WATER & ATMOSPHERE

November 2011

Shepherd's warning

A fickle forecast for farmers

Upping the ante
Time and tide wait for no council

The winds of change
Finding the energy

The psychology of climate change
Thinking positive

Ātahirā – A new challenge for Māori
Holding to the past, looking to the future

WATER&ATMOSPHERE

November 2011

Cover
Gladstone farmer Joe Bannister regards his ravaged pasture during the 2007–2008 Wairarapa drought. That blistering summer was the region's second driest on record. (*Alan Blacklock*)

Water & Atmosphere is published by the National Institute of Water & Atmospheric Research (NIWA).
It is available online at www.niwa.co.nz/pubs/wa

Enquiries to:

The Editor
Water & Atmosphere
NIWA
Private Bag 14901
Kilbirnie
Wellington 6241
New Zealand

email: wa-editor@niwa.co.nz

©National Institute of Water & Atmospheric Research Ltd 2011
ISSN 1172-1041

Water & Atmosphere team:

Editor: Dave Hansford

Production: NIWA Communications and Marketing team

Water & Atmosphere is produced using vegetable-based inks on paper made from FSC certifed mixed-source fibres under the ISO 14001 environmental management system.

NIWA
Taihoro Nukurangi

Editorial

Coming, ready or not

It took just under a month for 2011 to make the weather records, when, on 29 January, Cyclone Wilma brushed the North Island's east coast. Wilma drenched some regions with 400 per cent of their normal January rainfall, leaving a $24m cleanup bill behind.

Then, May wrote itself into the New Zealand record books as the warmest ever – a whopping 2.2ºC above average – but it wasn't all benign. Early that month, a tornado in Auckland killed construction worker Benedict Dacayan and flung cars into the air. Whakatane residents were later hit with 2.5 times their normal May rainfall, while Nelson homes were evacuated in the face of a deluge 3.5 times the region's monthly average.

In late April, warm, wet air was hemmed in by a blocking high off the Hawke's Bay coast on Anzac Day, and it wreaked havoc. Farmers lost hundreds of hectares of grazing as hills slipped into the creeks. Residents watched rivers of mud and backed-up sewage flow through their homes, leaving despair and $10m dollars' worth of damage.

In June, some Queens Birthday holidaymakers basked in another 21ºC record, but later that month, another deluge – this time at Ohope – took the life of teenager Hughie Biddle when a hillside behind his house collapsed. The next day, tornadoes struck again. This time, a swarm wreaked havoc in North Taranaki, hurling roofs into the air in New Plymouth.

Then, in August, the unthinkable: flakes of snow – more correctly, graupel – fell in Auckland, while heavy dumps closed businesses and paralysed traffic further south. It snowed at sea level in Wellington for the first time in 40 years.

2011 has so far been a big-ticket exercise; the Insurance Council of New Zealand says bad weather provisionally cost around $41.7m in claims in the first six months alone.

When people think of climate change, they often assume it simply means a warmer future, but warm air holds more moisture, carries more energy, than cool. That means we can expect more than just spikes in the mercury. As you'll read in this issue, Nature will deliver the weather with less routine and more force in future, and that has implications for us all.

New Zealand's average air temperature has warmed by around one degree Celsius over the last century, but we can't blame everything on climate change. It's not easy to unpick the tangle of influences – La Niña, El Niño, the IPO – that together decide our weather.

For Diane Tait, it hardly matters. She carried her two grandchildren through waist deep waters before a torrent of mud swept through their Waimārama home on Anzac night. She feared for her life that night, and all she knows is that life will be very different from now on.

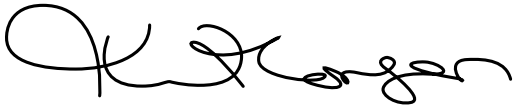
While some argue about the cause – even the very legitimacy – of climate change, as we seek to shift blame or responsibility, evade the costs or simply shoot the messenger – the weather keeps on coming.

We know that there is now more CO_2 in the atmosphere than at any time in the last 420,000 years. It's a matter of record that 20 of the warmest known years globally happened in the last 25 years. Each of the past three decades has been warmer than the one before, and each closed by setting a record. The 2000s is the warmest decade yet, but as May pointed out, the trend may not stop there.

Di Tait's grandchildren will not thank us for prevaricating. They may well remember us as the generation that knew climate change was happening, that had the information, the opportunity and the technology to act, but did not. The compound interest on our deferred action will be theirs to pay, and Christiana Figueres, Executive Secretary of the UN Framework Convention on Climate Change, claimed early in June that every year of delay adds another trillion US dollars to the bill we leave behind.

Builder, banker or bus driver, a more volatile climate will affect us all: our economy, our society, our environment. As NIWA climate scientist Anthony Clark says in these pages: "normal is changing".

In this issue of *Water & Atmosphere*, you'll meet some of the people for whom New Zealand is already a different place. NIWA will continue to play its part, informing our collective response with the best of evidence-based environmental science.



John Morgan
Chief Executive

HIRDS – The future of design

When designing infrastructure, such as a new bridge, to last well into this century, engineers must think worst-case scenario: specifications demand a structure so durable as to withstand the worst Nature might be expected to throw at it.

They might look at the rainfall records for the bridge's locality, and build for the maximums, but as climate scientists remind us, we can expect still more extreme storms in future, thanks to increasingly energetic weather systems.

Designing for an unpredictable future is now easier, thanks to NIWA's High Intensity Rainfall Design System (HIRDS). In a nutshell, it tells engineers how much rain they should design for at any location in New Zealand. What's more, it'll give them the probability of a really big downpour, and just how big it could be.

HIRDS, a web-based tool, helps design infrastructure for the future, says NIWA Engineering Hydrologist, Graeme Horrell. Its latest iteration, Version 3, he enthuses, "has a huge data set behind it, and it has the approval of its biggest users – regional councils – as well as hundreds of design engineers".

The applications are many: HIRDS can help design bridges and other road infrastructure, dams, or future-proof stormwater drainage systems, or just a supermarket carpark. "It's a key tool for all design work in New Zealand," says Horrell.

The system is simplicity itself: just go to www.niwa.co.nz/our-services/online-services/hirds, then enter a street address, or the coordinates of a given location. Alternatively, you can enter a general locality, then, when the Google map comes up, just click on the location you need.

HIRDS takes it from there, providing storm rainfall depths over durations from 10 minutes to 72 hours, for once-a-year storms, or one-in-100-years, and every contingency in-between.

A table appears on the screen with a series of depth, duration, and frequency statistics for rainfalls in minutes and hours.

"Let's say you want to design a carpark for optimum stormwater run-off," offers Horrell. "HIRDS will show you what rainfall depths you should expect, for example, during a 30-minute, one-in-five-year storm at that location".

A stream at Waimārama, bloated by three times the region's average April rainfall, seriously damaged this bridge in the small Hawke's Bay settlement. (*Dave Hansford*)

Longer time frames are especially useful, he says, for assessing flood risk around rivers.

"This version of HIRDS is considerably improved, because we included regional council rainfall data in its development. It was then tested by regional council design engineers, who gave it the thumbs-up".

The data that drive HIRDS come from regional frequency analysis of annual extreme rainfalls from around 3000 sites in New Zealand. Both NIWA and regional council data sets were compiled by mapping median annual maximum rainfall (or index storm rainfall), then devising regional growth curves that relate rainfall at different recurrence intervals to that index rainfall. Then the two components are combined.

HIRDS can also help meteorologists and hydrologists with climate analyses, and the insurance industry can use it to assess flood risks, and set premiums accordingly.

Version 3 also lets users generate tables of high intensity rainfall for a given range of climate change scenarios, by entering projected temperature changes (those changes can be obtained from NIWA, or from the Ministry for the Environment's climate change guidance manual at: www.mfe.govt.nz/publications/climate/preparing-for-climate-change-guide-for-local-govt/) for that location for up to three periods.

The development of HIRDS was funded by the then Foundation for Research, Science and Technology, since integrated into the Ministry of Science and Innovation.

Contact:
Graeme Horrell
Engineering Hydrologist
g.horrell@niwa.co.nz

In brief

Every year, Cook's petrels from opposite ends of the country make epic migration flights to two very separate destinations. NIWA research has shown that never the twain have met.

Birds of a feather don't always flock together

They might be the same species, but two discrete populations of Cooks petrels – one from Little Barrier Island in the Hauraki Gulf, and the other more than 2000km away on Whenua Hou, or Codfish Island – keep their distance genetically.

What's more, they haven't interbred for centuries, says NIWA's Dr Matt Rayner, who tracked the two populations of small seabirds on their migratory flights across the Pacific.

"We found that birds from Little Barrier Island crossed the equator to the North Pacific, whereas those from Codfish Island stayed within the South Pacific, migrating to waters off South America".

The 200-gram birds could easily visit one another's colonies – they can fly a 1000km in a single day – but when Rayner and his team compared DNA from tissue samples, they found significant differences. Then, when they sampled old Cook's petrel skins, collected a century ago from the North Pacific and South Pacific migration destinations, they found precisely the same variations.

That confirms, says Rayner, also a University of Auckland research associate, that the two populations have been migrating to their respective regions for a long time.

"We found that migrating to different locations contributes to genetic differences between seabird populations, as it impacts populations' breeding timetables".

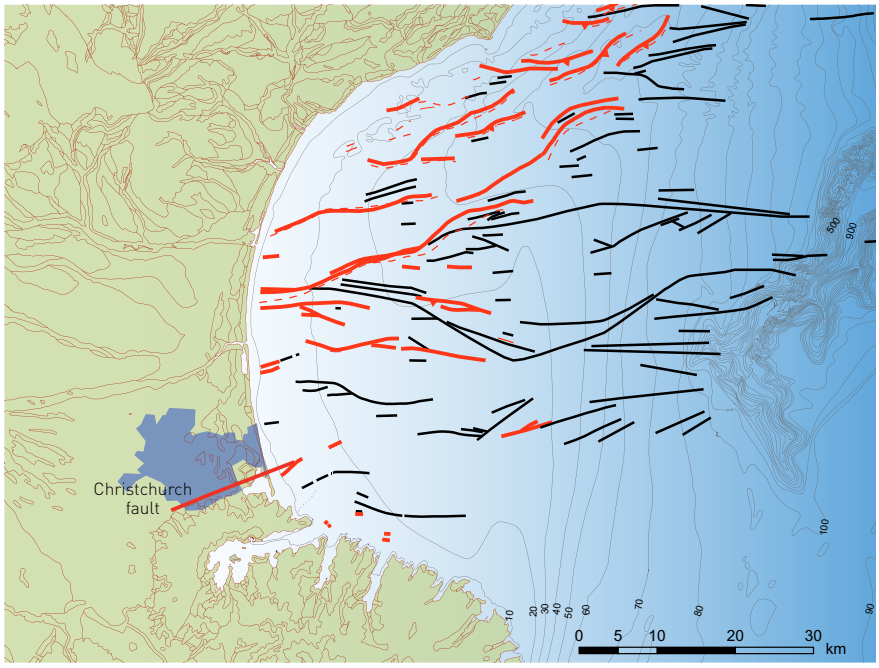
New lightweight tracking devices have only recently made it possible to track smaller seabirds on their epic flights. Rayner's team attached tiny geolocators – just two grams in weight – to the birds' legs. "They work just like a sextant," he says. "You get latitude from day length, and longitude from the timing of sunrise or sunset". The devices log information as they go, storing it for retrieval on the birds' return.

Many New Zealand seabird species fly thousands of kilometres between the northern and southern hemispheres each year, to take advantage of what Rayner calls an "endless summer", feeding and breeding in cool, productive waters.

The team now wants to investigate what implications climate change – or habitat damage from causes such as the Fukushima nuclear leaks – might have for the many millions of New Zealand seabirds that fly north each year.

This work was funded by the Ministry of Science and Innovation and the ASB Bank Community Trust.

Contact:
Dr Matt Rayner
Scientist
m.rayner@niwa.co.nz



NIWA's seismic survey found a number of previously unknown faults beneath the Pegasus Bay seabed, and a few old ones that had been jolted back to life.

Finding faults: NIWA probes Pegasus Bay

A preliminary seismic survey of the seabed off the north Canterbury coast has found a complex arrangement of geologic faults in the bedrock under Pegasus Bay.

In March, NIWA's research vessel *Kaharoa* surveyed an 800 square-kilometre area with geophysical seismic gear, and found widespread faulting in basement rocks. It also revealed a smaller number of 'reactivated' faults – those known to be long-dormant that now show signs of recent movement.

The survey, a collaboration with the University of Otago, uncovered a previously unknown fault east of Kaiapoi. The new fault – perhaps 25km long – could be capable of generating a magnitude six to seven earthquake.

The marine seismic data show how more recent faulting – over the last tens of thousands, to hundreds of thousands, of years – has reactivated old faults that first developed more than 60 million years ago.

NIWA Principal Scientist Dr Philip Barnes says they confirm "... what we sort of expected: the active young structures are also reactivating old faults".

The very old basement faults mostly run east – west, and extend throughout the whole North Canterbury region. Most of the reactivated offshore faults are as slow-moving as any known in New Zealand.

Barnes says offshore faults were found closer to Christchurch than those previously known, but "appear to have very low activity rates, implying that they're very long return-time earthquake hazards".

