Stats

Orchard area	30 ha
Mature yield	60 t/ha
Time to mature yield	7 years
Operating costs covered	4 years
Breakeven	8 years

Table 7.8. Cider Orchard Sensitivity Analysis- Gross Margin by Yield and Price

	Yield (t/ha)					
Price ($/kg)		**40**	**50**	**60**	**70**	**80**
	$0.25	$910	$3,210	$5,510	$7,810	$10,110
	$0.30	$2,910	$5,710	$8,510	$11,310	$14,110
	$0.35	$4,910	$8,210	$11,510	$14,810	$18,110
	$0.40	$6,910	$10,710	**$14,510**	$18,310	$22,110
	$0.45	$8,910	$13,210	$17,510	$21,810	$26,110
	$0.50	$10,910	$15,710	$20,510	$25,310	$30,110
	$0.55	$12,910	$18,210	$23,510	$28,810	$34,110

7.6.2 Assumptions

This cider orchard model was built solely at an indicative level for this project. It is based on having a point of sale after fruit has been harvested and freighted to a buyer, where it is sold unprocessed, and the orchard does not incur coolstorage costs.

Cideries will require a steady supply of fruit whether fresh or already processed (apple juice concentrate). Hence there may be added coolstorage costs on top of this. Coolstorage is expensive, costing about 10 cents per stored kg (air coolstore). This is $6,000 added into the gross margin, in which case the income would have to increase substantially for viability.

The model assumes tile drainage is required, and that there is no permanent irrigation system. This will vary site to site, but this case is a soil with high water holding capacity that has inadequate drainage. A permanent sprinkler system could be swapped in instead of tile drains for a similar figure.

The income figure of $0.40/kg is only an estimate. As part of this project a query was put out through the Fruit Wine and Cider Makers Association New Zealand as to what price would be workable for the members to purchase Tararua cider specific apples. On top of this 40c/kg cost, they would then need to pay for coolstorage (10c/kg) and pressing of the fruit. Cost to press was not found but I estimate it would be a similar cost to processed juice. This comes to 60c/kg which at 70% juice conversion rate is 85c/L to the cidery. This will be about double what they are currently paying for fresh pressed (sweet apple) juice. Through informal discussions, the consensus seems to be that if it was under double the current cost they would be interested in building a business case and investigating, and if it went much over double the current cost this was most likely not going to work.

The freight cost in the budget is based on distances of 20 to 50km, which is $7 to $8 per 400kg bin. Bin weights for cider apples are likely 420 to 450kg per bin for the smaller fruit. They depend on the variety, season and fruit size. Transport to Auckland would be much more, so although there are cideries there wanting supply, the cost of transport may render this unprofitable.

Running costs like pest and disease control, fertiliser, electricity and repairs and maintenance have been adapted from knowledge of export apple and vineyard cost structures. There is not enough data available to predict how this might change for cider apples in Tararua, but this is our best guess on what they will require.

Costs do not include items that are not specifically 'per hectare' costs, as these will change per unit hectare based on the scale of the operation.

7.6.3 Harvest machinery

Machines exist, such as the Tuthill brand apple harvesters, that harvest the apples by first shaking the tree, and then collecting the fruit from the ground into large containers. Some machines do this together as one but cost a lot more.

The examples used in this budget are the Pattenden grouse at $72,000 not including shipping, and assuming that a shaker will be acquired for another $70,000. A total of $160,000 was used as an estimate of the cost + shipping. So many options are available at different price points that more precise costings were not sought at this level.

7.7 Cider Apple: Resource limitations

Bud wood and varieties available are large resource limitations. Through this project, contact was made with a cider grower who is happy to supply budwood. From here a nursery must bud the trees and grow them to a point where they will be ready for planting out, generally after 2 years.

Free draining soils with low drought risk are ideal but the amount of these available is limited in the Tararua District. Artificial drainage has been budgeted however, meaning that the scope of this land use opens up into soils that have imperfect or even poor drainage.

Consultants and advice for apple husbandry, as well as expertise in nursery production, cider apple specific disease and pest issues, contractors to install tile drainage and plant trees and more are missing from either the Tararua locality or the whole of New Zealand. That is why the manager needs to be passionate about the crop, able to research issues themselves and good at problem solving to ensure the success of an operation such as this.

Machine harvesters for cider apples are not common in New Zealand, though other harvesters might be adapted to work for cider apples.

Current cider producers and apple processing companies are a large distance from Tararua, which increases costs and requires trucking and roading facilities.

7.8 Cider Apple: Skills and Labour

The manager of this operation would need to have experience in apple growing, an interest in cider and the fruit qualities that cider makers want, or an interest to learn. Tasks would include:

- Directing planting with help of a crew of farm workers in winter
- Applying the correct nutrition (and emergency water in a drought situation) to the young trees
- Disease control, including spraying, trapping and placing pheromone ties but to a much lesser extent than in export production, due to the greater tolerance of insect chewed or misshapen fruit
- Disease walks to cut out any canker or fireblight, or other disease
- Choosing the chemical thinning regime to control biennial swing
- Timing harvest based on apple maturity indices
- Overseeing or operating the harvester

Pruning trees to keep the branches of the correct angles and age to support next year's crop
A base of 1 manager and 1 orchard worker would be estimated across the 30-ha orchard year-round. There would be additional labour required for some seasonal tasks. In a mechanised harvest system only pruning would require additional labour.

At $2 per tree (12 trees/hour and $25/hour) and at a row spacing of 4m by tree spacing of 2m, a cider apple orchard ß100 labour hours of pruning per hectare, plus management; a 30-ha orchard would require 3000 labour hours of pruning. The manager would spend the entire time pricing trees and monitoring pruners. As an example, to prune a 30-ha orchard in 2 months, about 9 extra workers would be needed, if they worked 40 hrs per week. Pruning can start straight after harvest (May) and finish in August or even September, so the job could also be done with just 4 extra workers in 4 months, if they worked 40 hrs per week. This method assumes the manager would be pruning a little as well as managing others.

This estimate is based on each tree only taking 5 minutes, which means the pruning job is focussed on chain sawing the overgrown branches out and using a ladder to lop out such branches in the top and moving on. For comparison, 4 by 2 m tree spacing blocks of export apples would cost $2 to $4 per tree depending on growth the previous season. This is because pruning must be more detailed to maximise light and red colouration.

