FOREWORD

Climate change is a very real challenge for the entire agricultural industry.

Many issues are still to be resolved on how New Zealand will manage greenhouse gas (GHG) emissions from agriculture. DairyNZ's primary role, at this stage, is to keep dairy farmers well informed of what is happening (enabling you to comment or challenge given opinions or activities) and to use all our experience, knowledge and relationships to advocate on farmers' behalf.

This *Great Farming Guide* has been developed from resources created for the Ministry of Agriculture and Forestry (MAF) by Earthwise Consulting Ltd and NIWA. It sets out the agreed science, which was discussed at Copenhagen in December 2009. It also discusses what the science indicates for New Zealand so you can consider the potential implications for your region and your farming operation. It is designed as a ready-to-hand resource on areas such as climate science history, climate modelling and projections on the possible impacts of climate change on the dairy sector. It also has a comprehensive list of references for when you need to seek out more information.

I think it's reasonable to expect that policy related to climate change and carbon trading will continue to develop for many more years. Knowing when and how to react will be essential in maintaining a profitable and competitive dairy business.

Dr Rick Pridmore – Strategy and Investment Leader (Sustainability)

CONTENTS

USING THIS BOOKLET

This Great Farming Guide is designed to summarise the basic facts on climate change for dairy farmers so they are capable of making more informed decisions on their farms in the face of a changing climate.

It covers the following main themes:

- The theory, the history, the science
- New Zealand's variable climate
- Climate change scenarios and uncertainty
- Future New Zealand: Possible effects on our climate
- Climate change projections at a regional level.

This material can be viewed at *www.maf.govt.nz/climatechange* or phone 0800 CLIMATE to request a hard copy.

THE THEORY, THE HISTORY, THE SCIENCE

WHAT IS CLIMATE CHANGE?

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC, 2007) as follows:

Climate change refers to a change in the state of the climate that can be identified (eg, by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

IS CLIMATE CHANGE NEW?

No. Climate has changed over millennia because of natural processes. The cooling and warming experienced with ice ages and interglacial periods are examples of natural climate changes. The relatively stable climate of the past 10,000 years or so, since the most recent Ice Age, has allowed human civilisation to flourish through settled communities and the development of agricultural production.

Two well-documented changes since the end of the last major ice age are the Medieval Warm Period (10-14th century AD) and the Little Ice Age (16-19th century AD) that occurred in the Northern Hemisphere.

CLIMATE CHANGE AS A RESULT OF HUMAN INFLUENCE

The following graph shows the significant increase in atmospheric greenhouse gases (GHG) from around 1750, with the onset of the Industrial Revolution, rapid economic and population growth, and widespread deforestation.

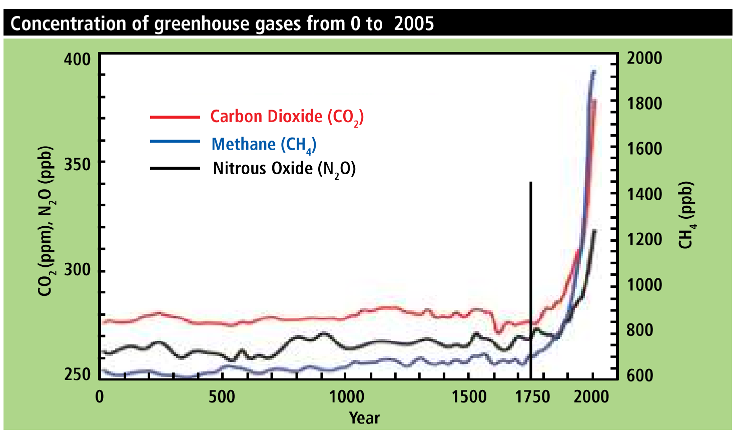


Figure 1: Atmospheric concentrations of greenhouse gases (GHG) over the past 2000 years. Concentration units are parts/million (ppm) or parts/billion (ppb), indicating the number of molecules of the GHG/million or /billion air molecules, respectively, in an atmospheric sample (IPCC,2007).

It's these increases in GHG concentrations that are considered to be the principal cause of the warming of the earth's atmosphere over the last century. As time goes by, the evidence is mounting that human activity is changing the global climate, along with many other well documented changes (such as species extinctions).

Over the past 100 years, the average temperature on Earth has increased by more than 0.5 deg C, and the 1980s and 1990s were the warmest decades on record.

New Zealand's climate, like the global climate, has warmed over the past century, and this trend is expected to continue for at least the next century.

The scientific theory that humans could change global climate had its beginnings in the 19th century. Climate change theory has developed considerably since the 1970s.

Joseph Fourier, 1768-1830, who is generally credited with the discovery of the greenhouse effect. (*The Discovery of Global Warming*, S. Weart, 2008).

A timeline of climate change science	
1824	**French physicist Joseph Fourier recognised the importance of the atmosphere in trapping heat and influencing the temperature of the earth. He uses the analogy of a greenhouse.**
1896	**Swedish chemist Svante Arrhenius makes the first climate prediction: halving CO2 could lead to an Ice Age, doubling CO2 could lead to an increase in global temperature of 5 deg C.**
1938	**Engineer Guy Stewart Callendar first suggested that fossil fuel burning was responsible for the observed warming of the world's climate. He predicted a rise of 2 deg C with poles warming most.**
1979	**The first World Climate Conference voices concern that "continued expansion of man's activities on earth may cause significant extended regional and even global changes in climate".**
1988	**The Intergovernmental Panel on Climate Change (IPCC) is set up by the UN to provide policy-makers with a source of information on climate change.**
1990	**The first IPCC assessment states that scientists are certain that emissions resulting from human activities are substantially increasing atmospheric concentrations of greenhouse gases (GHG), resulting on average in an additional warming of the Earth's surface.**
1995	**The second IPCC assessment states that the balance of evidence suggests a discernible human influence on global climate.**
2001	**The third IPCC assessment states that there is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities.**
2007	**The fourth IPCC assessment states that warming of the climate system is unequivocal and most of the recent warming is very likely to be a result of human activity.**

Source: http://www.metoffice.gov.uk/climatechange/guide/timeline/

WHAT IS THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)?

A scientific intergovernmental body set up in 1988 by the World Meteorological Organisation (WMO) and by the UN Environment Programme (UNEP). In 2007, it was awarded the Nobel Peace Prize for "efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".

The information it provides through its reports is based on the continually growing body of scientific evidence. The comprehensiveness of the scientific content is achieved through contributions from thousands of experts in all regions of the world including New Zealand, and across all relevant disciplines.

ISN'T THERE STILL A DEBATE ABOUT CLIMATE CHANGE?

There is inevitably debate with such a complex issue as climate change. However, the scientific consensus is that it is now unequivocal that warming of the climate system is happening. The evidence continues to grow that human activity is contributing significantly to this warming.

"Science moves forward by challenge and debate and this will continue. However, none of the current criticisms of climate science, nor the alternative explanations of global warming, are well enough founded to make not taking any action the wise choice."

– The Royal Society,
see http://royalsociety.org/page.asp?id=6229

CLIMATE CHANGE SCIENCE IN PRACTICE

Scientists in New Zealand and around the world are monitoring, measuring, modelling and analysing all manner of atmospheric and environmental changes that are being observed.

These changes include:

- Increases in atmospheric carbon dioxide and other GHGs.
- Increases in temperature and frequency of extremes such as heatwaves.
- Melting of snow and mountain glaciers.
- Ice melt from Greenland and Antarctica.
- Rising sea levels.
- Increased intensity and duration of droughts.
- Changes in rainfall patterns.
- Effects on Arctic and Antarctic ecosystems.
- Warming of lakes and rivers.
- Earlier timing of spring events such as, budburst and bird migration.
- Longer growing seasons in some regions and shorter, more drought affected, growing seasons in others (such as the Sahelian region of Africa).

Other scientists are focused on ways we can respond to climate change. This activity has increased significantly over the past decade as the evidence has grown of climate change and its effects, and of the human influence on climate.

HOW DO WE RESPOND TO CLIMATE CHANGE?

There are two main responses: mitigation and adaptation.

Mitigation relates to actions to reduce or offset emissions of GHGs. Effective mitigation will require international cooperation and action. While some action is being taken, emissions of GHGs are continuing at a level that will lead to significant climate change.

Adaptation involves actions to deal with the effects of climate change. The extent to which we need to adapt will depend on international actions to reduce emissions, and on the rate and extent of climate change that we experience.

Pragmatic farmers and growers tend to see mitigation and adaptation responses as ways of making their businesses more resilient and sustainable.

An example of two case studies of dairy farmers who are both responding to climate change but in different ways is given at the end of this guide (pages 38-45).

SO WHAT DO YOU BELIEVE?

Regardless of what the science says, for many people seeing is believing. Increasing numbers of farmers are experiencing changes in weather patterns. They are reading and responding to the climate signals, as they are to economic, market and consumer signals.

"Climate change means to me the change in how our rainfall is spread across the year and in the way that it occurs now."

– Hawke's Bay farmer.

CLIMATE CHANGE AND VARIABILITY

NEW ZEALAND CLIMATE IS INHERENTLY VARIABLE

New Zealand's climate is inherently variable and as a result might be described at times as predictably unpredictable. The variability of our climate is the result of our South Pacific location and our small, but mountainous, land area. Our location in the mid-latitudes of the southern hemisphere means that westerly winds dominate the climate.

Seasonal fluctuations, and north to south differences, are influenced by the tropics to the north and Antarctica and the southern ocean to the south. West to east variations are the result of the modifying effect of the Southern Alps and the mountainous ranges of the North Island.

The benefit of our geographic location and landform is a very moderate climate. Overall, our moderate (but variable) climate is a resource that gives a production advantage to New Zealand farmers and growers. They have learned to live with the variability of the climate. This has not been without significant cost at times, such as can be experienced through extended drought periods or with extreme rainfall and associated flood events.

