Manaaki Whenua
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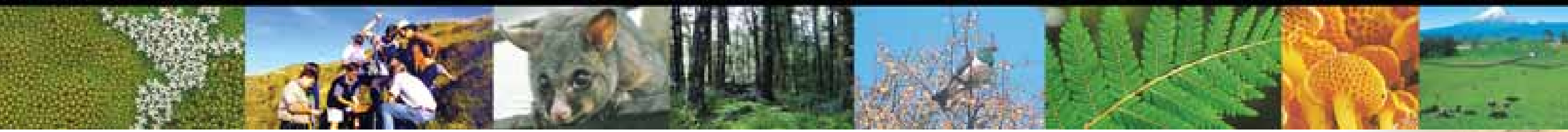
DISCOVERY



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What's Inside:

Understanding Kyoto

Few New Zealanders will have missed the media coverage on the Kyoto Protocol. It came into effect in February after months of global political wrangling. Then in June the New Zealand Government revised its estimates of greenhouse gas emissions and carbon sinks. Overnight, it seemed, the expected economic opportunity in 2008–12 had become a potential liability. Most people are struggling to understand Kyoto, its relevance to their lives, or what is being done to ensure New Zealand meets its obligation. This issue of Discovery aims to help that understanding by providing an overview of Landcare Research's science in this area.

The Kyoto Protocol aims to reduce mankind's contribution to global climate change. New Zealand's challenge is to reduce net greenhouse gas emissions to the 1990 level by 2012. Our national goal was less stringent than that of many of the 37 ratifying developed nations, but our performance since 1990 has gone in the wrong direction!

The challenge for New Zealand is much broader than meeting a net emissions target. First, we have to develop strategies for adapting to climate change and mitigating its impacts on our economy and natural environment. These impacts will not be averted by New Zealand's contribution to slowing global climate change! Second, we must redesign elements of our economy, business sector activities and activities as individuals to reduce dependence on fossil fuels and increase carbon sinks. Third, we need to quantify accurately national emissions and the carbon sinks that partially offset them.

The challenge of adaptation requires knowledge of risks and informed responses to them. On page 10 we report on how exporters in Marlborough are proactively addressing a trade risk relating to "*food miles*". On page 8 we describe the efforts of one sector, tourism, to address its role and liabilities in relation to climate change.

Hugh Gourlay

New Zealand is different from other "Kyoto" nations because half its greenhouse gas impacts come from methane and nitrous oxide, largely from ruminant animals and agricultural soils. That puts a specific onus on the pastoral industries to contribute to solutions.

A crucial part of the solution is to obtain accurate measures of our emissions and carbon sinks. Failure to do this to internationally accepted standards means New Zealand will face financial liabilities. On page 5 we describe advances by Landcare Research scientists in the measurement of agricultural emissions. On page 2 we address ways of measuring and interpreting carbon dioxide uptake by forests, leading to greater carbon sinks. On page 3 we describe world-leading science that helps us understand how forests behave as carbon sinks.

Science continues to provide the tools to understand our natural environment and how we can reduce our impacts on it. Arguably we are the best informed generation in the history of mankind. However, to attain a sustainable world in future we must first imagine it, and then make appropriate changes to see that it happens in reality. That is where science makes way for the human dimension. We conclude with a look into the future, around 2050, through the eyes of 25 "remarkable thinkers".

For more information on any of the following stories, please feel free to contact me or the people listed.

