


An update on CLIMATE CHANGE:

New developments since 2006 in climate science and legislation

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Contents

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Disclaimer: Various opinions are contained in this report. The information has been compiled by considering the most up to date published climate change information available at the time, including reports by Government and non-Government organisations, and also websites, journals and the press.

The nature of climate change predictions is that they contain elements of uncertainty.

This paper will require updating as further information comes to hand.

Foreword

This report to the Gisborne District Council is an addendum to "An Overview of Climate Change and Possible Consequences for Gisborne District", which was received by Council in 2006. Instead of going over too much of the same ground, this report looks mainly at what has changed in the past two-and-a-bit years. Its purpose is to guide Council in preparation of its long term Council Community Plan and the assist the wider community understanding.

With the passage of the Emissions Trading and Renewable Preference Bill, New Zealand has entered a new era of environmental awareness and accountability. We are now "world leaders" in emissions trading legislation. At the same time, both in New Zealand and overseas, acceptance of the gravity of the climate change crisis has further increased.

A major criticism of the Emissions Trading Scheme is that it remains "too easy" for polluters to simply go on polluting, and offset their emissions by buying in carbon credits. Nor has there been anywhere as much talk about working to reduce emissions as there has been about generating cash through investment in carbon sink activities, such as commercial forestry.

It is important to acknowledge that planting trees, or other types of offsetting activities, won't achieve much of a reduction in atmospheric carbon if we don't also reduce emissions. Since there is nowhere near enough available land in New Zealand to offset all NZ's carbon footprint with trees, this highlights a potential high future cost for farming ruminant livestock, as they are major emitters.

Over a quarter of New Zealand's land is held in the conservation estate, and must contain huge carbon stores. But as much of this land was already forested on the 31st of December 1989, it doesn't count towards our Kyoto commitments.

Afforestation, in the end, only buys some time, and in fact not very much time, to look at improving efficiencies, creating new technologies, and changing land use patterns in the long-term. Some scientists believe that despite millions of trees being planted this will not be sufficient to prevent the Earth tipping the $+2^{o}$ point some say is critical, and beyond which further dramatic warming is inevitable.

After doing some very rough calculations using figures readily obtainable on the internet, we can be virtually certain Gisborne District is at least carbon-neutral, and probably quite a major carbon sink (already – without any more forests). Many others will probably have done similar simple maths to arrive at this same conclusion.

Unfortunately it is not possible for the whole district to become a separate carbon-entity and cash in on "our" carbon sinks, while relieving residents of the extra costs the Emissions Trading Bill will precipitate. If only.

However, some Gisborne people are fearful we are poised to become "New Zealand's carbon sink". These concerns are justified.

In Gisborne District, where average hill country farm sizes are quite large, and sheep and beef production is the typical farming activity, it would actually be possible for many farms to offset their own emissions within the bounds of the farm property. Maybe in the future, farmers who choose to do this will be allowed to "opt out" of the Emissions Trading Scheme?

Arguably the most interesting area encountered in the research for this report was the huge potential for carbon sequestration in agricultural soils by grazing management. While techniques for doing this are already known, the methods of measuring carbon accumulation are really only in their infancy. This will be an area to watch in the future; some believe it is possibly the "magic bullet" for climate warming everyone is seeking, allowing farmland to both produce food and sequester carbon at the same time, while alternatives to fossil fuels are developed.

What does the future hold for residents of Gisborne in this new post-emissions trading era? We will probably notice around a 4c per litre rise in the price of petrol (then again, we may not notice that), and there will probably be an increase of around 5% in the price of electricity. These increases are hardly large enough to significantly change the behaviour of the well-off, although they will certainly impact on lower income households and elderly residents. Both these groups probably try to use fuel and electricity in a sparing way already. It does not look likely these increases will drive consumption down below 1990 levels.

The Government has also committed $15.5 million to the end of 2010 to a solar water heating programme. Details of this can be found at www.eca.govt.nz

Farmers of sheep, beef and dairy cows will probably notice some changes once their sector enters the Emissions Trading Scheme in 2013. There is currently a lot of speculation in newspapers and farming magazines about what the costs may be. Exactly what proportion of the additional costs will fall to farmers, and to consumers of meat and dairy products, are not precisely known yet. The Government has stated its preference for meat and dairy processing companies, and fertiliser manufacturers to participate in the scheme, rather than individual farmers.

The Government says it is covering the costs of the agriculture sector's methane emissions during the first Kyoto commitment period (2008-2012). Meanwhile the agriculture sector is contributing to research (via the Pastoral Greenhouse Gas Research Consortium) that is supposed to deliver abatement technologies that will lower methane and nitrous oxide emissions from farms by at least 20%, by the end of 2012.

Despite release of the IPCC's Fourth Impact Assessment Report, and the passage of the Emissions Trading and Renewable Preference Bill, the climate change debate remains polarised. On one hand, those who doubt anthropogenic climate change may be labelled "deniers", while those who accept it and want Governments to take action are labelled "alarmists".

For this report, a little time was given to looking for real "evidence" that there is no basis for anthropogenic climate change. Much of the evidence cited by skeptics has explanations that are in fact consistent with climate warming, if you look at the whole picture, rather than selective bits of information. Some simple answers to common skeptical questions are included in an appendix.

Despite the lack of evidence "against", and the "consensus" of thousands of scientists that global warming is a reality, there are some well-known personalities (some of whom are scientists) who remain firm in their belief humans are not influencing climate in any way.

In preparation of this report, new material surfaced repeatedly that made redundant things that had been covered in draft chapters. In just four months, some chapters went through four drafts.

Therefore, while every effort has been made to ensure the information contained within is the most up to date available, some information will need to be updated in the future as both climate science, research into carbon sequestration, not to mention regulations, continue to evolve.

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Summary

Chapter 1: What has changed since the last Gisborne Climate report in 2006?

The IPCC (the Intergovernmental Panel on Climate Change) released their Fourth Assessment Report in 2007, providing even stronger evidence than the Third Report of human-induced climate warming.

Findings include:

- The amount of water vapour in the atmosphere has increased since the 1980s.
- Melting of the Greenland and Antarctica ice sheets is very likely to have contributed to observed sea level rise from 1993 to 2003.
- Average Arctic temperatures have increased at twice the global rate over the past 100 years, and satellite data since 1978 reveal arctic sea ice has shrunk by 2.7% per decade.
- For permafrost areas in the Arctic latitudes, top-layer temperatures have increased since the 1980s by up to 3 degrees. The area of seasonally frozen ground has decreased by about 7% since 1900 (with a decrease in spring of up to 15%).
- Some areas of the globe have experienced a long-term (1900–2005) trend of increased precipitation (in eastern parts of North and South America, northern Europe and northern and central Asia). Meanwhile drying has been observed in the Sahel, Mediterranean, southern Africa and parts of southern Asia.
- Changes in precipitation and evaporation over the oceans are indicated by observations of freshening of mid- and high-latitude oceans and increasing saltiness in low-latitude oceans.
- Mid-latitude westerly winds have strengthened since the 1960s in both hemispheres.
- More intense and longer-lasting droughts have been observed over increasingly wider areas since the 1970s, particularly in the tropics and sub-tropics.
- The frequency of intense rainfall events has increased over most land areas.
- Cold days, cold nights and frosts have become less frequent, meanwhile hot days, hot nights and heat-waves have become more frequent.
- Cloud feedbacks remain the largest source of uncertainty as they produce both heating and cooling effects – depending on the cloud type.

Trends observed within New Zealand

New Zealand is now producing 25% more greenhouse gases than in 1990.

There has been a 58% rise in dairy cow numbers from 3.39 million to 5.28 million since 1990.

Dairy cow numbers in Gisborne District have more than doubled since 1990.

Sheep and beef cattle numbers have decreased, but since each individual animal produces more emissions than they did in 1990, the net effect is we're worse off.

There are around 40,000 individual farms in New Zealand, and they generate about half of the country's greenhouse gas emissions.

The planting of new production forests has slowed, and large areas formerly in exotic forest have been cut down and not replanted.

New Zealand's population has increased since 1990 from 3.4 to an estimated 4.26 million in August 2008.

We are further than ever from the goal of having 90% of energy generated from renewable sources: in 1999 72% of generation was renewable, but this had fallen to 66% in 2007.

Greenhouse gas emissions from the generation of electricity rose by 138% from 1990 to 2006.

Scientists at the Pastoral Greenhouse Gas Research Consortium announced they had mapped the genetic sequence of a microbe responsible for producing methane from the rumen of cattle and sheep.

A solution, possibly in the form of a drench, vaccine or feedstuff, is probably at least five years away, and integration into farming practice is probably at least ten years away.

On September the 10th 2008, legislation enabling the New Zealand Emissions Trading Scheme was passed.

The ETS is a framework document, and is likely to be amended many times over the coming years, particularly in response to new developments in climate science.

Chapter 2: 4th Impact Assessment Report implications for Gisborne District

For the East Coast of New Zealand, and for much of Hawke's Bay, the new IPCC rainfall information is quite different to that given previously.

Future temperature changes for Gisborne are likely to be smallest in the spring, compared to the other seasons. In winter and spring, more persistent westerly winds are predicted, which would make those seasons notably drier for the East Coast.

Gisborne's annual mean temperature is expected to increase by 0.9° by 2040, and by 2.1° by 2090.

There will be fewer cold temperatures and frost days, together with more high-temperature episodes.

For autumn, and particularly summer, *reduced westerlies* are predicted, therefore there could be an *increase in summer rainfall,* by as much as +10% to +15% by 2090, on the East Coast, coupled with a decrease in moisture loss by evapotranspiration in summer.

Predictions for autumn rainfall are +5% to +7.5% by 2090.

Rainfall in winter and spring could be 10% less; even so, winter will still be the wettest season.

A*verage annual* rainfall is still expected to decrease for Gisborne; it is the seasonal distribution of the rainfall that is significantly different.

Heavier and/or more frequent extreme rainfall events are still predicted with "moderate confidence".

The IPCC are "very confident" that sea level will rise by an average of 18 to 59cm (between 1990 and 2100). Ocean temperatures are expected to rise in parallel with air temperature increases.

During El Niño periods, ex-tropical cyclones are less likely to affect New Zealand directly, since their path tends to track further east.

Many of the climate change models indicate an El Niño-like state persisting in the tropical Pacific for the next 50 years. Exactly how this might affect the number of ex-tropical cyclones reaching New Zealand is not yet clear.

However, mid-latitude storms, or extra-tropical cyclones may increase in intensity .

Possible changes in storm tracks, and whether New Zealand will be more vulnerable, are as yet unknown.

The only clear conclusion made by the IPCC in the *Summary for Policymakers* is: *"Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s".*

Using the updated climate models for New Zealand, and new methodology, the EcoClimate team predicted pasture production on the east coast north of Napier would *increase over summer.*

In very dry years pasture production would still be expected to decline, but the reduction may be less for the East Coast than for other eastern regions of New Zealand.

Pasture may begin to grow earlier in late winter/ early spring as the climate warms.

Windier winters and springs may mean pasture dries out earlier. If, as predicted, there are summer 'top ups' of rainfall, these would certainly be appreciated by farmers and may allow more hay and summer feed crops to be grown for use over the autumn and winter.

Reduced winter rainfall may mean slower recharge of surface and groundwater storage.

Our hill country areas are likely to remain suitable for beef cattle production. Attractiveness for dairy conversion probably depends more upon what the markets are doing, climatic and geographical constraints.

Increased summer and autumn humidity are however potentially detrimental to sheep, due to a possible increase in fungal and metabolic diseases.

In any year, temperature can deviate from the long-term mean by +/- 1^{o}, and rainfall by as much as +/- 20%, depending on whether we are experiencing El Niño or La Niña.

Records from seven widely spaced climate stations are available from 1908, and show that since that date, temperatures in New Zealand have increased by 0.9^{o}.

The interdecadal Pacific oscillation (IPO), has a periodicity of 15 to 30 years, and has been shown to correlate with peak flood flows in the Bay of Plenty.

There will still be wetter and drier, warmer and cooler years while the long-term average annual temperature will continue to trend upwards.

Because Council already has procedures in place to deal with the effects of extreme climate events it will not be necessary to develop a whole set of new procedures, but rather to consider new climate information as it becomes available and continuously review the effectiveness of responses.

Climate change considerations will influence where development can take place, as much of the city is low-lying, and there is extensive coastline with apparent development potential.

Chapter 3: An emissions trading scheme for New Zealand

The principal purpose of the Climate Change (Emissions Trading and Renewable Preference) Bill was to amend the Climate Change Response Act (2002) to introduce the NZ ETS.

The greenhouse gases included in the NZ ETS are the six identified in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydro-fluorocarbons (HFCs), and sulfurhexafluoride SF_6 (from 2013).

In addition it amends the Electricity Act 1992 to create a preference for renewable electricity generation by placing a restriction on new coal/gas/oil-fired power stations.

The Bill passed by a 63-57 vote after its third reading in Parliament on the 10th of September, 2008. With the subsequent change of government, changes are likely. A special select committee has been established to review the ETS.

There may also be changes to the ETS required by changes to the international climate change policy framework after 2012.

The ETS:

- Puts a dollar value on emissions and creates a unit of trade, the NZ Unit (NZU), representing one tonne of CO_2-equivalent emissions.
- Requires that participants measure and report on the emissions they generate
- Puts a total cap on emissions, while enabling participants to trade their allowance to produce emissions
- Enables sectors that absorb and store greenhouse gases (such as forest growers) to earn credits that can be sold under the ETS.

There will be an initial 'free allocation' of units from the Government to some sectors. Units can be generated through creation of a carbon sink (for instance a forest), or by purchase of units from other participants who have made a corresponding carbon saving, either within New Zealand, or in another country.

Forestry entered the ETS in January 2008. Entry of other sectors will be:

- Stationary energy and industrial processes from January 2010
- Liquid fossil fuels and transport from January 2011 (originally 2009). The reason for the delay is given as "to reduce inflation pressures"
- Agriculture, waste and all remaining sectors from January 2013.

An "Allocation Plan" which will set the criteria and methodologies for distribution of allocations is yet to be drafted.

The sum total of all allocations cannot increase above the total "cap" set at 90% of 2005 emissions for the industrial and agriculture sectors, and at 90 NZUs for each 100 tonnes of direct emissions for the industrial and stationary energy sectors.

In addition, the pool would include units sufficient for businesses and industry to offset 90% of the increased price of electricity (based on electricity consumed in 2005)

Owners of pre-1990 forests purchased before the stipulated date in 2002 potentially face the greatest costs under the ETS, and will receive increased assistance (from 39 to an estimated 60 NZUs per hectare).

Indigenous pre-1990 forests (and any clearance of these) are excluded from the ETS. This means that intermittent clearance of areas of scrub for the purpose of maintaining land in pasture would not incur a penalty anyway (provided of course that this was a permitted activity, or received resource consent under regional/district plans).

Owners of pre-1990 forests cannot avoid deforestation liabilities by replanting the forest either on the same land or elsewhere.

Where trees are removed from land that was in forest pre-1990, and where the trees are eight years old or younger, the trees will be treated for the purposes of emission calculations *as if they were of the age and species of the trees last harvested.*

Points of obligation

On the following page are listed key sectors in the ETS, with (in italics) those who will be responsible for surrendering Units, and (in brackets) the estimated number of participants:

- Agriculture – *Processors* (25), *fertiliser companies* (10)
- Forestry - *landowners* (or *forestry rights holders*)

- pre-1990 forest if deforested (potentially > 1000)
- Post 1989 credits and obligations (2000-9000)

- Liquid fossil fuels and transport - *fuel suppliers* (5)
  - Domestic aviation may opt in and take on obligations
- Stationary energy - coal, gas, geothermal *suppliers* (45)
  - Large users may opt in and take on obligations
- Industrial processes - *end emitter* (35+)
- Waste - *landfill operators* (60)

The final decision as to whether the point of obligation for agriculture will rest with individual farmers or processors has not been made yet.

Monitoring and verifying farm-level emissions would be technically difficult and expensive.

The Select Committee recommended the Government's opportunity to set (by Order-in-Council) a farm-level point of obligation, will expire on the 30th of June 2010 (instead of 2012, in the original Bill).

International links

Because NZUs will be "backed up" by a Kyoto unit they can be used to meet international trading obligations.

An internationally tradable carbon credit unit called an AAU (Assigned Amount Unit) has been proposed which would represent one tonne of CO_2 emissions

Australia's ETS

Australia is believed to be about 20 months behind New Zealand in the development of an ETS.

The proposed Australian scheme does align with the NZ ETS on key principles.

It will cover all gases and eventually all sectors; all participants producing emissions above a prior level will ultimately have to pay the full cost; price signals for those emissions will be set in a cap-and-trade system rather than by carbon tax; the Australian national trading scheme will have international links to improve its liquidity and reduce its volatility; trade-exposed sectors will get help to keep them competitive; and the rate of emissions reduction will be adjusted to keep pace with competitor countries.