With climate change, the changes that will be most obvious in their effect are not so much the averages, but the variability and extremes. Three key challenges are associated with this:

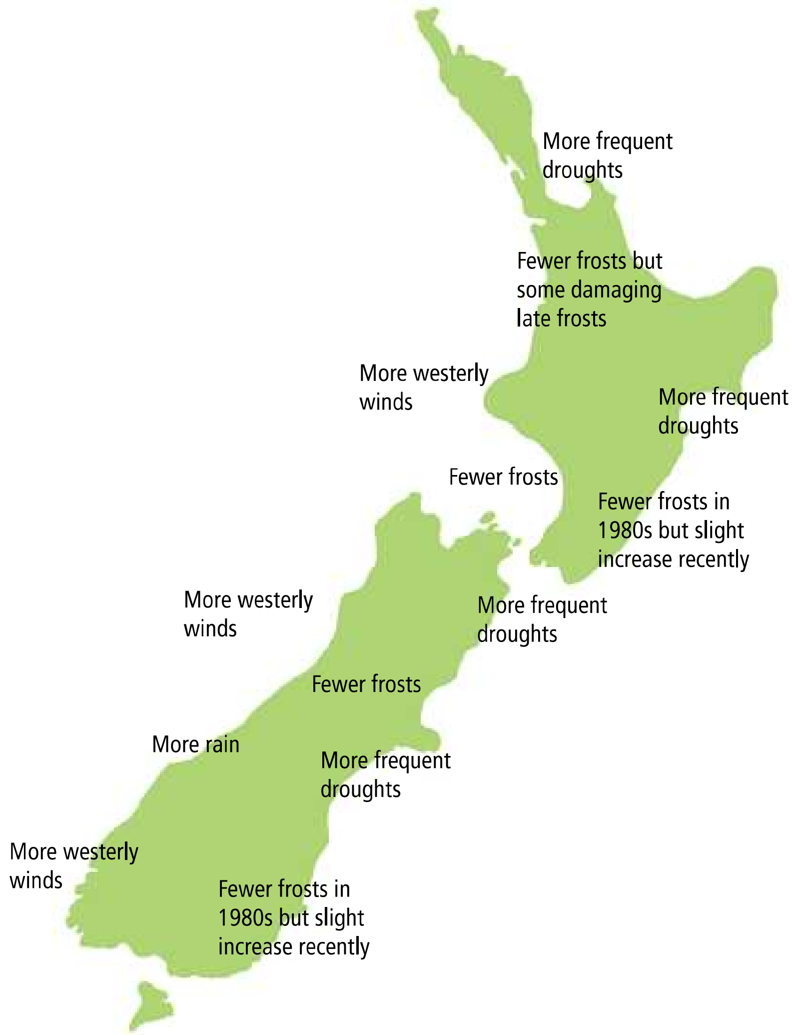
- At present, only about half of the climate variability within the growing season is predictable. Some farmers and growers are saying that things are generally becoming more unpredictable.
- Extreme events, such as floods and droughts, can occur at any time. In different regions, the frequency and intensity of such events may increase.
- With a changing climate, we cannot rely on the past as a complete guide to the future.

"Summers are too dry, spring is too wet, there are more extremes, and when it does rain it's intense and hard to utilise properly."

– Bay of Plenty dairy farmer.

OBSERVED CHANGES IN VARIABILITY AND EXTREMES

The effects of climate change are likely to happen more slowly in New Zealand than in other areas (the Northern Hemisphere, for example) simply because of the moderating or lag effect of the huge ocean area that surrounds us. Despite the lag effect, changes in variability and extremes in New Zealand are observed that are consistent with changes reported by the IPCC. These changes have been observed over the past three decades.



Scientists have tracked in the past 50 years:

	Observed global changes reported by IPCC	Observed New Zealand changes
Wind	• Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s.	• Westerly circulation has increased across New Zealand, with more persistent westerlies onto central and southern New Zealand.
Drought	• More intense and longer droughts have been observed over wider areas since the 1970s.	• The north and east of the North Island have been 10 percent drier and five percent sunnier on average since the late 1970s. Eastern regions have experienced more frequent droughts.
Heavy rainfall	• The frequency of heavy rainfall events has increased over most land areas.	• Since the late 1970s the west and south of the South Island have been about ten percent wetter and five percent cloudier with an increase in damaging floods. There is some evidence that extreme daily rainfall amounts have increased in the west.
Extreme temperatures	• Widespread changes in extreme temperatures have been observed over the past 50 years.	• No clear evidence of more extreme high temperatures in New Zealand. In general, frosts have been fewer since the 1950s but, since the 1970s, there has been a small increase in frosts in some eastern areas. In recent years there has been a greater incidence of damaging late spring frosts.
Tropical cyclones	• Some suggestion of increased intense tropical cyclone activity, but no clear trend in the annual numbers of tropical cyclones.	• No evidence at present of more intense ex-tropical cyclones over New Zealand or of more annual numbers of cyclones.

INTERACTIONS BETWEEN VARIABILITY AND CHANGE

There have likely been two main, and possibly inter-related, influences on these observed changes:

1. An underlying warming trend, with close to a 1.0 deg C increase in average air temperature over the last century.

2. Fluctuations in the El Niño-Southern Oscillation (ENSO) and another natural fluctuation called the Interdecadal Pacific Oscillation (IPO).

The period from the 1940s to late 1970s was dominated by a negative IPO phase, which coincided with several strong La Niña phases of ENSO. From the late 1970s to the late 1990s, there was a positive IPO phase and a greater frequency of strong El Niño events. It appeared that another shift of the IPO occurred around 2000. Since that time here have been some similarities to weather events experienced in the 1960s and 1970s. However, recent weather has not been as consistently wet as some regions experienced in the past, and some areas have experienced ongoing drought conditions.

It would be as simplistic to say that recent climate changes in New Zealand are solely due to global climate change as it would be to say that it's all because of natural variability. Both are influences on our climate. What is likely is that with current trends the influence of climate change, both on long-term averages and climate variability, will increase over coming decades.

CLIMATE CHANGE MODELS

While the theory that human activity is influencing global climate had its beginnings in the 19th century, it took until the latter part of the 20th century for it to be fully developed. This was for two main reasons. Firstly, by the mid-1970s there was growing evidence of changes in atmospheric carbon dioxide and temperature. Secondly, the advance of computer technology enabled the development of complex models to test the theory. The results from the first computer model that showed the effects of a doubling of atmospheric carbon dioxide were published in 1975.

The science has developed rapidly since then. While model outputs contain many uncertainties, extensive work over the past decade has produced models that are increasingly skilful in simulating aspects of global climate.

The following figure shows the consistency between model results (red line shows the average of 14 models and yellow line shows the range) and actual measured changes in global average temperature (black line).

MODELS OF FUTURE CLIMATE

The ability of these models to represent past and present climate features gives us confidence that they can represent the essential physical processes important for the simulation of future climate change. In practice, a range of models is used to simulate future climates, or what are typically called climate change scenarios. Climate change scenarios are plausible 'pictures' of what climatic effects might arise at national and local scales. They are not predictions or forecasts. The scenarios try to take into account a range of possible changes in human population, economic factors, technological driving factors, and the resulting changes in the amounts of GHG emissions.

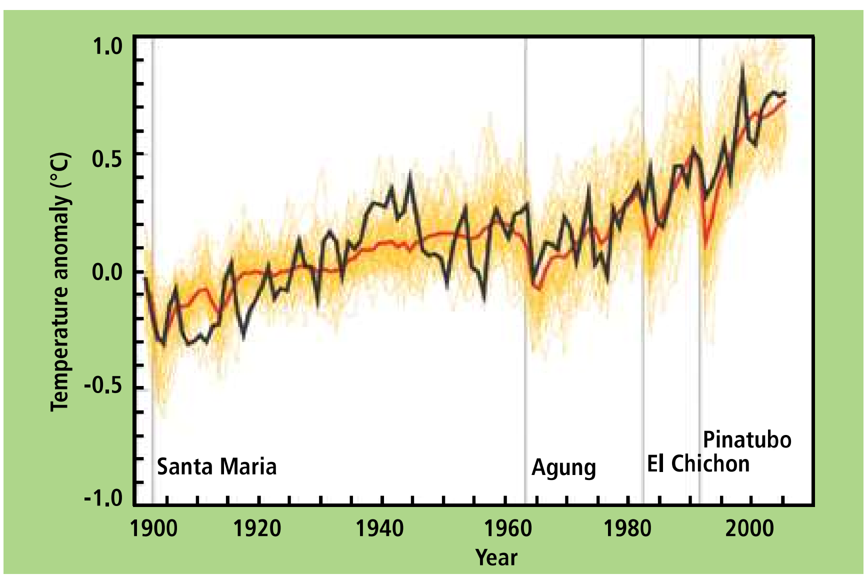
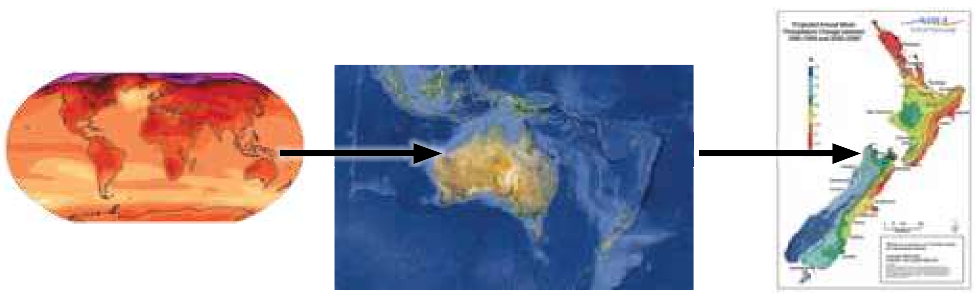


Figure 2: Multiple (yellow lines) and average (red) model simulations of global average temperature over the past century, compared to observed temperatures (black line) (IPCC 2007).

