FUTURE CLIMATE OF KAIPARA

Methodology

We now assess potential crop suitability for the future climate in Kaipara, specifically for the 2050s. This decade was chosen as it is far enough in the future to show a significant difference to the current climate while not being so far in the future that the plausibility of the results comes into question.

Modelled future climate data are provided by NIWA and processed using the same software as previous crop suitability assessments. Historical VCSN data currently spans 48 years from 1972 to 2020, and projected future climate data span from 2006 to 2100. Here we only use the future projections between January 1, 2045 and December 31, 2064.

We examine a twenty-year period centred on the 2050s as, per agreement from NIWA and Kaipara District Council, the statistics are more reliable than a ten year period and are less likely to be significantly affected by outliers. For comparison purposes, we have redone our suitability calculations for the period between January 1, 1986 and December 31, 2005, so we are examining a twenty year period in both cases.

We assess one representative concentration pathway (RCP) climate scenario here. RCP 8.5 is a 'worst-case' climate change scenario where global carbon emissions continue to increase over the 21st century, causing an estimated increase in mean global temperature of 2.0°C by 2065 and 3.7°C by 2100. Several other RCP scenarios are often used for climate change studies, but there is little difference in our projections between them for the 2050s. It is not until later in the century that the outcomes for the various scenarios diverge significantly.

Soil temperature is an important variable for some crops such as sorghum and peanuts. While most VCSN variables are modelled in NIWA's future climate projections, soil temperature is not. We have estimated soil temperature by performing a linear regression between mean air temperature and soil temperature for the historical VCSN data and using that relationship to estimate future soil temperature based on the future mean air temperature. We recognise that this estimation is somewhat imprecise and likely inaccurate, but we believe that it is sufficient for our purposes in this report.

General climate criteria

We compare current climate statistics calculated for previous reports with those calculated for RCP 8.5. Due to the large amount of data presented, we separate Kaipara into three regions for ease of displaying the data:

- Northern Kaipara: VCSN stations 20478 (Waipoua) and 28751 (Dargaville)
- Central Kaipara: VCSN stations 21434 (Te Kopuru) and 27564 (Ruawai)
- Southern Kaipara: VCSN stations 29120 (Pouto) and 25588 (Mangawhai)

First we present statistics for growing degree days base 10°C (GDD_{10}) between October and April, chill hours between May and September, and frost dates. Chill hours are important as crops generally require a period of winter dormancy to induce flowering. GDD_{10} is a common measure of how much heat is available for a crop to grow. Frost dates are important as early or late frosts can impact crop development or harvest.

Northern Kaipara

Table 1. GDD_{10} statistics for Waipoua and Dargaville.

GDD_{10}	Waipoua – VCSN station 20478		Dargaville – VCSN station 28751	
	Current	RCP 8.5	Current	RCP 8.5
Mean	1492	1698	1557	1775
20th percentile	1440	1639	1502	1728

Table 2. Chill hour statistics for Waipoua and Dargaville. Thresholds of 7°C and 7.2°C are shown.

Chill hours	Waipoua – VCSN station 20478		Dargaville – VCSN station 28751	
	Current	RCP 8.5	Current	RCP 8.5
7°C				
Mean	296	201	404	286
20th percentile	259	167	350	236
7.2°C				
Mean	333	227	437	311
20th percentile	292	193	377	263

Table 3. Frost date statistics for Dargaville. Waipoua is not shown as it experiences no frost currently, and only one day in the twenty years examined for RCP 8.5.

Frost dates (0°C)	Dargaville – VCSN station 28751	
	Current	RCP 8.5
Mean date of first frost	July 14	July 15
20th percentile date of first frost	June 26	June 12
Mean date of last frost	July 24	July 15
80th percentile date of last frost	August 2	August 11
Mean frost-free period	334 days	> 1 year
20th percentile frost-free period	314 days	325 days
Mean number of frost days per year with frost	1.4 days	1 day
Percentage of years with no frost	45%	75%

Both Waipoua and Dargaville are projected to have warmer growing seasons in the 2050s, showing an increase of generally 200-220 GDD_{10} compared to the present-day climate (Table 1).

Both locations are also projected to have warmer winters, with Waipoua experiencing around 90 fewer chill hours and Dargaville experiencing around 120 fewer chill hours on average (Table 2). Dargaville also sees a significant reduction in frost days (Table 3).

Central Kaipara

Table 4. GDD_{10} statistics for Te Kopuru and Ruawai.

