Taranaki Land and Climate Assessment

PROVIDING LAND OWNERS WITH A DOWN TO EARTH VIEW OF OUR REGION'S GROWING CAPABILITY

By Plant & Food Research

Foreword

Poipoia te kakano kia puawai.
Nurture the seed and it will blossom.

As Taranaki's economy looks to more diverse and complementary forms of land use to compliment its strengths in beef, sheep and dairy, it is worth reflecting on one of Plant & Food Research's key findings from this work, that 'there are around 207,000 hectares of land potentially suitable for generic horticulture within the boundaries of the Taranaki Regional Council'.

This statistic is built upon comprehensive surveying of Taranaki's land, environment and climate databases to quantify the region's untapped potential to support a range of commercial horticultural endeavours.

This report seeks to compare the region's differing climates, and the viability of eight mainstream crops that could offer commercially successful horticultural opportunities for the region's land owners.

Successfully leveraging the opportunities that horticulture presents is about much more than soil, seeds and climate, or simply growing things. Success will be achieved as much by these factors as by people, knowledge transfer, and the emergence of new chains, processing, and products to deliver these growing opportunities to market. Taranaki has proven over decades that it has all these components in spades and can adapt to continue to meet market demands over time.

In commissioning this report, Venture Taranaki underscores its role as an independent and apolitical advisor to the Taranaki region. In this document we look at the land, the climate and the region's potential to increase the share of horticulture that makes up the region's future prosperity.

Venture Taranaki acknowledges the work done by Plant & Food Research to produce, and the technical analysis behind, this report and welcomes the pathways proposed in the report to make best use of the opportunities ahead for our region.

This report should be read by all those considering opportunities to foster more diverse, complementary land uses within Taranaki.

JUSTINE GILLILAND
Tumu Whakarae/Chief Executive
Te Puna Umanga/Venture Taranaki Trust

About Branching Out

Branching Out is a collaborative exercise looking at our region's food and fibre value chain opportunities, to accelerate ideas and thinking that could have practical outcomes across the entire value chain.

It aims to broaden the region's food and fibre products through growing diverse and complementary forms of land use, enterprises, and products, adding greater prosperity and sustainability to the Taranaki region and economy.

New, high-potential ideas will be developed into 'Venture Blueprints' and be shared with local land owners, food and fibre processors and investors to broaden our existing farm-based production activities with potential commercial opportunities piloted.

Branching Out is managed by Venture Taranaki and a steering group of food and fibre sector participants. The two-year initiative is funded by Taranaki's three district councils and the Ministry for Primary Industries' Sustainable Food and Fibre Futures fund, with significant in-kind support from Venture Taranaki, Massey University, Crown Research Institutes, and primary sector/food and fibre industry enterprises.

The Branching Out initiative was developed as an action from the Tapuae Roa Strategy and aligns to the region's long-term vision for a low-emissions future: the Taranaki 2050 Roadmap.

SUPPORTED BY:

Ministry for Primary Industries
Manatū Ahu Matua

Te Kaunihera-ā-Rohe o Ngāmotu
New Plymouth District Council

REAL ENERGY
South Taranaki District Council

STRATFORD DISTRICT COUNCIL

About Plant & Food Research

Venture Taranaki commissioned Plant & Food Research to independently undertake an investigation into the land characteristics and climate of Taranaki, and how these datasets may be used to inform the selection of specific horticulture opportunities.

Plant & Food Research believe science can create a better future. By finding smarter, greener options today, Plant & Food Research are helping secure the world we want to live in tomorrow.

With our partners, Plant & Food Reserach use world-leading science to improve the way they grow, fish, harvest and share food. Every day, there are 1000 people working across Aotearoa New Zealand and the world to help deliver healthy foods from the world's most sustainable systems.

New fruits, better grains, smarter use of chemicals, stronger biosecurity, higher yields, exciting foods, great nutrition, reduced waste.

Plant & Food Research answer complex biological questions; design innovative products and technologies; and look over the horizon for new ways to grow a smart green future.

Plant & Food™ Research
Rangahau Ahumāra Kai

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Executive summary

We have assessed the value of known databases for their feasibility and ability to meet Venture Taranaki's long-term goals for building value, sustainability, and market and supply-chain resilience. Foundational to this is to understand the accessibility and quality of climatic land and soil data. Here we describe these data, and show how they can applied.

We undertook a comprehensive survey of land, environment and climate databases relevant to the sector and region including access of information, completeness, ability to integrate with other databases, strengths and weaknesses, relevance and trustworthiness, as well as noting information that is publically available, along with fee-paying sites.

We particularly focused on data pertaining to topography, soil attributes (texture, nutrients, water holding capacity, fertility, erosion potential), water (table-depth, streamflow, quality, drainage and leachate assessment), climate (rainfall, sunshine hours, number of growing degree days, daily temperature, frost-free days, altitude), and potential land use (pastoral, horticultural, arable).

Key missing databases include the availability of high-quality soil data (e.g. S-Map) for Taranaki.

As an initial demonstration of our capabilities, we summarised the climate data from seven Virtual Climate Station Network (VCSN) stations spanning the Taranaki region and have produced general climate statistics for the region, along with assessments for eight crops: apples; kiwifruit; avocados; blueberries; hops, hemp and CBD (cannabidiol) cannabis; hazelnuts and walnuts; potatoes; and wine grapes.

We have provided guidelines on information sources and questions that need answering when evaluating the potential for growing crops in the localised areas.

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1 Introduction

The long-term aim of Branching Out is to identify high-potential ventures in the food and fibre sector for Taranaki.

To help with this identification process we have assessed the value of known databases for their feasibility and ability to meet Venture Taranaki's long-term goals for building value, sustainability, and market and supply-chain resilience. Foundational to these long-term aims is to understand the accessibility and quality of climatic land and soil data.

We undertook a comprehensive survey of land, environment and climate databases relevant to the sector and region including access of information, completeness, ability to integrate with other databases, strengths and weaknesses, relevance and trustworthiness, noting information that is publically available, along with fee paying sites.

We particularly focused on data pertaining to topography, soil attributes (texture, nutrients, moisture content, fertility, erosion potential), water (table-depth, streamflow, quality, drainage and leachate assessment), climate (rainfall, sunshine hours, number of growing degree days, daily temperature, frost-free days, altitude), potential land use (pastoral, horticultural, arable).

We focused on data pertaining to the key crops that in discussion with Venture Taranaki we consider to have potential, namely:

- apples
- kiwifruit
- avocados
- blueberries
- hops
- hemp and CBD (cannabidiol) cannabis
- hazelnuts and walnuts
- potatoes
- wine grapes.

2 Survey of land, environment and climate databases

A range of databases covering various aspects of land, soil, environment and climate can be used to inform land-management decisions.

The GIS data detailing the soil and land can be visualised using online portals, while much of the climate data will need to be downloaded and viewed using Microsoft® Excel® or similar software. Table 1 summarises the key information about each of these databases.

We particularly focused on data pertaining to topography, soil attributes (texture, nutrients, moisture content, fertility, erosion potential), water (table-depth, streamflow, quality, drainage and leachate assessment), climate (rainfall, sunshine hours, number of growing degree days, daily temperature, frost-free days, altitude), potential land use (pastoral, horticultural, arable).

