PFR SPTS No. 19386

Evaluation of selected horticultural crops for Ward and surrounding areas

Ward R, Clothier B

May 2020















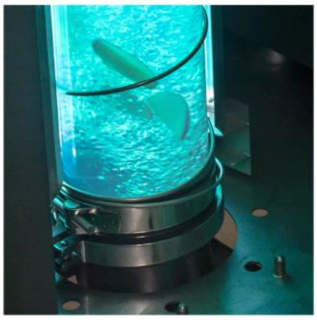


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Plant & Food Research has undertaken a horticulture-suitability assessment of Ward and surrounding areas for the Post Quake Farming Project.

The first stage was a generic assessment to identify locations potentially suitable for horticulture based on four broad criteria. We believe that most of the flat valleys around Ward, or about 2000 ha of land, would be suitable for horticulture, and indeed there already exists some horticulture in the area.

The second stage was an assessment of specific crops. These crops are:

- Apples: The climate appears well suited for apples, particularly mid-season varieties such as 'Royal Gala'. However there is a slight risk of frost before harvest on exceptionally cold years. This can be mitigated.
- Kiwifruit: While it appears possible to grow kiwifruit near the coast, it is likely to be too cool on average to maintain economic viability.
- Wine grapes: The climate is suitable for wine grapes. Indeed, there are already vineyards in the Ward area.
- Blueberries: Summers would appear to be consistently too cool for blueberries, without significant mitigation measures.
- Avocados: Maximum temperatures during the spring are sufficient for avocados, but there is a risk of cold snaps and frost damage due to cold winter and spring nights.
- Hazelnuts and walnuts: The winters are only cold enough for varieties with low to medium chilling requirements. Cultivar selection would be important.
- Hops, hemp and cannabidiol (CBD) cannabis: Hemp and CBD cannabis are likely feasible, however it is likely too windy for hops unless significant wind mitigation is implemented. Regulatory requirements would need to be met for hemp and CBD cannabis
- Olives: Both the climate and the soil appear suitable for olives, and this is not surprising since there are already olive plantations around Ward.

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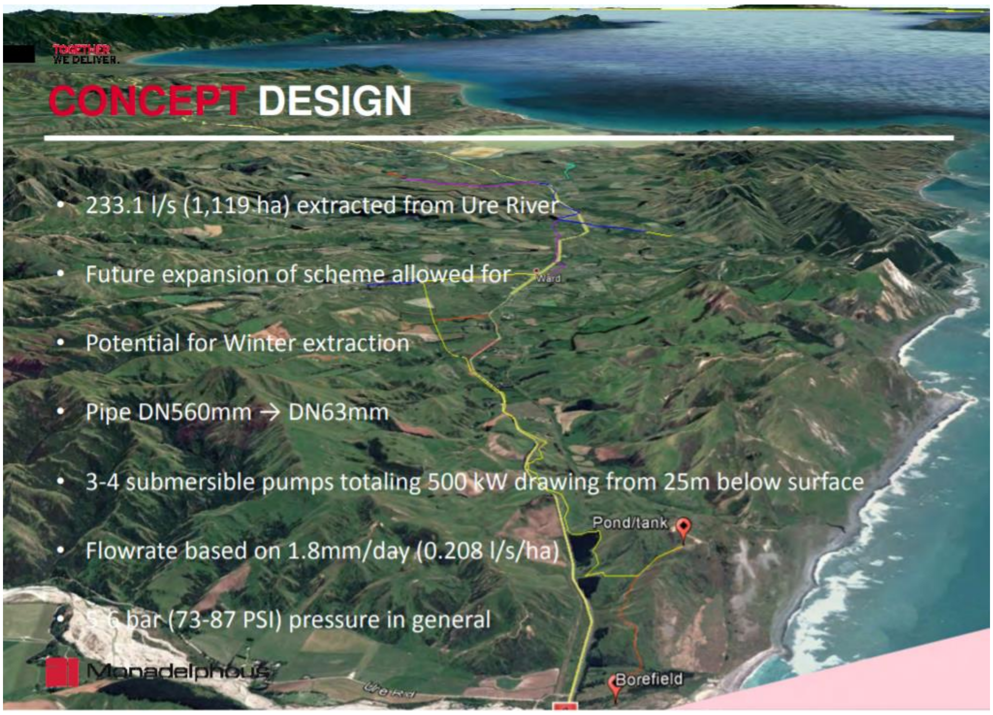
1 Introduction

We have already completed an assessment of the suitability for horticulture of the area encompassed by the Post-Quake Kaikoura project. This extended from Kekerengu in the north down to Cheviot and Culverden in the south. On 23 September, we gave a presentation to farmers in the township of Ward, where it became evident there is interest for new options in this area, especially as irrigation is expected to become available through the Flaxbourne Community Irrigation Scheme.

More details on this scheme can be found at: https://www.marlborough.govt.nz/repository/libraries/id:1w1mps0ir17q9sgxanf9/hierarchy/Documents/Services/Flaxbourne-Scheme/4_Concept_Design.pdf. A concept of the project design is presented below in Photograph 1.



Photograph 1. The concept behind the Flaxbourne Community Irrigation Scheme whereby water is drawn from below the Ure River in the south, and fed into the Ward basin to the north.

In February of this year, Mark Wheeler, the CE of the Marlborough District Council, commented that *"… concept plans for the Flaxbourne Irrigation Scheme, a $16m project paid for by the water users themselves, are being finalised. We hope to get that project started in late 2020, subject to a resource consent application*" (https://www.scoop.co.nz/stories/AK2002/S00247/infrastructure-update-marlborough-district-council.htm). Water will change the options and potential for agriculture and horticulture in the Ward area, and so within this post-quake project it was decided to complete an assessment of the suitability of the Ward area for horticulture.

This analysis is divided into two parts. Firstly, we perform a broad GIS sweep using criteria for general horticulture to determine areas where we consider generic horticulture to be viable. Secondly, we perform detailed analysis of the potential of specific crops using data from NIWA's Virtual Climate Station Network (VCSN, NIWA (2020)). The VCSN is a set of virtual weather and climate 'measurements' from 1972 to the present day, across a 5 x 5 km grid spanning the entire country. The data are interpolated from actual weather-station measurements.

The eight crops examined are:

- Apples
- Kiwifruit
- Wine grapes
- Blueberries
- Avocados
- Hazelnuts and walnuts
- Hops, hemp and cannabidiol (CBD) cannabis
- Olives

Ward, and the nearest VCSN sites 28101 and 28593, are shown in Figure 1.

While this analysis is done with the best information available, it must be emphasised that this is purely a desktop exercise, and ground-truthing will be required to validate any conclusions drawn.