At present, he says, most aftershocks are occurring under the land. "There's no strong evidence that they're associated with any of the offshore faults".

However, the large onshore earthquakes of 13 June appeared to be centred just to the west of faults found not far off the coast of Port Levy and Pigeon Bay. Barnes said they could potentially be related, but "the precise structure, extent, and significance of those faults are still unclear".

Before scientists could better understand the faulting close to Christchurch, more analysis was needed to take account of ongoing aftershocks and geophysical studies onshore, said Barnes.

NIWA's seismic survey work is part of the Natural Hazards Research Platform project to inform earthquake recovery work in Christchurch. Scientists from GNS Science, and the universities of Canterbury, Otago, and Calgary are also contributing.

Contact:
Dr Philip Barnes
Principal Scientist, Ocean Geology
p.barnes@niwa.co.nz

In brief

NUMBERS

65,536

The number of fish measured during NIWA's 20th annual Chatham Rise middle-depth survey. Laid end-to-end, they would stretch 29.5km.

60,000,000

The number of ones and zeros arranged to explain to a NIWA computer how to keep track of fisheries bycatch.

42,048,000

The number of images captured by two NIWA remote cameras each year at Raglan, where they automatically record information on rips, erosion, and other beach processes.

572 years

The total of data days of information collected since 2005 by 100 NIWA data loggers in Milford and Doubtful Sounds, measuring temperature and conductivity profiles.

117,552,930

The number of weather and climate values processed every day by NIWA's new 15-day forecasts on the Virtual Climate Station Network.

485,285,760

The number of eggs spawned by kingfish broodstock at NIWA's Bream Bay aquaculture facility during the 2010–11 spawning season.

A diver communes with snapper at Leigh Marine Reserve. If a snapper wants to grow old, found a NIWA study, it should stay put. (*Dave Hansford*)

Snapper that stay home, stay safe

Creating marine reserves may affect the behaviour of some fish that live in them, a NIWA study has found.

Using acoustic tags, scientists followed the movements of snapper both inside and outside Leigh Marine Reserve, north of Auckland. They found that the fish inside the reserve tended to stay put, whereas their counterparts beyond the boundary ranged far and wide – one travelled more than 400km.

"No other study has shown that reserves may affect the movements of animal populations that inhabit them," says NIWA scientist Dr Darren Parsons.

The findings can tell us something about the interactions between snapper, recreational fishing, and seafloor habitats, he says.

"Of the fish that settle inside the reserve, the individuals that range over the smallest areas have the lowest chance of leaving the reserve, and therefore the lowest chance of being caught".

Over the summer of 2006–07, NIWA also tagged and released 10,000 snapper in both shallow reefs off Kawau Island and Leigh, and in deeper waters of the inner Hauraki Gulf.

So far, recreational fishers have returned tags from 900 of them, giving valuable insights into how far the fish travel. Results show that more snapper were caught each year from rocky inshore reefs, despite a much lower overall fishing effort in those areas.

Snapper in shallow reefs were far more residential, with most fish spending the vast majority of their time within a few hundred metres of where they were tagged. "In contrast, snapper from soft sediment areas – especially those further out in the Hauraki Gulf – move on a scale of tens of kilometres," says Parsons.

Based on those results, he says, "we can predict movement behaviour from the location where the snapper was caught".

This research was funded by the then Foundation for Research, Science and Technology, since integrated into the Ministry for Science and Innovation, and the Department of Conservation.

Contact:
Dr Darren Parsons
Fisheries Scientist
d.parsons@niwa.co.nz

NIWA's Dennis Gordon: There hasn't been a mass extinction for 65 million years, "so we should probably assume that most niches are optimally filled – diversity today is probably as high as it's ever been". (*Dave Allen*)

Life: the next chapter

Dive beneath the Poor Knights Islands – or just kick over some leaf litter in the bush – and you'll be astounded at just what lives there. We share New Zealand – and its surrounding seas – with about 55,000 other species, and Dennis Gordon wants to name and describe every last one of them.

Bacterium or blue whale, booby or brachiopod, it will eventually find itself itemised in this labour of Gordon's love of living things: *The New Zealand Inventory of Biodiversity*.

The inventory is – and Gordon says it so casually as to seem oblivious to the magnitude – "a catalogue of all of life, through all of time, in New Zealand". To get some idea of how Herculean a task that really is, you need to know that his most recent release is just the second stage of a three-volume, 1500-page epic written by 227 co-authors from 18 countries.

Volume Two has been described as a "biological telephone directory" of some of Nature's most enigmatic – and abundant – creatures: the Ecdysosoa, or moulting animals. The group includes the centipedes and millipedes, arachnids, crustaceans and insects (New Zealand has around 5480 named, native beetles alone). In there, too, are the roundworms, horsehair worms, the mystifying mud dragons and the mischievously-named penis worms and corset worms.

Volume Two also makes sense of the cryptic Chaetognatha (arrow worms), and – presumably because the living didn't present challenge enough – then delves into the mists of time to classify our extinct, fossil species.

Gordon says that right from the beginning, back in 2000, he "felt that geologists should be involved, so that we could include palaeobiodiversity. If we want to understand the origins of the living biota, we need to know what came before. That's logical: we need to know those ancestral relationships".

But why do we need to know what's out there at all? "Think of it as a stocktake," offers Gordon. "Suppose you own a shop. You need to do an inventory of what you've got. You need to know how fast it's moving, you need to know how much you have of a particular item – so think of a taxonomic classification system of life as the different line items in your supermarket".

If we're to properly protect, or manage those species, then, we have to know what we're dealing with. "In biology, a name is absolutely basic to all of science. If it doesn't have a name on it, it might as well not exist," he says.

"This exercise has provided a gap analysis. We now know how many species we have, how many undescribed species there are in museum collections (about 8000), and we've got estimates of undiscovered species (maybe 40,000, and that's excluding bacteria). We also know who the relevant experts are. That's never been possible before".

Volume Three is due out in January 2012.

Contact:
Dennis Gordon,
Principal Scientist, Marine Biodiversity and Biosecurity
d.gordon@niwa.co.nz

In brief

NIWA's Dr Georgina Griffiths enjoys detective work. (*Geoff Osborne*)

New Zealand's new low

While poring through old temperature records, climate scientists recently discovered New Zealand's coldest known daily minimum reading – a shivering minus 25.6°C (originally recorded in the old Fahrenheit scale as minus 14°F).

That coldest of snaps struck in 1903, at Ranfurly in Central Otago.

On 18 July that shivery winter, *The Tuapeka Times* reported: "It is some years now since frost of equal severity to the present has been experienced in the district". Blocks of ice were seen tumbling down the Mataura River, and *The Otago Witness* reported that "ice-skating was general among the townspeople".

"I was quite excited [to find the record]," says NIWA climate scientist Dr Georgina Griffiths. "It's like detective work".

"We know the early 1900s were really cold, with extremely cold spells, and that Central Otago is really unique – it's the only region of New Zealand with a continental climate. It's not surprising that the new record is from this area," says Griffiths.

NIWA maintains New Zealand's national climate database, a collection of instrument measurements and written or oral records of temperature from the past 150 years.

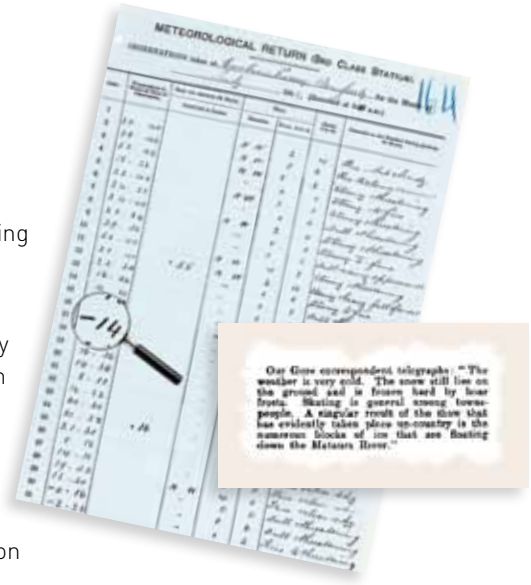
Records must be analysed carefully, to identify the influence of any non-climate factors, such as changes in observation site or method, or encroaching urban development.

To check the accuracy of the new record, the NIWA climate scientists examined other meteorological data from stations in the area. They chose stations at sites with a similar topography, over a range of dates, which also experienced similar freezing cold conditions.

"It was consistent," says Griffiths. "Southland and Otago were extremely cold, with cold air trapped for days on end. The other observations support the extremes. The paper record from Ranfurly was consistent, and the media reporting supports it".

The World Meteorological Organization (WMO) recently verified the new record, which contrasts sharply with our hottest: 42.4°C, recorded at Rangiora, in Canterbury, and Jordan, in Marlborough's Awatere Valley, on 7 February, 1973.

Contact:
Dr Georgina Griffiths
Senior Climate Scientist, Climate Applications
gm.griffiths@niwa.co.nz



The winds of change

Much of our electricity now comes from rain and wind, but, asks **Greta Shirley**, can they keep the lights on in a changing climate?

Imagine, if you can, a life – or just a day – without electricity. For generation Y, it's right up there with air and water. Houses no longer have enough power sockets, and one look along the groaning shelves of small appliances in any homestore soon reveals why. Widescreen TVs, heat pumps, dehumidifiers, benchtop grills, juicers, cordless phones, electric blankets – they all need a constant diet of watts, and when the power goes out, it's like the world is on hold.

Consider then, when you flick the telly on, where that power comes from. It comes, in large part, from the weather we hate – rain and wind. More of New Zealand's power is generated by renewables – mostly hydro dams, geothermal bores and wind turbines – than in practically any other country. As of March this year, renewables powered 79 per cent of all electricity generated – the highest contribution since December 1996.

Hydro makes up around 60 per cent of our total generation, and while wind currently adds just under four per cent, that figure's set to increase. Another 5000 megawatts (MW) of renewable generation is either on the books or being built, edging us closer to a national target of 90 per cent renewable generation by 2025.

Electricity generation produces around 19 per cent of the country's greenhouse gases, but as more renewables come on stream, that figure falls. Latest Ministry of Economic Development (MED) figures show that electricity's CO_2 emissions dropped by 24 per cent between 2008 and 2009.

But there's a down side: if you mean to make more and more power from wind and rain, you need a guaranteed supply, and Nature has yet to commit. Three of the last 10 years have been drier than average – a trend Dr James Renwick warns could become the new norm.

"The main message out of our climate change work," says NIWA's Principal Scientist, Climate Variability and Change, "is that the future isn't going to be all that much like the past. The shifts are going to be significant – we can't rely on what happened in the last 40 years to nail down how the future is going to look". That makes a weather-dependent generation network "very vulnerable" to climate change and variability, he says, and we need to start "paying attention".

> **"The future isn't going to be all that much like the past"**
>
> NIWA Climate Scientist Dr James Renwick

Natural climate cycles, such as the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO), have a huge bearing on our year-to-year weather, affecting westerly winds over the country which, in turn, determine the rainfall in the Southern Alps that feeds our hydro rivers and lakes (see sidebar, page 15). But there's another influence – still bigger, but less easy to predict, says Renwick. That's the greenhouse gases we keep pumping into the atmosphere. Ironically, our greenhouse gas emissions could hamper renewables' capacity to offset those very emissions.

Outlook changeable

Climate change will alter mean rainfall and wind patterns, and bring more extreme weather like droughts, flooding and storms. That's likely to hamper generation, and damage transmission infrastructure such as power lines. Temperatures are also tipped to continue rising. Depending on whether we curb, continue with, or increase our current greenhouse gas emissions, NIWA scientists predict that, by the end of the century, Auckland could get an additional 40 to 60 annual days above 25°C – well up on the 21 days it averages at the moment. Hamilton is tipped to get another 26 days a year over 25°C, and Christchurch 31. Wellington would get just three extra days.

That warming has interesting implications for electricity demand. All up, we currently use around 42,000 gigawatt hours a year, with about a third of that going to heat the water and homes of 1.7 million residential consumers. National consumption skyrockets on chilly winter nights, when heaters, heat pumps and electric blankets draw more than 6500MW (cold consumers set a new record during the big snow of mid-August: 7048MW at 6.00 pm on Monday 15). But as the mercury climbs, demand will start to shift to the

Meridian Wholesale Markets Manager Mike Roan: "We have to look out over longer horizons". (*Dave Hansford*)

summer, when we switch on more and more air conditioners, and farmers are forced to irrigate.

Together, that temporal shift, higher demand, greater fluctuations in our weather, and an increasing renewable generation portfolio conspire to make us "very dependent on what's happening with the climate," says Renwick. "We're vulnerable in a good way, I guess, because we're reducing our emissions, but ... we have to keep our eyes open".

Renwick says we should try to ease our dependence on rain "and look at other generation options like solar, marine and wind to help increase security of supply".

NIWA's National Centre for Energy Solutions conducts a range of research and consultancy work for the energy sector, including partnering new energy technologies like tide and wave energy. A growing appetite for renewables, says Chief Scientist for Energy, Dr Murray Poulter, means the Centre's work is increasingly about understanding how those energy resources will be impacted by weather and climate, over both short and long terms. That means producing resource assessments and models, national energy trends analyses and demand and resource forecasts.