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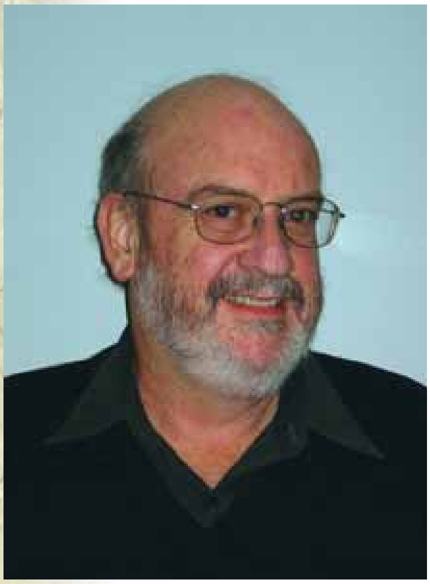
Kyoto, our position, and a sustainable future

Landcare Research scientist Dr Craig Trotter outlines New Zealand's Kyoto challenge.



Alison Fordyce

Craig Trotter

Until recently, it was thought that New Zealand would easily meet its Kyoto Protocol target of reducing total greenhouse gas emissions to 1990 levels, because of the amount of carbon stored in exotic forests planted since then. But the latest figures suggest we may not now meet our target for the critical first commitment period, 2008–2012, without reducing emissions or creating additional carbon sinks. Contributing to this deficit have been the "stronger for longer" economy, with its sustained increase in energy use by transport and manufacturing; as well as falling forest planting rates and increasing deforestation.

The Protocol rules themselves also mean that some areas of post-1990 exotic forest can't be counted as carbon sinks. To be eligible as Kyoto forests, reductions in emissions by afforestation must represent a **genuine expansion in carbon sink capacity since 1990**—that is, new forests, planted on former grassland. Exotic forests planted on cleared mānuka/kānuka scrubland can't be used to meet New Zealand's emission reduction targets, since mānuka/kānuka can itself store significant amounts of carbon, and may go on to develop into tall indigenous forest.

In principle, working out our Kyoto-compliant forest carbon storage is simple. Take the area of forest planted since 1990, subtract areas with a former scrub cover, and multiply by the average amount of carbon stored in the remaining area between 2008 and 2012. Then subtract losses from conversion of forest to other land uses since 1990.

In practice however, it is not that easy. Which forests have been planted on former mānuka/kānuka scrubland? How much carbon is in the eligible post-1990 exotic forests? Estimates are all we have at present.

New Zealand does not yet have a system of national forest inventory accurate enough for full Kyoto reporting, nor compliant with the strict Kyoto rules. Nor does it have a map of land cover at 1990. Kyoto also requires new mapping approaches, with higher levels of accuracy. Uncertainty can cost money, as we've found recently with national figures for our carbon accounts swinging from a surplus to a deficit as estimates are updated.

Resolving these issues is a collaborative effort between the Ministry of Agriculture and Forestry, the Ministry for the Environment, Landcare Research, Scion (formerly Forest Research), Canterbury University, and private forestry consultants. Landcare Research is developing the techniques required to ensure an accurate, Kyoto-compliant map can be created of land cover at 1990. It's a challenging task to recreate a map for a time 15 years ago. A wide range of existing and purpose-developed research must be brought together to provide methods for routinely processing old satellite imagery, to levels not previously attempted in New Zealand. Only once this is done will we have accurate areas for use in national carbon calculations.

To get figures for the carbon stored in post-1990 forests, about 400 plots will be established through the country. At each plot, trees are being measured, soil samples taken, and

Craig Trotter

Wanganui reversion: An example of carbon farming: allowing mānuka / kānuka reversion on steep erosion-prone hillslopes near Wanganui.

total carbon calculated, using measurement procedures developed jointly by Landcare Research and Scion. Carbon both above and below ground must be counted, in live and dead wood; in roots, woody material and leaf litter on the forest floor; and in the soil. Logistically, it's a huge job, and it must be done to a standard sufficient to pass international review.

Stepping up to the mark

So how can we meet our Kyoto commitments if our post-1990 forests haven't stored enough carbon? Obviously, by planting more, but the options are much wider than exotic forests alone. There's considerable scope for promoting indigenous afforestation. New Zealand has about 2.5 million hectares of pastoral hill country of moderate to severe erosion risk. From a long-term sustainability perspective, this area would be much better off in forestry. About 1.2 million hectares of this has remnant seed sources that should allow natural regeneration of indigenous species— possibly mānuka/kānuka, which store considerable amounts of carbon, followed by broadleaved species, and finally succession in many areas to tall forest.