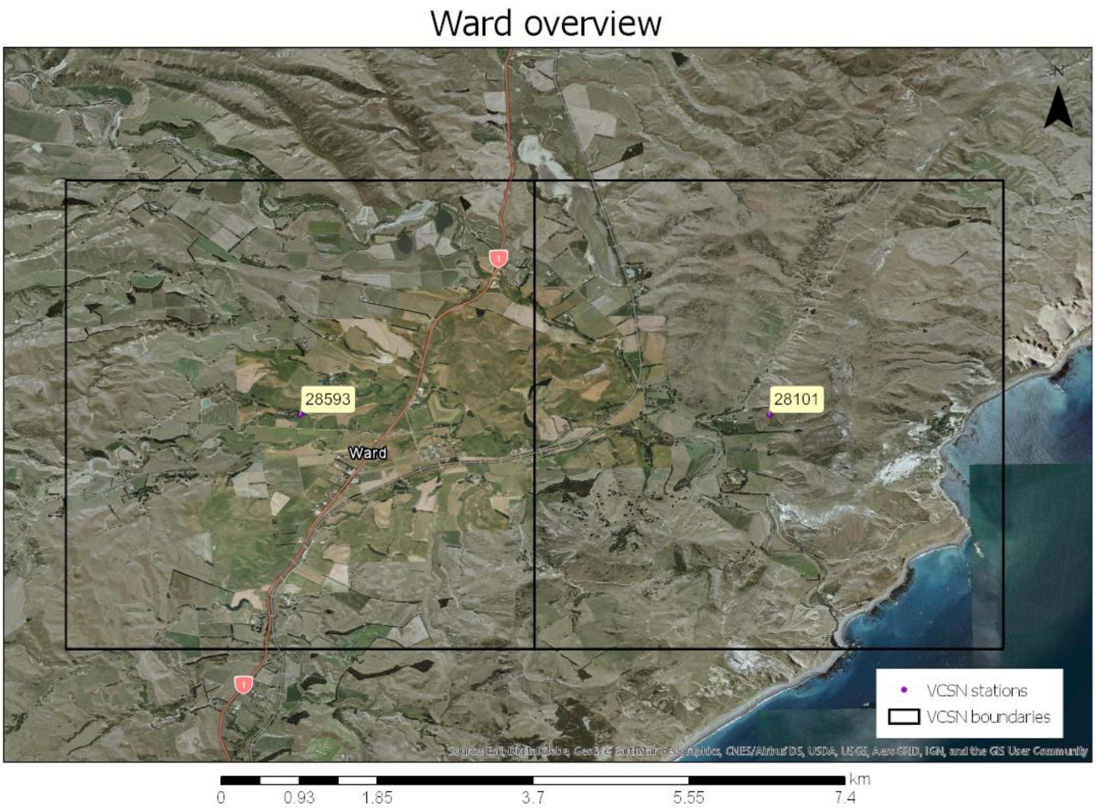


Figure 1. Overview of Ward township and surrounds, showing the Virtual Climate Station Network (VCSN) sites used for analysis, namely stations 28101 and 28593.

2 Broad GIS assessment

We consider four criteria for our broad GIS sweep to identify potential locations for generic horticulture. These criteria relate to Land Use Capability class (LUC), land slope, growing degree days base 10°C (GDD_{10}), and frost-free period (FFP). The LUC and slope data were reproduced with the permission of Landcare Research New Zealand Limited (https://lris.scinfo.org.nz/layer/76-nzlri-land-use-capability/ and https://lris.scinfo.org.nz/layer/48081-lenz-slope/), and the GDD_{10} and FFP data were reproduced with the permission of NIWA (https://www.niwa.co.nz/climate/research-projects/national-and-regional-climate-maps, Dr Andrew Tait, pers. comm.).

2.1 Land Use Capability class

Land Use Capability (LUC) is a general measure of the productive capacity of land and is widely used to inform decisions on land development and management in New Zealand (Lynn et al. 2009). It divides land into eight classes based on capability of sustained production and four subclasses reflecting the main physical limitation of said land. We consider LUC classes 1–3 to be suitable for horticulture, in general, and classes 4s–7s also suitable for wine grapes in particular. The s subclass refers to soil limitations, for example stoniness, and many prominent wine growing regions around New Zealand such as the Gimblett Gravels in the Hawke's Bay are on such land.

The LUC in Ward and its surrounds is shown in Figure 2. Most of the flat land in the valleys around Ward comprises LUC classes 2 or 3, and is suitable for general horticulture. There are also large areas of LUC class 4s which are more limited, but potentially suited for wine grapes. Most of the surrounding land is LUC class 6e which is unsuitable for horticulture, but, as seen in Figure 3, these areas also tend to have steep slopes and would also be unsuitable simple for that reason of steepness. Where land-owners have more detailed LUC and slope maps, it would be worthwhile to cross-check the broader-scale Figures 2 and 3 with their more-detailed information.

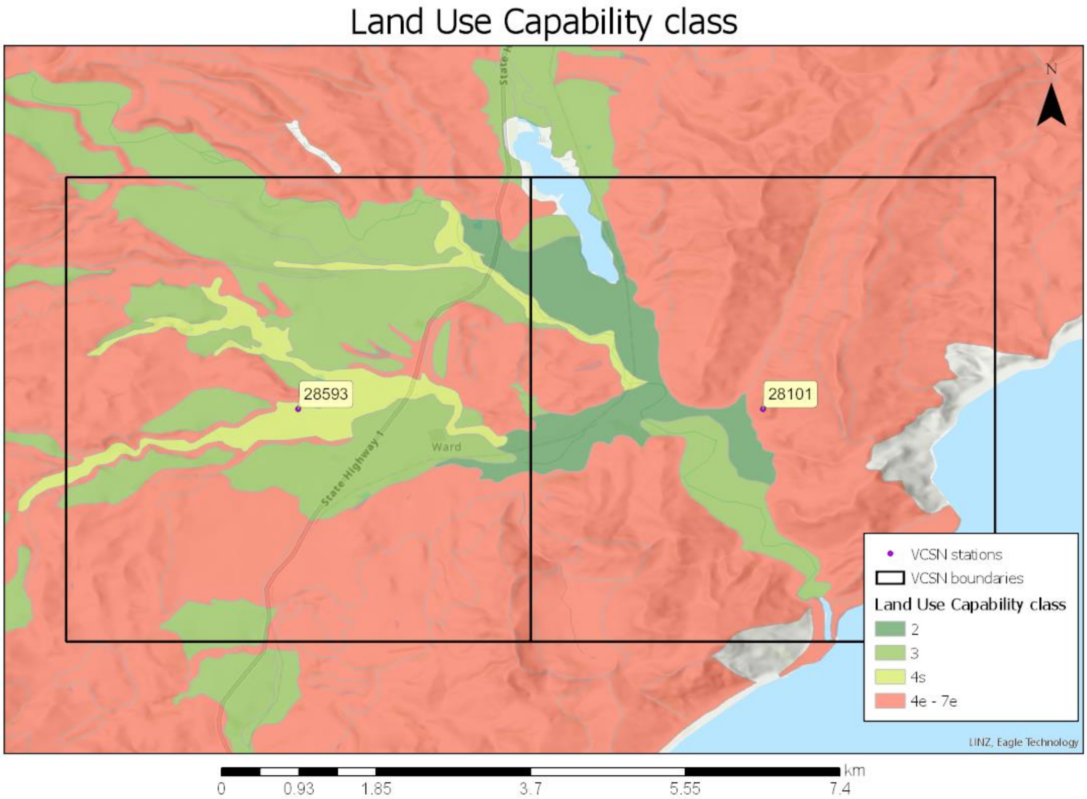


Figure 2. The land use capability (LUC) classes of Ward and surrounds.

2.2 Slope

We consider land with a slope of up to 15° to suitable for horticulture. This is because relatively flat land is required for trafficking and the use of farm machinery. While it is potentially possible to establish horticulture on steeper land, cultivation, management and harvest may be significantly more difficult.

The slope of the lands in the Ward area is shown in Figure 3. There is a large overlap with areas of suitable LUC class (Section 2.1) and the land which is flat. As mentioned in Section 2.1, there are large areas with steep slopes and these areas generally have unsuitable LUC classes for horticulture as well.