Understanding the resources we have, and developing the right technologies to utilise them, will ensure our future electricity system has the optimum mix of sources, says Poulter.

When the IPO rouses in the northern Pacific, the effects, even on distant New Zealand, can be dramatic. The Southern Alps, for instance, might receive ten per cent less – or ten per cent more – rain. That may not sound like much, but it gives a hydro manager a headache; wet seasons are as awkward as dry ones. The next two decades will likely see more dry years, but long-term, in the South Island at least, that trend will flip, with warmer, more energetic air dumping more rain, more often. "Then management of flood flows is likely to become more of an issue for hydro generators," says Renwick.

Then there's snow melt, another major source of hydro supply. Recent NIWA models predict significant loss of seasonal snow cover, particularly in the South Island, as rainfall and temperatures change. Warming will probably boost the amount of glacial meltwater in the short term, but ultimately, glaciers might shrink drastically, or disappear altogether.

A weather eye

Meridian's Mike Roan keeps a sharp eye on the weather most days. "The accuracy of weather forecasts is ... important to us," says the generator's Wholesale Markets Manager. Meridian is New Zealand's largest electricity generator, and manages about 70 per cent of total hydro storage through

the Waitaki hydro scheme and the Manapouri power station. It also operates four wind farms around the country.

"We can't control the fuel we receive – we can only forecast when it might arrive. That forecast is very important for the decisions we have to make around how we use our storage".

That "fuel" is wind, rain and snow pack, so understanding what's going on with the climate, says Roan, is a preoccupation, both for day-to-day operational running and for long-term investment. NIWA helps out by monitoring Meridian's sites, providing information on inflows into the hydro system, automatically or manually, that is then used to operate the assets and manage consents.

It's also developing detailed forecasting tools to help generators calculate the generation they can offer the electricity market day-to-day.

Wind generation is a particularly tough one to pick, says Roan, but system operator Transpower demands accuracy. "Some days it starts off quite windy, and then dies away entirely. Transpower coordinates all of the energy sources across the country, whether it's us, Mighty River Power, or Genesis. They need to know our best forecasts of what wind might do, so they can bring on thermal-fired assets if the wind isn't producing much".

> **"We can't control the fuel we receive – we can only forecast when it might arrive"**
>
> Meridian Wholesale Markets Manager Mike Roan

Emissions from the energy sector

Under the Kyoto Protocol, New Zealand is obliged to reduce its greenhouse gas emissions to 1990 levels (60.8 million tonnes per annum) before 2012, or pay a charge on any surplus. Since 1990, New Zealand's total energy emissions have increased by 35 per cent – around 1.6 per cent each year.

New Zealand's Greenhouse Gas Inventory 1990–2008, released last year, reported that our emissions were 74.7 million tonnes per annum, or 22.8 per cent higher than 1990 levels.

That was offset, however, by carbon sinks such as forests. In 2008, they soaked up around 26.2 million tonnes, bringing our net emissions down to around 48.5 million tonnes.

In an effort to meet our Kyoto obligations, the Government has implemented the Emissions Trading Scheme (ETS) which puts a price on greenhouse gases as an incentive to reduce emissions. The energy sector is subject to the ETS.

Seventy-nine per cent of our electricity comes from the climate: rain, snow, wind and sun. What happens when that climate changes? (*Dave Hansford*)

Meridian's Benmore Dam, in the Upper Waitaki Valley.

> "The economics of renewable electricity resources are far superior to the alternatives"
>
> Meridian Wholesale Markets Manager Mike Roan

Meridian is, understandably, very interested in how longer-term climate change will affect their "fuel". Last year, the generator looked hard at climate change and how it might impact future investment decisions. "When we're looking at refurbishing assets, or looking for places where we can build new ones that will last maybe 40 to 50 years, we have to look out over longer horizons," Roan says. "We need to be sure that the historical weather patterns for the catchments we operate in will remain reasonably the same".

Warmer temperatures this winter meant more rain, so hydro systems stood up well. But it's not always that way. Three dry years in the last decade showed us just how close black-outs can be.

Transpower knows this only too well. A temperamental grid has caused well-publicised power outages: the most serious, in 2006, left 700,000 customers in the dark. Transpower's Principal Strategy Investment Advisor, Mike Parker, says that's prompted the company to think harder about how future climate scenarios might impact on transmission. His job is to anticipate "all possible eventualities, however unlikely they seem today" – contingencies like more storms, high winds and snow. Or new technologies – or higher temperatures – pushing up demand. Parker says the lengthy lead-in time for new investment means that, more than most, Transpower has to think ahead. "If we have to build a new line somewhere because of new generation, we need seven to ten years to do it".

To best target investment, Transpower needs to know where new generation will come from. NIWA has helped out by developing a comprehensive map of electricity resources across the country. "We may not know exactly what new technologies will be developed," says Parker, "but we do know what the resources are, and where they are, so we can plan better for the future". But the wild card, he says, is Nature. "There's just so much uncertainty about climate change impacts. All we can do is keep monitoring what you guys (NIWA) are saying".

Running out of puff

So could renewables leave us in the lurch in a changing climate? MED's *Energy Outlook to 2030* suggests that too much reliance on renewables, while helpful in reducing greenhouse gas emissions, would both "significantly raise" electricity prices, because of the high cost of building new infrastructure, and cause "electricity security issues" in the

face of more climate variability. But Mike Roan disagrees: "The economics of renewable electricity resources are far superior to the alternatives – gas and/or coal-fired generation. Everyone is in the renewable generation space, with marginal investment in thermal peaking to offset some of the climate variability we might see".

The International Energy Agency recently commended New Zealand's "bold goal" of 90 per cent renewable electricity generation as "a large step in the right direction," a plaudit echoed by environmental groups. But a look through the Government's leaked draft energy strategy shows that direction has changed. Though it's still listed, the 90 per cent renewable target has slipped down the priority list, well behind development of more petroleum and mineral fuel sources.

Energy commentator and convenor of the Sustainable Energy Forum, Steve Goldthorpe, says renewables needn't be an Achilles heel: we just need to manage the climate risk by planning ahead, and maintaining some thermal back-up.

"It's a bit like having an off-grid wind turbine or solar power on your own section. You still need to have a petrol generator in the shed that you bring out once in a while to cover emergencies".

Renwick agrees: "The climate change scenarios NIWA puts out are designed to help energy companies think about risk to security of supply. They might say we don't have to think about it for 50 years. We say do it now". W&A

Contact:
Dr Murray Poulter
Chief Scientist, Atmosphere, Natural Hazards and Energy
m.poulter@niwa.co.nz

Dr James Renwick
Principal Scientist, Climate Variability and Change
j.renwick@niwa.co.nz

Natural climate cycles

NIWA's research is looking at future climate scenarios, based on both natural cycles and long-term climate change, which is driven by greenhouse gas emissions. Two influential natural cycles affecting New Zealand's climate are the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO). In certain phases, the various natural climate drivers combine – both with climate change and with each other – to produce highly variable weather. In other phases, they work against one another.

The ENSO cycle involves an exchange of heat in the upper layers of the ocean between the western and eastern equatorial Pacific, and associated changes to the trade winds in the tropical atmosphere. El Niño and La Niña refer to opposite phases of the cycle.

In El Niño years, New Zealand tends to get stronger or more frequent winds from the west in summer, leading to drought in east coast areas and more rain in the west. El Niño years tend to bring higher inflows to the key South Island hydro-generation lakes, increasing security of electricity supply.

La Niñas have weaker impacts on New Zealand's climate: we tend to get more northeasterly winds, which bring moist, rainy conditions to the northeast parts of the North Island, and reduced rainfall in the South Island.

As a consequence, La Niña years tend to reduce flows to the main South Island hydro lakes, and a decreased security of supply.

The IPO is basically a longer version of the ENSO cycle, bringing 20- to 30-year periods of more frequent El Niño events, alternating with periods of stronger La Niña conditions.

Positive IPO phases bring South Island lake inflows around 10 per cent higher than the long-term average, and a decreased risk of dry years.

In a negative IPO, westerly circulation slackens, and rainfall tends to ease in the west, bringing South Island lake inflows around 10 per cent lower than the long-term average, and an increased risk of dry years.

Climate patterns can affect the supply of electricity, but they also influence demand. In winter, El Niño phases are generally associated with cooler than normal conditions, triggering higher demand for heating.

In summer, La Niñas often mean warmer than normal conditions, prompting consumers to reach for the air conditioning remote. Climate change will likely boost electricity demand in summer for cooling, and ease demand in winter for heating.

The outlook

Out to 2040, the Ministry for the Environment expects annual mean rainfall to increase in Tasman, West Coast, Otago, Southland and the Chatham Islands. These areas are also likely to get more heavy downpours.

Northeastern districts – Northland, Auckland, Gisborne and Hawke's Bay – are predicted to get less rain.

A March 2011 NIWA study, Scenarios of Storminess and Regional Wind Extremes under Climate Change, found that extreme winds are likely to increase over this century in almost all regions in winter, but decrease in summer, especially around Wellington and across the South Island.

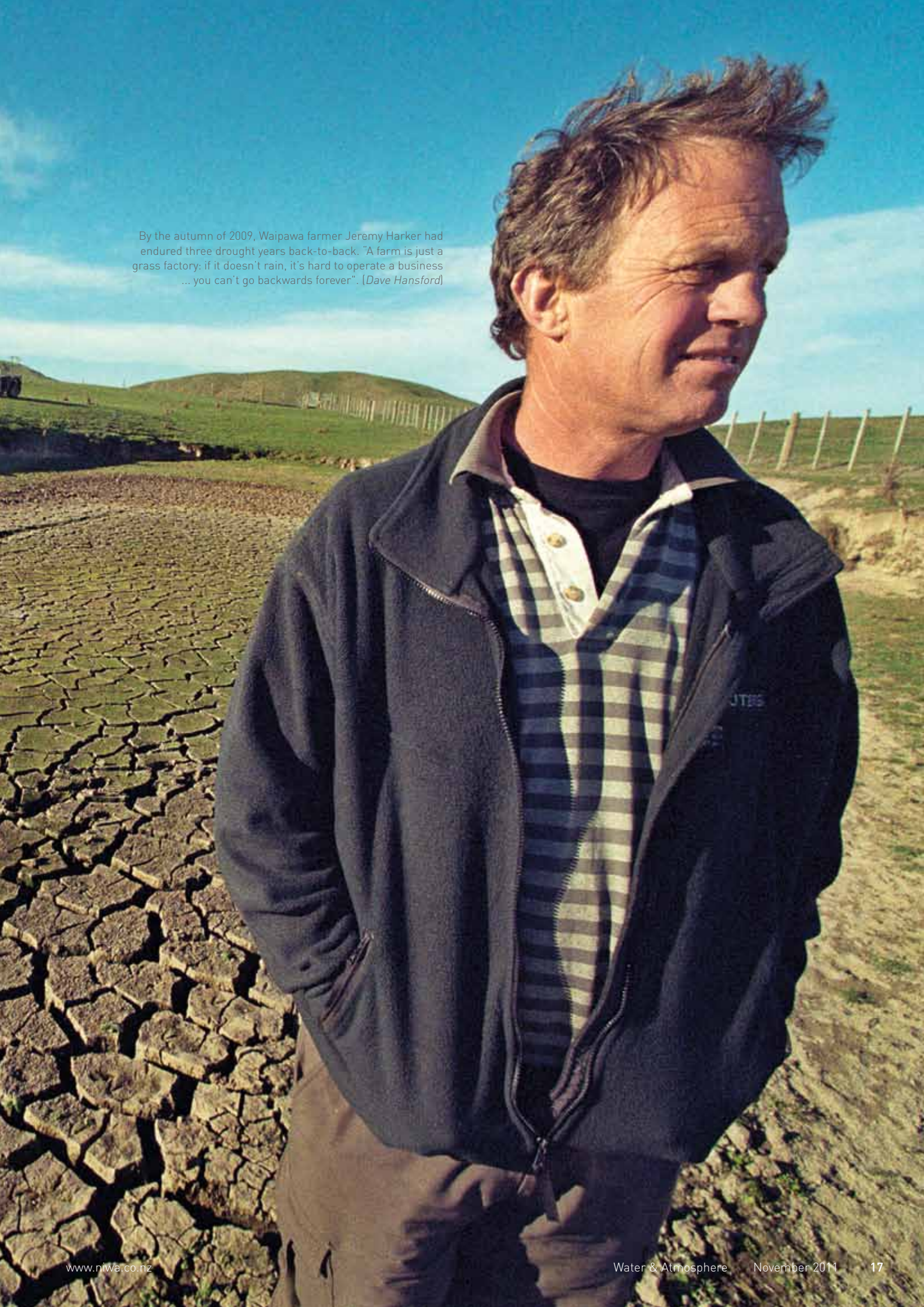
However, the increase in wind speeds isn't expected to be large; just a few per cent by the end of the century under a middle-of-the-range emissions scenario.

The study also predicted an increase in low-pressure activity over the Tasman Sea in summer, and a decrease in activity south of New Zealand.

Seasonal adjustment

Out in all weathers, farmers are the first to notice a change.