2.1 Currently available databases

Table 1. Summary of databases used for land use assessments

Name	Availability	Format	Details
CliFlo	Free – NIWA website	Numerical	Actual weather station data from 1950s to present – coverage is spotty. R package CliFlo can be used to find and import data. *https://cliflo.niwa.co.nz/*
Virtual Climate Station Network (VCSN)	Paid - $20 per station per month	Numerical	Interpolated gridded climate data for the entire country from 1972 to present. *https://data.niwa.co.nz/*
NIWA Our Future Climate New Zealand online tool	Free – NIWA website	Maps, charts and numerical	Climate predictions from six different climate change models and representative CO^2 concentration pathways. Data for selected sites such as New Plymouth can be downloaded as a csv file. *https://ofcnz.niwa.co.nz/#/nationalMaps* *https://ofcnz.niwa.co.nz/#/localCharts*
NZ Land Resource Inventory	Free – LRIS portal	GIS	Soil, rock, slope, erosion and vegetation data for the entire country, derived from soil surveys. Also includes LUC and FSL. *https://lris.scinfo.org.nz/layer/48076-nzlri-land-use-capability/*
Fundamental Soil Layers	Free – LRIS portal	GIS	16 soil properties – considered inaccurate and obsolete, but has coverage for the entire country. *https://lris.scinfo.org.nz/layer/48079-fsl-new-zealand-soil-classification/*
Land Cover Database	Free – LRIS portal	GIS	Land cover and land use classes. *https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/*
S-Map	Free – Smap portal	GIS	Soil properties – essentially updated FSL but only 1/3 of the country covered, and none of Taranaki. *https://smap.landcareresearch.co.nz/*
DEM	Free – LRIS portal	GIS	New Zealand National Digital Elevation Model (North Island) – a 25-metre resolution, floating point precision, elevation grid. *https://lris.scinfo.org.nz/layer/48131-nzdem-north-island-25-metre/*
NIWA Hydro Web Portal	Free – NIWA website	Charts and numerical	Water quality of 35 rivers, including the Manganui and Waingongoro rivers. *https://hydrowebportal.niwa.co.nz*
Taranaki Regional Council		Maps, charts	River levels, flow, and temperatures, soil moisture, soil temperature for various monitoring sites across the Taranaki region. Data from specific sites can be downloaded as a .csv file. *https://www.trc.govt.nz/environment/maps-and-data/regional-overview/*
Topo50	Free – LINZ portal	GIS	Topographic mapping for the New Zealand mainland at 1:50,000 scale, available in raster and vector formats. *https://data.linz.govt.nz/search/?q=topo50*
NZ Property Titles	Free – LINZ portal	GIS	Title and survey information to primary parcels. *https://data.linz.govt.nz/layer/50804-nz-property-titles/*
500m climate date	Paid – NIWA by negotiation	GIS	Interpolated from CliFlo and based on the 30-year period 1981–2010. *https://niwa.co.nz/climate/research-projects/national-and-regional-climate-maps*
Generic	Free - Koordinates	GIS+	Wide-ranging GIS and additional data and the platform that hosts both the LRIS and LINZ portal. *https://koordinates.com/*

FSL: Fundamental Soil Layers
LINZ: Land Information New Zealand
LRIS: Land Resource Information Systems
LUC: Land Use Capability
NIWA: National Institute of Water and Atmospheric Research

2.1.1 WEATHER AND CLIMATE DATA

Historical weather and climate data can be obtained from NIWA; for example, records of temperature, rainfall and wind (Table 1).

The freely available CliFlo database ***(https://cliflo.niwa.co.nz)*** consists of records from actual weather stations across New Zealand, dating back to the 1950s in some cases. However, since it is compiled from actual weather records, it can be lacking in spatial and temporal coverage.

NIWA has produced national and regional climate maps, summary maps at 500m resolution based on CliFlo data, for the 30-year period 1981–2010. These can be obtained from NIWA for a fee by negotiation.

The Virtual Climate Station Network (VCSN, ***https://data.niwa.co.nz***) is a database of daily weather variables that cover the entire country in a 5km × 5km grid, from 1972 to the present day. It is derived from interpolating actual weather-station data. Around 300 VCSN 'stations' cover the extent of the Taranaki Regional Council, and one month's access to the data can be obtained for $20 per station. Both the CliFlo and VCSN data are only available as tables of numeric data, and it is up to the user to download, analyse and interpret them. A custom extract of multiple sites might be negotiable with NIWA.

NIWA also provides visualisations of potential future climates with their 'Our Climate Future New Zealand' online tool (OCFNZ, ***https://ocfnz.niwa.co.nz***). This tool provides projections of how various climate variables could change in the future based on several different climate change scenarios and models. These projections are available as national maps, and as charts for selected locations, including New Plymouth.

2.1.2 LAND AND SOIL DATA

Manaaki Whenua – Landcare Research (MWLCR) provides GIS maps of many land properties, available to be visualised in online portals ***(https://lris.scinfo.org.nz)*** or downloaded for use in GIS software.

The New Zealand Land Resource Inventory (NZLRI) is an overarching dataset detailing information about many different properties of the soil and land across New Zealand; for example, slope, soil-type and erosion. The Fundamental Soil Layers (FSL) is a set of 16 detailed soil properties derived from the NZLRI; for example, soil drainage. In addition, the Land Cover Database (LCDB) details the coverage and usage of land in New Zealand, whether agricultural, urban, forestry or some other use.

While the FSL is a useful database, there are concerns about its accuracy since it has been compiled from many different sources, some of which are outdated. To address this, MWLCR have been developing the S-Map database ***(https://smap.landcarereserach.co.nz)***, which provides up-to-date data on soil properties. However, it currently only covers around one-third of New Zealand, and there is no coverage of Taranaki.

Digital Elevation Models (DEM) tend to underpin both modeled climate and soil datasets and can be useful in refining localised assessments, as can the derived slope and aspect layers.

2.1.3 WATER DATA

As part of the National River Water Quality Network (NRWQN, ***https://niwa.co.nz/freshwater/water-quality-monitoring-and-advice/national-river-water-quality-network-nrwqn***), NIWA provides long-term records of the water quality of the Manganui and Waingongoro rivers in Taranaki, including water temperature, alkalinity and dissolved nitrogen. Water quality data may be viewed or downloaded from NIWA's Hydro Web Portal ***(https://hydrowebportal.niwa.co.nz/)***. While we do not consider river-water or ground-water quality as part of our land-use assessments, it may be useful for other environmental assessments.

2.1.4 TOPOGRAPHIC AND PROPERTY DATA

Land Information New Zealand (LINZ) responsibilities include managing land titles, geodetic and cadastral survey systems, topographic information, hydrographic information, managing Crown property and supporting government decision making around foreign ownership.

Data available on the LINZ Data Service (LDS) includes:

- topographic data and maps
- hydrographic data and charts
- property data, like boundaries and land ownership
- place names, street address and roads data
- Crown land and property data
- aerial imagery.

LINZ data is free, customisable, reliable, and updated regularly.

2.1.5 GENERIC GIS DATA

Koordinates is a website and portal for GIS-related data, and a platform on which both the previously mentioned LRIS and LINZ portals run. This is a great site to start a search for various details that a specific assessment might require.

2.2 Limitations of currently available databases

The main limitations of the currently available data from NIWA and MWLCR are a lack of spatial coverage and resolution.

While the VCSN data from NIWA covers the entire country, through interpolation, each 'station' is 5km apart so that much of the small-scale variations in climate between stations is not apparent, as for example with niche microclimates in valleys.

The CliFlo database has limited spatial and temporal coverage, since it is compiled from actual weather station data. Main cities, airports and research stations tend to have comprehensive, high quality, consistent weather records spanning several decades. However, many smaller and more remote locations will have no records at all, or if they do have coverage may only span a few years and may consist of limited measurements such as air temperature only.

The various GIS datasets compiled by MWLCR are typically at 1:50,000 scale and miss a lot of the small-scale variations in the land characteristics and soil type. For example, the NZLRI GIS datasets consist of polygons with the average value of a given land aspect, which can be anywhere from several hectares to several thousands of hectares in size. Any given parcel of land may have many different areas with different land properties. For example, the LUC class, and hence these broad polygons need not reflect the variations in the land they cover.

In addition, since S-Map does not cover any of the Taranaki region, there is a lack of up-to-date, good quality soil information for the region.

Environmental data from Taranaki Regional Council are from various monitoring sites. For example, river levels and flows are presented for 31 sites, while data for soil moisture and temperature are monitored at 11 sites.