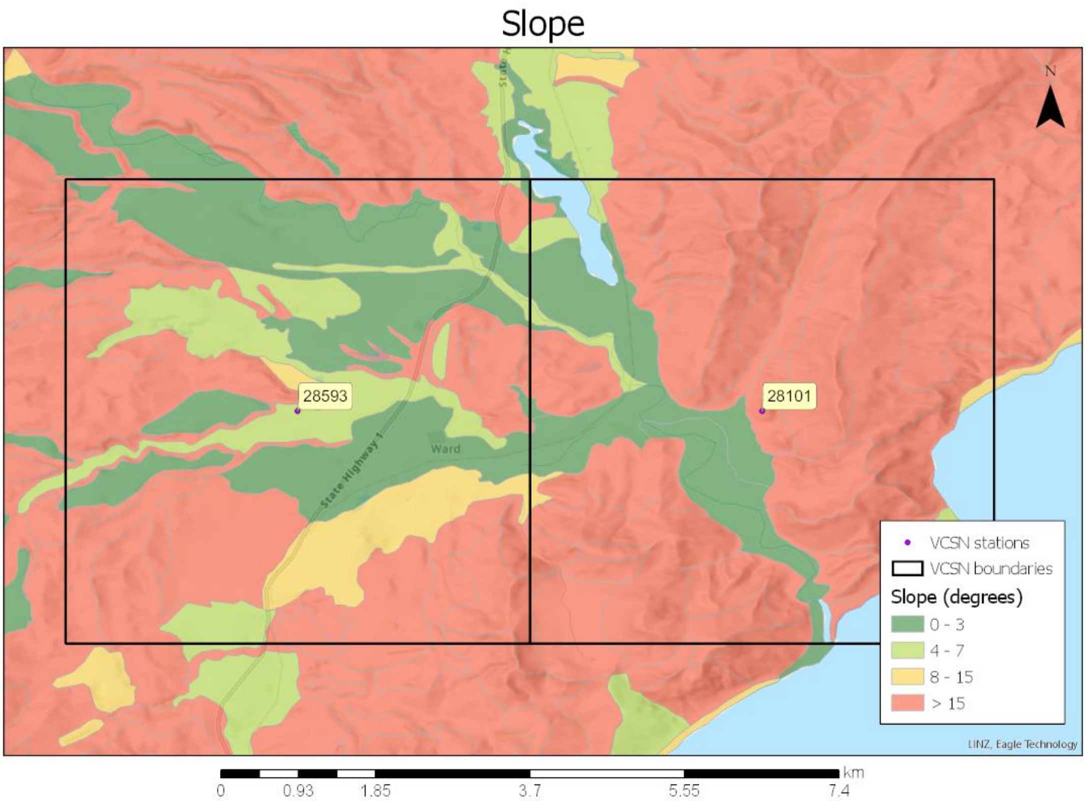


Figure 3. The slope of land near Ward and surrounds.

2.3 Growing degree days

Growing degree days (GDD) are a common measure of the amount of heat available for the growth of crops. It is calculated by subtracting a base temperature from the mean daily temperature, and then each degree above this base temperature is counted as one GDD. The base temperature is typically taken as 10°C, hence GDD_{10} is used here. We consider that the GDD_{10} must exceed 800 degree days, at least 80% of the time, to be suitable for general horticulture, and some crops may even require more.

The map of GDD_{10} values for Ward and surrounds is shown in Figure 4. The entire area experiences at least 1300 GDD_{10} annually, on average which is more than sufficient for horticulture. The valleys where some horticulture already exists generally receive slightly more, with the GDD_{10} being between1400 to 1500 degree days annually on average. It should be noted that these values are higher than those calculated in Section 3.1.2, since the GIS data available here are for the annual GDD_{10} and not the seasonal GDD_{10} we calculate later on in this report using the virtual climate station network (VCSN) from NIWA.

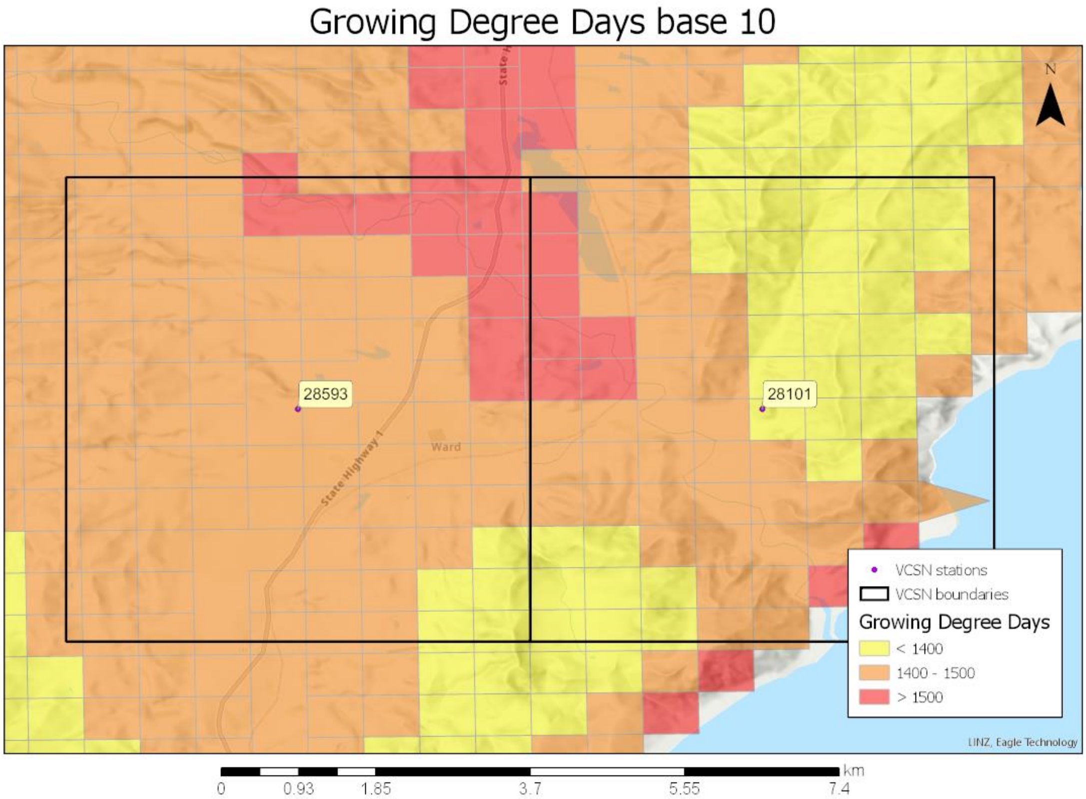


Figure 4. Growing Degree Days base 10°C (GDD_{10}) for Ward and surrounds.

2.4 Frost-free period

The frost-free period (FFP) is simply a measure of how much time there is between the last spring frost of one year and the first autumn frost of the following year. Days with frost are generally considered to be days where the minimum temperature drops below 0°C. It is important to consider this FFP since frosts after flowering in the spring, or before harvest in the autumn, can be damaging to a crop. In general, we consider a FFP of at least 200 days, 80% of the time, to be needed for horticulture.

A map of the FFP of the Ward area is shown in Figure 5. The entire area experiences FFPs of at least 220 days on average, and as calculated using the VCSN in Section 3.1.3, even the extreme minimum FFP exceeds 200 days. This is more than suitable for many horticultural crops, although such long FFPs could indicate a potential lack of cold temperatures for winter chilling that some crops require to break dormancy. We assess this later.