By Dave Hansford



By the autumn of 2009, Waipawa farmer Jeremy Harker had endured three drought years back-to-back. "A farm is just a grass factory: if it doesn't rain, it's hard to operate a business ... you can't go backwards forever". (*Dave Hansford*)

When the creek waters reached the house, John Nation decided to get out while he still could. He and his wife Sue waded out to the Pajero, threw in some warm clothes, and pushed a bow wave down the drive, headlights helpless in the teeming dark.

At first light, they returned to a homestead they barely recognised. The grounds, the garage, the driveway, the tennis court lay buried beneath a metre of mud, the high mesh fences hurled into what was left of the garden. Rank, rotting vegetation hung from everything.

But the biggest shock came when the clouds parted to reveal the hill country of Punawaitai, the couple's 540-hectare sheep and beef farm at Pourerere.

Half of it was gone.

Nations have farmed Punawaitai, 30km east of Waipawa, for three generations. John grew up here, but he can't recall any like of that deluge. A neighbour's rain gauge recorded that this particular bit of central Hawke's Bay coast got three times the April average in 72 hours. The inundation carried away 50 per cent of his pasture: "We lost 90 per cent of a single 30-acre (12 hectare) paddock".

He coaxes the quad, clawing for grip, to the crest of a low knoll. From there, we can look straight into the face of ruination – Punawaitai is gaunt, gashed down to its papa mudstone bones. "It's tearful," says Nation. "It's emotional. The world's going haywire".

Customised climate data mapping

If you have a question about the climate in your neck of the woods, NIWA can answer it with data tailored to your locality, gathered from the National Climate Database. NIWA can map any aspect – or combination – of climate, including rainfall, wind speed, growing degree days, evapotranspiration, sunshine hours and frost count.

Or we can combine climate parameters with soil maps and crop requirements to produce crop suitability maps for your area.

If you want to better understand the variability of your local climate, NIWA can also map the standard deviation, or the range, or the one-year-in-ten highs and lows or the number of days in excess of any threshold you specify.

Using our High Intensity Rainfall Design System, or HIRDS (see page 5, this issue), we can map return periods and/or 24-hour rainfall totals to help assess the probability of floods and design protection works.

Go to: www.niwa.co.nz/our-science/climate/our-services/mapping

"Normal is changing"

NIWA Climate Scientist Anthony Clark

Early that Anzac Monday, these Hawke's Bay hills snagged a southeasterly low. Ponderous, bloated with rain, it couldn't rise above them. Along a narrow coastal strip between Blackhead and Cape Kidnappers, it dumped what one farmer likened to "an atomic bomb".

When it finally stopped raining on Thursday, Landcorp's Te Apiti Station was cut off, Mangakuri Station had lost 400 lambs, washed out to sea. Another 60 farmers were left staring, like John Nation, at roads and dams swept away, fences down, fodder crops buried under tonnes of silt that used to be their hill pasture. They could contain cattle – so long as they had enough feed left to tempt them to stay put. But sheep happily cross slip faces and wander, over flattened fences, onto neighbours' properties. Most will end up at the saleyards.

Blow after blow

The singular cruelty of this flood is that, for the first time in four years, Hawke's Bay hill farmers actually had good pasture cover going into autumn. Nation's rising two-year-olds were in superb shape, but he was forced to sell most of them off. Like many, he was only just beginning to re-stock after three years of drought – 2007 through 2009 – that cost the region more than $700m, and pushed a lot of farmers to the end of their overdrafts.

"That three-year drought was awful," he tells me. "That's where our finances started going to (pot). We sold most of our ewes – the prices were terrible".

"I'd still rather have a drought than this," says Sue. "You can manage a drought. You get time to make decisions".

That same April, as he looked out over the brown hills of Bonaveree Farm, Doug Avery might have begged to differ. He and Wendy bought these 1100 hard hectares at Grassmere, eastern Marlborough, off his parents in 1979, and they nearly broke him.

"Farming was all I ever wanted to do," says Avery. "It was hard when the subsidies came off, but we got through that. Then it just got harder and harder".

Marlborough has never been a particularly pluvial place, but around 1996, says Avery, "we plunged into basically continuous drought for the next eight years". Records from the nearby Dominion saltworks confirmed that, in fact, 17 of the 19 years between 1986 and 2005 were below the region's average mean rainfall.

"I wanted to give up and go somewhere else, but my roots here were too deep".

Pourere farmer John Nation lost 90 per cent of this single 12-hectare paddock in the deluge that struck central Hawke's Bay on Anzac Day this year. (*Dave Hansford*)

> "The world's going haywire"
>
> Pourerere farmer John Nation

Withering heights

Such extremes – and the way we respond to them – consume Anthony Clark's thoughts. The NIWA climate scientist grew up on a bone-dry sheep farm in western New South Wales, where occasional clouds meted out just 250 meagre millimetres of rain a year. He spent a decade working on Australia's national drought policy, during which time he "started getting into the questions around links between drought and climate change".

Nowadays, nowhere is drought-proof, he says, and farmers suffer its sting more painfully because of the way we've ramped up our demands from the land. Farming today is a gamble with stakes many can barely afford; most spreads carry more animals now than ever, kept fed only by dint of heavy applications of nitrogen fertiliser. Water is the trump card; and farmers spare no expense nor technology to secure it. The dairy boom has pushed farming into a corporatised model, and shareholders have high expectations.

The costs of farming – energy, fuel, feed, fertiliser – keep climbing, yet farmers still have little control over returns.

"New Zealand's moved towards much more intensive systems," says Clark. "There are question marks around that – from a climate point of view, from a financial point of view, and from an environmental point of view".

In the fifties, he says, droughts "didn't affect agriculture as much as they do now. People got through them relatively easily, whereas the same event in the 2000s is very hard, because of that price/cost squeeze".

The 2007–09 drought changed the face of the Hawke's Bay hills. Farmers had to let stock go at fire sale prices, then had little capital left to replace them when the rain finally came.

Federated Farmers President Bruce Wills once ran 10,000 stock units on his property just off the Napier – Taupo Highway. Now, the place looks almost deserted. "Our numbers are down by 25 per cent," he tells me. "I could borrow to buy more, but four dry years in a row... you lose your nerve. We'll never run the sheep we used to – we'll never run the pasture down that close again".

Wills says it'll take him five years to repay his debts from the dry, but he counts himself lucky. The drought hiked sheep and beef farmers' average debt levels up to 46 per cent, cut incomes to an average $31,000. Federated Farmers estimated it will cost Hawke's Bay and Wairarapa farmers $190m to re-stock their farms, assuming they could feed those animals.

Adapting is what farmers do best – but climate change will be their sternest test. They might recover from one bad season, but how many hits can they take in a row? By the end of 2009, mortgagee sales were posted in the windows of Gisborne real estate agents. "Managing drought," says Clark,

Federated Farmers President Bruce Wills on his Hawke's Bay farm: "We'll never run the sheep (numbers) we used to". The North Island stock kill has fallen 30 per cent in the last three years. In June, meat processors Ovation announced they would close their Waipukurau lamb boning plant with the loss of 300 jobs. (*Dave Hansford*)

"is a critical part of our response to climate change. Many people concentrate on getting prepared, which is good, but what often gets forgotten is how you manage recovery after drought – whether you put your foot on the gas or not.

"In my experience, that's the critical time for most farmers. You might have a resilient business, but you can really come a cropper if you manage recovery poorly, because it's based on an expectation that things will return to normal.

"And that's where the real link to climate change comes in, because 'normal' is changing".

Making sense of statistics

Getting a handle on climate is trickier than it sounds. Droughts, or floods, don't happen solely because of climate change. They happen in a matrix of natural climate variations, combined with long-term climate change. From a background noise of what you and I would call weather, Clark and his colleagues must try to tease apart the influence of cyclic drivers such as the El Niño Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) (see sidebar, page 15).

Those things have a characteristic signature that Clark looks for in the data. Then he applies techniques to exclude their background noise, leaving a clearer image of the effects of climate change.

Dr Andrew Tait is a colleague of Clark's at NIWA. He goes through reams of climate data, gleaning the sort of information people – farmers, fruit growers, winemakers – need if they're going to bank their business on the weather. "Humans are putting out many more greenhouse gases than they were," he tells me. "Global temperatures have been rising – over the last 100 years, they've risen by about a degree. You can see that in New Zealand records, but also anywhere on the globe.

"So if you're introducing new farm systems ... or growing new crops, or converting to dairy – any long-term strategy – then understanding climate change projections over the next 20 to 50 years becomes really useful".

Says Tait, "We're talking about a degree warmer over most of New Zealand than it was during the latter part of the 20th century". The country may get the same amount of rain it always did, but it won't necessarily fall in the same proportions, over the same places. "In eastern areas, we're talking about five per cent drier, and in the west, maybe five per cent wetter".

Warm air holds more moisture than cold, which means that while rain may fall less frequently, it'll come in bigger dumps, as it did on John Nation's place. "You might get three dry months," says Tait, "then get those three months' worth in a single event".

If you want to know what your local climate is capable of, he says, look to the past. "Some places have 100 years of rainfall data. If you look through historical information, you can know what to expect for any time of year; air and soil temperatures, rainfall, evapotranspiration – all those things

> "It was a horrible time; I went from a guy who loved farming to just wishing ... someone would release me from my warrant"

Marlborough farmer Doug Avery

can help you understand how your pastures might grow, or how your animals might perform".

In particular, he says, watch for the anomalies. "You can see those years where things were a little different from normal, and that's particularly useful. You can put a risk assessment in place". For instance, a farmer could parse out the lowest ten per cent of low-rainfall years. From that, he might discern that he should be factoring in a drought every 10 years.

"In that sense," says Tait, "you can plan for the average, but you need a contingency in place to deal with extremes. Think about the possibilities; 'What if we got droughts three years in a row? Could we still farm through that using the systems we have in place now?'"

Clark says that when venerable agricultural production strategies struggle to cope, or fail altogether, they're flashing a warning that something has changed. "We've seen that in Hawke's Bay, where systems are not performing as they'd expect; that's a pretty good sign".

Seasonal climate outlooks

NIWA's seasonal outlooks give air temperature, rainfall, soil moisture, and river flow predictions for the coming three months. They state the probability for above average conditions, near average conditions, and below average conditions for those aspects.

Go to: www.niwa.co.nz/our-science/climate/publications/all/seasonal-climate-outlook for links that provide background information on how to interpret climate outlooks, and historical rainfall and temperature data ranges, for several locations within each climate outlook region.

NIWA also publishes climate summaries which review conditions and data over the past month, season, and year.

Go to: www.niwa.co.nz/our-science/climate/publications/all/cs

Consultancy services

NIWA climate scientists can provide advice and analysis on a range of climate-related issues, ranging from statistics of various climate parameters to detailed analysis and reporting of risk, vulnerability, and adaptation options.

As if Doug Avery needed telling. Day after bright cloudless day didn't just burn out pasture: "We plunged, skill-less, into a total collapse of environmental, financial, and social sustainability," recalls Avery. "This whole area fell to bits. Nobody had the skills to deal with the situation. It was a horrible time; I went from a guy who loved farming to just wishing that someone would release me from my warrant".

Avery tried everything to wrest some sort of living from Bonaveree. Nothing seemed to work. He watched his topsoil, his natural capital, turn to dust and blow away. He called for help, from soil scientists, agronomists, farm management consultants, anyone he could think of. At NIWA, Alan Porteous answered the phone. "When Alan first entered the scene," recalls Avery, "I thought; 'What can he do? He can't make it rain'. But what he did was to help me understand the climatic variability that had to be part of our thinking every day. If you're prepared, and you have the tools, you can cope".

Porteous climate-modelled Bonaveree back to 1890. "When I started farming," says Avery, "we thought we were farming through a very dry period, but Alan's work showed us that we'd begun farming in the wettest decade since 1890. What we took as normal, wasn't normal".

So what will a warming climate mean for New Zealand farmers? For the economy? Milk production, in particular, is critically sensitive to fluctuations in soil moisture, rainfall and growing degree days. A single La Niña season, 1998–99, slashed milkfat production by 10 per cent. More recently, the 2007–08 drought alone cost the country $2.8b in lost productivity.

Moving the fenceposts

"Drier and warmer," says Tait, "is likely to make it more difficult to maintain current productivity, unless you've got access to irrigation. It's fair to say that's the situation farmers already face along the east coast of the North Island, where more years than not tend to be drier than the historic average. So they're moving to different systems – adapting to that new climate.

"In some cases, that might simply be changes around the edges, but in others, small changes won't cut the mustard, and it'll need a different farming strategy altogether; such as converting from dairy back to sheep and beef, or retiring hill country into trees".

Clark's calculated what he calls "a range of potential climate futures," including the likelihood of drought for different regions, "and we've been able to quantify which ones we think are more likely". The good news, especially

NIWA's Anthony Clark: "A lot of farmers look at the climate projections for 2030, and they're not interested ... They don't want to think about it". (*Dave Allen*)

for Southland and West Coast farmers, is that not everybody loses; pasture modelling shows vast tracts of increased productivity under climate change as the number of growing days extends into autumn in the cooler, wetter southern regions.

