Adapting to climate change in the kiwifruit industry

Prepared for MAF Policy Climate Change – 'Plan of Action' Research Programme 2007-08

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Acknowledgements

Thanks are due to the kiwifruit growers who generously gave their time to be interviewed for this project. This report has only been possible because of their contributions and it is hoped that the contents form a fair reflection of what they have individually and collectively shared. This report was also made possible through the on-going support of staff at ZESPRI and NZKGI. Particular thanks are due to Jane Adams, Innovation Leader, ZESPRI and Mike Chapman, Chief Executive, NZKGI for facilitating early discussions relating to this work. Thanks are also due to Shane Max, Roger Hoebers and others at ZESPRI for helping identify growers and facilitating meetings with ZESPRI staff, and to the ZESPRI staff who contributed their thoughts and ideas. The scientists at HortResearch, Te Puke, who shared their ideas are also gratefully acknowledged. Finally, thanks are due to MAF for financially supporting this project and to MAF staff, in particular Trecia Smith for hitting the ground so effectively and providing valuable support and feedback.

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Executive Summary

A focus on adaptation encourages a shift towards positive thinking and actions in relation to climate change. The results of this study, founded on engagement with key kiwifruit growers, strongly reinforce this view. This study has built on a foundation of work that has focused on climate change and kiwifruit, as well as previous adaptation work with farmers and kiwifruit growers. The kiwifruit industry is currently well placed to adopt a planned, proactive, approach to adaptation. The timing is right for such an approach. This and previous work has provided some valuable momentum with a core group of growers engaged, a number of whom are keen to contribute to next steps. There are key areas that need attention, the most important ones being:

- Communication and education throughout the industry on climate change and adaptation with a focus towards practical solutions and actions.

- Long-term strategic research aimed at making the most of the climate resource in the future and minimising risks and costs. Of fundamental importance is breeding of new varieties that require less winter chilling and produce high quality fruit. Pest and disease issues, water and the evolution of management and post-harvest systems will all require some attention as well.

- The identification and realisation of marketing opportunities. There is an opportunity for the kiwifruit industry to profile positive stories in relation to climate change and adaptation.

- Water allocation issues need to be resolved for the future. Environment Bay of Plenty is currently working on a Water Sustainability Strategy for the western Bay of Plenty. It is hoped that the opportunity to resolve relevant issues will be taken in the development of this strategy.

The wider relevance of this work is in the grounding of current scientific knowledge with practical, forward thinking people. A two way dialogue emerges from such an approach. On the one hand people on the ground are more informed about the science and able to make it relevant and real in what they are doing and in their future planning. On the other hand the information and thinking shared by people on the ground provides insight and direction that is very relevant for the policy and science communities. It provides the opportunity to be strategic, practical, efficient and effective with our resources.

Key findings from Parts 1 and 2 of this report are presented below.

Part 1 – The current state of knowledge

Climate variability and change

- As with other New Zealand regions, the changeable climate of the Bay of Plenty is a result of natural variability and chaos along with influences from observed phenomena.

- Observed phenomena include variations as a result of the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) and an underlying warming trend (0.1ºC per decade over the last 100 years) which is consistent with human-induced climate change.

- Current scenarios of climate change show a mid-range warming in all kiwifruit growing regions of about 1ºC by the 2040s and 2ºC by the 2090s. The scenarios indicate drier winter and spring conditions in eastern North Island growing regions including the Bay of Plenty with slightly wetter summer and autumn conditions in the Bay of Plenty, Gisborne, Hawke's Bay and Nelson/Tasman.

- There will be changes in extreme weather events in all regions with the possibility of increased westerly winds in winter and spring, decreased frost risk, increased incidence of high temperatures in summer, increased frequency of extreme daily rainfalls, and a possible increase in strong winds.

Impacts on kiwifruit

- All published impact studies to-date have focused on the Green ('Hayward') variety. Since the first published assessment of impacts in New Zealand (MfE, 1990), winter chilling has been recognised as a key indicator of sensitivity to climate change of kiwifruit.

- Research completed in the 1990s as part of the CLIMPACTS research programme showed that a warmer climate would lead to later budbreak, a drop in flower numbers, and a southward shift in regions with the best temperature conditions for Green kiwifruit. It was concluded that production of Green in the Bay of Plenty would become uneconomic by the middle of this century without HC or a suitable substitute.

Overview of adaptation

- Adaptation involves measures to either reduce vulnerability or increase resilience in response to changes in climate that may be experienced or anticipated.

- In the first published assessment of impacts in New Zealand (MfE, 1990) it was suggested that relocation of the kiwifruit industry could be required.

- In a more recent review (Kenny, 2001) a phased adaptation response was recommended with a focus towards breeding of new varieties and maintenance of production of high quality fruit in the Bay of Plenty.

- Initial consultations on adaptation were held with growers and others in the Bay of Plenty in 2006. Key messages from this work were:

- Climate change is clearly an issue that the industry needs to take a lot more seriously, but there is a need to go beyond the talking.
- Use existing growers as role models. There are a number who are already doing relevant things.
- The water situation needs to be sorted out with Environment Bay of Plenty taking the lead on this.
- Coordination between the different parties is needed to ensure consistent messages are being given out.

- In order to go beyond the talking the key advice was to focus in more depth on innovative growers who have potential to provide leadership on adaptation.

Part 2 – In-depth consultations on adaptation

Current climate challenges

- There is a general consensus that over the last five years the seasons have notably changed towards warmer winters, less reliable spring conditions with increased frost risk, and warmer autumns.

- Such changes are generally consistent with seasonal trends identified by NIWA and are consistent with current scenarios of climate change. It should be noted that there is an observed trend towards warmer spring conditions and an expectation that frost incidence will decrease in frequency over time with climate change. This does not exclude the possibility of damaging events as experienced with greater frequency in recent years.

- Main concerns and challenges are related to loss of winter chilling with warmer winters, increased risk of late spring frost, effects of warmer autumns. There is also some concern with a possible increased frequency of hail and of insect pests.

- There are on-going challenges with strong winds, particularly with Gold kiwifruit in the period from November through to early January.

Current management tools/systems

- Kiwifruit growers are faced with a significant challenge to deal with the inherent variability of climate, changes in climate and other issues, and to consistently produce high volumes of a quality crop for the market.

- There are a relatively small number of growers who are actively meeting this challenge. These growers are providing leadership and are actively involved in experimentation and innovation.

- The majority of growers and managers are apparently struggling, as reflected in low average returns in recent years.

- The current adaptive capacity, in terms of available management tools and systems, is high. There is a wide array of management tools and systems available to growers including traditional tools such as HC, increased

sophistication with microclimate and canopy management, and emerging interest in biological soil management.

- Key factors in innovation are a willingness to go outside the square and push boundaries, as apparent with the development of a biennial cropping system for Gold, and taking time to interact with and learn from other growers.

- Warmer autumns in recent years have led to changes in post-harvest management.

Climate change

- There is increased awareness of climate change.

- The greatest concern is with the potential for increased frequency of extreme weather events. There is also concern with the effects of warmer winters and autumns, effects on rainfall patterns and changes to pests and diseases.

- Warmer spring and summer conditions will be beneficial.

Adaptations to future climate change

- A planned, proactive, approach to climate change and adaptation is required.

- There is confidence that growers and the industry as a whole have the capacity to adapt to a progressive warming of the climate. There is some concern regarding potential for increased frequency of extreme weather events.

- There are a lot of adaptation options with current tools and practices, there is on-going innovation and experimentation and a few growers are actively taking account of climate change in the things they are doing.

- Over time there will be changes in variety (more Gold, less Green, new varieties), location (sites with cooler winters) and land use (different crops, subdivision).

- There is no clear alternative to HC, which is more effective with some winter chilling. A general trend towards more organic-type approaches, driven by market requirements, will reinforce the need for new varieties that require less winter chilling.

- There are developments happening that are of high relevance to future adaptation. Important developments include the biennial cropping system that has been developed for Gold, experimentation with above canopy and sub-canopy shelter, and biological soil management.

- In most cases there is sufficient rainfall in the Bay of Plenty and projected rainfall changes are unlikely to be detrimental. Security of supply is becoming an issue for many growers. Some growers have already developed dams to capture and store runoff. Water allocation issues need to be resolved for the future.

- Post-harvest operations are already adapting to warmer autumns and will continue to adapt with a focus on issues related to removal of field heat, fruit curing prior to storage, and improved insulation and increased energy efficiency of coolstores.

- There will be on-going changes in ownership structure in the industry, with the possibility of more corporate ownership and fewer owner operators. It is difficult to gauge how such changes will affect adaptive capacity over time. Regardless of the ownership structure the industry will still need innovators and risk takers to provide leadership.

Industry responses to support adaptation

- Confidence in adaptability of the industry is balanced with a recognition that a planned, proactive, approach to adaptation is required to minimise risks and maximise opportunities.

- Communication and education are the key to engaging growers and others more widely in actively thinking about, planning for and acting on adaptation to climate change.

- ZESPRI has a key role to play in supporting a planned, proactive approach to adaptation. Integration of adaptation, alongside appropriate mitigation responses, into an emergent focus on sustainability is a sensible and cost effective way to operate.

- An important next step is to bring together key growers who have already been engaged with to focus on priority issues and a way forward. It is very important that this steps beyond the foundation work on adaptation completed in 2006 and what has been achieved through this current project.

- Relevant information needs to be collated for wide dissemination. Immediate outcomes from this work include an article for the kiwifruit grower magazine and a Kiwitech bulletin (a technical information series developed by ZESPRI) on climate change and adaptation. Other suggestions include:
    - Develop a whole information package for ZESPRI staff and growers.
    - Develop a comprehensive inventory of adaptation tools and a system for documenting what growers are doing.
    - Produce a series of short articles to go out in the monthly Kiwi Flier newsletter.
    - Provide a condensed summary of climate change and adaptation for the ZESPRI grower services team.
    - Provide a full copy of this report to the ZESPRI library so that growers who want the detail can access it.
    - Explore the marketing opportunities with this information.

- Disseminate relevant information through field days that are focused on adaptation to climate change.

- Support relevant underpinning research, focusing in particular on plant breeding, crop protection and water. A proactive approach is essential as it cannot be assumed, for example, that new varieties with low chill requirements will emerge by default.

- A positive, proactive, approach to adaptation which is integrated within a wider sustainability focus could provide marketing opportunities.

Role of regional and central government

- Both regional and central government have important roles to play in supporting the adaptive capacity of the kiwifruit industry.

- At regional level there needs to be active engagement between the kiwifruit industry and regional government to resolve concerns regarding water allocation.

- At national level it is important that necessary support is provided to enable the kiwifruit industry to adapt to climate change effectively and in a coordinated manner. Key areas for support include long-term strategic research and strict biosecurity controls.

Introduction

Internationally and nationally there is now clear recognition that adaptation to climate change is a necessity along with a continued focus on mitigation. This increased focus on adaptation is leading to a shift in the science and policy dialogue towards action. There are as yet few examples internationally of a major industry group adopting a planned, proactive, and action-focused approach to adaptation. Many people are still struggling with the 'how to'. Within New Zealand the kiwifruit industry has the potential to provide leadership in this regard. An adaptation case study provides valuable insight and direction in support of this potential, not just for the industry itself but more widely to other industry groups, to the science and policy communities and to wider communities of interest.

The kiwifruit industry is an ideal case study of adaptation and adaptive capacity for two main reasons:

- First there is the name, kiwifruit. There is something iconic about kiwifruit for New Zealand and New Zealanders. The name of the fruit is abbreviated overseas to 'kiwi', a word that is also used to refer to a New Zealand flightless bird, New Zealand nationals, and the New Zealand dollar. Through these associations kiwifruit have become strongly connected with our national identity.

- Second there is the story of the kiwifruit industry. It is an industry founded on innovation, has experienced and responded positively to a time of crisis, and is experiencing on-going challenges and change.

These attributes are all very relevant when considering adaptation to climate change.

The kiwifruit industry was originally founded on one variety, 'Hayward'. The export of 'Hayward' plants led to rapid development of competition and the near demise of the industry in the early 1990s. Major changes occurred through the 1990s with the development and implementation of the KiwiGreen programme and the commercial release of the 'Hort16A' variety. Alongside these developments there has been a restructuring of the industry and increased sophistication of growing, post-harvest handling and marketing. These industry changes have been accompanied by increased challenges with the climate, economic conditions, regulatory requirements, labour and effects of urbanisation. Against this background, kiwifruit growers increasingly have the challenge of producing a consistent high quality, high volume product to meet market requirements and make a living. More recently, the food miles issue has sparked an industry focus on its carbon footprint and a rapidly evolving focus on the wider picture of sustainability. This has been accompanied by an increased awareness of climate change, experienced directly by growers through effects of late spring frosts and warmer winters in recent years.

The experience and knowledge of growers is critical to developing effective responses to climate change within the context of the many challenges being faced. There is much that they are already doing that is potentially relevant to adaptation. This adaptation study, therefore, is focused on bringing together what is known scientifically with the

experience and knowledge of kiwifruit growers. The success of the KiwiGreen programme was founded on such an approach.

Following this example there are two main components to this report, which emerged from an initial adaptation study completed in 2006 and through subsequent discussions with ZESPRI and NZKGI:

1) A review of relevant research on climate change, likely impacts on kiwifruit and an overview of adaptation, which forms the first part of this report;

2) The outcomes of in-depth consultations with kiwifruit growers to identify more clearly the current adaptive capacity in the industry and what is required to support and enhance this in a proactive manner through both extension and research. This forms the second part of this report, with the overview presented in Part 2 and the grower interviews presented in Appendix 1.

The information and insights presented provide an opportunity, and some clear direction, for actively addressing the 'how to' of adaptation. There are elements that involve both individual and collective responsibility. This report demonstrates that as much as climate change provides a significant challenge to us all there is much to be optimistic about. In this sense there is a lot to be learned from the growers who have contributed to this work. Ultimately adaptation is about making a choice to act and getting the timing right. The challenge and opportunity is to make the most of what growers have shared.

Part 1 – The current state of knowledge

This section includes information on climate change and variability, a brief review of impacts research on kiwifruit, and an overview of adaptation. The climate variability sub-section is focused mainly on the Bay of Plenty. Relevant climate change information is provided for all relevant regions with more detail for the Bay of Plenty.

Climate variability and change

Key points – Climate variability and change

- As with other New Zealand regions, the changeable climate of the Bay of Plenty is a result of natural variability and chaos along with influences from observed phenomena.
- Observed phenomena include variations as a result of the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) and an underlying warming trend (0.1ºC per decade over the last 100 years) which is consistent with human-induced climate change.
- Current scenarios of climate change show a mid-range warming in all kiwifruit growing regions of about 1ºC by the 2040s and 2ºC by the 2090s. The scenarios indicate drier winter and spring conditions in eastern North Island growing regions including the Bay of Plenty with slightly wetter summer and autumn conditions in the Bay of Plenty, Gisborne, Hawke's Bay and Nelson/Tasman.
- There will be changes in extreme weather events in all regions with the possibility of increased westerly winds in winter and spring, decreased frost risk, increased incidence of high temperatures in summer, increased frequency of extreme daily rainfalls, and a possible increase in strong winds.

Climate variability refers to the inter-seasonal and year to year variations in the climate, such as the higher than normal summer temperatures this year in Bay of Plenty. Rainfall is also highly variable from year to year. Taking examples from the last 20 years, Te Puke annual rainfall was 20 percent above normal in 1989 and almost 30 percent below normal in 2002.

Climate change looks at the underlying trends in climate, in a sense a 'smoothing out' of the shorter term variability to identify the longer term changes. Recent studies show that New Zealand is already experiencing changes in the climate:

- Average air temperatures have risen by about 0.9°C between 1908 and 2006;
- Frost frequency has reduced over much of the country;
- South Island glaciers and snowlines are retreating;
- There is reduced alpine snow mass;
- The sea level is estimated to have risen by 16 cm during the 20th century.

Climate change may not create new risks, but is likely to change the frequency and intensity of existing risks and hazards, such as heavy rainfall events, storm surges, drought, windiness, and very high air temperatures. Often extreme events like this have the greatest impact and require the most carefully planned measures for adaptation.

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Past and current climate variability and change in Bay of Plenty

As elsewhere in New Zealand, much of Bay of Plenty's changeable climate is due simply to natural variability and chaos in the weather process. However, other changes are associated with shifting hemispheric or global scale climate patterns over the Southern Hemisphere and the Pacific Ocean. Two key climate phenomena that operate over time scales of several years or multi-decades are the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) respectively.

During La Niña periods of ENSO, both the temperature and rainfall are generally above normal for the Bay of Plenty region, while they are both generally below normal during El Niño periods. The relationships are weakest in summer (Dec-Jan-Feb) and strongest in spring (Sep-Oct-Nov). However, these linkages are not always reliable, and so the ENSO phase does not always help explain what's happening with the climate.

A change in phase of the IPO in the late 1970s, characterised by an increase in westerly airflow over Bay of Plenty in the 1980s and 1990s relative to earlier decades, has been linked to a decreased in rainfall over much of Bay of Plenty since 1951. More recently the IPO appears to have switched back to a negative phase, which may result in more frequent La Niña events, higher temperatures, weaker westerlies and increased rainfall for the Bay of Plenty over the next two to three decades. These changes could be modified by the longer term climate change trends.

A study conducted for Environment Bay of Plenty in 2003 (Griffiths *et al*), and other work, have shown the following main changes and trends in Bay of Plenty climate:

- In the last 30 to 40 years the Bay of Plenty has become generally drier (Figure A1[1]), with fewer and less intense extreme rainfalls. However, this has not resulted in an increase in the dry spell duration across the region.
- There has been a rising trend in mean annual air temperature across the Bay of Plenty of approximately 0.1˚C per decade over the last 100 years (Figure A2). The 1990s were the warmest decade on record both nationally and globally. Coastal areas of the region have experienced an increased rate of warming over the last 50 years, with inland sites showing little warming or even slight cooling in some seasons. Very high temperatures were recorded at Tauranga (the best temperature record in the region) in the 1990s.
- The number of frosts has decreased significantly in the region (Figure A3) and the frequency of hot days has increased in areas such as Tauranga and Waihi (Figure A4). This analysis did not explore risk of late frosts which have been experienced with greater frequency in recent years.

Recent seasons

Average seasonal temperatures in Bay of Plenty over the past three decades have been highly variable, but overall, at least in some seasons, have shown a trend consistent with or slightly larger than the observed gain of 0.1°C per decade noted above. While site changes and periods of missing data at Bay of Plenty climate stations make a definitive analysis difficult (see caption, Figure 2a), autumn temperature data for Te Puke (Figure

[1] Figures A1 to A13 are in Appendix 2

2a) suggest a temperature rise of more then 0.5 °C since 1973. This is consistent with growers' perceptions of recent autumn weather being warmer than in the past.

It is important to note that seasonal averages sometimes hide variability in monthly averages that could have important impacts on kiwifruit production. In the current autumn, March and April were both warmer than normal in Bay of Plenty, but May, with an average temperature of 11.8 °C at Te Puke, was the coldest May since 1992 (10.2 °C).

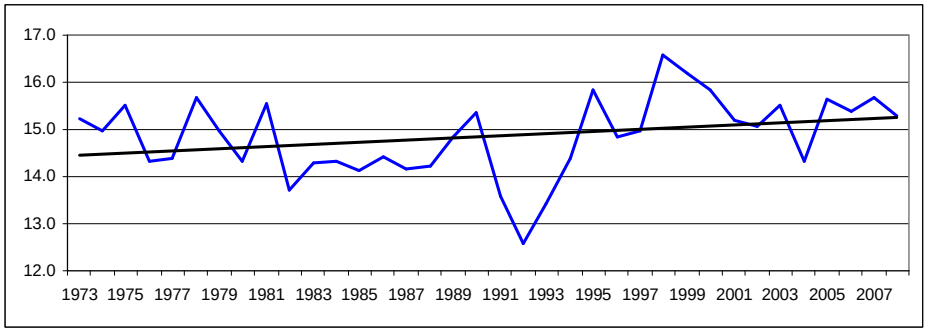

Figure 2a: Average temperature for autumn (March to May) for Te Puke, 1973 to 2008. Note that the Te Puke climate station was shifted twice during this period. Overlapping periods of data showed the shifts were to cooler sites, and the data were scaled to account for this as follows: for data from 1990, after the first site change, 0.24 ℃ was added to maximum temperatures and no adjustment made to minimum temperatures; for data from 1996, after the second site change, a further 0.1 ℃ was added to maximum temperatures, and 0.2 ℃ was added to minimum temperatures.

Spring temperatures at Te Puke have shown a similar trend (Figure 2b), although the variability in the data should be noted, particularly the significant cooling influence of the El Niño years of the early 1990s. The observed cooling during this period was also related to the global cooling of the Earth's atmosphere following the eruption of Mt Pinatubo in 1991. This cooling affected air temperatures for several years. It should also be noted that these seasonal averages do not provide any indication of the increased risk of late spring frosts that has been experienced in recent years.

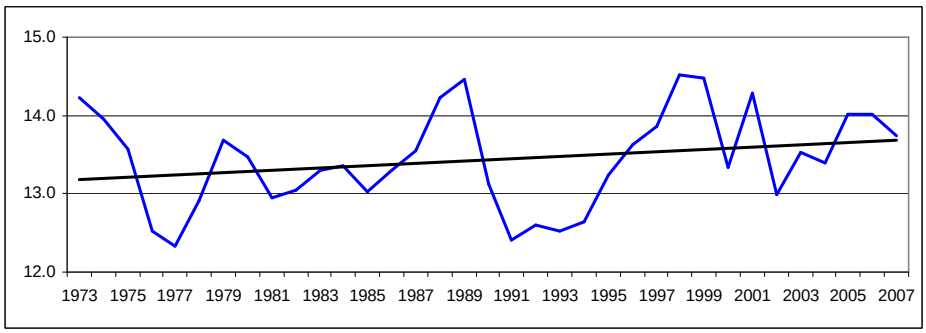

Figure 2b: Average temperature for spring (September to October) for Te Puke, 1973 to 2008. See cautionary note in Figure 2a caption regarding these data.

The average Te Puke air temperature data for the period June–July, an important period for winter chilling, have also risen (Figure 2c), suggesting a decreasing potential during the period to fulfil kiwifruit chilling requirements.

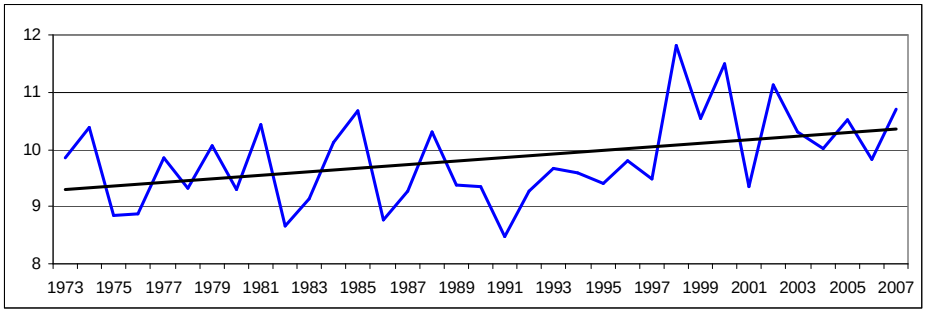

Figure 2c: Average temperature for June–July for Te Puke, 1973 to 2008. See cautionary note in Figure 2a caption regarding these data.

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The future: Climate change scenarios for kiwifruit regions

Climate change scenarios describe the most likely changes in the future climate of New Zealand. The scenarios take into account scientific understanding of the impact of various greenhouse gas emission levels, as well as plausible social, economic and technological developments. It is important to remember that the use of scenarios recognises the uncertainties in future climate, and should be used as informative guidance on the range of outcomes for the future rather than firm predictions.

For New Zealand as a whole, the scenarios show that air temperatures are likely to increase by about 1°C by about 2040, and 2°C by about 2090. However, there is a wide range of uncertainty due to the different emission scenarios and model climate sensitivities.

Increased westerly winds are likely in winter and spring, along with more rainfall in the west of both islands and drier conditions in the east and north. Conversely, in summer and autumn, westerly conditions may decrease, with drier conditions in the west of the North Island and possible rainfall increases in Gisborne and Hawke's Bay.

Other changes expected are: decreased frost risk, increased incidence of high temperatures, increased frequency of extreme daily rainfalls, a possible increase in strong winds, and decreases in average snow cover.

The tables below show climate change scenarios of air temperature, and seasonal and annual precipitation, for New Zealand's major kiwifruit growing regions (MFE 2008).

Table 3.1: Projected changes in seasonal and annual mean temperature (in °C) from 1990 to 2040, for kiwifruit growing areas. Changes shown are the average, with the lower and upper limits in brackets.

	Summer	Autumn	Winter	Spring	Annual
Northland	1.1 [0.3, 2.7]	1.0 [0.2, 2.9]	0.9 [0.1, 2.4]	0.8 [0.1, 2.2]	0.9 [0.2, 2.6]
Waikato	1.1 [0.2, 2.5]	1.0 [0.3, 2.7]	0.9 [0.2, 2.2]	0.8 [0.0, 2.0]	0.9 [0.2, 2.4]
Bay of Plenty	1.0 [0.3, 2.5]	1.0 [0.3, 2.7]	0.9 [0.1, 2.2]	0.8 [0.0, 2.1]	0.9 [0.2, 2.4]
Hawkes Bay	1.0 [0.2, 2.5]	1.0 [0.3, 2.6]	0.9 [0.1, 2.2]	0.8 [0.0, 2.0]	0.9 [0.2, 2.3]
Gisborne	1.0 [0.2, 2.6]	1.0 [0.3, 2.7]	0.9 [0.1, 2.2]	0.8 [0.0, 2.1]	0.9 [0.2, 2.4]
Tasman-Nelson	1.0 [0.2, 2.2]	1.0 [0.2, 2.3]	0.9 [0.2, 2.0]	0.7 [0.1, 1.8]	0.9 [0.2, 2.0]

Note 1: This table covers the period from 1990 (1980-1999) to 2040 (2030–2049), based on downscaled temperature changes for 12 global climate models, re-scaled to match the IPCC (IPCC 2007) global warming range for 6 illustrative emission scenarios (B1, A1T, B2, A1B, A2, and A1FI). Corresponding maps (Figures 2.3, 2.4) should be used to clarify sub-regional spatial gradients.

Note 2: If the seasonal ranges are averaged, the resulting range is larger than the range shown in the annual column, because of cancellation effects when summing over the year.

Note 3: Projected changes for the regions shown were the result of the statistical downscaling over mainland New Zealand.

Table 3.2: Projected changes in seasonal and annual mean temperature (in °C) from 1990 to 2090, for kiwifruit growing areas. Changes shown are the average, with the lower and upper limits in brackets.

	Summer	Autumn	Winter	Spring	Annual
Northland	2.3 [0.8, 6.6]	2.1 [0.6, 6.0]	2.0 [0.5, 5.5]	1.9 [0.4, 5.5]	2.1 [0.6, 5.9]
Waikato	2.3 [0.9, 6.3]	2.2 [0.6, 5.6]	2.1 [0.5, 5.2]	1.8 [0.3, 5.1]	2.1 [0.6, 5.6]
Bay of Plenty	2.2 [0.8, 6.2]	2.2 [0.6, 5.6]	2.0 [0.5, 5.2]	1.8 [0.3, 5.1]	2.1 [0.6, 5.5]
Hawkes Bay	2.1 [0.8, 6.0]	2.1 [0.6, 5.3]	2.1 [0.5, 5.1]	1.9 [0.3, 5.1]	2.1 [0.6, 5.4]
Gisborne	2.2 [0.8, 6.2]	2.2 [0.6, 5.6]	2.0 [0.5, 5.2]	1.9 [0.3, 5.2]	2.1 [0.6, 5.5]
Tasman-Nelson	2.2 [0.9, 5.6]	2.1 [0.6, 5.1]	2.0 [0.5, 4.9]	1.7 [0.3, 4.6]	2.0 [0.6, 5.0]

Note: This table covers the period from 1990 (1980-1999) to 2090 (2080–2099), based on downscaled temperature changes for 12 global climate models, re-scaled to match the IPCC global warming range for 6 illustrative emission scenarios. Corresponding maps (Figures 2.3, 2.5) should be used to clarify sub-regional spatial gradients.

Table 3.3: Projected changes for selected stations within major kiwifruit growing areas in seasonal and annual precipitation (in %) from 1990 to 2040. Lower and upper limits in scenario outcomes are shown in brackets.

Region:	Location	Summer	Autumn	Winter	Spring	Annual
Northland:	Kaitaia	1 [-15, 20]	-0 [-14, 16]	-5 [-23, 1]	-6 [-18, 4]	-3 [-13, 5]
	Whangarei	1 [-14, 23]	1 [-15, 33]	-9 [-38, -1]	-9 [-25, 3]	-4 [-16, 7]
Waikato:	Ruakura	1 [-18, 19]	2 [-13, 10]	1 [-4, 8]	-2 [-10, 13]	0 [-6, 6]
Bay of Plenty:	Tauranga	2 [-16, 25]	3 [-12, 25]	-4 [-16, 2]	-5 [-18, 7]	-1 [-10, 8]
Hawkes Bay:	Napier	4 [-33, 38]	5 [-14, 42]	-13 [-34, -1]	-7 [-17, 3]	-3 [-14, 14]
Gisborne:	Gisborne	3 [-26, 33]	4 [-18, 46]	-11 [-30, -2]	-9 [-21, 3]	-4 [-15, 14]
Tasman-Nelson:	Nelson	4 [-14, 27]	5 [-2, 19]	1 [-4, 9]	0 [-8, 9]	2 [-3, 9]

Note: This table covers the period from 1990 (1980-1999) to 2040 (2030–2049), based on downscaled precipitation changes for 12 global climate models, re-scaled to match the IPCC global warming range for 6 indicative emission scenarios.

Table 3.4: Projected changes for selected stations within major kiwifruit growing areas in seasonal and annual precipitation (in %) from 1990 to 2090. Lower and upper limits in scenario outcomes are shown in brackets.

Region:	Location	Summer	Autumn	Winter	Spring	Annual
Northland:	Kaitaia	-1 [-26, 21]	-3 [-22, 11]	-8 [-32, 2]	-11 [-33, 8]	-6 [-22, 5]
	Whangarei	0 [-20, 19]	1 [-27, 26]	-12 [-45, -0]	-16 [-45, 1]	-7 [-28, 2]
Waikato:	Ruakura	-1 [-34, 18]	-1 [-24, 10]	3 [-7, 15]	-4 [-23, 16]	-1 [-11, 11]
	Taupo	4 [-19, 30]	1 [-16, 9]	3 [-8, 15]	-5 [-23, 13]	1 [-7, 10]
Bay of Plenty:	Tauranga	2 [-20, 23]	2 [-15, 16]	-3 [-16, 8]	-9 [-32, 12]	-2 [-12, 5]
Hawkes Bay:	Napier	9 [-46, 52]	5 [-14, 25]	-16 [-45, -1]	-13 [-38, 9]	-4 [-20, 11]
Gisborne:	Gisborne	5 [-38, 41]	4 [-25, 27]	-13 [-41, 1]	-16 [-42, 7]	-5 [-22, 8]
Tasman-Nelson:	Nelson	6 [-13, 30]	5 [-4, 18]	6 [-2, 19]	-1 [-20, 19]	4 [-3, 14]

Note: This table covers the period from 1990 (1980-1999) to 2090 (2080–2099), based on downscaled precipitation changes for 12 global climate models, re-scaled to match the IPCC global warming range for 6 indicative emission scenarios.

Climate change in Bay of Plenty

Tables 3.1 to 3.4 in the previous section indicate changes that are likely in the climate of Bay of Plenty and the other important kiwifruit growing areas over the next 70 to 100 years. Air temperatures are expected to increase on average by between 0.5 and 3.8°C. Precipitation changes are less certain, but on balance there is more likely to be a trend towards a decrease in average annual rainfall, with, on average, 9 percent less rainfall in spring, particularly near the coast. Conversely, summer and autumn may become slightly wetter (2–3 percent).