Benefits through afforestation of marginal and erosion-prone land include reduced downstream siltation and flooding risk, with improvements to water quality and fisheries. Over time frames of 100 years (routine in Canada and Europe), sustainable harvesting of valuable indigenous timber becomes a possibility.

Forests and tall indigenous shrubland established to soak up CO_2 will be eligible for registration under the Government's new Permanent Forest Sinks Initiative. Landowners will get cashflow from the sale of carbon credits. Biodiversity benefits may be gained also.

New Zealand would gain both environmentally and economically through substantial afforestation. This could go a very long way to not only restoring New Zealand's ability to meet present commitments to reducing greenhouse gas emissions under the Kyoto Protocol, but would also more likely satisfy more stringent future commitments.

Funding: Ministry of Agriculture and Forestry (MAF); Ministry for the Environment (MfE); Foundation for Research, Science and Technology.

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Researchers hunt high and low for crucial carbon details

New Zealand shrublands are being identified as potentially valuable assets for meeting our international commitments on global change, as researchers scrutinise total flows of carbon dioxide into and out of our indigenous forests and shrublands – from the soil to the air above the treetops.

John Hunt

Instrumentation for measuring the net exchange of CO_2 above the forest canopy. The platform where the people are standing is 25 metres above the ground in a mature rimu forest in Okarito.

Under the United Nations Framework Convention on Climate Change, New Zealand is obliged to provide annual reports on changes in carbon storage in all our terrestrial ecosystems. In other words, how much of the carbon stored within trees, leaf litter and soil is lost to the atmosphere, and, in turn, how much CO_2 in the atmosphere is converted and stored as carbon in trees and soil? A very large proportion of the total carbon is stored in soil, so including it in measurements is critical to ensuring that our reporting meets international scrutiny.

Landcare Research scientists Dr David Whitehead and Dr John Hunt lead a project to study rates of CO_2 exchange in two contrasting types of native vegetation: rimu-dominated rainforest at Okarito in South Westland, and kānuka shrubland at Rakaia Island in Canterbury. "These two ecosystems are important for different reasons," says Dr Whitehead. "The rimu forest is finely balanced, absorbing little net carbon over a year. With expected temperature increases, it could actually become a source of CO_2, which is rather unusual. The kānuka shrubland, on the other hand, tells us about what happens during the early phase of succession back to native bush."

In 1999, a research team installed solar-powered micrometeorological instruments on towers high above the field sites, to measure CO_2 levels in the air above the trees and calculate the precise amount of carbon going into and out of the systems. The team also measured climate variables such as solar radiation, wind speed, humidity and rainfall, to help interpret seasonal variation in carbon exchange. In the forest canopy they measured photosynthetic processes in the leaves, and at the soil surface tracked the seasonal changes in soil moisture and temperature that determine how fast soil carbon is converted back into CO_2.

Dr Whitehead says the team now has the first direct, long-term measurements of net carbon exchange for both New Zealand temperate rainforest and kānuka shrubland. But most important of all is that they have captured the detail of how carbon exchange rates vary with climate and soil nutrient levels. These data are then used in computer models, providing more reliable predictions of how the annual carbon balance for these important indigenous ecosystems will likely change in various future climate scenarios.

Slow and steady growth

Results show that mature rainforest like that at Okarito is a sink for carbon, but *only just*. "A huge amount of carbon is stored in those mature native forests, but the annual rate of increase is very small," Dr Whitehead says. "Mature trees in these forests grow at an incredibly slow rate, and the loss of carbon from forest soil is high. The main advantage of indigenous forests is that they are very long-lived, and can act almost as *permanent* forest sinks. They also encourage native biodiversity."