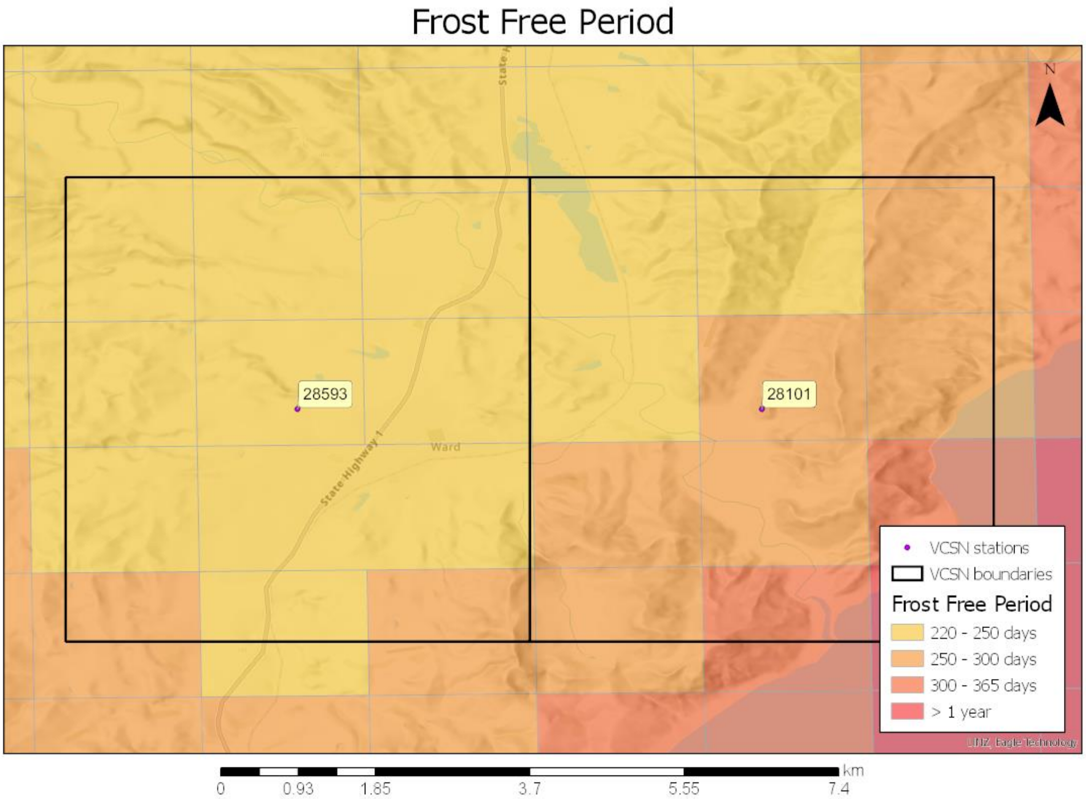


Figure 5. The frost-free period (FFP) for Ward and surrounds.

2.5 Suitability for general horticulture

We can now assess what areas are suitable for generic horticulture by considering the intersection of the areas meeting each of the four criteria. This result is displayed in Figure 6. We believe that most of the flat-bottomed valleys around Ward would be suitable for horticulture, and indeed there is already some horticulture in these areas. The area suitable for generic horticulture that is shown in green in Figure 6 covers around 2000 ha. The area is sufficiently warm for many crops, although such warmth might indicate a lack of winter chilling that some crops may require.

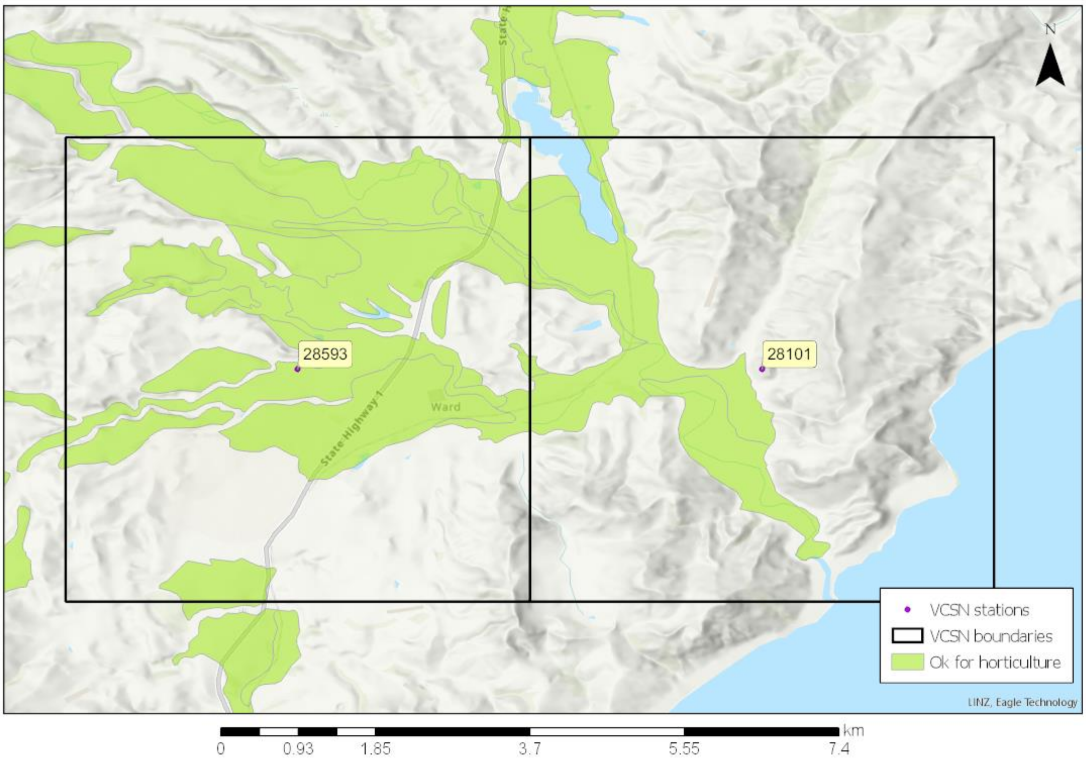


Figure 6. Areas we consider suitable for general horticulture in and around Ward.

It must be noted that even though the data used for this assessment are the best available, it is somewhat broad and generic. Hence, there are potentially areas that are suitable for horticulture that would appear to be unsuitable according to this assessment, and vice versa. Ground-truthing and even the use of new automatic weather stations could be merited.

3 Detailed analysis using climate data

We now carry out a detailed analysis of the local climate using data from the two nearest VCSN stations of VCSN 28593 and VCSNN 28101 (Figure 6). First we calculated chilling hours, GDD_{10} and frost dates as they are important for many crops, although different crops will have different requirements, and then we perform more specific calculations for individual crops.

The main caveat of these analyses is that the VCSN stations have a spacing of approximately 5 x 5 km. While the weather and climate data are considered to be useful predictions at the exact points of each VCSN station, they may miss variations in climate within the 5 x 5 km grid square, especially those niche microclimates in isolated areas such as valleys which require further investigation before committing to investment.

3.1 General criteria

3.1.1 Chill hours

Chill hours are important because fruiting crops generally require a period of chilling to break winter dormancy before flowering in the spring. Insufficient chilling may delay the onset and vigour of flowering, and hence reduce the crop yield at harvest. Chill hours are calculated by modelling the hourly temperature using the daily maximum and minimum temperatures and calculating how many hours are below a certain temperature threshold. Thresholds of 7°C and 7.2°C are used here as they are standard for many crops.

We consider the chill hours between May to September as that is when crops are typically in winter dormancy and these results are presented in Table 1. For inland Ward in the west there is a good degree of winter chilling with means of over 1300 chill hours, and 48-year minima of around 900 to 1000 hours. For the coastal area east of Ward there is a mean of around 1200 chill hours, and 48-year minima of around 800 to 900 hours.

Table 1. Chill hour statistics for Ward between May and September.

VCSN station	28101, West		28593, East	
Chill temperature	7°C	7.2°C	7°C	7.2°C
Mean chill hours	1307	1382	1193	1262
20th percentile chill hours	1068	1138	983	1047
48-year minimum chill hours	925	1005	824	901

3.1.2 Growing degree days base 10°C

As discussed in Section 2.3, GDD_{10} is a common measure of how much heat is available to crops for bud-break, flowering and the maturation of fruit. Similar to chill hours, different crops will have different requirements. We consider that the GDD_{10} between October and April, as that is when horticultural crops are typically developing, with harvest often occurring in late March or April. The GDD_{10} results are shown in Table 2, and there is a consistently high GDD_{10} for the area, with GDD_{10} minima of 800 to 900 degree days, and GDD_{10} means of around 1000 to 1100 degree days.

Table 2. The GDD_{10} statistics for Ward between October and April.

VCSN station	28101, West	28593, East
Mean GDD_{10}	1043	1139
20th percentile GDD_{10}	973	1079
48-year minimum GDD_{10}	821	912

3.1.3 Frost dates

As discussed in Section 2.4, frost is important to consider as frosts can damage crops if they occur after flowering or before harvest. We presented only the frost-free period in Section 2.4, but here using VCSN data we now calculate dates of the first autumn frost, and last spring frost of each year, assuming the temperature is indeed cold enough for frost. Days with minimum temperatures below a certain threshold are considered to be frost days, and we use 0°C and -2°C as these thresholds.