But the most likely, middle-of-the-road scenario, he says, amounts to "just below a doubling in drought probability in some key agricultural areas – mostly the Hawke's Bay, Canterbury and Northland. The most severe scenarios start to bite down in 2030".

Farmers will have to adapt, but Clark says much of it will be manageable. "This isn't about changing the face of agriculture". Nevertheless, farmers will have to take a long hard look at the intensity of their operations: "One response might be to farm more sympathetically with the land, or to adopt less financially-risky systems".

"It's absolutely about farming within limits," agrees Doug Avery. "We went through a crazy period where people hurled whatever they had at the land, and just expected it to perform.

"We've got a problem with the climate, and while people keep debating what's causing it, we should put all that aside and simply accept that there is change, and that CO_2 levels in the atmosphere are higher. If it all came from the ground, then that's where it has to go back. The more carbon we can get into the soil, the higher the water-holding capacity of our land".

Salvation for Avery came in the form of *Medicago sativa*. Half the world calls it alfalfa; we call it lucerne. It grows little more than a metre high, but can put roots down to 15m, seeking out every last drop of soil moisture. A tough crown at the top of the roots can be grazed and re-grazed.

"Lucerne grows animals very quickly," enthuses Avery, "and it's pretty reliable in the spring, so we get a short window to grow lambs to a killing weight, before the summer dries us off". He can now kill his lambs at a time of year when others can't, which means he gets good prices, and has to run very few stock through the summer. Avery has turned his greatest liability – those dry soils – into a water bank. "We shut the spring moisture in, and carry it through to autumn. That takes care of our biggest environmental challenge.

CliFlo – free climate data

CliFlo provides free online access to New Zealand's National Climate Database.

The database receives data from more than 600 climate stations around the country at ten-minute, hourly and daily frequencies. Some of those data come from NIWA's own stations: the rest is supplied from by other agencies such as MetService, the Department of Conservation, Plant and Food Research, the National Rural Fire Authority, and regional councils. It also holds historical records from around 6500 former climate stations – some of which began recording in 1850.

As such, the database is the leading national repository of public climate data.

CliFlo can provide raw data and/or statistical summaries. Users can access about 80 different types of monthly and annual statistics, and six types of thirty–year normals.

Go to: http://cliflo.niwa.co.nz/

"Instead of people getting all despairing, and creating fear," he tells me, "it's about solution thinking. Science came out of the university on to the farm and mucked in ... re-empowered our ability to manage this land. With that collaborative approach, we can move heaven and earth".

"Doug sifted all the information," says Alan Porteous, "and came up with a solution which certainly works for him. It's given him a new lease of life".

Porteous says producing the information is often the easy part: "but it needs to be teased out, in terms of options for the farmer. To make best use of that information, we need to be much more engaged with farmers on a regular basis".

"NIWA's done a lot of work to reduce the uncertainties about local impacts," says Clark, "and we'll keep doing that – it's really important to keep monitoring and updating. The National Climate Network's a major asset in that regard – there's a whole plethora of things farmers can access from NIWA to improve their risk awareness of climate variability.

"A lot of farmers look at the climate projections for 2030, and they're not interested; that's a long way away. They don't want to think about it, and you can understand that. But farming systems don't just miraculously pop up; they're usually long-term collaborations between farmers and researchers. We now have the technologies to start planning and re-designing farming systems".

Over most of the country, farmers will adapt to Clark's middle-of-the-road drought projections by adjusting their stocking rates and better managing their water storage. There's really a lot of adaptive potential in New Zealand farming". Then he adds, "up to a point".

Some farmers are already near that point, sailing very close to the winds of economic and environmental sustainability, where just a small degree of change could tip both balance sheets. "In some dairy systems, where we have high levels of debt, we're at those limits now. There's not much more room to move".

Canterbury – in the red

In NIWA's work, one place in particular keeps showing up in red. "We've consistently found the Canterbury plain to be the most exposed region to drought under climate change. And that's using indicators that don't factor in irrigation, so it's a pretty serious signal that we need to be on top of irrigation resource management".

Doug Avery recalls his first few years of system change as the hardest of all. "Initially, we had to slip further down the economic slide, and there was frustration and despair when some things failed. But I knew our business was doomed if we didn't change. We had to battle on.

"Until you've been severely mauled, you probably won't accept a need for change. It's all just the weather's fault. Most people just see whether they can pump the river dry – they try and box on with the same system, and enter a whole new level of debt. It's a treadmill".

Clark says any farmer on that path inevitably has to ask: "Is what I'm doing actually viable?"

His father made his own heart-rending decision to leave the land at Bathurst after the 1982 drought. "He made a business decision, in the end. It's hard, because you have that bond with the land.

"I've seen a lot of forced adjustments in Australia, and they're ugly, but they're going to happen, so ideally, you want them to be planned".

Back at Punawaitai, John Nation runs weary eyes across his ransacked hills. Unlike many of his neighbours, he won't plant pines on them. The papa slip scars will stay that way, but the easier country, he says, "will re-grass naturally. If we get a decent spring, the native clovers will come back. These slips won't look nearly as bad".

Nevertheless, Nation knows things will never be quite the same here: "The modern way hasn't worked. We tried it for years. It works for a while, but... somehow, we've gotten out of whack. It's dollar-driven; our costs have gone up so much, and they keep going up. We can't control that, and we can't control the price we get for our product, either. So we're getting squeezed".

There are two horses on the way; one for him, one for Sue. No more outlay on farm roads that could just be swept away again. They're going to farm Punawaitai the way John's grandfather did. "From now on, it'll be about what we can fence". Five paddocks instead of 65. Grow what they call, with a grin, free-range beef. A hydroponic barley feed sideline will, hopefully, keep the cashflow ticking over.

"You just hang in there and hope next year's going to be better". He laughs at his own realisation: "I've been doing that for 40 years". W&A

Contact:
Dr Andrew Tait
Principal Scientist, Climate Applications
a.tait@niwa.co.nz

Alan Porteous
Group Manager, Climate Data and Applications
a.porteous@niwa.co.nz

Upping the ante

Climate change will test the infrastructure of the future. We need to start planning now, finds **Harriet Palmer**, for higher tides and heavier downpours.

On 23 January, 2011, the moon was only three days past full, and had just passed the earth at the closest point of its monthly orbit. Few would have noticed, until the Waitemata Harbour inundated the Auckland waterfront.

King tides happen several times a year, but this one, swelled by a low-pressure system over Northland, took on a special energy. Every hectopascal below average air pressure can raise sea level by a centimetre. As the system bore down on Auckland, the phenomenon, abetted by high winds, had already lifted the harbour half a metre higher than the predicted tide.

Around noon, a 4.13m storm tide washed over parts of downtown, some eastern suburbs, and Herald Island, near Hobsonville, then flooded eastbound lanes on the northwestern motorway. Storm waves crashed over seawalls and beach boulevards, swamping shops, homes and roads. Stormwater systems, choked by sea water, backed up.

You have to go back to March 1936 to find the previous highest storm tide – 3.99m. Some people said climate change had arrived; others simply blamed the freakish conspiracy of weather and moon, but the inundation was compounded by one cold, hard fact: Auckland sea levels have risen by 17cm since 1900.

Much of New Zealand's urban coastline was built in the 19th century, when people and products got around by ship, and nobody had any inkling that their descendants would burn fossil fuels with such rapacity as to warm the very air. The seawalls built by the city fathers are starting to fail their great-grandchildren.

The Royal Society of New Zealand points out that many of us now live in the wrong place. In a 2010 Emerging Issues paper, it warned: "Twelve of New Zealand's fifteen largest towns and cities are coastal. They are already exposed to coastal hazards from current climate variability and weather events: coastal erosion, flooding from storm surges, waves and swell, king tides, extreme rainfall and saltwater intrusion into groundwater. Sea-level rise will compound these hazards, both in terms of frequency and intensity".

It falls mostly to territorial authorities to deal with all that. For now, they're working to the Ministry for the Environment's 2008 guidance manual, Coastal Hazards & Climate Change.

NIWA Principal Scientist Rob Bell helped write that guide. "We adopted a new, risk-based approach to help users decide which future sea-level rise to work with," he says, "but it's taken a while for councils to adapt to that more flexible strategy". He says practitioners crave a definitive single number – the precise amount of sea-level rise they should be planning or designing for – but they won't get one from Bell. "Due to the uncertainty around the likely rate of sea-level change, there's a reasonably wide range of increases one could look at," he says.

That range runs from a half-metre rise by the 2090s, to at least 0.8m or more, so it's important to weigh up the potential risk to each area or asset from each sea-level scenario.

"Consider how flexible it will be to adapt or retrofit that asset in the future, before deciding on an appropriate sea level to accommodate.

"Let's say you're building a toilet block on an esplanade seafront," he offers. "In that case, sea-level rise of half a metre is fine – the consequences of it being engulfed by waves are minor. But if you want to develop a coastal subdivision, or a thermal power plant, then you need a much higher benchmark. Applying a one-size-fits-all number to every activity, irrespective of risk, is potentially more costly".

So Bell advocates different numbers for different environments. For coastal greenfield projects – ventures or subdivisions built from scratch on largely undeveloped land – he cites top-end figures of 1.5m to 2m or more, "because you know that sea-level rise is going to continue for several centuries. There's no point in building something permanent, then having to uproot it and retreat inland in 100-plus years' time. You've got to face those levels eventually, so they should be factored in from the outset".

Seafront property owners at Haumoana, on the Hawke's Bay cape coast, routinely flee their homes in the face of waves that break a little closer every year. (*Dave Hansford*)

Existing development is different: "Auckland, Wellington and Nelson are classic examples of coastal urban centres – they're locked into a coastal squeeze around low-lying shores. Using top-of-the-range projections on such extensive development is just going to create a lot of angst. Say somebody applies to build a garage on to their home: you deal with that at a small, localised scale, but you do it within the context of a bigger, more strategic, long-term community plan to adapt to climate change in stages".

Most projections for sea-level rise are only available out to 2100. The updated New Zealand Coastal Policy Statement instructs councils to plan for coastal hazards and climate change effects out to at least the next 100 years. That means councils should now be looking out to 2115, says Bell, which means contemplating around a metre of higher tide.

Bell says sea-level rise – whatever the number – will be fairly uniform around the country, but there's room for discretion when it comes to dealing with it. He encourages planners and engineers to examine each case on its own merits – weigh up the specific risk – and tailor their response to the infrastructure, or assets, or environment at stake.

Some cases are better served by adaptive management, which lets decision-makers and their communities come up with a strategic plan, then decide how and when they stage it. By keeping an eye on sea levels, they can implement each pre-determined stage as those levels approach – rather than try to second-guess what the sea level will be in 2115.

"That could mean staged measures," says Bell, "such as nourishing beaches with sand, or shifting a road inland when sea levels reach a certain height. It could mean jacking buildings up, or eventually moving them as part of a managed retreat, but you can always accelerate an adaptive plan, or slow it down in response to sea-level trends".

There are more curve balls coming out of climate change than just sea-level rise. Planners and engineers must now design infrastructure and systems capable of coping with more dramatic weather: more frequent, heavier rains will sorely test ageing stormwater systems, and trigger more slips, and higher temperatures will shrink the very ground, as they did in Whangarei during the 2009–10 drought, shifting piles and cracking walls and roads. Water supplies will be found wanting.

Yet local authorities face those challenges in the absence of any policy guidance, says Frances Sullivan, a Senior Policy Analyst at Local Government New Zealand.

"Local authorities are really struggling around decisions to try to manage risk. We need a National Environmental Standard for sea-level rise, and a National Policy Statement to cover flooding. We keep trying, but so far have had no success at all in our efforts to integrate risk management into the RMA process".

Sullivan can't understand why policy measures so obviously in the national interest are not treated as such. "It's very frustrating," she says. "A local authority makes a sensible, precautionary decision that conflicts with a developer's plans, and then ends up fighting the developer in the Environment Court – it happens time after time, and it's very expensive".

Not as costly as cleaning up after natural disasters, though, so most major authorities are pressing ahead regardless. Wellington, Christchurch and Dunedin city councils are devising or updating climate change strategies which try to envisage a warming world, and offer ways to mitigate what impacts we can, and learn to live with those we can't.

Wellington – let's talk

Sea-level rise is high on Chris Cameron's mind, too. Much of Wellington's CBD, and major road and rail routes, are built on old seabed that was heaved upwards into terra not-so-firma by the 1855 earthquake.

As Wellington City Council's Principal Climate Change Adviser, Cameron is part of a team modelling a range of sea-level scenarios. They've already abandoned a half-metre projection – their scenarios begin with tides a metre higher by 2100. That, according to WCC simulations, would see much of the waterfront under water. Another half-metre rise, and the waterfront, the railway station, and most of Wellington's 'Golden Mile' would be committed back to the sea.

The city faces some difficult choices, says Cameron. He wants to start a conversation with Wellingtonians right away, to help them grasp the full magnitude of his scenarios through 3D computer simulations of 'their place'. "What I need most is some way to value an area in terms of everything it has – its multiple cultural, social, environmental and economic values. How can I compare the value of, say, Oriental Bay, with Centreport, or with a residential suburb?"

He's certain of one thing, though; poor planning will leave the city trying to engineer its way out of each new crisis as it arises – a costly option unlikely to preserve those multiple values.

