# 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**

New Zealand Climate Change Programme
Te Hōtaka Rerekētanga Āhuarangi ō Aotearoa

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Gavin Kenny
Earthwise Consulting Ltd
Hastings

Published in September 2001 by the
Ministry for the Environment
PO Box 10-362, Wellington, New Zealand

ISBN 0-478-24042-2
ME 412

Ministry for the
Environment
Manatū Mō Te Taiao

# Acknowledgements

This report was written with the help of contributions from Alistair Hall (HortResearch), Pete Jamieson (Crop and Food Research), Brett Mullan (NIWA), Paul Newton and Harry Clark (AgResearch), and Nick Pyke (Foundation for Arable Research).

Thanks are also due to Mike Butcher (NZ Pipfruit Ltd), Garth Eyles and Nigel Ironside (Hawke’s Bay Regional Council), Jacob Haronga (Federated Farmers), Stuart Kay (Zespri International), and Gerald Rys and Chris Ward (MAF) for taking the time to give comments on various drafts of this report.

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# Executive Summary

The main findings of this report are as follows.

- Climate change in New Zealand will probably have the greatest impact on agriculture through changes in climate variability and climate extremes. New Zealand farmers and growers are increasingly required to manage risk associated with climate events, and this will continue into the future with the possibility of increased risk in some regions.
- Eastern regions could experience more frequent, and potentially more severe, droughts through a combination of higher average temperatures, reduced average rainfall, and greater variability of rainfall. Western regions, and possibly some eastern regions, could be more prone to flooding and erosion from high rainfall events.
- Pasture production will generally increase, particularly in southern New Zealand, through higher carbon dioxide levels in the atmosphere and an extended growing season. There may be a reduction in feed quality in pastures as far south as Waikato, with an increased incidence of subtropical species. Feed quality may also decrease further in dry eastern regions, with more frequent drought leading to changes in pasture composition.
- Arable crops may generally benefit from warmer conditions and higher carbon dioxide levels in the atmosphere. However, potential yield increases will require higher fertiliser inputs. Availability of water for irrigation will be an important factor to achieve the potential gains, particularly in Canterbury, where there will be increased drought risk.
- Hayward kiwifruit may become uneconomic in the Bay of Plenty in the next 50 years under mid to high climate warming scenarios, although the current industry expectation is that this variety will continue to be its mainstay. Apple production is unlikely to be adversely affected, although there could be greater risk of heat damage in future and availability of water for irrigation may be an increasingly critical issue.
- There are a number of unknowns both with regard to basic climate changes and their impact on agriculture. While the existence of a human influence on climate, and projections of a trend towards higher future temperatures and a shift in rainfall patterns is considered reasonably robust, projections of absolute changes in particular regions are still highly uncertain and are usually considered as a set of scenarios. Within the agriculture sector, uncertainties about the impacts of those change scenarios particularly relate to changes in pest and disease profiles in different regions, changes in soil fertility, and changes in water availability.

If effective strategies are put in place it is likely that the worst possible effects of climate change on agriculture in New Zealand can be avoided, and the potential benefits realised. The most effective strategies are likely to involve a staged approach involving:

- *for the short term*, further development and implementation of strategies for dealing with present climate variability and extremes
- *for the medium term*, implementing plant-breeding programmes, developing water conservation programmes, and planning conservatively to ensure there are buffers against adverse years
- *for the long-term*, developing a more integrated approach to land management that considers climate change alongside other important issues such as biodiversity, biosecurity, land degradation, and water resource use.

# 1 Introduction

People often ask “What does climate change mean for me?”. When we talk about changes that may take place over the next 50 to 100 years, the obvious reaction is “Why worry? It won’t affect me in my lifetime”.

Climate change is an underlying trend that is already here, as an influence on our seasonal climate and on climatic extremes. The influence of this long-term trend is relatively small at present, but it is likely to increase over the coming decades, with a potential increase in the frequency and severity of extreme events, shift in yearly averages of temperature and precipitation, and probable changes to our present production systems.

Climate variability has a very strong influence on seasonal variations in production. Drought, as experienced in the north and east of the South Island, can have severe and costly effects. Different regions and different sectors are affected in quite different ways, with a mix of costs and benefits in any given year.

Over the past two decades farmers and growers have increasingly needed to develop risk management strategies to cope with climate variability and extremes. Such an approach now forms the basis for MAF guidelines on how to deal with the challenge of climate variability (Ministry of Agriculture and Forestry, 1998; Walker, 2000).. Most of our primary production industry groups are well attuned to climate variability, and an increasing amount of information is available to farmers and growers to help plan for its effects. However, such information does not provide certainty, as indicated by the following quote from the report on the 1997/98 El Niño event:

> *Research has shown that about half of the variability of New Zealand’s climate is potentially predictable. The remaining inherently unpredictable half arises from the random, chaotic nature of the atmosphere.* (Basher, 1999)

New Zealand primary producers face a range of challenges. Along with the effects of climate, they have to deal with an increasingly competitive global economy, an increasing requirement for environmentally friendly production methods, as well as more traditional problems of international competitiveness and market access. All of these issues are dynamic and changing.

It is arguable whether human-induced climate change is already having measurable effects in New Zealand. A southward shift in subtropical pasture species may be an indicator of change, as may an increased frequency of warmer winters in recent decades. It is possible that a recorded halving of the planted area in kiwifruit in Northland over the last six years could be at least partly attributable to a warming climate leading to reduced productivity.

What is most likely is that over the next two decades there will be an increased frequency of climate events and observed changes in our production systems that can be attributed to the effects of a warming climate. Developing a better understanding of what climate change could mean for New Zealand agriculture is no longer just an academic exercise. Planning for future climate change in a way that ensures benefits are realised and costs minimised is increasingly likely to make sound business sense, for present and future generations.

The information contained in this report is largely based on recent case studies that focused on the effects of climate change on:

- pasture production and subtropical grass distribution
- arable crops (wheat and maize)
- kiwifruit and apples.[1]

There is still a lot we don't know. This not only applies to the certainty of regional climate projections several decades into the future, but also the overall effects of these changes on our growing systems including water resources, soil fertility, and pests and diseases. The information presented here is aimed at stimulating a greater understanding of climate change, what it might mean, and the things individuals and industry groups might need to consider in order to plan for the future. Importantly, it is also aimed at stimulating a process for identifying gaps in knowledge and how these need to be addressed.

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1 An important source of information is a recent report prepared by researchers involved in the CLIMPACTS programme (Warrick *et al.*, 2001), funded by the Foundation for Research, Science and Technology. Copies of this report can be requested from the International Global Change Institute, University of Waikato, Private Bag 3105, Hamilton.

# 2 Future New Zealand Climate – The Broad Picture[2]

Global climate models indicate that New Zealand is likely to warm by only about two-thirds of the global mean temperature change that will be experienced in coming decades. This is largely because our climate is controlled by the South Pacific and Antarctic Oceans, which respond only slowly to global temperature changes. In general, temperatures in New Zealand are expected to increase faster in the North Island than in the South Island, and faster in winter than in summer. The difference in average rainfall between western and eastern parts of New Zealand is expected to become stronger, with rainfall likely to increase in the west of the country and decrease in the east. These changes are likely to be more pronounced in winter than in summer.