7.9 Cider Apple: Conclusion

Cider apples will grow in the Tararua district in the warmer and drier areas of Woodville, Pahiatua and Dannevirke. In these areas, they will need good frost protection, shelter belts and specific attention needs to be paid to rainfall at the flowering time of the variety chosen. Lack of pollination due to rain, disease being spread by water and wet soils dropping flowers are all risks of growing apples in the Tararua District.

Well drained soils are important, whether naturally or tile drained to 1m depth. Apple trees are good at accessing water, and roots go deep, so water for irrigation may only be necessary when young. This avoids the need to install a permanent irrigation system. However, consented water should be available to irrigate trees in hot summers when roots are still shallow.

Flat to mildly rolling land will be usable and soils should be 70cm or more in depth. Avoid very heavy clay soils or pans, and soils that stay saturated into spring.

Nutrient losses were modelled on Overseer and with management focus can be reduced to 10 to 20kg N/ha/year.

Cider apples will always complete with export over-run fruit in New Zealand, however there is demand from cider makers to have access to cider-specific varieties. The gross margin is attractive but could easily be eaten into by extra costs of coolstorage of fruit, or longer transport distances.

Land area required for a cider apple orchard at a minimum is defined by the need for volume support a machine harvester. Export apple orchards in Hawke's Bay can operate at 10ha, with a manager who also works on hands-on jobs. However, a cider apple orchard in the Tararua will need 30-40 ha to cover costs of machine harvesting equipment, and in this case can hire a full-time manager and one orchard worker on the property.

Main resource limitations include access to plants and varieties, people skilled in growing the fruit, machine harvesting equipment and distance to storage facilities.

Table 7.9. Cider Apple Summary Table

Crop	Cider Apple
Temp / GDD	>800 GDD
Frost	Protect at flowering to 0°C. Fruit damaged below -1.5°C.
Winter Chill	1200 to 1500 hours below 7°C
Flowering time	October
Harvest time	March-May
Rainfall	Compare to Nelson 270mm average Sept- Nov rainfall. Less rain at flower better
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat to mild rolling 0 - 10°
Soil depth	>70cm ideal. >50cm not suitable
Soil type	Moderate to well drained
Avoid	Dense soils with high clay content, standing water
Nitrogen loss if well managed	Tararua modelled N loss 15 to 17kg/ha
Fert timing	Postharvest (March to April, or foliar)
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	100% NZ process for craft level ciders
Supply chain end budgeted	Fresh apples freighted to Hawke's Bay, no processing or storage costs
Harvest	Machine harvested
Labour needs	Low- Moderate
Land area required	10ha to 30+ha
Gross margin and sensitivity	$14,510 per ha. If 50t/ha and $0.35/kg, $8,210/ha.
Development Costs	$35,000/ha in model, plus frost protection and shelter belts which vary widely in cost could increase to $50,000.
Breakeven (model)	8 years. Unlikely to achieve higher yields, prices constrained by export over-run

8.0 FEIJOA

8.1 Feijoa: Background

Feijoa is a hardy evergreen shrub to small tree, native to the south eastern part of Brazil, northern Argentina, eastern Paraguay and Uruguay. Commercial orchards are established in California, Chile, Columbia and New Zealand.

Presently New Zealand area is estimated to be 240 hectares and is estimated to produce 1200 tonnes of fruit. New Zealand orchards are found mainly in coastal eastern parts of the North Island and the Nelson area in the South Island.

Feijoas are widely distributed throughout New Zealand as garden plants. Initially plants were seedlings of variable yield and quality. Now that the feijoa have become an established commercial orchard crop, considerable effort has gone into the development of high quality clonally propagated and named commercial varieties. These varieties have a range of harvest periods covering a six to eight-week harvest season. Waimea Nurseries website lists the varieties available, harvest season and characteristics.

8.2 Feijoa: Soils

Feijoas need moderately well to well drained soils with good water holding capacity, moderate fertility, and slightly acid to neutral pH levels. Light stony soils are less suitable than sandy clay loam soils. Soils should ideally be greater than 60 cm deep.

Slope needs to be flat to mildly rolling, (0 to 10°) and is restricted by the type of machinery required, the type of trellis, and whether nets are used to catch fruit. The more intense the land development using trellis and nets, the better it is to have flatter land.

The tree is quite drought tolerant but requires good summer/autumn soil moisture levels for satisfactory fruit quality and yields. Therefore, a soil with a moderate to high water holding capacity would be necessary, unless permanent irrigation was to be installed.

For feijoa production, recommended soils classes in the Tararua district include:

- BFT - Typic Firm Brown Soils
- BLA - Acidic Allophanic Brown Soils
- BLT - Typic Allophanic Brown Soils
- LOT - Typic Orthic Allophanic Soils
- RFW – Weathered Fluvial Recent Soils

The soil class GOT (Typic Orthic Gley Soils) could be used in feijoa production if artificial drainage is installed. The cost of artificial drainage has been included in the development budget.

8.3 Feijoa: Climate

Feijoas tolerate winter temperatures down to about -10°C and will tolerate similar minimum temperatures to pipfruit once fruit is present i.e. about -1.5°C.

Moderate annual rainfall in the range of 750 to 1000mm is preferred, with relatively low humidity over the better part of the growing season and harvest period.

Growing season temperatures tend to determine harvest period with cooler districts maturing fruit some four to six weeks later than the warmest districts. Note that the Tararua District, particularly the area to the west of the Puketoi Range, is a cool district.

Feijoa plants are tolerant of wind and are sometimes used as a hedging or shelter belt plant. However, for satisfactory commercial yield and fruit quality, good shelter from wind is required. Tararua District is very windy, so feijoa orchards would require good shelter.

Tharfield nursery states that the requirement is low, around 200 hours below 7°C. Winter chilling will not be limiting for the crop in Tararua District.

Flowering time is late compared to other fruit crops, in November to December. This is advantageous to avoid frosts killing flowers. Harvest period in Tararua is likely to be April – May. Make sure frost protection can protect from early frosts occurring during May.

8.4 Feijoa: Environmental

8.4.1 Nutrition

There is scarce information on feijoa in relation to environmental impacts. It is likely that the N content of the fruit is similar to other fruit between 1 and 3 kg N per tonne of crop. This would mean the feijoa orchard growing 25t/ha will export between 25 and 75 kg N per year. Like other permanent crops, much of this N can be provided by the soil, and nitrogen will be critical for young, establishing plants. Nitrogen fertiliser requirements at specific sites should be determined by leaf testing, with the optimum leaf concentration between 1.3% and 1.5% N.