In Australia forest owners will not be liable for carbon debits if deforesting their land.

Australian-generated carbon credits will probably not be able to be sold offshore, and the purchase from overseas of some types of Kyoto credits is likely to be limited or illegal.

Free-allocations are to be far more generous in the NZ ETS.

Chapter 4: Trees on land – the creation of carbon sinks

A key tactic of Government's policy package to meet Kyoto Protocol obligations is to *offset* greenhouse gas emissions through carbon sequestration (including retention of existing forests, enhancing biomass build-up in existing forests, and developing new forests), rather than to solely bring about emission reductions.

Offsetting can occur in areas remote from where emissions are generated. For instance, emissions from dairy farming in Canterbury can be compensated by afforestation of North Island hill country.

Only a portion of the carbon captured by a forest is truly sequestered, and then only for a certain timeframe. Harvesting may be permitted, but replanting will therefore be necessary.

A forest cover will only be able to be removed in the future if landowners are prepared to pay for the re-release of stored carbon.

Although at present the Kyoto Protocol does not permit offsetting of forest harvesting/clearing by replanting elsewhere, this could change in the future.

On suitable land, trees are a fast, easy way to remove carbon dioxide from the atmosphere, particularly the fast growing plantation species.

Longer lived indigenous species, while their rate of carbon uptake is obviously slower, have the advantage of persisting in the forest much longer (up to hundreds of years), and providing other positive benefits to biodiversity, soil and water conservation and aesthetic qualities, meanwhile providing for some sustainable harvesting of valuable timber.

Over time the carbon stored in an indigenous forest will overtake and greatly exceed that stored in a plantation forest.

New Zealand forests and the Kyoto Protocol

At present high deforestation/harvesting and low replanting rates, New Zealand forests will actually release more carbon than they capture from around 2020 until around 2033.

The Government has therefore started the Afforestation Grant Scheme, aimed at encouraging forest planting by landholders who do not wish to be a part of the ETS. It will suit owners of small forests, including farm foresters.

Conversely, forests planted under the East Coast Forestry Project, and the Permanent Forest Sink Initiative are able to enter the ETS.

Afforestation Grant Scheme – what's it all about?

Key points are:

- It is a $50 million Government scheme to establish new forests, to assist in reaching New Zealand's carbon sequestration targets, alongside other environmental objectives (for instance reducing climate change impacts, erosion, nutrient leaching and flood peaks, and improving water quality)
- Grant recipients will own the new forests, and can earn income from timber when harvested.
- The Government retains responsibility for credits and liabilities, so forests established under the AGS won't participate in the NZ ETS.
- Nor are these forests eligible for the Permanent Forest Sink Initiative.
- Forests must be maintained for at least 10 years, however, there are no harvesting restrictions.
- Either the ECFP or the AGS can be used to afforest Overlay 3A erosion prone land within Gisborne District, or they could be used in tandem, the AGS to afforest additional or adjacent areas not eligible for the ECFP, but still requiring tree cover.
- AGS funding cannot be granted on land already entered in the ECFP.
- Minimum area required is 5ha, but this can be made up of blocks of at least 1 hectare, so it may be of interest to farmers wanting small blocks of trees, including those developing Works Plans under variation 176 of Gisborne's District Plan.
- Trees must be planted at a minimum density of 750 stems per hectare.
- Half the funding is available to Regional Councils to help meet their sustainable land management objectives, and half through MAF's public tender pool.

In the context of Gisborne District Plan variation 176, the AGS may therefore fill a useful niche in assisting landowners with Overlay 3A land requiring tree cover according to their Works Plans.

Anyone can apply for AGS funding if they either own land, or have the right to use land for forestry.

Participating councils (including Gisborne District Council) will act independently, not as agents of MAF, and have put in place an allocation panel to administer $25 million of the total pool, over a period of six years from 2008/09.

Closing dates for the AGS and ECFP have been co-ordinated, and are the 30th of June and the 31st of December each year.

The Permanent Forest Sink Initiative

Key points are:

- Applies to land that was not in forest on the 31st of December 1989.
- PFSI areas earn Kyoto Protocol-compliant "assigned amount units" (AAUs).
- It's not a grant to plant trees; establishment costs are the responsibility of the landholder, although forests planted under the ECFP can enter the PFSI
- Forests planted under the AGS are not eligible for the PFSI
- Active management to enable forest is required, but not necessarily planting of seedlings – facilitating natural regeneration is acceptable.
- Requires a covenant registered against the land title in perpetuity.
- There are penalties for deforestation (deliberate or by natural causes), as this would release carbon that AAUs have been paid out on.
- There is an option to exit after 50 years, provided units are repaid.
- Limited harvesting allowed.
- The forest could be indigenous, exotic, or a mixture of both.
- Minimum size is one hectare.
- Stock-exclusion fencing will probably be necessary.
- Can transfer to NZ ETS as post-1989 forest within 18 months of NZ ETS legislation becoming law (until March 2010).
- Landowner will incur liabilities if carbon is lost.

The East Coast Forestry Project

Some key points are:

- The ECFP is a Government-funded scheme, administered through MAF, to assist afforestation of the 'worst of the worst' eroding land in Gisborne District, identified as Overlay 3A.
- 50 year covenants are required, to be registered against land titles.
- *Pinus radiata* has in the past been a popular option, but poplars and willows, where applicable and at recommended spacing, and indigenous reversion are other options eligible for ECFP funding.
- Land cannot receive funding from both the ECFP and the AGS.

- Areas of land not identified as Overlay 3A, but still requiring tree cover, could be planted using AGS funding.
- ECFP grant recipients may, if they wish, participate in the PFSI with no change in their grant.
- ECFP grant recipients may participate in the NZ ETS but the grant would be adjusted.

What are the implications of all these forest-establishment incentives?

The East Coast Forestry Project has already produced a significant change in land use within the district as large areas of pastoral farmland have been converted to plantation forests.

The forest incentives made available under the ETS, together with the dis-incentives for future clearance, are likely to further exacerbate this trend particularly on the less-versatile steep hill country that predominates in large tracts Gisborne District.

Land use change to forestry has already created profound social changes as rural populations have thinned out, houses have been relocated, schools closed, and a relatively stable population of farm workers and their families has been replaced by a largely itinerant and seasonal workforce who tend to live away from the areas where they work and must commute large distances or live away from their families.

Anecdotal evidence from medical professionals in Gisborne point to an increase in time off work due to injury (alongside increasing ACC payouts) as the workforce has shifted from predominantly farm work to a far greater proportion of workers employed in forest harvesting.

While the ECFP has been around for a while, and is well understood by land owners, the new initiatives may take a while to catch on. Landowners may be distrustful of afforestation schemes given the continuation of the Kyoto Protocol is unclear after 2012.

Landholders may therefore wish to wait until beyond 2012 to see what happens next, meanwhile the Government is feeling increasing urgency to get trees in the ground in order to try to meet New Zealand's commitments ahead of a rapidly approaching deadline.

Chapter 5: Soil carbon sequestration

Sequestration of carbon in the soil is of great potential significance to the world's carbon stores, and therefore atmospheric concentrations of CO_2.

Collectively, organic carbon stored in the top 1 meter of the world's soils comprises an estimated 75% of the earth's terrestrial carbon stores.

The world's soils in fact hold more organic carbon (an estimated 1500 Gt) than the atmosphere (720 Gt) and terrestrial vegetation (600 Gt) combined.

Soil carbon sequestration can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, and enhance soil fauna activity. No-till crop production, mulching, use of cover crops, crop/pasture rotation and green manures are prime examples.

On hill country farms enhancing the activity of phosphorus-fixing *mycorrhiza* and clover with its associated nitrogen fixing *rhizobium* will benefit soil fertility as well as boosting carbon stores.

Conversion of land previously cropped to pasture can actually sequester more carbon in the soil provided good management is practised.

When the above-ground part of a grass plant is removed by grazing, the plant loses root mass to the soil, and exudes organic compounds in order to rebalance the biomass of the above and below-ground parts of the plant. This organic matter is then available to soil animals and microbes as a food source, much of it becoming incorporated into the soil as soil organic matter.

In order to best feed both livestock and the soil biota, grazing must be intermittent, and ideally sufficient stock would be let into an area where palatable species are at optimum length to quickly graze pasture to a short length in just one to three days, supply a good dose of animal manure and trampled pasture to the soil, then they would be moved on to the next area.

In a pilot programme, Western Australian Farmers will be paid $90/tonne annually and retrospectively for the increase in their soil carbon.

Chapter 1

What has changed since the last Gisborne Climate report in 2006?

The IPCC (the Intergovernmental Panel on Climate Change) released their Fourth Assessment Report in 2007. The climate predictions and scenarios presented in the earlier Gisborne report[1] were based on information contained in the IPCC's Third Assessment Report of 2001.

Climate science is by its very nature science-in-the-making. Because scientific knowledge is always advancing, some previously held ideas are sometimes rejected while others are added to and improved upon. The biggest news in the Fourth Assessment Report is just how fast the climate is changing.

It is therefore timely to review the climate information for Gisborne, and to look at where New Zealand legislation pertaining to climate change is heading, for there has been a lot of water under the bridge since the first Gisborne climate change report was received by Council.

The reality of climate change is certainly starting to hit home: Eleven of the twelve years 1995-2006 are included amongst the warmest twelve years recorded on Earth since 1850.

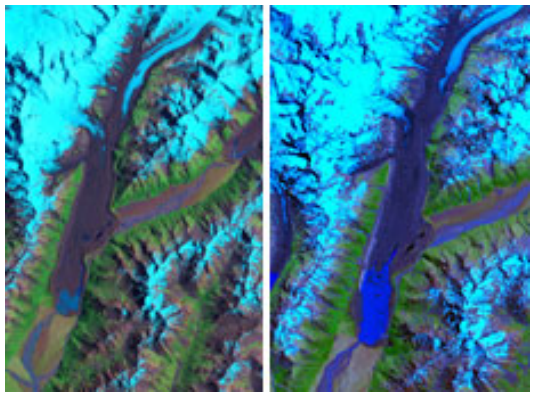
Observations since 1961 show that average global ocean temperatures have increased to at least depths of 3000m. This means the ocean has absorbed more than 80% of the heat added to the climate system. Thermal expansion of seawater would have therefore contributed to sea level rises already observed in many locations.

Glaciers and mountain snow cover have continued to retreat in both Hemispheres.

The Tasman Glacier, for instance, is retreating faster than ever and glaciologists from Massey University warn that it will in time disappear.

In 1973 there was no lake in front of the Tasman Glacier, however 2008 measurements confirmed the meltwater lake is now seven kilometres long, two kilometres wide and 245 metres deep. The lake can potentially grow to a length of about 16 kilometres, equating to a further nine kilometers of glacier retreat.

Since the 1990s the glacier has retreated 180m per year, on average, and this is expected to accelerate to a rate of retreat of between 477 and 822 metres each year. At these rates it would take between 10 and 19 years for the lake to expand to its maximum.



The Tasman Glacier, photographed from space in 1990 (left) and 2007 (right) – showing that Glacier's lake (blue, at the toe of the purplish tongue of ice) has grown significantly.

Photo / NASA

1. An Overview of Climate Change and possible consequences for Gisborne District, July 2006.

Research released in November 2007 by NIWA, the National Institute for Water and Atmospheric Research, shows that the volume of ice in the Southern Alps has in fact declined by around 5.8 cubic kilometers, almost 11%, over the past 30 years. More than 90% of ice loss is from 12 of the largest glaciers[2].

International climate findings

A very clear, concise report, based on the most recent scientific findings, "Summary for Policymakers", has been published by Working Group I of the IPCC. New Zealander Professor David Wratt of NIWA is a member of this working group, whose task it is to describe progress in the understanding of both human and natural drivers of climate change.

The updated climate information presented is the product of large amounts of new and more comprehensive data, more sophisticated analysis of that data, and improved simulation models.

The wording of this report is notably stronger than the information that has gone before. Terms such as "likely" and "very likely" are given clearly defined meanings, shown in the table below.

IPCC REPORT DEFINITIONS
Probability of occurrence:
virtually certain - more than 99%
extremely likely - more than 95%
very likely - more than 90%
likely - more than 60%
more likely than not - more than 50%
unlikely - less than 33%
very unlikely - less than 10%
extremely unlikely - less than 5%
(Source: IPCC)

Direct, recent observations of climate change noted by the IPCC include the following:

- The amount of water vapour in the atmosphere has increased since the 1980s, and this broadly corresponds to the expected amount warmer air would hold.
- New data shows melting of the Greenland and Antarctica ice sheets is *very likely* to have contributed to observed sea level rise from 1993 to 2003.
- Average Arctic temperatures have increased at twice the global rate over the past 100 years, and satellite data since 1978 reveals arctic sea ice has shrunk by 2.7% per decade.
- For permafrost areas in the Arctic latitudes, top-layer temperatures have increased since the 1980s by up to 3°. The area of seasonally frozen ground has decreased by about 7% since 1900 (with a decrease in spring of up to 15%).
- Some areas of the globe have experienced a long-term (1900–2005) trend of increased precipitation (in eastern parts of North and South America, northern Europe and northern and central Asia). Meanwhile drying has been observed in the Sahel, Mediterranean, southern Africa and parts of southern Asia.
- Changes in precipitation and evaporation over the oceans are indicated by observations of freshening of mid- and high-latitude oceans and increasing saltiness in low-latitude oceans.
- Mid-latitude westerly winds have strengthened since the 1960s in both hemispheres.
- More intense and longer-lasting droughts have been observed over increasingly wider areas since the 1970s, particularly in the tropics and sub-tropics.
- The frequency of intense rainfall events has increased over most land areas.
- Heat-waves have become more frequent.

2. The 12 glaciers are the Tasman, Godley, Murchison, Classen, Meuller, Hooker, Ramsay, Volta/Therma, La Perouse, Balfour, Grey and Maud Glaciers.

Predicted, but not observed

The IPCC highlighted aspects of climate change that have not in fact occurred as predicted in the earlier Third Assessment Report:

- A decrease in the diurnal temperature range (the difference between day and night temperatures) has not in fact occurred from 1979 to 2004. Day and night temperatures seem to have risen at about the same rate (although the trends are highly variable from place to place).
- Although there are summer-winter changes and localised changes, the average extent of Antarctic sea ice has not revealed a statistically significant trend. This is consistent with observations of Antarctic temperatures that do not reveal a clear warming trend.
- There is insufficient evidence to identify any trends in the meridional overturning circulation, that is – the overturning circulation of water in the Atlantic Ocean which carries warm upper waters into far-northern latitudes and returns cold deep waters southward across the Equator.
- There is insufficient evidence to see any trends emerging in small-scale climate phenomena such as tornadoes, hail, lightning or dust storms.
- Nor has there been any observed trend in the overall number of tropical cyclones. Climate models do project an increase in the 21st century, so there are discrepancies between model predictions and observed tropical cyclone activity.

Cloud feedbacks remain the largest source of uncertainty. Clouds may reflect incoming solar radiation back to space, and may absorb some out-going long-wave terrestrial radiation, reflecting that heat back to Earth, producing both heating and cooling effects – depending on the cloud type.

Low clouds tend to cool, high clouds tend to warm and have lower albedo, therefore reflecting less sunlight back to space than low clouds.

All in all, the climate models have been shown to accurately simulate observed temperature changes, and the Fourth Assessment Report, therefore provides even stronger evidence than the Third Report of human-induced climate warming.

About the IPCC

The IPCC is an intergovernmental body that was set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP) in 1988.

The IPCC is a scientific body, the role of which is to comprehensively assess the latest peer-reviewed scientific, technical, industry and social data produced worldwide that has relevance for the understanding of human-induced climate change.

However the IPCC does not itself undertake scientific research, nor does it monitor climate data, although hundreds of scientists and experts contribute to the IPCC as authors and reviewers.

For instance, people from over 130 countries contributed to the IPCC Fourth Assessment Report over the preceding 6 years. They included over 2500 scientific expert reviewers, over 800 contributing authors, and over 450 lead authors.

Of these, the Working Group 1 report (including the Summary for Policy Makers) included contributions by 600 authors from 40 countries, over 620 expert reviewers, a large number of government reviewers, and representatives from 113 governments.

All reports then undergo a thorough two-stage review process by experts and governments to ensure the information within IPCC reports is based on sound scientific evidence and reflects existing viewpoints within the scientific community.

Trends observed within New Zealand

Unfortunately, New Zealand's "blow out" in greenhouse gas emissions has continued, unabated. We are now, as a nation, producing 25% more greenhouse gases than in 1990 (the Kyoto 'baseline year').