Scientists are more confident about such general statements than they are about predicting absolute temperature and rainfall in particular places. However, despite this level of uncertainty, scenarios of temperature and rainfall change can be used to examine potential consequences of projected climate changes on agriculture in different parts of New Zealand. The term "scenario " implies that changes in particular areas cannot be predicted with great certainty, but rather that the projections should be used as "what if?" planning tools, i.e. "*What* would the consequences for Canterbury be *if* rainfall decreased by 20%?"

Table 1 summarises the projected annual mean temperature and rainfall changes for major New Zealand regions, using model calculations from four global climate models whose results have been scaled down to allow projections to be made for New Zealand regions. The models assume a continued growth in greenhouse gas emissions, and the table shows the considerable uncertainty for the expected changes in temperature and rainfall at the regional level.

**Table 1:** Range of projected changes in annual mean temperature and precipitation between 1970–99 and 2070–99 from four different global climate models, for continued increases in greenhouse gas emissions

| Region | Temperature (°C)[3] | Precipitation (%)[5] |
|---|---|---|
| Northland, Auckland | +1.0° to +2.8°C | –10% to 0% |
| Western North Island from Waikato to Wellington | +0.8° to +2.7°C | 0% to +20% |
| Eastern North Island from Bay of Plenty to Wairarapa | +0.9° to +2.7°C | –20% to 0% |
| Nelson, Marlborough, to coastal Canterbury and Otago | +0.8° to +2.5°C | –20% to +5% |
| West Coast and Canterbury foothills | +0.6° to +2.5°C | +5% to +25% |
| Southland and inland Otago | +0.6° to +2.2°C | 0% to +30% |

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[2] This section draws on material prepared by Brett Mullan and co-workers, NIWA, and presented in the Ministry for the Environment report *Climate Change Impacts on New Zealand* (Ministry for the Environment, 2001).

[3] The range of changes indicates differences between the four models. Note the potential for strong gradients in rainfall changes across some regions.

The actual impacts associated with future climate changes may however be greater than the average numbers suggest, since changes in average climate are also projected to lead to greater rainfall variability and more extreme events, such as heatwaves, droughts and floods, which are not included in this table.

The average projected temperature and rainfall changes during summer and winter, derived from the same four global climate models used in Table 1, are displayed for New Zealand's regions in Figure 1. As with the changes summarised in Table 1, there is considerable uncertainty about the absolute magnitude of the temperature increase and rainfall changes. Scientists are more confident about the general trend of an increasing difference in rainfall between the west and east coasts, with a likely decrease in average rainfall in many eastern regions, but specific predictions of the amount of change or regional boundaries are considered relatively uncertain at this stage.

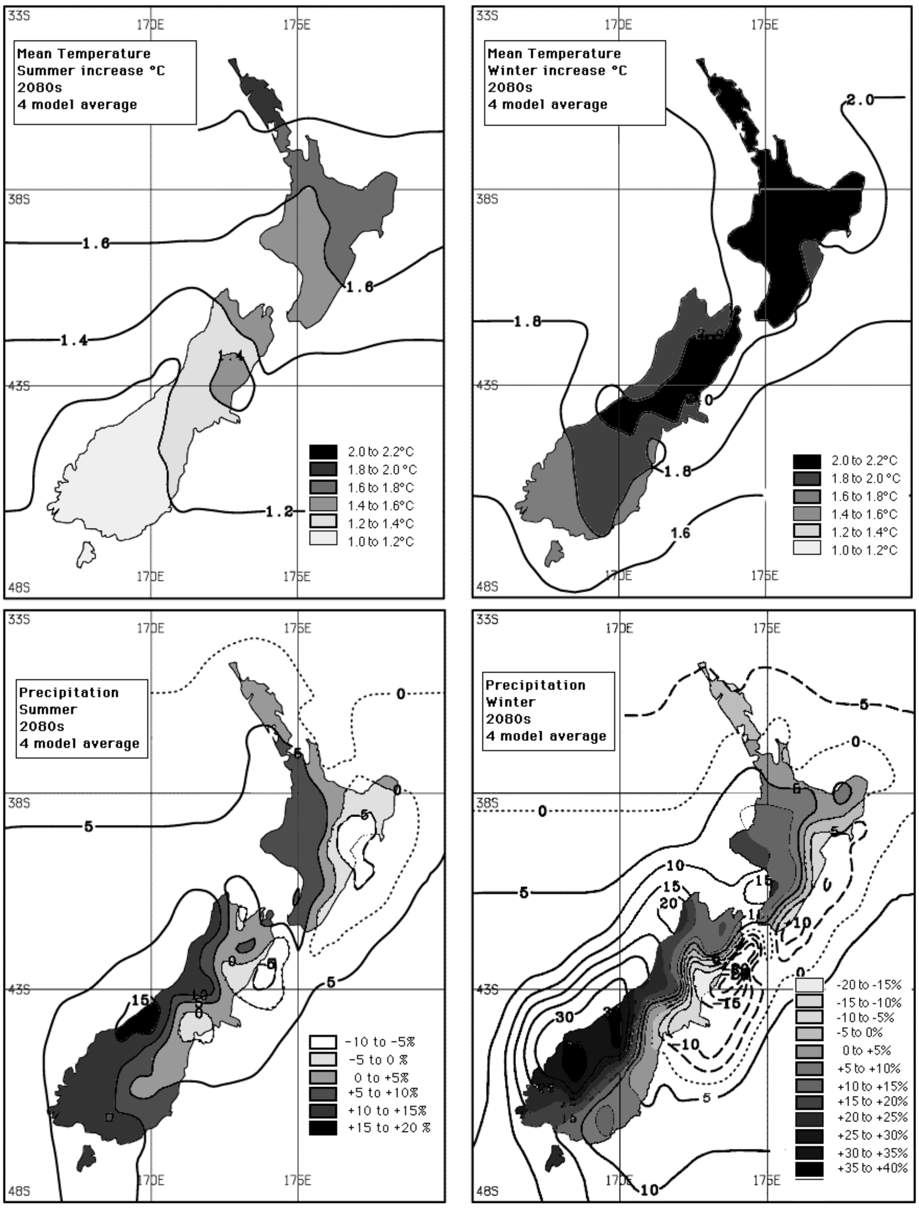


***Figure 1:*** *Average projected changes in annual mean temperature and precipitation between 1970–99 and 2070–99 from four different global climate models for continued increases in greenhouse gas emissions.*

There are two common responses to this information.

***1 “The uncertainties are too great, so why bother doing anything?”***

It is true that there is a large range of uncertainty, particularly with projected rainfall changes. However, uncertainty is already a significant factor in dealing with climate variability. A survey on drought predictability found the following:

**Farmer responses to a drought survey**

40% of a survey of above average farmers considered it impossible to predict drought and adopted a wait and see approach, 20% also considered it impossible but had a strategy ready, while the remaining 40% decided there was a drought by identifying a specific indicator, for example, dry winter or spring, drop in spring pasture, or moisture status at a particular date.

Source: MAF Policy Information Paper 20, Meeting the Challenge: Lessons from previous droughts (Ministry of Agriculture and Forestry, 1998).

There are indicators of long-term change that can be identified and monitored. Examples given earlier noted changes in the distribution of subtropical grass species and potential effects of warmer winters on kiwifruit. Having strategies ready to cope with future conditions that are likely to be warmer – and wetter or drier on average, depending on which region you are in – is a sensible option even if the worst consequences are not realised. Developing and implementing some of those strategies now would have the benefit of improving the ability of farmers and growers to deal with climate extremes and variability that are already occurring, while increasing our capacity to absorb and even benefit from future change.