The key changes in climate and hydrology taken from the scenarios of future climate that will have most impact on kiwifruit in the Bay of Plenty include:

- Warmer winters (Tables 3.1 and 3.2), reduced frequency of frost inland and at higher elevations.
- Higher summer temperatures (Tables 3.1 and 3.2)
- Lower spring rainfall (Tables 3.3 and 3.4), which may become important if irrigation and frost control water use demand increases.
- Later in the century, in spite of the predicted trend to lower annual rainfalls, there may be an increase in the frequency of extreme rainfall events. The consequence of this could be increased risk of flooding and erosion.
- Ex-tropical cyclones might be slightly less likely to reach New Zealand over the next 50 years, but if they do their impact might be greater.
- Westerly winds are likely to increase over New Zealand in winter and spring, and may decrease in summer and autumn. An increase in the number of extreme wind speeds could also occur.

Changes in autumn, winter and spring temperatures will all be of importance to kiwifruit growing in the Bay of Plenty. These changes are shown in Figures A5 to A13 and signal the potential for significant change in local climates within the region.

Bay of Plenty and Kerikeri temperatures

Projected climate change for Bay of Plenty by the 2080s is likely to create a temperature regime similar to that of Kerikeri today. Kerikeri air temperatures are more than 1°C higher than Tauranga temperatures during May to July, on average, and the winter climate in Kerikeri is not cool enough to meet ‘Hayward’ chilling requirements.

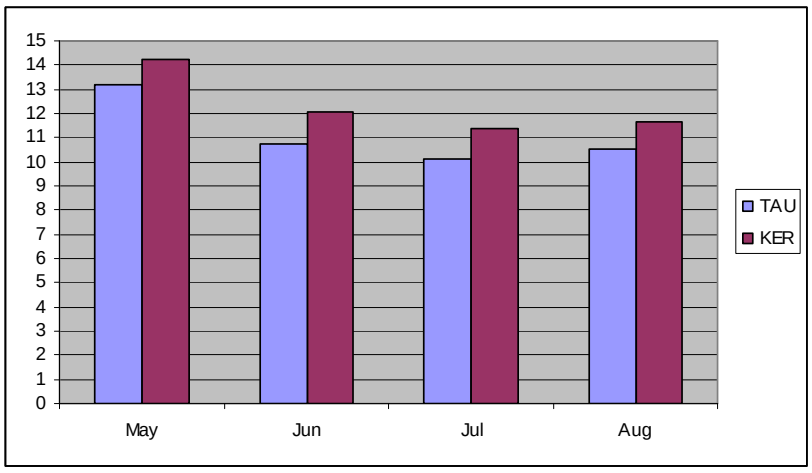


Figure 4a: Comparison of average Tauranga Airport and Kerikeri Airport monthly air temperatures 1981 to 2008, for May to August.

Impacts on kiwifruit

Key points – Impacts on kiwifruit

- All published impact studies to-date have focused on the Green ('Hayward') variety. Since the first published assessment of impacts in New Zealand (MfE, 1990), winter chilling has been recognised as a key indicator of sensitivity to climate change of kiwifruit.

- Research completed in the 1990s as part of the CLIMPACTS research programme showed that a warmer climate would lead to later budbreak, a drop in flower numbers, and a southward shift in regions with the best temperature conditions for Green kiwifruit. It was concluded that production of Green in the Bay of Plenty would become uneconomic by the middle of this century without HC or a suitable substitute.

Research on the impacts of climate change on kiwifruit has primarily focused on the likely effects of higher temperatures on Green kiwifruit[2]. Winter chilling, in particular, was seen as a key indicator of sensitivity to climate change. In the earliest assessment of impacts of climate change in New Zealand (Ministry for the Environment, 1990) it was concluded that Green kiwifruit production would cease in Northland and would become uneconomic in the Bay of Plenty over time (Martin *et al*., 1990). These responses were based on expert opinion that warmer winters would reduce winter chilling and reduce the effectiveness of Hydrogen Cynamide (HC) in both Northland and the Bay of Plenty.

Quantitative assessment of impacts became possible through increased understanding of the effects of temperature on the physiology and phenology of kiwifruit (see Hall *et al*., 1996; Hall and McPherson, 1997a, 1997b; McPherson *et al*., 1992; Salinger *et al*., 1993). The development of the CLIMPACTS system (see Kenny *et al*., 2001) enabled mapping of areas suitable for Green kiwifruit under present and future climate (Salinger and Kenny, 1995; Kenny *et al.* 2000). A detailed spatial analysis carried out for the Bay of Plenty region (Kenny *et al.* 2000) indicated that beyond about 2040 there would be potential for significant decline in the total land area suitable for Green. A more detailed analysis of changes in phenology (Hall *et al.*, 2001) reinforced these findings with key effects identified as follows:

1. The timing of phenological events may change significantly in warmer regions.
    - Budbreak is likely to occur later.
    - Effects on dates of flowering and maturity are less clear.

2. The most important effect will be a drop in flower numbers in warmer regions. Because of this we can expect that by around 2050:
    - Production may become uneconomic in Northland, even when HC is applied.

[2] There are currently two commercial varieties of kiwifruit: *Actinidia deliciosa 'Hayward' and Actinidia chinensis 'Hort16A'*. These are referred to as Green and Gold by kiwifruit growers and for consistency these terms are used throughout this report.

- Production in the Bay of Plenty without dormancy-breaking agents will be uneconomic.

3. In cooler regions, problems with low dry matter due to cool summers will become less important over the next 50 years.

A review by Kenny (2001) reiterated suggestions that Green could become uneconomic in the Bay of Plenty by 2050 under a high-end climate change scenario. It was further suggested that conditions could improve in Hawke's Bay and Nelson with fewer, or less severe, late frosts and warmer summers. Further work was undertaken in a study on biotic effects of climate change in the Bay of Plenty (Kenny and Shaw, 2006) using the winter chilling threshold developed by Salinger *et al.* (1993) along with more recent climate change scenarios (Ministry for the Environment, 2004). This analysis, with a mid-range scenario, further reinforced previous results, showing that higher average winter temperatures could lead to relocation of Green to cooler sites in the Bay of Plenty by the middle of this century and displacement from the region towards the end of the century.

Overview of adaptation

Key points – Overview of adaptation

- Adaptation involves measures to either reduce vulnerability or increase resilience in response to changes in climate that may be experienced or anticipated.

- In the first published assessment of impacts in New Zealand (MfE, 1990) it was suggested that relocation of the kiwifruit industry could be required.

- In a more recent review (Kenny, 2001) a phased adaptation response was recommended with a focus towards breeding of new varieties and maintenance of production of high quality fruit in the Bay of Plenty.

- Initial consultations on adaptation were held with growers and others in the Bay of Plenty in 2006. Key messages from this work were:
    - Climate change is clearly an issue that the industry needs to take a lot more seriously, but there is a need to go beyond the talking.
    - Use existing growers as role models. There are a number who are already doing relevant things.
    - The water situation needs to be sorted out with Environment Bay of Plenty taking the lead on this.
    - Coordination between the different parties is needed to ensure consistent messages are being given out.

- In order to go beyond the talking the key advice was to focus in more depth on innovative growers who have potential to provide leadership on adaptation.

After two decades of impacts research (a useful benchmark is the landmark IIASA study completed by Parry *et al.*, 1988) there is an increasing focus on adaptation, as reflected in the most recent IPCC assessment (see Adger *et al.*, 2007). Adaptation involves measures to either reduce vulnerability or increase resilience in response to changes in climate that may be experienced or anticipated. These measures can be either reactive or proactive and can occur in many ways, involving changes in human behaviour, perceptions of risk, management practices and investment decisions among other things. Adaptation can occur through individual initiative, community or corporate action, and through planning and policy frameworks. As the science of climate change has progressed there has been an increased understanding of the complexity of adaptation. This has been accompanied by increased realisation that adaptation to climate change is not independent of responses that individuals, communities and societies are implementing and will implement in relation to many different drivers of change.

Relevant research on kiwifruit has spanned the last two decades and provides a valuable case study of the evolution of understanding of potential adaptation responses. The earliest impacts work in New Zealand took, what is now, a rather simplistic view that higher winter temperatures would lead to a cessation of kiwifruit production in Northland and the Bay of Plenty. This work was founded on the assumption that the industry would remain dependent on Green kiwifruit. The principal adaptation response was considered to be a southward relocation of both kiwifruit production and accompanying infrastructure (Martin *et al.*, 1990). It was expected that this would be a consequence of decreased effectiveness of HC with warmer winters and/or its eventual banning because of public health concerns. A more recent report (Kenny, 2001) suggested a need for proactive adaptation with a phased response that involves: short-term adjustments using existing management tools and measures; medium-term planning that is focused on breeding varieties with low chill requirements; long-term planning that could see greater plantings in Hawke's Bay and Nelson (strongly dependent on water availability and other land use decisions), development of new varieties and maintaining production of high quality fruit in the Bay of Plenty.

There have been significant changes in the kiwifruit industry since the early 1990s with a current situation that is much more complex than assumed in earlier impact and adaptation assessments. The development of the KiwiGreen programme[3] in the early 1990s and the emergence of Gold as a viable commercial variety in the late 1990s are two notable changes. While developed primarily for its quality characteristics, it soon became evident that Gold kiwifruit could remain productive with less winter chilling. This alone is a significant development in terms of ***adaptive capacity*** of the industry.

[3] See http://www.martech.co.nz/images/02kiwi.pdf for a copy of "Zespri's KiwiGreen programme – world firsts in this vital crop management system". This report was produced by Martech Consulting Group Limited as part of a Growing Futures case study series.

A note on Adaptive Capacity

Adaptive capacity is defined in the Millenium Ecosystem Assessment as *" the general ability of institutions, systems, and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences."* (see http://www.millenniumassessment.org). A useful summary can be found on the Resilience Alliance website (http://www.resalliance.org/565.php) with definitions provided for ecological and social systems. There is a strong inter-relationship between adaptive capacity and resilience as identified in the following quote. *"Systems with high adaptive capacity are able to re-configure themselves without significant declines in crucial functions in relation to primary productivity, hydrological cycles, social relations and economic prosperity. A consequence of a loss of resilience, and therefore of adaptive capacity, is loss of opportunity, constrained options during periods of re-organisation and renewal, an inability of the system to do different things. And the effect of this is for the social-ecological system to emerge from such a period along an undesirable trajectory."* (Source: http://www.resalliance.org/565.php, original source Folke *et al.*, 2002)

Despite the various impact and adaptation studies there was not any active engagement regarding climate change with the kiwifruit industry until recently. Thus it isn't possible to gauge how thinking on adaptation might have evolved within the industry over the last two decades. However, given the many challenges and changes that have occurred it would be reasonable to assume that it has become a lot more sophisticated in terms of its adaptive capacity. Evidence of this greater sophistication, and growing awareness of climate change, was apparent in some foundation adaptation work supported by Environment Bay of Plenty (Kenny, 2006). This work involved:

1) Initial consultation with ZESPRI Innovation staff resulting in identification of key industry people for wider consultation.

2) Processing of these wider consultations into a workable plan for engagement with key growers.

3) Identification of key growers, with ZESPRI and NZKGI support, and invitations to participate in brief (1½ hour) adaptation workshops.

4) A final, half day, workshop to review outcomes and identify more clearly steps required to develop and implement an action plan for adaptation in the kiwifruit industry.

This initial engagement with kiwifruit growers and others in the industry provided an overview of issues and needs relating to climate change and adaptation.

The main issues identified related to:

- Increased volatility of weather
- Impacts of 'average' climate changes
- People pressures
- Markets

The main needs identified related to:

- Management of natural resources
- Managing change

The general view shared through this initial adaptation work was that there is a lot of innovative capacity and know-how within the industry. Alongside this was a recognition that a planned, proactive, approach to adaptation is required.

At the conclusion of the final, half day, workshop the following actions were identified as important next steps:

- Climate change is clearly an issue that the industry needs to take a lot more seriously, but there is a need to go beyond the talking and ensure that the momentum established through this process isn't lost.

- Use existing growers as role models. There are a number who are already doing relevant things.

- The water situation needs to be sorted out with Environment Bay of Plenty taking the lead on this.

- Coordination between the different parties is needed to ensure consistent messages are being given out.

Advice from the beginning of the initial adaptation work in 2006 was to focus on growers who were more innovative and/or more likely to be 'climate change champions'. The focus on implementing change through key growers is an integral part of ZESPRI's innovation and grower extension programme and is founded on the success of such an approach with the KiwiGreen programme in the mid 1990s. This approach is also consistent with that taken in previous adaptation work with pastoral farmers (see Kenny 2005). Early consultation with farmers in this latter work identified the need to share success stories and to foster positive role models for other farmers to learn from. This was considered essential in terms of developing a practical understanding of climate change and the development of resilience as a proactive adaptation response. ZESPRI have recently (in 2007) commissioned Colmar Brunton to develop a better understanding of kiwifruit growers. Colmar Brunton has identified four grower groupings: Entrepreneurs, Passionate Ecologists, Astute Business People, Traditionalists. Those in the former two groups are identified as more likely to be progressive and innovative. The majority of growers who have participated in past and recent adaptation work have tended to be representative of these two groups. The challenge with adaptation is the same that is currently with the kiwifruit industry, which is to identify positive ways to engage and empower all growers in change and innovation. Thus, the focus is not simply on engagement with the innovators and champions, but on how best to use their collective thinking, knowledge and skills to engage others more widely.

Part 2 – In-depth consultations on adaptation

This section draws together the collective thinking on adaptation of 19 Bay of Plenty kiwifruit growers who were interviewed in the period from 17 March to 18 April 2008. The full interviews with 18 of these growers are provided in Appendix 1. This work focused on the Bay of Plenty because it is the principal region of kiwifruit production and because of time and logistical constraints. A range of locations, growing conditions and management systems were covered (Appendix 1). This material needs to be read with the understanding that there are known differences in regional and within region climate and soil, every orchard is a microclimate, every grower is unique in their approach, and no single solution will work for all.

The main rationale for conducting in-depth consultations with identified kiwifruit growers was to develop a more comprehensive understanding of the adaptive capacity of the kiwifruit industry. This clearer understanding of adaptive capacity can then be put alongside what is known about potential impacts from previous research and current knowledge of climate change as a means of identifying steps and measures required to develop a planned, proactive, approach to adaptation. This is of high relevance to the kiwifruit industry. It also serves as an important case study on adaptation for other primary industry groups, to local and central government and more widely to communities around New Zealand.

Given the short timeframe of this work there was some trepidation with implementing a consultation process at the beginning of the harvest season. Such concerns were quickly dispelled. Growers were identified with the assistance of ZESPRI Innovation and Grower Services staff. Interviews coincided with the beginning of the harvest season. The fact that growers agreed to be interviewed at such a busy time is clear evidence that climate change has become an issue of concern. It proved fortuitous to interview growers when they were preparing to harvest after a very dry summer. In the last week of field work the results of grower interviews to-date were summarised and used to stimulate feedback from ZESPRI staff in four separate sessions and from a session with HortResearch scientists at Te Puke. Feedback from these sessions is incorporated in the sub-section on industry responses.

This section follows the format of the grower interviews, which were focused on:

- Current climate challenges
- Management tools/systems in place to address current climate challenges
- Primary concerns/issues with climate change
- Adaptation responses required to address climate change
- Support or steps required from industry, regional and central government to implement and support adaptation in the kiwifruit industry

Current climate challenges

"It seems to be getting harder each year to manage the climate"
"There is no winter now"
"There has been more fruit loss in the last 5 years than in the preceding 10"

Key points – Current climate challenges

- There is a general consensus that over the last five years the seasons have notably changed towards warmer winters, less reliable spring conditions with increased frost risk, and warmer autumns.
- Such changes are generally consistent with seasonal trends identified by NIWA and are consistent with current scenarios of climate change. It should be noted that there is an observed trend towards warmer spring conditions and an expectation that frost incidence will decrease in frequency over time with climate change. This does not exclude the possibility of damaging events as experienced with greater frequency in recent years.
- Main concerns and challenges are related to loss of winter chilling with warmer winters, increased risk of late spring frost, effects of warmer autumns. There is also some concern with a possible increased frequency of hail and of insect pests.
- There are on-going challenges with strong winds, particularly with Gold kiwifruit in the period from November through to early January.

The ideal climate conditions for kiwifruit are considered to be: cool conditions in June and July for winter chilling, high temperatures after budburst and throughout the summer, cool nights in autumn to harden the fruit and stop them growing. Long-term growers hold this as a historical ideal and consistently talk about changes towards warmer winters, less reliable spring conditions with increased frost risk, and warmer autumns. Such changes have been experienced with increasing frequency over the last decade, most notably in the last five years as reflected in the following comments:

> *"The weather used to be extremely predictable. The seasons seem to have slid with colder springs and warmer autumns."*
>
> *"The whole climate is getting a bit later. The winter season has shifted and the harvest season is warmer than in the past with fruit growth continuing later in the season than it used to."*
>
> *"Autumns are now warmer for longer, winter is later and springs are more variable and are subject to later frost." This change has become more noticeable since 2000, particularly over the last 5-6 years. In the 80s there were much more clearly defined seasons.*
>
> *"The seasonal temperature pattern has shifted by about a month. We don't get the good winter chilling in July and August. We're not getting good*

summer weather now until after Christmas. Warmer conditions in autumn mean that the fruit is taking longer to cool down after harvest."

"Fundamentally things are happening when they shouldn't. It is supposed to be cold in winter and warm in spring. Increasingly they're having mild winters with cool spring periods. There has been a general trend in the last decade, but things have been more marked in the last 5 years. Kiwifruit need winter chilling to break dormancy. If they don't get enough chill the plants are confused. Cold weather in spring further delays budburst and growth."

"We used to look out the window and say 'it's fairly frost free down there, that's good'. You wouldn't do that today. You'd say 'hey, I hope you got enough frost to get winter chill'. Climate, do you think it has changed over the last 20 years? In my observation, yes. There is no winter now."

One grower commented that there are cycles of climate and that some of what is happening now has been experienced in the past. Another commented that he doesn't see any major climate changes happening.

The observed change in seasons has been accompanied by an experience of more random weather events. For a number of growers it is the unknowns and unpredictable things that are the biggest concern.

"There have been more isolated, random, weather events particularly in the spring and early summer. We can't honestly say we're safe from frost until mid November and from hail who knows."

The main concerns and challenges associated with these changes are:

- The loss of winter chilling. A lack of chilling leads to lower flower numbers and a much wider spread of flowering and subsequent problems with fruit sizing. This is of greatest concern for organic production and with Green kiwifruit.

- Increased frost risk in spring. Good air drainage around the Te Puke area means less frost risk than down on the flats in Paengaroa. Gold is more susceptible because of earlier flowering (4-6 weeks earlier) and this has heightened awareness of frost risk in recent years. Frost has been more erratic and common since 1994 when there was a major event. However, spring frosts have been more frequent in the last ten years with three significant frost events in the August-November period over the last five years. There has been more fruit loss to frost in the last five years than the preceding ten.

- The effects of warmer autumns. There are other factors, including the introduction of Gold and modified fruit harvest criteria, but it is being observed that the fruit are definitely growing further into the autumn and are not hardening off the same. This is providing challenges to post-harvest operators. *"The last two years for Green have been the worst storing years ever." "Field heat was a problem two seasons ago (2006) with very high fruit loss. This*

resulted from a combination of a lot of crop, warmer temperatures and wet weather leading to high humidity."

There are also challenges associated with wind, hail and in some situations with lack of rainfall at critical times.

"Wind is the great enemy of kiwifruit plants." Gold kiwifruit are susceptible to wind damage in the period from November through to early January, particularly from westerly to nor'westerly winds. One grower commented that they can lose 10-20 percent of the Gold crop in a matter of hours with winds of 70-100 kph during this time. Another grower can have 30 percent rejects in a bad year.

More frequent hail events have been observed in the last few years. One grower experienced his first ever hail damage on 1 Jan 2007 and says he can afford this sort of event maybe once every 12-13 years.

In most parts of the Bay of Plenty there is sufficient rainfall for mature kiwifruit vines. Issues with water arise in some areas around Katikati, on lighter soils (eg, Pongokawa) and also on soils with high water tables as experienced near Edgecumbe. One grower commented that they have been dealing with more rainfall variability in the past few seasons, with very dry spells and very wet spells through the growing season. This is providing management challenges. For the majority though there is sufficient rainfall and if they have a dry period at some stage they are confident that there will be a catch up with rainfall at another time.

A couple of growers also commented that slightly warmer summers bring more pest issues and that there have been changes in pests in recent years. Related to this is the increased pressure from markets for both fewer pests on fruit and less chemical sprays. "*We're living in a world where the markets want fewer pests on the fruit and less chemical sprays. This is a huge challenge to growers and climate has a strong role to play with these issues."*

Management tools/systems to address current climate challenges

"If you don't try things you don't know"

Key points – Current management tools/systems

- Kiwifruit growers are faced with a significant challenge to deal with the inherent variability of climate, changes in climate and other issues, and to consistently produce high volumes of a quality crop for the market.
- There are a relatively small number of growers who are actively meeting this challenge.
- These growers are providing leadership and are actively involved in experimentation and innovation.
- The majority of growers and managers are apparently struggling, as reflected in low average returns in recent years.
- The current adaptive capacity, in terms of available management tools and systems, is high.
- There is a wide array of management tools and systems available to growers including traditional tools such as HC, increased sophistication with microclimate and canopy management, and emerging interest in biological soil management.
- Water allocation is becoming a major issue for growers. Environment Bay of Plenty is currently working on a Water Sustainability Strategy for the Western Bay of Plenty.
- Key factors in innovation are a willingness to go outside the square and push boundaries, as apparent with the development of a biennial cropping system for Gold, and taking time to interact with and learn from other growers.
- Warmer autumns in recent years have led to changes in post-harvest management.

To achieve good returns kiwifruit growers need to be consistently producing high volumes of large fruit with high dry matter content. This is a significant challenge given that they are dealing with the inherent variability of the climate and observed changes in the climate, along with a difficult economic situation, increasing challenges with labour, and increased compliance costs.

The majority of growers are struggling to meet this challenge, as shown in low average returns in the industry. The relatively small numbers of growers who are performing well are doing so as a result of factors including: personal motivation to be in the top five to ten percent, long-term experience as growers, dependency on kiwifruit for their livelihood. These growers are working on a range of technologies and strategies to

reduce the impacts of climate variability and make the most of the climate resource to increase and maintain production of high quality fruit.

> *"The big focus is on dry matter production. We're trying to use technology to overcome some of the limiting factors. For me it's about heat and light."*
> *"It's easy to grow large numbers of small fruit but much harder to grow large numbers of large fruit with high dry matter."*

In general this is requiring more investment, which some are reluctant or unable to make.

> *"With production levels in the industry getting higher it is increasingly challenging to sustain production off a difficult site and microclimate. You come to a point where technology can't help you any more. The benefits to small growers pulling out of kiwifruit are increasingly outweighing the costs, with significant costs now for:*
> - *water for frost protection and irrigation*
> - *wind protection*
> - *intensive management*
> - *good labour*
> - *reflective mulches*
> - *compliance*
>
> *With a re-evaluation of a small orchard (in a marginal location) it is more realistic to consider a shift to an alternative crop."*

Others have enough income diversity to be philosophical about the challenges of climate and are *"farming pretty much to what we're given."*

Growers have adopted a range of management tools and practices some of which have wider uptake than others. These have been categorised into microclimate, vine and orchard, people and post-harvest.

Microclimate management

The ideal site for kiwifruit growing is one with cooler winters, warm spring/summer conditions and access to water. Some growers have made decisions to relocate or purchase additional properties that they believe provide the best conditions possible. For the majority it is a matter of making the most of existing sites.

Growers are doing a lot of experimentation with above and below canopy shelter

Shelter

A lot of shelter was planted in the early days of the kiwifruit industry, possibly to the point of over-sheltering. Subsequently a lot has been removed to increased canopy area and give more light. *"We've probably reached the limits of that now and in some cases some blocks are too open."* The trade-off with increased canopy area and more light is less warmth and greater wind exposure. Ideally growers want a lot of shelter in spring to help heat the orchard up and minimum shelter in the summer to give more light and air movement. Spring and early summer shelter is also critical to minimise wind rub damage to Gold. Growers are now using a lot more artificial shelter both above and below the canopy, including trialling of overhead shelter. There is on-going experimentation as growers strive to manage air movement, temperature and light to best advantage.

Frost protection

The most effective (also the most expensive) protection against frost is with overhead sprinklers. Growers in more vulnerable locations have gone to sprinklers, installing systems that can be used for both frost protection and for irrigation if and when it is needed. Those in areas of lower risk are using frost fans/machines. These are effective so long as there is a temperature inversion to mix warmer air down into the canopy. Management of shelter and placement of the frost fan is very important to facilitate air movement through the orchard.

Dual purpose sprinkler systems are being used for both frost protection and irrigation. The sprinklers are readily moved above or below the canopy.

Irrigation and water storage

"The jury is out as to whether irrigation is required for mature vines." Good soil types, such as in Te Puke, will support mature vines without the need for irrigation. In the Katikati area the soils are older ash, shallower and there has been some (badly done) contouring. As a result irrigation is more critical in dry periods. Dealing with water is a critical issue in areas such as the Rangitaiki Plains, with orchards suffering seasonal fluctuations in the water table. Orchards in this situation require drainage in the winter and irrigation in the summer. The high water table means that the vines aren't deep rooted as they are in the prime growing areas. Gold in particular don't like wet feet.

In the most recent (2007/2008) season there have been different responses to a very dry summer period. At one orchard *"you'd expect fruit quality and size to be the main casualties of a dry year and yet they have just had one of the driest summers on record and the biggest fruit profile he can ever remember."* On the lighter Paengaroa soils a grower has irrigation in his orchards but has halved water use since switching from

computerised to manual monitoring. On a Katikati orchard the oldest vines are 25-30 years old but, with a lot of feeder roots near the surface, water makes a difference to production. There is a view that if you are watering it's best to be a bit under and to avoid over watering at all costs. The experience of a number of growers is that irrigated fruit can have lower dry matter.

Water storage is happening or is being considered, including contouring of land to store runoff. Because of the uncertainties with water in the Paengaroa area a grower has invested a lot in water storage on their two new properties to create buffering for times of shortage. Similarly, a Katikati grower has created water storage lakes to give storage for frost protection and possibly for irrigation in the future.

Some growers are creating water storage lakes

Water allocation is becoming an important issue among kiwifruit growers, not just the amount of water but the application rates that are allowed at any given time. Environment Bay of Plenty is presently working on a Water Sustainability Strategy for the Western Bay of Plenty, which will eventually be released for discussion with key stakeholders, including relevant industry bodies and local councils.

Orchard and vine management

Innovative growers are actively working on orchard and vine management. They are continually experimenting and in some cases are prepared to take risks and push boundaries to better understand the limits of the plant and what is possible. Growers with 20 to 30 years experience with kiwifruit say that they are still learning about Green kiwifruit and are working with the challenge of learning what is possible with Gold.

Varieties (fruiting, male pollinators, rootstocks)

With an active breeding programme growers are experiencing increased choice of rootstocks, male pollinators and fruiting varieties. The greatest development has come with the commercial release of Gold kiwifruit in the late 1990s. While taste has been a significant factor in the breeding and subsequent commercial success of Gold it was quickly apparent that it could cope with warmer winters than Green. This has given growers a significant tool to work with over time. The major constraints on more extensive plantings of Gold at present are the industry limits on area grown and the cost of obtaining a licence.

Hydrogen Cyanamide (HC)[4]

HC has long been used on kiwifruit to break dormancy, promote flower numbers and give a compact flowering period. Its use has a significant impact on fruit production, with good organic Green orchards achieving approximately 70 percent of the production of conventional orchards. Best results from HC use come with some winter chilling. One grower believes that winter chilling is an over-rated issue and that it would be possible to get by without HC. Others are very clear that its removal without a suitable replacement would have a major impact on the industry. Organic growers have recently completed a Sustainable Farming Fund (SFF) project which explored possible alternatives to HC but with no clear solutions.

Canopy management

Good canopy management is of fundamental importance. There is an industry trend towards lower vigour canes with higher vigour canes more susceptible to wind damage. Some are putting fruit canes (particularly with Gold) on strings with the aim of increasing fruit buds and reducing labour costs through easier canopy management. In an organic system things have to be managed very carefully to get the flower numbers.

Trunk girdling

Both trunk and cane girdling are being experimented with to increase fruit size and dry matter. Spring girdling is principally done for fruit size and summer girdling is principally done for higher dry matter. There are concerns about the sustainability of trunk girdling, with some holding a view that it is only a short-term solution to help meet the size and quality standards of ZESPRI. It has been observed that this practice is having some impact on the vines leading to less summer pruning and a thinner canopy. In this particular case, there will be some blocks that are rested from trunk girdling next year. Advice from an experienced orchard manager is to be selective with this practice and watch the plants carefully.

Biennial cropping

A biennial cropping system has been developed for Gold production. With this system they have alternate fruiting rows and alternate rows that are rested from production to grow replacement canes for the next season. The rested vines are cut back to the trunk after harvest to reinvigorate the plants. Under a normal vine management system the replacement canes are competing with the developing fruit for available energy. With the biennial system the vines that are fruiting no longer have the added work of producing replacement canes and can concentrating their energy on the fruit The exciting thing from a climate point of view is that it is believed that they can operate successfully under this system without HC. There is greater risk of wind and hail damage with this system, with a thinner canopy of fruiting vines and smaller leaves. Overhead protection is being trialled because of this.

[4] There was a review of Hydrogen Cyanamide by ERMA in 2006 because of its toxicity and concerns with spray drift (see http://www.ermanz.govt.nz/news-events/focus/ch2n2.html). This review recognised the importance of HC to the kiwifruit industry with no substitute available.


Biennial cropping and biological management systems have been developed by growers

Biological management

There is emergent interest in soil biological management. The main proponents of this are quick to point out that this is not organic growing, with allowance made for conventional inputs. The approach is founded on the work of William Albrecht, an American soil scientist, with a focus on trying to get the ideal balance of nutrition in the soil to get the desired responses from the plant. The system involves use of targeted inputs to get the desired nutrient levels, always with a focus on feeding the soil biology. It isn't a high input system, with inputs on well managed biological orchards now lower than in a conventional orchard. In this system the underpinning approach is that good nutrition management, in combination with good shelter and canopy management, is the key to producing a consistent high quality crop. The view is that a well managed biological system will buffer against climatic variations such as warmer winters and extremes of wet and dry.

Biodiversity

Biodiversity is not strictly a production issue but it is something that markets are looking for and there can be benefits to the orchard and wider environment. There is growing awareness of this with plantings of native species around ponds and along riparian areas occurring on some orchards.

People management

"Most of our greatest innovations have come out of our biggest disasters."

There are clearly many challenges but also many options available to kiwifruit growers. The face of the industry has changed enormously over the years with a high percentage (close to 50 percent) of orchards in corporate ownership, a lower skill base and challenges with finding good, reliable labour in some situations. How individual growers think and choose to work is a critical difference between those who are doing well and those who are struggling with these and other challenges. The higher performing growers and managers take time, both formally and informally, to see what others are doing. This is often a key to generation of ideas and adoption and dissemination of innovative practices. As an example, the approach of one grower is to continually work outside the square and be strategic in his thinking. He uses a management group to do most of the day to day running of the orchard. In some ways he sees it as his good fortune to be able to afford this. On the other hand he has the attitude that he cannot afford to do the pruning and things like that. Similarly in early February 2008 another grower and his managers went out to visit the six highest performing growers that they know of in this region. A further example of the innovation of this grower has been allowing their orchard managers to buy into the

business. This has given them a much greater sense of ownership and has improved the whole operation.

Postharvest

"After harvest you can do some things such as the way in which you cure the fruit and how long you do it for." Post harvest starts in the field and carries through to the pack-house. How the fruit are handled and stored at different stages is very important and is increasingly so with the earlier harvest and an apparent trend towards warmer autumns. A number of strategies are being employed to deal with increases in field heat of the fruit, including:

- Covered storage areas in the orchard to manage heat in bins immediately post harvest
- Curing areas at post-harvest facilities
- Improved design of new coolstores with better insulation
- Increased energy input to cool the crop to storage temperature and an increasing focus on ways to save power without compromising the crop

Climate change

"I saw Al Gore's movie and it was life changing for me."

Key points – Climate change

- There is increased awareness of climate change.
- The greatest concern is with the potential for increased frequency of extreme weather events. There is also concern with the effects of warmer winters and autumns, effects on rainfall patterns and changes to pests and diseases.
- Warmer spring and summer conditions will be beneficial.