3 Suitability of Taranaki for new ventures in horticulture

Based on the known plant phenology of plant growth and crop development, such as summer heat and winter chilling requirements for germination, flowering and fruiting, we considered high-value opportunities for land use in terms of appropriate climate conditions potentially suited for generic horticulture, as well as for seven specific crops.

We summarised the climate data from seven out of the approximately 300 VCSN stations spanning the Taranaki region (Figure 1). We have reproduced general climate statistics for the region (Table 2) along with assessments for eight crops: apples; avocado; blueberries; hops, hemp and CBD cannabis; hazelnuts and walnuts; kiwifruit; potatoes; and wine grapes. We performed a broad GIS sweep to give an indication of what areas might be suitable for horticulture.

3.1 Generic horticulture

In general, we consider three main criteria for the suitability of an area for horticulture:

- Winter chill hours between May and September. Winter chilling is important for flowering crops as they need to be dormant for a sufficient period over winter to induce flowering in spring. We consider 500 chill hours of 7 °C or below, between May and September, to be sufficient for general horticulture.
- Growing Degree Days base 10 °C (GDD_{10}). This is a measure of how much heat a crop receives and hence how much energy is available for it to reach maturity. The GDD_{10} is calculated as the daily average temperature minus the base temperature, in this case 10 °C. Every degree above this base is counted as one GDD_{10}. For example, if 18 February were to have an average temperature of 24 °C, then it would contribute 14 GDD_{10} to the season's total. We consider 800 GDD_{10} between October and April to be sufficient for general horticulture.
- Frost-free period (FFP). This is the time between the last frost of one year and the first frost of the next year. This is important as frosts after flowering, or before harvest, can damage a crop. We consider an FFP of at least 200 days to be suitable for horticulture.

For these criteria, we consider both the mean, and the 20th percentile values. The 20th percentile value means that 80% of the time, or eight years out of 10, the condition is fulfilled. The mean values indicate what a typical year might be like, while the 20th percentile values indicate what is likely to happen four years out of five, a typical risk baseline used in horticulture.

While these criteria are enough to give an idea of an area's suitability for horticulture in a general sense, specific crops may have different requirements.

In general, Taranaki meets all these generic requirements, although Stratford is somewhat cooler than the rest of the region, so may be more limited in what generic horticulture is possible there.

Table 2. Generic climate statistics for Taranaki

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean chill hours (<7 °C)	719	658	946	1227	721	941	961
20th percentile chill hours	624	569	816	1045	605	765	777
Mean GDD_{10}	1277	1215	1032	884	1136	1093	1148
20th percentile GDD_{10}	1190	1154	963	804	1079	1006	1052
Mean first frost	6 Jul	4 Jul	30 Jun	23 Jun	7 Jul	27 Jun	23 Jun
Mean last frost	26 Jul	25 Jul	1 Aug	16 Aug	23 Jul	5 Aug	9 Aug
Mean FFP	353 days	350 days	327 days	303 days	> 1 year	320 days	315 days
Percentage of years without frost	27%	52%	6%	0%	54%	13%	9%

FFP: Frost-Free Period
GDD_{10}: Growing Degree Days base 10 °C
VCSN: Virtual Climate Station Network

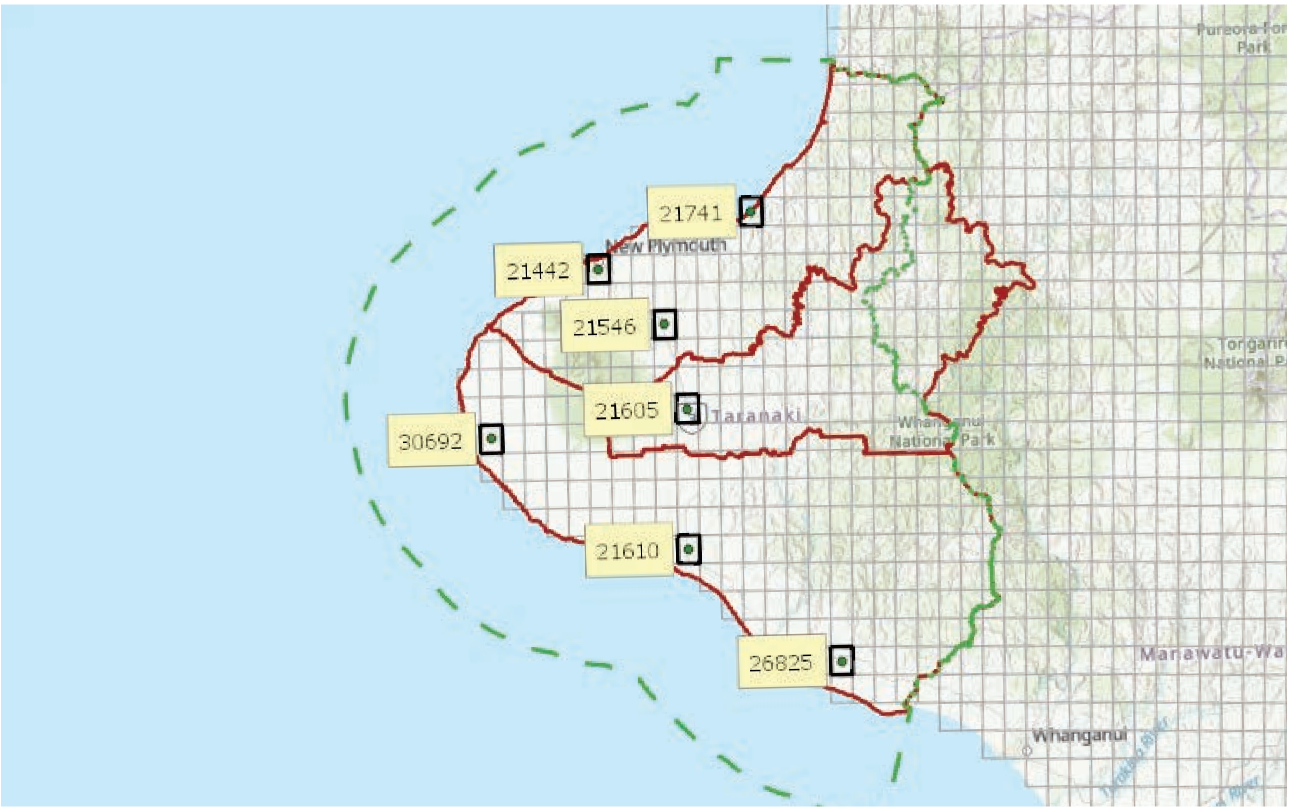


Figure 1. Seven VCSN stations selected to give a general overview of the suitability for horticulture of the region, marked in black. The grid of available stations is shown in grey. The Taranaki Regional Council borders are shown in green and the three district council boundaries (New Plymouth, Stratford, South Taranaki) are shown in red.

3.2 Specific crops

3.2.1 APPLES

We assess the potential for a mid-season variety such as *Malus x domestica* 'Royal Gala' in Table 3. Apples require at least 500 winter chill hours and 800 GDD_{10} between October and April. These are both consistently met throughout the region. Apples also require at least 120 GDD_{10} over the first 50 days after flowering, which is also consistently met. Based on temperature patterns throughout the year, we estimate that apples would flower around mid-October and be ready for harvest in mid- to late March, with Stratford's growing season generally occurring 1–2 weeks later. There is little frost risk after flowering; however, there is a slight risk of frost before harvest, with Stratford experiencing the highest frost risk of 30%. This can be mitigated, for example, through wind turbines. Apples are at risk of sunburn if the temperature exceeds 34 °C; however, there is little risk of this in Taranaki.