CLIMATE CHANGE SCENARIOS FOR NEW ZEALAND

The results from global climate models have been used for the past two decades to develop regional scenarios of climate change around the world. This then provides a basis for identifying possible impacts on individual countries and for planning what responses might be possible or necessary.Translating global model results to the New Zealand scale is not a simple task. This involves taking the very coarse global model data and combining it with knowledge of the climate around and within New Zealand. The subsequent interpretation of this information into plausible scenarios for New Zealand's regions involves a good deal of expert judgment. The possible climatic effects that might arise in New Zealand with scenarios of future climate are detailed later in the guide.



SCENARIO UNCERTAINTIES

Some key uncertainties are associated with climate change scenarios, at both the global and New Zealand scales:

Sources of uncertainty at the global scale

The two main sources of uncertainty associated with climate change models and scenarios, at the global scale, are:

- Uncertainties within and between computer models developed by different research groups around the world. These uncertainties result from the use of different assumptions in the models about specifics of the global climate system.
- Uncertainties related to future emissions of greenhouse gases and the effects that these will have on the global climate system.

Sources of uncertainty at the New Zealand scale

Climate scenarios for New Zealand carry the uncertainties associated with the global scenarios, but carry additional uncertainties associated with:

- How the natural variability in the climate of New Zealand will be affected by global changes, and how sources of variability such as El Niño will change with global climate change.
- The difficulty in quantifying future climate change in New Zealand regions to a level of detail that can ensure accurate planning.

INTERPRETING A REGIONAL SCENARIO

Given these uncertainties it's very important to be pragmatic with the scenarios that are presented for New Zealand and the interpretation of these. They provide us with information on possible effects of climate change, but over time our scientific understanding of climate change will improve and systems (both natural and managed) will respond in ways that we cannot yet foresee.

Climate change scenarios for New Zealand consistently show a pattern of rainfall change that suggests wetter conditions on average in the west and drier conditions on average in the east. However, there will still be dry years in the west and wet years in the east, as well as changing variability between years, seasonal rainfall patterns, and rainfall intensities.

When a climate change scenario says, "Spring rainfall in Hawke's Bay is likely to be 13 percent less, but the range of possible change is -38 percent to +9 percent", what does this actually mean?

The scenario suggests an average decrease of 13 percent is the best estimate for future rainfall, but you should be aware that some of the models are suggesting a greater decrease (down to –38 percent), while others suggest an increase (up to +9 percent).

Simply put, the odds are higher that there would be less rain in spring than more rain in spring.

In the short term, what will matter most to dairy farmers will be changes in variability between years, changes in seasonal rainfall patterns and distribution, and changes in rainfall intensities, all of which are uncertain.

New Zealand's climate is inherently variable. Extreme events, such as floods and droughts can occur at any time.

FREQUENTLY ASKED QUESTIONS

HOW CAN NEW ZEALAND FARMERS MAKE FIRM DECISIONS WHEN THERE IS UNCERTAINTY?

Dairy farmers are already using different sources of climate information to make farm management and planning decisions. Most of this decision-making is focused on the season ahead. When working with the weather, farmers constantly weigh up the value and likely outcomes of day-to-day decision-making, while keeping in view the options that are part of long-term planning.

The same approach can be used with responses to climate change by taking into account what is being experienced already, reliability of the available information, what isn't yet known, and what level of action is justified given the present weight of evidence.

For instance, how can you act on what you know already to get a win-win outcome? A sensible approach is to consider adaptation to climate change as part of what you might already be doing to increase your resilience. The adaptation case studies described at the end of this guide provide some good examples of such an approach.

ISN'T NEW ZEALAND CLIMATE TOO VARIABLE TO PREDICT INTO THE FUTURE?

New Zealand climate in the future is likely to vary from year to year and decade to decade, just as it does at present. However the science of climate change has confirmed that there is an underlying warming trend that may increasingly affect the variability of our climate. Climate change scenarios, while not predictions of future climate, use reasonable assumptions about current climate variability, as well as future conditions such as global economic, technological and political trends, to provide plausible indications of what changes in climate we might expect.

CAN WE BELIEVE THE MODELS?

A huge international effort has been focused on developing and refining global climate models over the past three decades. These models have become increasingly sophisticated. They now mathematically represent all the parts of the climate system – everything from clouds, ocean currents, rainfall, snow and ice to soil moisture. A growing body of evidence from scientific observation is giving proof to results from the models. However, there are still many unknowns.

A good test for the models is how well they represent the climate that has been measured. This has become possible as the signal of climate change has become more evident within the past decade. Figure 2 shows that the models represent past climate pretty well. The fact remains that it is not possible to model with certainty how the climate might change in the future, particularly at the regional and local scale.

In general, conditions will become increasingly suitable for maize production in the North Island with greater opportunities in Canterbury over time.

HOW WILL GHG EMISSIONS CHANGE IN THE FUTURE?

We cannot know with certainty how populations, economies, energy technologies and other social factors that influence GHG emissions will change in the future. The best we can do is to consider a range of plausible ways in which the world might develop.

Scenarios of future climate consider a range of possible emission scenarios – based on different levels of human activity and response. The IPCC emission scenarios give a range of global temperature change from about 1.5 deg C to 6 deg C by 2100.

By reducing the rate at which we put GHGs into the atmosphere, we may be able to slow the process of climate change. Further ways to reduce GHG emissions, such as carbon sequestration, will also help. International agreements, such as the Kyoto Protocol, aim to get countries to reduce emissions to minimise the adverse effects of climate change.

WHAT ARE THE LIKELY FUTURE IMPACTS OF CHANGES IN CLIMATE?

Even if changes in climate could be accurately predicted, uncertainty would still surround the effects these changes would have on the environment and society. Even more uncertainties are involved in modelling biological responses than are involved in modelling atmospheric responses.

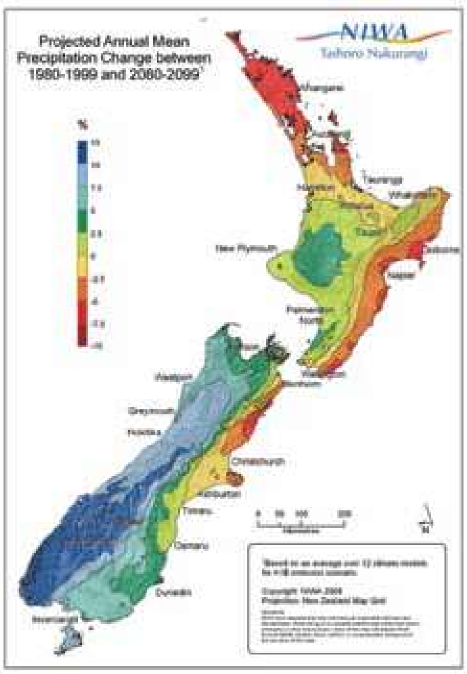
Many factors contribute to this, including differences in crop variety, location, soil type, water availability, nutrient supply, pest and disease problems and management. Local knowledge, experience and observation are, in many cases, the best sources of information on possible impacts of climate change.

FUTURE NEW ZEALAND: POSSIBLE EFFECTS ON OUR CLIMATE

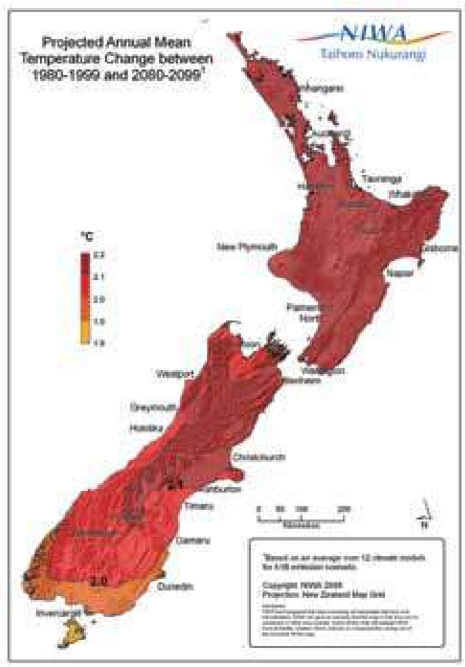
Scenarios for New Zealand's future climate are derived from global climate-change models. New Zealand climate scientists have developed techniques to derive climate-change scenarios for New Zealand, using both statistical techniques and a regional climate model, a process called downscaling. The scenarios are not predictions – they are plausible 'pictures' of future climate for New Zealand. Scenarios provide information on possible future effects, recognising the uncertainties associated with computer modelling, international decision-making on greenhouse gas emissions, feedbacks in and effects on the regional climate system, and scaling from global models to regions within New Zealand.

As a result of this work, there's confidence that temperatures are increasing on average, and will continue to do so, with a relatively uniform pattern of change over the country. There's also confidence, based on evidence to date, that there will be a more prevalent west to east pattern with rainfall and with westerly airflow.

However, there is a lot more uncertainty around scenarios of rainfall change and even more so with scenarios of wind change. These caveats need to be kept in mind with the following summary information.



Projected annual mean precipitation change for New Zealand between 1980-1999 and 2080-2099, based on an average of 12 climate models for a mid-range scenario, as described in the text on page 22.



Projected annual mean air temperature change for New Zealand between 1980-1999 and 2080-2099, based on an average of 12 climate models for a mid-range scenario, as described in the text on page 22.

EFFECTS OF CLIMATE CHANGE IN NEW ZEALAND

The following effects of climate change in New Zealand are based on a 'mid-range' scenario, and in some cases the range of uncertainty is also given. A mid-range scenario, as defined by the IPCC, assumes ongoing global economic growth and associated GHG emissions, with the introduction of new, more efficient, technologies and declining global population from mid century.

AVERAGE TEMPERATURE

New Zealand temperatures are likely to increase by about 1 deg C by mid-century and more than 2 deg C by 2090, relative to average temperatures in 1990. Temperature increases are likely to accelerate with time – warming later in the century will be greater than in the next few decades. There will be less warming in spring than in other seasons, although the seasonal differences are small. The average annual temperature is likely to increase slightly more in the North Island than in the South Island.