Frost statistics are shown in Table 3. Autumn frosts of 0°C are unlikely to interfere with harvest as the earliest they ever start is in May. However, spring frosts of 0°C may occasionally interfere with flowering as, while the mean date of the last frost is in July, there are occasionally frosts in September, and even October. Around a third of the time, the area around Ward does not experience frosts of 0°C, or cooler, at all during the whole of winter. It almost never experiences frosts of -2°C or cooler.

The frost-free period is consistently long around Ward. The shortest FFP for 0°C frosts is over 280 days, and many years do not even experience frosts at all. These frost data differ from those in Section 2.4, however we consider the VCSN data to be more reliable. Nonetheless, there could well be pockets of land that could experience frost, and so it would be prudent to consider land slope and the potential for cold-air drainage, and possibly even using wind turbines for frost protection.

Table 3. Frost statistics for Ward.

VCSN station	28101, West		28593, East	
Frost temperature	0°C	-2°C	0°C	-2°C
Mean date of first frost	1 July	4 July	27 June	27 June
20th percentile date of first frost	2 June	30 June	1 June	27 June
48-year earliest frost	23 May	27 June	22 May	27 June
Mean date of last frost	31 July	4 July	21 July	27 June
80th percentile date of last frost	20 September	9 July	17 August	27 June
48-year latest frost	4 October	12 July	30 August	27 June
Mean frost-free period	329 days	> 1 year	329 days	> 1 year
20th percentile frost-free period	309 days	> 1 year	314 days	> 1 year
48-year minimum frost-free period	281 days	> 1 year	284 days	> 1 year
Percentage of years with no frost	33%	96%	35%	98%

3.1.4 Soil water deficit

Soil water deficit (SWD) is a measure of how much water the soil is holding, and a simple climatological assessment can be based on the rainfall and evaporation data from the VCSN. In conjunction with an estimate of how much water can be stored by the soil, we can use this climatological assessment to estimate how much irrigation a crop might need over its growing season. Further more-detailed assessment, involving crop-specific information and soil-specific conditions, would be needed to determine irrigation quantities for consenting purposes.

Here our SWD is simply calculated by subtracting outgoing water in the form of evapotranspiration from incoming water in the form of rainfall. Generally, an empirical crop factor would need to be included to account for the temporal pattern of water used by each specific crop, but for generic simplicity we ignore this here, because it is a broad climatological assessment.

We consider the SWD around Ward from 1 October to 28 February, or 29 February on leap years, as this is the majority of the growing season. We assume that the soil water has been able to recharge over the winter, so we start the SWD at 0 mm on 1 October, and the cumulative SWD from then until 28/29 February is shown in Figure 2. The summary statistics are in Table 4. As expected, the SWD shows large variability from year to year, however there is a consistently large deficit, averaging just under 500 mm over the growing season with the eastern VCSN station being slightly drier. The driest seasons have total SWDs of almost 800 mm, while the wettest seasons are still quite dry with SWDs of over 100 mm.

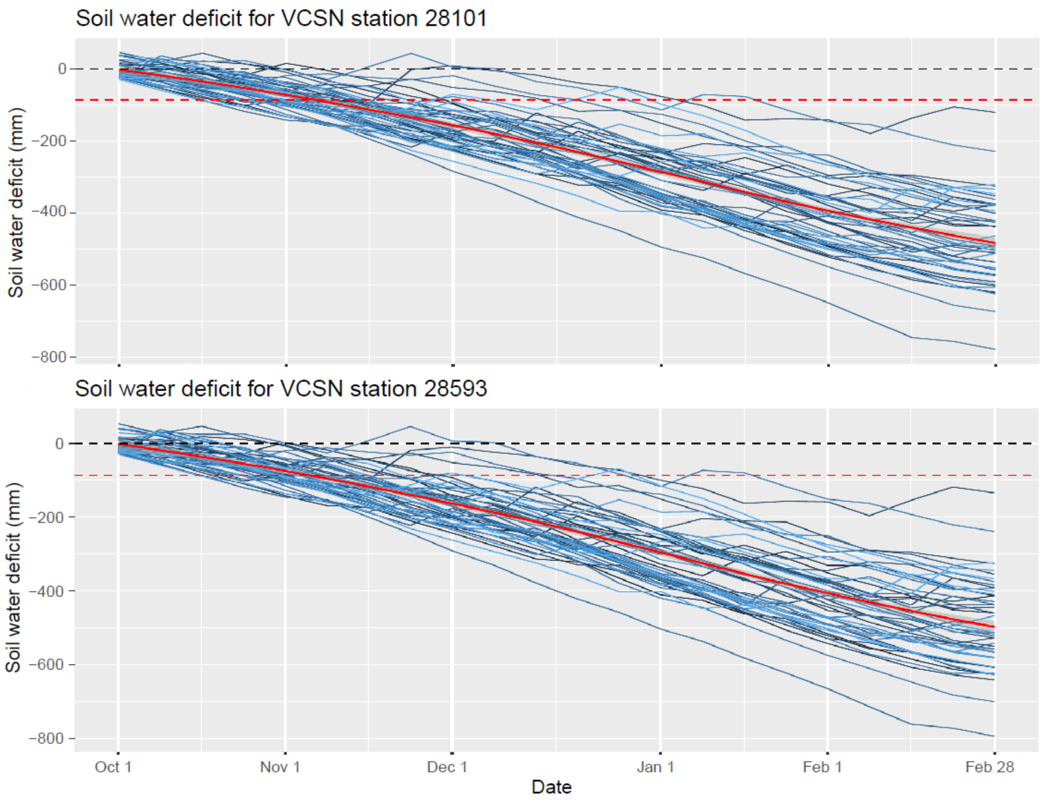


Figure 2. Weekly soil water deficit for the Virtual Climate Station Network (VCSN) stations around Ward from 1 October to 28/29 February. The local soil-profile's readily available water (PRAW) is shown as the red dashed line, being 87 mm for both stations.

Manaaki Whenua – Landcare Research estimates the soil-profile's readily available water (PRAW) for the valleys around Ward as Class 3, or with PRAW of between 75 and 99 mm (Manaaki Whenua - Landcare Research 2020). For further calculations, we simply take a midpoint of 87 mm for the general PRAW. Using that number as an estimate of how much water is available for crops to use over the growing season, we can the estimate how much irrigation might be needed and this is shown as the PRAW-adjusted SWD in Table 4. There is large variation, but on average, around 400 mm of irrigation would be needed over the growing season. Significantly more would be needed for the driest seasons. And even the wettest seasons would require some irrigation.

We can also use this measure to estimate when irrigation might start to become needed by looking at when the SWD becomes greater than the PRAW (Figure 2). For Ward, it would appear that irrigation would be needed from early November depending on crop type. There is large variation however, so in drier years irrigation may be needed even earlier in the growing season, while in wet years irrigation may not be needed until January.

It must be noted that these calculations ignore crop factors, local soil-water storage, and actual water requirements which will depend on the individual crop. Generally crops would therefore require less irrigation than presented here, for example for annual crops and perennial vine crops the crop factor will grow from zero, prior to bud-burst, in early October to its full-cover value in December. Even at full-canopy, the crop factor for grape vines is only 0.3–0.5.

Table 4. Soil water deficit statistics for Ward, both for the climatological soil-water deficit (SWD) and profile readily available water (PRAW)-adjusted SWD.

VCSN station	28101, West		28593, East	
	SWD	PRAW-adjusted SWD	SWD	PRAW-adjusted SWD
Mean SWD	474 mm	387 mm	488 mm	401 mm
20th percentile SWD	573 mm	486 mm	600 mm	513 mm

While relatively simple, this climatological assessment does highlight the value of irrigation in this region where rainfall is on average just between 700–800 mm, the majority of which falls during winter as the climate is Mediterranean-like.