There has also been a 58% rise in dairy cow numbers from 3.39 million to 5.28 million since 1990. Meanwhile a massive expansion of the dairy sector appears to be underway.

Dairy cow numbers in Gisborne District have more than doubled since 1990. Although these are predominantly grazers, the number of dairy farms is also likely to increase, albeit from a very low base.

Dairy conversion of forestry land (as is happening on the volcanic plateau) deals a double blow on the climate, as it releases carbon stored in the form of forests and replaces them with a high carbon-emission land use.

Meanwhile sheep and beef cattle numbers have actually decreased, but since each individual animal produces more emissions than they did in 1990, the net effect is we're worse off.

There are around 40,000 individual farms in New Zealand, and they generate about half of the country's greenhouse gas emissions.

The planting of new production forests, initially heralded as the answer to the country's greenhouse woes, has in fact slowed. Worse, in some regions, large areas formerly in exotic forest have been cut down and not replanted.

New Zealand's population has increased from 3.4 in 1990 to an estimated 4.26 million in August 2008. And we are driving a staggering 2.3 million cars, compared to 626,000 back in 1990. The increase in emissions from the transport sector has in fact been far greater than the increase in the agriculture sector, transport emissions having risen 62% (by September 07) above 1990 levels.

Thanks to the housing boom in recent years, the number of dwellings in New Zealand has dramatically increased. There were 1,471,749 occupied private dwellings on census night in 2006, over 195,000 more than were recorded in 1996 (1,276,332).

While apartments are becoming a popular type of new dwelling, far greater numbers of people are building larger houses further away from town centres, necessitating more heating and more fuel consumption.

We are further than ever from the goal of having 90% of energy generated from renewable sources: in 1999 72% of generation was renewable, but this had fallen to 66% in 2007.

Unsurprisingly, from 1990 to 2006, greenhouse gas emissions from the generation of electricity rose by 138%.

However, people are now more informed about climate change and green house gas emissions, and at least 4000 have attended the 200 or so public meetings that have so far been held on the topic of climate change. As a result, government agencies have received over 3000 written submissions.

A New Zealand breakthrough in methane-emissions research

New Zealand has a unique emissions profile, due to the fact 32% of our greenhouse gas emissions originate from the digestive systems of grazing farm animals. At the moment, there is next to nothing that can be done to alleviate this, short of reducing stock numbers.

In June 2008, New Zealand scientists at the Pastoral Greenhouse Gas Research Consortium announced they had mapped the genetic sequence of a microbe, called *Methanobrevibacter ruminantium,* responsible for producing methane from the rumen of cattle and sheep.

The genetic sequence is the culmination of five years of research, part of a $19 million R & D project. It is hoped the data will enable scientists to now look for ways to reduce ruminant methane emissions without decreasing animal productivity or affecting the many other beneficial microbes that live in the gut of farm animals. A solution, possibly in the form of a drench, vaccine or feedstuff, is probably at least around five years away, and integration into farming practice is probably at least ten years away.

Since there are more than a billion domestic farm animals in the world, and if New Zealand scientists can win the worldwide race to find a cheap and practical solution for reducing agricultural emissions, New Zealand can not only reduce our Kyoto Protocol liabilities – but commercialise and export the technology to the rest of the world.

The Emissions Trading Scheme has been criticised for penalising New Zealanders, while any reductions in greenhouse gases achieved will be but a drop in the ocean, and of no consequence globally. If technology to reduce ruminant emissions can indeed be developed here first, New Zealand will be able to make a great difference globally.

The Pastoral Greenhouse Gas Research Consortium is funded by Fonterra, Meat & Wool New Zealand, DairyNZ, PGG Wrightson, Fert Research, Deer Research and AgResearch in partnership with the Foundation for Research Science & Technology.

A New Zealand Emissions Trading Scheme

In September 2007, the government released its proposal for an emissions trading scheme (ETS) for New Zealand. The idea of emissions trading is that by placing a price on releasing carbon to the atmosphere, people's behavior and purchasing will change towards more carbon-friendly options.

The ETS is also supposed to reward those businesses and individuals that reduce their carbon 'footprint'.

Farmers and large industries attacked the bill, and political wrangling slowed the implementation of the ETS by putting back the dates when sectors must enter the ETS, and delaying the time when they must stand on their own two feet by purchasing credits to offset all their emissions.

Some critics, while supportive of the idea "we must do something", stated the ETS will do little to counter the effects of climate change, because New Zealand emitters can simply purchase credits on the international market sufficient to offset our emissions, and therefore there's no incentive to improve.

Nevertheless, a year later, on September the 10th 2008, the ETS legislation did pass by a 63-57 vote after its third reading in Parliament.

The ETS is a framework document, and a lot of detail is yet to be worked through into regulation. The ETS is likely to be amended many times over the coming years, particularly in response to new developments in climate science and political direction. Already since the change of government in November 2008, a special select committee has been established to review the ETS.

Since New Zealand is committed to Kyoto targets for the first commitment period (2008-12), the taxpayer will be forced to purchase even more emission units than previously thought, now that some sectors will have a delayed entry into the scheme.

Some of the finer detail of the ETS, its possible implications, and the process of the scheme's evolution, will be covered later in this report.

Chapter 2

4th Impact Assessment Report implications for Gisborne District

A recap of the earlier climate predictions for New Zealand

The IPCC's Third Assessment Report, issued in 2001, formed the basis of the New Zealand regional climate modelling done by NIWA, the National Institute of Water and Atmospheric Research. The statistically 'most likely' scenarios were presented in the first Gisborne climate report of July 2006.

The CLIMPACTS (2001) study

Scientists from various research organisations examined the effects of the Third Assessment New Zealand climate models on agriculture using the CLIMPACTS system.

The report flagged an increase in the moisture gradient across the country: In other words – the climate would become wetter on the west coast and drier on the east, while global temperatures continue to rise.

Pasture growth across the regions of the country was predicted using the Baisden (2006) methodology. This calculation takes into account "growing degree days", soil moisture deficit and average soil particle size.

The projected net changes in agricultural production for the *country as a whole* worked out to be less than –10%, because the severe reduction in production in eastern areas (Gisborne, Hawke's Bay and Canterbury) was offset by a significant increase in production for Southland and some west coast areas.

Gisborne's climate was predicted to become drier across all seasons, and the changes would be more pronounced in autumn and spring

For each climate scenario studied there was a striking decrease in production for the East Coast and Poverty Bay, from 40 – 60% of "average" production, down to zero (in which case farming activity could not be sustained without the importation of feed and/or irrigation).

The pasture production calculations did not take into account the so-called "CO_2 fertilisation effect". If soil moisture were the limiting factor on pasture growth for part of the year, CO_2 enhancement wouldn't help it grow anyway.

From a farming point of view, this was almost all bad news, and meant that although winters would be shorter and milder, pastures would start to dry off earlier, and dry conditions would extend longer into autumn. Drought risk was predicted to intensify significantly for all areas that are currently drought-prone, not only due to reduced rainfall, but an increase in drying northwesterly winds.

The models indicated that by the 2080s, for 'low-medium[3]' climate change scenarios, a drought we would currently consider a one-in-twenty-year event may have a return frequency of fifteen years for the district's hill country areas, and as often as one-in-five to one-in-ten years for the Poverty Bay flats and coastal areas as far north as Tokomaru Bay.

The situation would be even worse for a medium-high[4] climate scenario. By the 2080s a one-in twenty-year drought could have a return period of 2.5 to 5 years; in other words, 4 to 8 times more frequently than at present.

The situation would be even worse for a medium-high[4] climate scenario. By the 2080s a one-in twenty-year drought could have a return period of 2.5 to 5 years; in other words, 4 to 8 times more frequently than at present.

3. Low-medium climate scenarios assume an annual average temperature increase of +1.8° by 2080.
4. Medium-high climate scenarios assume +2.9° by 2080.

Meanwhile, predictions flagged an increase in the likelihood of intense rainstorm events, which may lead to flash floods, soil erosion, and the loss of moisture as run-off, meaning reduced infiltration into the soil.

Release of the IPCC's Fourth Impact Assessment Report

The fourth, most up-to-date report of the IPCC was released in 2007. While the newer report provides a refinement of the previous information for much of New Zealand, for our region here on the East Coast of New Zealand, and for much of Hawke's Bay, the new rainfall information is in fact quite different to that given previously.

Twelve updated climate models were generated using information contained in the Fourth Report and the EcoClimate[5] team has already carried out some work using the updated New Zealand regional models.

Differences on previous predictions became apparent when the IPCC models for the Pacific region were 'downscaled' for New Zealand – that is, specially developed statistical software was applied to the data to take into account the country's complex topography. This is how, from a broad-scale model, more detailed predictions are possible. There is no magic in this – there is already a huge data base of 'what actually happens' when weather patterns come across from the Pacific Ocean, the Southern Ocean and the Tasman sea and manifest in localised climatic effects.

For much of the country the newer models agreed with the earlier, 2001, predictions. However for the east coast of the North Island they threw up some unexpected climate effects.

Across the 12 new climate models there is a strong consensus that future temperature changes for Gisborne will be smallest in the spring, compared to the other seasons. In winter and spring, more persistent westerly winds are predicted, which would make those seasons notably drier for the East Coast.

Gisborne's annual mean temperature is expected to increase by 0.9^{o} by 2040 (range of six climate scenarios is 0.2^{o} to 2.4^{o}), and by 2.1^{o} (range 0.6^{o} to 5.5^{o}) by 2090.

The IPCC are "very confident" there will be fewer cold temperatures and frost days, together with more high-temperature episodes. "Very confident" implies the predictions have a 9 out of 10 chance of being correct and are unlikely to be substantially revised in future.

For autumn, and particularly summer, the models predicted *reduced westerlies*, therefore it is possible there could be an *increase in summer rainfall,* by as much as +10% to +15% by 2090, on the East Coast, coupled with a decrease in moisture loss by evapotranspiration in summer[6].

Predictions for autumn rainfall are +5% to +7.5% by 2090.

The updated predictions are quite different to what was reported following the Third Impact Assessment Report, in which summer rainfall was predicted to decrease by 10% by the 2080s.

Rainfall in winter and spring could be 10% less; even so, winter will still be the wettest season of the year.

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4. Medium-high climate scenarios assume +2.9^{o} by 2080.
5. The EcoClimate participants were from the following organizations: NIWA, AgResearch, LandcareResearch, Infometrics, GNS, Motu, and NZCEE.
6. It is estimated that westerly winds could be stronger in winter and spring beyond 2040. This prediction has low confidence and is likely to be revised in the future.

Note that *average annual* rainfall is still expected to decrease for Gisborne in the updated mid-range climate models, by –4% by 2040 and to –5% by 2090; it is the seasonal distribution of the rainfall that is significantly different.

Since a warmer atmosphere can hold more moisture (+8% per 1° of temperature increase), heavier and/or more frequent extreme rainfall events are still predicted with "moderate confidence" (meaning this prediction is more likely than not to be correct).

As a rough rule-of-thumb, the amount of rain falling in a discrete event could be assumed to increase in line with temperature, therefore by up to 8% more rain per event by 2040 and, it follows, 16% more by 2090. This has obvious implications for predicting future flooding. Variability caused by topography means in some areas rain events may be more (or less) extreme.

Return periods for extreme rainfall events have been calculated only for Auckland to date. The "worst case" scenario for Auckland indicates a severe rainfall event with a current return period of 50 years could have a return period of less than 10 years by the end of the century.

The IPCC are "very confident" that sea level will rise by an average of 18 to 59cm (between 1990 and 2100). Ocean temperatures are expected to rise in parallel with air temperature increases.

Ex-tropical cyclones and mid-latitude storms

Cyclones that originate in the tropics have changed characteristics by the time they reach New Zealand, and are usually referred to as ex-tropical cyclones. They typically affect northern and eastern regions of the North Island, but occasionally track further south.

During El Niño periods, ex-tropical cyclones are less likely to affect New Zealand directly, since their path tends to track further east.

Many of the climate change models indicate an El Niño-like state persisting in the tropical Pacific for the next 50 years. Exactly how this might affect the number of ex-tropical cyclones reaching New Zealand is not yet clear.

Mid-latitude storms, or extra-tropical cyclones may increase in intensity however, since these storms gain their energy from the temperature gradient that exists between the tropics and polar regions. Since the tropics are predicted to warm faster than polar regions, it may be expected that mid-latitude storms would both increase in wind-intensity, and hold more moisture.

Possible changes in storm tracks, and whether New Zealand will be more vulnerable, are as yet unknown.

The only clear conclusion made by the IPCC in the *Summary for Policymakers* is: *"Mid-latitude westerly winds have strengthened in both hemispheres since the 1960s".*

In New Zealand extreme westerly winds have shown a definite trend of increase (in both strength and frequency) in the south since 1960, and to a lesser degree over New Zealand as a whole.

Pasture production under the updated climate scenarios

Using the updated climate models, and new methodology, the EcoClimate team predicted pasture production across New Zealand.

This time, although pasture productivity across the country as a whole revealed similar results (with increases in some western areas and decreased in eastern regions), the east coast north of Napier in fact showed *increased pasture production over summer.*

Note that in very dry years pasture production would still be expected to decline, but the reduction may be less for the East Coast than for other eastern regions of New Zealand.

What could this mean for farming in Gisborne District?

Pasture may begin to grow earlier in late winter/ early spring as the climate warms. This may allow farmers to bring forward some activities, and may result in lambs being fattened earlier (for example).

However windier winters and springs may mean pasture dries out earlier. If, as predicted, there are summer 'top ups' of rainfall, these would certainly be appreciated by farmers. There may be increased potential to grow hay and summer feed crops for use over the autumn and winter.

Reduced winter rainfall may mean slower recharge of surface and groundwater storage. If summer rainfall is frequent enough, reduced demand for irrigation water might offset the reduction in storage.

Our hill country areas are likely to remain suitable for beef cattle production. Attractiveness for dairy conversion probably depends more upon what the markets are doing, climatic and geographical constraints.

Increased summer and autumn humidity are however potentially detrimental to sheep, due to a possible increase in fungal and metabolic diseases, as outlined in the first Gisborne climate change report.

An increase in the frequency of summer and autumn rainfall would certainly be advantageous for cropping on the Poverty Bay and Tolaga Bay flats.

There is still no clear scientific evidence to indicate changes in the frequency of El Niño conditions.

Natural climate variability versus climate change effects

While warming of about +0.2^{o} per decade has occurred across the Pacific Region since the early 20th century, this trend provides a background against which much more obvious and extreme changes in climate play out on a cyclical basis.

In any year, temperature can deviate from the long-term mean by +/- 1^{o}, and rainfall by as much as +/- 20%, depending on whether we are experiencing El Niño or La Niña[7].

Because of El Niño/ La Niña, which is a regional phenomenon with a periodicity of 3 to 8 years, New Zealand temperature records trace a 'wobblier' line on a graph than global average annual temperatures.

Despite this, records from seven widely spaced climate stations are available from 1908, and show that since that date, temperatures in New Zealand have increased by 0.9^{o}.

Abnormally high peak floods were recorded in the Rangitaiki, Whakatane, Waioeka and Kaituna Rivers prior to the mid-1970s and after 1998. This period of unusually high flood peaks coincided with negative phases of the IPO. From around 1977 to 1998, IPO was becoming increasingly positive, and the BOP rivers experienced much lower peak flood flows.

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7. The El Niño Southern Oscillation has a periodicity of around 3 to 7 years, and intensity of the phases varies. During El Niño New Zealand experiences stronger than normal south-westerly airflow, resulting in cooler temperatures and drier (possibly drought) conditions in north eastern regions. During La Niña the country experiences more north easterly flows, higher temperatures and wetter conditions in the north and east of the North Island; meanwhile the South Island may experience drought conditions.

Another cyclical climatic phenomenon, having a periodicity of 15 to 30 years, is the interdecadal Pacific oscillation (IPO). IPO has been shown to correlate with peak flood flows in the Bay of Plenty[8].

So we know climate varies naturally from year to year, and from decade to decade, and that human-induced changes in climate will be superimposed upon this natural variability. There will still be wetter and drier, warmer and cooler years while the long-term average annual temperature will continue to trend upwards.

Council's response to climate variability

Because Council already has procedures in place to deal with the effects of extreme climate events it will not be necessary to develop a whole set of new procedures, but rather to consider new climate information as it becomes available and continuously review the effectiveness of responses.

However climate change may not progress in a linear fashion; it is possible it may accelerate in future. Some scientists speculate there is potential for sudden, catastrophic change once certain, irreversible 'trigger points' are reached.

Areas for which Council has responsibility[9], and which are impacted by natural climate variability, and therefore also by change include: Management of water resources, soil conservation, biosecurity, natural hazard management, emergency management, council-owned roads, bridges, stormwater and wastewater systems, municipal and community water supplies (and other community assets), community services, provision of infrastructure, building controls, plus planning and decision making. In other words, virtually every area of Council responsibility has the potential to be impacted by climate change.