MAF made a tentative recommendation of a total of 120kg/ha for a mature feijoa orchard. However, at the time of writing of their recommendations, allowance was made that leaching will occur and so excess needs to be applied to compensate for this loss. This is no longer an acceptable strategy environmentally.

For phosphorus, leaf analysis within the range of 0.06% to 0.08% and Olsen P of around 30 are suggested by MAF.

Timing of fertiliser application is in August, and then again in November-December (Jackson, 1989). Again, August timing will be risky for nitrogen loss to the environment.

8.4.2 Water

Feijoas can grow well in many parts of New Zealand without irrigation, and Tararua, being a wetter district, with relatively uniform rainfall, should be able to grow without a permanent irrigation system available. However, it would be ideal to be able to water the trees in at planting. If applying for a water consent, it would be useful to use the apple table as a guideline.

8.4.3 Leaching loss

There have been no leaching loss studies in feijoa. Feijoa root systems are shallower and more fibrous than apple (Morton, 1987). This will change the way in which fertiliser should be applied to smaller amounts more often, since large amounts will quickly wash beyond the rootzone. With good fertiliser management, leaching loss will be possible to be kept below 20kg/ha/year on average.

8.5 Feijoa: Markets

Feijoa production relative to other fruit crops is very small. Most of this production is destined for the local fresh fruit market, with a small fresh fruit export market mainly to Australia.

The local fresh fruit market is considered by existing growers to be well supplied with limited scope for expansion. There are groups working on expanding knowledge of the fruit in export markets and there is potential for some late season export market supply.

Feijoa is a difficult fruit to market as a fresh product because of its susceptibility to handling injury, invasion of fruit wounds by various fruit rots and the short shelf life of only three to four days at ambient temperatures. It can be coolstored for about 30 days at 0°C.

Feijoa pulp and juice is in high demand by fruit processors who are willing to pay well for processing fruit. This is viewed as an expanding market that is limited by fruit supply.

There may be limited "niche" markets for fresh fruit becoming available after fruit from earlier districts has finished. Such fruit would have to be of very high quality, with superb presentation. Outlets for this fruit would be very limited, and suppliers would have to have passion for the crop and be very skilled in husbandry practices.

Production for processing appears to have good market prospects for fruit from the district. There is unsatisfied demand and an expanding market. One large processor commented though, that feijoa flavours tend to go through 'fashion cycles' and that it is the smaller 'boutique' buyers of flavourings that will drive an increase in feijoa products, after which large brands like Pam's will follow later. Hence there may be volume restrictions on how many process orchards can set up in the Tararua District, until the NZ process market is also fully supplied.

8.6 Feijoa: Infrastructure and Investment

Infrastructure required will depend on requirement of the market receiving the fruit. Fresh market will require packing and coolstorage facilities. Where it is possible to ship fruit rapidly to a processor need for infrastructure is likely to be much lower.

Orchard equipment should include an orchard sprayer, compact high-powered tractor, sprayer and grass mower as a minimum, plus a forklift for handling fruit bins. Other than perhaps staking young trees, expensive trellis or support structure is not necessary. A budget will be required for extra small items such as ladders and fruit bins.

Frost protection required will depend on the site selected and the growers accepted level of risk. Irrigation capacity will be similar, the suggested minimum being the ability to set up some temporary irrigation for drought mitigation while trees are young.

Shelter will be necessary in the Tararua District.

For ease of management commercial feijoa trees tend to be squat and spreading, however branches need to be well clear of the ground to enable catching nets to be set up under the trees. Feijoa fruit readily rots if it comes in contact with the ground.

Planting densities are in the order of 500 to 700 trees per hectare.

Reported average yields are only five tonne per hectare, which indicates that either there have been a lot of recent plantings yet to begin cropping, or there are a lot of poorly managed plantings. Published data on feijoa yields indicates the following yield profile by age for a well-managed orchard planted at 5m x 3m spacing:

First crop in	3rd year	-	4 tonne / hectare
	4th year	-	8 tonne / hectare
	5th year	-	12 tonne / hectare
	At orchard maturity	-	up to 25 tonne / hectare

During the establishment period good control is necessary to encourage rapid tree canopy development. Some pruning and tree shaping are necessary to develop a tree structure suited to efficient harvesting.

Process feijoa crops could be mechanically harvested using 'shake and catch' techniques.

For regular cropping, provision for cross pollination is necessary. One or two named varieties are reported to be self-fruitful under favourable fruit set conditions over the blossom period. Feijoas are said to be pollinated by birds or bees.

Orchard size also depends on the system. It is estimated that 30ha would be ideal to make the purchase of machine harvesting equipment economically favourable and have 1 permanent manager on site who also completed hands-on orchard work. This 30ha area could be made up of a number of 5ha blocks situated close enough to share orchard machinery and other equipment.

If looking at an export focussed orchard smaller sizes would be viable. It would be ideal to still have enough area to have 1 permanent staff member, perhaps 10ha.

8.6.1 Feijoa Model Farm – Capital Investment and Gross Margin

These budgets are based on a process feijoa orchard.

Table 8.1- Feijoa Orchard Gross Margin

Feijoa Orchard	**per Ha**	**per plant**
Plants/ha	500	
Yield (Kg)	**20,000**	**40**
Process Packout	100%	
Income $/kg (processing)	$0.80	
Income ($)	**$16,000**	**$32.00**
Postharvest costs	$1,022	$2.04
Orchard Gate Income ($)	**$14,978**	**$29.96**
Machine harvest	$0	$0.00
Pruning	$0	$0.00
Manager wages	$2,200	$4.40
Total labour expenses	**$2,200**	**$4.40**
Weed and Pest	$1,000	$2.00
Fertiliser and lime	$100	$0.20
Electricity	$150	$0.30
Vehicles	$90	$0.18
Fuel	$100	$0.20
R&M General	$700	$1.40
Sundry	$600	$1.20
Total working expenses ($)	**$2,740**	**$5.48**
Gross Margin ($/ha)	**$10,038**	**$20.08**

Table 8.2. Feijoa Orchard Development Costs

Development Costs	$/ha
Land Value	$0
Ground preparation	$1,000
Tile drainage 40m	$11,000
Planting Cost	$500
Tree cost	$6,000
Machine harvester	$4,000
Total	$22,500

**Frost protection, other machinery & shelter establishment not included*

Table 8.3- Feijoa Orchard Stats

Orchard area	30 ha
Mature yield	20 t/ha
Time to mature yield	7 years
Operating costs covered	4 years
Breakeven	9 years

Table 8.4. Orchard Sensitivity Analysis- Gross Margin by Yield and Price.