DAILY TEMPERATURE EXTREMES

In addition to changes in mean temperature, daily temperature extremes will also vary with regional warming. A large decrease in the number of frost days is projected for the central North Island and in the South Island as the 21st century progresses. An increase in the number of days above 25 deg C is also likely, particularly at already warm northern locations. These average changes should not be confused with recent experience of unseasonal extremes. For example, a decrease in total frost days does not preclude the possibility of damaging late frosts, as have been experienced in recent years.

FREQUENCY AND STRENGTH OF STRONG WINDS

Evidence suggests that westerly winds will increase on average. Strong seasonal differences are apparent in the scenarios with increased westerly flow in winter and spring and decreased westerly flow in summer and autumn. In spring, westerly winds could increase by about 10 percent by 2040 and 20 percent by 2090. Increases in winter could be greater. There could be a decrease of between five and 20 percent in summer and autumn. An increase in severe wind risk is possible.

RAINFALL

Changes in rainfall are likely to vary around the country and with season. Increases in annual mean rainfall are projected for Tasman, West Coast, Otago, Southland and the Chatham Islands, and decreases are likely in Northland, Auckland, Gisborne and Hawke's Bay. These annual changes are dominated by winter and spring rainfall. There's a tendency towards increased rainfall in south and west in the winter and spring. In summer and autumn there is a tendency towards decreased rainfall in the western North Island, and increased rainfall in Gisborne and Hawke's Bay.

DROUGHT RISK

Drought risk is projected to increase in frequency during the coming century for all areas that are now drought prone. Areas particularly affected will be eastern regions from Gisborne to Canterbury, as well as parts of Bay of Plenty and Northland. A greater frequency of more severe droughts is likely over time. For example, what are now defined as one-in-20-year droughts could occur on average once every five to 10 years. Droughts could also begin earlier in the season.

Dry hillside and low water level, Waikanae River, drought of May 2003. Photo: NIWA

HEAVY RAINFALL EVENTS

Heavy rainfall events are likely to occur more frequently in New Zealand over the coming century, particularly where average annual rainfall is projected to increase. What is an extreme rainfall event in the current climate might occur about twice as often by the end of the 21st century. A warming atmosphere will be able to hold more moisture, increasing the potential for heavier rainfall and consequently an increased risk of floods.

Floods in Northland, July 2007.

SNOWFALL AND SNOWLINE

Snow cover might be expected to decrease and snowlines rise as the climate warms. However, there are confounding issues. Warmer air holds more moisture, and during winter this moisture could be precipitated as snow at high altitudes. Winter snowfall to low elevations in some cases could increase for the same reason. However, with the projected increase in temperatures, any snow cover will melt more quickly, and thus the duration of seasonal snow lying on the ground should be shortened.

EX-TROPICAL CYCLONES AND MID-LATITUDE STORMS

Future tropical cyclones are likely to be more intense, but it is not clear whether numbers of tropical cyclones will increase. An increase in Southern Hemisphere high-latitude storminess is possible.

SEA LEVEL

The IPCC, in its fourth assessment report, projects that global mean sea level will rise by between 0.18m and 0.59m by late this century, compared with 1990 levels. A further 0.1- 0.2m rise could occur if ice-sheet discharges in Greenland and Antarctica were to increase above the present contribution to sea level, as a consequence of future temperature increases.

The IPCC also notes that an even larger contribution to sea-level rise from ice sheets cannot be ruled out. In addition, sea-level rise is not expected to be globally uniform, and current models suggest that sea level in the New Zealand region could be 0.05m to 0.1m above the global average by late this century, for a mid-range emission scenario.

EL NIÑO

Many climate models show that warming of the Pacific Ocean could result in a more El Niño-like state over the next 50 years. Such a change is consistent with an increase in westerly winds and a greater west-east rainfall gradient in New Zealand.

Canterbury snowstorm, July 2006. Photo: NIWA

FUTURE NEW ZEALAND: POSSIBLE IMPACTS OF CLIMATE CHANGE ON THE DAIRY SECTOR

As the 21st century advances, the climate of New Zealand is likely to become more sub-tropical in the north, wetter and windier in the west, drier in the east, with a milder, more temperate climate developing in cooler and southern regions of the country. This will provide a combination of threats and opportunities to the New Zealand agricultural sector.

Possible impacts and opportunities include:

DROUGHT AND WATER RESOURCES

Drought frequency and severity could increase in regions that are now drought-prone. Regions most likely to be affected are eastern Northland, Hauraki Plains, eastern Bay of Plenty, and eastern New Zealand from Gisborne to Otago. Pressure on water resources is likely to increase in these drought-prone areas.

Increased incidence of drought, and possible increasing frequency of westerly winds, will heighten the risk of fires in rural areas, particularly in areas prone to strong north-westerly conditions, such as Canterbury.

INTENSE RAINFALL

All regions of New Zealand can expect greater flooding and erosion risk with any intensification and increased frequency of rainfall events. Low-lying coastal land will be more prone to storm surges and flooding.

INSECT, PLANT PESTS, AND BIOSECURITY

Increased problems with insect pests are likely. Recent experiences in Northland with tropical grass webworm and crickets in Hawke's Bay, are indicative of what could occur more often with climate change. The spread of insect pests such as the clover weevil and clover flea could be accelerated with warmer average conditions.

Higher temperatures will likely increase the number of pest plants in the north of New Zealand and encourage southward spread of some species. This is already occurring in some species, although it could be due in part to natural acclimatisation. Nevertheless, higher temperatures will increasingly be an influence.

TEMPERATE PASTURE

Temperate pasture responses are likely to vary throughout New Zealand. Warmer and wetter average conditions could lead to yield increases in western regions of the lower North Island, in the West Coast, and parts of Otago and Southland. Yield response may be positive in northern regions, but higher temperatures could become increasingly limiting, along with increased predominance of sub-tropical grasses.

SUB-TROPICAL GRASSES

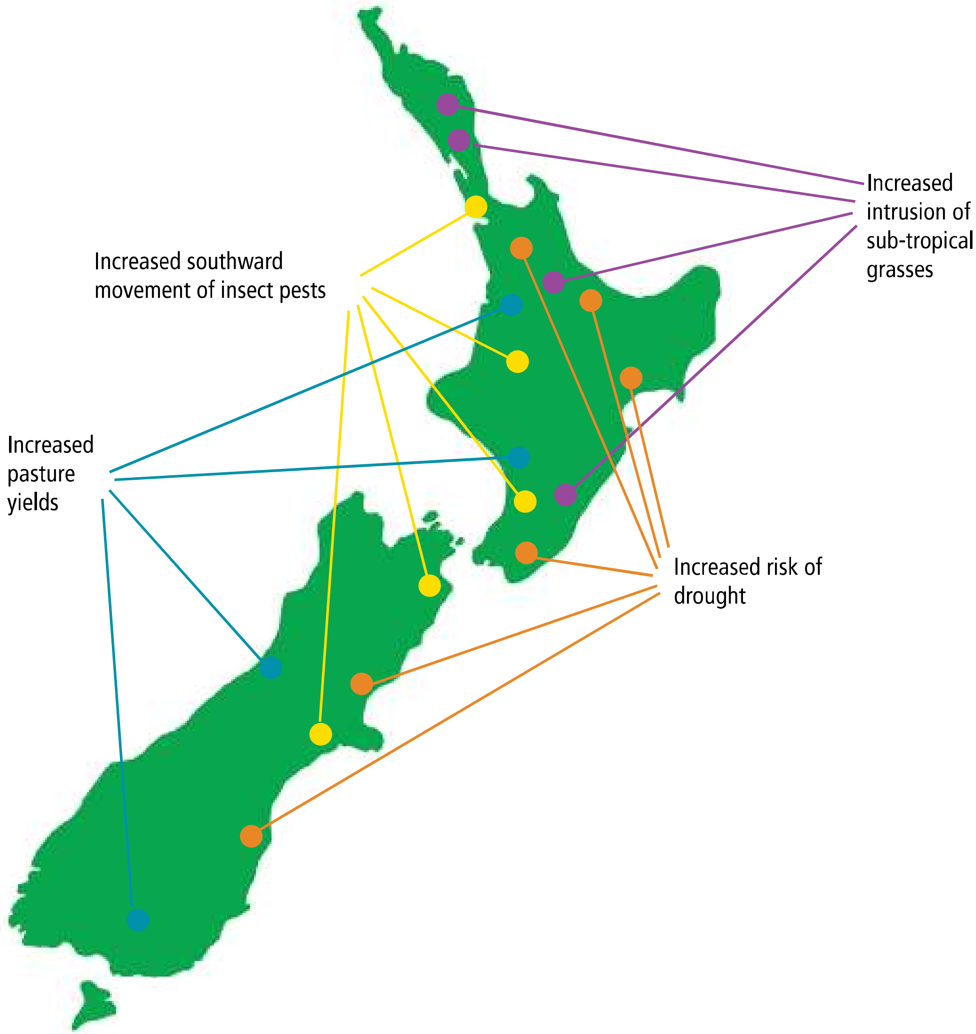
Sub-tropical grasses such as kikuyu and paspalum are already widespread in the North Island and will become more so. They may become significant invaders of the South Island over time. This would have a greater negative impact on dairy producers than sheep and beef producers, because of the high dependency of dairying on maximising pasture utilisation.

ANIMAL HEALTH

Animal health effects, particularly in northern and eastern New Zealand, could include increased heat stress on dairy cattle. Most of the North Island and warmer regions of the South Island could experience an increased incidence of diseases such as facial eczema. A warmer wetter climate in western parts of New Zealand will increase problems with internal parasites. In cooler and southern regions of the country, stock will benefit from warmer winters with less stress on stock and better reproduction rates.

CROPS

In general, conditions will become increasingly suitable for maize production in the North Island, with greater opportunities in Canterbury over



time. There could be yield and quality benefits to some of the temperate grains in the South Island with hotter, drier conditions. Wetter conditions could increase disease problems in some northern regions and in the west. In eastern regions, crop production may be constrained by limitations on the availability of water at certain times of the year.