One obviously important concern is to ensure that future climate extremes are taken account of at the early design stage of long-lived infrastructure. There will be situations were choices must be made between the cost of building climate extremes into design, balanced against the potential future cost of remediation.

From a planning point of view, climate change considerations will probably influence where development can take place. This is of particular relevance in Gisborne as much of the city is low-lying, and there is extensive coastline with apparent development potential.

Frequency of extremes

Taken at face value, a temperature increase of 1^{o} by mid-century and 2^{o} by the end of the century, sound insignificant. If it is 23^{o}C on a particular day instead of 22^{o}C, surely that's no big deal?

The reality is nowhere near this simple. As already discussed, small changes in average conditions can in fact lead to dramatic increases in the frequency of extremes. An increase of just a few degrees may make an area that previously experienced winter frosts completely frost-free. Some summer days would occur that would be hotter than any experienced before, and days previously considered hot could be two or three times as frequent.

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8. Reported in Climate Change Effects and Impacts Assessment A Guide Manual for Local Government in New Zealand, 2nd edition, May 2008.
9. For guidance on how to assess the impacts of climate change on a particular Council function or responsibility, refer to "Climate Change Effects and Impacts Assessment – A guidance Manual for Local Government in New Zealand, 2nd edition, May 2008 (Ministry for the Environment). This manual focuses on effects based on a 'middle of the road' climate change scenario.

Consider the simplistic (but possible) example of effects on a farming or horticultural operation that currently experiences temperatures ranging from –2°C to 30°C, with 25 frost days per year and the occasional day of up to 35°C. Imagine the effects on pest and disease concentrations of having no frosts whatsoever, and the stress on plants, animals and people experiencing frequent summer days in the range of 30 to 35°C, with occasional days of up to 40°C. This scenario is probable for Gisborne District before the end of the century.

While a lack of frosts might be considered advantageous for growing some frost-tender crops, the detrimental effects of such extreme hot days, combined with possible water shortages, may outweigh any potential benefits.

The only thing constant is change

It is impossible from where we sit to look into the future and make accurate predictions of what a changing climate will really do to agricultural production. In the past market forces, often from beyond our shores, and changes in technology, have to date had far more of an influence on what we have produced (and where) than a changing climate has.

Recall that in the days before refrigeration sheep were farmed for their wool only.

Policy changes within New Zealand and international agreements seem set to increasingly influence agricultural production.

Farmers and growers have been adapting to change since farming began, and what we currently consider an average, a very good, or a poor year, will most certainly change in the future.

Chapter 3

An emissions trading scheme for New Zealand

A recap of how we got to where we are now

New Zealand ratified the Kyoto Protocol, and in doing so bound the country to either reduce our greenhouse gas emissions to 1990 levels, or pay the price of offsetting those emissions. By 2012 (the end of Kyoto's 'first commitment period') it is estimated our carbon emissions will be 21.7 million tonnes in excess of 1990 levels.

Following release of five discussion documents and consultation which took place from December 2006 through March 2007, the Government decided in principle that an emissions trading scheme was the way to go to address New Zealand's greenhouse gas emissions.

The greenhouse gases included in the ETS are the six identified in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydro-fluorocarbons (HFCs), and sulfurhexafluoride SF_6 (from 2013).

Other options considered by the Government, and discarded, included a carbon tax, incentives and subsidies, direct regulation, negotiated greenhouse agreements and voluntary approaches.

The Climate Change (Emissions Trading and Renewable Preference) Bill

On 20th September 2007, the Government unveiled details of the proposed New Zealand Emissions Trading Scheme (ETS), along with related sustainability initiatives.

The principal purpose of the Climate Change (Emissions Trading and Renewable Preference) Bill is to amend the Climate Change Response Act (2002) to introduce the ETS.

In addition it amends the Electricity Act 1992 to create a preference for renewable electricity generation by placing a restriction on new coal/gas/oil-fired power stations, *"except to the extent necessary to ensure the security of New Zealand's electricity supply"*[10].

The Bill was introduced to Parliament on the 4th of December 2007, passing its first reading on the 11th of December, by 119 votes to 2.

Submissions on the Bill closed on 29th February 2008. There were 259 submissions from a wide range of interests. The Finance and Expenditure Select Committee conducted hearings from the 1st week of April 2008.

A 67-page report back from the select committee was released to the public on the 16th of June 2008, recommending the Bill be passed, including amendments. It provides a commentary on the reasons for the suggested amendments, and contains two reports opposing the Bill by the National and Green Parties.

The Climate Change (Emissions Trading and Renewable Preference) Bill passed into law, on a 63-57 vote, after its third reading in Parliament on the 10th of September 2008.

10. The National Party stated in August that should they win the election the restriction on new fossil fuel powered electricity generation plants will be removed.

The Select Committee report on the Bill also recommended restricting any upgrades to existing fossil fuel generation plants that would enable them to operate at >10% above original design capacity.

Government now intends to continue to work to resolve any remaining issues surrounding the design and implementation of the scheme in consultation with those sectors that are participants, and through a select committee review process.

There may also be changes to the ETS required by changes to the international climate change policy framework after 2012.

How will the scheme work?

The Government has a vision of not only meeting Kyoto obligations, but ultimately going further: for New Zealand to become a 'carbon neutral' country.

The implementation of the ETS intends, by placing a price on greenhouse gas emissions, to encourage emitters to as far as possible reduce their emissions, and to require the purchase of carbon-equivalent units to offset the emissions that remain.

The ETS therefore:

- Puts a dollar value on emissions and creates a new unit of trade, the NZ Unit (NZU). Each NZU represents one tonne of CO_2-equivalent emissions
- Requires that participants measure and report on the emissions they generate
- Puts a total cap on emissions, while enabling participants to trade their allowance to produce emissions
- Enables sectors that absorb and store greenhouse gases (such as forest growers) to earn credits that can be sold under the ETS.

Participants will be obliged to surrender one emission unit for each tonne of emissions generated by their activities in each year[11].

The Government believes that putting a price on emissions will, over time, change investment and consumption patterns, so that we develop an economy and lifestyle with lower emissions.

It is hoped that the ETS will ultimately lead to greater investment in energy efficient infrastructure, renewable energy, and more efficient consumer goods.

During the hearing of submissions on the Bill, two significant policy decisions were made by the Government: The first is to defer the entry of the Transport Fuel sector into the scheme for two years. The other is to defer by five years the phasing-out of free allocations of emission units (which are to be given to 'trade-exposed firms').

How are Units generated?

Participants can obtain units in various ways: There will be an initial 'free allocation' of units from the Government to some sectors. Units can be generated through creation of a carbon sink (for instance a forest), or by purchase of Units from other participants who have made a corresponding carbon saving, either within New Zealand, or in another country.

The process for allocation of Units is complex, and aims to ensure that the resulting costs of the initial years of the ETS are equitably shared among taxpayers, businesses, consumers and across sectors.

11. The time limit for filing emissions-returns will be four yearly (with the exception of post-1989 forestry participants, for whom returns would be required five yearly).

Timing of sector's entry to the ETS

The timing of entry of various sectors into the ETS will be staggered. Via the mechanism of free-allocation of units, and their gradual phase-out, full responsibility for the cost of emitting will be assumed in a gradual manner, in order to create as little disruption to business as possible.

Forestry entered the ETS in January 2008. Entry of other sectors, as recommended in the Select Committee report will be as follows:

- Stationary energy[12] and industrial processes fom January 2010[13]
- Liquid fossil fuels and transport from January 2011 (originally 2009). The reason for the delay is given as "to reduce inflation pressures"
- Agriculture, waste[14] and all remaining sectors from January 2013.

Concern New Zealand is 'sticking its neck out'

Many submitters on the Bill expressed the concern that New Zealand has moved too fast on introducing an ETS compared with our trading partners.

While the NZ ETS has been designed to meet our international obligations, it is intended to continue in force *even if there is no second commitment period under the Kyoto Protocol*, nor any other international agreement to take its place.

The select committee states in its report that emissions trading schemes are indeed being drafted by many countries around the globe, and that the "all sectors" approach is in line with the probable design of the Australian scheme. The potential is being explored for a link between the Australian National Emissions Trading Scheme (Au-NETS) and our ETS.

There has also been concern that New Zealand has included agriculture in its ETS, whereas other countries may not, placing our agriculture industry at a "disadvantage". However countries that choose not to include some sectors in their trading schemes must still bear the costs of those emissions in other ways, for example by direct taxes.

The report recommended a 'staged approach' for agriculture, with voluntary reporting to begin in 2011, to allow a trial of the system in the absence of 'real' unit obligations. Farmers would then be required to 'respond' to the price of carbon, and participate fully in the scheme by 2013.

Nor are transport fuels included in emissions trading schemes being developed in Europe and elsewhere. Some countries have instead decided to impose direct taxes on transport fuels.

A major concern of submitters to the Bill was that the phase-out of free allocations would erode the competitiveness of New Zealand producers and manufacturers by making them face the full cost of their emissions ahead of other countries that might still not have their greenhouse gas controls in place.

This is the reason the Select Committee recommended that the phase-out of free-allocations be delayed a further five years (by 2030 instead of 2025).

Another major concern was that emission-intensive businesses and industry might not start up here, or might relocate to other countries where controls may not be as stringent. This might disadvantage New Zealand's economy.

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12. Stationary energy includes electricity generation and direct uses of energy for heating and industrial processes but excludes transport.
13. An exception allows for a delay in the entry of HFCs and PFCs into the scheme (until 2013) to allow for development of non-greenhouse gas alternatives to these chemicals.
14. Note that the 2004 National Environmental Standard for air quality already imposes a regulatory control on the emission of methane, because it requires landfills to collect and destroy methane.

The Select Committee therefore recommended a pool of Units be set aside for allocation to "new entrants" or to cover growth in emissions by existing participants.

How will free allocations be made?

The Government's allocations to agriculture, stationary energy and industry[15] will begin in 2013, continuing through 2018. Allocations will be sufficient to cover 90% of each sector's 2005 emissions, and will decrease on a linear basis from 2019 until they are phased out entirely by 2030, at which time these sectors will be fully responsible for their own emissions.

There will be no allocation of units to businesses whose profits will be unaffected by the ETS, nor to liquid fossil fuel producers, electricity generators or landfill operators.

There will be an allocation to businesses that use waste oil in place of fossil fuels for generation of stationary energy. This is to ensure businesses recycling waste oil in this way are encouraged to continue to do so, rather than changing to other fossil fuels instead.

The sum total of all allocations cannot increase above the total "cap" set at 90% of 2005 emissions for the industrial and agriculture sectors, and at 90 NZUs for each 100 tonnes of direct emissions for the industrial and stationary energy sectors.

In addition, the pool would include units sufficient for businesses and industry to offset 90% of the increased price of electricity (based on electricity consumed in 2005)

An "Allocation Plan" which will set the criteria and methodologies for distribution of allocations, is yet to be drafted. The Crown can distribute Units via whatever method it considers appropriate at the time, for instance by tender or auction.

At this stage no size threshold for participants in the ETS has been set. The Select Committee recommended no threshold be set in the legislation, but consider a threshold significantly less than 50,000 tonnes of emissions would be appropriate.

Firms that cease to trade will not retain any allocation.

Allocation for exotic forests

In the forestry sector, free allocation will be provided so that the Crown assumes a total liability for deforestation emissions as follows:

- From 2008 to 2012, 21 million tonnes CO_2-eqivalent for plantation forest (plus a small allocation set aside to allow for forest weed control, e.g., wilding pine)
- From 2013, an additional 34 million tonnes CO_2-e for plantation forest.

Owners of pre-1990 forests purchased before the stipulated date in 2002 potentially face the greatest costs under the ETS, and will receive increased assistance (from 39 to an estimated 60 NZUs per hectare).

Future Treaty claimants who receive Crown Forest lands under a settlement, post-31 December 2007, will receive an allocation of 18 NZUs per hectare.

15. Indirect emissions associated with the consumption of electricity, as well as direct emissions from stationary energy and direct emissions from non-energy industrial processes will be treated the same as 'emissions from industrial producers'.

Any iwi that settled a Treaty claim involving Crown Forest land before the ETS comes into force will receive the same allocation as any other landowner that purchased land at the same time[16].

Definition of "forest"

The select committee have recommended 'forest', for the purpose of the ETS, be defined as "an area of land of at least 1 hectare that has, or is likely to have when the forest species reach maturity, tree crown cover from forest species of more than 30 percent in each hectare; and the definition would include an area of land that temporarily does not meet the definition but is likely to revert to a state meeting the definition."

So does this include or exclude areas of scattered or regenerating scrub?

For areas of scattered, regenerating scrub on pastoral land to achieve forest status there would have to be a management change (exclusion of stock) for the forest to be able to reach maturity.

To be Kyoto-compliant, a forest's establishment must have been "direct human-induced" through planting, seeding or possibly, if New Zealand's position is adopted, through human-induced promotion of natural regeneration (for instance, by excluding browsing animals).

Regenerating scrub

For a forest to be eligible to accrue Kyoto Protocol Units, (and therefore also NZUs), it must comprise land that was *not covered by forest* on the 31st of December 1989, and is now covered by forest that meets the New Zealand definition of a forest.

In other words, some regenerating land would seem to be eligible, but much would not. It would entirely depend on the interpretation of whether the land met the definition of 'forest' on the specified date.

Acceptable evidence to assist in determining post-1989 forest eligibility in Gisborne District could include post-Cyclone Bola aerial photography (March 1988) or land management records. It would however be next to impossible to determine precisely what was pre- and what was post-1990 scrub in an inspection "on the ground".

It would of course be very desirable for New Zealand to allow areas of regenerating scrub into the ETS, to provide for "carbon farming" while reaping the other environmental benefits of soil and water conservation, biodiversity enhancement.

None of these difficulties have been satisfactorily resolved yet.

In the other case the claimant explicitly chose to value the land transferred to them on the basis the ETS would be in place, and agreed to forgo all possible future claims for compensation in relation to limitations on the future use of the land.

The Select Committee recommended that Ministers allow for a different number of Units to be allocated in the above two instances.

How will scrub-clearing to maintain pastoral production be dealt with?

Indigenous pre-1990 forests (and any clearance of these) are excluded from the ETS. This means that intermittent clearance of areas of scrub for the purpose of maintaining land in pasture would not incur a penalty anyway (provided of course that this was a permitted activity or received resource consent under regional/district plans).

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16. With a couple of exceptions: One is for a situation where land that was transferred to iwi in November 2002, but this followed negotiations carried out many months prior.

Why aren't pre-1990 indigenous forests eligible to enter the ETS?

The select committee considered a number of submissions from Maori interests seeking inclusion of pre-1990 forests in the ETS for the expressed purpose of encouraging the retention and regeneration of indigenous forests.

The response was that there are already sufficient existing controls to prevent significant deforestation, and that the technical difficulties in determining pre- and post- 1990 biomass in a forest were prohibitive.

No forestry "offset provision"

The Select committee considered the proposal by several submitters that owners who remove or harvest pre-1990 forests should be allowed to replant on a hectare-for-hectare basis, either on the same land *or elsewhere*, and so avoid deforestation liabilities.

Under Kyoto there is currently no provision for 'offset planting' such as this to occur, but the Select Committee recommended that should international regulations provide in the future for offsetting, that this be catered for within the New Zealand ETS.

Removal of young trees from pre-1990 'forested land'

In situations where trees are removed from land that was in forest pre-1990, and where the trees are eight years old or younger, the trees will be treated for the purposes of emission calculations *as if they were of the age and species of the trees last harvested.*

Planting of commercial species within indigenous vegetation

There is potential for this to happen in Gisborne District, where regenerating (post-1989) kanuka-manuka shrublands could be interplanted with commercial tree species.

This would be detrimental to the future biodiversity of such areas, but they would be eligible to participate in the ETS. There is no requirement for landholders to prove compliance with other environmental legislation, such as the Resource Management Act, in order to participate in the ETS.

Coastal shipping and fishing

These activities are exposed to the effects of the ETS since fuel is the major component of their operating expenses (up to 40%). New Zealand vessels are also competing with international vessels operating within our waters, but which do not refuel here.

The Select Committee recommended addressing this discrepancy by requiring foreign vessels to surrender Units in respect of their consumption of fuel within New Zealand waters.

Where is the point of obligation? (Or "who pays?")

For practical reasons the Bill recommended the point of obligation be placed where there will be a limited number of participants, while still providing an incentive to reduce emissions.

In many cases this will mean the obligation will fall on parties who are not the major emitter in the supply chain. For instance in the case of farming, the point of obligation is recommended to rest with the 25 meat and dairy processors and the 10 nitrogen fertiliser suppliers, rather than the 40,000-odd individual farms in the country.