	Yield change (t/ha)					
Price Change ($/kg)		**15**	**17.5**	**20**	**23**	**25**
	$0.50	$1,800	$2,923	$4,046	$5,169	$6,293
	$0.60	$3,297	$4,670	$6,043	$7,416	$8,789
	$0.70	$4,795	$6,418	$8,040	$9,663	$11,286
	$0.80	$6,293	$8,165	**$10,038**	$11,910	$13,782
	$0.90	$7,791	$9,913	$12,035	$14,157	$16,279
	$1.00	$9,289	$11,661	$14,032	$16,404	$18,775
	$1.10	$10,787	$13,408	$16,029	$18,650	$21,272

Assumptions:

This is a process model which includes freight to Hawke's Bay for processing and does not include any other postharvest costs of coolstorage or processing of the fruit. The machine harvest and pruning costs are zero because this cost is included in the manager's wages and in capital expenditure on a machine harvester.

Costs of development not directly related to each hectare size increase are not included. This includes tractors, sprayers, mulchers, frost protection and shelter belts. Miscellaneous tools like secateurs and ladders can also add up so make sure these items are thought through and a budget included for this when forming a site-specific development budget.

Where unknown, some expenditure costs have been adapted from more well-known industry costs of apple and grape production.

Machine harvesting equipment is budgeted for at a value of $120,000 to cover the 30ha area but depending on the product this cost will vary widely. More investigation will be required in this area to budget for specific machine harvesting equipment.

8.7 Feijoa: Resource Limitations

Access to knowledgeable crop husbandry specialists is a limiting factor for establishing new crops in districts where there is no culture of similar crops.

Feijoa are a minor crop so few pesticides, if any, carry label claims for use on the crop. In the event of pests and diseases becoming problems under local conditions, options for control could be very limited. For example, little is known about fungal diseases on feijoa. As it is a member of the myrtle family, it is possible that myrtle rust could become a problem in humid climates. Also, there are several fungi have been implicated in postharvest rots which are a significant feijoa storage problem. There have also been reports out of Northland of anthracnose wiping out feijoa crops during the growing season.

Packing and postharvest handling facilities are not locally available. For these to be commercially viable it may take many years before industry critical mass capable of supporting these facilities develops.

In the case of process growing, harvest contractors may be required, and suitable machinery developed.

Feijoa trees are available from established nurseries in New Zealand, but there is expected to be a wait time to gain access to large numbers of trees.

8.8 Feijoa: Skills and Labour

Compared to most fruit crops, feijoa is considered a low input crop, possibly on a par with wine grape production. Outside of the harvest period there is not a lot of labour required for feijoa.

Harvest labour, particularly for the fresh fruit market needs to be well trained regarding technique so orchard managers and foremen need to have very good communication, personnel and supervision skills. Growers have tended to minimise this problem by letting fruit drop onto catching nets.

Apart from the harvest period one motivated labour unit should be capable of looking after 20 to 30 hectares of process feijoa orchard. This differs from the other crops in that it is expected this one unit will be doing all orchard tasks.

Harvest labour is required late March, April and into May.

It is estimated one harvest labour unit should be able to harvest 40 to 60kg per hour i.e. 17 to 25 hours per tonne of fruit.

If operating a process feijoa orchard, the only harvest labour required are those to operate the machine and transport the fruit to its destination, perhaps the manager and one other unit.

8.9 Feijoa: Conclusion

Feijoas already are grown in the Tararua District for export and local production. They are frost hardy, have a later flowering than many other fruit crops and tolerate a wide range of climates throughout New Zealand. Harvest timing is expected to be in April-May, later than warmer growing districts, which could present a market supply opportunity. They are wind tolerant but in Tararua's windy climate shelter will be required, especially if aiming for export markets where wind rub is an issue.

Feijoas will benefit from flatter land with moderate to well drained soils. More sloped land restricts trellising and machinery access, but systems can be tailored to work on undulating or mildly rolling country (0-10°). Feijoas grow on a wide range of soil types, but heavy clays with standing water present should be avoided. Light, stony sands should also be avoided, especially if there will be no permanent irrigation system installed. Soils should ideally be 60cm in depth or greater.

Nitrogen losses are likely to be able to be kept between 10 and 20kg N/ha/year with careful fertiliser application management. Timing of fertiliser application is in spring.

It is advisable to have a water consent available to provide water when trees are young, and for very dry years. Overall, feijoas are reasonably drought tolerant.

The local fresh market for feijoa is at capacity currently, and the opportunities for feijoa are process or export systems. The orchard set up will be targeted to one or the other market. The orchard model is for process which has a lower gross margin than export, but which can have a very low capital set up. One of the drawcards for feijoa is also the ease of management.

Land area required for a process feijoa orchard at a minimum is defined by the need for volume to support a machine harvester. A feijoa orchard in the Tararua will need 30ha to cover costs of machine harvesting equipment, and in this case can hire a full-time worker on the property.

Main resource limitations include people skilled in growing the fruit, machine harvesting equipment and postharvest, processing or storage facilities.

Table 8.5- Feijoa Summary Table

Crop	Feijoa
Temp / GDD	Wide range of temperate climates.
Frost	Frost tolerant. Winter down to -10°C. During season, -1.5°C.
Frost free period	n.d. Frost protection from Oct-May to -1.5°C
Winter Chill	200 hours below 7°C
Flowering time	November-December
Harvest time	April-May, 4-6 weeks later than warmer districts
Rainfall	Moderate, 750 to 1000mm. Low humidity harvest
Wind	Require shelter-live shelter belts
Slope	Flat to mild rolling 0 - 10°
Soil depth	>60cm ideal. >40cm not suitable
Soil type	Moderate to well drained
Avoid	Dense soils with high clay content, standing water
Nitrogen loss if well managed	Likely 10 to 20kg/ha/year
Fert timing	Spring, mainly Nov-Dec
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	NZ process or fresh export market
Supply chain end budgeted	Machine harvested and freighted to Hawke's Bay, no storage or processing
Harvest	Machine modelled. Other options are touch picked or catch-nets for export
Labour needs	Low for process. Otherwise extra workers just for harvest
Land area required	10ha to 30+ha
Gross margin and sensitivity	$10,038 per ha. If price is $1.00/kg, $14,032/ha.
Development Costs	$22,500/ha in model, plus frost protection, other machinery and shelter belts
Breakeven (model)	9 years. Unlikely to get price upside unless supplying non-commodity processor

9.0 HAZELNUTS

9.1 Hazelnut: Background

The commercial hazelnut, *Corylus avellane*, is a nut-producing shrub or small tree native to temperate areas of Europe and Asia Minor. Hazelnuts are one of the most important and widespread nut species in the world due their reported health benefits and versatility.