The experience of increased frost risk, warmer winters and warmer autumns is contributing to heightened awareness of climate change. There are concerns from some growers with these changes, in particular the potential for a greater frequency of extreme weather events.

> *"If climate change brings more wind and storms then that is going to be our biggest challenge because Gold is very vulnerable."*
>
> *"In the past people have taken an event like Cyclone Bola as a one-off. I think we have to learn to prepare ourselves for those sorts of events coming a lot more regularly."*
>
> *"The biggest concern is with extreme events, particularly hail and wind. Most growers would see warmer temperatures as a positive, aside from winter temperature increases. Water is a significant concern."*

"It would be a concern if there is an increased frequency of storm events and north-easterly weather events. Big challenges with warmer temperatures would be lack of winter chill and at harvest time."

The potential changes of greatest concern to growers are:

- More extreme weather events, including wind, hail and storm events.
- Less winter chill would increase reliance on bud breaking chemicals, particularly with Green. HC is less effective with warmer winters.
- Warmer autumns will create more challenges at harvest and post-harvest in terms of fruit hardening, curing, field heat and storage.
- Any increase in rainfall variability will heighten the need to protect water.
- Existing and/or new pests and diseases could arise. Such possibilities are considered to be unpredictable.
- There will be increased risk of salt water intrusion with coastal bores.

On the positive side there are potential benefits:

- A warmer climate with increased atmospheric CO_2 would give higher yields.
- Warmer spring and summer conditions (as experienced in the current season) would be good for dry matter content.

Adaptation to future climate change

Key points – Adaptation to future climate change

- A planned, proactive, approach to climate change and adaptation is required.
- There is confidence that growers and the industry as a whole have the capacity to adapt to a progressive warming of the climate. There is some concern regarding potential for increased frequency of extreme weather events.
- There are a lot of adaptation options with current tools and practices, there is on-going innovation and experimentation and a few growers are actively taking account of climate change in the things they are doing.
- Over time there will be changes in variety (more Gold, less Green, new varieties), location (sites with cooler winters) and land use (different crops, subdivision).
- There is no clear alternative to HC at present. A general trend towards more organic-type approaches, driven by market requirements, will reinforce the need for new varieties that require less winter chilling.
- There are developments happening that are of high relevance to future adaptation. Important developments include the biennial cropping system that has been developed for Gold, experimentation with above canopy and sub-canopy shelter, and biological soil management.
- In most cases there is sufficient rainfall in the Bay of Plenty and projected rainfall changes are unlikely to be detrimental. Security of supply is becoming an issue for many growers. Some growers have already developed dams to capture and store runoff. Water allocation issues need to be resolved for the future.
- Post-harvest operations are already adapting to warmer autumns and will continue to adapt with a focus on issues related to removal of field heat, fruit curing prior to storage, and improved insulation and increased energy efficiency of coolstores.
- There will be on-going changes in ownership structure in the industry, with the possibility of more corporate ownership and fewer owner operators. Regardless of the ownership structure the industry will still need innovators and risk takers to provide leadership.

There is a lot of confidence that it will be possible to adapt to a progressive warming of the climate using a combination of existing technologies and new innovations that will arise over time. A few growers are already well down the track with their thinking and with what they are doing. One very proactive and innovative grower sees adaptation as being wholly consistent with his business philosophy and has commented that the

discussions around adaptation to climate change over the last couple of years has sharpened his focus on what they are doing with their orchard developments. He and others see climate change as an opportunity to focus even more on innovations that they are experimenting with and introducing to their orchard management. The biggest concerns regarding adaptive capacity are the unpredictable changes that may arise, most notably with extreme weather events and to a lesser degree with changes in pest and disease risk, and current uncertainties relating to water allocation.

> *"If winters were consistently warmer we would develop ways of dealing with it. It's the unexpected weather events that catch you out."*
>
> *"With gradual warming it would be possible to adapt. Do what we can with the technology that we've got and if that's not enough we'll have to change variety."*
>
> *"What happens in the orchard, how growers respond and adapt and the returns to growers are fundamentally important to the pack-house operation."*
>
> *"The biggest challenge will be dealing with any increases/changes in extreme weather events."*
>
> *"Too many growers are focused on tradition rather than how we can create the future."*
>
> *"There are some alternatives to HC that look moderately promising and we can take some lead from organic growers."*
>
> *"As things get tougher we just have to get smarter. It is not going to come on us in one day. It's going to come on slowly. We need to do more investigating about alternatives and keep a very open mind to it getting warmer. What are we going to do? It's not going to be tomorrow that it's all changed. The industry needs to be proactive rather than reactive."*
>
> *"Farming and growing is about the need to be adaptable."*
>
> *"It is important to be open to change, to be open to suggestions."*
>
> *"I think we'll be alright in the short term. Water is the big one. Wind we can mitigate with shelter. With temperature we'll be OK."*
>
> *"We will survive as we are for many years with a progressive warming. Does it give me confidence to plant and develop more? No, it diminishes my confidence to do that."*

Kiwifruit growing already involves a strong focus on ways to reduce and/or spread risk and this is strongly reflected in potential adaptations identified by growers.

Varieties, location, land use

Growers have choice as to what they do on the land. Temperatures that are 1-2ºC warmer in the Bay of Plenty will be comparable to present Kerikeri conditions and

shouldn't be an issue for Gold. In fact warmer average conditions may well be beneficial to Gold. *"You can be a blind man and see that Gold potentially has a better commercial future than Green."* With an active breeding programme that is trialling potential varieties in different locations there is also optimism that new varieties will be developed over time.

Another option, already being adopted by some, is to invest in sites with cooler winter temperatures and potential to modify microclimates for spring and summer warmth.

There is also the potential for changes in land-use, with conversion to different crops or subdivision for urban development in some locations. This is already happening, with a grower in a marginal microclimate who has already made the decision to switch to another crop, in his case to olive growing. In another case, a grower is on the urban fringe of Te Puke and could be in a position to consider subdivision in ten years time. Their orchard is on prime kiwifruit growing land and it is likely that factors other than climate would drive any such future changes.

Winter chilling

"By not using HC you're increasing the variability of your orchard. Here we have ZESPRI saying we want less variability, we want that crop to be as level as we can. We're faced with a major problem if we don't have HC or a suitable substitute." Like other chemical tools available to growers HC is under pressure with markets wanting fewer and fewer sprays. Along with these pressures it is also evident that HC will become less effective over time with warmer winters, with some degree of chilling required for best results. There is no obvious alternative to HC at present and if it is not available as a management tool in the future the only adaptation growers see long-term is to switch to other varieties over time or move to a cooler location. Those who advocate the biological soil management approach believe that chilling is not an issue if you get the nutrients right. This view is countered by others who see some benefits from biological management but don't believe it can achieve what HC does. A manager of both conventional and organic orchards has seen the results of removing HC from a conventional production system. A number of the conventional growers interviewed believe that the industry has to inevitably move towards a more organic type approach over time. Organic growers are more philosophical about working with year to year fluctuations in production that are inevitable without use of HC. The underlying approach is to farm to the weather. An organic grower in Opotiki was the beneficiary of this approach a few years ago when all of his neighbours were hit by a late frost. His orchard was unscathed because his vines had not yet flowered.

Orchard and vine management

There is a lot of on-going experimentation in orchards and sharing of ideas between growers. Potential adaptation benefits exist with the biennial cropping system. The developer of this system believes it has the potential to be productive without the use of HC. The experimental work of others with sub-canopy shelter and reflective mulches provides opportunities to modify and manage the orchard microclimate to best advantage. Canopy shelter may become more widespread, particularly if there is increased incidence of extreme weather events over time. Equally important is the biological management work with a belief that *"it comes back to soil balances and soil biology. If we've got those things right then the plant will function fine."* There are question marks over the long-term sustainability of practices such as trunk girdling aimed at increasing dry matter and fruit size. In this regard warmer temperatures during

spring and summer are likely to be beneficial over time. The on-going work of organic growers is very important with conventional growers often benchmarking themselves against organic orchards. Some have the view that there will be a general shift to organic-type approaches, driven more by market requirements than climate change. Any such shift will provide challenges in terms of managing warmer winters and emergent pest and disease issues. With a more coordinated focus on climate change it is also likely that Bay of Plenty growers will look to warmer sites in their region as well as to Northland to benchmark their adaptations. Allowance for time to do strategic development work and thinking will likely become increasingly critical as challenges to production increase over time.

Water

In most parts of the Bay of Plenty there is sufficient buffering capacity with the current rainfall amount. The most recent warm, dry season supports the view that mature vines on good soils can survive and produce well under such conditions. Indications are for no significant average rainfall changes in the region, but changes in distribution could have implications in more marginal areas where there is already some dependency on irrigation. Those growers who have invested in sprinkler irrigation systems have done so for the dual benefits of frost protection and irrigation when they require it. A critical issue in many growers' minds is not so much changes in rainfall but availability of surface or ground water for frost protection and irrigation. Security of water supply for the future is seen as a key issue by approximately half of the growers interviewed. There is a clear need for water allocation issues to be resolved involving all relevant parties. Proactive growers are ensuring greater security by investing in on orchard water storage where possible.

Post-harvest

There will be on-going changes and refinements of post-harvest operations. Changes have already been introduced as a result of recent warm autumns, particularly aimed at curing and removal of field heat prior to storage. It is likely that further changes to post-harvest handling and management of fruit will be required with warmer conditions. Warmer autumns will increase the potential for fruit to be growing later into the season with no clear cooling signal to harden off. This could affect storage life of fruit. With cool stores ranging in age from two months to twenty years old there are differing levels of insulation. Higher energy demands and higher costs of energy will likely drive post-harvest operators to installation of better insulation as well as continue to work on improved energy efficiency in all parts of their operation without compromising fruit storage.

Changes in ownership

The challenges to the industry are already significant and it is likely that concurrent with climate change there will be changes in the ownership structure. There is already a trend away from small growers with approximately fifty percent corporate ownership at present. With an average grower age in the mid 50s, the high cost of productive orchards and a skill gap that the industry is just beginning to address, there are likely to be significant changes over the coming decade. Systems like the biennial cropping system are being developed with declining skill levels in mind. Such a system is considered a 'paint by numbers' approach with something like a fifty percent reduction in labour costs. It is highly likely that there will still be room for smaller-scale operators, but they will likely need to be very skilled and both strategic and adaptable in their approach.

Industry responses to support adaptation

Key points – Industry responses to support adaptation

- Confidence in adaptability of the industry is balanced with a recognition that a planned, proactive, approach to adaptation is required to minimise risks and maximise opportunities.

- Communication and education are the key to engaging growers and others more widely in actively thinking about, planning for and acting on adaptation to climate change.

- ZESPRI has a key role to play in supporting a planned, proactive approach to adaptation. Integration of adaptation, alongside appropriate mitigation responses, into an emergent focus on sustainability is a sensible and cost effective way to operate.

- An important next step is to bring together key growers who have already been engaged with to focus on priority issues and a way forward. It is very important that this steps beyond the foundation work on adaptation completed in 2006 and what has been achieved through this current project.

- Relevant information needs to be collated for wide dissemination. Immediate outcomes from this work include an article for the kiwifruit grower magazine and a Kiwitech bulletin (a technical information series developed by ZESPRI) on climate change and adaptation. Other suggestions include:
    - Develop a whole information package for ZESPRI staff and growers.
    - Develop a comprehensive inventory of adaptation tools and a system for documenting what growers are doing.
    - Produce a series of short articles to go out in the monthly Kiwi Flier newsletter.
    - Provide a condensed summary of climate change and adaptation for the ZESPRI grower services team.
    - Provide a full copy of this report to the ZESPRI library so that growers who want the detail can access it.
    - Explore the marketing opportunities with this information.

- Disseminate relevant information through field days that are focused on adaptation to climate change.

- Support relevant underpinning research, focusing in particular on plant breeding, crop protection and water. A proactive approach is essential as it cannot be assumed, for example, that new varieties with low chill requirements will emerge by default.

- A positive, proactive, approach to adaptation which is integrated within a wider sustainability focus could provide marketing opportunities.

"ZESPRI should have more focus groups where you get hands on growers together to talk about what they're seeing and what's happening with our crops. We need to be investigating things like HC alternatives, different styles of doing your canopy and looking at results like that. Make sure the information is well publicised and everyone knows what is going on. We need to push the boundaries. We need to bring the science of climate change down and focus it on what exactly it means for kiwifruit, where it is taking us and what we have to do."

The quote at the beginning of this section is a concise summary from one grower of the collective thinking of many of the people (growers and ZESPRI staff) who have been consulted through this project. There is confidence in the innovative capacity of the industry and a generally optimistic view that they can adapt to climate change and make the most of opportunities. However, at the same time it is recognised that a proactive and united industry approach is required to ensure that potential negative effects are minimised and opportunities maximised. *"We need as much information as we can to be both proactive and able to defend ourselves when necessary. We need to be in front of things, and proactive."* Such an approach involves a number of key roles and responses which are summarised below.

Communication and education needs to be the primary focus with a responsibility to ensure that the whole industry (which includes all regions where kiwifruit are grown) is well informed.

ZESPRI has a key role to play

Many growers are presently struggling to keep their heads above water as things are. With this situation there is a need for ZESPRI to be providing some leadership on climate change and adaptation. The advice is to *"put together a coherent picture from growers and then take it to ZESPRI to look at risks and opportunities"* and to develop a plan to mitigate risks and maximise opportunities. ZESPRI staff who have been consulted through this project clearly recognise the need for a more proactive approach. Questions from overseas markets relating to carbon footprints in the industry have led to an emergent focus on wider sustainability issues. This wider focus is recognition that climate change is one of a multitude of changes that are taking place in the world that will impact on their industry. There are clearly limited resources to respond to these multiple issues and the smart approach is to work adaptation responses in with existing activities as much as possible. Such responses need to be easy for people to comprehend as well as being practical and affordable. Most people will need to see both financial implications and benefits to understand and begin to respond.

Work through the innovators

"People follow leaders. The followers have just got to be shown by example. It's the only way you'll get through."
"The greatest response has always come from the experimentation of growers, which needs to be supported."
The general approach of ZESPRI Innovation is to focus on the leading, innovative, growers. The success of the KiwiGreen programme was founded on such an approach and serves as a benchmark for kiwifruit and other primary industries. The innovative growers themselves recognise the value and importance of sharing ideas relating to climate change and adaptation. The view from a few key growers and the ZESPRI Grower Services team is to get the interviewed growers together to share the overall picture from them all and work to get their collective input to next steps, with the aim of

getting more growers to be proactive. It is recognised that the majority of people need to see things working before they will consider taking something on board. Concurrently there needs to be ongoing recording and dissemination of relevant grower experimentation. One grower recognised the role and value of ZESPRI in carrying the bigger picture but reflected that it is impossible for them to be on the ground with every grower and know everything that is going on. In this context some means of formalising and documenting grower experimentation is needed.

Collate information for dissemination

A number of suggestions have been made in terms of suitable information and mechanisms for dissemination. Immediate suggestions, to be completed as part of this project are for:

- An article in the grower magazine.
- A Kiwitech bulletin on climate change and adaptation.

Other suggestions include:

- Develop a whole information package for ZESPRI staff and growers.
- Develop a comprehensive inventory of adaptation tools and system for documenting what growers are doing.
- Produce a series of short articles to go out in the monthly Kiwi Flier.
- Provide a condensed summary of the science and information from this project for the Grower Services team to work with.
- Provide a full copy of this report to the ZESPRI library so that growers who want the detail can access it.
- Explore the marketing opportunities with this information. For example, develop and integrate grower stories on adaptation as part of the wider sustainability focus.

Disseminate information through focused field days

In the short term there is a recommendation that a gathering of growers interviewed through this project be combined with a field day. Such an event would provide the opportunity to share and discuss results and provide a platform for further developments and dissemination over time. Ongoing discussions on adaptation and wider dissemination could take place through ZESPRI field days. These are considered a logical forum for engaging people more widely. ZESPRI already has five focus orchards spread from Paengaroa to Katikati. They run dedicated sessions at these field days and are beginning to get more growers, not just leaders. There is more awareness of changes in the climate. This year (2008) is a good time to engage more widely with growers because of recent warm winters. The key thing is to make things relevant to their orchard operations and what they are experiencing. If you can make the connection with winter chill for example that provides the opening.

Research

The successful KiwiGreen programme was founded on 15-20 years of research by the former DSIR and subsequently HortResearch. There is a feeling from some growers that the industry has become too focused on short-term research rather than the sort of long-term research that underpinned the KiwiGreen programme. Within the context of climate change key areas of concern are with plant breeding, crop protection and water. These areas of concern have been recognised by some growers, ZESPRI staff and HortResearch scientists based at Te Puke. There is a confidence from some growers that the solutions to potential challenges and risks associated with climate change will

be found by someone. The reality, as experienced with KiwiGreen, is that change can come quickly if there is a solid foundation of research to work from. To enable the industry to effectively and proactively adapt to climate change such a foundation needs to be developed. Reflecting on the KiwiGreen experience it may take a concerted effort and investment over the next 15-20 years to ensure that risks are minimised and opportunities are maximised.

A proactive approach to research is needed. HortResearch scientists at Te Puke were presented with a summary of issues identified by growers and asked to respond with their thoughts on research needs (see Appendix 3). They have identified a range of research opportunities relating to the key areas of plant breeding, crop protection and water. These are potentially of critical importance to the future of the kiwifruit industry and need wider discussion between the scientists, growers and ZESPRI.

A key priority is the breeding of new varieties with low chilling requirements. While existing trials are taking place at a range of locations it cannot be assumed that low chilling varieties will emerge by default from a breeding programme that currently has fruit quality as its primary focus. Specific research needs for development of varieties with low chilling requirements include:

1) Screening the large germplasm collection in Kerikeri and evaluating this material for low chilling requirement.
2) Prioritising introductions from warmer areas in China.
3) Increase and measure response for low chilling requirements on hybrid populations.
4) Development of new varieties for different growing systems which involves studying/modifying plant and orchard architecture.
5) Addressing the impact of changes to flowering phenology on pollination.
6) Development of alternatives to HC.

Comparable research needs/opportunities have been identified for the other key areas mentioned (Appendix 3).

Marketing opportunities

The kiwifruit industry has a demonstrated ability and capacity to be innovative and change quickly when needed. It has the potential to be proactive, to provide leadership and use such an approach to full advantage. The development of a stronger environmental focus, which takes an integrative and cost effective approach to adaptation, has the potential to have significant marketing potential.

Role of regional and central government

Key points – Role of Regional and Central Government

- Both regional and central government have important roles to play in supporting the adaptive capacity of the kiwifruit industry.
- At regional level there needs to be active engagement between the kiwifruit industry and regional government to resolve concerns regarding water allocation. The Water Sustainability Strategy that is currently being formulated by Environment Bay of Plenty for the Western Bay of Plenty is an ideal opportunity to address and resolve these issues.
- At national level it is important that necessary support is provided to enable the kiwifruit industry to adapt to climate change effectively and in a coordinated manner. Key areas for support include long-term strategic research and strict biosecurity controls.

While there is clearly a strong adaptive capacity within the kiwifruit industry there are some key areas where input and support from regional and central government are required.

At the regional level the key issue of concern is with water allocation and in general with protection of valuable soil and water resources. Growers are universally concerned about water quality and water availability. The pressures from rapid population growth in the western Bay of Plenty are significant. Water is now being drawn from aquifers in rural areas to support the urban population. Concurrently there has been a growth in demand for water, mainly for frost protection but also for irrigation when and where it is needed. There are clearly growers who are concerned about the current situation and the lack of guaranteed access to water in some places. This is an issue that clearly requires some active engagement between the regional council, ZESPRI and key growers who are in the most affected areas. The Water Sustainability Strategy that is currently being formulated by Environment Bay of Plenty for the Western Bay of Plenty is an ideal opportunity to address and resolve these issues.

At national level it is important that necessary support is provided to enable the kiwifruit industry to adapt to climate change effectively and in a coordinated manner. Key areas for support include long-term strategic research and strict biosecurity controls. There is recognition that "*New Zealand has a great opportunity because we have this loose tag of a clean green image. Why don't we make ourselves such that we can use it.*"

Discussion and conclusions

There is a tendency with climate change to focus on the bad news. Climate change impacts research developed in response to a need to better understand what the worst effects might be, who might be worst affected, and what the costs of adaptation might be. This provided a background to the strong focus on mitigation that emerged through the 1990s. With understanding of what the worst effects might be the case for mitigation was strengthened. More recently, as evidence of climate change has begun to emerge, there has been increased attention on adaptation.

A focus on adaptation encourages a shift towards positive thinking and actions. Rather than perceiving climate as a source of risk, threat, or disaster there is an opportunity to identify climate as a resource. In New Zealand we have, for the most part, made good use of our climate resource albeit with some mistakes made along the way that have increased our vulnerability to climate. Climate change provides both a challenge and an opportunity. Most of all it is requiring us to make choices, in the face of considerable uncertainty, which will determine the extent to which future opportunities are realised and future costs are incurred.

This current study has built on a foundation of work that has focused on climate change and kiwifruit, as well as previous adaptation work with farmers and kiwifruit growers. The brief review of previous impacts and adaptation research highlights a transition from a focus on the bad news for kiwifruit to a more comprehensive focus on challenges and opportunities that may arise with climate change. Previous engagement with farmers and growers on the subject of adaptation has considerably enriched thinking and added depth to the relatively confined, but still valuable, understanding provided by impacts research. Most of all the contribution of people on the ground, particularly those who tend to be proactive, innovative, and forward thinking, is a strong focus on opportunities and what needs to be done to ensure that these are realised.

The in-depth consultations with kiwifruit growers, which form the bulk of this report, have strongly reinforced the value of such a focused engagement. It is apparent that there are considerable challenges being faced by kiwifruit growers and the industry as a whole. Climate variability and change is one of a number of issues being faced. They are already dealing with an inherently variable climate and more recent changes in climate that are, for the most part, consistent with future scenarios of climate change. Adaptation, innovation and resilience are all positive attributes of the kiwifruit industry. These qualities are all evident in the information shared by growers, both in summary form in Part 2 of this report and through the individual interviews that are documented in Appendix 1. There is a considerable amount of innovation and experimentation being undertaken by growers and good systems and networks available for sharing and dissemination of information for those who choose to take advantage of it. In this sense it can be concluded that the adaptive capacity of the kiwifruit industry is high. However, it is also apparent that it should not be assumed that adaptation will happen simply because the capacity or potential is there.

The kiwifruit industry is currently well placed to adopt a planned, proactive, approach to adaptation. The timing is right for such an approach. This and previous work has provided some valuable momentum with a core group of growers engaged, a number of whom are keen to contribute to next steps. The industry is currently developing a

sustainability strategy, which has emerged from questions relating to its carbon footprint. With limited resources and a number of inter-related issues to address it clearly makes sense for adaptation to be an integral part of this emerging sustainability strategy. There are key areas that need attention, the most important ones being:

- Communication and education throughout the industry on climate change and adaptation with a focus towards practical solutions and actions.

- Long-term strategic research aimed at making the most of the climate resource in the future and minimising risks and costs. Of fundamental importance is breeding of new varieties that require less winter chilling and produce high quality fruit. Pest and disease issues, water and the evolution of management and post-harvest systems will all require some attention as well.

- The identification and realisation of marketing opportunities. There is an opportunity for the kiwifruit industry to profile positive stories in relation to climate change and adaptation.

- Water allocation issues need to be resolved for the future. Environment Bay of Plenty is currently working on a Water Sustainability Strategy for the western Bay of Plenty. It is hoped that the opportunity to resolve relevant issues will be taken in the development of this strategy.

What is the wider relevance of this work? Adaptation, innovation and resilience are not only positive attributes of the kiwifruit industry. They can be found throughout New Zealand. This is reflected in the statement from a Hawke's Bay hill country farmer a few years ago who commented, at the end of an adaptation workshop, that he didn't realise how many options they actually had. The wider relevance of this work is in the grounding of current scientific knowledge with practical, forward thinking people. A two way dialogue emerges from such an approach. On the one hand people on the ground are more informed about the science and able to make it relevant and real in what they are doing and in their future planning. On the other hand the information and thinking shared by people on the ground provides insight and direction that is very relevant for the policy and science communities. It provides the opportunity to be strategic, practical, efficient and effective with our resources.

As stated in the introduction, adaptation is ultimately about making a choice to act and getting the timing right. The challenge and the opportunity is to make the most of what growers have shared through this study.

References

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K O'Brien, J. Pulhin, R. Pulwarty, B. Smit and K. Takahashi, 2007: Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge University Press, Cambridge, UK, 717-743.

Folke C., J. Colding, and F. Berkes, 2002: Building resilience for adaptive capacity in social-ecological systems. In: Berkes F., J. Colding, and C. Folke (eds). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press, Cambridge, UK.

Griffiths, Georgina, Brett Mullan, Craig Thompson, Stuart Burgess and Andrew Tait, 2003: *The climate of Bay of Plenty, past and future*. Report prepared for Environment Bay of Plenty.

Hall, A.J., McPherson, H.G., Crawford, R.A., Seager, N.G. 1996: Using early-season measurements to estimate fruit volume at harvest in kiwifruit. *New Zealand Journal of Crop and Horticultural Science*. 24: 379-391.

Hall, A.J and McPherson, H.G. 1997a: Modelling the influence of temperature on the timing of budbreak in kiwifruit. *Acta Horticulturae*. 444(1): 401-406.

Hall, A.J and McPherson, H.G. 1997b: Predicting fruit maturation in kiwifruit (*Actinidia deliciosa*). *Journal of Horticultural Science.* 72(6): 949-960.

Hall, A.J., Kenny, G.J., Austin, P.T., McPherson, H.G., 2001: Changes in Kiwifruit Phenology with Climate. In: Warrick, R.A., Kenny, G.J., Harman, J.J. *The Effects of Climate Change and Variation on New Zealand: An Assessment Using the CLIMPACTS System.* International Global Change Institute, University of Waikato.

IPCC 2007: Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. WMO 2007.

Kenny, G., 2006: Adapting to Climate Change: Enabling community responses project, 2006-2008. Phase 1 Report on outcomes from kiwifruit industry workshops. Report to Environment Bay of Plenty.

Kenny, G., 2005: *Adapting to Climate Change in Eastern New Zealand: A Farmer Perspective*. Earthwise Consulting Limited, Hastings.

Kenny, G., 2001: *Climate Change: Likely Impacts on New Zealand Agriculture*. A report prepared for the Ministry for the Environment as part of the New Zealand Climate Change Programme.

Kenny, G. and Shaw, W. 2006: *Biotic Effects of Climate Change in the Bay of Plenty*. http://www.envbop.govt.nz/media/pdf/Report_Bioticeffectsstudy.pdf

Kenny, G.J., Warrick, R.A., Campbell, B.D., Sims, G.C., Camilleri, M., Jamieson, P.D., Mitchell, N.D., McPherson, H.G., Salinger, M.J. 2000: Investigating climate change impacts and thresholds: an application of the CLIMPACTS integrated assessment model for New Zealand agriculture. *Climatic Change*. 46: 91-113.

Kenny, G.J., Harman, J.J., Warrick, R.A. 2001: The CLIMPACTS Programme and Method. In: Warrick, R.A., Kenny, G.J., Harman, J.J. *The Effects of Climate Change and Variation on New Zealand: An Assessment Using the CLIMPACTS System.* International Global Change Institute, University of Waikato.

Martin, R.J., Salinger, M.J., Williams, W.M. 1990: Agricultural Industries (Chapter 22). In: Ministry for the Environment, 1990: *Climate Change Impacts on New Zealand: Implications for the Environment, Economy and Society.*

McPherson, H.G., Hall, A.J., Stanley, C.J. 1992: The influence of current temperature on the time from budbreak to flowering in kiwifruit (*Actinidia deliciosa*). *Journal of Horticultural Science*. 67(4): 509-519.

Ministry for the Environment, 1990: *Climate Change Impacts on New Zealand: Implications for the Environment, Economy and Society*.

Ministry for the Environment, 2004: Climate Change Effects and Impacts Assessment: *A Guidance Manual for Local Government in New Zealand.* Prepared by David Wratt, Brett Mullan and Jim Salinger, NIWA, Sylvia Allen and Tania Morgan, MWH New Zealand Ltd, and Gavin Kenny, Earthwise Consulting Ltd.

Ministry for the Environment, 2008: Climate Change Effects and Impacts Assessment: *A Guidance Manual forLocal Government in New Zealand, 2nd Edition.* Brett Mullan, David Wratt, Sam Dean, and Michele Hollis, NIWA, Sylvia Allan and Tania Williams, MWH New Zealand Ltd, and Gavin Kenny, Earthwise Consulting Ltd.

Parry, M.L., Carter, T.R. and Konijn, N.T. (eds): 1988. *The Impact of Climatic Variations on Agriculture, Volume 1: Assessments in Cool Temperate and Cold Regions; Volume 2: Assessments in Semi-Arid Regions*. Kluwer, Dordrecht, The Netherlands.

Salinger, M.J., Kenny, G.J., Morley-Bunker, M.J. 1993: Climate and kiwifruit (*Actinidia deliciosa)* cv. Hayward 1. Influences on development and growth. *New Zealand Journal of Crop and Horticultural Science* 21, 235–245.

Salinger MJ and GJ Kenny, 1995: Climate and kiwifruit cv 'Hayward' 2. Regions in New Zealand suitable for production. *New Zealand Journal of Crop and Horticultural Science* 23, 173–184.

Appendix 1 – Grower case studies

The growers interviewed are geographically spread from Katikati to Opotiki, with the majority from the core production areas of Te Puke/Paengaroa and Katikati. They include a mix of Gold and Green growers engaged in conventional, organic and biological production. Most are owners with varying degrees of hands-on involvement in their orchards. Two of the interviewees are involved in family businesses that have evolved from fruit growing to medium sized packhouse operations. Three are involved in orchard management.

Grower	Location	Variety Gold (Go) Green (Gr)	Management system Conventional (Con), Organic (Org), Biological (Bio)	Management role Owner (O), Manager (M), Packhouse operator (P)
1	Te Puke	Go	Con	O
2	Te Puke	Go	Org	O
3	Te Puke	Go, Gr	Org	O, P
4	Te Puke	Go, Gr	Org	O
5	Paengaroa	Gr	Con	M
6	Paengaroa	Go, Gr	Con	O
7	Paengaroa	Go	Con	O
8	Paengaroa	Gr	Con	O, M
9	Tauranga	Go, Gr	Con, Org	O
10	Katikati	Go, Gr	Con	O, P
11	Katikati	Gr	Con	O
12	Katikati	Gr	Bio	O
13	Katikati	Gr	Con, Bio	O
14	Katikati	Go, Gr	Con, Org	M
15	Katikati	Gr	Con, Bio	O
16	Katikati	Go, Gr	Con, Org	O
17	Whakatane	Gr	Con	O
18	Opotiki	Go, Gr	Org	O

A qualitative assessment was used involving semi-formal interviews and orchard walks. All interviews were recorded on a digital voice recorder. Growers were asked to share information on:

- Current climate challenges
- Management tools/systems in place to address current climate challenges
- Primary concerns/issues with climate change
- Adaptation responses required to address climate change
- Support or steps required from industry, regional and central government to implement and support adaptation in the kiwifruit industry

Grower 1: Don Heslop, Te Puke

Background

Don has been in the kiwifruit industry since 1978. Most of that time was spent managing orchards. He and his wife now own and run two orchards. The home orchard on No. 3 Road is 1.5 canopy ha and the other, 4.9 ha block, is on Old Coach Rd (OCR). They have owned the home orchard since 1995.

Both orchards are conventionally grown Gold, all on pergola. The home orchard was one of the first commercial plantings of Gold, converted in 1997 by cutting the tops off the Green and stump grafting. This meant one year out of production. It has been a high yielding block.

They bought the OCR block three years ago. It was planted in 2000 but hadn't been well managed.

The home block is on rich volcanic soil with plenty of black topsoil. The OCR block is very light pumice soil. They're managed quite differently as a result.

Current climate challenges and responses

Don thinks we're going through cycles of climate. They're having a really good summer this year. He grew up on No. 3 Road and believes they used to have good summers like this one in the past.

Home block

Temperature is generally not a problem. The biggest challenge is warm temperatures in June/July and not enough winter chilling. However, Gold is better suited to warmer winters and doesn't seem to suffer as much. The shift to Gold wasn't because of

warmer winters, more because of needing a change and wanting a new challenge but Don is more aware now of the potential benefits.