Placing the point of obligation higher in the supply chain allows costs to be passed down, so there is scope for price increases to influence consumer behaviour.

Below are listed the other key sectors in the ETS, with (in italics) those who will be responsible for surrendering Units, and (in brackets) the estimated number of participants:

- Forestry - *landowners* (or *forestry rights holders*)
    - pre-1990 forest if deforested (potentially > 1000)
    - Post 1989 credits and obligations (2000-9000)
- Liquid fossil fuels and transport - *fuel suppliers* (5)
    - Domestic aviation may opt in and take on obligations
- Stationary energy - coal, gas, geothermal - *suppliers* (45)
    - Large users may opt in and take on obligations
- Industrial processes - *end emitter* (35+)
- Waste - *landfill operators* (60)

Agriculture: Point of obligation

The final decision as to whether the point of obligation for agriculture will rest with individual farmers or processors has not been made yet.

This is a major, contentious, issue. While processor-level participation in the ETS would obviously be far easier and less costly to administer, it may not be an effective tool in "changing farmer behaviour". If processors are held responsible for emissions generated in the production of meat, fibre and milk solids, emissions would likely be calculated as an "average" of emissions across a range of producers. This system would fail to reward farmers with the best environmental practices.

A processor point-of-obligation also raises the question of how the additional costs will be passed on, whether to consumers, by charge-back to farmers, or by a combination of both.

Meanwhile, farmers (rightly) argue that New Zealand farming systems are already the most efficient in terms of energy- and greenhouse gas- output, and without major technological developments, there is limited scope, aside from reduction of inputs and / or reduction of outputs, for reducing farm greenhouse gas emissions anyway.

On top of this, estimating, monitoring and verifying farm-level emissions would be technically difficult and expensive.

The Select Committee recommended that the ability of the Government to bring a farm-level point of obligation into force by Order-in-Council, should expire on the 30th of June 2010.

If a processor-level point-of-obligation comes into effect, and this is the way Government is leaning, it was recommended that farmers be allowed to opt into a farm-level obligation if they so choose.

How does the NZ ETS link with international schemes?

Greenhouse gas emissions are of course very skewed geographically. The "rich" industrialised nations support only about 20% of the world's population, but use about 80 percent of the Earth's resources and produce many times more greenhouse gases per capita than developing countries. Worryingly, people in developing countries strive for our resource-hungry, high-emission standard of living.

The Kyoto Protocol therefore set specific restrictions on emissions for the industrialised "rich" countries' (Annex B countries[17]) – those deemed most able to cut emissions.

The Kyoto Protocol encourages countries to cooperate by sharing both advances in greenhouse gas reduction technology and science.

Because NZUs will be "backed up" by a Kyoto unit they can be used to meet international trading obligations, including Clean Development Mechanisms (CDMs)[18] and Joint Implementation (JI)[19] projects.

These are among so called 'flexibility mechanisms' designed to help Annex B countries (including individual companies) meet their Kyoto commitments using methods other than directly reducing their own emissions.

The flexibility mechanisms have caused some of the biggest arguments about the Kyoto protocol. There is concern that some of the rich countries may use CDM and JI initiatives to avoid having to cut their own domestic emissions.

However it is generally agreed that without those mechanisms the size of the agreed reduction targets, realistically, would have had to be much smaller.

An internationally tradeable carbon credit unit called an AAU (Assigned Amount Unit) has been proposed which would represent one tonne of CO_2 emissions

New Zealand participants in the ETS can hold AAUs imported from overseas during the First Commitment Period of Kyoto (2008-2012), but will not be allowed to surrender them against liabilities occurring after 2012.

Only projects that result in a reduction of emissions by sources, or an enhancement of removal by sinks, and would not otherwise happen without the additional incentive provided by emission reductions credits, qualify as a CDM or JI.

An explanation of credits gained under the Clean Development Mechanism

Project participants in afforestation/ reforestation in developing countries under the CDM may choose which type of tradeable unit they will receive: either Temporary Certified Emission Reduction unit (tCERs) or Long-term Certified Emission Reduction units (lCERs). Both are equivalent to one tonne of carbon dioxide-equivalent gases.

If tCERs are chosen, a request must be made to have a number of tCERs issued equal to net greenhouse gas removals since the start of the project activity.

tCERs expire at the end of the Commitment Period in which they were issued, and may be counted by Annex B Parties towards compliance with their emissions targets.

lCERs on the other hand are issued equal to net greenhouse gas removals since the previous certification. They expire at the end of the crediting period of the Project (though these crediting periods may be renewed so that the Project may continue for up to 60 years).

Individuals are not allowed to hold lCERs in the New Zealand Emission Unit Register.

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17. Annex B countries are: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland, and the United States.
18. The Clean Development Mechanism (CDM) allows industrialised Annex B countries or private entities to invest in projects that reduce emissions in **developing countries** as an alternative to more expensive emission reductions in their own countries. They get credit for these reductions as 'certified emission reductions' (CERs)
19. Joint Implementation (JI) projects allow an Annex B party to earn emission reduction units from an emission-reduction or emission removal project in **another Annex B country**.

Price cap for NZUs

The Select Committee recommended against setting a price-cap for units, considering this an unnecessary barrier to the NZ ETS linking with international emissions trading schemes.

It is also desirable that the price of an NZU closely reflects the international price of carbon emissions.

The Select Committee recommended that an "independent panel" review the operation and effectiveness of the ETS at least 12 months ahead of the end of a Kyoto commitment period (or at five-yearly intervals if there are no commitment periods).

Reviews will also consider social, economic and wider environmental effects of the ETS

Where to from here?

Consultation will now be required on the draft regulations pertaining to each sector, and on how data collection and verification will be tackled.

Regulations and reporting obligations are expected for pre-1990 forest owners and liquid fuel suppliers 'as soon as possible' now the Bill has been passed.

Regulations specifying the qualifications for organisations and individuals to be approved verifiers are also pending.

Sales and purchases of emission units would also be subject to GST under current law.

What difference will the change of Government make?

During the 2008 election campaign the National party expressed disappointment they had not been engaged over the design of the ETS, and criticised the overall cost to the country at attempting to be a word leader in emissions trading and reduction of greenhouse gas emissions.

At the United Nations Climate Change conference in December 2008, the New Zealand position was that our climate change policies would be reviewed, not to step back from the Kyoto Protocol, but in search of "a more politically durable way of moving forward". Emphasis was placed on the importance of maintaining our export base, 63% of which is primary sector based and which was suggested to have a smaller food production carbon footprint than many other countries.

To honour the terms of a confidence and supply agreement between National and Act, a special select committee has been established to review the ETS and "related matters". The terms of reference include:

- Identification of benchmark projections used as the motivation for international climate change agreements.
- The prospects for an international agreement on climate change post Kyoto 1.
- Analysis of net benefits or costs to New Zealand of any policy action.
- Consideration of the impact of any climate change policies on the New Zealand economy.
- Examination of the relative merits of mitigation or adaptation approaches to climate change.
- The need for any additional regulatory interventions to combat climate change if an ETS or a tax is introduced.

The signals are for changes to the ETS as passed to soften the impact on the primary production sector in particular. The Climate Change Minister has said "The new government takes a more modest view of New Zealand's role in the global efforts to tackle climate change".

How does NZ's ETS stack up against what the Australians are going to do?

Australia is probably about 20 months behind New Zealand in the development of an ETS. However, Canberra's Green Paper and Garnaut Report do reveal alignment with the NZ ETS on key principles.

The proposed Australian scheme is similar to ours in that it will cover all gases and eventually all sectors; all participants producing emissions above a prior level will ultimately have to pay the full cost; price signals for those emissions will be set in a cap-and-trade system rather than by carbon tax; the Australian national trading scheme will have international links to improve its liquidity and reduce its volatility; trade-exposed sectors will get help to keep them competitive; and the rate of emissions reduction will be adjusted to keep pace with competitor countries.

Where details differ, they reflect some significant differences between our economies and emissions.

Agriculture, which in New Zealand accounts for 49% of our emissions (and comprises our main export earner), contributes only 16% of emissions in Australia, and is a minor export-earner compared with minerals. Australia has not yet set a date for bringing agriculture into its emissions trading scheme.

New Zealand and Australia will both introduce a price on carbon in electricity generation in 2010. Burning coal to generate electricity accounts for a massive 50% of Australia's emissions.

In contrast, electricity contributes only 11% to New Zealand's emissions because 65% of our electricity is generated renewably. The New Zealand National Energy Strategy states the goal of 90% of electricity being generated renewably by 2025.

In Australia forest owners will not be liable for carbon debits if deforesting their land, in contrast to New Zealand's ETS. This reflects the fact that plantation forests are a far bigger carbon sink in New Zealand than Australia, coupled with significant potential for plantation forest land in New Zealand to be converted into grazing land. There is limited opportunity for this in Australia.

Trading mechanisms are likely to be different in the Australian scheme. Australian-generated carbon credits will probably not be able to be sold offshore, and the purchase from overseas of some types of Kyoto credits is likely to be limited or illegal. The Australian Government may set upper and lower limits on the Australian price of carbon in the early years of its market, in order to give some protection to participants if international markets become expensive or volatile.

The New Zealand Government intends to promote full access to global markets, so that New Zealand businesses generating credits can maximise their sales opportunities and purchasers of carbon-credits can get the 'best world price'.

Free-allocations are to be far more generous in the NZ ETS: Australia is proposing to allocate credits for heavy transport users for only the first year of the scheme and for the first three for cars.

New Zealand's trade-exposed sectors will be given 79% of this country's free allocations, meanwhile Australian trade-exposed sectors are likely to get only 30% of theirs.

Chapter 4

Trees on land – the creation of carbon sinks

A key tactic of Government's policy package to meet Kyoto Protocol obligations is to *offset* greenhouse gas emissions through carbon sequestration, rather than to solely bring about emission reductions.

Offsetting will involve retaining existing forests (by protecting indigenous forests and requiring replanting of harvested forests), encouraging biomass build-up within existing forests (for instance via pest and grazing animal control), and developing new forests.

Offsetting will be able to occur in areas remote from where emissions are generated. For instance, emissions from dairy farming in Canterbury can be compensated by afforestation of North Island hill country.

Carbon sequestration will only work if carbon is all (or at least mostly) bound-up in plant material permanently. Harvesting may be permitted, but replanting will be necessary.

A forest cover will only be able to be removed in the future if landowners are prepared to pay for the re-release of stored carbon.

Although at present the Kyoto Protocol does not permit offsetting of forest harvesting/clearing by replanting elsewhere, this could change in the future.

Why are trees the focus of carbon sequestration?

As trees grow, carbon dioxide from the atmosphere is absorbed during photosynthesis, and is stored in the leaves, branches, stems and root system of the living tree. For carbon storage, and for a tree or forest to be considered a sink, the fate of the timber contained within the woody stem is significant.

When a tree is harvested, the carbon stored within is ultimately released back into the atmosphere, but there is a lag time, the length of which varies, depending on the fate of the various components. Slash left on site when plantation forests are harvested, and roots left within the soil will obviously decay and return a portion their carbon to the atmosphere quite quickly. Some carbon may become incorporated into soil organic matter. A glossy book or building may store carbon for tens of years, but a newspaper will probably release its carbon as quickly, or even quicker, than the slash left on site.

In addition, branches or whole trees fall to the forest floor as a result of storm damage, and release their carbon via fungal and bacterial decomposition. Deciduous trees shed their leaves annually. Some vegetation is consumed by insects, birds, and introduced browsing pests such as possums and deer.

A forest is therefore continually in a state of gaining and losing carbon. Only a portion of the carbon captured by a forest is truly sequestered, and then only for a certain timeframe. Herein lies a major challenge in determining the net amount of carbon truly sequestered by a forest, whether of a single species, or a mixture of species. .

However, on suitable land, trees are a fast, easy, measurable way to remove carbon dioxide from the atmosphere, particularly the fast growing plantation species. Longer lived indigenous species, while their rate of carbon uptake is obviously slower, have the advantage of persisting in the forest much longer (up to hundreds of years), and providing other positive benefits to biodiversity, soil and water conservation and aesthetic qualities, meanwhile providing for some sustainable harvesting of valuable timber.

Even a forest that undergoes cyclical harvesting and replanting will still on average sequester and store more carbon than the same parcel of land could if it were in pasture. A land use change from pastoral farming to forest of any type is therefore a positive for climate change.

A mature forest that is not harvested, such as indigenous bush, will ultimately reach a plateau or steady-state where uptake of carbon equals loss of carbon. Many of our mature indigenous forests would be in this situation. They contain significant carbon stores, far greater than cyclically harvested forests, but have limited to no potential to store any more.

A newly created indigenous forest will continue to absorb carbon for decades to centuries, albeit at a slower rate than fast-growing exotic tree species. In time the amount of carbon stored in a regenerating indigenous forest will overtake, and go on to greatly exceed, the average level of carbon stored in a cyclically-harvested plantation forest.

At the moment, spaced conservation, shelterbelt and amenity trees, and perennial horticulture, such as orchards and vineyards, are not included in the NZ ETS, since they don't fit the Kyoto definition of forest. They do of course sequester carbon.

New Zealand forests and the Kyoto Protocol

Forests planted in New Zealand during and after 1990 (which are 'Kyoto compliant' and eligible to voluntarily enter the ETS) are expected to absorb more carbon dioxide than what they will release. However, at present high deforestation/harvesting and low replanting rates, New Zealand forests will actually release more carbon than they capture from around 2020 until around 2033. This is a problem. We need more forests to meet our Kyoto targets, and avoid having liabilities to pay.

The Government has therefore added another afforestation initiative to its repertoire of two existing ones: The new Afforestation Grant Scheme, is aimed at encouraging forest planting by landholders who do not wish to be a part of the ETS. It will suit owners of small forests, including farm foresters.

Conversely, forests planted under the East Coast Forestry Project, and the Permanent Forest Sink Initiative are unable enter the ETS.

Afforestation Grant Scheme (AGS) – what's it all about?

Since this is a new initiative (2007) it is described in detail here. Key points are:

- It is a $50 million Government scheme to establish new forests, to assist in reaching New Zealand's carbon sequestration targets, alongside other environmental objectives
- The Government retains responsibility for credits and liabilities, so forests established under the AGS wont participate in the NZ ETS
- Nor are these forests eligible for the Permanent Forest Sink Initiative
- Forests must be maintained for at least 10 years, however, there are no harvesting restrictions
- Either the ECFP or the AGS can be used to afforest Overlay 3A erosion prone land within Gisborne District, or they could be used in tandem, the AGS to afforest additional or adjacent areas not eligible for the ECFP, but still requiring tree cover
- AGS funding cannot be granted on land already entered in the ECFP
- Minimum area required is 5ha, so it may be of interest to farmers wanting small blocks of trees, including those developing Works Plans under variation 176 of Gisborne's District Plan
- Half the funds are available through regional councils, and the remainder through MAF.

Introduction to the AGS

The Afforestation Grant Scheme (AGS) is a new option available to assist in the establishment of forests (minimum size 5 hectares) on land that was not in forest at 31st December 1989, including land that would also meet the criteria of the East Coast Forestry Project (ECFP). The 5 hectare size criterion can be met by adding together smaller blocks (of at least 1 ha each[20]), a useful feature that will no doubt suit farmers and farm foresters.

Landowners within Gisborne District that have erosion-prone Overlay 3A land on their properties could alternatively apply for both ECFP funding for 'target' land, plus an Afforestation Grant to plant other areas of their property, not eligible for the ECFP. The closing dates for applications to both schemes are synchronous.

In the context of Gisborne District Plan variation 176, the AGS may therefore fill a useful niche in assisting landowners with Overlay 3A land requiring tree cover according to Works Plans.

Grant recipients will own the new forests, and can earn income from timber when harvested. Meanwhile the Government will retain the carbon sink credits and take responsibility for meeting harvesting and deforestation liabilities.

The AGS has the parallel objectives of establishing Kyoto-compliant forests to meet carbon sequestration targets, while achieving other environmental objectives (for instance reducing climate change impacts, erosion, nutrient leaching and flood peaks, and improving water quality).

Another stated objective is "improving biodiversity", but this seems to be at odds with the apparent preference for fast-growing exotic species set out in the grant criteria, which will receive 70% of the funding.

Landowners interested in having indigenous reversion areas on farms may prefer the Permanent Forest Sink Initiative. For the most severe erosion-prone land (comprising overlay 3A) the East Coast Forestry Project is still available. These will be described further on in this chapter.

What land is eligible for the Afforestation Grant Scheme?