***2 “The range of projected changes is within the range of what we presently experience”***

This tends to lead to misunderstandings. The numbers given in Table 1 represent changes in the *average* climate. Seasonal climate extremes will be *additional* to the underlying trend, with the likelihood, for example, of more frequent hot, dry summer conditions in the east and thus the potential for more frequent, and possibly more severe, droughts and heatwaves than have been experienced in the past.

More frequent heavy rainfall events could occur in the west and in the main ranges. In brief, apparently small changes in average temperature and rainfall will almost certainly alter the range of extremes we presently experience.

The projected changes in climate will have variable effects. One change that could have widespread adverse consequences is that eastern New Zealand will experience drier conditions.

### Drier Conditions Expected in Eastern New Zealand

The projected rainfall decreases for eastern areas of the Gisborne, Hawke's Bay, Wairarapa, Marlborough and Canterbury regions, in tandem with the expected increases in temperature in these regions, is likely to lead to decreased run-off into rivers and increased evaporation.

Earlier climate scenarios predicted a similar decrease in rainfall in eastern New Zealand and are thus still a useful guide for estimating future changes. This suggests we could experience run-off decreases of around 40% in eastern Marlborough and Canterbury, and decreases of 10 to 40% in eastern areas of the Gisborne, Hawke's Bay and Wairarapa regions.

However, some major eastern rivers whose catchments reach back into the Main Divide or the central North Island high country could maintain or even increase their flows because of projected rainfall increases in these central areas. While the generally drier conditions in eastern areas and increased precipitation in the west are considered relatively robust long-term projections, there are several factors that are still uncertain, and the focus of on-going research, including:

- the magnitude and decadal variability of rainfall changes
- their impact on river flows
- the separation between drier and wetter conditions over the centre of the North and South Islands.

It is likely that under reduced average rainfall and increased evaporation, droughts in the east of the South Island would become more frequent and severe (see Figure 1) and some river reaches could dry up in non-irrigated downland areas, putting increased pressure on current water resources. While little change to groundwater recharge is projected for Canterbury, a greater demand on groundwater for irrigation is also likely. Similar conclusions about ground water, drought and river flows can be drawn for the eastern North Island regions, which are also subject to decreasing rainfall.

Along with a greater risk of drought there could also be an increase in the frequency and intensity of high rainfall events. This would result in a range of impacts, including increased flooding and soil erosion, and increased pressure on government and private flood insurance schemes and disaster relief. Areas most prone to such events are the western coasts of New Zealand, and rivers with catchments near the Main Divide in the South Island or the axial ranges of the North Island. But even in drought-prone areas the risk of extremely heavy rainfall is expected to increase. In areas such as the summer dry hill country of coastal Hawke's Bay, an increased drought frequency coupled with occasional very heavy rainfall could have major adverse effects on soil stability.

These are the likely worst effects that could arise from changes in climatic variability and extremes. They are highlighted to identify some of the changes that could have the greatest negative impact and would require the greatest level of preparedness. A range of positive impacts on agriculture are likely to arise not so much from the change in climate itself, but from the increased carbon dioxide concentrations in the atmosphere which lead to faster plant growth and increased water use efficiency. Higher winter temperatures and a consequent extension of the growing season are expected to have beneficial effects particularly in southern areas.

Summaries of the current knowledge of climate change impacts on specific agricultural sectors are provided in the following chapters.

# 3 Climate Change and Pastoral Agriculture

## 3.1 The present situation

Climate variability is a significant determinant of year-to-year variations in production for pastoral agriculture, and thus can have a significant impact on the New Zealand economy. For example, the farm-gate cost to agriculture of the 1997/98 El Niño drought was estimated at over $425 million, the bulk of which was borne by the pastoral sector. Such costs, of course, were not spread uniformly throughout New Zealand.

In New Zealand a diversity of farming systems operate in a variety of regional and local climates. These range from the dairy farms of the subtropical north to the high country sheep farms of the south. At a regional scale, certain climate influences can be identified that have become increasingly important in recent years. For example, in the north, higher temperatures over the last couple of decades have encouraged the spread of kikuyu, which is requiring adjustment of farm management practices. In eastern areas there has been the far more dramatic effect of drought, on a widespread basis during the 1997/98 El Niño event and, more regionally, in the eastern South Island over the summer of 2000/01.

Farmers have had to adjust to many changes over the last decade or so, with an increased focus on risk management. Increasingly they are required to bear the cost of climate variability, highlighted by the fact that the first catastrophe insurance was offered in 2000. Different regions, different industry groups and different individuals have varying capacities to cope.

Presently, the dairy industry in New Zealand is well adjusted to the effects of climate variability. The climates of our major dairy production regions, in the north and west of the North Island, provide adequate rainfall and sufficient warmth in most years. During the 1997/98 El Niño event there were mixed results for the industry. Spring milk production was the highest on record, but summer drought conditions developed in the main production areas leading to a decline in production in the latter part of the season. Farmers recovered quickly from this summer drought, and in the 1999/2000 season production was up by about 14% and was mainly attributed to good climatic conditions.

The vulnerability of the dairy industry to drought could increase if the planned expansion into Canterbury occurs. In the 2000/01 season Canterbury dairy farmers faced irrigation bans, which led to high supplementary feed costs. This situation could be repeated with greater frequency in future because of increased water demands for expanding and more productive farms, even without considering the effects of climate change.

Sheep and beef farmers are spread over a diversity of land types and climates throughout New Zealand. In general, they have been more economically affected in recent years than the dairy sector. A poor season, combined with a competitive global market, can have a big impact. In recent years drought has had a significant affect on sheep and beef farmers in eastern New Zealand. Hot, dry conditions tend to exceed the optimum growing range for ryegrass and clover, with less productive pasture species appearing. A shortage of summer feed often leads to the early use of winter feed stores, as occurred in the most recent drought in the eastern South

Island. A range of other factors, such as animal health and welfare concerns, can also arise in a drought situation.

**Drought in Marlborough**

Drought had a dominant effect on hill country farms in Marlborough in 1997/98. Summer greenfeed crops failed. Farmers had to begin feeding conserved or bought-in feed very early. Lamb growth rates were below average, and some cow herds were completely dispersed. It was estimated that up to 35% of breeding cows in Marlborough were killed. By the 1999/2000 season stock numbers were recovering, with small increases planned for the 2000/2001 financial year. It was generally felt that the availability of good feed supplies had helped prevent stock numbers drop as dramatically as during droughts in the 1980s. The 2000/2001 year resulted in another severe drought with a relief package prepared by Government for farmers who had suffered from the fires that hit the region.

Source: Canterbury/Marlborough Farm Monitoring Reports for 1997/98, 1998/99, 1999/2000. Available at the MAFnet web site, http://www.maf.govt.nz (Ministry of Agriculture and Forestry, 1998, 1999, 2000).

An increased amount of information is available to farmers, ranging from seasonal forecasts provided through the National Institute of Water and Atmospheric Research (NIWA), often in close collaboration with regional councils, to initiatives from service industries such as the drought recovery package developed by Wrightson Ltd (Agriculture New Zealand, 1998). This information provides an improved framework for decision-making in a drought – but not long-term remedies.