The main hazelnut producing countries are Turkey, Italy, Azerbaijan, USA and China.

Hazelnuts have been commercial grown in New Zealand for nearly 50 years. Many areas of New Zealand are well-suited for hazelnut production and orchards can be found as far north as the Waikato and as far south as Southland.

Currently, New Zealand grows only small areas of nut crops and most of the nuts consumed in New Zealand are imported. Hazelnuts are a non-perishable product and therefore New Zealand production needs to be competitive with imports from overseas. A commercially successful hazelnut orchard will need to be productive, not located on very valuable land, and use machinery to reduce production costs.

There are opportunities for New Zealand hazelnut producers to supply domestic and export markets. High nut quality and high yields are necessary for profitable hazelnut growing and these requirements are achievable in the Tararua District.

This report focuses on the production of hazelnuts for the raw, unprocessed market.

9.2 Hazelnut: Soils

There are large areas in the Tararua District that are very well suited to growing hazelnuts as a primary crop or as part of a diversified cropping system on small holdings and larger farms.

For successful harvesting using machinery, the orchard must be flat or gently and flat land (slope class A) is ideal. Slope class B (undulating, 4 to 7°) or even the gentler areas of class C (rolling, 8-15°) could be used in depending on the ability of the machine harvester to work on slopes.

Hazelnuts have a fibrous root system with most of the feeding roots in the top 60 cm of the soil profile, therefore commercial hazelnut orchards require a fertile, well-drained soil. Land Use Class 1 and 2 soils are ideal and usually need very little modification. Class 3 soils will usually need extra management such as additional fertiliser, drainage (wet soils), ripping (clay soils and soils with a pan within the soil profile) or additional irrigation (free draining sandy or stony soils with a low water holding capacity).

The ideal soils for growing hazelnuts are loams with low salinity, a pH of 6.0 to 6.5, and soil depth greater than 60cm with no impeding layer within 1m of the surface. They tolerate clay soils and short periods of wetness better than many fruit crops, but inversely do not tolerate soils with low water holding capacity that are susceptible to drought

The bulk of root growth occurs in the upper 60cm of the soil profile, therefore, a soil depth of >60 cm is most preferable. Soil depths between 40 and 60cm can still grow productive hazelnuts, however, soils less than 40cm are not suitable for commercial production.

Hazelnut tree's fibrous root systems appear to have difficulty penetrating poorly structured soils. They also need good soil aeration, so moderate to freely draining soils are the most suitable. Topsoil pH of 6.5 is optimal, however, hazelnut production is possible at values between 5.5 and 7.1.

Although hazelnut trees can grow on less favourable soils, tree growth rates are slower, and trees take longer to come into full production because yields are strongly influenced by shoot growth.

For hazelnut production, recommended soils classes in the Tararua district include:

- BFT - Typic Firm Brown Soils
- BLA - Acidic Allophanic Brown Soils
- BLT - Typic Allophanic Brown Soils
- LOT - Typic Orthic Allophanic Soils
- RFW - Weathered Fluvial Recent Soils

The soil class GOT (Typic Orthic Gley Soils) could be used in hazelnut production if artificial drainage is installed. The cost of artificial drainage has been included in the development budget.

9.3 Hazelnut: Climate

9.3.1 Temperature

The primary climate factors that contribute to a successful hazelnut crop are the temperature at key growth stages and dry weather at harvest.

Commercial hazelnuts require a mild temperate climate. The main hazelnut growing areas in the northern hemisphere (i.e. Turkey and Italy) are characterised by mild summers and cool winters without extremes of heat or cold. Key temperature characteristics are:

1. Average annual temperature 12˚C to 16˚C
2. Maximum temperature 35 to 36˚C
3. Minimum temperature -8 to -10˚C
4. Chilling of 600 to 1200 hours (depending on variety)

Daily minimum temperatures during July should be above -8°C and below 10°C. Hazelnuts are frost tolerant. Male catkins shed pollen from late April to July, and female flowers open from June to September. Flowers will tolerate temperatures down to -8°C. For good flower fertilisation, mean maximum air temperature should be greater than 21°C. The mean maximum temperature in the warmest month should not exceed 30-35°C as hazelnuts could suffer heat stress if high temperatures combined with low humidity persist. There are variable reports as to heat requirements for hazelnuts, however, the growing degree days across the district would suit most hazelnut varieties.

Hazelnut trees have soft leaves and do not tolerate extreme heat, wind or moisture stress. In New Zealand conditions, good shelter is essential.

Warm dry weather over the harvest period between late February to early April in most areas of New Zealand, is advantageous. Dry weather lets husks dry quickly so that nuts fall free, the moisture content of the harvested nuts is low, and dry ground conditions favour easy machinery operation to pick up the nuts. Out of season frosts in November and December have caused hazelnut crop losses in parts of New Zealand. Temperatures recorded in orchards affected by frost damage in the South Island suggest that air temperatures of -2 to -3˚C may be enough to cause damage to nut clusters at this time. However, damage has been inconsistent, both within orchards and regions.

9.3.2 Water Requirements

Ideal annual rainfall is 800 to 1000 mm, with rain evenly spread throughout the growing season. Locations with rainfall well distributed up until February may not require irrigation. Locations that experience prolonged periods of dry weather between November and the end of January should install irrigation, especially if the soils have lower water holding capacities (often sandy or stony soils).

Another method of estimation is about 1 to 1.5 megalitres of water per hectare per season for every 150 mm of annual rainfall less than 900 mm (Redpath, 2016).