Land eligible for a grant must be land that:

a. Either was not forest land on 31 December 1989; or

b. was forest land on 31 December 1989 but;

- was deforested between 1 January 1990 and 31 December 2007; or
- was deforested on or after 1 January 2008, and for which NZUs have been surrendered to the Government to cover the carbon that would have been released.

Any pockets of non-complying land within the proposed forest area must be identified in the application, and will be excluded from the grant. These might include archaeological sites marked on Council planning maps or registered with the Historic Places Trust, and RAPs (Recommended Areas for Protection).

Applicants with such areas on their land will need to seek advice from the Council about the boundaries of these sites. Finally, MAF will inspect land for which grants are applied for, to ensure eligibility.

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20. Shelterbelts or riparian strips can be included if they are at least 30 metres wide (canopy-edge to canopy-edge). Afforestation on both sides of a waterway can be assessed as one riparian strip, so it would need to be 30m wide excluding the width of the channel.

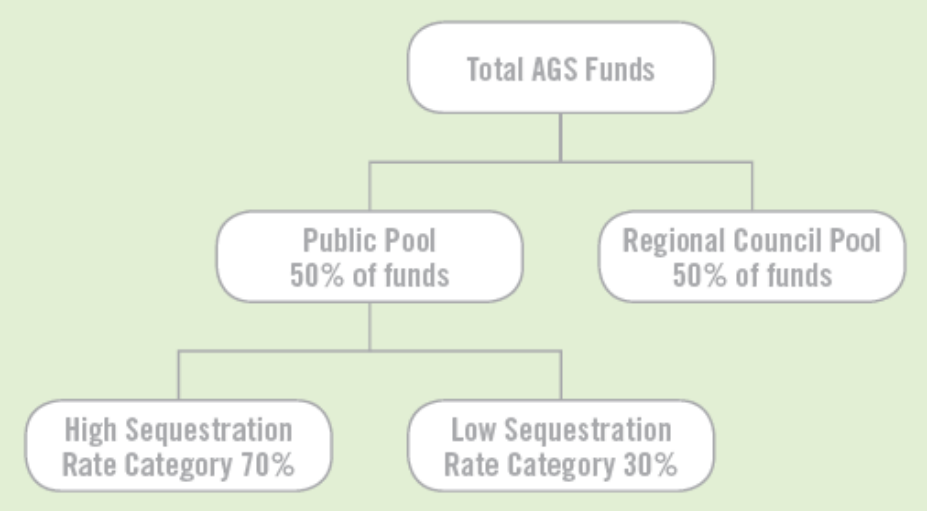
What is the definition of "forest"?

"Forest" land for the purposes of the AGS is defined more stringently than in the Kyoto Protocol. The minimum area is 5 hectares, potentially made up of smaller blocks of at least 1 hectare. The forest must be established at a minimum planting density of 750 stems per hectare, comprising species with the potential to reach a minimum height of 5 metres at maturity and achieve 30% crown canopy cover. A forest may contain trees of various storeys and undergrowth covering a high proportion of the ground, or be quite open at ground level, as in a pine plantation.

Forests/plantations that have not yet reached 30% crown density or crown tree heights of 5 metres, but are expected to in time, still fit the definition of forest. Areas normally forming part of the forest but which are temporarily destocked (as a result of harvesting or due to natural causes) are included in the definition providing they will be replanted.

Who will administer the AGS?

Half the funding in the AGS pool is available to Regional Councils to help meet their sustainable land management objectives. The other half is available directly to the general public through a competitive public tender pool, administered by MAF.



Source: MAF

Within the MAF tender pool, 70% will be allocated to afforestation proposals using fast-growing exotic species that therefore have 'high carbon sequestration rates' such as *Pinus radiatia*, eucalyptus species and poplar.

The remaining 30% of funding will be reserved for species with 'low sequestration rates', including New Zealand's indigenous tree species.

The reason for the preference for exotic trees is presumably because the Government wants a fast initial 'grab' of carbon, however it should be noted that indigenous reversion, while slower to sequester carbon, will continue to do so for around 300 years (or longer), compared to 20 to 30 years for a typical pine rotation. The emphasis on exotic trees is disappointing from a biodiversity point of view.

In the case of the Gisborne District where the East Coast Forestry Project (ECFP) also operates, the closing dates for the AGS and ECFP have been co-ordinated, and are the 30th of June and the 31st of December each year.

Who can apply, and how will grants be allocated?

Individuals, businesses and local government are eligible to apply for AGS grants either through the public pool or by applying to participating Councils provided they either own the land, or have the right to use the land for forestry.

The MAF–administered grants

The MAF-administered AGS grants will initially be made through a competitive tendering process, intended to establish the required grant levels and to allow for efficient allocation of funds. After a number of tender rounds, there may be a change to a fixed-rate grants system for the MAF pool.

Grants will be paid by way of reimbursement once the forest is established. The maximum grant rates won't be disclosed to the public.

Positive weighting will be given to proposals that offer environmental benefits such as soil conservation, an improvement in water quality and biodiversity gains.

Unsuccessful applicants have the option to re-submit their applications as a new tender for the same areas, or applicants may choose to enter the NZ ETS or the PFSI as an alternative.

Successful applicants will be offered a grant agreement with a term of ten years. This will probably happen after release-spraying in the spring following planting, when the forest is deemed to have successfully established. For planted indigenous species, the claim would be lodged when specified operations such as fencing and pest animal control have been completed.

If the grant land is deforested within the term of the agreement, the grant plus interest will be repayable.

An administrator will have the right to access the land for carbon measurement purposes.

The steps to follow in order to apply for AGS funding are outlined in the MAF website:

http://www.maf.govt.nz/climatechange/forestry/initiatives/ags/page-04.htm#pp

Application forms are also available online, or contact the Gisborne office of MAF for advice:

http://www.maf.govt.nz/climatechange/forestry/initiatives/ags/AGS-Application-Form.pdf

Council-administered grants

Participating councils will put in place an allocation panel to administer $25 million of the total pool, over a period of six years from 2008/09. This panel will consider all applications and allocate grants to the successful applicants. Hawke's Bay Regional Council is the central contact and nine other councils have agreed to take part at this stage (including Gisborne District Council).

There is a funding agreement in place between MAF and participating councils, which will act independently and not as agents of MAF. An administration fee of 7.5% of grant allocation has been agreed, and is subject to review after a year. This is a fraction of the cost spent administering the ECFP.

Assessment criteria for the Council-pool include consideration of sequestration rates, land use capability class, water quality benefits, flood protection and biodiversity gains.

Eligible Species

Species must be chosen that are compatible with the selected site, and they must be able to ultimately become "forest", according to the definition already given.

Indigenous species are supposed to be "eco-sourced", in other words be propagated from seeds collected in the locality. Natural forest reversion projects may include the initial establishment of exotic trees as a nurse crop, to facilitate a transition to indigenous forest.

For instance, pines could be inter-planted with high-value species (such as rimu). This could be done at the outset, or after thinning the pines at around 4 years, to create gaps in the canopy.

Forest species that have been identified in Regional Council Pest Management Strategies as having weed potential will be ineligible.

Forest establishment

For a forest to be eligible for Kyoto sink credits it must be *"direct human induced … through planting, seeding and/or the human-induced promotion of natural seed sources".*

In addition the AGS requires establishment of *"seedlings, cuttings or other plant material achieving a minimum stocking of 750 stems per hectare, and free of significant weed competition"*. A forest could therefore be planted with long-lived tree species (such as rimu) comprising say 10% of seedlings, with the remainder made up of manuka, kanuka or other species. Simply fencing and allowing nature to take its course will not suffice for AGS funding.

For indigenous forest blocks, a management plan will also be required from applicants to show the actions they will undertake to ensure the forest establishes, for instance stock-exclusion fencing, pest control and replacement of seedlings that don't survive. Other than ensuring the required number of trees "take" there are no other silvicultural requirements.

Two other mechanisms for establishing forest on land within Gisborne District are briefly described on the next two pages, the Permanent Forest Sink Initiative and the East Coast Forestry Project. Both these were covered in more detail in the 2006 Climate Report to the Gisborne District Council, so just a quick run-through is given here.

The Permanent Forest Sink Initiative

Key points are:

- Applies to land that was not in forest on the 31st of December 1989.
- PFSI areas earn Kyoto Protocol-compliant "assigned amount units" (AAUs).
- It's not a grant to plant trees; establishment costs are the responsibility of the landholder, although suitable forests planted under the ECFP can enter the PSFI.
- Forests planted under the AGS are not eligible for the PFSI.
- Active management to enable forest is required, but not necessarily planting of seedlings – facilitating natural regeneration is acceptable.
- Requires covenant registered against land title in perpetuity.
- There are penalties for deforestation (deliberate or by natural causes), as this would release carbon that AAUs have been paid out on.
- There is an option to exit after 50 years, provided units are repaid.
- Limited harvesting allowed.
- The forest could be indigenous, exotic, or a mixture of both.
- Minimum size is one hectare.
- Stock-exclusion fencing will probably be necessary, but active planting of seedlings is not a specified requirement.
- Can transfer to NZ ETS as post-1989 forest within 18 months of NZ ETS legislation becoming law (until March 2010).
- Landowner will incur liablilities if carbon is lost.

The PFSI provides an opportunity for landowners who voluntarily establish permanent forest sinks to obtain tradeable Kyoto Protocol compliant assigned amount units (AAUs) in proportion to the carbon sequestered in their forests during the First Commitment Period of Kyoto (2008 –2012).

These would be paid out after 2012, upon verification of the amount of carbon stored in the forest. This has been referred to in the media as "carbon farming".

To be eligible for this initiative, the land must not have been covered in forest as at 31 December 1989 and some form of active management must have been required in establishing the forest. This could include fencing to exclude stock, but while additional seedlings can also be planted, this is not a requirement, as it is for the AGS.

While limited harvesting of the forests established under this initiative is allowed after 35 years and on a sustainable continuous-canopy basis, clear-fell plantation forests are obviously not compatible with the PFSI.

The new forest must be protected by a binding contract or covenant between the forest owner and the Crown. The covenant would be in perpetuity, binding any future owners of the forest. The PFSI is managed by MAF's Indigenous Forestry Unit in Christchurch.

The forest may comprise indigenous or exotic species. For areas of patchy scrub intermixed with pasture, eligibility and boundaries would be determined on a case-by-case basis. Areas of poplars and willows where crown cover will exceed 30% and the trees were planted *after October the 17th 2002* would also be eligible.

Eligibility of a forest to qualify for the PFSI will require adherence to an agreed management plan. The emission units would be paid against the amount of carbon sequestered by the vegetation between 2008 and 2012 (the first commitment period for Kyoto). Units would be awarded to landowners after 2012 once the amount of carbon stored in the forest is verified. They could then be traded with whomever the landowner wishes. It is unclear at this stage what the emission units would actually be worth.

After 35 years there is provision to remove some timber from the forest provided a closed canopy is retained. Unauthorised harvest or clear-felling would incur penalty payments. If the forest is blown or burnt down, landowners would be required to purchase emission units to cover carbon emitted to the atmosphere, but would not incur additional penalties.

Landowners would be responsible for all costs associated with forest establishment, ongoing monitoring and verification.

The PFSI may appeal to landowners wishing to retire marginal land, which could include Overlay 3A target land under the East Coast Forestry Project.

The PFSI may also be compatible with creation of a QEII reserve area, where significant regeneration will take place once the area is fenced. This may appeal to some landowners as a way of generating some extra funds to offset fencing or additional planting.

Pine trees alone would not be suitable to create a permanent forest sink without active management to facilitate a transition to longer-lived species. A pine forest 'let go' would result in very spindly, weak trees at risk of being blown over. If large tracts of forest were lost this way, most of the sequestered carbon would be lost to the atmosphere.

Beyond 2012

If, after 2012, the Kyoto Protocol no longer allows for emission units to be generated from PFSI-forests, it is proposed that all harvesting and land-use change restrictions would then be annulled. However, there may still be liability in respect of units already claimed by landowners should the forest be clear-felled.

Resource consent would probably be needed for any proposed land-use change, and District Plan rules may apply to the vegetation present.

The East Coast Forestry Project

Key points are:

- The ECFP is a Government-funded scheme, administered through MAF, to assist afforestation of the 'worst of the worst' eroding land in Gisborne District, identified as Overlay 3A.
- A goal is to achieve long-term erosion control.
- 50 year covenants are therefore registered against land titles.
- *Pinus radiata* has in the past been a popular option, but poplars and willows, where applicable and at recommended spacing, and indigenous reversion are other options eligible for ECFP funding.
- Land cannot receive funding from both the ECFP and the AGS.
- Areas of land not identified as Overlay 3A, that are ineligible for ECFP assistance, however still require tree cover, could be planted using AGS funding.
- ECFP grant recipients may, if they wish, participate in the PFSI with no change in their grant.
- ECFP grant recipients may participate in the NZ ETS but the grant would be adjusted.

Some erosion-prone land is suitable for the "reversion" option under the East Coast Forestry Project, where kanuka/manuka scrub is already established, or there is a suitable seed source to allow this to happen. ECFP reversion blocks require stock and feral animals to be excluded, but a fence is not specified, and in some cases is not needed.

Further information on the East Coast Forestry Project, including grant criteria and how to apply, may be found at www.maf.govt.nz/forestry/east-coast-forestry/

What are the implications of all these forest-establishment incentives?

The East Coast Forestry Project has already produced a significant change in land use within the district as large areas of pastoral farmland have been converted to plantation forests.

The forest incentives made available under the ETS, together with the disincentives for future clearance, are likely to further accentuate this trend particularly on the less-versatile steep hill country that predominates in large tracts of Gisborne District.

Because the Afforestation Grant Scheme does not consider Land Use Capability Classes as part of eligiblity there is potential for the possible conversion to forest of whole farm properties, including the 'better' classes of land, for the purpose of 'carbon farming'.

Land use change to forestry has already created profound social changes as rural populations have thinned out, houses have been relocated, schools closed, and a relatively stable population of farm workers and their families has been replaced by a largely itinerant and seasonal workforce who tend to live away from the areas where they work and must commute large distances or live away from their families.

Anecdotal evidence from medical professionals in Gisborne point to an increase in time off work due to injury (alongside increasing ACC payouts) as the workforce has shifted from predominantly farm work to a far greater proportion of workers employed in forest harvesting. The comment has also been made that the longevity of forestry workers is shorter than that of farm workers, because of the hard physical nature and repetitiveness of the work, and the predominance of injury.

While the ECFP has been around for a while, and is well understood by land owners, the new initiatives may take a while to catch on. Landowners may be distrustful of afforestation schemes given the continuation of the Kyoto Protocol is unclear after 2012.

Landholders may therefore wish to wait until beyond 2012 to see what happens next, but may be tempted by investors seeking to purchase land for C-sequestration. Meanwhile the Government is feeling increasing urgency to get trees in the ground in order to try to meet New Zealand's commitments ahead of a rapidly approaching deadline.

Which forests will and won't participate in the Emissions Trading Scheme?

Pre-1990 Forests and the ETS

Pre-1990 plantation forests will compulsorily enter the ETS. Currently, pre-1990 indigenous forests are not included.

Owners of pre-1990 forest will be obliged to surrender NZUs if deforesting more than 2ha of (non-exempt[21]) trees over the period 2008-2012.

There is, however, no requirement to surrender NZUs if harvested trees are replanted (or allowed to regenerate).

Owners of pre-1990 forest have a one-off opportunity to apply for an allocation of NZUs, however no NZUs can be claimed for carbon sequestration.

Post-1989 forests and the ETS

Owners of post-1989 exotic or indigenous forests have the option to enter the NZ ETS voluntarily, and in doing so take responsibility for the ongoing net changes in the carbon stocks of their forests.

They would therefore receive NZUs if carbon stocks increased as a result of tree growth, and would be required to surrender NZUs if carbon stocks decreased as a result of harvesting, fire or storm damage. Note that the liability would not exceed the number of NZUs earned.

The Government will retain responsibility for changes in the carbon stocks of post-1989 forests that don't enter the NZ ETS, including of course those established under the AGS, keeping any credits earned and remaining responsible for any future liabilities.

The key points to note for post-1989 forests entering the ETS are:

- NZUs earned for forest growth from 2008
- No NZUs for forest growth from 1990 - 2008
- Forests owners can exit NZ ETS at any time, provided NZUs are repaid
- Compatible with forests established under ECFP, at reduced grant rate
- Post-1989 forest owners not participating in the ETS have no liability for harvesting or deforestation
- Participation will transfer with the sale of the land or forestry right
- It is possible to exit the ETS at any time providing NZUs earned are repaid
- If post-1989 forest owners chose not to enter the NZ ETS, they incur no liability for harvesting or deforestation, nor do forests earn NZUs.

21. Forest owners can apply for exemption from the ETS if owning less than 50ha total pre-1990 forest holdings, as at 1st September 2007. The exemption runs with the land. Exemption from ETS obligations may also be applied for if removing weed trees.