Table 3. Growing statistics for apples

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean flowering date	11 Oct	13 Oct	18 Oct	23 Oct	14 Oct	15 Oct	14 Oct
Frost risk after flowering	0%	0%	0%	0%	0%	0%	0%
Mean harvest date	14 Mar	17 Mar	27 Mar	4 Apr	21 Mar	23 Mar	20 Mar
Frost risk before harvest	2%	2%	12%	30%	2%	12%	12%
GDD_{10} for first 50 days after flowering	210	200	175	152	187	182	192
Risk of sunburn	0%	0%	0%	0%	0%	0%	0%

GDD_{10}: Growing Degree Days base 10 °C
VCSN: Virtual Climate Station Network

3.2.2 AVOCADOS

Avocados are relatively sensitive to temperatures in the spring (Table 4). Ideally, they require the mean maximum temperatures to be above 15 °C, 16 °C and 17 °C in September, October and November, respectively. This is achieved at all sites. Avocados also require mean minimum temperatures to be above 8 °C, 9 °C and 10 °C in September, October and November, respectively, although mean temperatures up to 1 °C cooler are sufficient, yet less than ideal. These requirements are met in New Plymouth and almost met at Urenui and Ōaonui. The other sites are marginal in terms of exceeding these minimum temperatures. Finally, extreme annual minimum temperatures should not drop below 0 °C, although down to –2 °C is marginal, and all sites meet this requirement as well.

Table 4. Growing statistics for avocado

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean maximum temperatures (°C)							
September	18.5	17.9	17.2	16.6	17.6	17.8	18.2
October	20.0	19.4	18.8	18.4	18.9	19.4	20.0
November	21.9	21.3	20.7	20.3	20.9	21.3	22.0
Mean minimum temperatures (°C)							
September	7.9	8.0	7.0	6.1	7.7	7.0	7.0
October	9.2	9.2	8.1	7.3	8.8	8.2	8.4
November	10.6	10.5	9.5	8.6	10.1	9.6	9.8
Extreme annual minimum	-0.3	0.0	-0.8	-1.5	0.1	-0.8	-1.1

VCSN: Virtual Climate Station Network

3.2.3 BLUEBERRIES

Blueberries have winter chill requirements of anywhere between 200 and 800 winter chill hours depending on cultivar (Table 5). While varieties with low and medium chill requirements would be suitable throughout Taranaki, varieties with high chill requirements would likely only be suitable in the inland areas around Inglewood and Stratford. Blueberries also require at least 600 GDD10 between October and April, which is consistently met throughout Taranaki.

However, blueberries also prefer consistently high temperatures during the summer, in particular daily maximum temperatures that exceed 18 °C and preferably 19 °C between December and February. In most years this is not met for 18 °C, and is almost never met for 19 °C. This could be due to afternoon sea breezes that place a cap on the daily maximum temperatures. Apart from Inglewood and Stratford, most of the region will experience 1 or 2 weeks of maximum temperatures cooler than 18 °C, and 2–4 weeks of maximum temperatures cooler than 19 °C.

If suitable mitigations are put in place, such as tunnel houses, then blueberries could be suitable for much of Taranaki. This would eliminate the cooling effect of the sea breezes, and the greenhouse effect would warm the ambient air in the tunnel house.

Table 5. Growing statistics for blueberries

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Chance of summers with <18 °C	75%	89%	97%	100%	91%	97%	93%
80th percentile number of days <18 °C	6	10	18	25	14	13	12
Chance of summers with <19 °C	97%	97%	100%	100%	97%	100%	100%
80th percentile number of days <19 °C	15	20	32	41	25	24	20

VCSN: Virtual Climate Station Network

3.2.4 HOPS, HEMP AND CBD CANNABIS

We assess these three crops together as they are closely related taxonomically. Because of the differing legal status between hops plus hemp, and CBD cannabis, much more research has been done on hops. However, we expect that the conditions required for hops apply to hemp and CBD cannabis too (Table 6).

The main driver of growth in these crops is the day length, or photoperiod. Hops grow vegetatively with increasing day length, and then flower when the days become shorter. However, a critical day length must be met before flowering is triggered. This varies between cultivar but is generally considered to be a day length of 15 hours, including an allowance for twilight. We consider days with 14 hours between sunrise and sunset plus 1 hour of twilight to be above this threshold. Since the only factor that influences maximum day length is latitude, it is generally considered that anywhere between 35° and 55° in latitude is ideal for hops, provided the land is suitable for horticulture in general. All of New Zealand except for the very top of the North Island lies within this range, and Taranaki in particular experiences 90–94 days per year with day lengths of 15 hours or greater.

For hops specifically, wind needs to be considered, since hops are typically grown on 5-m tall trellises. For this we calculate the windrun, which is a measure of how much wind passes over a given point during the day. The majority of hops in New Zealand are grown in Motueka, which has an average daily windrun of 120 ± 27 km. We know from in-house experience that Marlborough, with an average daily windrun of 291 ± 66 km, is too windy for hops. Taranaki would appear to be too windy for hops, as there is considerably more wind than Marlborough. Wind mitigation such as shelterbelts, or growing hops on shorter trellises may potentially help, although the windier coastal regions of Taranaki may still be too windy despite this.

Table 6. Growing statistics for hops, hemp and CBD cannabis

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
First day of >15 hours light	7 Nov	7 Nov	6 Nov	6 Nov	6 Nov	6 Nov	5 Nov
Last day of >15 hours light	4 Feb	4 Feb	5 Feb	5 Feb	5 Feb	5 Feb	6 Feb
Mean windrun	370 km	489 km	382 km	347 km	509 km	415 km	422 km
Windrun standard deviation	± 160 km	± 193 km	± 158 km	± 143 km	± 195 km	±161 km	± 161 km

VCSN: Virtual Climate Station Network

3.2.5 HAZELNUTS AND WALNUTS

Hazelnuts require at least 500 GDD_{10} and walnuts require 800 GDD_{10} of warmth between October and April. These are easily met across Taranaki (Table 2). Both nuts can require significant winter chilling, with hazelnuts requiring at least 1200 chill hours, and walnuts requiring anywhere between 400 and 1600 chill hours depending on cultivar (Table 7).

Walnuts with low chill requirements would be suitable across the region. However, hazelnuts and walnuts with high winter chill requirements would likely be unsuitable, and even Stratford would be marginal. Choice of cultivar will be important.

Table 7. Growing statistics for hazelnuts and walnuts

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Chance of sufficient winter chilling							
400 hours	98%	96%	98%	100%	96%	98%	98%
800 hours	37%	14%	82%	98%	33%	69%	76%
1200 hours	0%	0%	8%	55%	0%	8%	12%
1600 hours	0%	0%	0%	6%	0%	0%	0%

VCSN: Virtual Climate Station Network

3.2.6 KIWIFRUIT

For winter chilling, kiwifruit require mean temperatures to be cool from May to July depending on variety, and whether or not Hi-Cane® is applied to induce flowering. Two cultivars are considered here: Green (*Actinidia chinensis* var. *deliciosa* 'Hayward') and Gold (Gold3, *A. chinensis* var. *chinensis* 'Zesy002'). For Green without Hicane® the average May–July temperature needs to be below 11.7 °C, while with Hicane® it needs to be less than 14 °C. Gold has a lower winter chilling requirement. For Gold without Hicane® the average May–July temperature needs to be lower than 12.7 °C, and with Hicane® the average May–July temperature needs to less than 15 °C.

We consider the entire region to have sufficient winter chilling (Table 8). We would expect green-fleshed kiwifruit to flower mid- to late September on average, and gold-fleshed kiwifruit to flower around a week earlier. However, we also consider kiwifruit to require at least 1100 GDD_{10} from October to April, which is only consistently met in northern Taranaki (Table 2).