INFRASTRUCTURE

Changes in the seasonality and/or frequency of high intensity rainfall events will potentially have consequences for farm infrastructure in all regions. This includes land drainage, flood protection, community water schemes, culverts and bridges, erosion control, farm dams, water reticulation and irrigation.

WHAT DOES CLIMATE CHANGE LOOK LIKE AT A REGIONAL LEVEL?

NORTHLAND AND AUCKLAND

KEY EFFECTS

- Increased risk of longer dry periods.
- Extreme rainfall events may increase in intensity and frequency.
- Large reductions in rainfall are likely in winter and spring, increasing the risk of early drought.
- Annual temperature increases of about 1 deg C by mid-century and more than 2 deg C by 2100. Most warming is likely in summer.

RISKS

- Increased heat stress and incidence of diseases such as facial eczema.
- Sub-tropical grasses such as kikuyu and paspalum are already widespread and will become more so. Conditions could become increasingly less suitable for temperate pasture species. This would have a greater negative impact on dairy producers than sheep and beef producers.
- More frequent, intense, rainfall events would require ongoing improvements in erosion control and better drainage in all areas
- Increased pressure on water resources in drought periods and also greater flooding and erosion risk with any intensification and increased frequency of precipitation events.
- Changes in rainfall, with the possibility of more extremes of wet and dry, will lead to consequences for local and regional infrastructure.
- Several pest plants, such as lantana, now in small or not very vigorous infestations in Northland, would become a serious pest through parts of northern New Zealand, if there were even a slight increase in temperature. Warming would not only increase the number of pest plants, but would also shorten the time-span over which a plant becomes established and then begins to become a problem.

WAIKATO AND BAY OF PLENTY

KEY EFFECTS

- Wetter average conditions, particularly in the west, could possibly manifest as more frequent and intense rainfall events.
- Increased risk of flooding in the west and also in river catchments in the Coromandel and inland Bay of Plenty.
- Increased drought risk in the Hauraki Plains and coastal and eastern Bay of Plenty.
- Fewer frosts, particularly inland, and more hot days in summer are likely.
- Annual temperature increases of about 1 deg C by mid-century and more than 2 deg C by 2100.

OPPORTUNITIES

- Increase in temperate pasture yield depending on changes in pasture composition.
- Warmer, wetter conditions would generally be of benefit to maize production, although increased summer rainfall may not always be beneficial, depending on timing and intensity.

In areas where conditions could be drier on average, the greatest effect would be from any increase in frequency and intensity of summer drought.

RISKS

- The possibility of increased drought risk in Hauraki Plains and coastal and eastern Bay of Plenty, resulting from increased evapotranspiration and lower average rainfall, could contribute to reduced clover content in pastures and a higher incidence of sub-tropical species.
- A warmer wetter climate (particularly in the south and west of Waikato) is likely to see such increased incidences of facial eczema, increased problems with internal parasites and heat stress risk for dairy cows over time.
- Increased risk of flooding in the Thames Valley because of a rise in sea-level.
- Sub-tropical grasses such as kikuyu and paspalum are already spreading and are likely to become more widespread over time.

GISBORNE TO WAIRARAPA - EASTERN NORTH ISLAND

KEY EFFECTS

- A longer growing season and reduced frequency of frost.
- More frequent hot, dry, summer conditions and potential for more frequent heat waves. These are often associated with El Niño episodes, as occurred through the 1980s and 1990s, which coincided with a positive phase of the Interdecadal Pacific Oscillation (IPO).
- Lower rainfall and increased evaporation over the growing period and possibly increased drought frequency and severity.
- Decreased runoff into rivers and thus reduced river flows, on average. Run-off decreases of 10-40 percent could be experienced in eastern parts of Hawke's Bay. There is uncertainty over rainfall changes in the western ranges, which means uncertainty about changes in run-off and river flows in the river catchments that extend back into the ranges.
- Depending on changes to weather patterns, an increase in frequency and intensity of high rainfall events could also be possible. Together with drier average conditions, this could lead to increased problems with erosion and flooding. The area at greatest risk is the hill country between Hawke's Bay and Poverty Bay, which has historically experienced the most intense 24-hour, five-year rainfalls in the eastern North Island.
- Westerly winds are likely to become more persistent in spring and summer.

OPPORTUNITIES

- Higher temperatures will generally increase opportunities for maize and similar crops through reduced frost risk, the opportunity for earlier sowing and more rapid maturation. The availability of water will be the greatest limitation.

RISKS

- Security of water supply is likely to be the greatest issue for the eastern North Island in the future. Drier average conditions, together with increased growth in demand for water, are likely to place increasing pressure on available water resources.
- With drier conditions on average, increased drought frequency, and potentially more wind in spring, there would be a reduction in pasture productivity. These impacts will be greatest in drier parts of the east coast, which are already experiencing the effects of three consecutive droughts.
- The expected drier average conditions, combined with possibly more intense rainfall at times, will increase the erosion and flood risk of most hill country in the eastern region. Windier springs could also increase the potential for wind erosion.
- Changes in pasture composition are likely, with the possibility of a decreased legume component with drier average conditions, depending on grazing management. An increased incidence of subtropical grasses such as paspalum and kikuyu is likely.
- Some increase in existing weedy species, such as woolly nightshade, could occur and other plant pests could also emerge with warmer, drier, conditions.
- Increased incidence of facial eczema, viral pneumonia and heat stress.
- Security of water supply is likely to be the greatest issue for eastern North Island in the future. Drier average conditions, together with increased growth in demand for water, is likely to place increasing pressure on available water resources.
- Changes in rainfall, with the possibility of more extremes of wet and dry, will be an important factor for local and regional infrastructure.

TARANAKI-WESTERN NORTH ISLAND

KEY EFFECTS

- Warmer winters, reduced frequency of frost inland and at higher elevations, and a longer growing season.
- Wetter average conditions, particularly in the west, which could possibly manifest as more frequent and intense rainfall events.
- An increased risk of flooding and erosion, with the potential for more frequent, intense rainfall events. Erosion risk is high over significant tracts of land and will be exacerbated with any increase in rainfall frequency and intensity.
- A possibility of increased drought risk, particularly on lighter soils in coastal areas.

OPPORTUNITIES

- With warmer and wetter conditions, on average, western regions of the North Island could experience increases in temperate pasture yields.
- Stock could generally benefit from warmer winters, with less stress on animals (stock losses down) and better reproduction rates/ less calving losses.

RISKS

- Increased risk of flooding and erosion throughout the region.
- Security of water supply in parts of the region, in the face of increasing demand for irrigation, and the possibility of increased drought severity in dry years.
- The spread of insect pests, such as the clover weevil and clover flea, could be accelerated with warmer average conditions.
- Warmer, wetter seasons will likely increase the incidence of fungal diseases. Facial eczema for example could emerge as a significant problem over time. Any potential effects on animal health are likely to be indicated by changes in the Waikato and further north that may occur over the next one to two decades – for example an increase in the risk of internal parasites and heat stress.

NELSON AND MARLBOROUGH

KEY EFFECTS

- A longer growing season, and reduced frequency of frost.
- The possibility of more frequent hot, dry, summer conditions and potential for more frequent heat waves and drought severity and intensity. This could occur even if conditions become wetter on average.
- Run-off decreases of around 40 percent could be experienced in eastern Marlborough, with the likelihood of decreases in other areas in the summer months.
- Depending on changes to weather patterns, there could also be an increase in frequency and intensity of high rainfall events, which could lead to increased problems with erosion and flooding. Historically, the most intense 24-hour rainfalls have been experienced in the Tasman Mountains and Richmond Ranges, which are the principal catchments for Nelson and Marlborough.

OPPORTUNITIES

- There could be pasture productivity gains in wetter areas of Nelson.

RISKS

- With increased drought frequency there could be a reduction in average summer pasture productivity in Marlborough.
- A number of undesirable sub-tropical grass species are already present in parts of Nelson and Marlborough. Paspalum has already spread in parts of the eastern Nelson hills and is likely to become more widespread with warmer, wetter average conditions.
- Increased risk of facial eczema. Any such changes are likely to lag behind changes in the North Island.
- The risk of fires in rural areas, as experienced in Marlborough recently, may also increase with potentially severe effects.
- Security of water supply is likely to be the greatest issue for Nelson and Marlborough in the future, even if the worst effects of climate change are not realised. Drier average conditions during the summer months, together with increased growth in demand for water, is likely to place increasing pressure on available water resources.
- Changes in rainfall, with the possibility of more extremes of wet and dry, will be an important factor for local and regional infrastructure.