GDD_{10}	Te Kopuru – VCSN station 21434		Ruawai – VCSN station 25764	
	Current	RCP 8.5	Current	RCP 8.5
Mean	1473	1708	1563	1790
20th percentile	1409	1723	1506	1714

Table 5. Chill hour statistics for Te Kopuru and Ruawai. Thresholds of 7°C and 7.2°C are shown.

Chill hours	Te Kopuru – VCSN station 21434		Ruawai – VCSN station 25764	
	Current	RCP 8.5	Current	RCP 8.5
7°C				
Mean	472	334	295	187
20th percentile	414	274	260	138
7.2°C				
Mean	511	365	332	215
20th percentile	444	297	290	158

Table 6. Frost date statistics for Te Kopuru. Frosts of -2°C or colder are not shown as neither station experiences temperatures that cold. Ruawai is not shown as it experiences no frost either currently or under RCP 8.5

Frost dates (0°C)	Te Kopuru – VCSN station 21434	
	Current	RCP 8.5
Mean date of first frost	July 13	July 3
20th percentile date of first frost	June 10	June 14
Mean date of last frost	August 4	July 16
80th percentile date of last frost	August 27	August 11
Mean frost-free period	340 days	333 days
20th percentile frost-free period	303 days	330 days
Mean number of frost days per year with frost	1.9 days	1.3 days
Percentage of years with no frost	40%	45%

Similar to Dargaville and Waipoua, both Te Kopuru and Ruawai are projected to experience warmer growing seasons in the 2050s with around 200-300 more GDD_{10} than currently (Table 4).

Both locations are projected to experience warmer winters. Te Kopuru is projected to experience around 130-150 fewer chill hours on average (Table 5) and less frost (Table 6). Ruawai is projected to experience around 110-120 fewer chill hours on average and is projected to experience no frost at all.

Southern Kaipara

Table 7. GDD_{10} statistics between October and April for Pouto and Mangawhai.

GDD_{10}	Pouto – VCSN station 29120		Mangawhai – VCSN station 25588	
	Current	RCP 8.5	Current	RCP 8.5
Mean	1487	1700	1571	1790
20th percentile	1416	1649	1521	1714

Table 8. Chill hour statistics between May and September for Pouto and Mangawhai. Thresholds of 7°C and 7.2°C are shown.

Chill hours	Pouto – VCSN station 29120		Mangawhai – VCSN station 25588	
	Current	RCP 8.5	Current	RCP 8.5
7°C				
Mean	533	404	307	217
20th percentile	464	360	252	173
7.2°C				
Mean	571	437	338	242
20th percentile	503	390	282	192

Table 9. Frost date statistics for Pouto for frosts of 0°C and -2°C. Mangawhai is not shown as it only experiences one frost in the twenty past years examined and no frosts under RCP 8.5.

Frost dates	Pouto – VCSN station 29120		Pouto – VCSN station 29120	
	Current	RCP 8.5	Current	RCP 8.5
Frost temperature	0°C	0°C	-2°C	-2°C
Mean date of first frost	July 2	July 1	July 26	June 14
20th percentile date of first frost	June 8	June 14	July 14	June 8
Mean date of last frost	August 3	July 19	July 30	July 6
80th percentile date of last frost	August 24	August 12	August 22	July 22
Mean frost-free period	329 days	353 days	> 1 year	> I year
20th percentile frost-free period	309 days	320 days	> 1 year	> I year
Mean number of frost days per year with frost	2.9 days	1.5 days	1.2 days	1.5 days
Percentage of years with no frost	0%	15%	70%	80%

Consistent with the previous four sites examined, both Pouto and Mangawhai are projected to experience warmer growing seasons in the 2050s than in the current climate (Table 7). Under RCP 8.5, both sites are projected to experience 200-230 more GDD_{10} on average.

Both sites experience significantly warmer winters, with Pouto experiencing around 130 fewer winter chill hours on average and Mangawhai experiencing around 90 fewer chill hours on average. Both sites also experience reductions in frost days.

Summary

The Kaipara region is projected to experience consistently warmer growing seasons in the 2050s under the RCP 8.5 scenario, with the district experiencing 200-300 more GDD_{10} on average, depending on region. This indicates that a larger range of warm-weather crops could potentially be grown, and that crops that are currently marginal in terms of GDD_{10} could be easier to grow in the 2050s.

Similarly, winters are projected to get warmer with the district experiencing 90-150 fewer chilling hours on average, depending on location and chill threshold. In terms of frost, the district is projected to experience fewer frosts overall, both in the number of years with frosts, and the number of days per year with frosts.