9.4 Hazelnut: Environment

9.4.1 Nutrition

Nuts are a strong sink of nitrogen due to their high protein content. They remove between 18 and 26 kg N per tonne of crop (Roversi et al., 2005), and with yields ranging around 12 kg/plant at maturity (Jackson, 1986) N removal per ha is high, as shown in the table below.

Table 9.1. Hazelnut Crop Removal of N and P

Tonnage	N Removed/ha	P Removed/ha
2 t/ha	36 - 52	NA
3 t/ha	54 - 78 kg	NA
4 t/ha	72- 104 kg	NA

In production regions around Oregon and western regions of Washington and British Columbia, yields range from 2 to 4.5 t/ha (Olsen, 2013b).

Timing of nitrogen demand is from shoot elongation in spring to leaf fall in autumn (Braun, 2016). Because nitrogen in the wood and leaf can buffer levels in the nut itself, nitrogen application to hazelnuts can be seen not so much as an immediate gain for the next month's nut nitrogen demand, but as supplying N for long term tree health. Nitrogen fertiliser requirements at specific sites can be determined by leaf testing, with the optimum leaf concentration of 2.2% (Kowalenko, 1996). The ideal situation would be leaf testing and combining this with soil nitrogen tests to determine supply and demand and applying a small amount each month in response to these indicators.

Jackson (1986) made a general recommendation for deciduous fruit trees in the absence of specific hazelnut knowledge, to use 72kg N per ha per year and 24kg of P per ha per year but note this is at the lower end of the crop removal table. There is also potential to make use of more foliar fertiliser that has been shown to increase vegetative growth and kernel weight (Pannico, 2014).

For phosphorus, leaf analysis within the range of 0.14 to 0.45% are said to be normal for the Pacific Northwest (Olsen, 2013) and they do not need to apply any P to achieve this. This is likely due to soil type differences, so does not mean the same goes for the Tararua district.

9.4.2 Leaching loss

There have been no known leaching loss studies in hazelnut. Hazelnut root systems are fibrous, and the majority reside in the top 600mm, though they can access further down in deep, well drained soils (Redpath, 2016). The main difference to other crops will be the amount of nitrogen that is required to be applied to the ground, and in what months. Considering the above insights, it is likely that risk of leaching losses from hazelnut will be greater than other woody tree crops, due to their high level of nitrogen requirement and then export in the form of nut protein. However, if done well, the amounts applied should be taken up and exported in the crop, not leached. With a well-considered nutrition program leaching loss should be under 25 kg N/ha/year.

9.5 Hazelnut: Markets

9.5.1 Global Market and Trends

The wide-ranging uses of the hazelnuts have increased the demand for hazelnuts in the market, but bad weather conditions have affected the global production of the hazelnuts in past few years, particularly in Turkey and Italy. Shortages of hazelnuts has increased the price and affordability issues among the end-users. The global production of hazelnuts has reduced year on year from 2012 to 2014.

In 2018, the global hazelnut consumption was valued at USD 0.52 billion. The demand for hazelnut is expected to increase 6.4 to 10.1% annually from 2019 to 2026. By 2026-end, nearly one-third of global hazelnut revenues will be accounted by sales of raw hazelnuts. However, processed hazelnut products will witness a considerably higher consumption, and revenues from which will be valued at USD 0.74 billion by the end of 2026.

Currently, Turkey dominates the hazelnut production, with an estimated share of 67.1%, and a consumption share of 52.3%, globally. In terms of consumption, Europe is predicted to have the highest market growth of 7.6% during the forecast period (2019-2026), due to the increasing demand for hazelnuts from the chocolate industries of Europe.

In Australia and New Zealand, hazelnuts are mostly used in desserts, such as cakes, muffins, chocolate dishes, praline, or pastries. With increasing demand from consumers due to the reported health benefits, the market is expected to grow over the forecast period. Research studies show that consuming hazelnuts can lower LDL (bad) cholesterol and increase HDL (good) cholesterol, which is increasing the sales of hazelnuts.

High Demand in the Chocolate Industry

Chocolate manufacturers are re-introducing their signature products with hazelnut-incorporated product lines, which are coming out as an innovation in taste in the global confectionery market. Examples include:

1. Lindt recently launched a chocolate spread made with 40% hazelnut in the UK market, in 2018.
2. M&Ms filled with hazelnut spread are expected to be available globally in 2019-2020.
3. The escalating popularity of Nutella has led to an increased demand for hazelnuts from the industries catering to the growing global consumer demand.

9.5.2 Domestic Opportunities

Apart from the sale of dry-roasted and raw hazelnuts ($30–$40/kg), hazelnuts can be processed into a variety of products including hazelnut meal ($40/kg), hazelnut oil ($75–$100/litre), hazelnut flour ($10–$20/kg), hazelnut spread/paste ($40–$60/kg) and roasted hazelnut butter ($50/kg), which can go on to be used in confectionery and other end uses.

New Zealand has several processors including The Hazelnut Company, which has a medium-sized processing plant in Canterbury, and Uncle Joe's Nuts in Marlborough, through to smaller grower-processors who sell through farmers markets and small local retail outlets. Many also offer internet sales. Internet sales have seen small quantities of New Zealand hazelnuts exported to Australia, the United States and Europe. There are no large processors in the North Island.

Due to price competitiveness of imported hazelnuts and scale of competition for processing, it is likely that the target market for the Tararua District will be high quality fresh production for smaller, higher value markets. The target will be the consumer that will pay more for fresh, local produce for locally made hazelnut butter and other added value products.

9.6 Hazelnut: Infrastructure and Investment

Infrastructure required will include:

1. Tractors
2. Sprayers
3. Irrigation shift pipes to mitigate drought risk while trees are young
4. Shelter belts on windward side
5. Harvesting machinery
6. Mowing and mulching equipment
7. Ladders for pruning

Expenditure on infrastructure will be influenced by the expected value of the returns over subsequent years balanced with the budget available and will depend on whether the farm's existing assets can be used or modified for use.

Typical infrastructure may include a drying and packing shed, implement shed, irrigation, shelter belts, fencing, mower, sprayer, harvesting and miscellaneous equipment.

The capital cost of harvesting equipment increases with the sophistication of the equipment, from hand-held devices available at $150 each to self-propelled machines in excess of $75,000.

Costs of establishing a hazelnut orchard vary according to how much development work (shelter, irrigation, land preparation) is required, ranging from about $8,500/ha (established shelter, no irrigation required), up to $25,000/ha starting with bare undeveloped land requiring significant modification.