Indications are that in coming years farmers will have to adjust to variations in climate much more than in the past as a result of climate change. Making the best use of available information on climate variability and change will continue to be important.

## 3.2 What effect will climate change have on pastoral agriculture?

It is likely that climate change will have beneficial effects on pasture production over coming decades. Higher atmospheric concentrations of carbon dioxide will increase photosynthesis (the so called ‘carbon-fertilisation’ effect), allow for more efficient use of available water and improve pasture growth rates, particularly with temperate pasture. Experimental and modelling studies indicate that the higher temperatures and carbon dioxide concentration expected by 2030 could lead to up to a 10 to 20% increase in annual pasture yields. Rates of increase are predicted to slow in the latter part of the century. The highest increases are expected in cooler, wetter areas such as the southern South Island, while already warm and dry areas are expected to gain least. These model results do not consider factors such as changes in seasonal distribution of yield due potential increases in summer drought, changes in pasture composition, and the potential for the spread of less productive subtropical species.

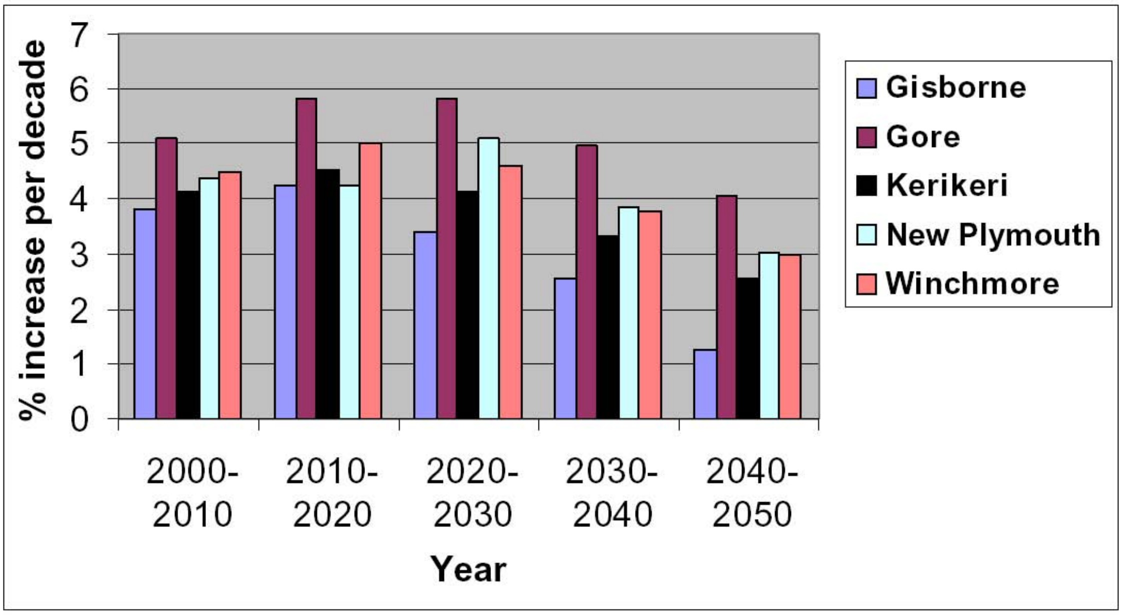


***Figure 2:*** *Average projected changes in pasture yield at 5 different sites in New Zealand. The projections use the output of one specific climate change model and assume continued growth in greenhouse gas emissions. Source: Warrick* et al. *(2001).*

Little change in the seasonal distribution of pasture yield is expected in most areas. However, some reduction in summer productivity could occur in areas where an increased risk of drought is predicted, mainly Hawke's Bay, Wairarapa, the eastern South Island and Central Otago. The potential change in drought frequency and intensity under climate change in New Zealand is the subject of ongoing research.

### Summer dry hill country in Hawke's Bay

Most of the eastern summer dry hill country in Hawke's Bay experiences significant problems during drought years. Current pasture species aren't well suited to drought conditions, and the inability to cultivate the land doesn't provide a lot of scope for pasture replacement. No work has been done on alternative species for the region. If there is a greater frequency of drought years then this could have quite disastrous effects in this area, if the current pasture grazing system is maintained.

Source: Garth Eyles, Hawke's Bay Regional Council (personal communication).

Pasture composition is likely to change due to different responses of pasture species to increased carbon dioxide, temperature and moisture supply. Legumes and weedy species respond more strongly to increased carbon dioxide than most grasses, and experimental evidence points towards an increased legume component in pastures. However, this shift is also likely to depend on soil moisture availability and temperature, and the legume and grass species already present. Changes in pasture composition will therefore differ from region to region, but it is likely that the more drought-prone eastern regions will be most strongly affected.

The potential spread of lower feed-quality subtropical grasses into pastures is a concern. A 1990 study found a southward shift of 1.5º latitude (roughly from mid-Waikato/East Cape to Wanganui/Cape Kidnappers) in the occurrence of the subtropical grass *Paspalum dilatatum* between 1976 and 1988. Under warmer conditions paspalum could become prevalent in all of the Waikato, and parts of Taranaki and the North Island east coast.

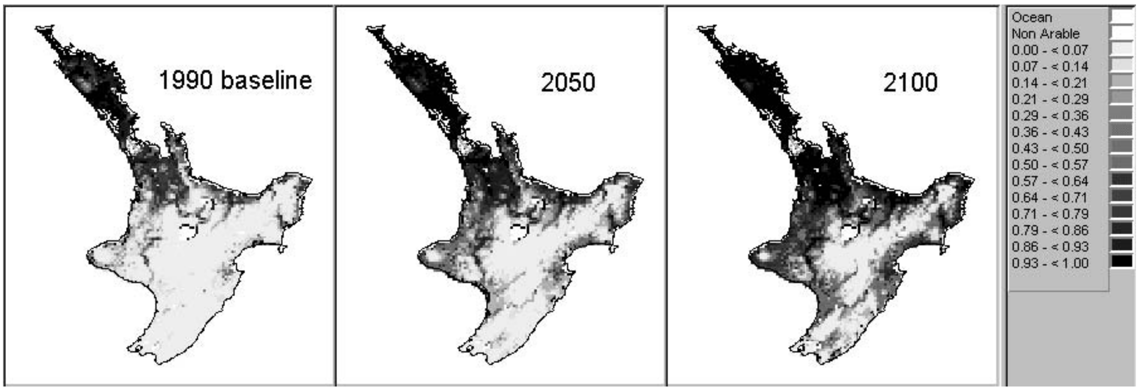


***Figure 3:*** *Projected changes in the likelihood of occurrence of the subtropical grass paspalum under a scenario of continued greenhouse gas emissions, using projections from one specific climate change model. Source: Ministry for the Environment (2001).*

A southward shift in the prevalence of kikuyu is already being noted in Northland, and is likely to continue. While subtropical grasses are of lower feed quality than temperate species, they do have the potential to provide animal feed during periods of low soil moisture. At the same time, there is the potential for higher methane emissions from cattle and sheep that feed on lower quality subtropical grasses. Methane is an important greenhouse gas, and New Zealand is looking for ways to reduce emissions of such gases.