Dunedin – cheques and balances

Further south, a 2010 study, *Climate Change Impacts on Dunedin*, found that Dunedin's shoreline roads and railways, and the coastal hamlet of Aramoana near the Otago harbour entrance, are vulnerable to rising tides. More critical, though, is densely-packed, low-lying South Dunedin, which lies squarely in the path of advancing seas. Storms have already seriously eroded the sand dunes in places, and the study, penned by Blair Fitzharris, Professor Emeritus at the University of Otago, found that shoring up those dunes might only delay retreat or eventual evacuation.

"Some coastal land and infrastructure may have to be abandoned," he wrote, "in a planned retreat inland and to higher ground. These communities are unlikely to be able to afford the cost of building and maintaining protection structures". Storms have already undermined a sea wall built at St Clair, along with any faith that hard engineering can long resist the elements.

Not all sea water comes in over the top; some invades underground aquifers, forcing back storm and waste waters and raising water tables to bedevil infrastructure and services. Climate change projections foretell heavier rains, and pumping stations, such as the one in Dunedin South at Musselburgh, will struggle against the power and weight of an incoming sea, as will rivers and streams. We can expect to see more suburbs flooded when high tides coincide with storm surges.

> "How can I compare the value of, say, Oriental Bay, with Centreport, or with a residential suburb?"
>
> Chris Cameron, Wellington City Council Principal Climate Change Adviser

Dunedin Airport, on the lower Taieri Plains, was heavily flooded in 1980, and Airport Operations Manager, Richard Roberts, says it's only a matter of time before it happens again. He's seen three more close calls during his 12 years at the airport, most recently in May 2010, after five days of rain. Water was lapping at the top of the stopbanks, and contractors were lined up to start sandbagging.

"The airport itself can do nothing to stop this area flooding," explains Roberts. "The Regional Council is responsible for maintaining stop banks and pumping stations; and the whole valley is artificially drained".

But past experience is driving present practice. "In 1980, the internal damage was very serious, and that's what delayed re-opening. So we've lifted everything up; all our main switchboards, all our IT – everything we need to run the airport – is on the first floor. And our standby generator is 1.2m off the floor in the car park. We've mitigated the risk".

Still, rising groundwater could fracture the runways, and Roberts's contingency plan is to drill hundreds of small holes in the tarmac to relieve the pressure.

Back-up in a box

But emergency, or stopgap, measures won't be enough, says Dr Andrew Tait. A principal scientist at NIWA in Wellington, he says that while many local authorities are thinking strategically about climate change, many lack science-based support to help them assess likely impacts, or devise a response. Accessing recent, relevant research can be difficult. For example, many local authorities have sophisticated water yield data and population projections, but lack future climate scenarios, quite apart from the expertise and resources to integrate them into their own regional data.

Tait means to fix that with a toolbox to help urban authorities deal with coastal inundation, storms, flooding and drought.

The toolbox offers information in four tiers: risk, hazards, cost-benefit analysis of possible action and integrating all these factors.

"It's all about helping urban planners and engineers work smarter," he says, "to show them what types of information and resources exist, and provide examples of how they can be used.

At Clifton, near Havelock North, waves have damaged stormwater infrastructure and undermined the road that services the Clifton campground. (*Dave Hansford*)

"So we're helping them develop processes for managing climate change impacts, and also helping them overcome barriers to implementing them".

GNS Science, engineering consultants MWH, and the Building Research Association of New Zealand (BRANZ) have brought their own expertise to the project, and a number of urban councils have supplied priority models and case studies. GNS scientists have developed landslide models for Wellington City Council based on future rainfall projections, and NIWA scientists worked with the old North Shore City Council to model future wastewater flows based on similar scenarios.

Time and tide

Rob Bell has been helping Auckland Council and Nelson City Council factor sea-level rise into their resource management plans. Now, more than ever, he says, councils need credible advice: "Five years ago, we had a fairly well-defined band of sea-level rise projections out to 2100, but since then, the polar ice sheets have come into the equation. That's added increasing uncertainty around the upper range.

"So we're giving sound, credible guidance on adaptive approaches, tailored to the types of environments and community assets people are trying to manage. We're also providing information on coastal hazards – wave overtopping, storm surge, coastal erosion – because all those things will be exacerbated by sea-level rise.

"The natural instinct is to defend ourselves from the sea," he says. "We've been doing that since the days of King Canute, but that instinct will grow stronger as sea levels rise".

Contact:
Dr Rob Bell
Principal Scientist, Coastal and Estuarine Processes
r.bell@niwa.co.nz

Kilbirnie: in harm's way

Kilbirnie is a low-lying Wellington suburb. Its northern boundary is Evans Bay, and the main access road to Wellington airport and Miramar peninsula runs along this boundary. Its southern foreshore is Lyall Bay, a popular, expansive recreational beach. Wellington City Council (WCC) says the suburb, largely built on sand, has potential for more high-density residential development. However, much of it lies between just one and three metres above sea level.

WCC has simulated three sea-level rise scenarios and their effects on Kilbirnie. In the medium term, groundwater flooding is tipped as the greatest consequence of a one-metre rise, exacerbated by storms and heavy rain.

Scenario One: 0.5m sea-level rise, plus storm surge

A likelihood the Council considers: "Almost a given – there is a strong probability that sea level will rise by 0.5m by the end of the century".

With reasonable planning, the suburb should be able to cope. High rainfall will likely cause more flooding, with lower discharge capacity and increased saltwater intrusion into stormwater pipes. Planners and engineers will need to better understand how a rising water table will affect Kilbirnie's largely sandy foundation.

Scenario Two: 1m sea-level rise, plus storm surge

A less-likely scenario. Says WCC: "it is possible that sea level could rise by one metre by the end of the century, though this is not by any means certain. The probabilities of a one-metre rise will increase over a longer period – current science suggests that this could become a reality some time in the 22nd century".

Hard engineering solutions, such as raising roads and building more stormwater pumping stations will become increasingly likely.

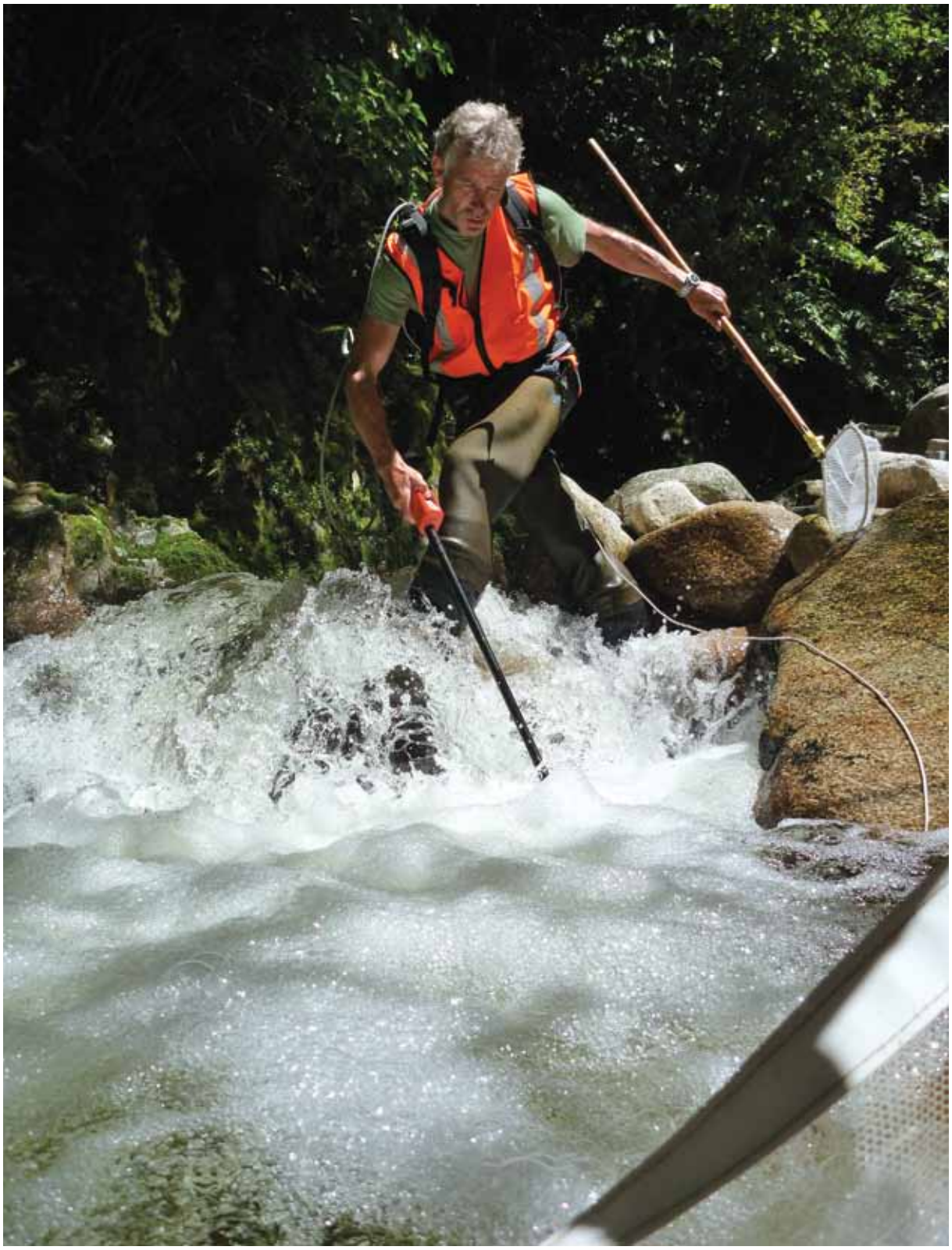
Planning restrictions will be phased in to specify precautions such as minimum floor-level heights for new houses, and 'no build' zones.

Along beaches, artificial barriers like sea walls, or natural ones like restored and enhanced dunes, will be considered. Failing those, a plan for managed retreat will be developed.

Scenario Three: 2m sea level rise, plus storm surge

A top-end scenario, says WCC, "only for consideration of very long term expectations beyond the 23rd century (or if predictions increase significantly from current scientific understanding)".

Overtopping, inundation and wave damage to beachfront properties and roads are expected. Sea water will invade stormwater and wastewater systems, making Kilbirnie's streets difficult to drain. A combination of major engineering works and retreat would be needed, but wave action and storm surge would hamper engineering solutions. More stringent planning restrictions would be needed.



Jo Hoyle. Category winner – Our people. Julian Sykes electro-fishing for short-jawed kokopu in the steep cascades of Anderson Creek.

Portfolio

NIWA researchers document their work in some of the country's most spectacular reaches. In August, the company celebrated their efforts with a photo competition for South Island staff. Here, we present the best of the best.

Evan Baddock. Category winner – Land, water and skyscapes. Sunset over Castle Mount Snow Station, above the Clinton Valley and Milford Track, Fiordland.

Jani Diettrich. Category winner – Plants and animals. Kea at Broken River.

You go first... the psychology of climate change

Psychology may yet be the most potent foil to climate change, finds **Harriet Palmer**.

> "We associate truth with convenience, with what most closely accords with self-interest and personal well-being, or what promises best to avoid awkward effort or unwelcome dislocation of life"
>
> John Galbraith, institutional economist.

Seventy-six per cent of Kiwis, found a survey for the New Zealand Business Council for Sustainable Development, believe that climate change is a problem. Sixty-four per cent believe humans are causing it, and 65 per cent say we're already feeling the impacts.

More than half of us (53 per cent) told the Shape New Zealand survey that we worry about that, but New Zealand's greenhouse gas emissions are nevertheless set to increase by 26.4 per cent above 1990 levels by 2012.

That contradiction between what we feel we *should* be doing, and what we *are* doing, is fertile ground for the social sciences. Psychologists, analysts, academics, policymakers, politicians – they're all dying to know why what we think about climate change, and what we do about it, seem to be two very different things.

Many argue that, in fact, our very success or failure to address climate change depends on the answer.

Mike Hulme, a climate scientist at the University of East Anglia, addressed the British Science Festival last year with the contention that "Science evidence is not enough. Scientists have made the mistake of assuming that if we understand the climate science, we just have to communicate this, and contribute to a consensus on policy".

In fact, he said, the situation now demands a social science and humanities approach. It was clear, he added, that our culture, beliefs and knowledge all play a big part in shaping our perception of climate change.

Richard Nottage, Coordinator of the New Zealand Climate Change Centre (NZCCC) agrees. He wants to see more social scientists in New Zealand's climate change research mix.

"Many of the solutions now lie in the behavioural space," he says, "and that needs recognition from researchers across all disciplines. Then the public will have confidence in what they have to say. Our challenge, ultimately, is to bridge the gap between what scientists know and what people understand".

A recent workshop organised by the NZCCC brought social researchers together to debate just how 'social knowledge can contribute to the understandings of, and human responses to, climate change'.

Dr Karen Cronin, a Science Leader at Environmental Science and Research, co-authored the workshop proceedings: "The many different aspects of society – social processes, institutions, behaviours, cultures, beliefs and practices – which are central to our high-carbon lives are also an important component of future low-carbon lives," says Cronin. "The key to successful transformation – to more sustainable and low-carbon ways of living – is social knowledge".