CANTERBURY

KEY EFFECTS

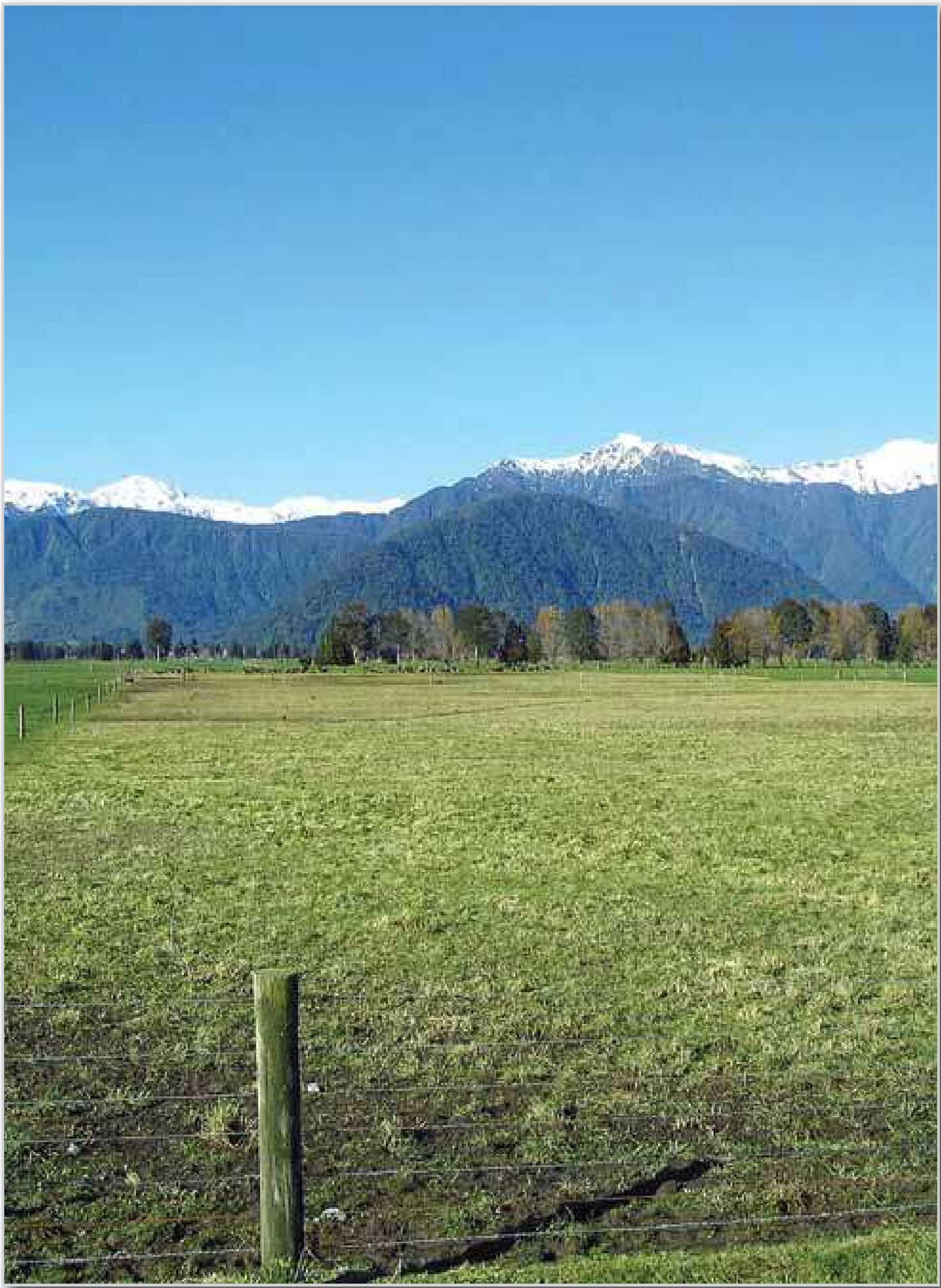
- Warmer winters, reduced frequency of frost, and a longer growing season.
- Drier winters and more frequent hot, dry, summer conditions.
- In the Canterbury Plains, lower rainfall and increased evapotranspiration over the growing period and possibly increased drought frequency and severity.
- Increased rainfall in the Southern Alps and Canterbury foothills would lead to increased river flows in the principal rivers of the region. Run-off decreases of 40 percent could be experienced in eastern parts of the region.

OPPORTUNITIES

- A warmer average climate in Canterbury will increase opportunities for maize production, depending on the availability of water.

RISKS

- The biggest issues for pasture production in Canterbury will be changes in species composition in dryland farming systems and impacts on water resources of drier conditions.
- There is no clear evidence of sub-tropical grass species becoming a problem, although the risk of invasive species establishing over time would increase, particularly on dry, northern slopes in North Canterbury.
- Security of water supply is likely to be the greatest issue for Canterbury in the future, even if the worst effects of climate change are not realised. Drier average conditions during the summer months, together with increased growth in demand for water, are likely to place increasing pressure on available water resources.
- Changes in rainfall, with the possibility of increased rainfall in the ranges and drier average conditions on the plains, will lead to consequences for local and regional infrastructure.



WEST COAST

KEY EFFECTS

- The South Island's West Coast will become wetter, particularly in winter and spring. Average annual temperatures are likely to rise by about 1 deg C by mid-century and 2 deg C by 2100, accompanied by reduced frequency of frost, and a longer growing season.
- Increased average rainfall in the main divide would increase river flows throughout the region.

OPPORTUNITIES

- The greatest gains are likely to arise with possible increases in pasture productivity from higher temperatures and increased CO_2 in the atmosphere.
- Higher temperatures would generally be of benefit to pastoral farming throughout the West Coast.

RISKS

- An increase in frequency and intensity of high rainfall events could increase flood risk, which is already high in many parts of the region.
- Changes in pasture composition could take place, particularly in the north of the region, with a potential increase in incidence of sub-tropical pasture species such as paspalum.
- Warmer and more humid conditions in the north of the region could cause problems such as facial eczema.
- Plant pests will likely become more of a problem with higher temperatures and increased rainfall.
- West Coast communities are located along narrow coastal and river strips beneath mountain ranges, hence they're very exposed to increased risks of storms, flooding and landslides. Increased rainfall may pose a more immediate threat to those farms without any flood protection works at present, and to those farms that may not be able to afford to maintain/improve existing flood protection works.
- Higher rainfalls will increase the risk of problems with soil management, such as compaction and nutrient run-off.
- Increased rainfall will be an important factor for local and regional infrastructure.

OTAGO AND SOUTHLAND

KEY EFFECTS

- Warmer winters, reduced frequency of frost, and a longer growing season are likely. The daily temperature range is already decreasing in Southland at a faster rate than anywhere else in New Zealand.
- More frequent hot, dry, summer conditions in coastal North Otago and possibly Central Otago.
- The possibility of a greater frequency of droughts (and a greater need for irrigation) comparable to those experienced during the 1997/98 El Niño and the 1998/99 La Niña episodes.
- Increased rainfall in the Southern Alps in the main divide could increase river flows in the Clutha and Waitaki rivers. The frequency and intensity of high rainfall events could increase throughout the region with a significant increase with associated flood protection costs. Recorded floods from the past 30 years have all arisen from completely different weather situations, so it's very difficult to specify where, and to what extent, flood risk might increase.
- Run-off decreases could be experienced in coastal Otago if warmer and drier conditions are realised. Existing water-short areas, eg, the Waireka-Kakanui and Shag Valley catchments, could anticipate significant problems with water supply for both rural water and community township supplies.

OPPORTUNITIES

- Pasture productivity could increase in some areas and decrease in others. Potential increases in pasture production are more likely to be realised in South Otago and Southland hill country and intensive farming systems. The Otago dry hill country could benefit with warmer winter conditions and higher average precipitation. However this benefit may not extend into the East Otago hill country – where there may actually be less rainfall. The extent to which any benefits are realised will depend on whether there is any increase in drought frequency and severity, which is a possibility.
- A warmer average climate, and higher precipitation in South Otago and Southland, may have a mix of costs and benefits for arable cropping. More rain at harvest time would be detrimental. Higher temperatures and a longer growing season will be beneficial.

RISKS

- Water security is most likely to be an issue in parts of Otago and Southland where drought is already a major constraint. Flood risk could also increase throughout the region over coming decades with projected average rainfall increases and the possibility of an increased frequency and intensity of rainfall events.
- Higher rainfalls during winter in dairy farming areas will make the management of winter conditions more difficult.
- Higher intensity rainfalls will increase the risk of problems with soil management, such as erosion, compaction and nutrient run-off.

TWO CASE STUDIES OF DAIRY FARMERS ADAPTING TO THE CHANGING CLIMATE

The response to a changing climate depends on circumstances and the goals and vision of each farmer. The following case studies illustrate two very different ways farmers are working so their businesses can adapt to the climate.

CASE STUDY 1: BUILDING DROUGHT RESILIENCE IN A DAIRYING SYSTEM WITH AUTUMN CALVING

NAME OF FARMER:

Alan Cole

LOCATION:

Pukekohe

BUSINESS/FARM DETAILS:

Alan Cole has a 135ha dairy farm at Pukekohe, south of Auckland. He runs 443 cows on the property and is one of the few farmers who managed to come through the 2008 drought with minimal impact on production. Alan is developing a strategy, including maize silage and autumn calving, that shifts production to take advantage of more favourable periods in the regional climatic pattern.

THE CLIMATE FOR PRODUCTION AND CLIMATIC CHANGES

Alan's standard management plan anticipates the potential impacts of a dry summer period. In most years, a dry spell lasts four to six weeks and causes feed deficits that require advance planning. While an affordable supply of supplement is available in most years, during the 2008 drought the high demand for supplement from the large number of affected farmers caused significant price increases. That drought ranks among the two worst that Alan has experienced. It challenged his ability to react quickly and obtain his farm goals.