The overall impact of climate change on pasture quality and animal performance is difficult to quantify and will vary by region, with the greatest potential for negative effects in Northland, Waikato, the eastern North Island, and possibly the east of the South Island under projected rainfall decreases, particularly if drought conditions become more frequent. Pastures in southern areas of the South Island are likely to see the biggest benefits from climate change. Increased legume content would improve pasture quality where sufficient soil moisture is available. The expected increased presence of subtropical grasses would be detrimental in the north. Careful management and targeted plant breeding will be necessary to ensure that the benefits from an increased presence of subtropical species (through greater drought tolerance) outweigh the potential negative impacts on animal performance.

## 3.3 What don't we know yet?

Overall effects on animal production and health have not been quantified yet. Particularly nutrient cycling and the botanical composition of pastures will also alter under climate change, with the potential to modify overall feed quality, soil fertility and fertiliser requirements. Climate change will also alter the range, identity and incidence of our current pest, weed and disease problems and it will be important to identify details of these changes. The possible extent and overall effect of such changes has not been quantified yet. Changes in water availability also need to be better quantified, which will be particularly important to eastern hill country farmers.

Despite these uncertainties, scientists now widely agree that that the climate is changing due to human influences, and that it will continue to change towards warmer conditions throughout the 21st century. This will have measurable effects at the farm scale in our lifetimes, whether through an increased incidence of paspalum or kikuyu or other pasture composition changes, an increased productivity of some pastures, a greater frequency of drought years or general changes in water availability. It is not clear at this stage where the balance between positive and negative impacts will lie. Despite this uncertainty, it appears very plausible that proactive adaptation to these changes will help farmers to shift the balance more towards the positive side of effects. Ongoing research will help address some of these issues and provide a better basis for informed decision-making.

## 3.4 What measures can be taken to adapt?

One approach in the face of current uncertainties is to develop a range of strategies that are compatible with short-, medium- and long-term farm management plans.

### Short-term planning

In the short term, the best option is to keep developing and implementing strategies for dealing with present climate variability. Such strategies will arise from individual farmer experience, farmer discussion groups, service industries and improved linkages with climate monitoring and short-term prediction services. Regional councils have an important role in this context, and some are very proactive in working with farmers, particularly on soil and water conservation.

A good source of information on drought is the drought-recovery strategies report prepared by Agriculture New Zealand (1998). This report provides a comprehensive range of options that can be implemented in the short term. MAF has identified key factors that contribute to recovery from drought (Ministry of Agriculture and Forestry, 1998). In northern New Zealand drought is less of a problem, but some areas are experiencing increasing problems with invasive subtropical species. A range of management practices are used, including spraying and re-sowing of pasture, and mulching mower management, which has been used effectively to manage kikuyu on dairy farms in Northland.

### Medium-term planning

Medium-term planning may need to take more explicit account of some of the changes that are expected with climate change. Pasture breeding programmes should focus increasingly on higher temperature- and drought-tolerant species which also provide high feed quality. Availability of water for irrigation will be an increasingly important management issue, particularly in eastern regions. Developing efficient and effective water conservation strategies should become a priority, which will be driven by continued increases in demand. The uncertainty of a changing climate and the need to deal with an increasingly competitive global market will probably require an increasingly delicate balance between conservatism and risk-taking in farm planning. Climate change will also affect our global export market, which could have both positive and negative effects on our export potential, in addition to the strong exposure that New Zealand agriculture already experiences.

## Long-term planning

A long-term farm plan has a timescale of no more than 20 to 30 years and is normally focused on issues such as catchment management for soil conservation, as encouraged by the Hawke's Bay Regional Council, for example. Ideally, strategies to adapt to climate change need to be considered over even longer time horizons, out to the next 50 to 100 years, and designed around whole catchment planning that encompasses climate change along with a range of other issues, including biodiversity, biosecurity, land degradation and water resource use.

In the short to medium term, the pastoral sector could gain under climate change conditions if it effectively manages the potential changes in soil moisture availability and species composition. This would probably require a range of adaptation measures, targeted regionally, including the wider use of current drought-tolerant species, and development of new drought-tolerant forage species and high-quality subtropical grasses. Long-term impacts and adaptation measures are very uncertain at this stage, particularly due to the limited knowledge of changes in rainfall patterns and the rate at which extreme events like droughts and heavy rainfall will occur. Current models indicate that the benefits from climate change will gradually decrease, while the negative effects from extreme events are likely to become stronger as climate change progresses.

# 4 Climate Change and Arable Crops

## 4.1 The present situation

Arable cropping is a relatively small contributor to the New Zealand economy, but is an important component of our agricultural system, particularly in Canterbury, where arable cropping is a dominant land use. The 1999 statistical survey shows New Zealand with a total cropped area of 212,000 ha, of which 67% was in Canterbury. Canterbury is the principal growing region for wheat, barley and peas. Grass seed is also a major crop. Other regions of importance for temperate crops are Otago, Southland and Manawatu. Waikato is the predominant growing region for maize.

Compared to recent years, confidence is generally high in the arable sector at present and this is expected to continue for some time. The expansion of the dairy industry in Canterbury and Southland is providing new options for arable farmers. Confidence for peas, both for process and seed production, is not high at present. Grain maize production is showing average confidence, with much higher confidence in silage maize.

The regional diversity of New Zealand's climate provides the opportunity to grow a variety of arable crops successfully, as indicated above. Year-to-year variations in climate can have significant impacts on production. A poor growing season combined with poor market conditions can have significant adverse effects. Arable farmers have developed a strong capacity to adapt to climate variability, and it is likely that this adaptive capacity will be needed in the future with the increasing influence of climate change.

## 4.2 What effect will climate change have on arable cropping?

Climate change is likely to be generally positive for arable cropping. Higher temperatures will allow earlier sowing of crops, and they will generally reach maturity faster – depending on sowing time. Higher temperatures could lead to decreased yields, but the fertilising effect of higher levels of carbon dioxide will potentially offset this, resulting in yield increases for temperate crops such as wheat and barley. Crops such as maize, which utilise carbon dioxide differently to the temperate crops, show little or no yield response to higher levels of carbon dioxide. However, higher temperatures will generally increase opportunities for growing maize and similar crops in cooler regions.

A recent study of the effects of a range of scenarios on wheat production indicates a 10 to 15% increase in wheat productivity by 2050 (Jamieson and Cloughley, 2001). This positive yield response is due to carbon dioxide fertilisation offsetting the negative yield response due to reduced grain filling under higher temperatures. However, increased use of nitrogen fertiliser would be required to achieve these potential yield increases, and irrigation will continue to be vital for wheat production, particularly under higher average temperatures and in the lighter soils of Canterbury and Manawatu.

Similar opportunities and constraints apply to the production of maize. Maize will probably not show a strong yield response in present areas of production, but there will be increased opportunities over time to grow a greater range of hybrids in more southern locations. Canterbury, in particularly, could gain with climate conditions becoming increasingly suitable for maize production, particularly from about 2030 onwards, due to reduced risk of frost and higher summer temperatures. However, maize has a longer growing season than crops such as wheat and has a higher demand for soil moisture, so the availability of water for irrigation will be crucial, particularly with anticipated increases in drought risk in Canterbury. Also, the potential for a higher turnover of soil organic matter under warmer and drier conditions on the low organic carbon soils in some parts of Canterbury would require careful management with a nutrient-demanding crop such as maize.