Psychologists are trying to find out what happens in our heads when we hear the 'CC' words. They suspect that climate change presents a unique set of barriers that stop people engaging with the reality, and sap their will to act.

Crime, unemployment, the economy, are potent everyday reminders of our vulnerability, but the diffuse, creeping nature of climate change means the signals are generally weak. We don't notice gradual, tiny increases in temperature, because they're often swamped by normal daily and seasonal temperature variations.

Climate scientists tell us that, even if we sell our cars and turn everything off now, the mercury will go on climbing for years – possibly beyond the critical two degrees of warming tipped to precipitate drastic change – thanks to a lag effect. For a lobbyist, that's a powerful incentive; it ramps up the immediacy of the threat, and puts a physical face on an abstract phenomenon.

For most commuters, though, it's well down the order. Psychologists suggest we have a "finite pool of worry" – as one perceived risk takes immediacy, others get bumped down, or off, the list. Respondents told the NZBCSD survey that climate change was sixth on their list of concerns, with things like fuel prices, the economy, household finances and crime much more likely to occupy people's worrying time. Studies in the US – even in green California – have shown that climate change takes precedence during the good times, but recedes to the back of peoples' minds in times of high unemployment.

So most of us save our worrying for today, or for when the mortgage is due. Asking us to worry about a problem 50 or 100 years away ignores a fundamental human trait; our minds evolved to solve mostly immediate challenges – communicating, finding food, evading predators. There's little hard-wiring in the human brain devoted to analysing the plausibility or impact of events more than a few months away. We're not much good at assessing impacts that, however alarming the projections, still sound hypothetical.

In fact, work has shown that dire predictions about natural disasters, mass evacuations, ice-cap melt and extinction might actually stupefy people, rather than galvanise them. Last year, Berkeley psychologists Robb Willer and Matthew Feinberg found that people shown scientific evidence of the most negative aspects of warming were more likely to dismiss or deny what they saw.

> "Our challenge, ultimately, is to bridge the gap between what scientists know and what people understand"
>
> Richard Nottage, New Zealand Climate Change Centre Coordinator.

Scepticism was highest in those study subjects who'd previously indicated an implicit belief in a fundamentally just world. Messages about the biggest losers from climate change – developing nations, polar bears, future generations, those least responsible for it – apparently challenged their convictions around fairness so deeply that they went straight to denial.

Many people equate cutting their emissions with a loss of freedom and convenience. When faced with the choice of a cold, wet bike ride or taking the car, human nature usually dictates that our personal short-term interests tend to outweigh the longer-term interests of future generations. Appeals to do 'the right thing' can contravene our other desires, which can run from the purely indulgent, like a patio heater, to the aspirational – 'getting ahead' can mean a bigger house, two cars, holidays to the Gold Coast.

It feels like environmentalists are asking us to give up the good life. That's when we're tempted to slip into what Albert Bandura, Professor of Social Science in Psychology at

New Zealand Climate Change Centre Coordinator Richard Nottage: social sciences could hold the key to public engagement on climate change. (*Dave Allen*)

> **"The key to successful transformation – to more sustainable and low-carbon ways of living – is social knowledge"**
>
> Dr Karen Cronin, Science Leader, ESR.

Stanford University, calls "selective moral disengagement," a neat trick we've learned to keep guilt at bay.

"Disengagement of moral self-sanctions," he writes, "enables people to pursue detrimental practices freed from the restraint of self-censure". We do this in a number of ways, argues Bandura. We might, for instance, justify environmentally-harmful practices by invoking the social or economic good. Mining proposals are sure to mention the jobs they'll create.

Or we might, in Bandura's words, minimise our accountability "by displacement and diffusion of responsibility". In other words: 'What harm can my widescreen TV do when China's building a coal-fired power station every other week?'

NIWA scientists have encountered many of these beliefs. Dr Helen Rouse is a resource management specialist, leading a project looking at how coastal communities can be encouraged to consider, and counter, the anticipated effects of climate change. As part of that work, she's run workshops with coastal dwellers in the Coromandel. Her experience is that people do, indeed, consider climate change as something very hazy and distant, both in time and space.

"People are still at the 'Is it real or not?' stage," says Rouse. "They feel it's something remote, and haven't thought about how it might affect them, or their children and grandchildren. Knowledge about climate change is general and vague, and people are frightened away from seriously engaging with the implications.

"The distance from the issue to what people can actually do is a real challenge".

Psychologists describe climate change risks as having 'high psychological distance' – a long way off in the future, happening to somebody else, on the other side of the world. You might call that optimism, or you could call it a foreshortened perspective. Writer Donald Collins coined the apocryphal example of the man who fell from the Empire State Building. As he passes the 68th floor, he thinks to himself: "So far, so good".

Survey after survey has shown that, while people acknowledge that climate change is real, they don't feel it will affect them personally. Americans in particular believe strongly that technology, not their own actions, will rescue the climate.

Psychologists tell us that emotional responses drive motivated decision-making. Interviews with Australians who believe humans are responsible for climate change found that fear was their strongest emotional response. But fear can leave us feeling overwhelmed or powerless, overcome by the lifestyle changes we feel we should be making.

Dr Niki Harré, Associate Professor in the Department of Psychology, University of Auckland, argues a better appreciation of human psychology would prompt a much wider response.

Harré believes our morals, and beliefs about justice, are a big part of the equation. Inherent moral values guide much of our behaviour, and Harré says we'd make more progress if people thought about conserving resources at least as a societal convention, but better still, as something that was simply morally right.

People tend to self-police moral behaviour, she says, and will intervene when others do things we consider morally wrong. If we seriously believed that risking the well-being of future generations was immoral and unjust, we would take action, and strongly encourage others to do the same.

Instead, argues Harré, behaviour driven by convention is rather left to authorities to regulate, and her preference is for peer pressure from the ground up, rather than risk a nanny state backlash.

People respond better to the offer of a bright green future, say pundits, than the threat of climate damnation. (*Dave Hansford*)

It's time for more positive emotions around climate change response, she insists. Social research overseas backs her up. Too many climate messages are either dull, patronising or depressing, according to Futerra, the UK sustainability communications gurus.

A neural phenomenon called the 'availability heuristic' means that humans put the most credence in that outcome they can most readily or vividly imagine. So if they're repeatedly subjected to a vision of climate hell, it becomes the most believable conclusion. Dire predictions and warnings of climate chaos may actually be goading people towards it.

Paul Kennett (centre) and his brothers Simon (left) and Jonathon. The concept of eco-friendly transition towns, says Paul, offers people a "social response" to environmental issues. (*Dave Hansford*)

> "I think there's a shift now in people's attitudes, even if it's only happening very slowly"
>
> Paul Kennett, Wellington environmental advocate.

But psychologists have long argued that the reverse is true too: that people who carry positive scenarios or goals in their minds tend to move towards them, or as one researcher put it: "when you change the way you look at things, the things you look at change".

So the answer, many contend, is to substitute climate hell for a low-carbon, smart green future, and it looks like the sort of place we'd all want to be. Guilt-free travel on electric trams powered by wind turbines that don't just generate kilowatts but jobs.

New Zealanders are increasingly buying into just such a future. Forty-eight North Island towns and suburbs, and 10 in the South Island, have signed up to the transition town movement. Some have formally adopted a strategic vision for 'their place', while others operate less formally.

This ground-up initiative is about getting local people together to create a vision of how their community could look in the future. By sharing knowledge – it can be something as simple as how to grow vegetables – people are equipped and empowered to take on two big challenges – climate change and peak oil.

In Wellington, Paul Kennett, one of a trio of cycling brothers and local environmental campaigners, is pushing the concept hard.

"The idea of transition towns has been around for a while, but since 2008 the whole thing has really taken off," says Kennett. "It provides a social response. I think there's a shift now in people's attitudes, even if it is only happening very slowly".

Transition towns, then, ferment positive emotions as people work towards their shared vision of a better future, a better place to live. They also offer people something more tangible, more immediate, to think about, reducing the problem of psychological distance.

More of a smart green heaven than a climate hell.... W&A

Contact:
Richard Nottage
Coordinator, New Zealand Climate Change Centre
r.nottage@niwa.co.nz

Ātahirā – a new challenge for Māori

Māori survived landfall in this cold, harsh place to settle and thrive in it – a triumph of adaptation. Now Nature places another challenge in their path, writes **Dave Hansford**.

Robert MacDonald's first thoughts were for the kaumatua. Down on the flats, they were in the direct path of the rampaging Pouhokio. It had been raining now for six hours, and the river, denied a path to the sea by thickets of willows, sought another way. The line of least resistance, it turned out, lay down the main Waimārama road, then across the low paddocks behind the shore.

The plan, recalls MacDonald, was to fetch the elders from their threatened homes and bring up them up here, up the steep hill to his house. "Well, that never happened, because we found the river had cut them off completely".

The rain, if anything, fell harder after nightfall. The floods knocked out a bridge, while 120km/h winds took out the power, then the phone. Waimārama, like communities up and down the battered coast, was cut off to all but the helicopters that evacuated the young, the elderly and the ill.

A tide of water and mud flowed through the marae, spiritual and social touchstone for Waimārama whānau Ngāti Kurukuru, Ngāti Hikatoa, Ngāti Urakiterangi and Ngāti Whakaiti. Floods ravaged the whare tipuna and destroyed bedding and fixtures. An urupā was all but buried under mud, but it was the isolation that most sorely tested the town's Māori people. "That's distressing for anyone," explains MacDonald, "but more so for Māori, because we depend heavily on one another, especially in a situation like that, and our ability to support one another was lost completely.

"For nearly three days, we were isolated from each other, and that's not a natural way for Māori to live. Civil Defence and the Rural Fire Brigade did a marvellous job, but Māori people look for help from family, or the Māori community itself, in the first instance".

The emergency at Waimārama neatly encapsulates a broader issue for Māori facing climate change. Yes, all New Zealanders will be affected to some degree, but Māori communities will have to overcome challenges specifically their own, in their own way.

Climate change is a complex issue for Māori, says Darren King, a researcher at Te Kūwaha, NIWA's Māori Environmental Research Group. "There are multiple dimensions – across different people, politically, environmentally – that make it difficult to specify any implications with certainty". King runs climate change adaptation programmes with three hapū – Ngāti Huirapa at Arowhenua, Te Tao Maui at Mitimiti and Ngāti Whanaunga at Manaia – that set out, in the first instance, simply to get a handle on the range of threats and issues they face. "We can identify a whole range of exposures and sensitivities that make Māori vulnerable to climate change impacts.

"There are a number of challenges and barriers that are common to all communities, but there are others that are quite distinct. And that really underlines the diversity among different Māori communities – you can't come up with a single policy expecting it to address everybody's issues".

For King, that complexity defines the challenge facing Māori. "Māori society comprises different whānau, different iwi, different hapū, different business enterprises". From within that diversity, Māori must also juggle geographical separation, varying skill levels and uneven access to resources and expertise. "Some have good internal relationships within the hapū, some don't. Some iwi enjoy a productive range of relationships with external agencies, others don't".

Climate change will likely exacerbate many of the socio-economic difficulties and disparities Māori already face. Many iwi still lack the money and skills they need if they're to build resilience into their communities, but there's still more at stake. As of last year, Māori enterprise owned assets worth nearly $40b and contributed almost six per cent of GDP, but fully half of those assets lie in climate-sensitive primary industries like forestry, fishing, agriculture and tourism.

Some threats to terrestrial assets – drought, flooding, slipping, or the spread of invasive species – are obvious, but King says policy decisions, or market forces subtle or otherwise, can radiate hundreds of kilometres to hit remote Māori communities and businesses in ways unanticipated. "There's a range of indirect impacts that are often overlooked. We don't always appreciate that climate change is more than simply the biophysical side of life," he says.

"How do we think about our natural resources? Do we regard them as something separate? Or are they a part of us? And we a part of them?" (*Geoff Osborne*)

> **"We don't always appreciate that climate change is more than simply the biophysical side of life"**
>
> Darren King, Māori Environmental Research Centre, NIWA

"The decisions of other people in other places can have a major impact on Māori living in remote and seemingly isolated places".

Robert MacDonald says Māori people don't always choose their home for pragmatic reasons. They live where they do because of the pull of family, and an abiding ancestral bond with the land. For many pākeha, he says, Waimārama is an investment or lifestyle choice, "but for our people, it's home, and it's always going to be the place of their choice. It may not be the best place to find work, or to educate your children, but Māori people choose to live here because of that tie".

That, says Lisa Kanawa, a senior advisor on Māori policy at the Ministry of Agriculture and Forestry, has huge implications for the way Māori might decide to respond to the challenges of climate change, especially sea-level rise. "Most of our marae and papakāinga are along the coast". Terms like 'managed retreat' – in which people essentially evacuate nearshore areas and start again on higher ground – get a guarded response from people with an affinity that stretches back over generations.

"Those things are really special to us," says Kanawa. "They're bound in cultural values. Retaining walls aren't going to work for much longer, so we need to think seriously about relocating. But how do we start making those decisions, while still upholding all those values and traditional knowledge? It's a heartbreaking decision".