Table 8. Growing statistics for kiwifruit

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean temperature for May–July (°C)	10.8	10.9	9.9	9.0	10.7	10.0	10.0
Mean date of budbreak (Green)	Sep 22	Sep 23	Sep 17	Sep 14	Sep 21	Sep 18	Sep 18
Mean date of budbreak (Gold)	Sep 17	Sep 17	Sep 15	Sep 11	Sep 11	Sep 11	Sep 11
Frost risk	0%	0%	0%	0%	0%	0%	0%

Gold: gold-fleshed kiwifruit
Green: green-fleshed kiwifruit
VCSN: Virtual Climate Station Network

3.2.7 POTATOES

Potatoes, and other root vegetables, generally require sufficient soil temperature to germinate and grow, in this case 15 °C. On average, the soil temperature in Taranaki will reach that temperature for the first time on 31 August (Table 9). The GDD_7 values for two chipping-potato cultivars were used here. Emergence occurs after a GDD_7 of 213 degree days, flowering after 804, and maturity at 1500 degree days. If sown then, potatoes will emerge in mid-October, flower in late December or early January, and mature around early March on average, except for Stratford where the potatoes will take around a month more to mature. If sowing were delayed by a month, the potatoes would mature in mid- to late March on average, although the growing season would be around 20 days shorter on average. This indicates the spread in potato growing rotations is possible. It is first bounded by the temperature required for sowing, and latest bound is through the requirement to realise the growing season GDD_{10} required for tuber maturation.

Table 9. Growing statistics for potatoes

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean date of sowing	31 Aug	31 Aug	31 Aug	31 Aug	31 Aug	31 Aug	31 Aug
Mean date of emergence	13 Oct	14 Oct	23 Oct	1 Nov	17 Oct	17 Oct	18 Oct
Mean date of flowering	26 Dec	30 Dec	11 Jan	22 Jan	4 Jan	4 Jan	4 Jan
Mean date of maturity	28 Feb	4 Mar	23 Mar	15 Apr	12 Mar	12 Mar	11 Mar
Mean season length	180 days	185 days	204 days	227 days	193 days	193 days	192 days

VCSN: Virtual Climate Station Network

3.2.8 WINE GRAPES

We assess the suitability for Sauvignon Blanc and Pinot Gris grapes. For sufficient winter chilling, grapes require the temperatures in July to be below 12 °C on average, which is met throughout Taranaki. In addition, there is little frost risk for grapes (Table 10).

Grapes require a certain amount of GDD_{10} between bud break and autumn senescence for sufficient growth. For Sauvignon Blanc, at least 1200 GDD_{10} is ideal, but 1050 GDD_{10} is considered acceptable, and 850 GDD_{10} marginal. Pinot Gris requires slightly less, with at least 1150 GDD_{10} being ideal, 1000 GDD_{10} acceptable and 800 GDD_{10} marginal. We model the date of budbreak based on the temperatures in September, and we estimate this to be around the end of September, or beginning of October, throughout Taranaki. Pinot Gris is slightly earlier than Sauvignon Blanc. We estimate senescence to occur when the autumn temperatures drop below 13 °C, which is around late April to early May on average; however, Stratford cools down somewhat earlier.

In terms of GDD_{10}, we would consider northern Taranaki to be ideal for wine grapes, and eastern and southern Taranaki would be acceptable, though not ideal. Inglewood would appear to be marginal for Sauvignon Blanc, but slightly better suited to Pinot Gris. We consider Stratford to be marginal for Pinot Gris, and not suitable for Sauvignon Blanc.

However, we consider that Taranaki is likely to be too wet in late summer for wine grapes. Excess rainfall approaching harvest affects ripening and increases the chance of the fungal disease of botrytis. We consider an average monthly rainfall in March and April of under 70 mm/month to be suitable. However, this is exceeded throughout Taranaki, with Inglewood and Stratford in particular experiencing over twice as much rain as this.

Table 10. Growing statistics for wine grapes

VCSN station	Urenui 21741	New Plymouth 21442	Inglewood 21546	Stratford 21605	Ōaonui 30692	Hāwera 21610	Waverley 26825
Mean July temperature (°C)	9.6	9.7	8.7	7.8	9.5	8.8	8.8
Mean autumn date <13 °C	May 4	May 5	Apr 21	Apr 10	May 1	Apr 23	Apr 23
Mean monthly March/April rainfall	124.2 mm	117.5 mm	166.6 mm	172.8 mm	107.0 mm	88.4 mm	85.9 mm
Sauvignon blanc							
Mean budbreak	Sep 29	Sep 30	Oct 2	Oct 5	Sep 30	Oct 2	Oct 1
Mean GDD_{10}	1293	1236	1008	832	1143	1067	1116
Frost risk after budbreak	0%	0%	0%	0%	0%	0%	0%
Pinot gris							
Mean budbreak	Sep 27	Sep 27	Sep 30	Oct 2	Sep 28	Sep 29	Sep 29
Mean GDD_{10}	1299	1242	1013	836	1149	1073	1122
Frost risk after budbreak	0%	0%	0%	0%	0%	0%	0%