They are very lucky as they are basically frost free, with very good air drainage. They tend not to worry about the spring frosts. These aren't a problem so long as he keeps the orchard well mowed and the bottom of the shelter clear.

Water has never been an issue since they've been here. Rainfall is not a problem at the home block and is much higher than at the OCR block. Often it is raining at the home block and not raining at OCR. They had a dry year in 1997 and it didn't hold the vines back even though all the grass died off. The rootstock is from the early 1970s and so is very deep rooted.

The orchard is well sheltered. There is an odd problem with wind in November/December. The nor'westers are the worst.

They are below the area that tends to be more prone to hail. Last year (New Years day) they had their first hail ever.

Don's focus is on nutrition management to get consistent production of good quality fruit. Half of the home orchard is strip mown, half has a biennial cropping set up. He has been quite happy with the results from this and is restructuring the vines totally. The orchard is single planted, using old rootstocks. The crop volume is down with the biennial system but he is working to get it back. This system is easier to manage with very little summer work. Dry matter has increased slightly.

Old Coach Road block

Because of the temperature characteristics of this location it is likely to be less affected than the home block if HC is taken away. There are higher day temperatures and cooler nights at this site with about a 5ºC temperature difference with night temperatures (between home and OCR blocks). The higher summer temperatures at the OCR block are generally beneficial for dry matter and fruit growth.

There is water for irrigation and overhead frost protection on this block. Don has upgraded an existing system which was put in by the previous owner after being hit by frost in the first year when he was due to harvest. The reasons that the vines didn't take off after they were first planted was because of lack of water. The water is from a surface take which is part of a bigger water scheme for part of Old Coach Road. This area is a challenge in some ways but also beneficial as they can turn the water on when they want to. They can manage the water and achieve fairly good dry matter. A bit of water stress is good at certain times of the year.

Wind is probably the biggest challenge. One of the first things he did was to put in quite a lot of overhead shelter. He is now in the process of putting in under-vine shelter which will hopefully help reduce reject rates. It is also used to improve light. He's not using the reflective cloth that Alan Luckman (Grower 5) is using.

At present he isn't using the biennial system at OCR because of the age of the vines and the way they were poorly managed to begin with.

Climate change and adaptation

"If climate change brings more wind and storms then that is going to be our biggest challenge because Gold is very vulnerable."

Warmer spring and summer conditions would be good. The current trend in the Te Puke region seems to be toward a cooler spring/early summer and warmer summer. The perception of "normal" conditions is a cool winter and warm spring/summer. They have not been experiencing this over the last couple of years although this last season wasn't too bad. A trend towards higher temperatures would require continued use of HC to make sure of flower numbers. *"I'm not sure what we could do to minimise the risk (without HC) apart from moving to another location that is cooler."* The purchase of the OCR block was made with climate change and HC in mind. They are spreading their risk with two orchards in different locations.

More wind and storms would be the biggest challenge if they are a consequence of climate change. It is very hard to protect the home orchard from nor'westers, so it would be a problem if they became more prevalent. The main issue with wind is skin blemish, which is only cosmetic and has no effect on taste or keeping quality. Consumers don't want blemished fruit.

The downfall of the sub-canopy shelter is the lack of air movement at night time. Nov/Dec is the time when winds can be a problem and use of shelter at this time is beneficial to daytime temperatures. The challenge of managing under-vine shelter is that you want to stop air movement to prevent fruit damage and increase light and warmth, but can block air movement at night time. Warmth during the day will hopefully increase canopy cover and help protect the sub-canopy.

If there were more frequent hail storms it would be quite devastating. At present their home property is below the area that is more susceptible to hail. Don may look at

overhead shelter at OCR if necessary, but would need to weigh the benefits against the costs. He can afford to lose half a crop to hail in 13 years as they have experienced and would look at things seriously if they suffered such losses with greater frequency.

He is already putting systems in place to spread the risk, is looking at different production systems and is still experimenting with ways of getting a more consistent crop. An option for the future is to move the OCR block into biennial bearing. Don is still learning with this system and trying different things. He is noticing buds further apart with canes grown up the strings. You can get a lot more fruit per cane with buds closer together. He uses BENEFIT (an Italian product) for sizing of the Gold fruit. The product limits the natural processes in the vine, increases the cell division of fruit and takes the vigour out of the vine which means fruiting buds are much closer together.

There are issues with field heat. They are now picking in much warmer temperatures, as early as March, when historically the harvest of Green began on 1 May. HC is being used to create an artificially early harvest. The orchard location (microclimate etc) and date of application of HC determine harvest time.

Don does what needs to be done to manage the orchard well. *"One thing that I try and make sure I have plenty of is worms in the soil."*

Industry issues and responses

If the climate is getting warmer then removal of HC would be a big one. It would be great if the scientists could come up with an alternative.

Some practical advice is needed on what can be done to help prevent climate change. The industry needs to be sensible about C footprints. It has to be practical and affordable. Globally, we ought to focus our energies on restoring areas in desert, rather than be caught up with C as such.

Don agrees with a wider sustainability focus but it needs to be done sensibly. He shared the example of removal of willows on a neighbour's riparian area with subsequent erosion problems after a high rainfall event. The ideas that come from people in offices aren't necessarily practical.

Grower 2: Graeme Crawshaw, Te Puke

Background

The property was bought by the family as an orchard in 1979, which Graeme has managed since 1986 and owned since 1992.

He and his wife Jill have 7.5 canopy ha of organic Gold kiwifruit. Jill has a pollination business. They have a half share in a 5 canopy ha organic Gold orchard at the top of No. 3 road. At the home orchard they also run organic free range chickens.

They first moved into organic production in 1994. Production is about 7000 trays/ha which is close to the industry average.

The soil is a very free draining volcanic soil. Water is from a spring in the gully that is on the property and this hasn't stopped flowing in all the time they've had the property. This includes the last summer which has been particularly dry.

The land provides sufficient moisture for the mature vines and to his knowledge it hasn't been a limitation to production, so there is no use of irrigation.

Apparently HortResearch have done some work in this general area which shows you might get an economic benefit from a water contribution once every 10 years for mature vines. The conclusion was that investment in water isn't necessary.

Current climate challenges and responses

Temperature in this locality is limiting for growing organic Green. If they were growing Green they might be limited for flower numbers in years with mild winters or with a cold snap in the spring. With Gold they have never had problems getting the flower numbers under their organic management. The shift to Gold was partly because of temperature, but more strongly driven by the taste of the fruit and perceived market demand.

There is a higher frost risk with Gold, with bud burst up to 6 weeks earlier than Green. There have been years with lots of frost but they've all been after Gold budburst. Graeme believes that frost events have been more erratic and common since about 1994. Frost control is a "must have" for Gold because of greater susceptibility. They converted to Gold in 1997 and used helicopters for frost control for the first five years, with significant frost damage in two of those years. They then put in a wind machine which they've now had for 5 years. They have one wind machine for the property which is proving to be very effective. They have some areas with natural air drainage and so the one machine is sufficient for the 7.5ha (recommendation is one machine per 6ha). They will use it from 2-10 times per year.

They've changed quite a lot of shelter to facilitate air flows from the wind machine. They use a combination of natural and artificial shelter. He has been putting in some under-vine shelter for the last 2 years. It is not as effective as high shelter but is far more affordable. Shelter management and improvement is on-going.

Their neighbour has invested heavily in overhead sprinklers for frost protection.

There is no feeling of water limitation or potential for damage from high rainfall events at present. There have been some intense rainfall events in the area but this has never caused a problem on their property. A dry year, as experienced this season, slows down the young vines but there are no major problems. If the bottom line is to keep the vines alive then they will apply water. However their philosophy is to encourage the vines to establish their root system with minimal irrigation input. The root system will stay near the surface if you irrigate constantly, but it will chase the water if you don't put too much water on.

The Gold vines are more susceptible to wind damage than Green. This year has been good with a really low wind run and minimal wind rub damage to fruit. In the past they have experienced up to 25 percent losses at the packhouse with wind rub and that has been after thinning off about 10 percent of the wind rub fruit in the orchard. Tight quality standards are very important to maintain the premium position of ZESPRI fruit in the market place, with their fruit getting up to twice the price of fruit from other countries. This is a big advantage of the single desk. If there was one more group selling kiwifruit from NZ you would immediately see a ratcheting down of prices to the NZ grower.

Climate change and adaptation

Graeme is comfortable to leave longer-term assessment of changes to the experts. *"I saw Al Gore's movie and it was life changing for me."* He hasn't seen anyone who has refuted the arguments and this is a benchmark for Graeme.

If it becomes up to 2ºC hotter that's not such a big issue for Gold. Kerikeri is presently good for growing Gold which is a fair indicator for the future in the Bay of Plenty. A main concern for the future would be the possibility of more wind.

Changes in rainfall are not an issue yet. Very dry years are presently not an issue and in warmer years they tend to do better in terms of both fruit size and dry matter. With organic Gold growers consistently have higher dry matter than conventional growers. They may need to think about investing in irrigation if conditions become drier, or there are more dry years, over time. They wouldn't worry about water unless there was significant drying over time**.** *"I think we've got quite a lot of leeway with quite a bit of buffering in the system."* They used to have a water right for the property from a nearby stream, until about 1990, but allowed this to lapse. This water right was sufficient to irrigate the orchard but they gave it up because of the financial situation at the time. When they inquired about water in about 2003 there was no longer water available from this stream. Their neighbours have put down bores for frost control and now have the water available for irrigation as well. There is the possibility of storing water sourced from the neighbour if they needed it. Graeme feels that it is probably a good time to research the water situation a bit more in particular to be clear that it is not limiting vine growth and fruit production at present.

Wind damage can be a significant cost with Gold in the present climate. This is the only really big issue of concern in terms of variation of production from one year to the next. If there was more wind or more extreme wind events they would need to invest more in shelter.

Fruit size is the challenge with organic Gold. The neighbour across the road is getting 90,000 trays off 5ha, which is higher than the industry average but isn't uncommon. In one year they took their No. 3 Road property out of organic production and they went from 5000 trays/ha to 11000 trays/ha with the application of BENEFIT PZ (made from a plant extract and used to increase fruit size). They converted back to organic

management two years ago and they're now back to 7000 trays/ha, which is close to the industry average for organic production.

"A more erratic climate at both ends [of the growing season] will eventually be a problem."

Grower 3: James Trevelyan, Te Puke

Background

James is involved in a family business on a property owned by his mother. The property covers 20 ha and houses a packhouse and three orchard blocks, all adjoining. The land was formerly a dairy farm that was subdivided and over time they've bought the separate blocks. The family bought the original block of land 43 years ago. They bought the second block ten years ago and the third two years ago.

They have 1.1 ha of organic Gold, 2.3 ha of organic Green and 2.5 ha of Green in conversion to organic. The packhouse includes 20 coolstores which are capable of storing five million trays of kiwifruit. They are currently packing seven million trays of kiwifruit.

They are located on good Te Puke soils with 200-250mm of topsoil and 3.5 to 4 metres down to a very wet pumice layer. The vine roots go down to 6-7 metres and so pick up the moisture.

They have recently developed a camping ground which can presently site 64 people. This has been developed primarily to provide accommodation for their seasonal staff. They employ about 700 people with a growing proportion of overseas people. Three years ago they had a small amount of overseas staff, last year 40 percent were from overseas, this year 60-70 percent are from overseas. Accommodating these people is increasingly an issue which is why they have developed the camping ground. They tried to expand this year and ended up with a bill of $160,000 for development impact fees. James sees this situation as the 'creaks and groans' of a council adjusting to a new activity, with the rapid increase of overseas seasonal staff.

Current climate challenges and responses

The weather used to be extremely predictable. The seasons seem to have slid with colder springs and warmer autumns. They haven't had the late spring frost problems experienced elsewhere. This land is pretty much frost free. As a result they don't need sprinklers for frost protection. The packhouse operation probably provides some benefit with a localised heat island effect into the orchard.

Being organic they don't use HC and so they are very conscious of the need for winter chilling. So far they have been OK without using HC. As long as you do the work at the right time you're alright. If you don't get your summer work done or your winter work done and have the canopy well lit and the wood well exposed to the sun then with a warmish winter you'll have lack of buds. Good canopy management is critical, with the aim of achieving nice dappled light on the orchard floor with grass growing throughout the year.

When you get slightly warmer summers you have higher pest issues. So long as you know what's going on you can pretty much fight the battle. They're tending to push things harder with pre-blossom sprays and they've been able to control the pests to date. But there is a lesser and lesser margin for error in growing. If you miss a spray or two you have pest issues.

They have ample rainfall and the moist subsoil. The mature vines tend to be okay on this soil whereas young vines will struggle.

High winds can be a problem at times. They went through a period of removing a lot of internal tree shelter which cooled the orchard. This was removed to provide more canopy area. Now they're putting in under-vine shelter to get the warmth of the blocks up again.

They shifted to organics because the conventional system of growing didn't make sense. The more that they backed out the more sensible it was to be organic. They became aware of the imbalance that conventional management created and the impact this had through to the storage quality of fruit. They had previously used HC about twice. To get more bud numbers in an organic system you have to tie down more wood. It is a financial struggle growing Gold organically. With the Green they're not too far behind.

The 5-year average production from their Green block is about 8000 trays/ha, and from their Gold it is about 8500-9000 trays/ha. You have to be passionate to do the latter organically.

They have no trouble achieving high dry matter. Probably the best tasting Gold fruit is organic. Conventional growers are catching up a bit with trunk girdling and using less BENEFIT than they did initially. James take for higher dry matter is a warm spring, coolish summer, warm autumn.

James' view is that organics has helped provide a balancing influence to conventional production. It has helped balance off some of the issues that are challenging the conventional guys. The trend is definitely towards an organic approach. There is no doubt that the market do not want to consume chemicals.

"The big climate challenge for the packhouse is that the fruit is coming in warmer, especially at the start of the season. Our refrigeration plant is having to work harder."

More energy input is being required to cool the fruit. James is questioning in some cases whether the insulation is thick enough in the older coolstores. Their coolstores vary in age from two months to twenty years old. What they spend on power is a significant cost. Increasing power costs and demand are impacting on their business. They are doing extensive monitoring of their power usage and have been looking at ways to save power and reduce costs, but not at the expense of the fruit. So far this year things haven't been too bad. The fruit temperatures (fruit flesh temperature in the bins) are about 7ºC higher compared to what they will get in the main harvest period (in May). Last year in some cases there was a 12-13 ºC difference.

Climate change and adaptation

If late spring and early summer became windier there would be more reject fruit, especially with Gold, and increased shelter costs. Any increase in spring rainfall would create more fungal disease problems. With warmer temperatures there may need to be a change of rootstocks, for example to the Kaimai rootstock which promotes more flowers. At present they are alright with winter temperatures.

With the packhouse there would be issues relating to insulation. The plant will be working harder with a warmer climate. It is already too warm for the workers in their packhouses and they're going to have to spend some money to cool it down as it is. In terms of retrofitting coolstores with better insulation James see this as quite a challenge. The only adaptation options for coolstores are to install better insulation which is a big expense. He has to look at the balance between the cost of better insulation and the power saving from doing this.

What happens in the orchard, how growers respond and adapt and the returns to growers are fundamentally important to their packhouse operation. Their packhouse operation is dependent on their client base (growers). The client base needs to be making money to support the packhouse operation. What makes the difference? They have to be above average to keep the growers coming to their packhouse. So they have a strong focus on fruit handling. James puts a lot of effort into fruit handling, developing a history of the fruit from the different orchards that supply them and watching them in the coolstore. Fruit from different orchards will have different expiry dates. It is for them to sort out and put a date on it.

They are developing a broad environmental sustainability focus with their business. Key issues are:

1) Waste management
2) Energy efficiency
3) Considering water capture

There are dollar drivers to be more environmental but James also has underlying concerns that motivate him.

Grower 4: Noeline Almond, Te Puke

Background

Their property is in the kiwifruit "dress circle". They bought the orchard in 1990. The total area is just over 4 ha, with just under 3 canopy ha. The first plantings were made in 1961. The rest was mixed orchard that was gradually all converted to kiwifruit by 1986.

In 1997 they converted roughly half to Gold and half to Tomua and shortly after also began conversion to organic production. They have been certified organic since 2000. At that stage ZESPRI required removal of all Tomua and vines were re-grafted to Green.

They now have 1.7ha of Gold and 1.25ha of Green, all on pergola structures and are now beginning to use strings. Production last year was about 8000 trays/ha and about 7500 trays/ha for Gold and Green respectively. This year is looking good and could be one of their better seasons.

Noeline has been the orchard manager since 1996 and they have a settled labour pool of Sikh people who do all of the major pruning work and picking. She and her husband do all of the other bits and pieces, including training of new canes, mowing and other orchard work.

All organic Gold dry matter is higher than average conventional Gold. Fruit size is becoming more comparable to conventional. They can't use BENEFIT. There is a lot more focus in the industry on harvesting solar energy with canopy management to get higher dry matter. Overuse of BENEFIT and pruning gels were leading to lower dry matter in conventional orchards. The short-term solution is to use trunk girdling. They don't do any trunk girdling, but do cane girdling.

The soil is a Te Puke pumaceous sandy loam soil, with a consistent organic matter content of about 10 percent.

Current climate challenges and responses

Over the years that they've been there they haven't had any noticeable trends in the climate aside from frosts, which have moved with less at the beginning of winter and more at the end of winter and in spring. They don't have any need for frost protection. They rarely get more than the tips of leaves burnt.

They're using a biodynamic preparation called Thermomax but it's not clear if they are getting benefits from this. They use this on the Gold because budbreak is quite early. They had one year when leaves hadn't greened up, so they have used Thermomax to try and get the plants moving more quickly.

So far they've usually had enough winter chill. There was some recent work by COKA (Certified Organic Kiwifruit Association) on managing winter chill, funded by SFF. There are some things that seem to be increasing budbreak.

It seems like it has changed with rainfall but if you went through the records you would probably find comparable years in the past. They don't suffer from long dry periods because of the good deep soil and the fact that the vines are well established. When they plant young vines they try to plant them in sheltered areas. They don't irrigate the young vines. If young plants are struggling they hang a 20 litre container and drip it down to the plant.

They've installed a 22,500 litre water tank for harvesting rain water off the shed roof, which they use for their orchard sprays. This is the only water that they need for the orchard. It hasn't run out in the five years that they've had it.

Wind can be a problem. Some years it is a problem and some years it isn't. Wind is at its worst in terms of potential to do damage in November, with more prevalent westerly to south-westerly winds.

They're thinking about using white cloth not so much for wind but to raise under-vine temperatures to get increased growth and dry matter in the fruit. They'll try it in the Green and maybe Gold blocks.

She is putting Gold up on strings, aiming for shorter internodes and more buds per cane. The main problem until now has been sizing fruit rather than the number of buds. A main advantage of this system it to simplify the labour input with future labour shortages in mind. Any additional benefits will be a positive. They've been looking at other orchards.

Noeline is dubious about whether the biennial bearing system (see Grower 7) would work in an organic system. Organic vines are not as vigorous as conventional and she is concerned as to whether they would withstand the radical pruning that is being used in the biennial system. Noeline is interested to see whether this system would work for organics but is not keen to do it herself.

In their present system they use a lot of old cane, particularly if they don't get better replacement canes. It is simpler for them to maintain their current orchard set up and refine that with using the strings to grow replacement canes.

At present they're cane girdling on the Gold and have girdled half of the Green. Cane girdling feeds carbohydrate to the fruit but also allows for root feeding to replacement canes. They had a lot of effects just with cane girdling. Noeline read one research paper that said root carbohydrate was 50 percent less after a couple of years of trunk girdling and does wonder how sustainable this practice is.

There is a lot of experimentation going on in the industry.

Climate change and adaptation

Noeline has no idea how much warmer they could cope with. *"If winters were consistently warmer [with climate change] we would develop ways of dealing with it. It's the unexpected weather events that catch you out."* If it's consistently warmer you can change things to accommodate it. It's the more extreme fluctuations that catch you out. With gradual warming it would be possible to adapt. The organic budbreak work has focused on the use of mineral oil, but more oil on organic orchards may not be a good move in this regard. *"We've got to be careful about oil because of the markets opinion of the use of oil."*

So far they're okay with water but it is going to be one of the major issues. Over a longer time it could become more of an issue if conditions became drier over time. At present they rely on the ground water held in the pumice subsoil but if that dries out they'll have a problem.

They could look at changing the crop they grow, which was an option they had planned when they first bought the property. Another option that they could consider would be

the possibility of subdividing, which could be possible in another ten years. This would be a shame because it is a prime horticultural area.

At present they're getting better profit from Green kiwifruit. Gold is more expensive to manage but gives higher returns initially. Green is cheaper and easier to manage. Their Gold yield is about half of the conventional optimum, which (8000 trays/ha compared with 15,000 trays/ha) and is marginally economic even with the organic premium. With their Green production they are matching conventional average production levels. They had one year with 20 percent fewer flower numbers with the Gold, but still had the same yield due to increased size. In the absence of HC in an organic system their primary focus is getting flowers on the vine to fruit in trays. The orchard covers its costs and returns some income. The change in canopy management ought to reduce labour costs which will make things better. However the pressure is definitely off with another income. There are other options they could be exploring. Trunk girdling is a big one but there are other options that could be explored first. One thing the industry has been doing is trialling a new male polleniser, which is now released for use in the industry. The new polleniser is very well coordinated with the female. Noeline won't be replacing the existing male varieties completely.

The demands from ZESPRI and markets are getting greater, with increases in costs. There is a heck of a lot more paper work now than in the past. Noeline spent much more time doing paper work over recent seasons, dealing with ZESPRI, BIOGRO and GlobalGap, accounting and tax requirements. The different auditing systems don't change what they do on the orchard but they have to do the reporting to meet the requirements.

They had a wake up call a few years ago with a problem with the water line down No. 2 Road. They had no household water for six weeks. Someone had plugged in an irrigation system without telling anybody. It was a bit of wakeup to say well we're not independent. We're totally reliant on the council's water supply. They had an old water tank that fell down and they didn't replace it, so when the council came around with the water tanker they didn't have any storage capability. Since then they've been thinking that it would be nice to be more independent. So they're looking at wind and solar power.

Industry issues and responses

Noeline thinks the research community is ahead of some others. Making future options more available and more visible to people would be helpful.

"We need readily available models and need to make things easy for people. For the general community things need to be put in front of people and made easy. Until it becomes simple to do people won't do it."

Grower 5: Allan Luckman, Paengaroa

Background

Allan is the manager of three properties owned by Aronia Corporation (the majority are Auckland business investors). All three properties are within a 3 km radius of each other. The business is self sufficient aside from some early set up investment. Allan has been in the industry for nearly 30 years. He had part shares in a block and had to learn fast, then the kiwifruit crash happened and he has been managing this ever since. Allan likes innovation and thinking outside the square.

The orchards are all Green kiwifruit on pergola, but he's looking over his shoulder at Gold. They've purchased the right to transfer 4 ha to Gold, but have shelved this for the time being because of fruit losses over the last couple of years.

The business began with a 16 canopy ha block (Dominion Park), which has been in production for 20-21 years. Five years ago they bought the Longwood block as bare land, which is 11.5 canopy ha and is now having the second full crop. The first crop from this gave 1000 trays/ha, last year they produced 72,000 trays from 11.5 ha and this year they're hoping for about 100,000 trays. The third property (Greenwood) is on Gullivers Road, 5 ha, which was bought in 2007 as fully mature vines (20-30 years old). It is highly productive land that was doing 12,000 trays/ha when bought and they got that last year.

The orchards are on light sandy soils. Longwood Park is the most different. The flat areas are the same as the other two blocks, but the lower areas were Kahikatea swamp. They have put drainage in and planted it in kiwifruit because it is much easier to run the block with full rows. At the worst they will use the swamp area to create more canopy space.

Current climate challenges and responses

Frost is the biggest challenge with the climate out here. Spring frosts have been getting more frequent in the last ten years. Dominion Park had been running 20 years and never needed frost fans until the last three crops (including the current one). They were hit once by a major frost and lost about 20,000 trays over all. They have always been on the fringe with frost, but have noticed frost getting more frequent and they're getting nearer to the fringe. The cost of helicopters is too much so they now use frost fans at Dominion Park. It was a cost decision to use fans. They are much cheaper than overhead sprinklers which are better but much more expensive. The year they put in fans was the year there was another big hit, so the investment was justified. Fans are placed on the shelter line. They are less useful if there is too much shelter, so they have four large blocks with two fans covering about 6 ha each (the recommendation is for 1 fan per 4 ha). They are using natural air flows and you need big open blocks to do this.

They usually get enough winter chilling here, more than a lot of people because of their location. Down on the plains it appears that early spring temperatures are lower through the night and early mornings.

Their big focus is on dry matter production and they are doing a lot with temperature management at Dominion Park. *"We're trying to use technology to overcome some of the limiting factors. For me it's about heat and light."*

You need good spring temperatures for dry matter production. In the big block with no shelter they struggle with spring temperature due to frosts or effects of wind. The main struggles on the plains around Paengaroa are due to frost and wind.

You don't always get rainfall when you want it. They don't get as much rain as up in the hills around Te Puke. Too much rain can create problems with bud rot and also rain around pollination can be detrimental.

The Longwood block has overhead sprinklers, for irrigation and frost protection. They needed irrigation for the young plants and so decided to beef up the system for frost protection as well. The neighbour has a flow of about 200 cu m per hour. They put in a 12in bore and got 390 cu m per hour, hitting an unusually big flow of water. With this flow they can do the whole property in one go. Normally you would use valves and apply the water by blocks.

They used existing information on application rates for the water right at the Longwood block. Soil moisture is monitored by Fruition Horticulture, using a computerised system and they apply water to their recommendations. Existing information was that they needed 3-3.5 mm/day. By monitoring they found that they needed more so they got an extension to their consent. Their consent allows 5 mm/day/ha over a 6 day period. This wasn't quite enough during the recent drought. The normal allocation allows for 10 hours per week and they needed 15 hours per week (3 days at 5 hour waterings) according to Fruition. However this situation didn't appear to give any problems. The water consent allows for 12 hours of water application per day for frost protection, which theoretically should be enough.

They don't use irrigation on the two mature blocks. The jury is out as to whether irrigation is required for mature vines. The industry hasn't been able to prove that kiwifruit need irrigation. At Dominion Park they can irrigate about 4 ha out of 16 ha,

and have no difference in fruit quality if they do. There is a trial running at present to look at whether there is an economic benefit from irrigation. Maybe it won't be so dramatic if conditions get drier, because of the deep rooting of mature vines. One year it went very dry and they did have a lot of leaf die back. Kiwifruit vines have a lot of surface feeder roots so the theory is that you need a moist soil for nutrient flows to the vine. However, extremes of wetting and drying can be detrimental, as they've observed in the former swamp area.

The conventional approach to managing wind and temperature is with traditional shelter belts, but they have removed shelter so they can move air around with frost fans. Traditional shelter gives problems with shading and you can't use frost fans effectively. Every second row has artificial shelter.

They are doing a lot of work with sub-canopy shelter at the Dominion Park orchard where they get their best crop. The cloth they are using is called EXTENDAY®[5], a white cloth that was developed for use in organic orchards. It was not designed as shelter and it doesn't let air flow through. The effect they're getting is that with the air unable to move underneath the vines it tends to be deflected upwards. As well as using it as a vertical sub-canopy shelter they are laying it on the ground where it acts as a mulch and reflects light back into the canopy and raises the air temperature. The overall effect is a warmer microclimate. They lay the ground cover out in September and then roll it up in March. This cloth gives a lot to play with in terms of managing temperature. It was cheaper to put up but Allan is not sure how long it is going to work for. They are also using traditional sub-canopy green shelter around the ends of the rows which has virtually sealed the block and helps keep it warmer.

There is an industry trend towards lower vigour canes with higher vigour canes more susceptible to wind damage. They have moved to lower vigour canes through pruning

[5] See http://www.extenday.com/index.html

management (removing any canes that have vigour), with a focus on producing as many good quality fruit as possible.

Allan is always evaluating performance of their orchards. He looks at what went wrong in the previous year and what they need to do to improve things. It is easy to grow large numbers of small fruit but it gets harder to grow large numbers of big fruit.

Climate change and adaptation

"As we go to warmer temperatures you will start losing winter chill which Green definitely need."

Warmer temperatures will mean a loss of winter chill, which is important for Green. There is talk of banning HC. Green may become impossible to grow without HC and with a warmer climate. Allan would possibly look at Gold as an adaptation, but the amount that can be planted at present is capped by the industry (ZESPRI).

"We'll do what we can with the technology that we've got and if that's not enough we'll have to change variety."

EXTENDAY® is an example of a tool that can help long term. It was originally developed for organic orchards to increase flower numbers. They have one orchard heavily into this and could extend its use to the other two. They are monitoring the costs and benefits and it isn't clear yet that they are having an economic benefit from using this. But it could be a tool to help as conditions become warmer.

More or stronger spring winds could be a problem.

Increased disease problems would also be a concern. For example "Fat Trunk Syndrome" has become more noticeable in the last 5-10 years. Alan is more concerned about diseases than pests at present.

"It seems to be that each year it is getting harder to manage the climate." **(**frost, water, wind). This year was a strange one with not as much wind.

Allan's approach is to keep monitoring what they're doing and to keep doing what they can. Usually someone in the industry will find something that works. They do a lot of things differently and share the information around. He interacts with other smart growers, formally and informally by going to field days and visiting other growers.

There are two ways of looking at it. One is that you stay open and share information and usually that gives you more ideas to bounce around. The other way is to work diligently on your own and when you find a breakthrough you hold on to it and make the most of it. You are more likely to make more breakthroughs when you're sharing information. Allan is not averse to sharing information. He is inclined towards sharing information rather than keeping things to himself. His belief is that the best ideas come from sharing.

Industry issues and responses

The industry needs to be sharing more information on climate change. Most growers are struggling to get their heads above water as it is.

There need to be more field days on how to deal with a changing climate. Use a small cluster of growers to keep chipping away at things and people will start taking it on board.

To give an example, one problem the industry has at present is with labour. Allan is looking at ways of rewarding good pickers by introducing a single bin picking system. Each picker is assigned to a row. They found that faster pickers picked 17 bins in a day, slow pickers picked 8 bins. In the first year we do it, in a second year a couple of others do it and after a few years maybe ten percent of growers are doing it.

The majority of people need to see things working and the resultant benefits before they will consider changing what they do.

Grower 6: Greg Sommerville, Paengaroa

Background

Greg was a dairy farmer for 18 years in the Waikato and has been a kiwifruit grower since 2002.

He and his wife own two adjoining kiwifruit blocks and Greg manages a third. He also runs a picking gang. They have a 7.5 ha block of Gold, which was one of the first blocks ever converted to Gold, and an 8.2 ha block of Green. The latter was purchased four years ago. He also manages an 8.5ha Gold property in relatively new plantings which is across the road from their own properties.

They've had challenges with the Gold block, given that it was one of the first conversions, because the older the vines get the lower the taste levels get and consequently the lower their income gets. So they've been through radical changes in the management of this block. They have doubled the Green production since buying this property, which was previous run organically. They have planted an additional 1 ha of Green.

Current climate challenges and responses

Their properties slope towards the Kaituna River and they have unique microclimates associated with this. There are problems with frost and also some insect pest problems from a neighbouring organic property. Extreme weather events are his greatest concern at present. Frost can be monitored and managed. High winds through December to early January are the biggest concern, particularly with Gold. Even a leaf rubbing on a fruit will cause surface damage to Gold.

They don't get the sea breezes where they are and high temperatures can arise. Over the current summer he recorded 10 days with temperatures at 37ºC outside the house. His

understanding is that kiwifruit stop producing carbohydrates at 30ºC. He thinks this might be a factor in the lower fruit size from the managed orchard.

Frost is managed with wind machines. Greg has put in an extra machine, so they now have three. He's had to prune the shelter belts at ground level to assist wind flows through the orchard. The challenge is to get the right balance between wind protection and air movement for frost protection.

Ninety five percent of his properties are in mature rootstocks which go down to about 20m. They don't have an issue with the need to irrigate with the mature vines. They priced out irrigation for their young vines, but instead he made a deal with his wife to irrigate with the tractor.