Land area for an economic unit will be flexible with the above variables, however, to have a full-time manager and enough nuts to keep a harvesting machine busy (and therefore economic) it is estimated that 30ha would be required. This can be spaced among multiple smaller blocks that can share machinery and equipment between them.

With a manager who also does much of the on-orchard work, and less automated harvesting, smaller land areas, estimated around 10ha can be viable.

Early production is an important factor in economically viable production. Hazelnuts should have a small crop in the second or third year after planting, with the first commercial harvest in the fourth or fifth year. Growers should plan to harvest 1 tonne/ha by year 5 and 3.0 tonnes/ha by year 10. These yields have been achieved by New Zealand growers with good management in suitable environments.

9.6.1 Hazelnut Model Farm – Capital Investment and Gross Margin

Table 9.2. Hazelnut Orchard Gross Margin

Hazelnut Orchard	per Ha	per plant
Plants/ha	740	
Yield (Kg)	3,000	4.05
Process Packout	90%	
Income $/kg (unprocessed)	$7.50	
Income ($)	$20,250	$27.36
Postharvest costs	$82	$0.11
Orchard Gate Income ($)	$20,168	$27.25
Machine harvest	$0	$0.00
Pruning	$1,480	$2.00
Other wages	$3,000	$4.05
Total labour expenses	$4,480	$6.05
Weed and Pest	$1,000	$1.35
Fertiliser and lime	$200	$0.27
Electricity	$200	$0.27
Vehicles	$90	$0.12
Fuel	$100	$0.14
R&M General	$700	$0.95
Sundry	$500	$0.68
Total working expenses ($)	$2,790	$3.77
Gross Margin ($/ha)	$12,898	$17.43

Table 9.3. Orchard Development Costs

Development Costs	**$/ha**
Land Value	$0
Ground preparation	$1,000
Tile drainage 40m	$11,000
Planting Cost	$400
Tree cost	$18,500
Irrigation	$0
Machine Harvester	$4,000
Total	**$34,900**

**Does not include shelter establishment and other machinery*

Table 9.4. Hazelnut Orchard Stats

Orchard area	30ha
Mature yield	3 t/ha
Time to mature yield	10 years
Operating costs covered	5 years
Breakeven	11 years

Table 9.5. Orchard Sensitivity Analysis- Gross Margin by Yield and Price.

	Yield change (t/ha)					
Price Change ($/kg)		2	2.5	3	3.5	4
	$4.50	$783	$2,796	$4,809	$6,822	$8,835
	$5.50	$2,580	$5,043	$7,505	$9,968	$12,430
	$6.50	$4,378	$7,290	$10,201	$13,113	$16,025
	$7.50	$6,175	$9,536	**$12,898**	$16,259	$19,620
	$8.50	$7,973	$11,783	$15,594	$19,405	$23,215
	$9.50	$9,770	$14,030	$18,290	$22,550	$26,810
	$10.50	$11,568	$16,277	$20,986	$25,696	$30,405

In New Zealand, assuming yields of 1 tonne/ha by year six and 3.0 tonnes per ha by year ten and based on an average price of $7.50/kg for nuts in-shell, the gross margin would be $3,000/ha by year six and $12,898/ha by year ten. However, returns also depend on whether nuts are processed further. Adding value through further processing into flour, meal and oils in packaged products would likely increase returns.

9.6.2 Hazelnut Assumptions

This hazelnut orchard model was built solely at an indicative level for this project. It is based on having a point of sale after hazelnuts have been harvested, stored and freighted to a buyer, where the nut is sold unprocessed. It is assumed a barn shed is available to hand and dry nuts before freighting to market. Therefore, the orchard does not incur storage and processing costs.

Currently there are no hazelnut processors in the North Island and therefore growers may need to build storage facilities which would impact the gross margin. Storage is less expensive than other crops covered in this report because nuts just need to be kept dry, not cool. Farmers may have a barn or shed on site that can be used for this.

The development assumes tile drainage is required, and that there is no permanent irrigation system. This will vary from site to site, but this orchard is modelled on a soil with high water holding capacity with poor drainage. A permanent sprinkler system could be swapped in instead for a similar figure.

The income figure of $7.50/kg was taken from current Australian hazelnut gross margins and the income will vary based on variety, season and fruit size.

Most of the New Zealand hazelnut crop is grown in Canterbury where grain and seed drying facilities are available at hazelnut harvest time at relatively low cost. Harvested nuts could be placed in bins or sacks suitable for subsequent product drying at harvest time, taken to a drying shed for a relatively short drying period and then transported to the final processing plant and point of sale.

The freight cost in the gross margin is based on distances of 20 to 50km, which is $7 to $8 per 400kg bin.

Running costs like pest and disease control, fertiliser, electricity and R&M have been adapted from knowledge of export apple and vineyard cost structures.

9.6.3 Hazelnut Harvest Machinery

Hazelnut trees start producing small quantities of fruit after about 2 to 3 years but generally production is limited until the 5th year after planting with maximum production expected after 8 to 10 years. For the first few years the crop can be harvested manually but as the trees mature, production increases rapidly and mechanical harvesting is required.

Currently there are no commercial harvesting contractors in New Zealand, so orchardists must either share harvesting equipment with other orchardists or invest in their own equipment.

Harvesting systems fall into three main types:

1. Hand collection with small tools or small hand-propelled collectors.
2. Vacuum systems:
    a. small two-stroke powered vacuum harvesters, either bac-pack type or mounted on a small trailer
    b. medium-sized four-stroke powered vacuum harvesters that are towed or mounted on a smaller trailer
    c. large vacuum harvesters that are self-propelled or power take-off (PTO), driven behind a tractor
3. Mechanical systems:
    a. medium-sized harvesters that are usually front mounted with side sweepers
    b. large harvesters that are usually self-propelled and fitted with side sweepers
    c. large harvesters that are either towed or self-propelled and that rely on separate sweeper machines to windrow the crop

The capital cost of harvesting equipment increases with the sophistication of the equipment, from hand-held devices available at $150 each to self-propelled machines in excess of $75,000. The budget includes a generous $120,000 for harvest machinery mostly to be consistent with other models as all models' costs could vary widely. This is on the conservative end for budgeting purposes. More investigation will be required in this area for individuals to budget for specific machine harvesting equipment.