These projections for winter chilling and frost indicate that, depending on region, care would need to be taken for crops which have strict winter chill requirements.

Crop-specific projections

Now we assess the projections for individual crops, using the same criteria as for previous assessments.

Avocados

Avocados require spring temperatures above certain thresholds and do not tolerate winter frosts well (Table 10).

Table 10. Temperature criteria for avocados.

Criterion	Optimal	Marginal
Mean minimum temperature for September	8°C	7°C
Mean minimum temperature for October	9°C	8°C
Mean minimum temperature for November	10°C	10°C
Mean maximum temperature for September	15°C	14°C
Mean maximum temperature for October	16°C	15°C
Mean maximum temperature for November	17°C	17°C
Mean annual extreme minimum temperature	0°C	-2°C

Table 11. Temperature statistics for avocados.

Criterion	VCSN station		VCSN station	
	Waipoua – 20478		Dargaville - 28571	
	Current	RCP 8.5	Current	RCP 8.5
Mean minimum temperature				
September	9.2°C	9.7°C	9.5°C	9.9°C
October	9.9°C	10.6°C	10.0°C	11.0°C
November	11.1°C	11.1°C	11.3°C	11.9°C

Mean maximum temperature				
September	20.0°C	20.6°C	20.7°C	21.7°C
October	21.7°C	22.8°C	22.3°C	23.6°C
November	23.2°C	24.2°C	24.0°C	24.9°C
Annual extreme minimum temperature	1.8°C	2.1°C	0.0°C	0.6°C
	Te Kopuru – 21434		Ruawai - 27564	
	Current	RCP 8.5	Current	RCP 8.5
Mean minimum temperature				
September	9.1°C	9.7°C	9.3°C	9.9°C
October	9.9°C	10.6°C	10.1°C	10.8°C
November	11.0°C	11.7°C	11.2°C	11.9°C
Mean maximum temperature				
September	20.2°C	21.4°C	20.4°C	21.2°C
October	22.0°C	22.9°C	21.9°C	22.8°C
November	23.9°C	24.8°C	23.9°C	24.6°C
Annual extreme minimum temperature	-0.5°C	-0.1°C	1.8°C	2.0°C
	Pouto – 29120		Mangawhai - 25588	
	Current	RCP 8.5	Current	RCP 8.5
Mean minimum temperature				
September	8.9°C	9.6°C	9.8°C	10.5°C
October	10.0°C	10.6°C	10.7°C	11.1°C
November	10.9°C	11.8°C	11.7°C	12.4°C
Mean maximum temperature				
September	20.6°C	20.9°C	20.3°C	21.2°C
October	21.8°C	23.1°C	21.9°C	22.7°C
November	24.1°C	25.1°C	23.9°C	24.2°C
Annual extreme minimum temperature	-1.8°C	-1.1°C	1.8°C	1.5°C

In terms of spring temperatures, Kaipara was already suitable for avocados and is projected to remain so in the 2050s under RCP 8.5 (Table 11). All monthly mean minimum and maximum temperatures remain optimal with small increases over current mean temperatures.

While most of the district will have sufficiently warm winters, the coastal areas of Pouto and Te Kopuru are projected to experience occasional frosts which could affect avocados, with annual mean minimum temperatures slightly below 0°C. However, these minima are still what we would consider

marginal (0°C to -2°C) so we would regard avocados to remain a potentially suitable crop in the 2050s.

Hops, hemp and CBD cannabis

As detailed previously, the main driver of growth for hops, hemp and CBD cannabis is day length. As this is a function of latitude, it will not change in the 2050s. However, wind is a concern for hops specifically as they are typically grown on very tall trellises. We compare the projected windrun with the current windruns for Kaipara and the windrun for Motueka (120 ± 27 km) which we know is suitable for hops.

Table 12. Wind statistics for Kaipara

Windrun (km)	VCSN station		VCSN station	
	Waipoua – 20478		Dargaville - 28571	
	Current	RCP 8.5	Current	RCP 8.5
Mean windrun	464	450	429	416
Standard deviation	223	216	218	210
	Te Kopuru – 21434		Ruawai – 27564	
	Current	RCP 8.5	Current	RCP 8.5
Mean windrun	464	451	428	416
Standard deviation	230	221	218	209
	Pouto – 29120		Mangawhai – 25588	
	Current	RCP 8.5	Current	RCP 8.5
Mean windrun	449	437	410	400
Standard deviation	229	220	218	210

The wind in Kaipara is not projected to change significantly (Table 12). We considered wind to already be a concern for hops cultivation, so this indicates that care would still be needed when selecting sites for hops. We would not consider the wind to have a significant impact on hemp or CDB cannabis due to the differing cultivation practices.