Chapter 5

Soil carbon sequestration

Until now, most efforts to manage greenhouse gases have focused on above-ground sequestration, primarily through planting trees. Sequestration of additional carbon in the soil is an area that seems to be below the public radar at present, but is of great potential significance to the world's carbon stores, and therefore atmospheric concentrations of CO_2.

Collectively, organic carbon stored in the top 1 metre of the world's soils comprises an estimated 75% of the earth's terrestrial carbon stores.

The world's soils in fact hold more organic carbon (an estimated 1500 Gt) than the atmosphere (720 Gt) and terrestrial vegetation (600 Gt) combined[22].

Land management changes can result in significant carbon sequestration: one hectare can potentially hold hundreds of tonnes of carbon; therefore even for a country the size of New Zealand the numbers could be very large.

For example, many cropland soils of the United States are known to have lost as much as 50% of their original soil organic carbon stores to the atmosphere, due to the effects of land clearing and cultivation. With proper management it is believed much of the carbon released from soils in US over the past two centuries can be restored. Possibly as much as 30,000-60,000 million tonnes of carbon could be sequestered in this way.

What is soil carbon sequestration?

Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil in a form that is not immediately re-emitted. This enhances soil quality and long-term agronomic productivity.

Soil organic matter is created by the cycling of organic compounds in plants, animals, and

Micro-organisms into the soil. Well-decomposed organic matter forms humus, a dark brown, porous, spongy material that provides a carbon and energy source for soil microbes and animals.

Soil carbon sequestration can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, and enhance soil fauna activity. No-till crop production, mulching, use of cover crops, crop/pasture rotation and green manures are prime examples.

On hill country farms enhancing the activity of phosphorus-fixing *mycorrhiza* and clover with its associated nitrogen fixing *rhizobium* will benefit soil fertility as well as boosting carbon stores.

Conversion of land previously cropped to pasture can actually sequester more carbon in the soil provided good management is practised.

A current challenge is how to measure soil carbon stores accurately and economically. Carbon accounting is similar to financial accounting and certain standards must be met to make claims credible. Currently there is a lot of research looking at soil C sequestration both in New Zealand and overseas.

There is a finite and limited supply of land suited to and available for planting forests, but practices known to enhance soil carbon could be implemented on any and all agricultural and pastoral soils, and those practices can only enhance soil's physical properties, fertility and productivity.

22. *Source:* United Nations Food & Agriculture Organisation

Carbon stored in forests is at risk of deforestation by fire or storm damage. Soil carbon stores are similarly vulnerable if management practices change resulting in loss of carbon back to the atmosphere.

Increasing soil carbon on hill country farms by 'root pruning'

Soils can progressively lose organic carbon under set-stocking regimes as little root biomass is allowed to build up in the soil.

Of particular importance to soil carbon levels is the supply of carbon compounds from the roots of pasture plants to soil biota as an energy source.

In a green grass plant, there is generally more nitrogen in the leaves than in the roots, and more carbon in the roots than in the tops. When the leaves are removed by grazing, the plant responds to re-adjust this balance. Some carbon (in the form of carbohydrate) is mobilised to the crown for the production of new leaves, some is lost to the soil as 'pruned roots' and some is actively exuded into the rhizosphere (the soil surrounding plant roots) where it stimulates the activity of soil biota.

What are 'pruned roots'?

When the above-ground part of the plant is removed by grazing, the plant loses root mass to the soil, and exudes organic compounds in order to rebalance the biomass of the above and below-ground parts of the plant. This organic matter is then available to soil animals and microbes as a food source, much of it becoming incorporated into the soil as soil organic matter. One can therefore picture a grass plant as striving to keep the size of the root system a mirror image of the above-ground part of the plant, as shown in the photograph below:

Left: Grass plants have root systems that mirror the size of their tops (Source: Dr. Christine Jones)

If grazing is optimized, ensuring that pasture plants have recovered sufficiently for their root systems to be well re-established before grazing, the net effect will be an increase in soil carbon (energy) levels.

The carbon exuded from the roots of grazed plants stimulates soil flora involved in the uptake and transfer of nitrogen, phosphorus and other nutrients, assisting rapid re-growth of leaves.

Left: Grass plant on the left shows the root mass that is pruned due to grazing of the top, and made available to soil processes. (Source: Dr. Christine Jones)

How is this done in practice? In order to best feed both livestock and the soil biota, grazing must be intermittent, and ideally sufficient stock would be let into an area where palatable species are at optimum length to quickly graze pasture to a short length (ideally) in just one to three days, supply a good dose of animal manure and trampled pasture to the soil, then they would be moved on to the next area.

Conversely, if plants are grazed continuously, they tend to have poorly developed root systems and there will be very little carbon available to the soil at each grazing event.

Benefits of controlled, intermittent grazing

Optimal management of grazing helps to synchronise nutrient mineralisation with plant demand, and stimulates microbes to produce a wide range of plant growth stimulating substances in soils, including natural hormones, enzymes and vitamins. The pasture therefore rapidly recovers once stock are moved on.

Increased levels of soil biological activity not only improve nutrient availability, but also minimise nutrient losses and stabilise soil pH.

Pasture plants allowed to recover between grazing episodes will have deeper-reaching roots that can better withstand dry conditions.

Soil that is accumulating carbon is also accumulating nitrogen. Conversely soils losing carbon are losing nitrogen too.

Improved soil organic matter content promotes faster infiltration of rainwater, reducing runoff (and associated nutrient losses), and slows evaporative losses, so moisture is also retained longer.

Increasing soil carbon improves soil structure. When soils are 'light', soft and springy they are easier, and take less energy to cultivate. Soils with high carbon levels are less prone to erosion and waterlogging.

Increasing soil carbon stores in this way is low-tech, low-cost, and really only requires man-power and a commitment to follow the intermittent grazing regime.

An increase in soil organic carbon of just 1% will enable soil to hold an extra 14.4 litres of water per square metre, or 144,000 litres per hectare. A 4% increase in soil organic matter will enable soil to hold an extra 57.6 litres per square metre, or a staggering 576,000 litres per hectare! This is in addition to the moisture the soil could already hold, before carbon stores were increased[23].

If carbon levels drop due to mismanagement, soil become increasingly compact and erosion-prone, and difficult to cultivate, requiring ever-increasing numbers of passes to break down clods.

Maintaining continuous ground cover of plants, promoting production of root biomass and high levels of soil microbial activity can actually create topsoil. Home gardeners know well the benefits of increasing soil organic matter in improving and building the topsoil. Farmers will in the future increasingly think along these lines as well, to benefit the soil, reduce artificial inputs, and probably increase profits as well.

Pilot programme pays Western Australian farmers for soil carbon sequestration

This scheme[24], launched in March 2007, is the first of its kind, and allows WA farmers to register up to four "Defined Sequestration Areas" on any part of their properties. These areas will be tested for soil carbon content annually for an initial trial period of three years.

Farmers will be paid $90/tonne annually and retrospectively for the increase in their soil carbon.

Dr Christine Jones from the Australian farmer education group 'Carbon for Life' says, "It would only require a 1% increase in soil carbon on 15 million hectares of land to sequester 8GT of carbon dioxide in the soil, which is equivalent to the greenhouse emissions for the entire planet."

The WA scheme is the result of a private arrangement between Carbon for Life and Rio Tinto Coal, which will provide funding for the initial three years of the trial, by way of purchasing the credits generated.

To pay farmers to sequester carbon at the rate of $25 per tonnes of atmospheric carbon dioxide would cost $200 billion, and could potentially prevent global warming in a matter of years and markedly improve soil productivity at the same time.

Recognition of soil carbon in New Zealand

The NZ ETS does not allow for Kyoto Protocol "Article 3.4 sinks" which include *carbon in soil and vegetation, both above and below ground on crop and grazing land.*

Such sinks would include not only soil organic carbon, but also carbon stored in scattered or space-planted trees, orchards, vineyards and shelter belts.

It will be of great interest to New Zealand farmers to see whether the Australian ETS, development of which is around 18 months behind our own, will allow for Article 3.4 sinks.

By excluding Article 3.4 sinks, another incentive is created for 'good' land currently used for food production/farming to be replaced by other land uses including biofuel production or carbon-sink forests.

However, if Article 3.4 sinks were to be included in the Australian ETS, it may prove to be possible to both produce food and sequester significant amounts of carbon on the same parcel of land. If Australia leads the way in this area, there may be a case to have the NZ ETS amended to include these sinks.

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23. Dr. Christine Jones, presentation at 'Managing the Carbon Cycle' National Forum 22-23 November 2006
24. Source: ABC News Online: www.abc.net.au/news/newsitems/200703/s1879520.htm

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Appendix 1

Livestock numbers and estimates of methane and nitrous oxide emissions

Agriculture is the largest source of emissions for New Zealand, amounting to 48% of our total greenhouse gas emissions (for 2006).

This fact gives New Zealand a unique emissions profile. In other developed countries, agricultural emissions typically comprise around 12% of national emissions.

By 2006, New Zealand's agricultural emissions had increased by an additional 16% over the 1990 levels. Agriculture also contributed 96 % of New Zealand's total nitrous oxide emissions and 90% of total methane emissions in 2006.

The tables below give a sure (although crude) indication that total livestock emissions have increased for all classes of stock in Gisborne District. This is despite a significant reduction in the numbers of sheep and beef cattle in the district. Each individual is on average producing more emissions: animals grow faster and reach heavier weights because farmers are now growing more pasture dry matter per area. On top of this, lambing and calving rates have improved significantly since 1990, which would be significant for New Zealand as a whole.

Numbers of dairy cattle and deer have both increased significantly since 1990, and this is reflected in the large increase in total emissions given for these classes of stock.

Note that the 'minor' classes of stock including horses, goats, pigs and poultry, are not included in the calculations, and were not looked at in the MfE calculations either.

Comparison of livestock numbers for 1990 compared with 2007

	Sheep	Beef cattle	Dairy cattle	deer
1990	2,284,130	324,258	3,376	17,127
2007	1,825,000	287,000	8,000	27,000
Change	-20%	-11.5%	+137%	+58%

Comparison of estimated methane and N emissions from sheep in Gisborne District

	Number in Gisborne District[25]	Estimated kg/methane/head/annum[26]	Total estimated sheep methane emissions	Estimated Nitrous oxide output per animal in kg/N/ head/annum	Total kg N emissions from sheep
1990	2,284,130	8.99	20,534,328	12.2	27,866,386
2007	1,825,000	11.72 [27]	21,389,000	15.9	29,017,500
Change	-20%		+4.2%		+4.1%

25. *Source of figures: Agriculture Statistics 1990 (at 30 June) and Agriculture Production Statistics (final) June 2007.*
26. Methane emissions directly from the animal, plus emissions from animal wastes.
27. I used 2010 projected figures for the 2007 estimates, as used by MfE. This at least gives a "worst case scenario".

Comparison of estimated methane and N emissions from beef cattle in Gisborne District

	Number in Gisborne District	Estimated kg/methane/head/annum	Total estimated beef cattle methane emissions	Estimated Nitrous oxide output per animal in kg/N/ head/annum	Total kg N emissions from beef cattle kg
1990	324,258	51.65	16,747,925	65.2	21,141,621
2007	287,000	59.65	17,119,550	76.1	21,840,700
Change	-11.5%		+2.2%		+3%

Comparison of estimated methane and N emissions from dairy cattle in Gisborne District

	Number in Gisborne District	Estimated kg/methane/head/annum	Total estimated dairy cattle methane emissions	Estimated Nitrous oxide output per animal in kg/N/ head/annum	Total kg N emissions from dairy cattle kg
1990	3,376	73.73	248,912	106.2	358,531
2007	8,000	86.87	694,960	122.1	976,800
Change	+137%		+179%		+172%

Comparison of estimated methane and N emissions from deer in Gisborne District

	Number in Gisborne District	Estimated kg/methane/head/annum	Total estimated deer methane emissions	Estimated Nitrous oxide output per animal in kg/N/ head/annum	Total kg N emissions from deer kg
1990	17,127	21.2	363,092	27.4	469,280
2007	27,000	23.62	637,740	30.6	826,200
Change	+58%		+76%		+76%

Figures used are given by MfE in a report published on the web were used in the above calculations of methane and nitrous oxide emissions. The emissions tables are in the appendix of the report and can be found at:

www.mfe.govt.nz/publications/climate/projected-balance-emissions-jun06/html/page11.html

Appendix 2

Could a farm business realistically take responsibility for its own emissions?

Estimates published in some farming magazines have suggested establishing tree cover on about 10 to 15% of a farm would sufficiently offset the emissions from traditional sheep/beef farming.

This would of course depend on the type of trees planted. Bear in mind the fact that if ultimately the trees are to be harvested, they are only a temporary carbon sink. Eventually any forest, at maturity, reaches an equilibrium situation where carbon sequestration equals emissions from natural die back and decay of trees.

There would also be potential for individual farms to become carbon-neutral through a combination of afforestation, reducing inputs through careful nutrient budgeting, and purchasing of carbon credits from off-farm.

Landcare Research is currently developing the methodology for farming businesses to measure their green house gas emissions with the idea that they would be able to off-set these emissions and be certified carboNZero[28] (carbon neutral).

Products originating on a farm could potentially gain carboNZero certification, however this is quite a bit more complicated, as the inputs and outputs extend beyond the farm gate.

Landcare Research intends to conduct a pilot project with a farming group and a particular product in the near future which will look at the 'cradle to grave' emissions along the supply chain of a product, for example a lamb from the farm to the supermarket shelf in the UK through to disposal of any packaging waste associated with the product. This would allow a packaged piece of lamb to carry a label with the embodied emissions for the full life cycle of that product. This may become a requirement of suppliers into UK supermarkets in the near future.

Can fencing off bush remnants on parts of a sheep and beef farm offset all the emissions from that property?

On average a sheep would emit the equivalent of 0.2 tonnes of CO_2 and a beef cow about 1 tonne, per year. Regenerating, fenced off, bush will (on average) sequester 3 tonnes of carbon/ha/year. A tonne of carbon credits will offset a tonne of CO_2 so using the hypothetical example of a 600ha Gisborne hill country sheep and beef farm, the figures would look something like this:

	Number	CO_2 equivalent emissions (tonnes)/animal/year	Total CO_2 equivalent emissions (tonnes)	Estimated area of regeneration to offset (ha)
Sheep	1850	0.2	370	123
Cattle	460	1.0	460	153
Totals			830	276

Ruminant emissions are likely to account for the vast majority of a farm's carbon footprint (unless large amounts of N fertiliser are used). Fuel use will be minor compared to ruminant emissions.

Nevertheless, 276ha of bush represents just under half the area of our theoretical farm, so offsetting all emissions by fencing off bush remnants within the boundaries of a property is not realistic.

28. CarboNZerok is a system designed by Landcare Research for measuring, offsetting and certifying the carbon status of individuals, businesses and events.

Since regenerating native forest will not reach climax capacity for (possibly) hundreds of years, it will continue to sequester carbon for much longer than a plantation forest comprising introduced species, albeit at a slower rate. In time, indigenous forest will reach an equilibrium at which it will contain far more carbon than the average achieved by exotic plantation forest.

What about faster growing species: Can they offset a farm's emissions?

Planted *Pinus radiata* forests have an average annual carbon sequestration rate (or 'mean annual increment') rate of 18 tonnes[29] of CO_2 (equivalent) per hectare per year, during the growth phase of the trees, and manuka/kanuka shrublands sequester 7 to 9.2 tonnes[30]/ha/year. Taking the same hypothetical 600ha farm in the above example we get:

	Total CO_2 equivalent livestock emissions (tonnes)	**Planted /vegetated area needed to offset farm emissions (ha)**	
		Pinus	**Manuka/kanuka**
Sheep	370	20.5	40 -53
Cattle	460	25.5	50 - 66
Totals	830	46	90 - 119

These give much more realistic results in the short term. If using pines alone, less than 8% of the 600ha farm area would be needed to achieve this 'fast grab' of carbon. This is close to the minimum 50 ha size needed for verification (to be economical for auditing purposes). However, at maturity of the stand(s) the fate of the harvested timber will decide whether those emissions are released once again.

Manuka/kanuka scrub planted or present at sufficient density on 15 to 20% of the farm could also offset livestock emissions, and over a much longer time period than blocks of pines would, provided the areas were protected permanently from grazing stock.

These are of course simplistic examples, and ignore what happens to the carbon sequestered in the pine trees when harvested. The growth phase of kanuka/manuka shrubland is of course much longer, and replacement of the trees would only be needed if they were lost to fire or storm damage.

Ultimately, the rate of carbon sequestration by manuka/kanuka would plateau, but would later begin to increase once more as later-appearing canopy species emerged in the normal course of forest evolution.