He has invested $40,000 in artificial shelter for the Green orchard, for added protection against westerly winds, which knocked a lot of production in the previous year. He believes this has paid for itself in the first year. The reject rates are much lower this year because of less wind, so wind is a significant factor. Westerly winds are the big problem with Gold in late spring and early summer. Protection from wind is on-going and he will probably look at more artificial shelter. Greg is looking to convert some of the Green to Gold which probably means more intensive shelter. The idea of converting is to go alternate row cropping so he still gets some income from the remaining Green. The main reason is financial, because he can get higher returns from young Gold fruit.

Generally they can manage the climate but it is the unknowns and unpredictable things that are the issue.

Climate change and adaptation

There were two main things that Greg got from the adaptation workshops run in late 2006[6]:

1) More weather extremes, such as cyclones, winds, frosts and droughts.
2) The need to protect the rights to use underground water. If you have a water consent you go by the letter of the law to maintain your water right.

"We've already seen a situation where two growers got frosted as a direct consequence of the District Council installing two bores to take water from the Pongokawa area for urban expansion in Te Puke." The council bores were deeper than those of the growers and so they found there was no water when they went to access it for frost protection.

With situations like this he believes that the securing of water will be critical for the future. He's personally not concerned with water so long as you have mature vines which are deep rooted. At the present he can't justify the expense of putting in irrigation based on the value of the orchard.

There is a huge difference between growers who have their eye on the ball and those who do it for lifestyle. The top orchardists are getting about $80,000 per ha whereas the industry average last year was about $22,000 per ha. With costs of about $20,000/ha the returns are not good if you're at the average.

[6] See Kenny (2006)

More summer days with extreme high temperatures (greater than 30ºC) are a concern for the future. An adaptation would be to try to bring the crop forward, which they're already doing to get Early Start fruit. He is looking to use black weed mat to raise ground temperatures from the end of winter pruning to the end of the first frost period. Trials done so far indicate that this can promote harvest date by three to four weeks. He's still waiting for the result on effects on frosting. There should be less frosting with more heat radiated from the ground at night time. He's going to try this in the Green before the Gold.

Greg came into the industry with a clean sheet and no historical knowledge of growing kiwifruit and no pre-conceived ideas. He sees this as an advantage. He was able to learn and listen. Having no preconceptions he believes it makes it a lot easier for him to make decisions. His focus is to be in the upper quartile of producers.

"The upper quartile is going to come through, the middle ones will struggle and the bottom ones will go out … if current payouts continue."

"A lot of people, 90 percent, are going to put their head in the sand with climate change."

Fluctuations in the economic climate and orchard performance will strongly influence the capacity to adapt.

Industry issues and responses

He's only been in the industry for six years and this last spring with what they're doing they were having 25-30 people a week coming onto the orchard.

"People follow leaders. The followers have just got to be shown by example. It's the only way you'll get through. There have to be financial implications for people to understand."

Greg doesn't see himself as a leader, but as someone who will try something new. If you want to change anyone's opinions, ideas or management systems you hit them in the wallet. There is probably a bigger divide in this industry than any other primary industry between those who plod and take the status quo year in year out and those who are always looking to improve.

"In the past people have taken an event like Cyclone Bola as a one-off. I think we have to learn to prepare ourselves for those sorts of events coming a lot more regularly."

Grower 7: Murray McBride, Paengaroa

Background

Murray has been involved in kiwifruit growing for 20-30 years. He has had several orchards and has been involved in ownership for 17 years.

There are three main properties in Murray's operation and all are Gold kiwifruit orchards. They are all conversion of pasture land and all are within a few kilometres of each other. The home property covers 26 ha, the Coach Rd property is 43 canopy ha and there is a new development called La Vigna. They have planted 22 canopy ha here and they will have 57 canopy ha when they've finished planting.

The soil in the Paengaroa area is volcanic ash, typically with about 30cm of good topsoil then 2-3m of sandy clay and then 2-6m of raw pumice. It is great, free draining country. The pumaceous subsoil is dry, raw pumice and doesn't have the moisture holding capability of the pumice soils around Te Puke.

They currently average 13,500 trays/ha.

Murray's business is orchard development. His focus is to be smart with location and Gold kiwifruit. He has explored developments in other places, in Gisborne for example. This was partly driven by early fruit and spreading geographic risk but he decided not to because of personnel reasons. They did develop a fairly significant orchard at Te Teko and learnt about a different climate and the challenges of managing the distance. Murray believes that their current location is the ultimate for growing Gold kiwifruit. His first 15-20 years in the industry was inland from the present site, at about 130-200m above sea level, with twice the rainfall and lower summer temperatures. This site was only about 12kms away but very different. They were achieving about 20 percent less

yield because of the lower energy available in summer. They have chosen what they believe is the best location. Future developments are more likely to happen in this area.

Current climate challenges and responses

The climate is fantastic for living and for what they're trying to do. It is ideal for kiwifruit production. They have cooler winters, by up to 5ºC, than the surrounding hills and thus more winter chilling. This is the result of their greater exposure and cool air drainage from the hills. They have been experiencing more weather extremes in recent years. In the last five years they have experience two to three 1 in 100 yr frost events in the August to November period. More hail has been observed in the last few years.

They have automated systems to monitor rainfall and temperature in all three orchards. Relatively small local climate changes can have significant effects on productivity. Murray believes that ideally they need warm springs, cool summers, and warm autumns for high taste fruit. Warmer spring and autumns would be beneficial

Water

Current rainfall is about 1200 to 1500mm. Periods of low rainfall are not a problem now with irrigation in all of the orchards. They're using sprinklers that can be moved above the canopy for frost and below the canopy for irrigation and believe that their system is efficient. Using the sprinklers under the canopy for irrigation gives widespread coverage with water on ground and is better for plant productivity. The plants love a humid environment under the canopy. They have used a computerised system in the past to monitor water but now use a manual system through the growing season from September to March/April. In the last season they have halved their water use with their manual system, even with a very dry summer. This system involves observation of key plants in the orchard and also digging to 600-700mm, which is where the feeder roots are. They grab a handful of soil and squeeze it, if it maintains shape it's okay. The water demand of kiwifruit vines change as they mature. They're still learning the requirements of the Gold plants in this regard.

While they can offset water shortages or avoid frost damage with their irrigation system there is a big concern with current and future access to ground water in this area. Their core business is developing properties and key things are land and water availability. It is getting more difficult to develop new properties because of water allocation issues. At present they have a ten year consent on the home property but no consent on the other two properties. This creates a lot of uncertainty. At the same time there is now tension with urban use of the ground water in this rural area. The District Council have put in two large bores for town supply to Te Puke and Papamoa. Murray has questions and concerns about the decision making process and the information that is been used by the regional council. There doesn't seem to be a clear understanding of the balance between what is being taken out and what is going back in through irrigation and frost control, nor of the groundwater resource itself. There is a review underway at present by the Regional Council but Murray has experienced frustration and delays with this process[7]. He would like to be more engaged with the council and has offered to share information that they have gathered from their bores and others from up to 5km away. From their own monitoring they are becoming more and more confident about the water

[7] According to Environment Bay of Plenty there has recently been work done, by GNS, on the groundwater resource in the Paengaroa area. The draft report is currently being peer reviewed, but it is not clear when this report will be publicly available.

that is there. Murray's concern is that we have this fantastic resource and wants to make best use of it, but not to impact negatively.

Because of the uncertainties with water they have invested a lot in water storage on their two new properties and thus are doing what they can to create buffering for times of water shortage. In both cases the land has been contoured to capture at least 90 percent of the runoff into large storage ponds. On Coach Rd they have put in two 12 inch bores and two storage ponds. They are capturing 5-10,000 cubic metres of water in both ponds. On the new property they will have about 15,000 cubic metres of storage capacity. These pond systems are all designed for continual delivery of water in a frost event. The surrounds of the ponds have been planted in natives with a goal of creating an aesthetically pleasing environment for people as well as providing water security.

Temperature

Temperature is a big deal for them. They need a cool winter to set the crop and a warm growing season to develop the crop. There is a problem with HC use, given its unpopularity. HC is very important for breaking dormancy to get flowers and also for the concentration of flowering to get a consistent line of fruit. It is also important in terms of the timing for beehives for pollination. With HC a really good tight flowering would be spread over about five days, whereas in organics flowering can spread over three weeks. A greater spread of flowering creates problems with fruit sizing, with the fruit from late flowers struggling to compete with those from early ones.

The industry focus on late frost has been enhanced by the presence of Gold, which breaks bud about six weeks earlier than Green. They introduced overhead sprinklers after the first hard frost and have moved from a pulsing to a continual delivery system. They need about 30,000 litres of water per ha per hour to fight frost.

With the Gold harvest beginning in March, with higher temperatures, they are at risk from post harvest heating of fruit in bins. As part of their risk management they are using round hay barns, on concrete pads, which are a perfect place to store fruit out of sun and rain.

Wind

This is a big climatic challenge as well. They can lose 10-20 percent of the crop in a matter of hours with winds of 70-100km/hr in the November to January period. Given their hairless skin and tendency for fruit to cluster together, Gold kiwifruit are much more prone to wind damage than Green. The wind rub is only surface damage but consumers' link surface blemish to internal rot. The principle management tool for wind is shelter.

They are presently running a small trial with an overhead shelter system. A number of growers are now using this. It is a permanent structure. The overhead shelter reduces radiation by about ten percent, which doesn't appear to have an economic impact on the crop. They thought they were marginal with sunshine hours but are okay. There is some debate about the effect of white cloth on light quality. HortResearch did some work in the past using black cloth which wasn't so successful. Growers are trialling different colour cloths (yellows and reds). The Italians are much further ahead, managing vast areas with overhead shelter mainly for hail protection. Locally overhead shelter provides wind, hail and bird protection.

Management

They have covered most bases in terms of managing climate risks with available management tools. Murray has become more philosophical about the bad things that have happened**.** *"Most of our greatest innovations have come out of our biggest disasters."* They lost 60,000 trays with a big frost but great things came out of it. Everything is being managed towards consistent production of a high value product

from one year to next. The challenge is to produce consistency in the face of variability. You only really get paid for Class 1 trays with premiums attached. For a large operation like theirs it helps to be growing only one variety.

They endeavour to run a conservative model with risk management on debt. Property values and interest rates are a challenge. Many growers have come out of other sectors. You can't drive cash flow like a dairy farm. With kiwifruit you can lose 20 percent of your crop in one night and need to be prepared for such possibilities. Frost insurance has been wiped from the industry. Three to four years ago growers voted against retaining frost insurance, driven partly by increased premiums. Instead they chose to invest the money into frost fighting. There is also an in-house focus on hail with a fund managed through ZESPRI.

Biennial cropping

They have made some very significant changes with their management practices, in particular through the development and trialling of a biennial cropping system. This change has come about from a desire to meet ZESPRI goals of taste and also to reduce labour costs. They are driving almost 50 percent of labour costs (normally about $7000/ha) out of the management system. At the same time they are achieving high yields of higher tasting and high grade fruit. This hasn't been done primarily because of climate change but Murray believes it will have spin off benefits. The idea came from a frost disaster in about 2002. With this system they are doubling up the number of female vines, planting to 1080 plants per hectare. They have achieved this by going away from the ribbon male system (alternative rows of males and females) and planting the male rows with female vines. They now have male vines planted across the rows with the same balance of canopy cover (90 percent female, 10 percent male). With this system they have alternate fruiting rows and alternate rows that are rested from production to grow replacement canes for the next season. The rested vines are cut back to the trunk after harvest to reinvigorate the plants, similar to what is done with grape vines. Under a normal vine management system the replacement canes are competing with the developing fruit for available energy. With the biennial system the vines that are fruiting no longer have the added work of producing replacement canes and can concentrate their energy on the fruit. Murray believes it is a hugely exciting system. They trialled the system for about three years and converted all of the orchard two years ago. Murray believes in time this system will revolutionise growing on large orchards. He calls this 'paint by numbers' growing. By separating fruit and replacement canes, plant and workers only have to think about one thing. The exciting thing from a climate point of view is that he believes that they can operate successfully under this system without HC. It is on the agenda for the next season to trial a block without HC application. Because the plants energy on the rest vines is focused only on canopy development then they are ready to go for fruit production in the following season. The canes are very fruitful. There is greater risk of wind and hail damage with this system, with a thinning canopy on fruiting vines and smaller leaves. They are looking at overhead protection because of this.

Staff

Their orchard managers are constantly trialling systems. In the last season one manager has run about six trials with different management adjustments. Their focus on quality translates to people. Part of their strategy has been to invite their managers to invest in the business. Murray believes that they can go forward better personally and the business will succeed more with the managers being engaged in this way. This

approach was initiated about three years ago, partly driven by one of the managers wanting a stake in the business and partly by Murray's desire to see young guys succeed. Murray likes to think he is flexible and adaptable. He wants managers to be empowered from a strategic point of view to effect change in their systems. *"They will drive more change if they are engaged and excited with what they are doing."* Plenty of his contemporaries have challenged Murray on this approach. There are some challenges with giving the managers a stake in the business but it certainly has an upside. He could see an immediate change in them and it has taken a lot of the load off Murray.

Climate change and adaptation

Murray is certainly concerned with what might arise with climate change in the future. He has been focused for 5-6 years on the possibility that they will be faced with more extremes in future and this has affected their business. A key thing that Murray got from the previous discussion days on adaptation (November 06 workshops[8]) was that he was really impressed with the fact that they could have a discussion on adaptation and that it inspired them to think a lot more about it**.** *"Previously we were thinking about those aspects, but bogged down with all of the negatives that the sky is falling and the whole focus and emphasis on managing carbon. We need the motivation to focus on adaptation."* He can get his head around adaptation, can see the opportunities more clearly and the fact that other bright people are thinking about it with them.

His biggest concern is with changes in extreme events. They have already experienced more extremes and are expecting to see more of the same. Hail and wind are the major concerns for the future. Late hail is very rare, but can break the skin and rot the fruit. Hail events are more likely to be early in spring when the fruit can heal.

[8] See Kenny (2006)

In terms of the expectation that temperatures may rise, most growers see it as a positive apart from winter. It would be nice to think there would be less frost risk. He believes that his biennial system will work with a warmer climate.

Water is a significant concern. They have been out there with developments and have been criticised for taking undue risk but have a strong desire to grow and develop. The last farm they took over had been in one family for 99 years. Water is one of those things they have to deal with and are presently struggling to move things forward because of the current moratorium. At present they are in a vulnerable situation with no long-term guarantee of access to groundwater. Murray would like to see Environment Bay of Plenty complete their review and set some workable ground rules. There needs to be a clear understanding of the aquifers.

He is a bit concerned about the potential for existing pests becoming more of an issue, or for new pests to emerge.

For wind protection they are mainly using artificial shelter and can make it closer or taller if there is more wind. Their new developments are moving to larger blocks with artificial shelter with structures in place that will merge with an overhead canopy system if they move into that.

They are taking the potential for sea-level rise seriously and are conscious of staying away from coastal sites with the potential for salt water intrusion. Their current location is 10km from the coast. They have had orchards that are 4-5m above sea level.

Industry issues and responses

"Too many growers are focused on tradition rather than how we can create the future." It would be healthy to get growers together and learning from each other about how we can adapt.

Murray and his staff see HortResearch people quite regularly. His managers are in contact with someone from HortResearch almost on a weekly basis. He values local scientists, who visit their orchard at least twice a year. Murray also recognises the need for growers to engage with each other. He believes in sharing and learning from others. However, if they had another significant idea to give them an edge they probably wouldn't share it widely. They shared the biennial system and Murray found a lot of conservative responses. Since then he has deliberately stood back, trying to lower their profile a bit. The classic scenario is that ZESPRI says it wants something for the market, they or other innovative growers develop solutions on their orchard, then others jump in and the premium disappears. He is happy to be completely open with other innovative growers.

How do we make positive use of Murray's leadership? Things happen from interacting with people. The biggest thing that impacts on most growers is their lack of getting out. In early February he and his managers went out to visit the six highest performing growers that they know of in this region. Ninety-five percent of growers are stuck within their orchards and constrain themselves. He doesn't know how to change that.

He believes that the kiwifruit industry has the structure to manage adaptation. *"Adaptation at the end of the day is more likely to be a voluntary situation … unless the economic connection is made."* The C footprint is likely to be more regulated.

Grower 8: Paul Jones, Tauranga/Paengaroa

Background

Paul has been involved in the kiwifruit industry for nearly 20 years as a grower and manager. Currently he is both a grower and a partner in Direct Management Services (DMS). As a grower Paul and his wife run a total of 25 canopy ha of Green on two properties at Paengaroa and have interests in other orchards as well. DMS is an integrated company that is involved in orchard management and also runs a post-harvest operation for kiwifruit and avocados. He is operations manager in DMS and is in charge of the orchard management division running about 350 ha of orchards which are a mix of Green and Gold. The company also runs a post-harvest operation with packhouses on four sites in the Bay of Plenty. They're seeking to pack 6-6.5 million trays of kiwifruit in 2008.

Current climate challenges and responses

As growers they have seen the climate change over the years. They're not getting the winter chill that they used to. Last year aside they're getting more spring frosts. The whole climate is getting a bit later. The winter season has shifted and the harvest season is warmer than in the past with fruit growth continuing later in the season than it used to. He has been told that the average temperature in May in Te Puke is now 5ºC[9] warmer than in the 1980s when some of the coolstores were first built. The design specifications of these early coolstores are not adequate to cope with current conditions. They won't cool as many pallets per day as they were originally designed for because of the higher field heat in the fruit.

[9] There may be a decimal error in this statement. A more realistic figure would be a 0.5ºC increase, which is more consistent with the observed changes presented in Part 1 of the main report.

The increase in spring frost risk is another big change. They have experienced more fruit loss to frost in the last five years than in the preceding ten years.

The fruit are definitely growing further into the autumn and its not hardening off the same which affects fruit storage. With more field heat from harvest you have to exert more energy to get the fruit down to 0ºC. It's a big difference if the fruit start at 17ºC as against 14ºC.

Not all of the changes are negative. Ideally you want a warm spring and a warm December. They're not seeing a warmer December as yet. Ideal conditions for kiwifruit are: plenty of winter chill, high temperatures post budburst, summer can be as hot as it likes, cold nights in autumn to harden the fruit and stop them growing. Some of these things we're getting and some we're not.

HC is the primary management tool to deal with warm winters and low chilling. There are environmental reasons why you'd prefer not to have to use it. In terms of spring temperatures it's all about shelter and how you can stop the cold winds blowing through. In summer there's not a lot you can do. They don't irrigate vines much and they don't seem to need it. Even in the most recent dry season most orchards have coped very well without irrigation. There are some vines on shallower soils that are suffering from the combination of hotter weather and less rainfall this summer (2007/08), but the majority are not. Most affected are the sandy pumice soils of Pongakawa and further east. Paengaroa, central Te Puke and Tauranga are all fine. In fact the trial work that has been done hasn't been able to find a positive impact from applying irrigation to mature vines. If you're establishing a young orchard it definitely needs water in the early years. They're not a big water user and Paul doesn't anticipate using more water than now although there is a certain limit of dryness where it would be necessary. *"It's not called the Bay of Plenty for nothing, we seem to get enough rainfall to get by."*

People are trialling things like reflective cloth, as is being done by Allan Luckman (Grower 5) who they're involved with. This sort of innovation hasn't had a great uptake because it is very expensive. In terms of post-harvest, coolstores built within the last five years are designed to a higher specification than in the early 80s. The industry is far more conscious of load plans and design.

The last two years for Green have been the worst storing years ever. Other factors have come into that, but there is a certain amount of fruit physiology knowledge that says if fruit is still growing rapidly at the time of harvest it is less likely to store well because the fruit haven't had the hardening off on the vines. Coming into harvest (April/May) you want a big diurnal variation in temperature with cool nights to harden the fruit. They haven't been getting this in recent years and he believes that this has contributed to less robust fruit. After harvest you can alter some things such as the way in which you cure the fruit and how long you do it for. For example some are putting Gold into coolstores in bins before packing. There are other reasons for doing this than for packing. They'd rather have the fruit coming in at 10ºC rather than 20ºC and it would store better if it did.

Over the years the industry has gone from very intensive shelter to more open blocks over time. We've probably reached the limited of that now and in some cases some blocks are too open now. The shift to less shelter has been driven by the need for

balance between warmth and light. The detrimental effects are shading and competition for water and nutrient. Ideally you want a lot of shelter in the spring when you want to heat the orchard up and minimum shelter in the summer. The ideal would be to have adjustable shelter so that you could tailor it for different requirements through the growing season. The reason that you want less shelter in summer is that there is some evidence of higher dry matter with more open blocks because there is more light and the wind blowing across has benefits. With air movement the plants respire more and lose more water. This past season (2007/08) they've had a warm spring and good summer which have been theoretically good for dry matter.

Water is not an issue in this region. If you're behind in some period of the year there will be a catch up. So far there is enough water in the central growing region.

Climate change and adaptation

In the Bay of Plenty there is a safety margin with the current rainfall amount. The longest we tend to go without any rainfall at all is about a month. It's not unusual for all of January or all of February to be without rain. To go two months with no rainfall is unusual and they haven't even had that with the recent dry summer.

It would be a concern if there is an increased frequency of storm events and north-easterly weather events.

Increased temperatures will increase reliance on HC or some alternative to get the flower numbers. An extra couple of degrees for the rest of the year would be beneficial, although it would be preferable to be cooling off at the harvest period. The big challenges therefore will be lack of chill and hotter conditions at harvest time. In terms of actually growing the fruit an average increase of 2ºC would be good. Kerikeri currently has warmer conditions and Paul doesn't see any major problems with growing the fruit if it becomes that warm in the Bay of Plenty.

"If the average temperature went up 2ºC it's not going to make too much difference to the industry. We'd use more energy in the coolstores to get the heat out of the fruit. In terms of growing the fruit I don't see a problem. It's fairly broad brush. There might be times with that extra 2ºC, there may be certain months, when there'll be a whole bunch of effects that we hadn't foreseen. Possibly pest pressure might be one of those."

There is some evidence already of pests that are doing better with warmer weather.

Industry issues and responses

Paul is confident that the innovative capacity of the industry will carry it into the future. New varieties are very important, which ZESPRI already have a huge focus on. Tolerance of warmer winters would be a desirable attribute in evaluating a new variety.

Transport and fuel costs obviously are of concern. *"We haven't been able to develop too many methods for reducing energy usage, but innovation will happen as costs of energy increase."*

Paul is not particularly concerned about water. Most of the orchards they manage only use water for spraying. If you don't have it you don't use it. Ninety five percent of orchards that they currently manage don't have or don't need irrigation. If you've got it, as some do, you'll use it. Yields are presently increasing, not decreasing, in the

absence of irrigation. This is being motivated by cleverer growing techniques and lower payouts per tray.

Paul is not particularly concerned about water amounts but is concerned about water allocation. If you try to get a water consent to draw water you may not get it. Part of the problem in an area like Paengaroa is that the council put in a massive water scheme for household use. Where a council needs water for household use then the orchardist is going to lose out. This will affect the future likelihood of a kiwifruit orchardist getting a right to use water. The other thing about water is that you can store it above ground, for example in dams.

There is another branch of all of this around the C issue. The industry needs to simplify itself to reduce its C footprint. We have expensive packaging and other things that could all be simplified.

Grower 9: Peter Ombler, Welcome Bay

Background

Peter is a grower and an Innovation Director at ZESPRI. The gross size of the property is 12.1 hectares. They've been there for 21 years and pretty much developed the property from scratch. They have 5.3 canopy ha in kiwifruit, 2.4 ha of organic Green, 2.1 ha of conventional Green and 0.8 ha of conventional Gold.

They also have some organic plums and avocados (most of the latter have been removed recently from an approx 1 ha block) and a planting of Tasmanian Blackwood timber trees. So they have quite a diverse property.

They're making some substantial changes this year. Most of the avocados have been removed and they are replanting the avocado block in Gold kiwifruit on a trial rootstock. They're totally enclosing it in artificial shelter to protect it from frost and wind. This development will more than double the area planted in Gold. They will then have about 6.1-6.2 ha of kiwifruit.

It is becoming increasingly difficult to reliably grow a good crop of organic Green kiwifruit because of the lack of winter chill. Peter was contemplating taking the organic Green out of certification for this reason but has since decided to keep his organic block.

The soil type is a pumaceous sandy loam with good moist subsoil. It is a fantastic soil, like potting mix. With kiwifruit it would have to be remarkably dry for a very long time for the vines to be affected. The vines were unaffected in the current dry summer.

Current climate challenges and responses

Fundamentally things are happening when they shouldn't. It is supposed to be cold in winter and warm in spring. Increasingly they're having mild winters with cool spring periods. This is not a good combination for plants, particularly kiwifruit. Kiwifruit need proper winter chilling in order to break dormancy for the following spring. If they don't get enough chill the plants are confused. Cold weather in spring further delays budburst and growth.

They have had to put in frost protection on the Gold, at a cost of about $30,000. They have installed overhead sprinklers for this purpose. They haven't been hit by frost yet but Peter believes that sooner or later it's going to happen. The planned overhead shelter for the new Gold block is partly for protection from wind, but also for hail protection and there may also be benefits in terms of frost protection.

There have been more isolated, random weather events particularly in the spring and early summer. *"We can't honestly say we're safe from frost until mid November and from hail who knows."*

Things are happening out of sequence and it's generally more chaotic. There has been a general trend in the last decade, but things have been more marked in the last five years. More often in the last five years there has been inadequate chilling to break dormancy properly. The problems with spring frost go back as early as 1994 when there was a substantial event (19 November). A lot of the big frost protection systems went in as a response to that.

We've always had wind. There have been less of the tropical cyclone events in recent years. Dealing with wind is part of being in New Zealand.

In the new block, it's much cheaper to put in overhead shelter with a bare paddock, than once the vines are established. So they're taking the opportunity. You can never say you'll have a guaranteed crop but in this particularly situation this block should produce consistently from year to year. The planned protection for this block is more a function of the variety they're growing and the risks around that, in particular to wind and frost, than a direct response to the more chaotic weather. However Peter is mindful of the more chaotic, random weather events.

As an aside their family goes skiing and they're noting that there is now less snow in July than in September. This is paralleling the situation they're experiencing with cooler weather in early spring in the orchard.

Peter doesn't share the same view as some others regarding irrigation and doesn't irrigate. Kiwifruit is a deep rooted plant. It is ideal to have regular rainfall every 2 weeks, but the mature vines can cope with long dry periods. You'd expect fruit quality and size to be the main casualties of a dry year and yet they have just had one of the driest summers on record and the biggest fruit profile he can ever remember this year. If irrigation is important to grow kiwifruit then the two don't match up based on this experience. Irrigation is necessary to establish new vines.

The main thing you can do for dry matter accumulation is to harvest light. So you manage the canopy to achieve this. You want to manage the plant to send as much dry matter as possible to the developing fruit. Warmth is also a factor so block size and

location all come into play. Peter doesn't believe that in the Bay of Plenty that you need water.

The challenge is getting the balance between shelter for wind protection and less shelter to get as much light as possible into the orchard. With overhead shelter there is some light loss but increased temperature and anecdotally it appears there is no downside in terms of dry matter and maybe an upside.

One of the goals with new rootstocks being trialled is better fruit attributes including higher dry matter. The kiwifruit industry is miles behind apples in terms of rootstocks. *"Change is usually driven by necessity and maybe there hasn't been a necessity until now to have a focus [on rootstock development]."*

"We're also living in a world where our markets want less and less chemical input and they also want fewer pests. There are conflicting demands constantly from phytosanitary requirements and chemical residue requirements and so ultimately you have to think you're on a collision course if you do nothing. We need to be proactive with issues like this to ensure we don't collide."

Climate has a role to play with these issues. For example, passion vine hopper is a problem in the industry. They used to have control with synthetic pyrethroids which are now banned. In warm years like this passion vine hopper, which enjoys the heat, is much worse so we're going to have much higher rejects from sooty mould, which results from this pest. Another example is cicadas, which are increasing dramatically in some orchards with no current control. This increase may well be temperature related.
"Climate change could be affecting our business in terms of insect control and our ability to respond given the confliction of this increasing awareness of chemical residues on fruit."

Different production and management systems work well at different scales. The McBride biennial bearing system (see Grower 7) is a very smart 'painting by numbers system' for a large area. Peter's focus is on a well run conventional horticultural system, with continual fine tuning. Accuracy is important for this sort of operation.

Climate change and adaptation

The main threat for kiwifruit is warmer winters, which will particularly impact on Green. Green is increasingly reliant on bud breaking chemicals such as HC. At the moment HC is critically important to a lot of orchardists. As with the situation with insect control the management tools are there but are increasingly under pressure and it is important to be proactive. HC will become less effective with warmer winters. It is still useful in Kerikeri, but there is still a combination of HC and some winter chill that makes the whole plant response better. You can assume that as time goes on Green production will be more challenging. Gold is less risky in terms of winter chill and will be less affected because of its natural propensity to flower.

The randomness of weather events will always be a problem. If you've got early spring growth and cool weather around that then you've got a problem. As it has got warmer over the last ten years there has been more uncertainty with the spring weather. The average spring temperature now is quite different from ten years ago. This has hit the radar more because of the presence of Gold, which breaks bud about four to five weeks earlier.

We can't even foresee or predict some of the pest pressures. Peter believes it is a matter of time before a major pest comes in, particularly if they develop an international airport at Tauranga. The big issue with pests is with biosecurity with pressures from a more mobile population and imports of potential threats. These sorts of pressures and associated risks will be exacerbated by climate change.

There will be some opportunities:

- ZEPSRI has a substantial plant breeding programme which may bring new varieties and rootstocks that are more suitable for a warmer climate.
- Fruit size is substantially bigger this year than we've almost ever had in response to a warm, dry summer
- Dry matter is good this year and we know that it is affected by temperature. So fruit quality will potentially be better with climate change.
- There may be opportunities in terms of marketing the C footprint of the industry.
- There are bound to be opportunities for us with a stronger environmental focus. They may be very valuable in protecting market share.

Part of the plant breeding programme is happening in Kerikeri, which could have benefits in terms of new varieties for a warmer climate in the Bay of Plenty. But it's a slow process. It may take 20 years for commercial release.

For the future Peter believes he doesn't have enough Gold. *"You can be a blind man and still see that Gold has potentially a better commercial future than Green."* He still has 60-70 percent of his orchard in Green, which doesn't make commercial sense. Over time he will probably consider changing from Green to new varieties that may be more user friendly in a warmer climate, which may not necessarily be Gold. It may be another five years before a new variety comes in.

Industry issues and responses

Peter believes there is a need for the industry to be proactive in looking at risks associated with climate change. There is a marketing opportunity. We need to link science with marketing. In this sense we need to be collating data on how good we are and package the information effectively as a marketing tool.

"We need as much information as we can to be both proactive and able to defend ourselves when necessary."

The food miles issue, which has been in the news recently, is a great example of why we need to be proactive.

You need to be able to predict where things are going and be in front of it. What needs to happen from this current work is a summary report, with common themes picked out. From this put together a coherent picture of issues from growers and then take it to ZESPRI to look at risks and opportunities. Then ask *'where are we going and where are you going in terms of your planning to ensure that these risks are mitigated and these opportunities are maximised?'*

The key areas are:

- Plant breeding
- Crop protection
- Marketing – risk mitigation and opportunities to increase market share

"We need to, as best we can, maximise the opportunities as quickly as possible. The good thing with the single desk is that we are all under one roof. We can have a united approach and make claims as an industry with a bit of solid science that our competitors probably can't." It is very important that there is a united approach.

Ultimately *"Growers do as you pay, not as you say"*. Growers by in large won't react to things unless there is a dollar benefit. Growers need to see opportunities and dollar benefits and put their ideas into the melting pot with ZESPRI to develop a strategy. If there are opportunities then ZESPRI needs to develop a package deal to incentivise growers to respond. It's what has been done with dry matter, pest free status, packing fruit to export standard, fruit size. The cake is getting smaller because of the current exchange rate situation. There are some very desperate growers at present because of the exchange rate. People under pressure can make irrational decisions.

The Government has a critical role in protecting the kiwifruit industry. Peter is concerned at the potential for the ZESPRI single desk to be used as a trading chip at WTO talks.