The handling of hazelnuts after harvest can be described as having two stages. In the first stage, the shell is cracked, and the kernel separated. In the second stage, the kernel may undergo a variety of processes, namely: blanching, roasting, slicing, mincing, pulverising or being made into a paste.

9.7 Hazelnut: Resource Limitations

Supply of hazelnut trees are limited and as a result trees can be expensive. However, hazelnuts can be propagated from cuttings and once a bud wood supply is found, propagation costs should decrease significantly. There is one larger sized hazelnut nursery in Canterbury, but they are currently not able to supply enough trees for their current demand.

Hazelnut trees have a moderate tolerance to soil wetness. Artificial drainage can be used to lower the risk of waterlogging this way soils that have imperfect or even poor drainage can be considered for hazelnut production.

Consultants and advice for hazelnut husbandry, and contractors to install tile drainage and plant trees and more are missing from either the Tararua District. The manager therefore needs to be passionate about the crop, able to research issues themselves and be good at problem solving to ensure the success of an operation such as this.

Machine harvesters for hazelnut production are not common in the Tararua District, though they can be found in other regions (e.g. Nelson and Canterbury).

Currently there are no hazelnut processing facilities in the Tararua District and freighting the nuts to other districts will increase costs and requires trucking and roading facilities.

9.8 Hazelnut: Skills and Labour

The manager of this operation would need to have experience in nut or fruit growing, an interest in hazelnut production, and the ability to perform research and problem solve as issues arise.

Operational and management tasks would include:

1. Directing planting with help of a crew of farm workers in winter.
2. Mowing and weed control.
3. Plant nutrition management, including leaf and soil analysis, and fertiliser applications.
4. Irrigation monitoring, including irrigation scheduling and system maintenance.
5. Pest and disease control, including scouting, identification and spraying appropriate chemistries.

6. Harvest management, including hazelnut maturity monitoring, orchard floor preparation, and harvester operation.
7. Tree pruning to maintain tree structure and plant productivity.

A base of 1 manager and 1 orchard worker would be estimated across the 30ha orchard year-round. There would be additional labour required for some seasonal tasks. In a mechanised harvest system only pruning would require additional labour.

Established orchards need to be managed with the aim of maximising the area of fruiting canopy and ensuring the orchard floor is maintained to enable efficient harvesting and high-quality nuts. Seasonal jobs include:

- All year
  - Mowing and weed control
  - Monthly sucker control
- Winter
  - Pruning
  - Weed, pest and disease management
- Spring
  - Plant and soil nutrient management
  - Pest and disease management
  - Irrigation maintenance
- Summer
  - Leaf/soil analysis
  - Harvest preparation
- Autumn
  - Harvest
  - Disease management

Pruning is the most expensive labour cost for hazelnut producers. At approximately $2 per tree (12 trees/hour and $25/hour) and at a row spacing of 4.5 m by tree spacing of 3.0 m, each hectare would require approximately 62 labour hours pruning. A 30-ha orchard would therefore require approximately 1860 labour hours of pruning, plus management. The manager would spend the entire time pricing trees and monitoring pruners. As an example, to prune a 30-ha orchard in 2 months, about 6 extra workers would be needed, if they worked 40 hrs per week. Pruning can start straight after harvest (May) and finish in August or even September, so the job could also be done with just 3 extra workers in 4 months, if they worked 40 hrs per week. This method assumes the manager would be pruning a little as well as managing others.

This estimate is based on each tree only taking 5 minutes, which means the pruning job is focussed on hand sawing overgrown branches out and using a ladder to lop out such branches in the top and moving on.

9.9 Hazelnut: Conclusion

Hazelnuts will grow well in Tararua as long as they have adequate shelter, soil moisture and lower rainfall at harvest. Rain at harvest time in the Tararua as researched in the climate section of this report, indicated that Eketahuna and Norsewood will be less suitable than the other main centres analysed.

Soils for hazelnut production should be flat or slightly sloping to accommodate harvest machinery. They should be 60cm deep or more, with high water holding capacities. Dense poorly structured soils or standing water should be avoided.
Nitrogen requirements to form protein in the nut are higher than other crops in this study, and it is estimated that with good nutrient management nitrogen losses should be 15 to 25kg N/ha/year. Irrigation is not costed in the model but may be required, perhaps instead of tile drainage depending on soil characteristics.

Tararua hazelnut production will struggle to be price competitive with imports, so will likely target smaller boutique markets and will need strong branding. Hazelnuts are slower to reach mature production than other crops, but once they do reach maturity, they will continue producing for many years with minimal labour requirement.

Land area required is 30 ha based on having enough scale to have a machine harvester. Smaller land areas of 10 ha are estimated to be viable to have 1 full time labour unit focussed on the crop.

Resource restrictions include tree availability, skills and advice around growing the crop, machine harvest equipment, contract drying facilities and processing facilities.

Table 9.6. Cider Orchard Stats

Crop	Hazelnut
Temp / GDD	Mild summers below 30°C and cool winters to -10°C
Frost	Very frost tolerant. Flowers tolerate temperatures to -8°C.
Frost free period	n.d. Not the most important factor for Hazelnut
Winter Chill	600 to 1200 hours
Flowering time	Female flowers open June - September
Harvest time	Late Feb to early April
Rainfall	800 to 1000mm, evenly distributed but less over harvest
Wind	Require shelter-live shelter belts and sheltered microclimates
Slope	Flat to mild rolling 0 - 10°
Soil depth	>60cm ideal. >40cm not suitable
Soil type	Fertile loam with high water holding capacity to mitigate drought
Avoid	Soils with poor structure, standing water, low water holding capacity
Nitrogen loss if well managed	Likely 15 to 25kg/ha/year
Fert timing	Little and often through growing season
Water requirement	Irrigate when young. 75 to 90mm for hottest months. 100 to 200mm/year
Market modelled	High quality nuts for fresh local and export market
Supply chain end budgeted	Harvested and hung to dry in a barn, no cost added for storage materials
Harvest	Machine harvested
Labour needs	Low, 2 permanents for 30ha, one manger one worker. Extras for pruning.
Land area required	10ha to 30+ha
Gross margin and sensitivity	$12,898 per ha. At 3.5 t/ha and $9.50/kg, $19,405/ha
Development Costs	$35,000/ha in model, plus other machinery and shelter belts
Breakeven (model)	11 years. Likely to be able to achieve upside on yield and price

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