4 Analyses for specific crops

4.1 Apples

These calculations are based on criteria for a mid-season cultivar such as ‘Royal Gala’. There is wide variation among apple cultivars in terms of the climate requirements for bud-break, flowering and the thermal time to reach maturity. The general results presented here could also be considered to apply to mid-season cultivars of pears. Indeed, the variation in the average climate requirements between apples and pears is smaller than the variation between the individual cultivars of apples and pears themselves (Parkes et al. 2016).

The apple results are presented in Table 5.

Apples generally require winter chilling of at least 500 chill hours below 7.2°C, and summer warmth of at least 800 GDD_{10}. Both of these requirements are well met, with Ward consistently experiencing at least 824 winter chill hours (Table 1), and at least 901 GDD_{10} (Table 2). In addition, apples require early-season warmth, with at least 120 GDD_{10} in the first 50 days after flowering. This is easily exceeded, with Ward experiencing 200 GDD_{10} on average in that time period.

We have developed rules for predicting the dates of apple flowering and harvest based on the local weather conditions (Austin and Hall 2001). For Ward, on average, apples will flower in mid- to late-October, and be ready for harvest in mid- to late-March. There is no risk of frost after flowering, however there is a slight risk of frost before harvest if the growing season has been somewhat cool. This risk could be mitigated.

Apples are at risk of sunburn if the temperature exceeds 34°C, however there is no risk of ambient temperatures that hot in Ward.

Table 5. Growing criteria for apples.

VCSN station	28101, West	28593, East
Mean flowering date	20 October	16 October
Probability of frost after flowering	0%	0%
Mean harvest date	25 March	19 March
Probability of frost before harvest	4%	2%
Mean GDD_{10} for the first 50 days after flowering	200	213
Risk of sunburn at 34°C or greater	0%	0%

We consider the Ward area to be suitable for apple growing.

4.2 Kiwifruit

We perform calculations for both green (‘Hayward’) and gold (‘Zesy002’ (commonly known as Gold3) kiwifruit. Results are shown in Table 6.

Kiwifruit require at least 1100 GDD_{10} over the growing season, however Ward experiences this only around half the time (Table 2). Towards the coast, there may be pockets of land that are sufficiently warm, as the 20th percentile GDD_{10} there is only just under this requirement. However, there is unlikely to be a suitable climate further inland.

For winter chilling, the mean temperature between May and July should not exceed between 11.7°C and 15.0°C, depending on variety, and whether or not Hicane® is required to induce bud-break (Hall and Snelgar 2014). The winter is sufficiently cold in Ward to make the use of Hicane® unnecessary.

We estimate that kiwifruit bud-break would occur in mid-September, on average, and that there is no risk of frost after this.

Table 6. Growing criteria for kiwifruit.

VCSN station	28101, West		28593, East	
Mean May-July temperature	9.0°C		9.4°C	
	Green	Gold	Green	Gold
Mean date of bud-break	14 September	14 September	15 September	14 September
Frost risk after bud-break	0%	0%	0%	0%

Given the lack of summer warmth, we think the Ward area is marginal for growing kiwifruit.

4.3 Wine grapes

These calculations are specific to Pinot noir and Sauvignon blanc grapes, but we consider these values to be representative for other red and white varietals, respectively. Results are shown in Table 7. Regardless, we do recognise that Ward is suitable for wine grapes, as several successful vineyards already exist in the area.

Ward experiences sufficiently cold winters for wine grapes for winter chilling, with a mean July temperature of around 8°C, being less than the requirement of 12°C.

We consider that Pinot noir require between 800–1000 GDD_{10} during the growing season for successful berry maturation, and the GDD_{10} value for Sauvignon blanc is required to be in the range of 850–1050. There is sufficient warmth during the growing season for both varietals. The mean date of bud-break is estimated using a model based on the temperatures in September (Parker et al. 2011), and that grapes are generally ready for harvest by the time autumn temperatures drop below 13°C. We can then calculate the growing-season GDD_{10} between these dates, which is almost 1000 GDD_{10} inland, and over 1100 GDD_{10} near the coast for both varietals. In addition, there is no risk of ambient temperatures above 40°C which can cause sunburn in the grapes, and there is no risk of frosts after bud-break which could damage the grapes.

Ward is relatively dry around harvest time, so we consider the risk of botrytis disease prior to harvest to be low. We consider a mean monthly rainfall in March and April of less than 70 mm to be dry enough to avoid a high risk of botrytis, and the mean monthly rainfall at this time for the Ward area is around just 60 mm.

Table 7. Growing criteria for wine grapes.

VCSN station	28101, West		28593, East	
Mean July temperature	7.8°C		8.2°C	
Mean monthly rainfall for March and April	59.8 mm		60.0 mm	
Risk of sunburn at 40°C or greater	0%		0%	
Mean autumn date where temperatures fall below 13°C	12 April		18 April	
	Pinot Noir	Sauvignon blanc	Pinot noir	Sauvignon blanc
Mean date of bud-break	1 October	3 October	29 September	1 October
Mean GDD_{10} for the growing season	992	987	1106	1100
Risk of -2°C frost after bud-break	0%	0%	0%	0%

The Ward area is considered suitable for the growing of wine grapes, as evidenced by extant vineyards.

4.4 Blueberries

The winter-chilling requirements for blueberries are quite variable depending on cultivar. Different cultivars require anywhere from 200 to 800 chill hours below 7.2°C. Ward consistently experiences over 800 chill hours every year, so this chilling requirement is met for all varieties (Table 1).

In terms of general summer warmth, blueberries require at least 600 GDD_{10} over the growing season. This is easily exceeded in Ward, which consistently receives over 800 to 900 GDD_{10} (Table 2).

However, blueberries have the additional requirement of needing maximum daily temperatures to consistently exceed 18°C, and ideally 19°C, from December to February. This requirement is never met as every year has summer days cooler than these temperatures (Table 8), possibly due to the incursion of late afternoon sea breezes. In addition, there is almost always at least three weeks with insufficient temperatures. While a standard method of mitigation for cool temperatures is to grow blueberries in tunnel houses, the summers are still possibly cool enough that this may not be sufficient for Ward.

Table 8. Growing criteria for blueberries.

VCSN station	28101, West		28593, East	
Maximum temperature	18°C	19°C	18°C	19°C
Percentage of years with at least one summer day cooler than required	100%	100%	100%	100%
80th percentile of number of days cooler than required	26 days	34 days	22 days	30 days

We consider the Ward area to be marginal for the growing of blueberries, even with protected cultivation.

4.5 Avocados

For avocados we only consider the ‘Hass’ cultivar here. Since the ‘Hass’ avocado accounts for 80% of the worldwide harvest, and 95% of the New Zealand harvest (New Zealand Avocado 2020), we consider this restriction sufficient for assessing the potential of avocados in Ward.

Avocados require fairly high temperatures during the spring, both in terms of daily maximum and daily minimum temperatures. The ideal temperatures necessary for September, October and November are detailed in Table 9, along with temperatures that we consider to be marginal.

As well as the need for sufficient spring temperatures, avocados require winters that are not too cold. Ideally the temperature will never get below 0°C on average, although an annual extreme minimum temperature of -2°C is acceptable, albeit marginal.

The mean spring and annual extreme temperatures for Ward along with the reference temperatures are shown in Table 9. While the mean maximum temperatures are more than sufficient, the mean minimum temperatures are generally marginal, or slightly below marginal, both in the spring and for the annual extreme. This indicates that while there is likely sufficient warmth in Ward, mitigation of cold and frost is potentially necessary for the successful cultivation of avocados.

Table 9. Growing criteria for avocados.