If we look at the Gisborne District as a whole (this is of course a crude calculation), the figures look like this:

	Livestock numbers (2007)	**Tonnes CO_2 equivalent emitted per animal per year**	**Total CO_2 equivalent livestock emissions (tonnes)**
Sheep	1,825,000	0.2	365,000
Beef cattle	287,000	1.0	287,000
Dairy cows	8,000	1.5	12,000
Deer	27,000	0.4	10,800
Total			674,800

29. This is an overall average carbon sequestration rate for planted forest in New Zealand during a rapid growth phase, as determined by Tate, Giltrap *et al*.

30. General New Zealand mean net increment for Manuka/Kanuka scrubland during an active growth phase averaged over 40 years and taking into account changes in all carbon pools, after Trotter *et al.*

Post-1990[31] plantation forests alone cover 99,302 ha of Gisborne District, which at an average mean annual increment of 18 tonnes of CO_2 (equivalent)/ha/year, will sequester roughly 1,787,000 tonnes of carbon in total per year.

This means plantation forests in Gisborne District are offsetting over two and a half times our approximate agricultural emissions, and would certainly offset our total emissions when all other forests and carbon emissions such as fuel, fertiliser and electricity usage are taken into account.

Gisborne District is, in all probability, carbon neutral.

31. This figure is actually post-1991 because of the age brackets used in the National Exotic Forest Description.

Appendix 3

A section for skeptics

This section has been included in an attempt to refute some of the currently fashionable objections to the whole concept of human-induced climate change.

Climate change is all to do with sunspot cycles

Sunspots appear and disappear on the surface of the sun, having an irregular cycle about every 11 years. Sunspots are darker, cooler areas on the surface of the sun, however they have bright, very hot edges; so more sunspots actually increase the sun's solar constant or brightness. The variation caused by the sunspot cycle to solar output is relatively small, around 0.1% of the solar constant, but is indeed sufficient to induce climate effects. During the 17th Century there were hardly any sunspots at all. This coincides with a well-known period of cooling referred to as the Little Ice Age.

But sunspots are cyclical, and so cannot alone explain longer term trends in either climate warming or cooling, and certainly not the unprecedented rapid warming period we are currently experiencing.

The warming trend has actually stopped - the Earth has cooled since 1998

This is an example of how statistics can be used selectively! 1998 was a stand-out year and was much warmer than any previous one. The years since 1998 have not been so warm, but they were warmer than any year before 1998. If we disregard that one anomalous year, the warming trend can be seen to have continued.

What about the carbon cycle we learned at school – surely carbon is just cycled around?

The problem is ever-increasing amounts of carbon are being continually added. Human mining of fossil carbon from beneath the surface of the Earth has added huge amounts to the system, meanwhile extensive deforestation continues to remove vast tracts of forest that once absorbed CO_2 from the atmosphere and converted it to plant matter. The balance has shifted to mean less and less carbon is resident in forests, coal and oil beneath the ground, and more and more in the atmosphere, and this is being added to at a very fast rate.

It has been argued in the Gisborne Herald and some of the farming newspapers that the carbon emitted by livestock into the atmosphere has previously been removed (by grass and other vegetation) from the same atmosphere, and that (aside from any fossil fuel usage) farming must therefore have a zero carbon balance.

Of the carbon absorbed by pasture plants, about 75% is released quickly back to the atmosphere via plant decomposition and respiration (at night when they are not photosynthesising). The remaining 25% of the pasture carbon is digested by the animal and turned into energy and biomass. At some stage, the metabolised carbon is also returned to the atmosphere via respiration, waste material, and via the consumption of meat (or milk) products.

The problem is, the animal is releasing a portion of the carbon it injested as methane, a potent greenhouse gas which has a 'global warming potential' of 21 times that of carbon dioxide.

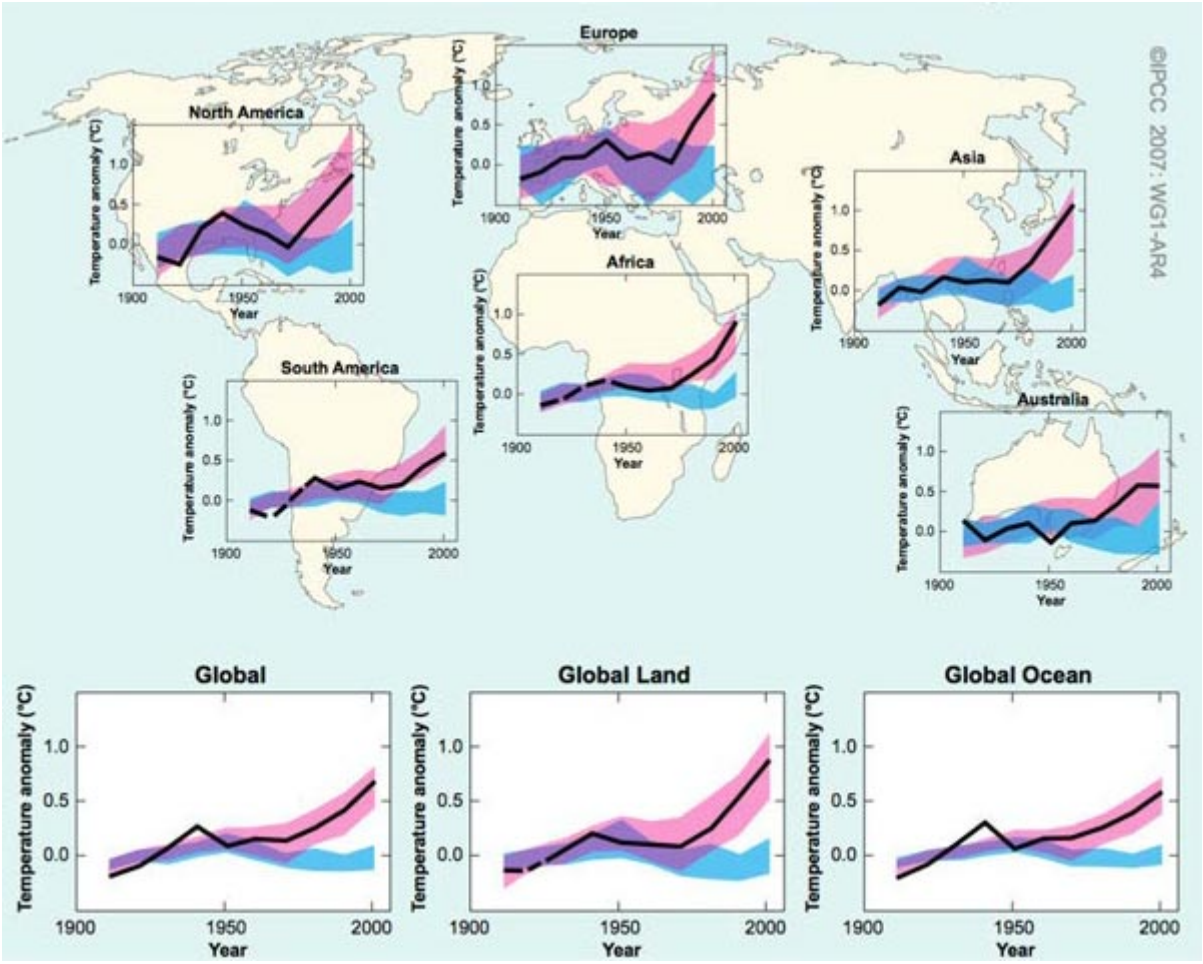
Climate change has always happened and it's part of a natural cycle

Past climate change can indeed be attributed to natural causes, and we know from reliable evidence in ice cores, sediments and preserved fossils that Earth's climate, the area of land above sea level and the relative concentrations of atmospheric gases have indeed changed throughout time.

In this report and in others dealing with the issue of the unprecedented warming period we are currently in, what is spoken of as climate change or global warming is in reference to warming caused by and exacerbated by human activities on the face of the planet.

The IPCC's "Working Group 1" looked into all the possible 'natural' phenomena that would produce climate change and compared the amount of warming that would occur driven by only natural cycles compared with warming driven by natural plus man-induced changes.

Observed warming is outside of what we would expect if only natural phenomena were at work. This is clearly illustrated in the figure reproduced below:



Above: Figure SPM-4. (WGI) Global and Continental Temperature Change

Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906–2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%.

Blue shaded bands show the 5–95% range for 19 simulations from 5 climate models using only the natural forcings due to solar activity and volcanoes.

Magenta shaded bands show the 5–95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings.

Source: IPCC

Doesn't water vapour contribute far more to global warming than CO_2?

Water vapour is indeed the largest contributor to the Earth's natural greenhouse effect, and keeps our planet at temperatures suitable for life.

However, the fact there is much more water vapour than carbon dioxide in the atmosphere does not mean that changes in carbon dioxide concentration are insignificant for climate change.

The oceans are the major source of water vapour in the atmosphere, due to evaporation. It is impossible to keep adding more and more water vapour to the atmosphere infinitely, because when concentrations get high enough, water vapour condenses into cloud droplets and falls as rain

However, if the atmosphere warms due to increased concentrations of other greenhouse gases, it is able to hold more water vapour. Thus adding carbon dioxide to the atmosphere warms it a bit enabling more water vapour to be held, and hence produce more warming. In this way, water amplifies the greenhouse effect caused by increasing CO_2 concentrations. This is one of the processes referred to as a "positive feedback" by climate scientists.

Aren't some of the South Island glaciers advancing? This would mean the climate was cooling, not warming?

Globally, most glaciers are retreating. The World Glacier Monitoring Service reports that the annual loss in thickness of glaciers is around half a metre a year since 1980, averaged across the 625 glaciers that organisation monitors.

However, some of the South Islands smaller glaciers, especially those west of the Main Divide are unusual in having their sources in an area of unusually high precipitation: an incredible 10,000mm (or 10 metres) of rain and snow a year. During most of the 1980s and 90s that area experienced a 15% increase in precipitation because of more El Niño events plus stronger westerly winds over New Zealand.

Therefore these glaciers, that are particularly responsive to El Niño / La Niña cycles (and some others in Norway) from time to time appear to buck the melting trend. The overall picture we get from all over the world, and indeed from New Zealand's larger and eastern glaciers, is one of retreat and net loss of ice volume.

For instance, the Franz Joseph glacier retreated by about 400m between 2000 and 2005, but then advanced 170m in 2007. The Franz Joseph is overall much shorter than it was in 1900, and the unusual 2007 advance nowhere near makes up for the retreat that has occurred over the past century.

How good have previous IPCC reports been at projecting the future? Can we trust them?

Actually, over the last 16 years (since the first report in 1990), they've been remarkably good for CO_2 changes, temperature changes but in fact under predicted sea level changes.

The IPCC does not itself monitor the climate or collect data. Scientific information comes from research and projects undertaken by hundreds of scientists and experts all around the world that are then compiled and reviewed by IPCC expert authors, reviewers and governments. The composition of the IPCC Working Groups reflects a range of views, expertise and geographical location.

Preparation of IPCC reports represents possibly the most comprehensive, open, thoroughly peer-reviewed scientific study ever undertaken in any discipline.

New Zealander Dr David Wratt is a vice-chair of Working Group I.

Do the IPCC scientists have a vested interest in promoting climate change?

This comment was posted in on a personal blog by one of the scientist/reviewers on an IPCC working group:

"The 600+ scientists working on the IPCC reports do this for free in their spare time. That involves lots of hours wading through review comments (the report attracted over 30,000 such comments), and evenings and weekends away from the family. A voluntary effort I right now don't feel like ever doing again, once seems enough for a lifetime".

IPCC's Fourth Impact Assessment Report derided as being "too soft"

The Fourth Impact Assessment Report describes very serious, even bleak, future predictions including more than a billion people in need of water, extreme food shortages in Africa, and increasingly frequent and extreme floods and droughts.

But despite the apparent harshness of the predictions, the report was criticised by many of the participating scientists who said that findings were watered down by government bureaucrats seeking to deflect calls for action.

The last-minute negotiations apparently led to deleting timelines for future events and scaling back the degree of confidence in some projections

Even in its softened form, the report outlined a range of devastating effects that will strike all regions of the world and all levels of society. The poorest of the poor, who lack the resources to adapt to the changes will suffer the greatest impact, according to the report.

Following release of the Fourth Assessment Report, several scientists vowed afterward that they would never participate in the process again because of the political interference.

Original source: The LA Times, April 7th, 2007. Article still available online at:

www.climateark.org/shared/reader/welcome.aspx?linkid=72515

Here's something to appeal to conspiracy theorists:

Scientists offered cash to dispute climate study

The following comment appeared in the UK Guardian newspaper, in reference to the publishing by the IPCC of the Fourth Impact Assessment Report in 2007: "Scientists and economists have been offered $10,000 each by a lobby group funded by one of the world's largest oil companies to undermine a major climate change report due to be published today".

The American Enterprise Institute (AEI), a thinktank with close links to the Bush administration, has received more than $1.6million in funding from ExxonMobil, and more than 20 of its staff have worked as consultants to the Bush administration. Lee Raymond, a former head of ExxonMobil, is in fact the vice-chairman of AEI's board of trustees.

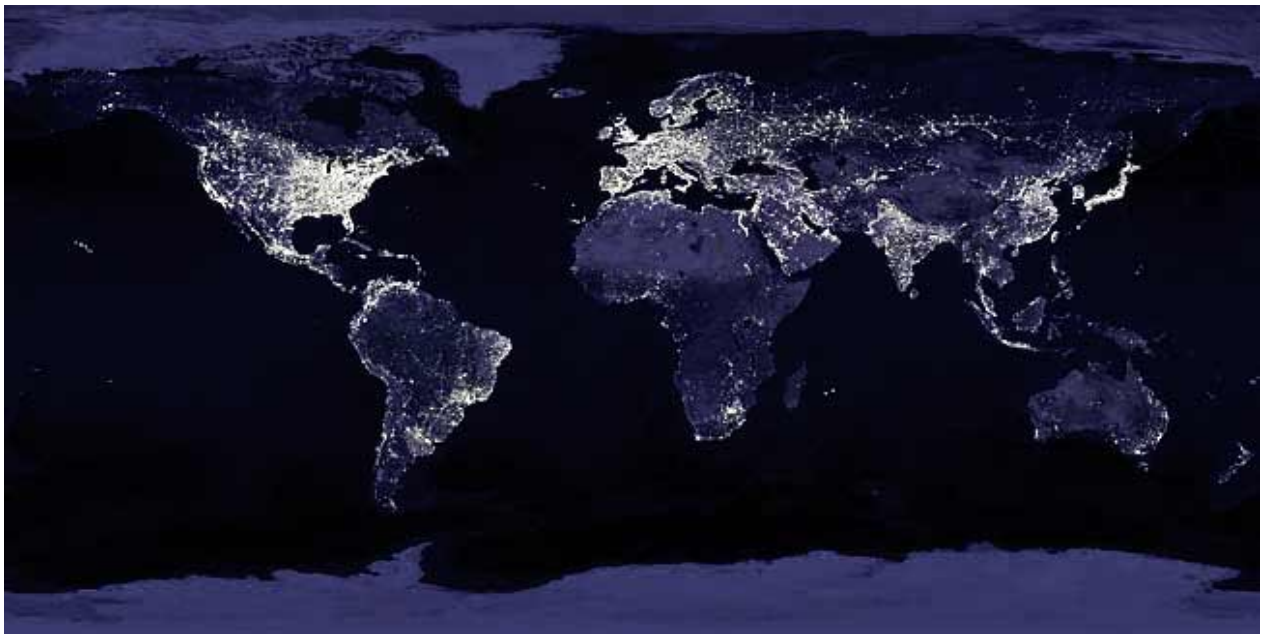
Letters sent to scientists by the AEI allegedly offered the payments for "articles that emphasise the shortcomings" of the IPCC's 2007 Fourth Impact Assessment Report.

Travel expenses and additional payments were also offered.

The original Guardian article by science correspondent Ian Sample can still be viewed online at:

www.guardian.co.uk/frontpage/story0,,2004399,00.html

Humans are just a tiny part of Earth's ecosystem. The Earth is so huge there's no way we could have an influence on it!



Above: NASA's famous Earthlights photograph.

Appendix 4

Age class of Gisborne District Plantation forests

1-5 years (ha)	6-10 years (ha)	11-15 years (ha)	16-20 years (ha)	21-25 years (ha)	26-30 years (ha)	31-35 years (ha)	36-40 years (ha)	41-50 years (ha)	51-60 years (ha)	61-80 years (ha)	Total (ha)
15,359	32,115	51,828	20,719	23,394	11,059	2,452	484	896	22	34	158,362

Post 1990 (Kyoto) forests = 99,302 ha (it's actually post 1991 because of the age brackets used)

Source: New Zealand Exotic Forest Description