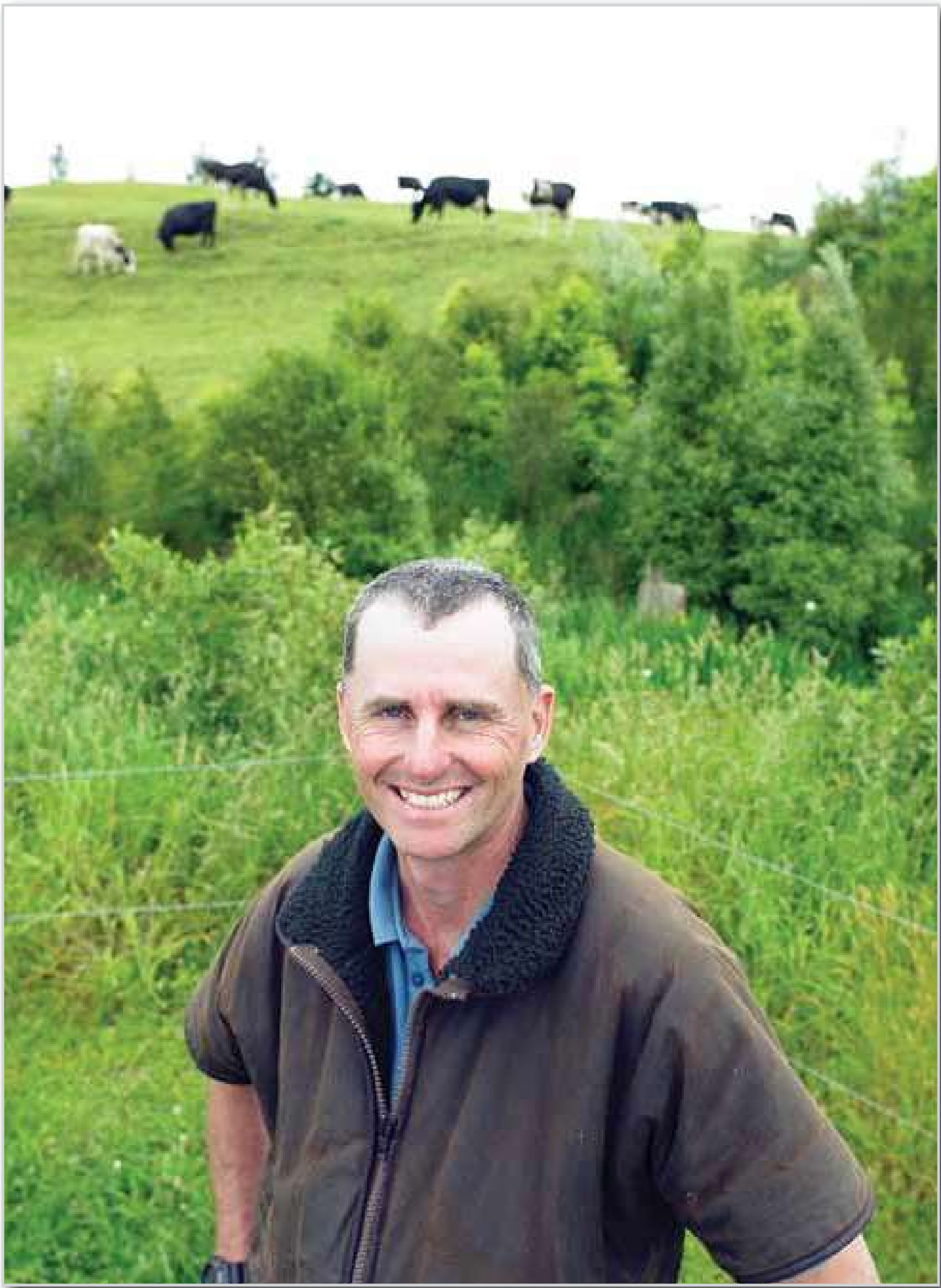
Alan sees substantial variability in the amount and timing of rain during the summer, which he believes has recently become more and more pronounced. These climatic trends have encouraged him to adopt changes in his management practices. His observations of weather patterns indicate that his response will correspond to regional climate change projections.

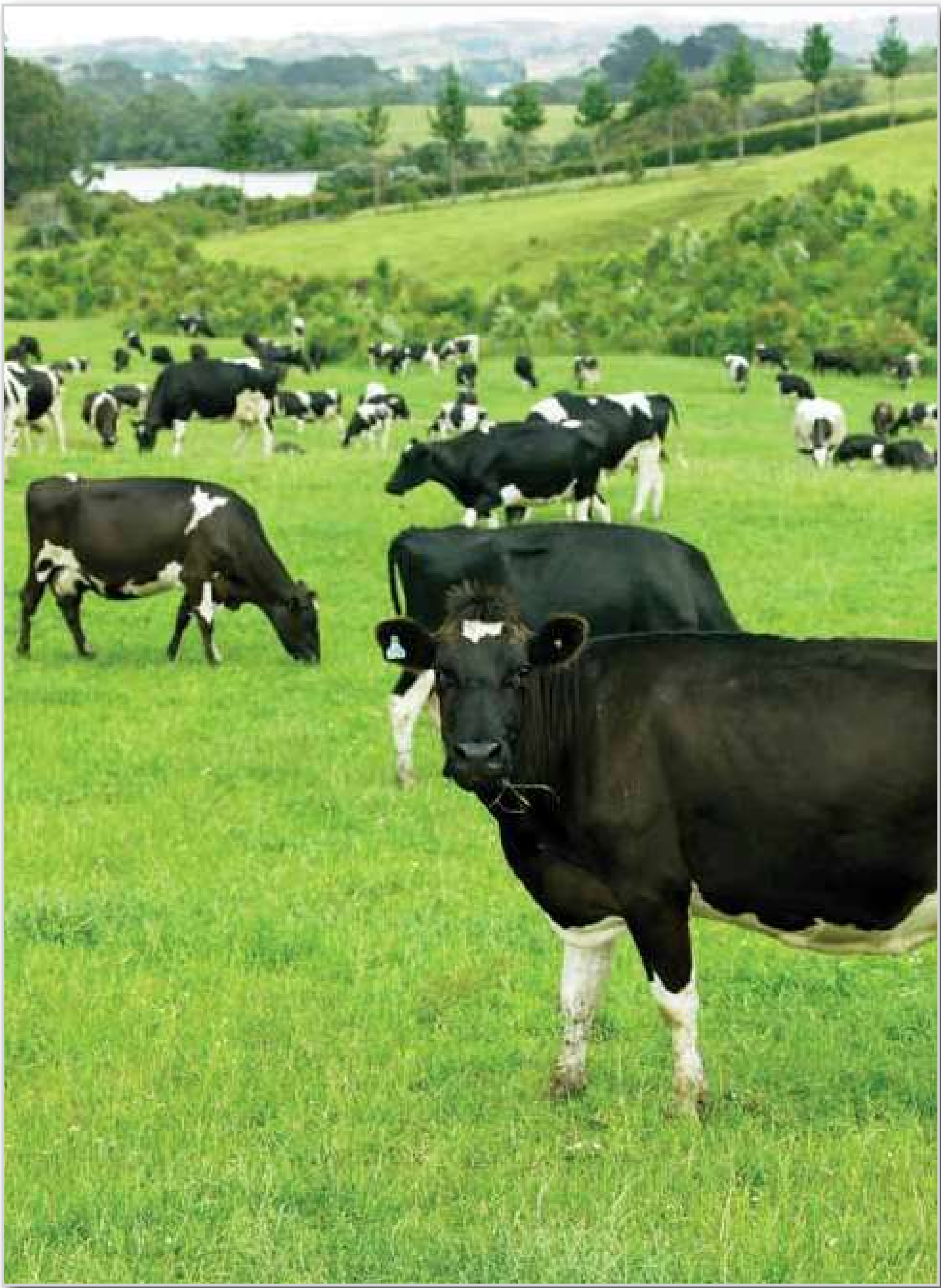
"We tend to stick to those ranges [700-1300mm] all the time, but recently it was like chalk and cheese, one year was wet in the dry months and it was opposite the next year."

RESPONSES TO THE DROUGHT AND TO DRY PRODUCTION CONDITIONS

Alan believes that his autumn calving strategy had the most positive impact on the farm's performance through the 2008 drought. The farm has always had some autumn calving, which allows cows to be dried off and pasture growth to be conserved during the dry summer months. This is to some extent due to the demands on the system of supplying milk for town supply, and autumn calving is popular in his area, but not necessarily a widespread or widely applicable practice.

In 2008, Alan was even more vigorous in drying off cows early. When, in the late summer, the rains had not come, the decision was made to





dry cows off and send most of the autumn calves away for grazing. Although later rains may have mitigated the need for this move, the decision was consistent with his farm plan and did not negatively impact his operation.

Alan is moving all his stock to calve in autumn so they are dried off during the problem months of January to March. This allows the farm to maximise production during the growing season and shift feed demand away from vulnerable months.

In addition to his autumn calving strategy, Alan has decided to increase his home-grown feed. He planted maize for the first time in 2008 as a buffer against the expected drought. Just over 3ha yielded a 60t crop that was cut in February. Maize was added out of a desire to find the cheapest option for additional feed during the dry period. The maize comes with the additional benefit of improving the effluent paddocks and contributing to a four-year regrassing programme.

"I've got a problem over here in that I've got eight effluent paddocks and I'm not putting any fertiliser or lime or anything on them and my pH is actually lifting dramatically. The idea is that I'd put two maize paddocks in each year and try to suck some of the nutrient out."

Using effluent paddocks for maize cropping has improved feed outputs without negatively affecting other farm activities.

"All I'm doing is shifting that bulk of food I grow in the spring. I'm shifting feed into this hole here, so I didn't actually destock anything, which meant my stocking rate actually went up at that stage."

Alan is also working to reduce the costs of maize cropping by coordinating with nearby farmers to obtain better economies of scale. This project is enhanced by working through a single contractor for all of their farms. The participating farmers also benefit from the sharing of knowledge and experience. The cropping has already proved to be a success in responding to drought and feed shortages.

CONCLUSIONS

These two changes dramatically improve Alan's resilience in drought years, while at the same time making financial sense in years with more regular rainfall. They are part of a broader strategy of farm planning, shifting to autumn calving, and increasing feed grown on the home farm.

The drought and the variability of production conditions have increased the length of his planning horizon.

"You're always looking out further. You know if a dry spell's coming you've got these options and you need to act quicker than you normally would."

Alan believes there's a need to plan ahead to set a maximum amount or percent of the payout that you are willing to pay for off-farm feed. It may not always be possible to maintain satisfactory levels of production in very difficult growing conditions and farmers should have an established plan to inform the financial considerations of buying supplementary feed, early culling, and destocking.