GDD_{10}: Growing Degree Days base 10 °C
VCSN: Virtual Climate Station Network

3.3 Broad GIS sweep

3.3.1 LAND USE CAPABILITY CLASS

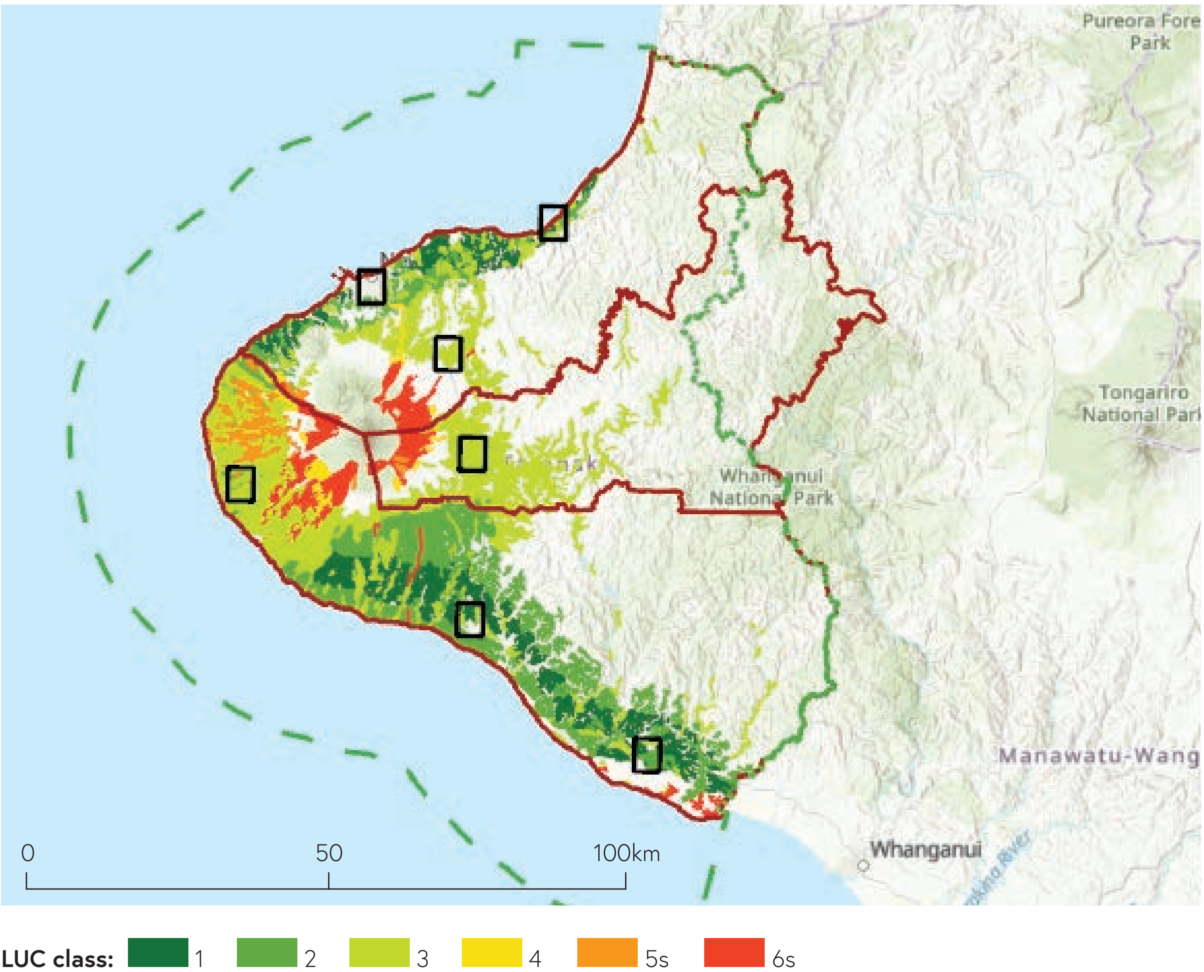


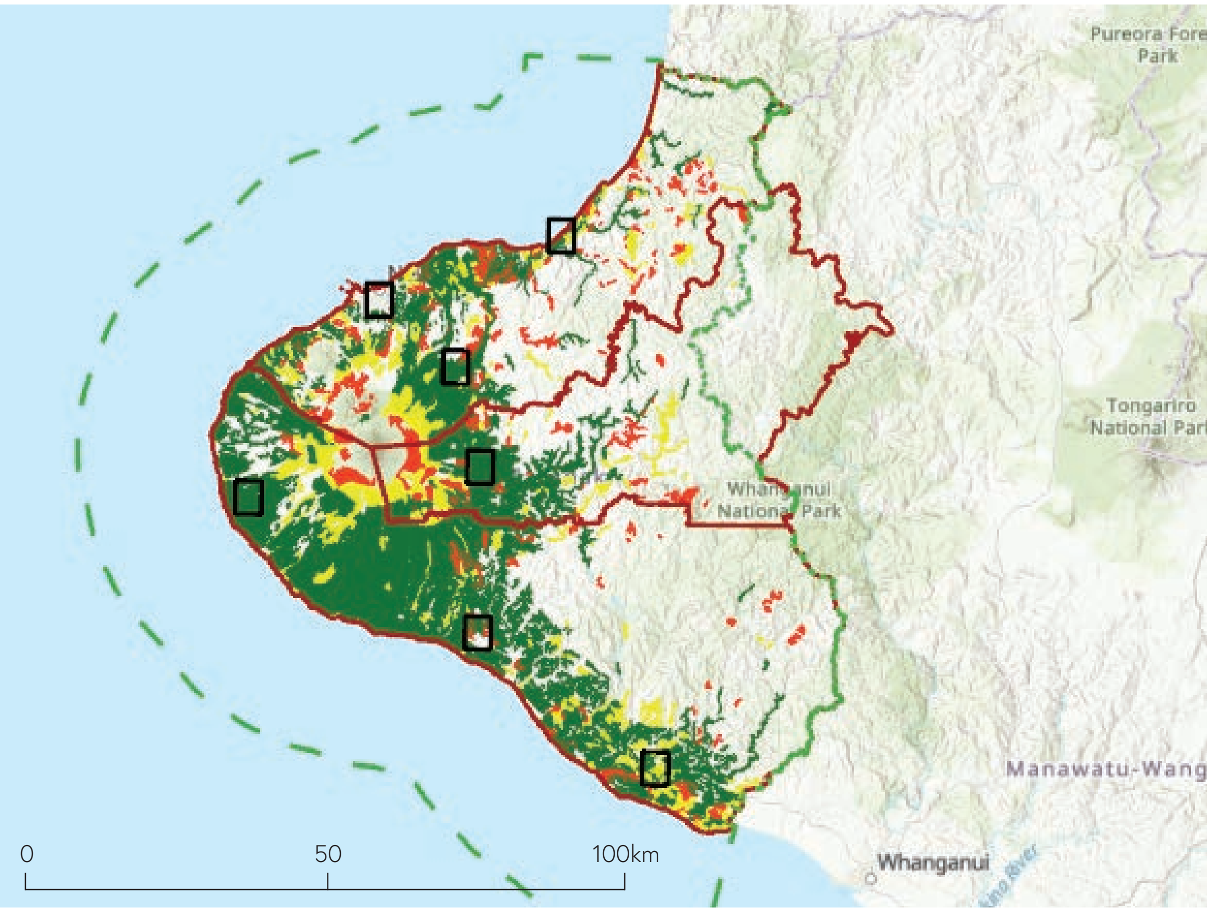
Figure 2. Land Use Capability (LUC) classes in Taranaki. Data reproduced with the permission of Landcare Research New Zealand Limited.

Sources: Esn, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

For this broad sweep, we simply consider four criteria:

- Land Use Capability (LUC) class – this is a general measure of the productive capacity of land, divided into eight classes ranging from prime agricultural land (LUC 1) to marginal land such as cliffs and beaches (LUC 8). We consider LUC class 1-3 suitable for horticulture and LUC class 4s-7s suitable for viticulture in particular, with s referring to soil limitations such as stoniness (Figure 2).

3.3.2 SLOPE



Slope (degrees): 0 - 3 4 - 7 8 - 15

Figure 3. Slope classes in Taranaki. Data reproduced with the permission of Landcare Research New Zealand Limited.

Sources: Esn, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

- Slope – we consider land with a slope up to 15° suitable for horticulture, as farm machinery generally requires relatively flat land for use. Horticulture may be possible on steeper land in some situations, although it would be more difficult (Figure 3).