"I'm guilty, as I believe most people are, in that I have a passion for the welfare of the globe and the welfare of the environment. I do what I can on my little patch here to contribute to that but my fundamental driver is commercial success. I'll do what I can to be as responsible as possible, but I'm not going to go broke doing it. What that means in terms of ZESPRI's position is that if they want me to behave in certain way then they have to send the appropriate commercial drivers to adjust my behaviour."

ZESPRI have to send the appropriate signals and there needs to be solid backing from the Government.

"New Zealand has a great opportunity, because we have this loose tag of a clean green image, a lot of which isn't accurate, but why don't we use it. Why don't we make ourselves such that we can use. It's a great opportunity for us."

Grower 10: Allan Dawson, Katikati

Background

Allan graduated from Massey University in 1972 with a BAgSc. He was a MAF farm advisory officer, predominantly in the Waikato, for some years before coming to the Bay of Plenty in the late 1970s. They bought and developed some bare land into a kiwifruit orchard in 1979 and subsequently began developing a post-harvest facility, primarily for their own use and immediate neighbours.

Having been in the industry for 30 years he has weathered the ups and downs and the evolution of the industry. Throughout this time he has continued to develop the orchard and post-harvest businesses.

They own four orchards, with a mix of Green and Gold and a total of 18 canopy ha. These properties are in the Katikati locale, spread from Athenree through to Wright Road. They don't encompass the extremes of climate that they pack for, tending to be early to mid harvesting. One is a coastal property and is quite warm. Another is at about 80m elevation and has more wind exposure.

The post-harvest business, Aongatete, will be packing out a bit over 3.5 million trays of Green and Gold fruit last year. This business is continuing to expand quietly.

Current climate challenges and responses

Autumns are now warmer for longer, winter is later and springs are more variable and are subject to later frost. These can affect Gold in particular. This change has become more noticeable since 2000, particularly over the last five to six years. Allan isn't sure if this is a short-term phenomenon or not but in the 80s there were much more clearly defined seasons. This shift in climate to more variable springs and out of season frosts has prompted more frost protection.

Orchard
In the early days it was thought that water was reasonably important for vine establishment but it wasn't considered to be critical for mature kiwifruit. The early experience from Te Puke was that water was not important later on, although the soil types there are very different from Katikati. Most of the early irrigation was from bores, some from surface water, and almost all used trickle irrigation technology.

With the introduction of Gold in the late 90s there has been more awareness of certain climate challenges. Budbreak is about a month earlier which makes it more prone to frost than Green, so growers are more conscious of the need for frost control. Gold has been a spark for the stronger focus on frost protection, but Green has historically been at risk from frost at both ends of the season. *"In the early 80s I can clearly remember damage to fruit on the vines in May from frost. We don't see that much now."* The increased awareness of late frost risk has translated over to Green. There is now a shift to overhead sprinkler systems for frost control, which is regarded as the most reliable form of frost protection.

Overhead sprinklers serve two purposes:

1) Frost protection. Other options for frost protection include wind machines and other possibilities. Frost risk is not just associated with bud break. They are getting some damage into November and even December on Gold. There is a reasonable supply of water from the ground through bores and from surface water takes in some cases. Some growers are building reservoirs for storage.
2) Irrigation. Having a system that can be used for dry summer irrigation is an added bonus.

They irrigated their orchards over the last summer but not in the previous summer because it wasn't needed. You have to look at the soil type and microclimate to determine whether summer irrigation is needed. Superimposed is the proximity to ranges, with an almost doubling of rainfall from the coast to the ranges. Good soil types, such as in Te Puke, will support mature vines without the need for irrigation. In the Katikati area the soils are older ash, shallower and there has been contouring. As a result irrigation is more critical. Local knowledge and experience determines need.

When they started growing their biggest fear on the orchards was wind, with channelling of the wind over the Kaimai Ranges in the Katikati area. They went to a lot of trouble of planting shelter, to the extent of significantly over sheltering, mainly using hybrid willows and some artificial shelter. They subsequently learnt about the effects of shading on kiwifruit production. Kiwifruit is very sensitive to shading and temperature, and so there is a need to get a balance between light and warmth in the orchard. Subsequently orchards have developed to a situation of less shelter. This has perhaps partly been a result of modification of the climate in the area (mesoclimate) with more orchard development (more surface roughness). There don't seem to have been the storms that they've had in the past. There has also been a change in growing structures, from T-bars to the pergola system, which gives more crop protection. All of these factors have led to less of a problem with fruit rub than in the past.

Postharvest
"My picture of harvesting kiwifruit and packing it in the 80s is that it was quite bitterly cold then and you had your jerseys on in the packhouse and you were rubbing your

hands at smoko. Now we've got half the time when it's too hot in the tea room for the workers."

The packing season for Green used to start on the 1 May then with the introduction of brix testing (with a 6.2 brix threshold) the season started around 7-10 May. Now these brix levels are being reached earlier and they're getting a significantly longer packing season through a combination of modified brix standards from the industry and milder autumns. This has a positive effect for post-harvest operations which are able to spread the use of their expensive machinery. The post-harvest facility has not had to expand quite as rapidly as it might have as it has been able to cope with the bigger window. It has made other adaptations such as the introduction of controlled atmosphere storage so the fruit doesn't have to all be packed at once. The main season for packing is now ten weeks whereas ten years ago it was five weeks. So far this season (as of 1 April 2008) they had already packed 0.25 million trays.

When you look at these changes people look at practices such as girdling, which are aimed at getting high dry matter fruit earlier in the season. Notwithstanding these sort of practices that bring harvest forward we're definitely warmer in the autumns over the last five to ten years and don't seem to get our winter chilling until later.

Field heat was a problem two seasons ago (in 2006) with very high fruit loss. Certainly warmer autumn conditions were a factor. There was a combination of a lot of crop, warm temperatures and wet weather leading to high humidity. A lot of post-harvest facilities weren't geared up to deal with such big volumes of fruit either for packing or going into cool stores and some cool stores weren't able to cope.

Post harvest you ideally want a period of curing. This is associated with a slight weight loss in the fruit at this time and healing of the picking scar. This period of curing gives a better storage life. Under a well ventilated, covered, curing system you get a lot of

effect in the first 24 hours and some effect over the next couple of days. So a couple of days of curing are a good compromise. In 2006 there were situations where the fruit were taken into curing areas that were inadequately ventilated. Post harvest operators are now giving more attention to curing areas.

There is also more emphasis on other things such as prevention of damage at picking, focusing on the quality of the pickers and the type of picking bag. Any damage is exacerbated by the higher temperatures we're operating in. Post harvest starts in the field and goes through all stages to curing areas then to the packhouse. With Early Start some liberties are taken because of the speed to the market compared to packing for longer term storage.

At a slightly higher temperature you get quicker development of scar tissue. It's not critical to have it cold at harvest. The ideal is a moderate temperature for curing, of about 10-14ºC (max daily of about 18 ºC). It wasn't uncommon in the 80s to have 13 ºC days at harvest time, which they don't experience now.

Climate change and adaptation

Allan's understanding is that the Bay of Plenty won't be as drastically affected as other parts of New Zealand. He sees both positives and negatives with climate change. Kiwifruit is a warm temperate to sub-tropical fruit and likes it warm, and Gold likes it warmer than Green.

Allan expects ZESPRI and HortResearch to develop new varieties that will be adapted to a warmer climate. A warmer climate with more CO_2, and if water is unlimited, will mean higher photosynthesis and higher yields.

On the negative side Green has a definite chilling requirement and HC does have a limited life. There are some alternatives to HC that look moderately promising and we can take some leads from organic growers. So not having HC would not be a complete disaster although its removal without a reliable substitute would have immediate impacts. In Kerikeri they have gone more to Gold which is an indicator of what could happen over time in the Bay of Plenty.

There will be insect and pest management changes. Allan's feeling is that the industry has taken its eyes off the ball with pest management. Fifteen years ago they had integrated pest management which was a shock to growers at the time. He believes the industry has tended to lean on that for the last 15 years without making significant improvements. *"What we should be doing is moving towards a more organic type approach because of the market requirements. If we don't keep our market position we're not going to be growing kiwifruit anyway."*

There have been bigger crops in the last few years (both total and packed yield). Is this the result of better management and/or the climate? Once you get big crops then size becomes critical. This didn't matter so much in the past when you'd be harvesting 5000 trays/ha and the fruit would size up alright. A lot of tools are being used to increase fruit size and quality, the most notable being BENEFIT on Gold and things like girdling after flowering (cane or trunk), which gives a similar result.

If rainfall becomes more variable in future and possibly more droughts then irrigation will become increasingly critical. There are already increasing demands for water for frost protection and irrigation. Sustainability of water is a big issue.

"The water quality and the sustainability of numerous small bores is a concern. I see that as something we're going to have to plan and manage extremely well. This is not just an orchard, kiwifruit industry, or Bay of Plenty issue, It's actually the whole of New Zealand. Water is going to be a critical component. We're going to have to be very wise and very well planned in our use of it."

Other issues around water include risks of salt water intrusion in coastal areas and the encroachment of the urban population into rural areas, including lifestyle people.

Industry issues and responses

There is a need for the industry to focus more on environmental awareness. Allan believes that dairying is setting a bad example with N-fertiliser use and C mining. *"Nutrient enrichment of all our water sources is an urgent problem because of the time taken for nutrients to work their way through the system. Dairy cows are significant polluters because (among other reasons) of the soils inability to retain all the urine nutrients which are subsequently leached into the ground water, rivers, lakes etc***."** This is not to ignore, for example, the effects of runoff from kiwifruit orchards.

We need to be conscious of the need for total efficiency. "*If we want to be smart … and we have to be smart to sell our kiwifruit and all our produce to the world, it's got to be the best so we continue to get the best price. The organic system is a model that we could be looking at as an example that gets us to the end point. We need to study organic and biological systems with a view to evolving sustainable systems. The world markets are increasingly demanding sustainable methods producing healthy food."*

The post-harvest system has become more complex and more costly. There is a need simplify things. For example we put labels on the fruit which is part of our branding. They have now become an unnecessary expense and an environmental hazard. If we had a product that met all of the sustainability criteria then we could promote fruit without labels as the "green way". Our competitors are manufacturing ZESPRI labels anyway and putting them on lookalike fruit. ZESPRI has done a brilliant job with branding, but it's time to move forward.

This sort of focus is getting towards a practical application of adaptation within a wider sustainability picture. In Allan's view the industry needs to develop a wider sustainability picture. It needs to be in a position to be a price maker by being proactive with this. Supermarkets are demanding a lot but if we meet their requirements and produce the best in the world we can also make our own demands!

To get more growers thinking about climate change, there needs to be leadership from ZESPRI with things enacted by post harvest operators and leading growers. One third of orchards are leased or managed through post-harvest operations and another third are trading pretty marginally. There is quite a small group of growers who are motivated by dollars who have worked on short-term solutions, such as girdling which has question marks over it.

"We have let slip some of the fundamental research. For example it's all very well to go out and do some research on girdling but we need people to be doing stuff that is ten years away. ZESPRI has been too much focused on the short term and in reactive mode which is where we've been for the last decade. The longer term focus needs to be on things like crop protection."

- We have to look after our soil and water. It's what we have that gives us the comparative advantage to produce our food.
- We need to be putting money into longer-term strategic research. Monitoring orchards are good when you have some ideas to sell. These give a good mix of orchardist ideas but we need some good science as well. The next step is "demonstration" orchards rather than just monitoring!
- New Zealand has an opportunity to take the lead rather than be reactive.
- We're losing sight of basics, such as management of the C cycle, recycling of orchard waste.
- What is the likely climate resource in the future?
- What type of plant and management system is needed to capitalise on that?

Future growing systems will need to be developed to not only harvest light efficiently but also to allow automation of operations (mechanical pruning and robotic picking etc.).

Grower 11: Bert van Heuckelum, Katikati

Background

Bert came on to the property with ten years experience in the kiwifruit industry as a packhouse manager. He and his wife have a total of 8 ha of land, an original 6 ha block with another 2 ha added. They bought the original property in 1993, which had 1.5 canopy ha of Green kiwifruit (planted in the late 70s, early 80s) and the balance in timber trees (pines, cypress and some walnut). The kiwifruit were partly on T-bars which they converted to pergola. In 1998 they grafted all of the kiwifruit to Gold. However they had problems with a lot of wind damage and low production. In years without wind they were getting over 10,000 trays/ha which is good. The property isn't irrigated.

The additional 2 ha that they bought in 1999 has been planted in olives. They were looking for a crop that didn't need as much wind shelter and wasn't dependent on bee pollination. In 2006 they harvested the last of their Gold kiwifruit because of the wind. Some of the vines were converted back to Green (4 blocks) and some of the kiwifruit area (2 blocks) was converted to olives. Within a year a further block was converted to olives. The last three blocks of kiwifruit are due to be pulled out after the harvest this year and converted to olives.

The driver away from kiwifruit has been the challenge of their site along with lower returns and higher costs with the kiwifruit. Olives are harder to do commercially but they have invested in an olive press and are focused on producing and marketing their own product as well as doing olive and avocado pressing for others.

Current climate challenges and responses

Their orchard is in three tiers and falls to the southwest and away from the sun. The southwest aspect also gives strong exposure to south-westerly winds. The level of exposure requires a high degree of shelter which then brings shading problems with kiwifruit. There is no irrigation on their property. Contouring in the past has left minimum top soil in one block. With kiwifruit being a hungry feeder it means that extended periods of dry weather impacts on productivity.

Overall they are challenged by wind and their ability to capture temperature and light. With production levels in the industry getting higher it is increasingly challenging to sustain production off a difficult site and microclimate. You come to a point where technology can't help you any more. The situation for smaller growers is exacerbated by the increasing challenges with reliable labour. As a 1.5 ha grower in a marginal situation you can't make a living from kiwifruit and effectively become a hobby farmer. With insufficient income you need a job off the orchard, as Bert had, and then become a weekend grower.

The benefits to small growers pulling out of kiwifruit are increasingly outweighing the costs, with significant costs now for:

1) water for frost protection and irrigation
2) wind protection
3) intensive management
4) good labour
5) reflective mulches
6) compliance

On a per ha basis the costs are significant. With a re-evaluation of a small orchard it is more realistic to consider a shift to an alternative crop, which in their case involves a shift to olives.

Bert's advice to people in a similar situation is to do your sums. If you're a small grower with low returns and are relying on capital gain with your property then you are involved in property investment not orcharding. He believes that over time there will be a rationalisation to larger professional operations because of the capital investment required these days. More and more investment is required to deal with the physical climate to increase performance in a difficult economic climate. The only option within the industry to increase income is to focus on increased production and higher returns, through bigger fruit size, high dry matter, and aiming for the premium that comes with Early Start.

He believes that Mr Average won't survive and that the industry would benefit from losing small growers, particularly in marginal areas that are hard-pushed to meet the requirements. On the other hand the industry can't afford to lose too many growers. The post-harvest industry needs though-put to stay financially viable and will often offer to manage orchards rather than see them converted to another crop.

For Bert and his wife olives offer lifestyle benefits. This includes the satisfaction of being linked from planting the tree to the consumer who buys the end product. They've gone from a high pressure situation to a low return situation with a boutique operation that they can manage.

Climate change and adaptation

Flowering is under pressure with warmer temperatures. At present we're using HC to counter the effects of warm winters. HC is under pressure and there is a need for an alternative that is as effective. Girdling is being used as a short-term solution to achieve higher dry matter, but how long can it be done before you impact on the vines ability to regenerate?

If there were increases in spring rainfall, or more frequent wet springs, leading up to and during flowering it would be serious. At present the industry can spread risks with flowering through the timing of HC application.

Irrigation is dependent on water out of the hills around Katikati. Some bores are striking areas of thermal activity which exist in the area. We can't take the current amount of rainfall and the groundwater recharge for granted.

Katikati is second to Te Puke as a growing area in the Bay of Plenty and so these issues are critical. Many of the new plantings are happening in the lowlands of Paengaroa, Maketu etc. where there is lower rainfall and greater dependence on water. There are benefits from growing in this area but it is exposed to more risks, particularly with regard to rainfall.

The world markets are wanting fewer and fewer chemical sprays. Is a warming climate going to bring in new pests that we haven't dealt with yet? Already things like cicadas are becoming more prevalent. Then he looks at olives and doesn't see any major challenges that he might have to deal with.

Bert sees a future with a lot of challenges for kiwifruit.

"On our property I would say I am not able to viably fight all of the challenges. I can not justify making the same investments as some people do in better locations."

As a small grower he is making a rational decision by converting to olives. Other small growers will make their own choices over time, whether to convert to other crops or land uses or have their properties managed by a packhouse.

Corporate growing will probably take over. There will still be a place for small growers but location will be very important as will the skill level of the grower. The successful small grower in the future will need to have high skills levels and have orcharding in their blood.

Other crops such as avocados will benefit from climate change.

Grower 12: Clarrie Head, Katikati

Background

Clarrie bought into kiwifruit in 1992 looking for a new challenge. He was involved in the KiwiGreen programme as a field officer. He sold his orchard to his son in 1998 and then did six years running some orchards in South Auckland. All along he was concerned about the excess use of chemical fertilisers and what they were doing to soils so he dramatically changed what they were doing with a shift in focus to soil management. They got very good results very quickly and then things tailed off a bit and he realised there was more learning to do. They've got production levels back now but have current issues with fruit size due to the dry summer.

The home orchard is 8.5 ha. There is another 4 ha block at Waihi and a 2 ha block at Omokoroa. All produce good quality fruit. Most of the crop is Green, with 0.75 ha of Gold at Omokoroa. They're all carrying heavy crops this year but they haven't had enough rain to size the fruit. Clarrie's focus is on producing a good volume of high quality fruit. This year they're aiming for about 13,000 trays/ha. It's not the best result in terms of fruit size because of the dry weather and lack of irrigation.

They use a biological approach to soil management. With this approach you can use any fertiliser but the bottom line is to feed the soil biology and doing what is necessary to counter any toxic effects. Clarrie has been following this approach for the last decade with input from US people such as Arden Anderson over the last four to five years. They tried girdling last year and had no difference in dry matter content. Dry matter is only the first step in determining good flavoured fruit. There is a need to look at dry matter composition. Soil is the foundation for managing energy and nutrient flows. Girdling is a short-term solution that he believes is unsustainable and is not providing the answers. They have higher dry matter than most in the industry. The answer is in

nutrition not in starvation, not in denial of the soil microbes. Nutrition will get everything working properly.

Current climate challenges and responses

They tend to get cold winds in spring which can limit early leaf growth which affects energy supply early in the season so they have to change some things to cater for that.

In this past dry summer they have had less than half the normal summer rainfall. This hasn't impacted on the plants themselves, which are pulling the water from deep down, but they have lost nutrient flows in the surface feeding zone which has impacted on fruit growth.

Temperature has not been a huge issue in that kiwifruit love warm temperatures. The vines love high humidity and moisture as well which they haven't had this year. Clarrie thinks that the winter chilling issue is over-rated. When the nutrient balances are right the plant will do what it's supposed to do. Last year when they had a warm winter they applied low rates of HC and had 60 flowers/m^2. So he doesn't think chilling is a major issue if we get the nutrients right. Clarrie believes that you can go to no HC with good soil biological management.

His approach is based on Albrecht's work with a focus on trying to get the ideal balance of nutrition in the soil. They use targeted inputs to get the desired nutrient levels, always with a focus on feeding the soil biology. It isn't a high input system, with their inputs now lower than in a conventional orchard.

They have put in sprinklers for frost protection at the Waihi and home (Kauri Point) orchards. At Kauri Point there are only certain parts of the orchard that need protection. He expects things to get better over time with reduced frost risk as the soil biology works better and with the replacement of some shelter. Based on US stories he says you can warm the soil by up to 2ºC with good biology. They're not monitoring soil temperature to see whether such changes are occurring over time. In general they aren't monitoring the changes that they're observing but do monitor things like their worm counts, which are high with more than 500/m^2.

They don't have any irrigation in any of their orchards but could use it at Waihi in the future. The function of irrigation is simply to keep some moisture in the topsoil. That means giving an 8-10 hour irrigation no more than once a week. In a normal season you might need to do this two to three times.

Councils need to understand the needs for water. If people have a water right they need to be allowed to use that water the way it can be used properly. This doesn't mean giving a little bit every day, which is what the councils usually say. They need to be educated to the reality of the crop we're growing. Growers also need to be educated to irrigate properly.

He told the story of a South Auckland grower who lost his whole crop this season because the water right to the orchard was cut in February. He's now going to cut his orchard out. There needs to be an understanding from all parties. Growers need to understand how to irrigate and also should be able to get the water takes that they need to match the needs of the plant.

"To mitigate the challenges we have to get more C in the soil because it holds four times its weight in water. So we need a system that sequesters carbon." He gave the example of an Edgecumbe farmer doing 1400 kg of milk solids with no N and no maize sileage and who stayed green during the drought this last summer. We can hold more water with more C and release more water over time, so that takes care of both the rainfall issue and the drought issue.

In their situation they'll be putting some shelter back in to warm up some blocks in the winter. In Clarrie's view, shelter is not to stop wind but to hold warm air. Wind rub mostly occurs on spur wood above the canopy and is not such an issue if you get the fruit below the canopy. Certainly shelter has a huge impact on Gold, but its important function is that it holds temperature and humidity.

Climate change and adaptation

By improving soil balances, getting better biology and increasing soil carbon Clarrie sees the biological approach being better placed than conventional growing.

"I'm not sure there is any one thing that could be put in place in now. It's a combination of doing a lot of things. It's evolution if you like. The industry will evolve."

He believes that it will still be possible to produce Green kiwifruit in the Bay of Plenty with climate change. We will change and adapt as we go along. The process he follows is one of constant fine tuning and adjustment. Observation is a huge necessity for any farmer.

"It comes back to soil balances and soil biology. If we've got those things right then the plant will function fine. Nutrition will get all the balances right for the plant to work properly, for the biology to work properly. Everything will work properly with the

proper nutrition. Nutrition will answer any disease problems or anything else. It's all nutrition related."

Water will be the biggest issue but it can be managed. A well buffered soil system will help deal with water issues. We'll hold water for longer with more C in the soil. Water is a necessity for good soil biological activity.

Industry issues and responses

Clarrie believes there is a strong movement in the industry towards a more biological approach, driven primarily by quality. He believes this is where the long-term answers will be, not through the current short-term focus on things like trunk girdling. Research needs to go to basics more, to develop a ground up understanding. A lot of time is spent looking at different problems but they need to look back to the beginning at how the fruit is grown in the first place.

The biological system is not straightforward. It requires an understanding of how the soil works.

Grower 13: Eric Hutchinson, Katikati

Background

Eric was born and bred in Mokau, North Taranaki. He has worked on the land all of his working life, was a hill country farmer and bought into kiwifruit in the early 1990s.

They own four orchards in the Katikati area covering a total of about 16 canopy ha, spread from Athenree through to Matahui Road. All of the orchards are planted in Green kiwifruit and all have been converted to the pergola system.

They have at least doubled the production on their orchards, from 5000 trays/ha up to about 11,000 trays/ha. He uses advice from people, particularly the local Fruit Fed manager who has had a lot of input, but manages the orchards himself. He uses a contractor for all of the vine work. Over the last few years a lot of effort has gone into the orchards given the lower returns. He's going for bigger fruit with higher dry matter to meet the ZESPRI requirements. Eric wants to be in the top ten percent of kiwifruit growers.

He is having a go at biological management, with a ZESPRI trial running in one of his properties using the biological approach that is being promoted by Arden Anderson. Eric is giving it three years. Environmental concerns are a driver for him, with concerns about effects of fertiliser runoff on the harbour and so on.

Current climate challenges and responses

Localised flooding in the Athenree orchard is a recent issue he has had. Last year it went under water twice when they about 160 mm of rainfall from two separate weather events within an eight day period.

Very dry periods have become worse in the last few years and he is using more irrigation in some of his orchards to keep the plants in a healthy state. So far he has installed a dual irrigation system, for frost protection and summer irrigation, in two orchards covering eight canopy hectares. All of the orchards have been set up for summer irrigation. The soil is monitored for moisture.

"When I first came here the guy that ran my orchards for the first year said that the MAF advice was to pull all of your irrigation out and throw it away." Being a farmer he decided not to do that. His farming experience was to keep existing irrigation systems, not remove them, and has been proven right. Water is making a difference to production in his orchards. The oldest vines are 25-30 years old but they have a lot of feeder roots near the surface.

There are no real problems getting water. On two orchards the water comes from surface takes from nearby rivers, on another it comes from a bore and on the other it comes from a council supply which he pays for.

There are a few frost issues in a couple of orchards but these have been fewer in recent years and they have them covered with their overhead sprinkler system. Eric uses Taupo temperatures, not Tauranga temperatures, to guide his frost fighting in the cooler orchards. He has been very successful in using this information to anticipate and fight frosts.

With warmer winters he uses a bit of copper spray to get rid of leaves to enable the pruners to do the winter pruning.

He doesn't think that winter chill is an issue with HC. Last year he didn't apply HC until the end of August, closer to the natural time of budburst, and got the best crop he's ever had.

Wind is a big challenge around Katikati. He has one orchard that is quite badly hammered. On this orchard he has been steadily dropping the height of the natural shelter and is having fewer problems with wind in the orchard as a result. He is now looking at the possibility of using sub-canopy shelter, mainly to further reduce wind damage to the fruit.

Eric takes time to look at what other growers are doing to improve and refine his orchard management and productivity.

Climate change and adaptation

Water is his biggest concern for the future. Security of supply from the council is very important. At present Environment Bay of Plenty are monitoring bores and he is concerned with the possibility of water restrictions in future. On his orchards he has proven that he can maintain the crop and vine health with water use in a dry year.

Heavy rainfall events in the future would be a problem in low-lying orchards, but it is okay if the water drains away within a day or two.

Warmer temperatures are not a concern. It will be possible to use HC or a substitute and he would look to organic or biological systems for solutions. He is already doing a bit of artificial pollination which helps fruit loading.

"The past season has been very warm. I believe that the fruit do well under a warm climate, particularly after fruit set, so long as you have water to keep them going."

Grower 14: Glenn Roberts, Katikati

Background

Glenn has been involved in kiwifruit for 20 years. He originally trained as a horticultural cadet in the 1980s. He managed Aongatete Orchards for four years before coming to work for the Trebilco brothers. He now manages 36 canopy ha.

The Trebilco brothers own separately or in partnership a number of different properties. The main orchard is the Riverside orchard, which is 22 canopy ha with 12 ha on river flats, 5.2 ha of the property in Gold and the balance in Green. There are another two orchards at Tuapiro (towards Waihi), with a 2.75 ha organic Green orchard, and a 14 ha conventional orchard with 9 canopy ha in conventional Green and 2.2 canopy ha in conventional Gold. There is also a 1.1 ha Gold block at Whakamaramara.

They have been doing 8500-9000 trays/ha from the organic block consistently for four years, which compares favourably with the 8000-10,000 trays/ha that they get from the conventional blocks. With the Gold they're packing about 14,000 trays/ha and are getting very good dry matter. The fruit go through four different packhouses.

The organic block requires very careful management. Glenn is using trunk girdling at present but is a bit concerned about the long-term effects. This practice is having some impact on the vines and they're doing less summer pruning and getting a thinner canopy. There'll be some blocks that he rests from trunk girdling next year. His advice is to be selective with what you do and watch the plants carefully.

Current climate challenges and responses

The river flats on the Riverside property are very low-lying and have night temperatures comparable to Taupo. The wind and the chilling factor are real problems on this 12 ha of land. The first year he was there they put in 14km of pipes with overhead sprinklers

for frost protection which have been used in more recent years for irrigation. Because of the shallow soils on this block you need to keep the surface wet. They have introduced irrigation this year to the Gold block, which is on the mid-plateau of the Riverside property. The other blocks aren't frosted and don't need irrigation.

Wind is an extreme problem at Riverside. They have been changing the varieties of shelter used and are using quite a lot of sub-canopy shelter for warmth and it's better for flowering. There has been removal of shelter over time to get more light. The challenge is to get the right balance between wind protection, light and warmth. Glenn has some concerns with the possibility of more botrytis problems if they continue using sub-canopy shelter, but mostly sees it as providing a bonus with the extra warmth.

HC application is made with the assistance of winter chilling monitors. HC should be applied 40 days before natural bud break. He also uses the organic block to help monitor the timing for HC application. HC is very important in a conventional orchard management system. On one block at Tuapiro they stopped applying HC because of the neighbouring Marae and experienced a halving of fruit production and chronic shape problems. He's interested to see how this block comes back this year, which they're now converting to organics.

They've been putting in extra drainage for water. They need to be conscious of flooding problems with their orchard locations, which are next to rivers.

Climate change and adaptation

He wouldn't be so concerned with a warmer climate if he was an avocado grower. For kiwifruit it is a real concern, particularly with Green which needs a certain amount of chilling and HC to get good bud break. If you apply HC before you get a minimum level of chilling then you risk having patchy budbreak. Gold may not be such a problem.

You would normally say that you ought to have a month gap between flowering in conventional and organic orchards. What he is observing is that the organic orchard is getting closer to conventional regarding the timing of flowering. He's not sure why this is happening. Organics would be harder to do with a warmer climate because of the lack of winter chill. He agrees that biological soil management could have some benefits but doesn't believe that it can do what HC does. He believes that lack of HC would be a major issue. Based on his observations and experience you get increased variability of production and all sorts of problems without HC.

"By not using HC you're increasing the variability of your orchard. Here we have ZESPRI saying we want less variability, we want that crop to be as level as we can. We're faced with a major problem if we don't have HC or a suitable substitute."

A major problem would be to give more consistency of production to ZESPRI with a warmer climate. Glenn would like to think that alternatives to HC can be found but he hasn't seen anything over the years that would get close to it. He thinks that variety changes are a more viable option than looking at HC. There is a need to look more at other options.

On the river flats they are already dealing with climate extremes. If there are more extremes of wet and dry in the future then irrigation could become more critical for the industry.

"As things get tougher we just have to get smarter."

It used to be that ZESPRI would take whatever was grown. Now they want a consistently good product with no variability and you have the growers who are dealing

with huge variability. This situation will become even more challenging in the future with climate change, particularly if there is an increase in variability and/or extremes.

To remove variability in production:

1) HC application compacts flowering.
2) Use pollen collected from the orchard and artificially apply it.
3) Constant fine tuning of canopy management, which can vary from one block to the next.
4) You also have soil variations to deal with, requiring irrigation in vulnerable locations.

"It is not going to come on us in one day. It's going to come on slowly. We need to do more investigating about alternatives and keep a very open mind to it getting warmer. What are we going to do? It's not going to be tomorrow that it's all changed. The industry needs to be proactive rather than reactive."

Industry issues and responses

"ZESPRI should have more focus groups where you get hands on growers together to talk about what they're seeing and what's happening with our crops. We need to be investigating things like HC alternatives, different styles of doing your canopy and looking at results like that. Make sure the information is well publicised and everyone knows what is going on. We need to push the boundaries. We need to bring the science of climate change down and focus it on what exactly it means for kiwifruit, where it is taking us and what do we have to do."

Glenn believes that there is a need for solid information from the hands-on growers from whole orchard observation and experimentation, not just block trials. He has seen and experienced the limitations of trial work which can be very site specific.

Growers need to understand more and be more proactive in managing their crops rather than be led by packhouses. It is very important to understand the game and play the rules. There is a real knowledge gap at present and a need for hands-on managers. The cadetship has started again which will help address this, although he has concerns about the education they're getting with not enough apprenticeship type learning from people like himself. The industry is going to need higher and higher skill levels as time goes by.

Grower 15: Keith Holdom, Katikati

Background

Keith was born in the UK and grew up on a dairy farm there. He has always had an affinity with the land. He has been involved in the kiwifruit industry since 1990. He began with a 1 ha property then bought another 7 ha. Until 2000 they were leasing their orchards and living in Taranaki. In 2002 they sold and moved to Walker Road, for a better growing climate, better growing conditions and better orchards. They bought three orchards, all within 1 km of each other, that are 4.5, 2.2 and 3.0 canopy ha in size. The former two are adjoining properties and the third is just down the road. They lived on the 3.0 ha orchard and sold it in October last year. In the time that they had this orchard they took it from 22,000 to 30,000 trays.

Both of their current properties are Green kiwifruit. Keith aims for Early Start to get the premiums and achieved this with all of their orchards in 2007. All of their production is conventional, grown on pergola.