VCSN station	28101, West	28593, East		
Mean maximum temperature	Actual		Optimal	Marginal
September	19.3°C	20.1°C	>15°C	>14°C
October	21.5°C	22.3°C	>16°C	>15°C
November	23.6°C	24.4°C	>17°C	>17°C
Mean minimum temperature	Actual		Optimal	Marginal
September	6.6°C	6.9°C	>8°C	>7°C
October	8.0°C	8.4°C	>9°C	>8°C
November	9.7°C	10.1°C	>10°C	>10°C
Annual extreme	-0.5°C	-0.4°C	>0°C	>-2°C

We consider that the Ward area is marginal for growing avocados. We recognise that there are avocados growing right on the coast just south of Ward near Kekerengu. However a recent planting of young grafted seedlings there were badly hit by frost. Furthermore, a lack of irrigation there is affecting the production of the mature trees.

4.6 Hazelnuts and walnuts

Regardless of cultivar, hazelnuts and walnuts generally need at least 800 GDD_{10} during their growing season. This is consistently exceeded, with Ward experiencing over 800 GDD_{10} every year (Table 2).

Winter-chilling requirements are much more variable however, depending on cultivar. Hazelnuts generally require at least 1200 chill hours at 7°C or less, while walnuts require anywhere between 400 and 1600 chill hours, depending on cultivar. Conversely, both nuts are relatively intolerant to frost during their active growing season which generally extends from about mid-October to mid-March.

The probabilities of sufficient chill hours and frosts are shown in Table 10. There are consistently sufficient chill hours for walnut cultivars with low to medium chilling requirements, but insufficient chill for walnut cultivars with high chilling requirements. There is sufficient chilling for hazelnuts only around half to two-thirds of the time. Cultivar selection would be important. There is no risk of frost during the growing season for either nut.

Table 10. Growing criteria for hazelnuts and walnuts.

VCSN station	28101, West	28593, East
Chance of >400 chill hours	100%	100%
Chance of >800 chill hours	100%	100%
Chance of >1200 chill hours	67%	48%
Chance of >1600 chill hours	10%	4%
Chance of frost before 15 March	0%	0%
Chance of frost after 15 October	0%	0%

We consider that the Ward area is suitable for the growing of hazelnuts and walnuts. However, the winters are only cold enough for varieties with low to medium chilling requirements. Cultivar selection would therefore be important.

4.7 Hops, hemp and CBD cannabis

We consider hops, hemp and CBD cannabis together as they are very closely related crops and the requirements for successful cultivation are very similar. Due to the current legal status of cannabis in many countries, not as much research has been done on this crop compared with hops and hemp. We present results for hops in particular, but we believe our conclusions are valid for hemp and CBD cannabis too, albeit the cultivation protocols will be different.

4.7.1 Hops

Hops are quite hardy, and will grow in a large range of conditions. The main driver of growth and development is sunlight, and in particular days of sufficient length. As such the main requirement for successful cultivation is latitude. Hops in particular requires day lengths of at least 15 hours, including an allowance for twilight, without temperatures being too cold. It is generally accepted that latitudes between 35° and 55°, north or south, are ideal for hops (Rossini et al. 2016).

The majority of hops in New Zealand are grown around Motueka, but this is largely because of historical reasons rather than anything unique about the climate there. There is precedent to grow hops in other areas of the country, as we are aware of commercial growers in Queenstown (https://www.noted.co.nz/money/money-small-business/hops-garston-a-southern-man-goes-for-gold) and the Hawke's Bay (http://www.godsownbrewery.co.nz/). Plant & Food Research has hops trials at our Clyde and Kerikeri research stations. Hobby growers and wild hops also exist all over the country.

Figure 3 shows the equivalent latitudes of New Zealand and the USA with major hop growing areas in the US highlighted, being in particular Washington, Oregon and Idaho in the northwest, and North Carolina in the southeast. All of New Zealand lies below 35°S apart from the top of the North Island, and based on the large spread of hops plantations in the US, we consider that hops could potentially be able to be grown commercially in most of New Zealand, including Ward which is at a latitude of approximately 41.8°S.

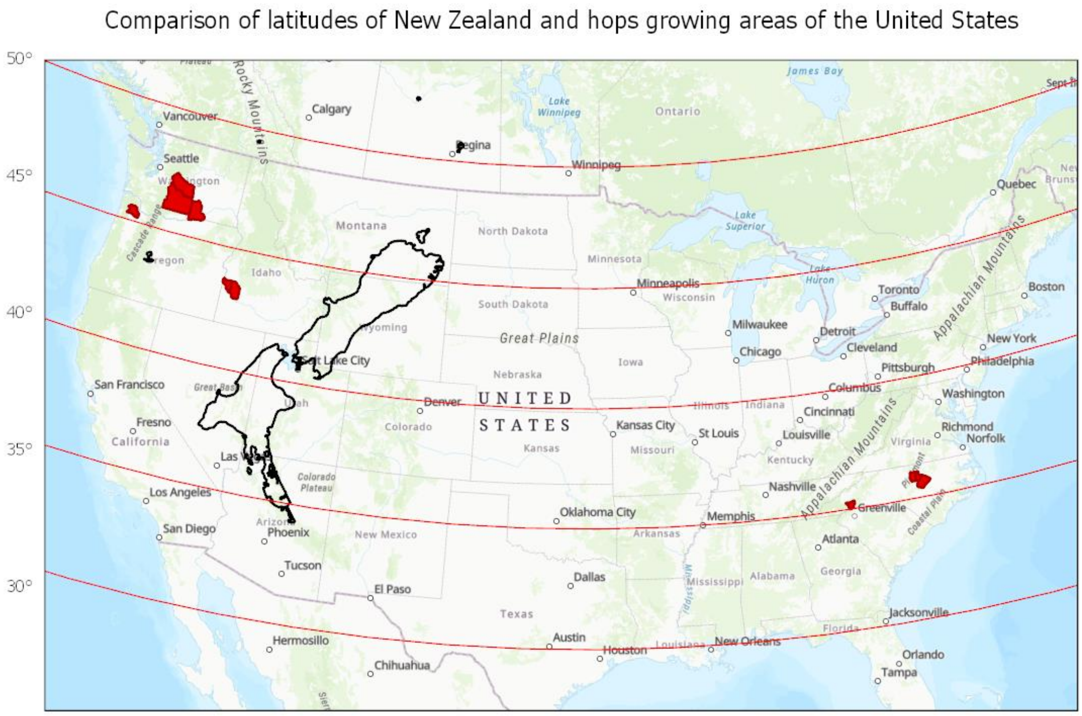


Figure 3. Equivalent latitudes of New Zealand and the United States. Major hop growing areas of Yakima, Washington; Willamette, Oregon; Parma, Idaho; and Raleigh and Henderson, North Carolina, are highlighted in red.

Hops are typically grown on trellises five metres high, and therefore wind needs to be taken into consideration when assessing the suitability for hops. This is because, in windy areas, hop bines are liable to be blown off the trellis and destroyed. Hops are a bine, where the main stem itself winds around the support string, whereas vines have tendrils which link onto the support structures. This impact of windiness is corroborated by in-house experience where Plant & Food Research had trialled hops in Marlborough, but the crop failed due to wind damage. Since we know that the wind is suitable in Motueka, yet excessive in Blenheim, we can compare the wind in Ward to both to estimate how feasible hops could be, and what kind of mitigation strategies might be necessary.

Windrun is a measure of how much wind passes over an area in a given time, in this case a day. It is calculated using the mean wind speed and extrapolating that over the entire day. The mean daily windruns for Motueka, Blenheim and Ward are shown in Table 11 with standard deviations to give an idea of how variable the wind is. Ward is significantly windier than both Motueka and Blenheim, so significant wind protection, or mitigation, would be needed for hops to be feasible. This could include shelterbelts, careful selection of a growing site out of the wind, or alternative methods of growing hops such as using short, three-metre trellises that are common in China. However, we are not aware of any New Zealand-based experience with using these short trellises.