Olives

Olives have fairly diverse winter chilling requirements depending on variety. For example, Italian cultivars such as ‘Frantonio’ require at least 600 winter chill hours below 7°C while Spanish cultivars such as ‘Arbequina’ require 150-300 winter chill hours. However, Frantonio olives are grown successfully around Mangawhai despite the region averaging around half of the reported chilling requirement (Table 8). Because of this, we would surmise that the areas which are projected to experience little change in winter chilling, or an increase, would continue to be suitable for olive cultivars that are currently grown. However, for the areas which are projected to experience a large decrease in winter chilling, such as Ruawai, careful selection of cultivar would likely be needed, potentially Spanish or Greek cultivars with low chill requirements.

Table 13. Mean rainfall for March and April.

Rainfall (mm)	Waipoua 20478	Dargaville 28571	Te Kopuru 21434	Ruawai 27564	Pouto 29120	Mangawhai 25588
Current	187.2	147.6	133.8	146.6	138.6	155.0

RCP 8.5	195.0	153.8	160.2	159.2	160.4	162.2

A major concern with olives in New Zealand currently is the incidence of olive leaf spot, also called peacock spot. High rainfall in March and April increases the risk of this disease, and the average rainfall at this time is between 134 and 187 mm in Kaipara (Table 13). In particular, Mangawhai averages 155.0 mm of rain in March and April so good fungal control programmes are necessary.

Under RCP 8.5, Kaipara is predicted to be slightly wetter overall. This indicates that good fungal control would still be necessary and potentially even more important than currently.

Sorghum, soybeans and peanuts

Previously we considered the sowing date of sorghum, soybeans and peanuts to be the first day when the soil temperature reached 15°C, which currently averages around the beginning of October for Kaipara. However, using our simple linear regression between air temperature and soil temperature, these dates are very early, in July or early August. We consider these dates to be unrealistically early for typical horticultural practices so for our purposes here we set them as one month after the first day of 15°C soil temperatures (Table 14).

Table 14. Current and projected sowing dates for sorghum, soybeans and peanuts.

Sowing date	Waipoua 20478	Dargaville 28571	Te Kopuru 21434	Ruawai 27564	Pouto 29120	Mangawhai 25588
Current	October 4	October 1	October 5	September 29	October 4	October 2
RCP 8.5	August 25	August 9	August 22	September 3	August 26	August 12

All three crops can roughly be divided into short- and long-season varieties based on their general GDD_{10} requirements, detailed in Table 15. We then assess estimated harvest dates and growing season lengths based on these requirements and the planting dates detailed in Table 14.

Table 15. GDD_{10} requirements for short- and long-season varieties of sorghum, soybeans and peanuts.

Crop	Short-season GDD_{10}	Long-season GDD_{10}
Sorghum	1485 GDD_{10}	1867 GDD_{10}
Soybeans	1283 GDD_{10}	1629 GDD_{10}
Peanuts	1450 GDD_{10}	1600 GDD_{10}

Sorghum

Table 16. Growing season statistics for sorghum

Criterion	VCSN station		VCSN station	
	Waipoua – 20478		Dargaville - 28571	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	May 4	March 2	April 18	March 6
Growing season length (days)	216	207	201	208
Years with enough GDD_{10}	90%	100%	95%	100%

Long season				
Harvest date	May 4	May 6	May 25	April 19
Growing season length (days)	257	260	257	253
Years with enough GDD_{10}	10%	90%	30%	100%
	Te Kopuru – 21434		Ruawai - 27564	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 29	March 18	April 14	March 13
Growing season length (days)	209	208	197	195
Years with enough GDD_{10}	85%	100%	95%	100%
Long season				
Harvest date	April 29	May 5	May 22	April 30
Growing season length (days)	247	261	251	243
Years with enough GDD_{10}	10%	85%	35%	100%
	Pouto – 29120		Mangawhai - 25588	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 25	March 20	April 17	March 6
Growing season length (days)	205	205	199	206
Years with enough GDD_{10}	90%	100%	95%	100%
Long season				
Harvest date	May 14	May 8	May 2	April 20
Growing season length (days)	224	259	251	251
Years with enough GDD_{10}	15%	85%	35%	100%

Projections indicate that sorghum could become a much more viable crop than it currently is (Table 16). While the growing season length does not change significantly, there is much more flexibility in when to plant and harvest short-season varieties of sorghum. In addition, for long-season varieties, there is a much higher chance of there being sufficient GDD_{10} over the growing season, however harvest dates would still continue to be relatively late.