3.3.3 GROWING DEGREE DAYS BASE 10

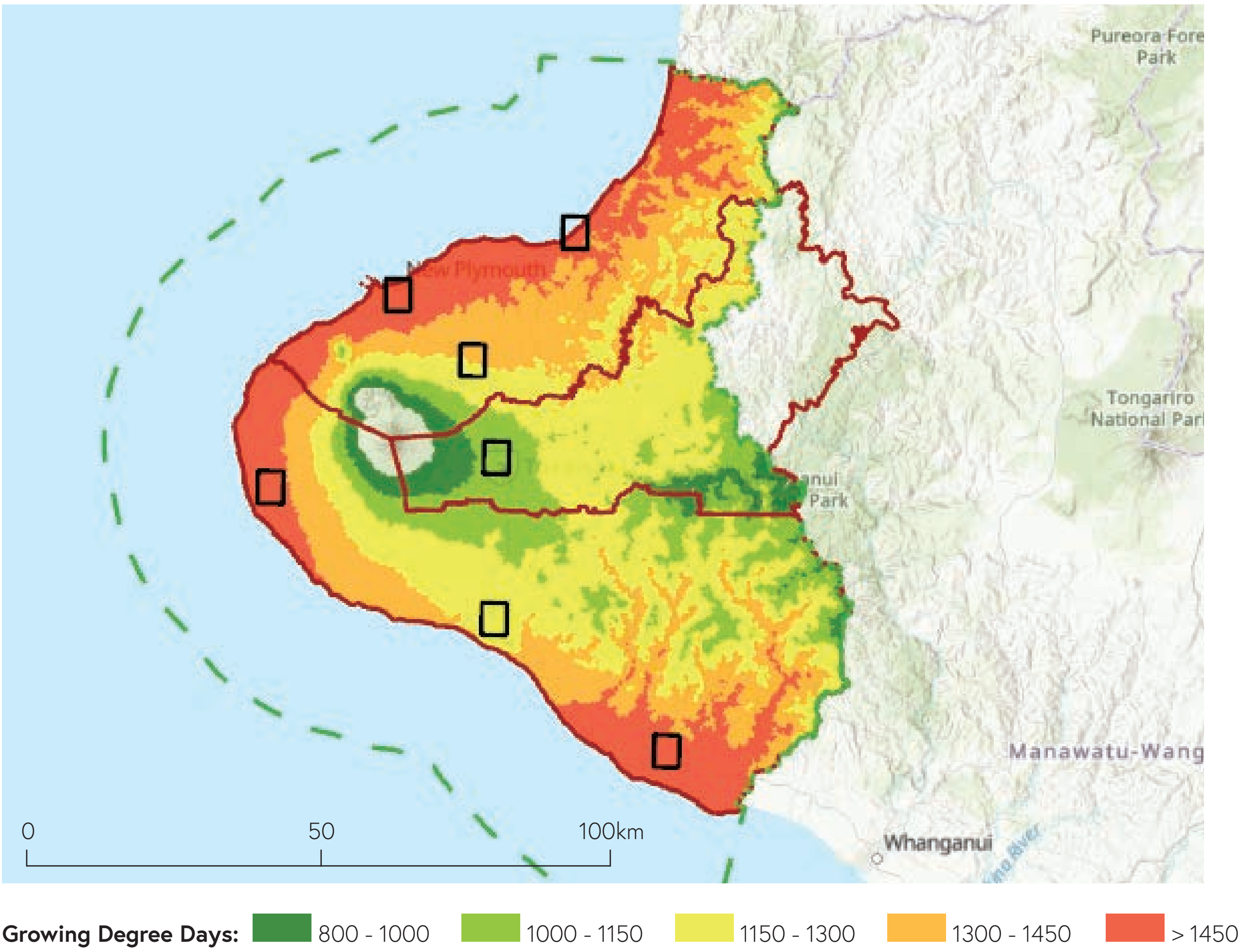
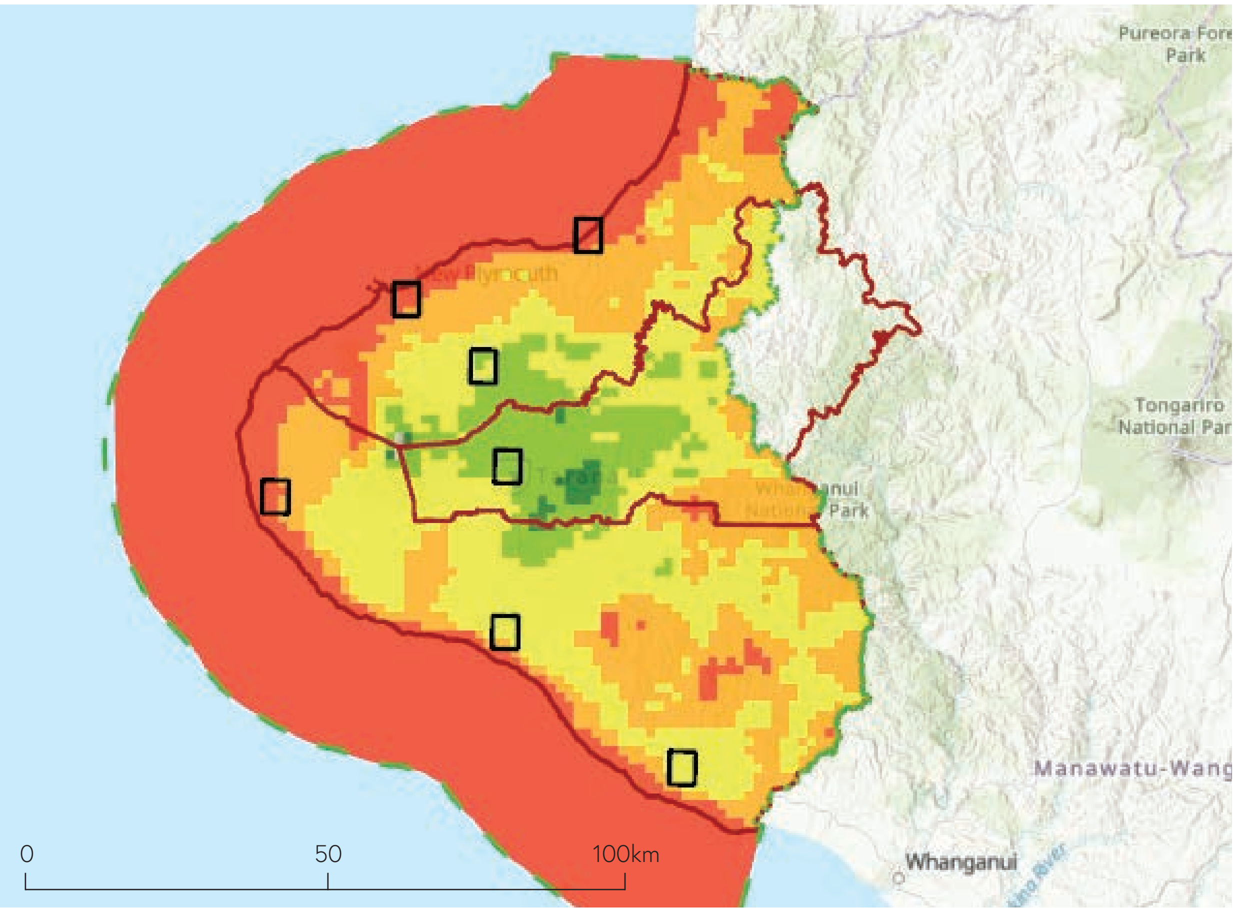


Figure 4. Growing Degree Days (GDD$_{10}$) in Taranaki. Data reproduced with the permission of the National Institute of Water and Atmospheric Research (NIWA).

Sources: Esn, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

- Growing Degree Days base 10°C (GDD$_{10}$) – as detailed previously, we consider GDD$_{10}$ of at least 800 to be suitable (Figure 4).

3.3.4 FROST-FREE PERIOD



Frost-Free Period (days): 180 - 200 | 200 - 250 | 250 - 300 | 300 - 350 | > 350

Figure 5. Frost-Free Period (FFP) in Taranaki. Data reproduced with the permission of the National Institute of Water and Atmospheric Research (NIWA).

Sources: Esn, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

- Frost-Free Period (FFP) – as detailed previously, we consider FFP of at least 200 days to be suitable (Figure 5).