"We are, partly from the global warming side, partly from the customer demand side and my own philosophies moving more to a biological growing system." He got involved in this approach after attending an Arden Anderson course two years ago and it made a lot of sense. This year the fertiliser programme was a combination of conventional and biological sprays. Over the coming season (2008/2009) the plan is to move totally into a biological programme but still using a base mix of conventional fertiliser. The biggest effect that Keith has noted so far is the loss of weed pressure.

The biggest crop from the 2 ha property has been 15,000 to 17,000 trays. This year they're looking at just over 9,500 trays/ha.

Current climate challenges and responses

The biggest hurdle here is spring frost. Springs are definitely colder and more frosty now than when he first started in 1990. They moved from the hills where there was good air drainage. When they first moved here they had a baptism of fire. They took over on the 26th September and on 5th October 2003 they were totally fried by frost. They're now fully protected with overhead sprinklers. Keith has installed bigger sprinkler heads (less likely to block) that are well spaced. The economics are better with bigger spray heads. They have 90 percent protection and he is prepared to accept a ten percent loss from the unprotected area.

"The seasonal temperature pattern has shifted by about a month. We don't get the good winter chilling in July and August. We're not getting good summer weather now until after Christmas. Warmer conditions in Autumn mean that the fruit is taking longer to cool down after harvest."

Water is going to be extremely important. They have excavated lakes from former wetland areas to give water storage for frost protection and possibly for irrigation in the future. They've planted natives around this. Irrigation is used in small amounts at times. They discovered that watering kept the fruit growing during the summer and it didn't accumulate quite as much dry matter. When it did rain the fruit that had no water caught up and ended up with higher dry matter than the irrigated fruit. So now they don't tend to use water for irrigation. In the past dry summer they irrigated twice (two applications of 25mm), only doing it when it was a necessity.

"I just keep looking. I try and think outside the square. I don't want to be doing what everyone else is doing."

Keith's whole approach is to continually work outside the square and be strategic in his thinking. He uses an orchard management group to do most of the day to day running. In some ways he sees it as his good fortune to be able to afford this. On the other hand he has the attitude that he cannot afford to do the pruning and things like that. It's not a good use of his time. He does the mowing and weed spraying, looking around and a lot of the thinking. When he mows he has time to look at the whole orchard in a short space of time and if anything is wrong he's seen it and can raise it with his manager. This approach gives him time to do the strategic things as well. In his view too many orchardists are doing basic work such as pruning that someone else could do, rather than giving themselves time to look outwards.

Climate change and adaptation

He believes that HC, or a suitable substitute, will become more significant with climate change. Spring frosts could become more significant and so frost protection will be essential. At the other end of the season, if the late summer, early autumn temperatures continue to increase will the fruit naturally become later maturing because the cooler temperatures aren't there to drive the brix levels?

Like most things Keith believes that if ZESPRI throws enough money at it they will find a solution to any such problems that might arise.

Keith expects to see changes in varieties. He has stayed away from Gold. Green has always been the backbone of the industry and he favours that. He is hoping for new varieties that are more robust like Green but with more of the flavour of Gold.

The water that is being stored can be used for irrigation in the future if needed. He doesn't know if this will be enough for the future. Long-term he may have to think about tapping into ground water, but for now has two large storage ponds. The plants are reasonably resilient and don't need too much water.

"My gut feeling is the climate is going to be much more extreme. We're going to go from very dry to very wet, very warm to very cold. I think we're going to see more thunderstorms in the middle of summer."

"Farming and growing is about the need to be adaptable. No season is the same. Some years you're going to have losses. People are very good at whinging about things that they have no control over. If you're in the business of growing you're very reliant on the weather. You have no control, you have to farm with the weather, not against it. We will get the extreme weather events and suffer crop losses."

Both Keith and his wife are reasonably flexible. They aim to increase their asset value as a way of buffering against bad years. He believes that some people who are struggling are their own worst enemies. Luck does happen but mostly you make luck happen. *"I'm a very firm believer that if you sit back and wait for luck to happen you're going to be waiting for a very long time. You go out there, you drive it, you put things in place that make the best chance for luck happening possible."*

Grower 16: Terry Newlands, Katikati

Background

Terry originally trained and worked as a mechanical engineer in Auckland. They purchased their land near the Athenree Gorge in 1993. The land covers a total of 10 ha and is all river flat, bounded by the Waiau River. There were originally 5 ha in peaches and nectarines at the front of the property and 5 ha in kiwifruit at the back.

In 1996 ZESPRI were looking for people to grow a new variety they were trialling, called Tomua, so they pulled out the peaches and they planted 2.5 to 3.0 ha. When ZESPRI subsequently pulled the plug on Tomua they grafted over to Gold. In 1993/94 they converted to organic production. By then they had a mix of Green and Gold. They had problems with pests on the Green in particular, with sooty mould resulting from passion vine hopper, and were getting 50 percent of their fruit rejected. So they've now converted back to conventional production with Green, but the Gold is still in organic production. They now have 3 ha in Gold in the front block, 0.5 ha in Gold at the back, all organic, and 2.5 ha in Green at the back.

They also have shares in a property next door, which is 165 ha under management with 50 ha in forestry, 35 ha in kiwifruit (23ha Gold, 12 of Green), 15 ha in avocados and some deer, sheep and dairy cattle.

Their soil is a sandy loam with some volcanic ash, with about 150-200mm of topsoil. It is not as deep as the good Te Puke soils. They don't get the production and trunk size that is possible on the deeper soils. They need about 80mm of rain to saturate the soil.
The oldest vines on the property were planted in 1983-84 in the back block. In the front block they have transplanted stumps and new plants on different rootstocks, some Kaimai rootstock which gives earlier flowering, and a mixture of other rootstocks.

They get more vegetative growth on vines nearer to the river and more balanced growth higher up.

On the home orchard they are now getting 8000 trays/ha with Green and 8500 trays/ha with Gold. Next door they are getting up to 12,000 trays/ha on Gold. Green is around 7000 to 7500 trays/ha and this year will be up around 9000 trays/ha. With the high exchange rate at present you're not covering your costs if you get less than 7000 trays/ha. A lot of people will exit the industry if the dollar doesn't come down.

Current climate challenges and responses

Their local climate is about 1-2ºC warmer than the Bay of Plenty average. They've had a rainfall range of 1200 to 1800 mm over the last seven years. Meaningful rainfall comes from the north-east. They get a wind funnelling effect over the Kaimai Ranges and through the nearby Athenree Gorge. Sunshine hours are good. There are good growth rates on the pine trees next door which are ahead of a predictive model. It is suggested that these superior growth rates are to do with good sunshine hours and warmth.

There are local challenges with lack of winter chill. They haven't had a warm winter for a few years and Terry is dreading a really warm winter. Cold air pools in the small valley where they are located, but up on ridges kiwifruit can really struggle with lack of chilling.

On the Green kiwifruit they were getting 5000 trays/ha before using HC, then jumped to 7000 trays/ha with HC. With Gold you can mitigate this with trunk girdling and canopy management. The latter tools can be used to promote higher flower numbers. They do trunk girdling and have been doing this for about five years. Dry matter has increased as a result. Early girdling gives a lift in fruit size and a bit of a dry matter lift, later girdling gives higher dry matter. Terry believes that dry matter is rising with warmer summers.

There are no problems with frost. They've had one frost in 13 years that tinged the leaves on about ten percent of the property.

They harvest early because of the coastal location (about 4m above sea level) and warm spring and summer temperatures.

Next door, kiwifruit is being grown on ridges. They are using a number of strategies including conversion of males to better varieties and a strip male planting system, trunk girdling, canopy management to a more open, low vigour system and nutrition management. They've been doing a lot with canopy management and girdling to get higher flower numbers. They're using this along with smart use of HC. They've really been struggling to get flower numbers but have been getting success with this strategy. A cold winter and HC will give fantastic flower numbers.

They are dealing with more rainfall variability. In the last few years they have been getting some very dry spells and very wet spells through the growing season. This is providing management challenges.

They had a water consent but let it go, but may need to reapply. There is an old irrigation system which needs upgrading, but this is not a priority at present. The tap

roots of the vines can keep things ticking over but they probably suffer with drying out of the topsoil. They're not using irrigation at present. They have a water consent for the property next door. If it's dry for 2-3 weeks then they start looking to water.

This winter, because of flooding problems, they have cleared 1500m of river bank. After doing clearing work ten years ago the result was that it deepened the river course and reduced flood problems. They are talking about doing riparian plantings as part of their local Stream Care group. It's a matter of getting the species right.

With wind in a bad year they can have 30 percent reject fruit with Gold. They have been putting in some sub-canopy shelter this year and will be doing some more, using a white wind cloth. Evidence is that it will increase temperatures and be beneficial to dry matter. They're putting the white cloth parallel to the rows to get air drainage.

Green management is semi-organic. The only difference is use of HC. If HC was banned then trunk girdling and canopy management would provide some benefit. They're looking at a product called Erger-K which is being tested.

There have been changes in pests. Latania scale has become more of a problem.

Climate change and adaptation

Terry's neighbour believes that warmer temperatures and higher CO_2 could be beneficial to crop yields.

The leaves are staying on the Gold vines into June/July and this could be more of a problem for organic growers with warmer winters. Conventional growers burn them off with nitrogen sprays.

If there are more extreme rainfall events they can manage with better drainage and also manage times of shortage during dry spells by using ponds and dams to store water. *"If you were in Australia they would think you were nuts if you weren't storing water."*

To deal with more wind they can increase sub-canopy shelter, which is cheap to do and looks very promising. From a management point of view Terry wants to keep natural shelter as open as possible. With sub-canopy shelter you can remove turbulence and increase light and warmth. The pay back period is very quick with much lower reject rates.

The main management strategies would be to use more artificial shelter to reduce reject rates and more use of trunk girdling and low vigour canopy management to get higher fruit numbers. Gold was a diversification to deal with warmer winters. They could possibly go to all Gold or to some other variety that may have a low winter chill requirement. Careful fruit handling and cool store management is very important to ensure good returns to growers.

Industry issues and responses

The tools that the industry has been introducing to manage dry matter also lift the floral response and to a degree reduce dependence on HC. So these are existing tools in the toolkit that have been facilitated by the industry.

A shift to new varieties would potentially provide benefits in terms of longer term adaptation. They've been very open to trialling new varieties on their property.

"I think that we'll be alright short term. Water is the big one. Wind we can mitigate with shelter. With temperature we'll be okay."

Grower 17: Brian Carter, Awakeri

Background

Brian's predominant focus is as a dairy farmer. His father and uncle led the way with diversification in the Muldoon era, but Brian believes you can be too diverse. He has previously done maize cropping, run beef and horses and grown blackcurrants, citrus and feijoas. These have all been shed now with a focus on just dairying and kiwifruit.

He runs five dairy units supporting 1200 cows, with 300 ha freehold locally and 500 ha leased towards Galatea.

With kiwifruit he has 4.5 canopy ha in Green on one block and recently sold a 3.0 canopy ha block of organic Green to his son and daughter-in-law. The 4.5 ha block was planted in 1984 with a limited water supply that was less than optimal for irrigation. Three years ago he put in a 10 inch, 93 metre deep bore which gives a secure water supply and enough to provide options for expansion of the area in kiwifruit in future. A third of the home farm is on what is called sandy ridge soils, which are well drained, and the other two thirds is drained peat soil. Some of the farm will probably be below sea level when the peat fully settles down. The sandy ridge soils are former sand dunes which have built up as the plains have formed, with sandy ridges interspersed with wetland peat soils out to the coast.

Current climate challenges and responses

The fact that they're planting maize earlier than in the past is an indicator of warmer conditions. The amount of winter frost has significantly decreased. His father quoted 100 frosts in a row in the past, more recently the most Brian has observed in a year is 30. However it is still a big challenge. Spring warmth followed by late frosts leads either to aborted buds or disfigured fruit.

The lack of water has been a key issue on the sandy ridge soil. They're now into their third season with the bore and they're hoping to lift production from 25,000-30,000 trays to 40,000 to 45,000 trays. He's hoping to increase yields with more reliable water and better vine management. This last summer they irrigated almost every day in between rainfall events. They've never had any problems with flooding or high water table issues on the sandy ridge soils.

With wind, they followed the early MAF advice for shelter and have subsequently slowly removed shelter belts to open the orchard up. Brian is more prepared to take the risk with a more open orchard than deal with the issues associated with managing a lot of natural shelter. At present he uses very little artificial shelter.

His present focus is on keeping costs down, easy management and low cost given the low returns for kiwifruit and high returns from dairy farming.

He has backed off trunk girdling. They did about half the orchard as a trial and had some results that showed benefits. But it is against his growing principles and he is not prepared to risk wrecking the orchard.

His approach is fairly conservative at present. If and when the returns per hectare increase he will invest more. Kiwifruit is a roller coaster industry and it is high risk with dependency on one crop. You need to be getting things right all the way through.

Climate change and adaptation

Brian has land suitable for further orchard development and a bore providing a water supply that can cope with expansion. There is a lot of pressure on water.

In the future he sees opportunities, even if he gets some level of inundation of sea water onto the farm. There could be opportunities for aquaculture.

Kiwifruit are part of the diversity that Brian grew up with. He has honed in on dairying and kiwifruit and that's enough for him. His heart is more in animals and dairying is his primary focus for now because of the high returns.

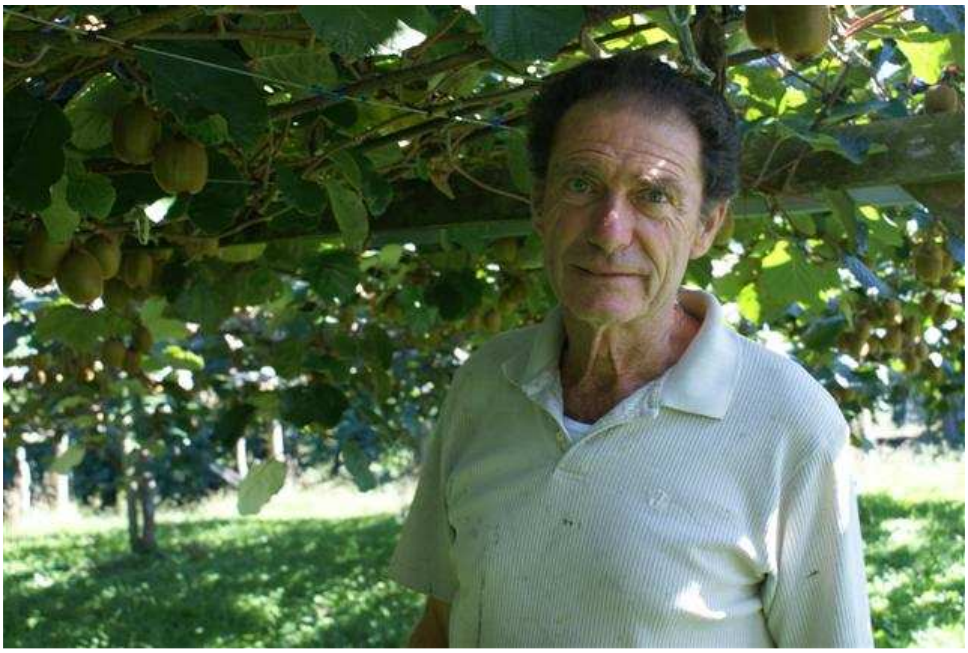
Grower 18: Ken Young, Opotiki

Background

Ken's operation is based on a family farm. He started dairy farming 45 years ago. This has grown from 130 acres to a larger farm with 300 cows, which his son is running. It remains a family farm and this will continue with his son taking over more. Ken is totally focused on the kiwifruit.

He took over the family farm in 1976 and immediately started planting shelter for growing kiwifruit. He made an initial planting of 5.5 ha and has progressively planted more from the income that has been generated. They now have 20 ha (canopy) in Green and 2 ha in Gold, 11 ha of the Green is in new plantings, which are under five years old. On the original 10ha block they get 5500 to 8000 trays/ha

The soil is a volcanic sandy loam and is very deep and well drained. The orchard and farm are all organic. They applied for organic certification in 1993 and they currently have both BIOGRO and Demeter certification.



Current climate challenges and responses

"We used to look out the window in the winter and say 'it's fairly frost free over there, that's good', you wouldn't do that today. You'd say 'hey I hope you got enough frost to get winter chill'."

"Climate, do you think it has changed over the last 20 years, in my observation, yes. There is no winter now. The grass now grows all winter whereas in the past it used to stop growing for about a month, in any one of the winter months."

The warmer winter is something that Ken definitely believes has happened. However, he doesn't believe that summers are drier, they're not as bad as were experienced in the 1970s.

He's now looking at how much winter chill they're getting. They don't worry about how hot the summer will be or how much rain. The orchard production is quite dependent on natural budbreak. At present there is enough winter chill to get enough crop to be a good business.

What are they doing about it? Trunk girdling of mature vines is something they're going to do more of. However it does not mean every year or twice every year, although they did do it twice this year. They did a second girdle this year on the mature Green for dry matter and to try and enhance budbreak for next year. When they first started girdling they did one large girdling and subsequently had questions about the results including smaller size, and the crop didn't store as well. So they stopped the next year, doing only one block. This is a work in progress, experimenting for themselves because no one is doing it for them.

They're going to start putting on a bit more fertiliser, although they're limited to what they can do with organics. Being organic and having a good location for growing kiwifruit they do have high dry matter at present on both Green and Gold kiwifruit. The soil here is beneficial.

It seems to work that in smaller crop years that they get bigger fruit size and can make just as much money. The orchard isn't consistent with tray numbers because of the nature of the growing system which is to live with the natural variability. *"We're farming pretty much to what we're given."* This variability is linked to warmer winters and biennial characteristics of the vines. It is part of his farming philosophy to work in this way.

Late spring frost is not a problem on their land, which is elevated. There is one block at lower elevation where they could start to worry about early frosts. Gold has been planted where there is good air drainage because of its earlier flowering and potentially greater exposure to frost.

They set up a frost protection group from Tablelands growers involving five people and eight orchards and put up the money to boost the water supply for frost protection use. Others who didn't take up the invitation to join the scheme at the start and are now wanting to opt in are having to look after themselves. They'll have to use a pond or some other system. The original water scheme was completed in about 1984 by the former Ministry of Works. At the time they had no choice but to be part of the scheme, but were subsequently left to run it themselves. It is a surface water take from the local river. The scheme nearly fell into disuse until about 2000. Since then everything has gone wild in terms of demand for water.

Ken is taking his chances. He hasn't opted into the scheme. *"With my diversity I'm not so vulnerable."* Ken sees this sort of situation as the opening shots in the coming water wars and he sees more of this in the future. *"We didn't foresee this frost situation and can't foresee other things."* What he does see is more Green being converted to Gold and then there will be more demand for water for frost protection. There has been an

evolution in the area from irrigating young plants to now irrigating mature vines with sprinklers and using water for frost protection.

The annual rainfall is about 1300mm. Ken's rule of thumb is an average rainfall of 100mm per month, except for February. Water for irrigation is available on tap. They thought they were fine and dandy but were over their allocation this year. It is becoming more fashionable to irrigate. Gold irrigation is more necessary and common because the vines are higher yielding and the crop is more valuable. Everything demands more attention with Gold. Ken has sub-canopy irrigation set up with the Gold. For Gold the majority would say yes you need water for irrigation, but not in every year. He irrigates by eye and observation. He shies away from over irrigating. A little water is better than none. If you understand your soil then you can get it right. His understanding is that the ones using tensiometers are using far too much water. He agrees with the principle of avoiding over-watering at all costs, don't worry if you're a bit under.

This year they were over their water allocation of 5040 cubic metres on quite a few days. At the moment if they get several more orchards converting to Gold then they'll be right up to the limit of the water take even in a moderately dry summer. The current water consent period is for 15 years. To increase their take they had to measure river flows at a low flow period. The council will tell you that you can't take more than ten percent of the low flow.

"Wind is the great enemy of kiwifruit plants and any plant." There is a trade off between shelter and ground for production. He has planted shelter and will put up more artificial shelter above the canopy on the young blocks. In the old blocks they only have half the shelter that they used to have. Once the canopy is properly established it does shelter itself to an extent. He wouldn't say no to using more artificial shelter. The wind that damages the Gold won't do much damage to the Green. The Gold block

didn't do any good until they put in artificial shelter. He has gathered information and observed air movement on his land and placed shelter accordingly, so tree shelter is planted part way down the hill. Multiple lower shelters are more effective than tall shelters.

They don't worry about cooler seasons. Last season, around Nov/Dec 2006, was very cool from spring right to Christmas and he's sure it affected the growth and quality of fruit.

Ken's vines are late flowering, with the Green flowering this season on 10 December. Their average from earlier years was 25 November. When there was a bad late frost a number of years ago Ken escaped the damage because of the later flowering of his vines. There is some disadvantage with the late natural flowering, losing 20-30 days from the potential growing period. As a result they have habitually been a late harvest property with Green, harvesting in the latter part of May. The maturity of the vines can affect harvest towards later dates.

Climate change and adaptation

They wouldn't consider relocating because of the family farm focus. *"We will survive as we are for many years with a progressive warming. Does it give me confidence to plant and develop more? No, it diminishes my confidence to do that."*

They have tools to adapt. For a conventional grower that's HC. We can also grow Gold.
He can potentially grow as good a crop as a conventional grower. There are also possibilities for other varieties. There are options with the possibility of other crops such as avocados, which would do better with higher temperatures. Diversification is part of their game.

Kiwifruit have to have winter chill, but they like hot summers. Gold like hot summers and water. This crop could do better under a warmer climate.

Ken is looking for answers. He's aware of things like the biennial system. If you're really well organised that's probably the ultimate. Ken is looking more at other options such as low vigour pruning. Cool winters can override any management techniques from the previous season.

The greatest response has always come from the experimentation of growers.

Industry issues and responses

What is needed to support the inherent innovative and adaptive behaviour of growers? He liked Shane Max's article asking growers to look out for 'sports' on Gold and telling them what to do if they do see something. He thought this was a good idea. Growers can observe things and feed information back.

Ken evaluates his experiments (eg, with girdling) to his own satisfaction, but it is not easily translatable for others. How to formulate/document grower experimentation?

ZESPRI is good at the big picture. It isn't able to get down to the grower level detail (eg, knowing the variation between blocks).

Appendix 2: Present and future climate in the Bay of Plenty

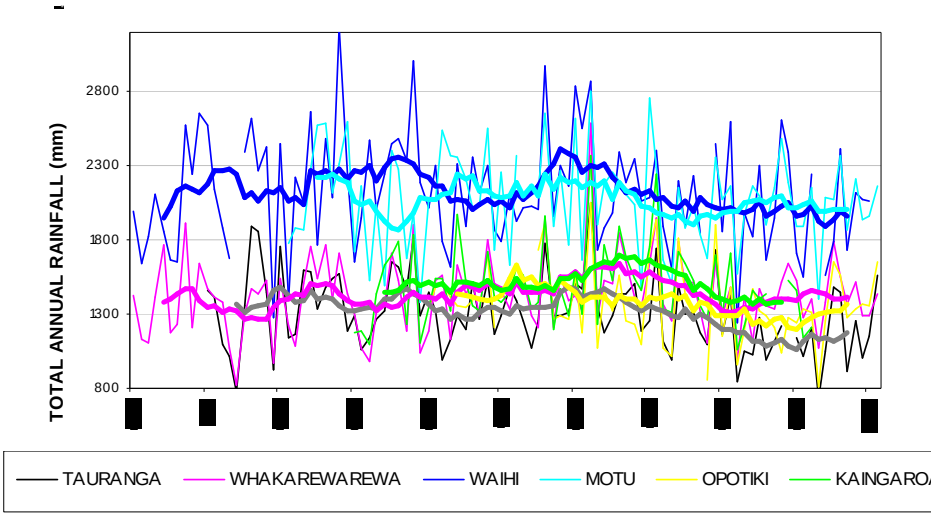


Figure A1: Total annual rainfall for six Bay of Plenty stations. Thin lines show annual data, while thick lines depict 9 year (centred) moving averages. All stations show a decrease in annual rainfall over the period of record, although only at Tauranga is this statistically significant. [Reproduced from Griffiths et al, 2003]

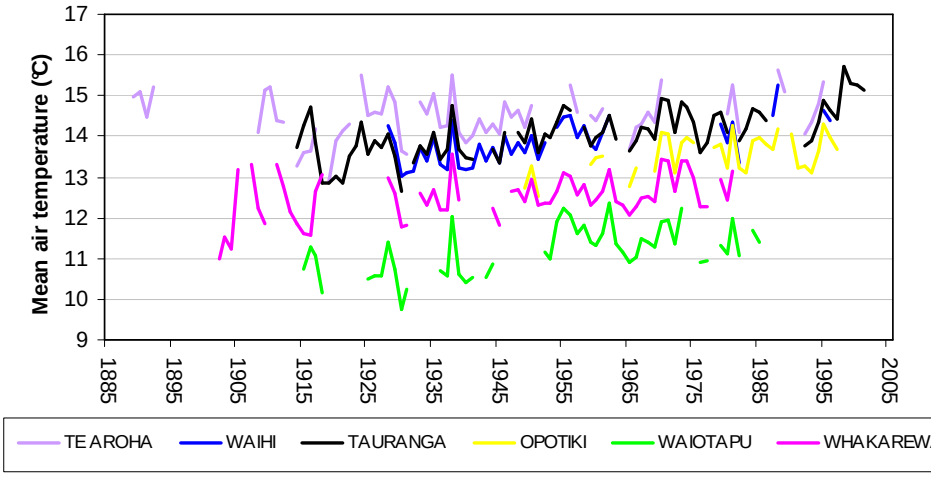


Figure A2: Average temperature at six locations in the Bay of Plenty. Gaps in the curves indicate years with significant amounts of missing data. [Reproduced from Griffiths et al, 2003]

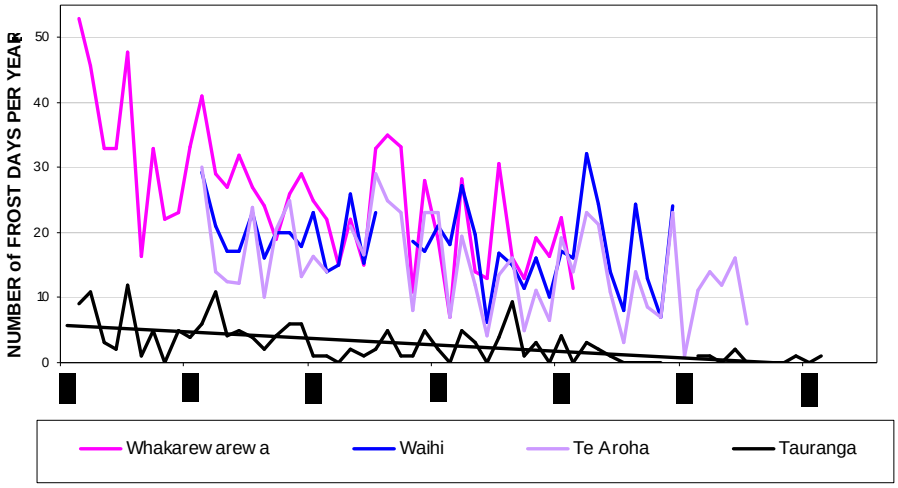


Figure A3: Frost days at four Bay of Plenty stations. A linear trend has been added to Tauranga, used here as the reference station. [Reproduced from Griffiths et al, 2003]

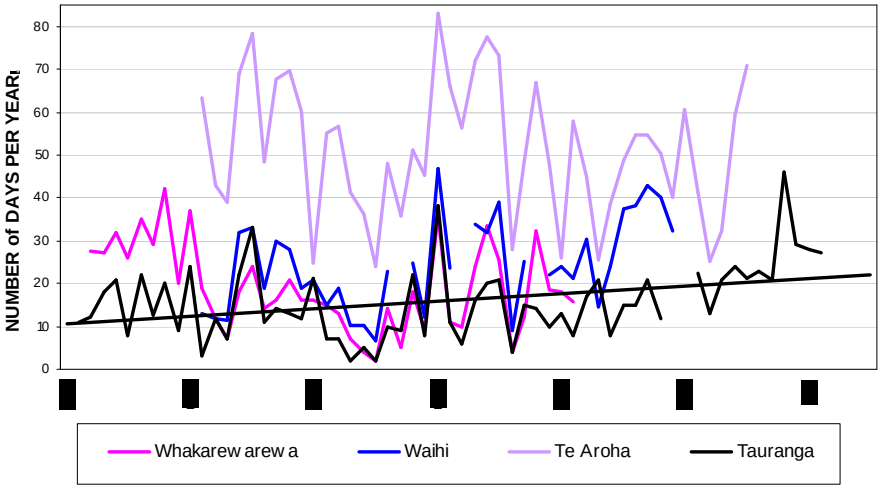


Figure A4: Number of 25℃ days at four Bay of Plen ty stations. A linear trend has been added to Tauranga, used here as the reference station. [Reproduced from Griffiths et al, 2003]

Figure A5: Present (1971 – 2000) median autumn (March–May) air temperature in Bay of Plenty.

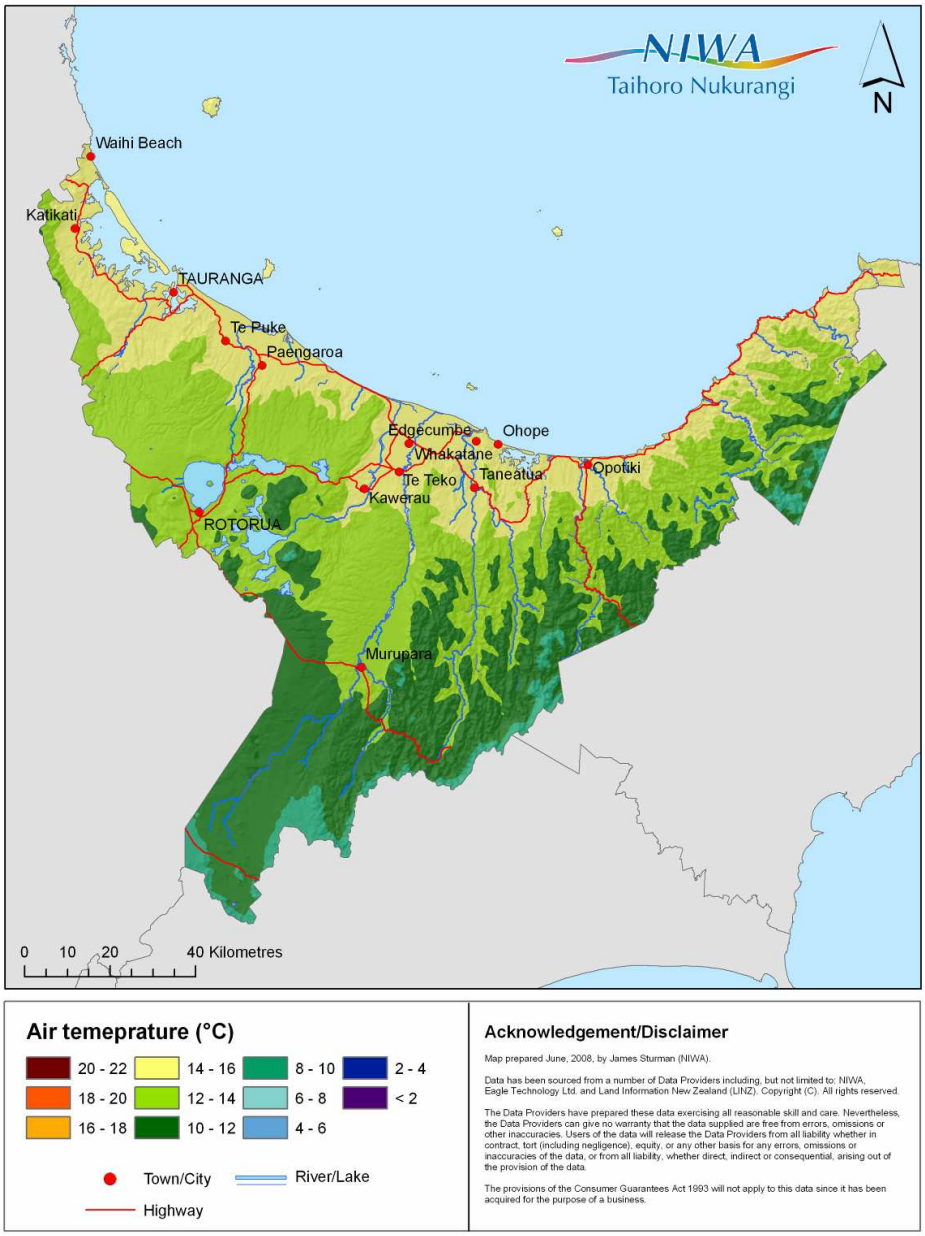


Figure A6: Projected median autumn (March – May) air temperature in Bay of Plenty for the 2040s.