Soybeans

Table 17. Growing season statistics for soybeans.

Criterion	VCSN station		VCSN station	
	Waipoua – 20478		Dargaville - 28571	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 5	February 28	March 21	February 15
Growing season length (days)	183	186	171	189
Years with enough GDD_{10}	100%	100%	100%	100%

Long season				
Harvest date	May 15	April 7	May 6	March 21
Growing season length (days)	234	225	221	223
Years with enough GDD_{10}	50%	100%	80%	100%
	Te Kopuru – 21434		Ruawai - 27564	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 3	February 25	March 18	February 22
Growing season length (days)	180	187	169	174
Years with enough GDD_{10}	100%	100%	100%	100%
Long season				
Harvest date	May 12	April 4	May 2	March 29
Growing season length (days)	229	225	218	210
Years with enough GDD_{10}	50%	100%	80%	100%
	Pouto – 29120		Mangawhai – 25588	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	March 29	February 26	March 22	February 15
Growing season length (days)	175	183	171	186
Years with enough GDD_{10}	100%	100%	100%	100%
Long season				
Harvest date	May 6	April 7	May 11	March 21
Growing season length (days)	221	224	223	221
Years with enough GDD_{10}	60%	100%	85%	100%

Similar to sorghum, while there is not projected to be a large change in growing season lengths, there is much more flexibility in planting and harvest dates due to the increase in time for which there is sufficient soil temperature (Table 17). In addition, while some areas of Kaipara are currently marginal for long-season soybeans, the entire district is projected to consistently experience sufficient GDD_{10} in the 2050s.

Peanuts

Table 18. Growing season statistics for peanuts.

Criterion	VCSN station		VCSN station	
	Waipoua – 20478		Dargaville - 28571	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 28	March 16	April 13	March 2
Growing season length (days)	209	203	195	205
Years with enough GDD_{10}	85%	100%	90%	100%

Long season				
Harvest date	May 6	April 3	May 3	March 18
Growing season length (days)	225	221	217	220
Years with enough GDD_{10}	50%	100%	80%	100%
	Te Kopuru – 21434		Ruawai - 27564	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 26	March 14	April 7	March 9
Growing season length (days)	206	204	191	191
Years with enough GDD_{10}	85%	100%	90%	100%
Long season				
Harvest date	May 10	April 1	April 30	March 26
Growing season length (days)	224	222	216	207
Years with enough GDD_{10}	55%	100%	85%	100%
	Pouto – 29120		Mangawhai - 25588	
	Current	RCP 8.5	Current	RCP 8.5
Short season				
Harvest date	April 18	March 15	April 12	March 3
Growing season length (days)	199	201	193	203
Years with enough GDD_{10}	85%	100%	90%	100%
Long season				
Harvest date	May 17	April 3	May 4	March 18
Growing season length (days)	227	220	217	218
Years with enough GDD_{10}	80%	100%	85%	100%

Peanuts show similar projections to sorghum and soybeans. While the growing season length is not projected to change significantly, there is likely to be greater flexibility with planting and harvest dates (Table 18). There is also more chance of there being enough GDD_{10} for long-season varieties of peanuts.

Conclusions

We have assessed the potential suitability of crops in Kaipara for the 2050s, using data provided by NIWA for the projected climate under the RCP 8.5 climate change scenario and comparing with suitability calculations for 1986 to 2005. In general, we expect there to be significantly more GDD_{10} over the growing season and a corresponding decrease in winter chilling and frost.

We project that crops with significant summer warmth requirements and no specific winter chilling requirements would be better suited for Kaipara in the 2050s, including avocados, sorghum, soybeans and peanuts.

We would consider there to be no major change in the suitability of olives for Kaipara in general, however appropriate selection of cultivar would be important depending on the area and how the

winter chill hours are projected to change for that area. Fungal control is an important consideration for olives currently, and we would not expect that to change in the 2050s as the autumnal rainfall is projected to increase.

While the projected temperatures in the 2050s would appear to be suitable for hemp and CBD cannabis, we project Kaipara to remain about as windy as it currently is, so we consider hops would be difficult to grow with conventional tall trellises.