The greatest risk issue for arable cropping, particularly in eastern regions, will probably be the availability of water. Demand for water is expected to increase due to increased evaporation and a possible reduction in average rainfall. In some regions, surface water resources are already fully allocated. Any increases in surface water, and potential for greater recharge of ground water, will largely depend on rainfall changes in the main ranges, which remain highly uncertain, and the extent to which river catchments reach back into the main ranges. The capital costs for irrigation will therefore probably increase, with more water required on more land and (potentially) for longer periods, with the likelihood of greater regulatory costs. This could be a major barrier to any expansion of irrigation and increase the potential for crop losses under increased drought risk. Thus there will be a need for more efficient water use by growers using irrigation, and improved water conservation practices in dryland systems.

Another import factor will be changes in pests and diseases. These have not been subject to a detailed study under climate change conditions yet and therefore projections are highly uncertain. In general, however, warmer, drier conditions in the east could reduce the incidence of some cereal diseases that favour humid conditions. Disease problems with maize, such as leaf blights, could become more prevalent in the Waikato, where conditions are likely to be warmer and more humid.

## 4.3 What measures can be taken to adapt?

Despite the overall positive outlook for the near term, a number of adaptive measures have been identified for arable cropping, which will probably need to be considered over time [9]. Proactive adaptation could not only avoid negative impacts from identified risks, but also increase the benefits of climate change to arable cropping.

- Breeding new cultivars that are suited to changing conditions in the different arable cropping regions in New Zealand may be required.
- Arable crops such as soybeans, rice and sorghum may become increasingly viable in some areas. Success of such crops will be strongly dependent on market conditions in the future.
- Changed pest and disease regimes could require altered plant protection strategies.
- Any geographical changes in crops grown could require changes in infrastructure that need to be considered long-term (for example, irrigation systems and water resource allocation).

### Process vegetable crops

For companies such as Heinz-Watties, who contract growers to produce sweetcorn, peas and tomatoes for processing, the main issue is the short-term management of present climate variability. Of particular importance is the variability around the harvest span. The company relies on pre-season estimates of what the harvest date is likely to be and uses that to establish the timing for processing at the factory. Changes from these estimates as the season progresses can incur significant costs. From 30 years of records the harvest span varies between 50–75 days. Warmer conditions with climate change are not seen as a big issue as such. Of importance are the implications for climate variability and effects this could have on harvest span.

Pests and diseases could also be a problem for process vegetables. For example, green vegetable bug, which has been in New Zealand for decades, has only recently become a problem in Gisborne. It is hard to say if this is related to a changing climate, but it is indicative of the indirect effects that could be associated with future climatic changes. Water is also an issue of importance, and there is a concern that if water supply becomes a limiting factor in places like Hawke's Bay, annual croppers could lose out in favour of higher value perennial crops.

Source: Stuart Davis, Heinz-Watties (personal communication).

# 5 Climate Change and Fruit Production

Variations in climate, between regions and between years, can have a strong influence on horticultural production. In general, a warmer climate will have benefits for production of subtropical fruits such as avocados and citrus. There will be both costs and benefits for temperate fruits such as kiwifruit and apples, depending on location. Generally, wine grapes will benefit if sufficient water supply is available.

To date, detailed studies on the possible effects of climate change have only been done on kiwifruit and apples. The sections below highlight some of the complexities involved in considering the effects of climate change on these fruit crops.

## 5.1 Kiwifruit

### The present situation

Kiwifruit is grown commercially at a range of locations, but predominantly in the Bay of Plenty, where 73% of the national crop is grown. Soil and climate conditions are considered to be optimal in this region, but it is now widely acknowledged that winter temperatures do not always provide sufficient chilling for adequate bud break and flowering. The Northland growing region, centred on Kerikeri, is even more marginal. For example, the warm winter in 1998 led to a significant reduction in flower buds. An increased frequency of warm winters in recent years is probably one of the factors that have led to a decline in kiwifruit in Northland, with a halving of the area planted (from 1382 ha to 639 ha) in the period 1994–2000.

Other regions, such as Hawke's Bay and Nelson, meet the chilling requirement more often but can suffer other problems. For example, there is a greater risk of crop losses due to late frosts in spring. This occurred in Nelson in September 2000, with a late frost wiping out 25% of the forecast crop at an estimated loss of $5 million. On the positive side, the cooler winters in Hawke's Bay lead to an earlier harvest, for which growers in this region get a bonus.

Warmer than average winters are not always bad news. The warm winter of 1998, while leading to a significant reduction in flower buds in Northland, was followed by a warm summer and resulted in larger average fruit size across the growing regions and a very profitable season for the kiwifruit industry.

Kiwifruit orchardists manage their crops to specified quality criteria and implement a range of techniques to deal with variations in climate. The overriding influence on orchard management decisions is the market place, and this is likely to continue into the near future. The introduction of the new Zespri Gold variety has provided a buffer for growers against possible adverse production years with the Hayward variety. There is an on-going breeding programme to develop new cultivars, and while there are many factors that need to be taken into account to meet the needs of the market, the potential benefits of varieties with a low winter chilling requirement are being considered. Organic growers already implement a range of strategies to offset the effects of warmer winters, and acceptable alternatives to HiCane (a product containing hydrogen cyanamide used to promote flowering) are also being evaluated.

**Kiwifruit breeding programme**

Important attributes in selection of new kiwifruit varieties are the need for good taste, good handling and a long storage life, all attributes that have made Hayward kiwifruit so successful. Along with such attributes, HortResearch scientists are evaluating new varieties for reduced sensitivity to warm winters. Their plant collection contains many selections and species that appear to have less sensitivity than Hayward and Zespri Gold. If new varieties are successfully introduced then this would overcome the problems that are experienced with mild winters and reduce the need for HiCane.

Source: News Note – New Kiwifruit Variety Looking Good After Mild Winter (HortNet, http://www.hortnet.co.nz/news/note/tomua.htm).

## What effect will climate change have on kiwifruit?

The trend towards a warmer climate will lead to an increased frequency of warmer winters, with western Bay of Plenty growing conditions projected to become comparable to present-day Northland (Kerikeri) conditions over the next 60 to 100 years. Results of a recent study show that warmer temperatures would lead to progressively earlier dates of bud break, but there would not be any significant change in the average date of maturity, except in Northland, where there is likely to be a significant change towards later maturity dates.

While this is important information it does not give an indication of how well the kiwifruit crop will perform under a warmer climate. An indicator of crop performance used in a recent study was the number of ‘king’ flowers per winter bud. Experience shows that when there is less than one king flower per winter bud, growing Hayward kiwifruit becomes uneconomic.

Studies of the effect of climate change on the mean number of flowers per winter bud show that the marginal situation in Northland could become increasingly marginal, and that conditions in Bay of Plenty could become uneconomic for Hayward kiwifruit in 50 years’ time under a high-end climate change scenario. Conditions are likely to remain suitable in Hawke’s Bay and Nelson and may actually improve in coming decades, with a tendency towards fewer, or less severe, late frosts and warmer summer conditions. If there were to be an expansion of kiwifruit in these two regions, important constraints would be the availability of water for irrigation and the competition for land from other valuable fruit crops, such as wine grapes.