We consider that the Ward area is marginal for hop growing, primarily because of its windiness. Wind mitigation would need to be implemented.

Table 11. Wind statistics for hops.

Location	Mean daily windrun	Standard deviation
Motueka	120 km	27 km
Blenheim	291 km	66 km
VCSN 28101, west Ward	553 km	206 km
VCSN 28593, east Ward	523 km	190 km

4.7.2 Hemp and CBD cannabis

Hemp and CBD cannabis share the requirement of sufficient day length with hops, and since most of New Zealand is within the generally accepted range of latitudes for hop growing, we surmise that most of New Zealand is suitable for hemp and CBD cannabis as well.

Unlike hops, we do not believe wind is a necessary consideration for hemp or CBD cannabis since they are generally grown to a relatively short height. Therefore, we would consider hemp and CBD cannabis to be more feasible for Ward than hops. Regulations would need to be met to enable the growing of these crops.

4.8 Olives

We recognise that at least some of the area around Ward is suitable for olives, as they are already grown there. However, it is worthwhile performing an analysis for the sake of completeness.

Olives require 150 to 300 hours of winter chilling for Tunisian, Greek and Spanish cultivars, while Italian cultivars require at least 600 chilling hours. These requirements are easily met in Ward (Table 1).

A major potential problem with cultivating olives in New Zealand is the risk of olive leaf spot, also called peacock spot, which thrives in cool, wet conditions (Obanor et al. 2008). However, the mean rainfall in March and April in Ward is about 120 mm (Table 7), and since this is dry enough for a low risk of botrytis in wine grapes, it is likely dry enough for a low risk of olive leaf spot too.

Olive trees prefer soils with low acidity or slight alkalinity, as well as relatively deep and free-draining soils. In particular, their root structure is concentrated in the top 50 to 70 cm so they require a potential rooting depth (PRD) of at least this much, as well as sufficient drainage so their roots do not become waterlogged (International Olive Council 2007).

The three soil properties of pH, PRD, and drainage for the area around Ward are shown in Figure 4. As seen in Figure 4a, most of the area previously identified as suitable for horticulture has neutral or slightly acidic pH values. The majority of the suitable area also has a PRD of at least 60 cm (Figure 4b), and is well- or moderately well-drained (Figure 4c).

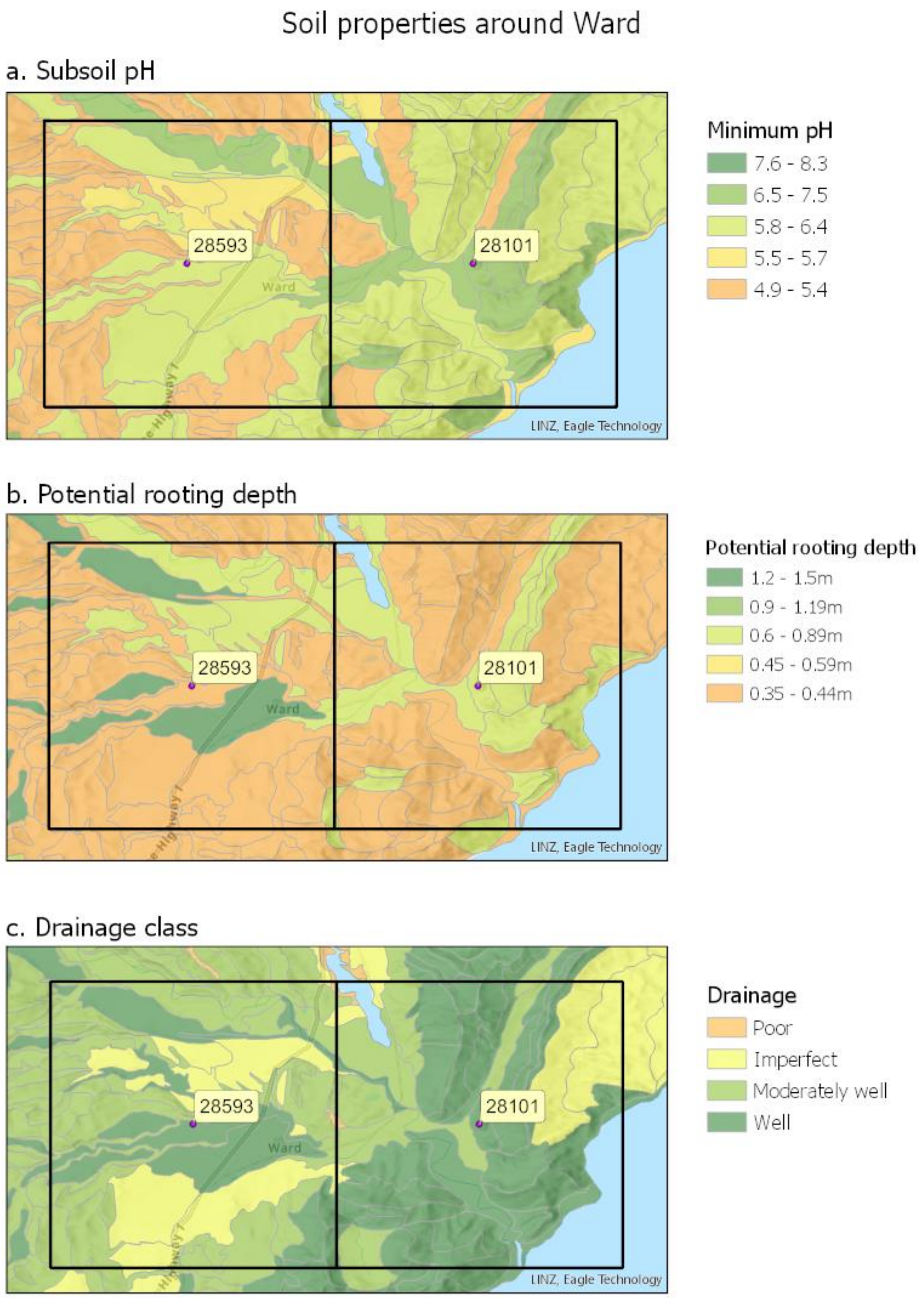


Figure 4. Soil properties around Ward. a. Minimum soil pH. b. Potential rooting depth (PRD). c. Drainage class. Data reproduced with the permission of Landcare Research New Zealand Limited. Source: https://lris.scinfo.org.nz/.

We consider that the Ward area is suitable for olive growing

5 Conclusions

We first performed a large-scale assessment of Ward, and surrounds, to identify locations which may be generically suitable for horticulture based on four broad criteria. We believe that most of the flat valleys around Ward would be suitable for horticulture, and indeed there already exists some horticulture in the area. There is about 2000 ha of land that is suitable for generic horticulture.

We then performed assessments of specific crops. These crops are:

- Apples: The climate appears well-suited for apples and pears, particularly mid-season varieties such as ‘Royal Gala’. However there is a slight risk of frost before harvest on exceptionally cold years. This can be mitigated.
- Kiwifruit: While it appears possible to grow kiwifruit near the coast, it is likely to be too cool on average for economic viability.
- Wine grapes: The climate is suitable for wine grapes. Indeed, there are already vineyards in the Ward area.
- Blueberries: Summers would appear to be consistently too cool for blueberries, without significant mitigation measures.
- Avocados: Maximum temperatures during the spring are sufficient for avocados, but there is a risk of cold snaps and frost damage due to cold winter and spring nights.
- Hazelnuts and walnuts: The winters are only cold enough for varieties with low to medium chilling requirements. Cultivar selection would be important.
- Hops, hemp and CBD cannabis: Hemp and CBD cannabis are likely feasible, however it is likely too windy for hops unless significant wind mitigation is implemented. Regulatory requirements would need to be met for hemp and CBD cannabis.
- Olives: Both the climate and the soil appear suitable for olives, and this is not surprising since there are already olive plantations around Ward.

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