Such weighty decisions are all the more burdensome for the responsibility they carry. Kanawa says Māori people know that their decisions today – around communities and business – will guide the fortunes of their descendants. "With the kind of inter-generational approach that Māori have to their land ... it's in our best interests to start planning now. That inter-generational approach is very strong. Another investor might pull their money after a few years; that's not going to happen in Māori business".

Whatever course, she says, "needs to be bound in tikanga. Every decision we make, whether that's our primary sector interests, whether it's around our families and households, needs to be bound in those fundamental values around being Māori".

A critical start, she says, for any Māori organisation, "is to be strong in who they are. Knowing what their vision is for themselves, as an iwi, or a hapū, or a trust. Then binding that into their tikanga and their values. Then, any decision that comes after that will be safe for you, and for future generations".

MacDonald says his people must effectively make their way with a foot planted in each of two worlds: Te Ao Māori, and "Pākeha law". And while they must be conversant with both, the understanding isn't always two-way.

"If we decide, for instance, that our choice is to do nothing, then that's often seen as an impediment – that we simply don't want to do anything. Often, the reasons we do things, or don't do them, are very poorly understood by the rest of the community".

Ngāti Kahungunu Incorporation Chair Dawn Bennett: "I know some would prefer to stay here and let Tangaroa take us". (*Dave Hansford*)

King's work is showing that cultural ignorance often stymies progress on climate adaptation. "If there was a bit more effort to understand the Māori way – and there are a number of ways, I might add, not just one way – I think there would be greater understanding of the reasons people make the decisions and choices they do".

People need to try to understand the position that others find themselves in, he says. "There's always an historical context to any situation. If you want to understand that situation, then you have to understand the history, and a major part of history for many hapū, for many iwi, is that they're still dealing with the legacy of land confiscation".

> "Often, the reasons we do things, or don't do them, are very poorly understood by the rest of the community"
>
> Ngāti Kahungunu kaumatua Robert MacDonald

According to Statistics New Zealand, more than half of all Māori are "economically deprived", a reality that not only hinders the Māori response to climate change, but makes some more vulnerable, says King: "If you work at a freezing works, for instance, you could have your hours cut as a result of the impact of drought.

"Another one is insurance; if you don't have enough money coming in, are you going to choose paying insurance premiums, or putting food on the table? It's not uncommon that, where people are earning very little money, they forego insurance. Or, because houses can fall into disrepair, when people actually seek insurance, they're declined because the house isn't in a fit state to insure".

Maybe seven kms up the coast from Waimārama, big, Pacific breakers explode on Ocean Beach, just 30m from Dawn Bennett's place. This small community exists, by dint of a single, vertiginous road that snakes down the coastal escarpment to a surf club and 40 or so houses.

If you want to visit Dawn this day, though, you'll have to walk, because the Anzac Day deluge triggered a massive slip about halfway down the road.

Ocean Beach typifies a situation many Māori communities find themselves in – comparatively remote, accessed by a single, vulnerable road, with electricity delivered or denied at the whim of nature. NIWA's climate forecasting contends that, as the atmosphere warms and gains more energy, there are likely to be more storms like the one that closed this road. It might deliver any monthly rainfall average in a single inundation. "We're seeing more severe storms, more flooding, which is ruining our infrastructure," says Kanawa. "When we should be re-investing in productivity, we're spending those reserves on repairing infrastructure instead".

Bennett shows me where thousands of cubic metres of mud have sloughed off the steep escarpment behind the village, come to rest against some of the houses – punched clean through the cladding and come to rest inside others. Tonnes of silt and torn trees lie piled up beside the now-quiet stream. At least the bridge abutments held up. Otherwise, the community would have been cut off entirely.

Bennett is a blur: quite apart from chairing the hapū

incorporation, she's the local Civil Defence commander, a member of the Rural Fire Authority, one of the community's fisheries officers, and attends hui and hearings across the country. "I get involved because I know that, as a coastal community, we need to know what's going on, and what's coming before it hits us.

"We're looking at getting a strategic plan together for the environment here, because without that, you can kiss these houses goodbye. A resilient environment will ensure a resilient community". She points to the 12,000 native trees the people of Ngāti Mihirora, along with local schools and other groups, have planted, not just to lure back the tui, but to stabilise the scarps behind them.

Down on the beach, more plantings: this time native dune grass – pingao – that will hopefully trap and bind the sands swirling in the nor'easter, and build up some defences against a tide that rises a little higher each day.

Sea levels are tipped to rise along the coast by between 50 and 100cm before century's end, maybe higher. Around the other side of Cape Kidnappers, at Haumoana and Clifton, homeowners are already trying to keep the waves at bay with ever-more substantial fortifications, but still the sea routinely drives them from their homes.

That sort of havoc isn't expected at Ocean Beach, but Bennett has a plan, just in case. She's talking with Hastings District Council about creating 15 lease blocks on higher land behind the community. "Then we'd put houses up there on skids, so we can relocate them if necessary". If the council agrees, she says, "we'll take out every second bach down the front, so we don't end up with any Haumoana issues".

The incorporation is lucky: it owns 600 hectares of land here. "We could retreat all the way back to the Waimārama Road if we wanted to," says Bennett, "but I know some would prefer to stay here and let Tangaroa take us".

"We need to start planning now for what's coming," says Kanawa. "Māori are very good planners; we've navigated vast oceans, so there's no reason why we can't plan for the next 20 or 30 years".

But planning needs good information, and getting it to the right people, by the right means, is harder than it sounds. "It's very resource-intensive: it's about getting out there and talking to people. Who gets the information out to those remote communities? Who's the right agency or entity? Māori have different learning needs. Some still don't have access to the internet".

Whatever approach, she says, "must be culturally safe; not just for Māori, but for the organisations themselves, because it's a very sensitive space. Relationships are key, and they're bound in integrity, and trust, and honesty, and openness".

Robert MacDonald agrees: "Māori people will do things the way they are most comfortable with. Even in times of crisis, we have difficulty just shrugging those ways off".

And therein lies one of Māoridom's greatest strengths, says King. "For many, that connectedness between people makes many communities quite resilient. That manaakitanga, the principles of generosity, of reciprocity, of care – tautokotanga, and maintenance of internal relationships, these are the core values that underpin the Māori world.

"It's something that other, non-Māori communities could learn a lot from". W&A

Contact:
Darren King
Climate Research Scientist, Te Kūwaha, Māori Environmental Research Group
d.king@niwa.co.nz

Darren King (left) at a mapping exercise with kuia from Ngāti Huirapa at Te Hapa O Niu Tireni Marae, Arowhenua Pa, Temuka. (*NIWA*)

NIWA's work with Māori

Victoria University's Climate Change Research Institute has contracted NIWA to examine the vulnerability – and resilience – of different Māori communities to climate change impacts. A series of place-based studies around the country – conducted by members of Te Kūwaha, NIWA's Māori Environmental Research Centre, will assess socio-economic considerations, the types of assets at risk, and the capacity of those communities to adapt.

"We're currently halfway through two community-based projects," says project leader Darren King, "with a third in the early stages. The principal aim is to produce information the community can use, so it can develop adaptation plans for dealing with future climate change impacts. We want to better understand the context-specific issues those communities face: before you can come up with solutions, you need to know what the challenges and barriers are".

King and his team are working with three communities: Ngāti Huirapa at Arowhenua, Ngāti Whanaunga at Manaia, and Te Tao Maui at Mitimiti. Through semi-structured meetings, interviews, and site assessments, the project starts by ascertaining the scope and scale of climate threats a community might expect to face.

Scientists, policy analysts, and decision-makers will add more information to the mix, which will guide the development of adaptive strategies, not only for those involved, but also for others who may share similar challenges and experiences.

Q&A

How do we model the climate?

NIWA's climate model calculates values at the intersections of approximately 30 kilometre-square grids that cover the country. On top of those, sample grids also extend 30km up into the atmosphere. Because most important interactions occur closer to ground level, the vertical grids are stacked more closely at lower altitudes. (*base illustration: Geographix*)

What's the difference between climate and the weather?

The difference between weather and climate is time. Climate refers to averages of weather conditions, including temperature, rain and wind, that characteristically prevail in a particular region, over a long period of time (e.g. 30 years). In contrast, weather describes meteorological conditions in the short-term (e.g. instantaneous, daily or weekly).

Why do we need to know about future climate?

Understanding how the climate is changing makes it easier to plan for any new risks that might impact on New Zealand, such as a change in frequency of climate extremes such as droughts, flooding and storms.

At the same time, new opportunities will emerge as the climate changes. For instance, we could grow different food crops in a warmer future. It's critical that New Zealand has the best tools and information available, to help anticipate and plan for such changes. NIWA uses its model to produce climate projections out to 2100.

How do scientists predict the future climate?

Working out what will happen to the climate in the future isn't easy. Regional and global climates are the result of many complex interactions between processes in the atmosphere, ocean, land surface and cryosphere (snow, ice and permafrost).

To see what impact those various interactions might have on the climate, scientists have developed computer models which mathematically simulate relevant physical, chemical and biological processes to indicate what the climate might look like under various scenarios for future greenhouse gas concentrations.

How do the models work?

A climate model is basically a huge mathematical calculation that creates a simulated picture of what the real-world climate might be like in 10, or 20 or 100 years from now. The many physical, chemical and biological interactions in the atmosphere, ocean, land surface and cryosphere all follow constant natural laws. A model simply converts those laws into mathematical equations so a computer can work with them, modelling what might happen to the climate when the different elements interact.

Large climate models (such as global climate or global circulation models (GCMs)) do so many calculations that they need to be run on supercomputers, like NIWA's IBM p575 POWER6 supercomputer. GCMs are very complex – even a supercomputer can take up to two months to simulate a century of climate information.

Are all climate models the same?

No. There are various types. Models that simulate the atmosphere are called Atmospheric General Circulation Models (AGCMs) and have been developed from weather forecasting models. Similarly, Ocean General Circulation Models (OGCMs) simulate the ocean. The acronym GCM is often also translated as Global Climate Model, since these models encompass the entire globe. GCMs are widely used for weather forecasting, understanding the climate, and projecting climate change.

An AGCM and an OGCM can also be 'coupled' together to form an atmosphere-ocean coupled general circulation model (AOGCM). Climate models can also be run at higher resolution over a limited area of the globe – these are known as Regional Climate Models (RCMs). RCMs are usually run as atmosphere-only models, and must be loaded with 'boundary conditions' – sea surface temperatures at the lower boundary and atmospheric conditions (wind, temperature, humidity, etc.) at the lateral boundaries. These boundary conditions are provided by the GCM.

What kind of model does NIWA run?

NIWA uses the UK Met Office's 'Unified Model' suite. Within this suite, there is a GCM which can be run as atmosphere-only or as a coupled AOGCM, and also an RCM which NIWA has modified to suit local conditions.

GCMs calculate the behaviour of wind, temperature, ocean currents, humidity, etc. at a number of prescribed points on an imaginary three-dimensional grid, covering the surface of the Earth and extending vertically upward in layers through the atmosphere. Many influential climate interactions happen down low in the atmosphere, where the air pressure differential is greater than higher up. So while the NIWA model has 19 separate levels, spanning 30km up to the middle stratosphere, the majority of them are concentrated in the lower troposphere.

The model makes calculations at every intersection in the grid. The model's resolution (the amount of detail it can calculate) is defined by the size of each box in the grid: how close or distant the points are.

Grid size is critical. It must be small enough to capture the localised effects of flow over and around topographic features like hills. However, the more points a model has, the more calculations need to be made, and the longer the model takes to run. Most models are a compromise between resolution and run time.

The GCM NIWA uses for climate simulations is run with grid-points approximately 140km apart. The model makes a calculation every 30 minutes. The higher-resolution RCM covers New Zealand with a grid of points about 27km apart (about 300 boxes). The RCM makes a calculation at each point every three minutes. A future model to be implemented in 2011–12 will use points around 12km apart.

Are climate models accurate?

NIWA scientists compared simulations of past climate with actual observations, to check that their model accurately reproduced what we know about the climate from that period. It did.

Another good test of models is their ability to simulate abrupt climatic changes. A NASA model run some months after the eruption of Mt Pinatubo in 1991, using known measurements of the aerosols it released into the atmosphere, delivered an excellent fit with what actually happened to the climate subsequently.

Contact:
Dr Brett Mullan
Principal Scientist, Climate
b.mullan@niwa.co.nz

NIWA
enhancing the value of New Zealand's natural resources

NIWA (the National Institute of Water & Atmospheric Research) was established as a Crown Research Institute in 1992. It operates as a stand-alone company with its own Board of Directors, and is wholly owned by the New Zealand Government.

NIWA's expertise is in:

- Aquaculture
- Atmosphere
- Biodiversity and biosecurity
- Climate
- Coasts
- Renewable energy
- Fisheries
- Freshwater
- Māori development
- Natural Hazards
- Environmental Information
- Oceans
- Pacific Rim

NIWA employs approximately 670 scientists, technicians, and support staff. Our people are our greatest asset.

NIWA also owns and operates nationally significant scientific infrastructure, including a fleet of research vessels, a high performance computing facility, and unique environmental monitoring networks, databases, and collections.

Back cover:

A NASA satellite image of the South Island, taken on a rare winter's day in June 2006 when most of the island was free of cloud.

NIWA
Taihoro Nukurangi