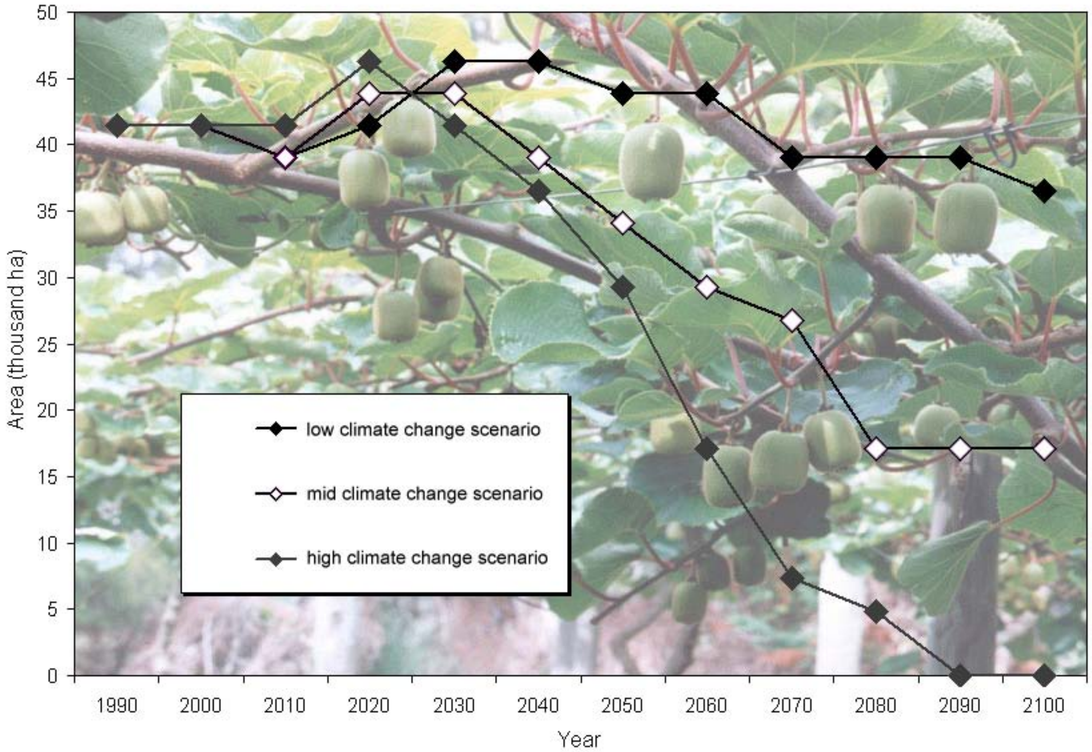


***Figure 4:*** *Projected changes the area suitable for Hayward kiwifruit production in the Bay of Plenty, using projections from one specific climate change model and a range of global climate change scenarios. Source: Warrick* et al. *(2001).*

The new Zespri Gold variety may fare better under warmer winters because, despite a similar sensitivity to winter temperatures to Hayward, it produces more flowers and so gives a greater margin for error. However, plantings of this variety are tightly controlled and there is a significantly higher management cost, which growers seek to compensate for, in part, through a higher level of fruit production.

None of this information need be cause for immediate alarm, but it does suggest a need for the industry to be proactive in considering climate change, even though it falls outside current planning horizons. There are two good reasons for being proactive.

- *Overseas markets:* climate change is a global phenomenon and will have impacts on New Zealand's competitors. Forward thinking could pay off in decades to come.
- *Time horizons for breeding*: at present it is believed that Hayward kiwifruit will continue to be the mainstay of the kiwifruit industry, yet results clearly show that this crop could become increasingly marginal in Bay of Plenty. There will be a limit to how much the crop can be managed against the effects of a warmer climate, as shown in Northland. It will take time to develop new, commercially acceptable varieties.

## What measures can be taken to adapt?

### Short-term planning

In the short term (over the next decade) the industry can cope with measures already in place, particularly with a continued focus on developing acceptable alternatives to HiCane.

### Medium-term planning

In the medium term (over the next 10 to 30 years) there could be an increased need for varieties with a lower chill requirement. These may not replace Hayward, which the industry presently expects to maintain as its main variety, but will help spread the risk with the likely trend towards more frequent warm winters. A possible downside is that a greater diversity of varieties will add greater complexity – and cost – to both orchard management and marketing.

### Long-term planning

Over the next 50 to 100 years relocation could be a possibility, but is not considered an option by Zespri because of the very high cost of relocating the industry infrastructure. There would be potential for greater plantings of kiwifruit in Hawke’s Bay and Nelson, although the present view is that the percentage of the national crop grown in Hawke’s Bay is likely to diminish, principally as a result of an expansion of plantings in the Bay of Plenty. The ability of the industry to develop commercially viable varieties with low chilling requirements and maintain production of high-quality fruit in the Bay of Plenty will probably be crucial.

# 5.2 Apples

## The present situation

Each of the major apple production regions has its own climatic and soil characteristics, which in turn influence the tree and variety performance, the quality and yield of fruit, and the pest and disease profile. We can develop a picture of the climatic influences that lead to good or bad crops. This picture tends to be quite specific for individual growers, but some generalisations are possible from an extended period of observation.

Poor production years can result form cold and/or wet spring conditions. This has been demonstrated in the most recent season, with cool springs in both Nelson and Hawke’s Bay. Fruit size in Central Otago is generally lower, which may be related to the effect of cooler spring temperatures on cell division in the post-bloom period. Excess rainfall in early spring can lead to problems with fruit finish and disease. Summer conditions in New Zealand are generally well suited to fruit development, with the greatest problems arising in drier and hotter conditions.

**The 2000/2001 season in Nelson**

The 2000/2001 growing season in Nelson resulted in reduced fruit sizes. This arose from a combination of factors, with the seasonal climate playing a major role. A cool spring was followed by hot, windy conditions in summer. To compound the adverse effects arising from this combination of conditions, Waimea orchardists had to cope with irrigation cuts in the second half of February. This was expected to have a significant impact on growers preparing fruit for export. Suggested strategies for dealing with these cuts included ceasing irrigation of young trees or those that had already been harvested.

Source: HortNews, at http://www.hortnet.co.nz/news/2001/n4024.htm.

In contrast to the 2000/01 season, the weather pattern associated with the 1997/98 El Niño event, which resulted in widespread drought conditions in the north and east of New Zealand, contributed to larger apple sizes, but sunburn and water-core damage resulted in significant crop losses.

Availability of water for irrigation, as indicated in the above example, is becoming an increasing problem in Nelson. Extreme weather events have a big impact. Hail storms can damage the crop at any time from blossom to harvest, and there have been some particularly severe ones in Hawke's Bay and Nelson recently. Late frosts can also be damaging.

It is delicate balance for the grower: to manage the orchard in anticipation of the market in the next season and beyond, and also to account for what the seasonal climate may hold in store – which is never certain. Long-term planning over the next 20 to 30 years should also take account of the likely effects of climate change.

## What effect will climate change have on apple production?

Higher average temperatures in future are likely to lead to earlier dates of bloom and maturity, and greater fruit size. These effects are likely to be small over the next 50 years. This is the finding of a recent study by HortResearch scientists, who developed an apple production model and used it to predict changes using weather data from Havelock North, Riwaka and Lincoln (Warrick *et al.*, 2001). A number of technical aspects to this study ideally require refinement, but this would not substantially alter the main findings. For example, the effect of winter chilling was not fully accounted for. However, it is not expected that an increased incidence of warmer winters will have a major impact on flowering and fruit set in the major production regions of Hawke's Bay and Nelson.