3.3.5 OK FOR HORTICULTURE

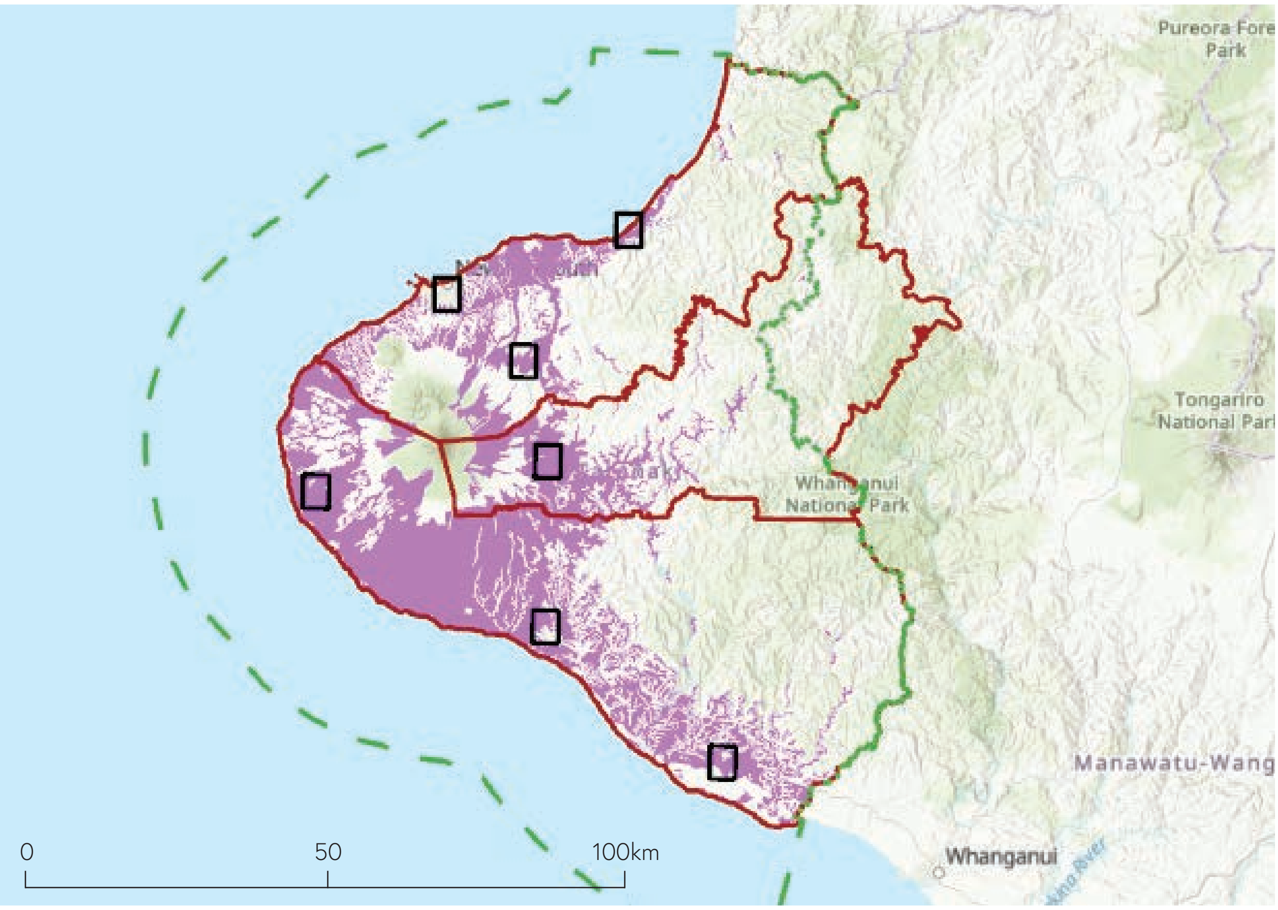


Figure 6. Areas suitable for generic horticulture in Taranaki based on the suitable areas in Figures 2-5.

Sources: Esn, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

We can work out the areas suitable for horticulture by finding the overlap of all four criteria, as shown in Figure 6. We estimate that there are around 207,000 hectares of land potentially suitable for generic horticulture within the boundaries of the Taranaki Regional Council.

We do not assess the area of the Stratford District Council that lies within the Horizons Regional Council boundaries. However, due to its hilly nature, it is unlikely that there are significant areas of land suitable for horticulture in that region.

4 Future climate change and future options

Averaging across the different models suggests increases in temperatures and number of hot days, but similar amounts of annual precipitation as the present.

While we have not performed any specific studies of future crop suitability for Taranaki, we would surmise that crops with high winter chilling requirements would potentially become less suitable for Taranaki, and conversely crops with high GDD_{10} requirements would potentially become more suitable.

NIWA provide an online tool to examine different climate change projections for New Plymouth *(https://ofcnz.niwa.co.nz/#/localCharts).*

5 Decision-based framework for using datasets

Two key scenarios are considered important for new ventures in Taranaki:

Scenario 1: I have some productive land – what should I grow on it?

Scenario 2: I have a particular product of interest – where is best to grow it?

The key steps for making decisions based on these scenarios vary, and they depend greatly on known information about each crop. However, we can roughly divide the decision making into two parts:

a) What crops are biophysically possible to grow in the area of interest (§ 5.1)? This requires gathering information on the growing requirements of a range of crops along with the climate, soil and land conditions in the area of interest. Suitability for given crops to grow in given locations will vary and mitigation strategies may be necessary if conditions are marginal.

   Alternatively, where is it physically possible to grow the product of interest (§ 5.2)? This requires gathering information about what conditions are required for the crop to grow, then determining what areas meet those requirements, again taking into account any mitigation strategies that may be needed for marginal conditions.

b) What is economically feasible to grow (§ 5.3)? Once a crop or location has been selected, the outlay needed for cultivation needs to be compared with the expected return, taking factors such as labour, transport and packhouse and cool-storage into account.

We present decision trees for both scenarios in the following sections. They detail aspects to consider and questions to ask when deciding what or where to grow. These trees are not exhaustive, and there may be other aspects to consider based on the particular area or crop of interest.

5.1 Scenario 1: I have some productive land – what should I grow on it?

Climate

What are the climate conditions:

- Temperature -> GDD_{10}
- Winter chilling
- Frost conditions
- Rainfall
- Wind

Soil and land

What are the soil and land conditions:

- Land Use Capability class
- Slope
- Soil types and variability
- Water availability
- Susceptibility to floods or other extreme conditions

Crop choice

What crops could potentially be grown based on climate, soil and land conditions?

- How much suitable area is available
- If a crop is marginal, what kind of mitigation strategies might be needed? Are they feasible?
- Even if a crop is suitable, could anything be done to improve the growing conditions?
- Is there an emotional attachment to any of the potentially suitable crops?

5.2 Scenario 2: I have a particular product of interest – where is best to grow it?

Crop suitability criteria	**What conditions does the crop need to grow?** • Climate: GDD_{10}, winter chilling, frost, wind, rain, etc. • Soil/land: LUC, slope, water needs, soil acidity, etc. • Have others grown it in the region? Or in other regions with similar conditions? • If conditions are marginal, what kind of mitigation strategies could be used?
Available land	**How much land is available?** • How easily accessible is it? • How easy is it to cultivate? Is significant infrastructure needed, e.g. trellises for grapes? • How close is it to industry infrastructure, e.g. packhouses? • Is it possible to collaborate with other growers or land owners?
Climate, soil and land conditions	**What are the conditions across the available land? How much do the conditions vary?** • Do the conditions meet the criteria for the crop? • If there is land that does not meet these criteria, what mitigation options are available? What options are feasible? • How much land meets the criteria? How much land is marginal but can be mitigated?

5.3 Is the crop economically feasible?

Industry

- Is there any industry body for the crop? What are the costs and benefits of affiliating?
- Are there any regulatory or biosecurity requirements?
- Is there any local infrastructure, e.g. packhouses?
- What logistics are necessary for distribution or processing?
- Do others in the region grow the crop? Are they competitors or is there potential for co-operation?

Financial

- What is the market space like?
- What is the potential return? Does it depend on domestic or export, raw or processed, conventional or organic?
- What costs are involved? Initial outlay, infrastructure, maintenance, labour, management, harvest, distribution, etc.
- What kind of time commitment is needed?
- Is it possible to pool resources with other growers?
- What is the potential profitability? Does it depend on how much area is cultivated? How long would it take to turn a profit?

Decision

- Yes
- Maybe, depending on ...
- No

6 Ground-truthing

It must be emphasised that these assessments are purely derived from a desktop exercise.

Even though the assessments are performed with the best available data, because of the limitations explained in Section 2.2 there is always the possibility to indicate land is locally unsuitable for horticulture, when in reality it is suitable, or vice versa. There can be niche locations that are 'hidden' from our assessments.

In terms of land and soil properties, small-scale, detailed survey services are offered by consultancy companies such as Landvision *(www.landvision.co.nz)* and they can be used to inform assessments on a farm scale. This is not an endorsement, rather an indication of the type of agency that is available.

Weather and climate data are more difficult as the assessments generally need long-term records in order to calculate seasonal and annual weather patterns. Weather records from other sources, whether anecdotal or actual measurements, may be used to supplement, or even replace, weather and climate data from the NIWA databases. Alternatively a weather station could be set up on a given property. However, this would require a long period of measurements to obtain any useful information for these crop assessments. But such weather stations can also be used in real-time to guide land management decisions.

About Venture Taranaki

Te Puna Umanga/Venture Taranaki is Taranaki's regional development and promotion agency, encompassing a wide range of activities spanning local and regional economic development and strategy, enterprise innovation and growth, regional promotion and marketing, sector development, and major event attraction. Venture Taranaki is a Council Controlled Organisation of the New Plymouth District Council, is governed by an independent Board of Trustees, and guided by Te Tiriti o Waitangi.

The long-term impact that Venture Taranaki is working towards is a Taranaki economy that helps enable the well-being of our people and our environment, underpinned by resilient enterprises, economies and communities.

Venture Taranaki does this by:

- promoting Taranaki as a great place to learn, live, work, play, visit and create
- providing enterprise support and enablement
- undertaking research and thought leadership
- promoting investment in Taranaki.

Venture Taranaki's work is also guided by *Make Way for Taranaki Tapuae Roa*, Taranaki's 2017 regional economic development strategy, and by the 2019 intergenerational *Taranaki 2050 Roadmap* for transitioning to a low-emissions future.

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