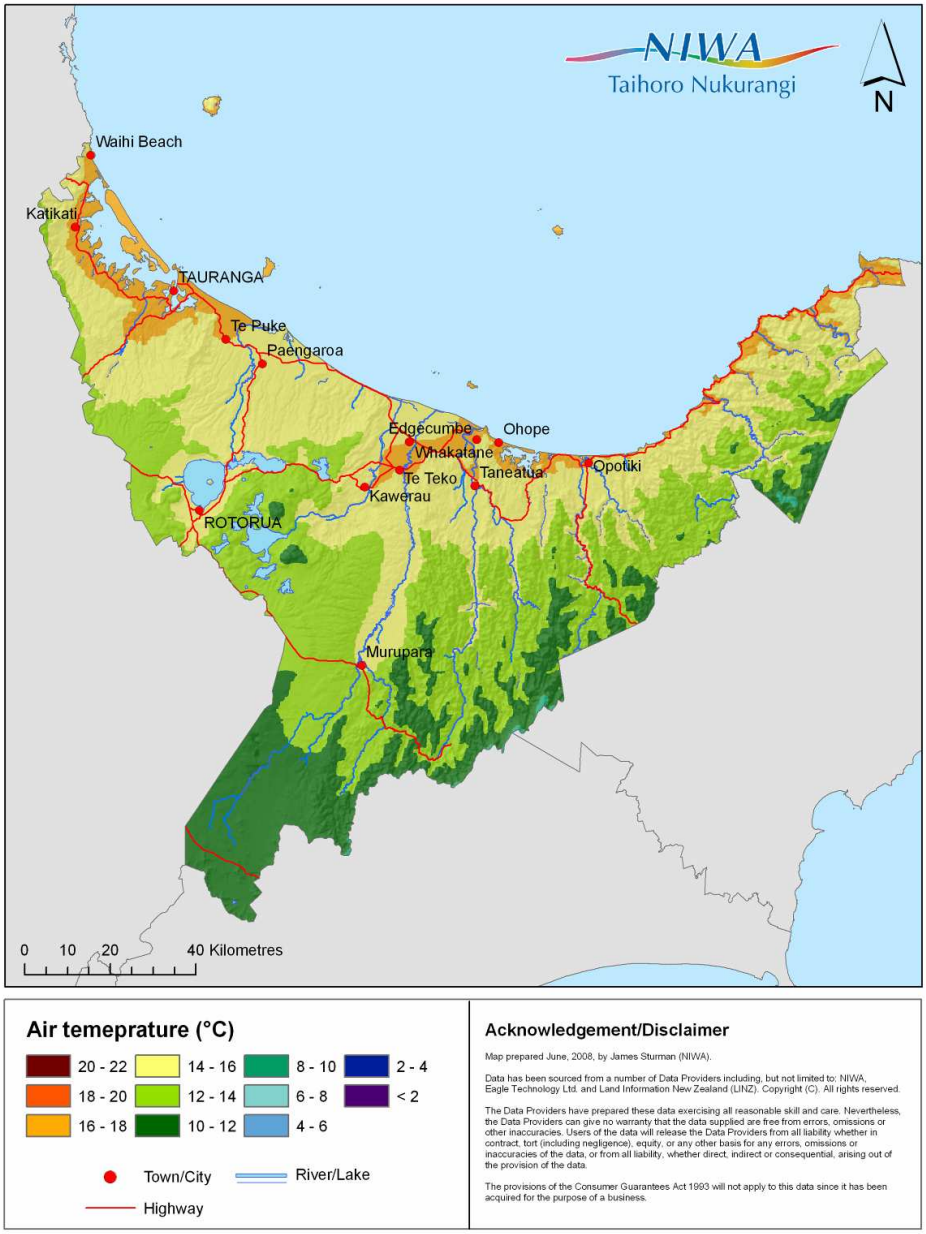


Figure A7: Projected median autumn (March – May) air temperature in Bay of Plenty for the 2090s.

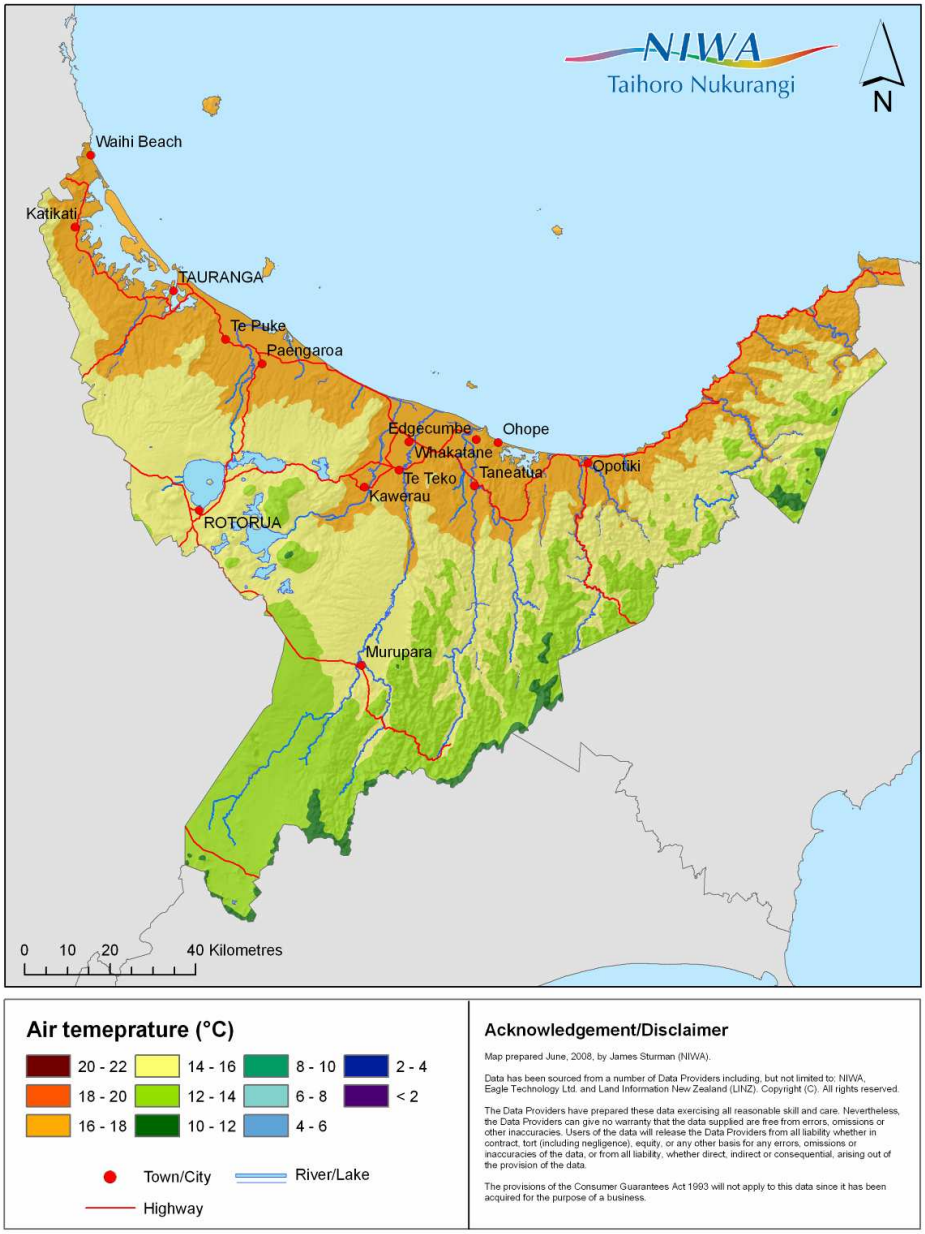


Figure A8: Median June–July air temperature in Bay of Plenty under the present (1971–2000) climate.

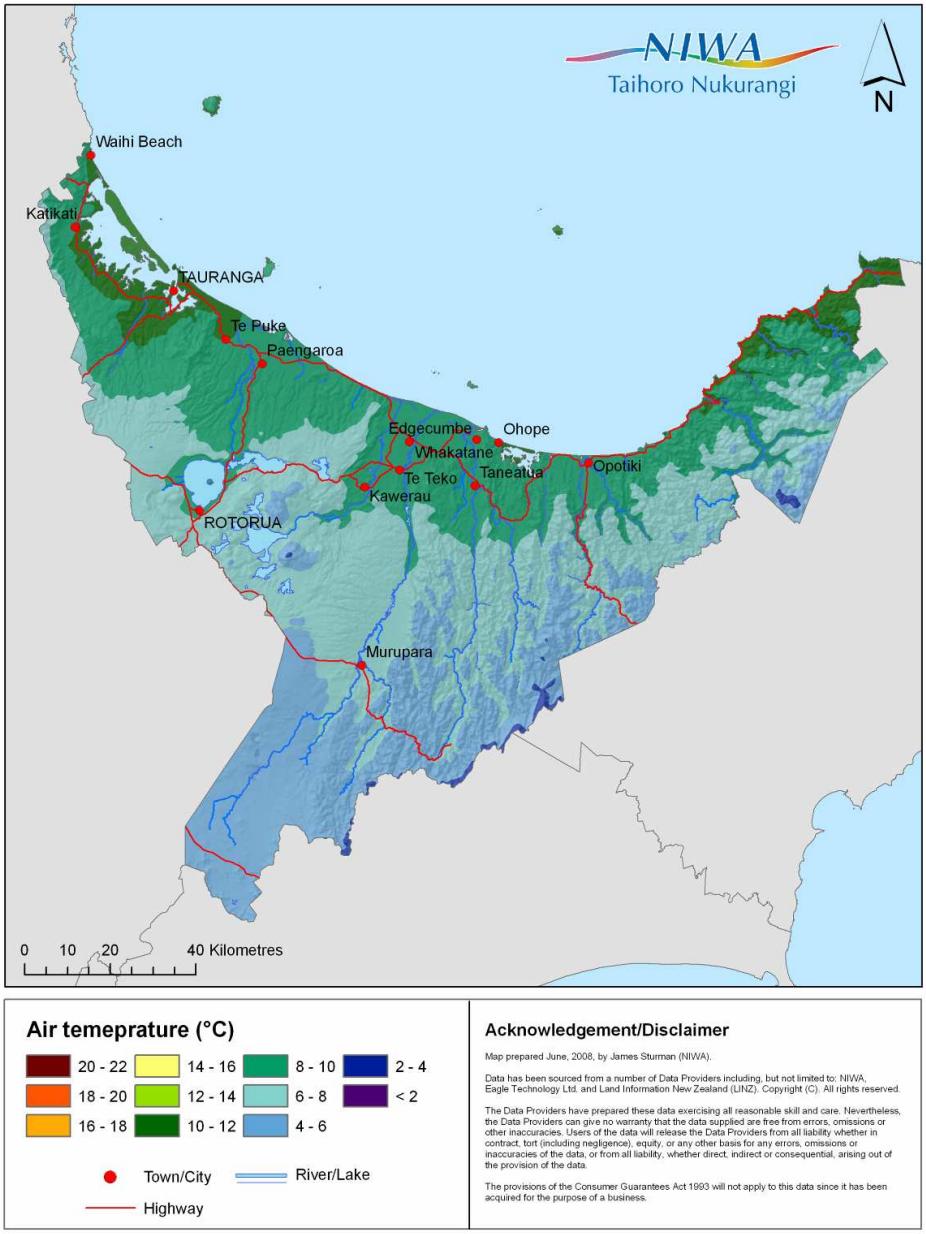


Figure A9: Projected median June–July air temperature in Bay of Plenty for the 2040s.

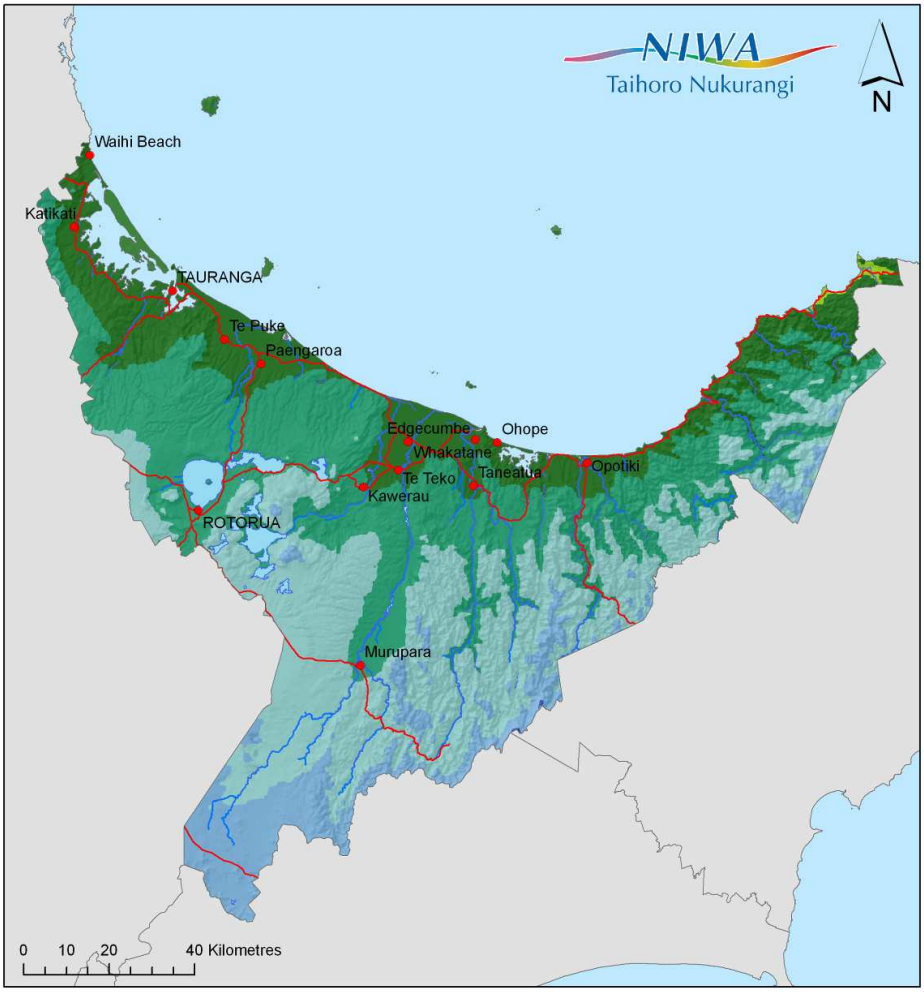


Figure A10: Projected median June–July air temperature in Bay of Plenty for the 2090s.

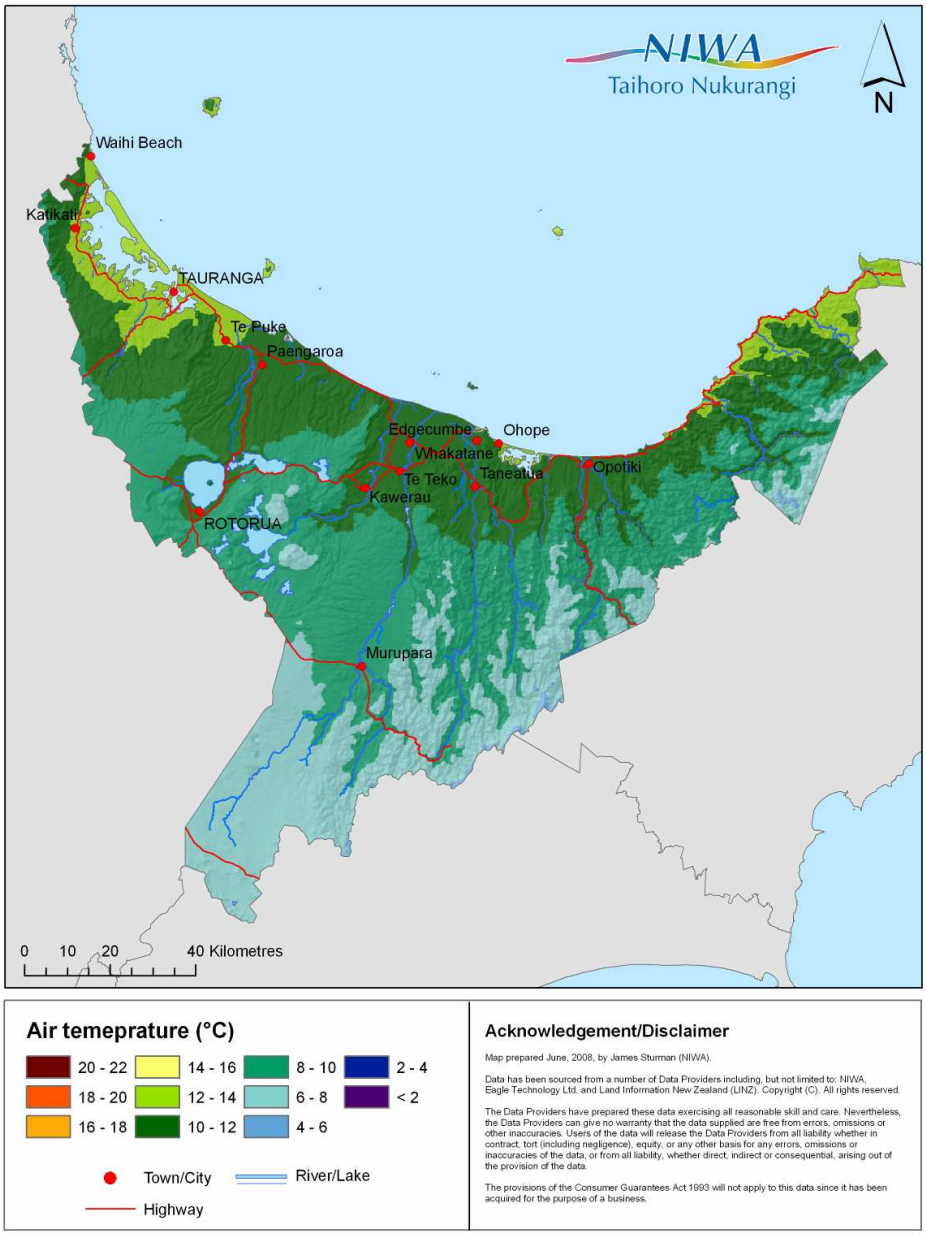


Figure A11: Present (1971 – 2000) median spring (September–November) air temperature in Bay of Plenty.

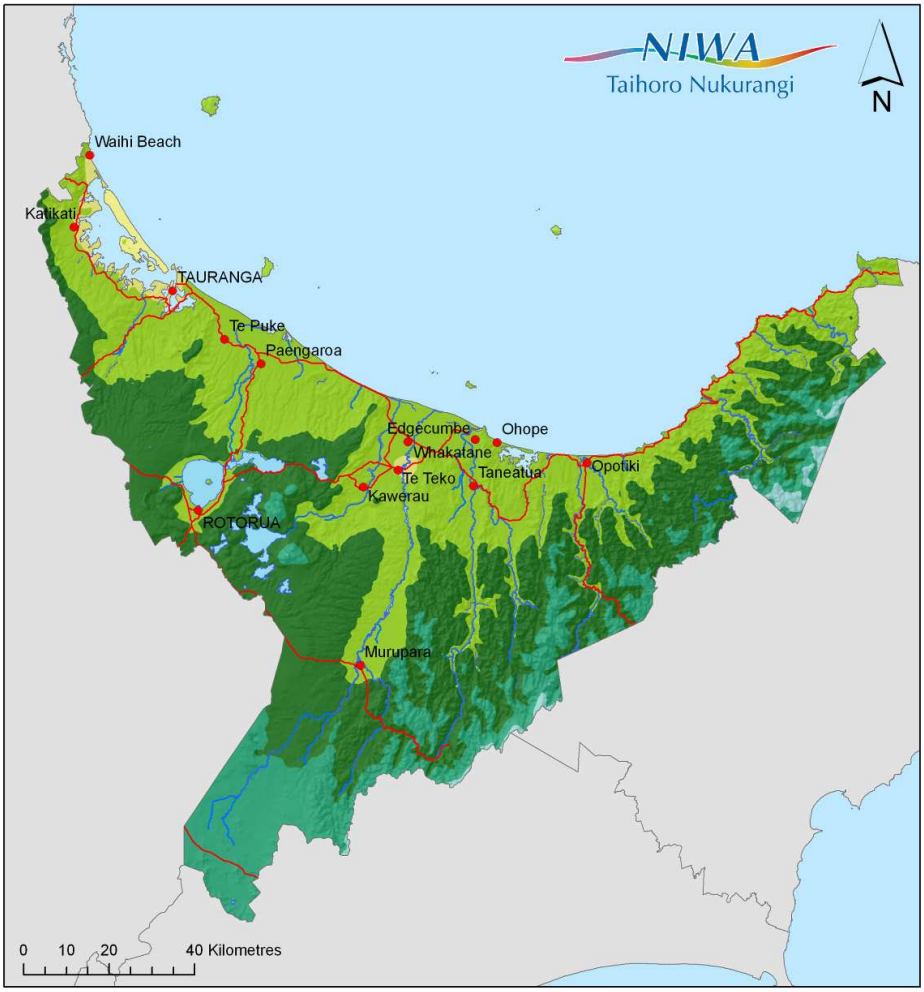


Figure A12: Projected median spring (September–November) air temperature in Bay of Plenty for the 2040s.

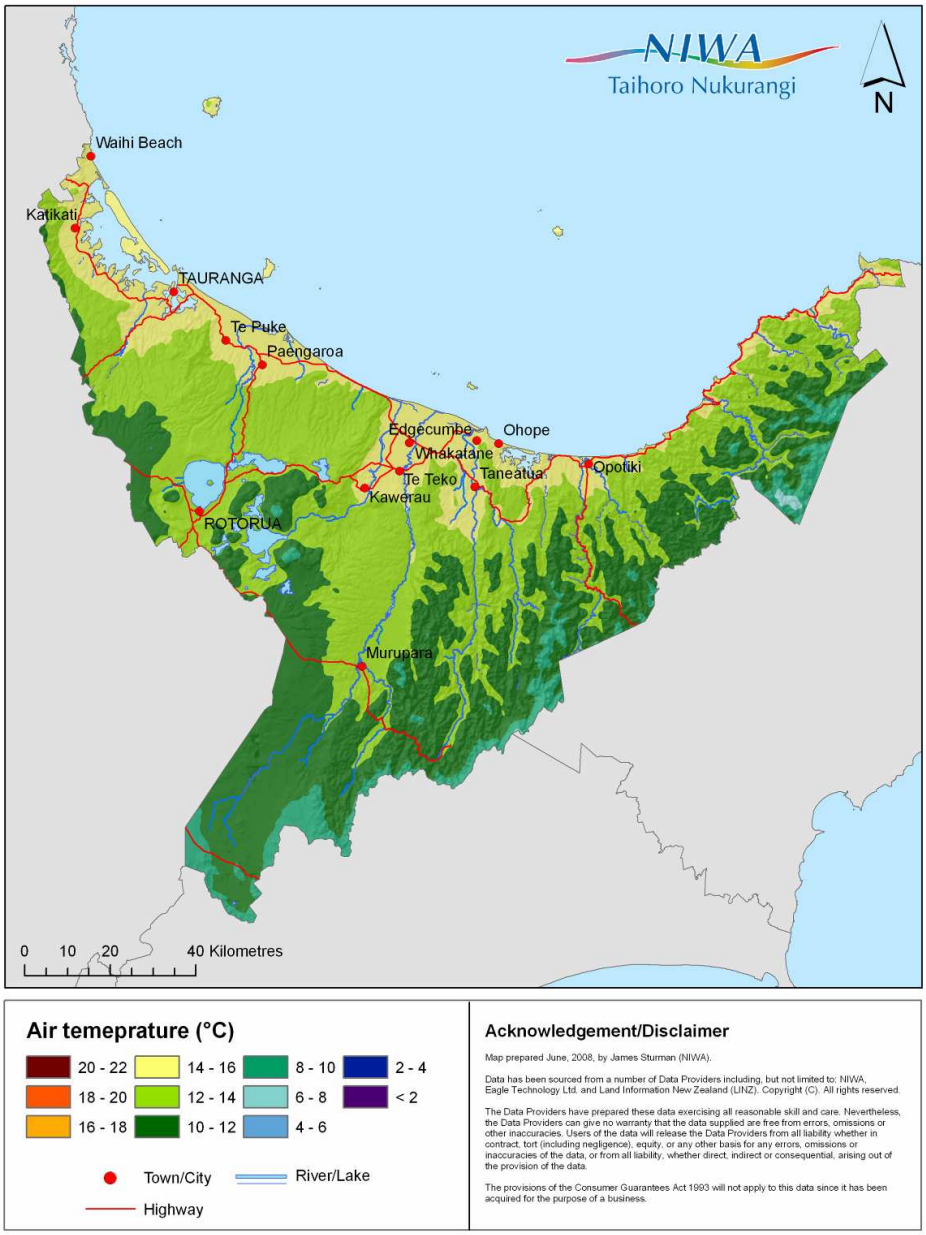
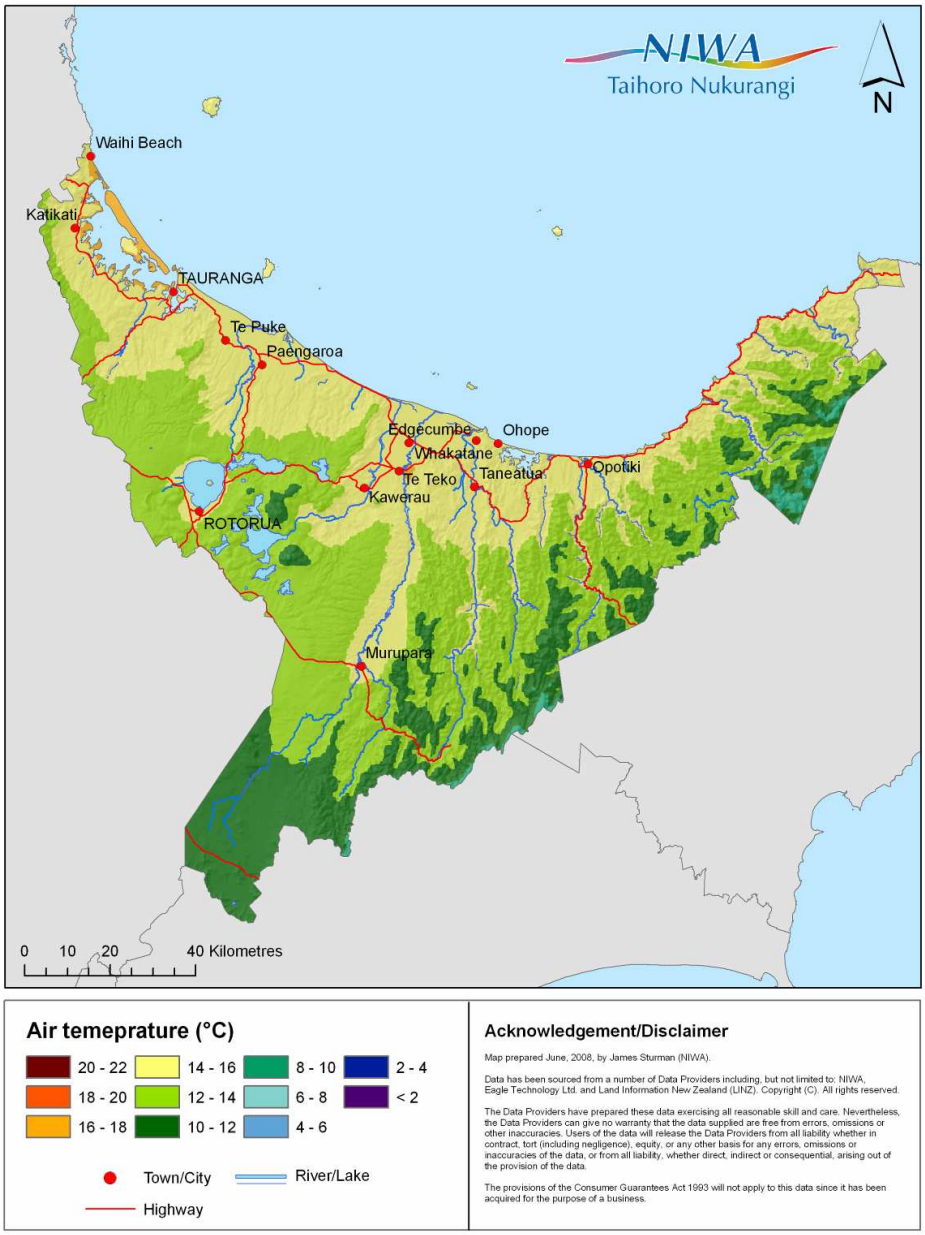


Figure A13: Projected median spring (September–November) air temperature in Bay of Plenty for the 2090s.



Appendix 3: Challenges for kiwifruit production under climate change, prepared by scientists from HortResearch, Te Puke

Short to medium term challenges for kiwifruit production related to climate change are listed below:

1. Breaking winter dormancy as a result of low winter chilling
2. Impacts of warmer spring and summer temperatures on fruit quality and vine vigour
3. Changes to pest and disease problems such as increased establishment of new insect pests, increased overwintering survival of existing pests and diseases, and changes to the distribution and abundance of pests and diseases.
4. Unpredictable climate patterns, such as late spring frosts, increased winds, and changes to rainfall patterns
5. Water becoming a limiting factor

Current and past research activity is addressing or has addressed the effects of climate on budbreak, fruit quality and on some insect pests, and on the effect of water availability on vine growth.

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Chilling requirements for kiwifruit production

Currently low fruit yield as a result of insufficient chilling is a common problem affecting kiwifruit production. The requirement for chilling is expected to become a critical issue as winter temperatures increase and existing budbreak enhancer chemicals such as HiCane are banned. Higher temperatures may also dramatically affect vine vigour increasing management costs.

Opportunities for research: (1) We can screen our large germplasm collection (and /or selected lines) in Kerikeri (a warm climate) and evaluate this material for low chilling requirement. (2) Prioritise introductions (awaiting quarantine testing) from warmer areas in China. (3) Increase and measure response for low chilling requirements on our hybrid populations. (4) Develop new varieties for quite different growing systems studying/ modifying plant and orchard architecture. (5) Address impact of changes to flowering phenology on pollination. (6) Develop alternatives to HiCane.

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Fruit quality, in particular dry matter

Increased temperature could detrimentally affect some fruit quality characteristics such as dry matter accumulation and vitamin C.

Opportunities for research: (1) Scale up our breeding programme for high DM cultivars for current/future climate. (2) Continuing work aimed to understand what determines fruit DM will suggest new management methods that effect DM.

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Changes to insect pests and diseases

Climate change may lead to changes in distribution and abundance of existing insect pests and diseases as well as increasing the likelihood that new pests will establish. Changes to pests and disease incidence threaten organic and conventional kiwifruit production and the ability to export fruit meeting export market requirements for pest- and residue-limited fruit.

Opportunities for research: (1) To screen our germplasm collections and select parental materials for resistance/tolerance to insects and diseases (2) To develop new models or modify current models to assess the impact of climate change on pest abundance and on the establishment of new pests (3) to initiate genomic studies of

insect/pathogen resistance (3) To initiate studies of host-pathogen interaction overseas to understand and predict population behaviour in NZ.

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Late spring frosts

Late spring frost damage reduces productivity and increase growing costs. Our current programmes have mainly focused on flavour and storage but not on late spring frost damage.

Opportunities for research: Similar to 1

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Limited water and changes to rainfall patterns

Most current kiwifruit production in New Zealand is not limited by water availability. Climate change may lead to increasing periods of dry weather that have an impact on fruit production and quality. Research in California and Italy has identified some affects of water stress on fruit development in gold kiwifruit. Amelioration includes adoption of irrigation in the short-term and development of new rootstocks and cultivars in the long-term.

Opportunities for research: (1) Development of rootstocks that are more efficient water users. (2) Further research on plant water-use to identify critical periods for fruit development.