There are a number of unknowns in these projections. For example, these results do not take account of the likely interacting effects of increased temperatures and increased carbon dioxide in the atmosphere, and the impact this might have on tree vigour, fruit production and, importantly, fruit quality. A trend towards more frequent hot, dry summers could lead to more frequent problems with water-core and sunburn. Pest and disease regimes could change. Changes in rainfall patterns, combined with projected increases in demand, could lead to decreased availability of groundwater for irrigation.

The general view in the apple industry is that there is sufficient capacity to manage these effects. Unlike the situation with kiwifruit, a lot of genetic diversity can be drawn on from conventional breeding programmes. The shift towards integrated fruit production and organics is likely to have flow-on benefits in the medium and long term. For example, increased attention is being paid to under-storey management. Increased use of ground covers and practices such as mulching are likely to have multiple benefits, including improved tree health, host plants for beneficial insects, and improved soil water conservation.

The biggest climate-related issue the apple industry is likely to face in coming decades is the availability of water. Indications are that climate change will mean a trend towards drier average conditions in Hawke's Bay and Nelson. This will add to the demand for ground and surface water resources in these regions.

There could be local costs as well. For example, a trend towards warmer, humid conditions in Waikato could make commercial apple production less viable over time. This could result in a southward consolidation of the industry to the current centres of production in Hawke's Bay and Nelson.

### The water situation in the Heretaunga Plains, Hawke's Bay and Nelson

Surface water resources are already fully allocated in the Heretaunga Plains. At present there are no serious problems with groundwater, with sufficient recovery during winter to offset losses to irrigation through the growing season. However, any depletion in recharge, coupled with increased evaporative demand, as a result of climate change could change this situation. A lot will depend on rainfall changes in the ranges, which are the catchments for the major rivers in the region and provide the main source of recharge.

In Nelson, the situation is much more critical. Summer water resources are fully allocated (mainly for irrigation) in the Waimea and Moutere catchments, and in the southern Motueka Plains. There was up to 60% water rationing in last summer's drought. Any change in climate that reduced summer rains (or winter recharge) would reduce the security of water supply for those users and increase the need for water augmentation through dams or other storage.

Source: Andrew Fenemor, Manager Environmental Information, Tasman District Council (personal communication).

# 6 Summary

The main findings of this report are as follows.

- Climate change in New Zealand will probably have the greatest impact on agriculture through changes in climate variability and climate extremes. New Zealand farmers and growers are increasingly required to manage risk associated with climate events, and this will continue into the future with the possibility of increased risk in some regions.
- Eastern regions could experience more frequent, and potentially more severe, droughts through a combination of higher average temperatures, reduced average rainfall, and greater variability of rainfall. Western regions, and possibly some eastern regions, could be more prone to flooding and erosion from high rainfall events.
- Pasture production will generally increase, particularly in southern New Zealand, through higher carbon dioxide levels in the atmosphere and an extended growing season. There may be a reduction in feed quality in pastures as far south as Waikato, with an increased incidence of subtropical species. Feed quality may also decrease further in dry eastern regions, with more frequent drought leading to changes in pasture composition.
- Arable crops may generally benefit from warmer conditions and higher carbon dioxide levels in the atmosphere. However, potential yield increases will require higher fertiliser inputs. Availability of water for irrigation will be an important factor to achieve the potential gains, particularly in Canterbury, where there will be increased drought risk.
- Hayward kiwifruit may become uneconomic in the Bay of Plenty in the next 50 years under mid to high climate warming scenarios, although the current industry expectation is that this variety will continue to be its mainstay. Apple production is unlikely to be adversely affected, although there could be greater risk of heat damage in future and availability of water for irrigation may be an increasingly critical issue.
- There are a number of unknowns both with regard to basic climate changes and their impact on agriculture. While the existence of a human influence on climate, and projections of a trend towards higher future temperatures and a shift in rainfall patterns is considered reasonably robust, projections of absolute changes in particular regions are still highly uncertain and are usually considered as a set of scenarios. Within the agriculture sector, uncertainties about the impacts of those change scenarios particularly relate to changes in pest and disease profiles in different regions, changes in soil fertility, and changes in water availability.

If effective strategies are put in place it is likely that the worst possible effects of climate change on agriculture in New Zealand can be avoided, and the potential benefits realised. The most effective strategies are likely to involve a staged approach involving:

- *for the short term*, further development and implementation of strategies for dealing with present climate variability and extremes
- *for the medium term*, implementing plant-breeding programmes, developing water conservation programmes, and planning conservatively to ensure there are buffers against adverse years
- *for the long-term*, developing a more integrated approach to land management that considers climate change alongside other important issues such as biodiversity, biosecurity, land degradation, and water resource use.

# References


Agriculture New Zealand. *Drought Recovery Strategies: A report prepared as part of a drought recovery package developed by Wrightson Ltd for Marlborough, as a result of the 1997/98 drought*, 1998. Available at http://www.agnz.co.nz

Basher R. 1999. *The 1997/98 El Niño Event: Impacts, responses and outlook for New Zealand.* Ministry of Research, Science and Technology, Wellington.

HortNet. News Note – New Kiwifruit Variety Looking Good After Mild Winter, http://www.hortnet.co.nz/news/note/tomua.htm. Additional information searches can be made on the HortNet website at: http://www.hortnet.co.nz

Jamieson PD, Cloughley CG. 2001. Impacts of Climate Change on Wheat Production. In: RA Warrick, GJ Kenny, JJ Harman (eds). *The Effects of Climate Change and Variation in New Zealand: An assessment using the CLIMPACTS system.* International Global Change Institute, University of Waikato.

Kenny GJ, Harman JJ, Flux TL, Warrick RA, Ye W. 2001. The Impact of Climate Change on Regional Resources: A case study for Canterbury and Waikato regions. In: RA Warrick, GJ Kenny, JJ Harman (eds). *The Effects of Climate Change and Variation in New Zealand: An assessment using the CLIMPACTS system*. International Global Change Institute, University of Waikato.

Ministry for the Environment. 2001. *Climate Change Impacts on New Zealand*. Ministry for the Environment, Wellington.

Ministry of Agriculture and Forestry. 1998. *Meeting the Challenge: Lessons from previous droughts.* MAF Policy Information Paper 20. Ministry of Agriculture and Forestry, Wellington. http://www.maf.govt.nz/MAFnet/publications/drghtles/drghtle1.htm

Ministry of Agriculture and Forestry. *Farm Monitoring Reports. 1998, 1998, 2000*. Available at http://www.maf.govt.nz/MAFnet/

Pyke NB, Wilson DR, Stone PJ, Jamieson PD. 1998. Climate Change Impacts on Feed Grain Production and Quality in New Zealand. *Proceedings of the Agronomy Society of New Zealand* 28: 55–8.

Walker A. 2000. *Climate Variability and Risk Management in New Zealand Farming: A policy perspective*. http://www.maf.govt.nz/MAFnet/publications/rmupdate/rm5/rm5004.html

Warrick RA, Kenny GJ, Harman JJ (eds). 2001. *The Effects of Climate Change and Variation in New Zealand: An assessment using the CLIMPACTS system*. International Global Change Institute, University of Waikato.