Key points

- **Alan is developing a strategy of autumn calving and maize silage that shifts production to take advantage of more favourable periods in the regional climatic pattern.**
- **Farm planning should include detailed financial scenario building and decision-making. It may not always be possible to maintain satisfactory levels of production in very difficult growing conditions and farmers should have an established plan to inform the financial considerations of buying supplementary feed, early culling, and destocking.**

CASE STUDY 2: REDUCING SOIL DAMAGE IN HIGH RAINFALL

NAME OF FARMER:

Abe and Anita de Wolde (Woldwide Farms)

LOCATION:

Winton, Southland

BUSINESS/FARM DETAILS:

Woldwide Farms consists of three properties with a total area of more than 1410ha. The farm has 707ha in a milking platform, and another 707ha of support land, including 160ha of forestry. They produced about 1m kg milksolids (MS) in the 2007/08 season.

SUSTAINABLE DAIRYING

Abe and Anita de Wolde are confident that a healthy environment and a healthy dairy industry can be achieved together. After several years of rapid growth and development, they took stock in 2004. They were running three dairy farms managed by contract milkers, and had increased their total land area, both through purchases and leases, to support the milking platforms. But they started to consider the long-term sustainability – including social, environmental and economical aspects – of their farming system.

"We could see that a healthy dairy industry was potentially on a collision course with a healthy environment. We became more and more convinced that in order to farm in a sustainable manner, we needed to be sensible in all three areas."

They investigated the effect of wintering dairy cows under traditional brassica systems. The farm had struggled to achieve good brassica yields for wintering cows and faced problems of soil compaction, erosion, pests and weeds, which had led to rising wintering costs.

HOTTER AND WETTER CONDITIONS LIKELY

Current climate change projections have Southland likely to experience higher average temperatures and rainfall, fewer frost days, more hot days, and greater frequency of extreme rain events. Higher average temperatures will be beneficial because a longer growing season will increase the amount of dry matter (DM) produced/ha.

Meanwhile, higher rainfall and more extreme rainfall events will present significant challenges to many in the region. The de Woldes can expect their farm's average annual rainfall to increase by between 5-7.5 percent (48-72mm), on top of the current average of 960mm. Changes to projected rainfall distribution also means much higher winter rainfall and extreme rain events. Soil will become more waterlogged with more chance of pugging and soil damage. This will put more pressure on grazing management in early spring and late autumn, and will also lead to greater nutrient loss through run-off when irrigating wet soil.

THE WINTERING SHED

After investigating various different systems, Abe and Anita built a wintering facility on one of their farms, as part of their solution to support future environmental, economic and social sustainability. They now have two wintering sheds – one housing 400 cows and the other 500 cows – situated on the milking platforms close to the dairies. Their use during the wettest period of the year (between late autumn and early spring) has prevented soil damage caused when cows were wintered on crop, and also enabled more grass to be grown.

Manure scrapers installed in the dairies and wintering sheds have reduced the volumes of effluent. In the dairy, each cow now produces just six litres of effluent/milking, compared with the 50 litres of water typically used/cow for washdown.

Effluent is collected and stored in a bunker at the end of the yard, then emptied by slurry tanker two or three times a season, when soil conditions are favourable. Just one area is washed down – a 3m area from the rotary that drains into a stone

trap and is spread with a travelling irrigator. In the wintering sheds, the manure scrapers have reduced effluent production to 50 litres/cow/day.

The wintering sheds were designed and positioned to take prevailing weather conditions into account. Their south end is closed and windbreaks are on the west, while a roof vent running the length of the shed allows air to circulate.

Inside the shed, the cows are free to walk around, eat and socialise in walking areas, and individual cubicles have rubber matting that traps a cushioning layer of air underneath. Establishing the first shed was a learning process for both farm staff and the cows.

Initial stress on the cows was overcome by rotating them into the shed at night and outside onto pasture during the day. After about 10 days the cows became used to sitting on the rubber mat in their own cubicle.

Because of the results of the wintering shed so far, Abe and Anita plan to have all their cows wintered indoors. The shed investment, including effluent pump to storage and rubber matting in cubicles, cost $2000/cow.

HOW IS FEED MANAGED IN THE WINTERING SHEDS?

Silage is fed out twice a day from a feed alley that runs the length of the wintering shed. Cows still being milked are separated by subdividing gates and are fed higher protein rations. Abe said this housing system allows them to set individual drying off dates and safely increase the average lactation and therefore, the farm's income from milk. The change to wintering sheds means brassica crops are no longer grown. However, the support land is now used to produce barley and silage for winter feed. Whole crop barley is undersown with a short rotation Italian ryegrass. Barley is harvested in late summer, and ryegrass silage is made in spring and stored next to the wintering shed, during which time the support land is used to graze and grow young stock.

WHAT BENEFITS DO WINTERING SHEDS BRING TO THE FARM?

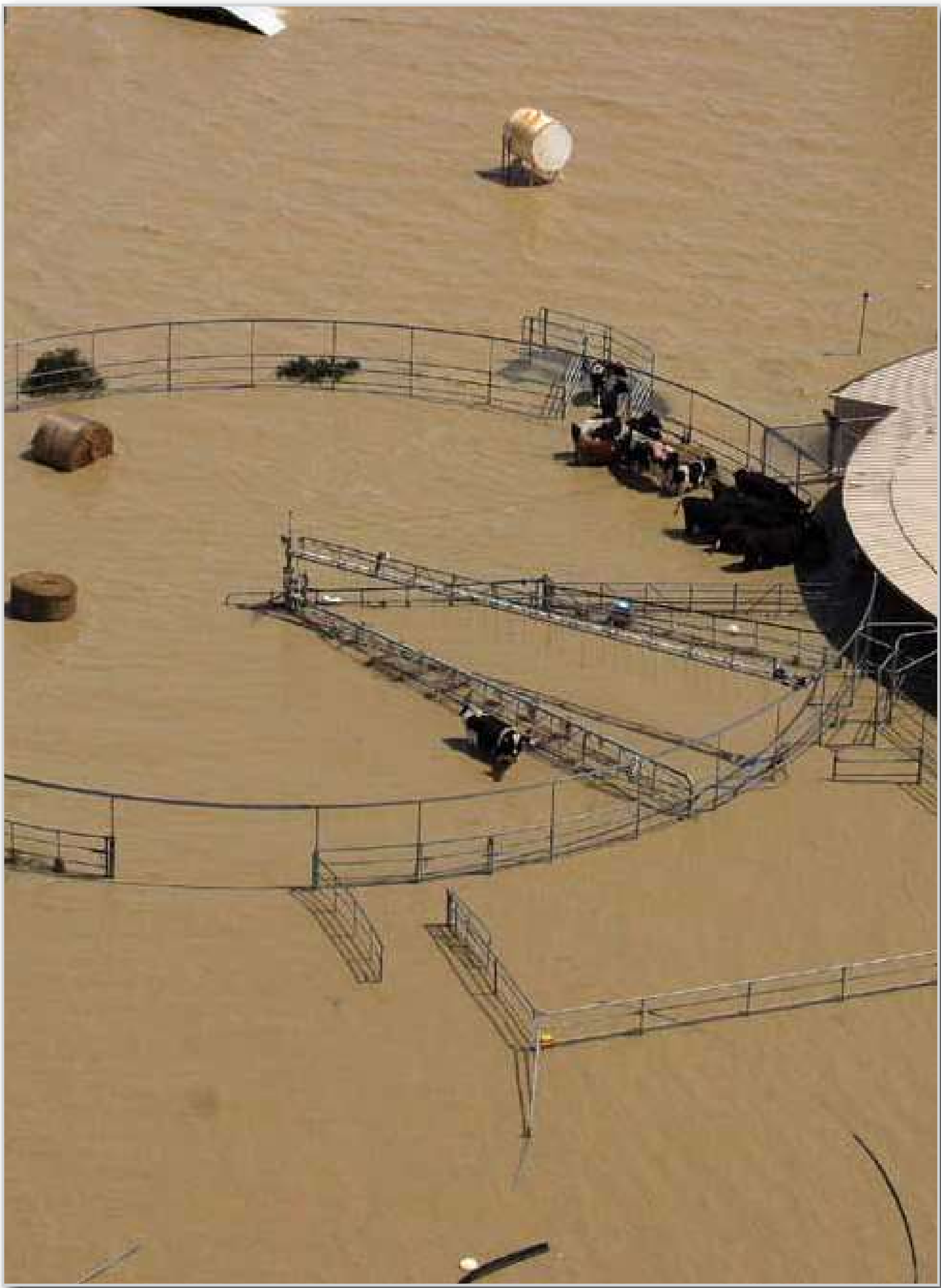
- Farm soil doesn't become pugged.
- Soil characteristics and pasture growth have improved.
- Less tillage is needed.
- Nutrient loss is reduced. Manure adds about $23,000 worth of nutrients to the farm's budget. Estimated 22.5 percent return on capital investment (the wintering sheds will have been paid back in five or six years).
- Less impact on waterways.
- Increased production (60kg MS/cow).
- Less feed wastage (two percent indoors compared with 53 percent outdoors).
- Cows eat less but have higher body condition scores (BCS).
- Intensification through higher production/ha (6 sq m for winter feed compared with 12 sq m in traditional crop wintering).

WHAT DOES THE FUTURE HOLD FOR THE DE WOLDES?

Abe and Anita are considering extending the wintering sheds' use to spring when the ground is still very wet, to further reduce pugging and soil damage.

Key points

- **The de Woldes aim to achieve long-term sustainability by balancing the environmental, social and economic aspects of their dairy farming business.**
- **The move to wintering sheds reduced soil damage caused by high rainfall, expected to occur more frequently. The sheds also allow for future pasture growth and production.**
- **Manure scrapers in the wintering and milking sheds reduce the volume of effluent by cutting out water used for wash-down.**
- **The wintering sheds have realised economic benefits associated with higher lactation, higher production/ha, reduced fertiliser cost and more efficient use of feed.**



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FOR MORE INFORMATION

General Information Land Based Sectors *http://www.maf.govt.nz/climatechange/*

New Zealand's Climate Change Solutions: *http://www.climatechange.govt.nz*

Ministry for the Environment: *http://www.mfe.govt.nz/issues/climate/*

DairyNZ: *http://www.dairynz.co.nz/climatechange*

Sector and industry organisations, local regional, district or city councils.