In contrast, younger forests store carbon at much higher rates.

"The next stage in the research is to determine more precisely what happens to the rates of net carbon exchange when pasture reverts to shrubland – often the first step towards native forest," Dr Whitehead says. The team has chosen a site near Oxford in Canterbury to track those early years as kānuka and mānuka become established in retired pasture.

Dr Whitehead says the research is illustrating the benefits of long-term datasets.

"Our approach allows us to explain just why the soil-plant-atmosphere system responds with differences in carbon uptake through seasons and years. By relating these observations to detailed understanding of plant and soil processes we can better predict future trends. You can't do this sort of work with measurements over short periods.

"We need to work through several years, including extreme weather events such as droughts, to provide the key responses we need to know about."

Dr Whitehead says the team's results are now being used in advising on climate change policy.

"In future they may also help satisfy international scrutiny that the required reduction in net greenhouse gas emissions has been achieved. This has very significant financial and environmental implications for New Zealand."

Funding: FRST (Foundation for Research, Science and Technology)

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John Hunt

David Whitehead measuring the growth of rimu foliage.

John Hunt

Margaret Barbour preparing instrumentation for measuring water use by mature trees.

Honeydew reveals carbon clues

Honeydew scale insects have provided a real sweetener to scientists researching how long carbon takes to move through forests.

New Zealand's Kyoto commitments require a mechanistic understanding of processes driving carbon cycling and sequestration in our forests. There is still a poor understanding of the time required for carbon fixed in foliage through photosynthesis to be returned to the atmosphere as carbon dioxide through respiration.

Landcare Research scientists, with collaborators from the University of Canterbury, NIWA and the Australian National University in Canberra, investigated carbon movement in our native beech trees in two Canterbury forests. Sugars formed from recent photosynthesis are moved from the leaves to the roots within the phloem. Scale insects within the bark tap into these sugars and excrete the excess as honeydew. Honeydew therefore allows repeated, non-destructive access to recently fixed carbon.

Since honeydew contains sugars produced by photosynthesis, the stable carbon isotope 'signature' of the honeydew provides a record of environmental conditions at the time of fixation (stable isotopes are naturally occurring and not radioactive). Researchers used the signature to identify the time delay between carbon being fixed in the leaves and reaching the roots. Isotopic analysis of CO_2 respired by the forest allows further tracing of the carbon through the roots and soil, and back into the atmosphere.

The project leader, Landcare Research scientist Dr Margaret Barbour says it takes just three days for carbon fixed in the leaves to reach the roots.

"Demonstration of such a rapid movement of carbon in mature trees under natural conditions is an exciting new finding," Dr Barbour says.

"At one forest, most of the carbon respired by the ecosystem had been fixed within the previous few days. Surprisingly, the same process took significantly longer at the other forest.

"Clearly there were interesting differences in how these two forests function, despite the fact they have very similar species composition and climate."

Dr Barbour says the knowledge gained through this new research will improve New Zealand's capacity to construct carbon budgets for indigenous forests.

Funding: Royal Society of New Zealand Marsden Fund

Margaret Barbour

Honeydew droplet on the anal tube of a scale insect. Honeydew allows researchers to sample carbon being transported to tree roots.

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Researchers seek on-farm facts for two potent gases

Landcare Research scientists are in a race against time to measure greenhouse trace gas emissions – methane and nitrous oxide – and through measuring them, to understand how to reduce them.

While carbon dioxide is perhaps the world's most publicised greenhouse gas, nitrous oxide (N_2O) is an astonishing 310 times and methane (CH_4) 21 times more potent. As with carbon dioxide, New Zealand is required under the Kyoto Protocol to account for methane and nitrous oxide emissions above the 1990 levels.

New Zealand is among the top ten greenhouse-gas-producing nations per capita, and about half of these emissions come from the millions of sheep and cattle that produce considerable quantities of these two gases.

Landcare Research scientists are making major progress towards large-scale measurement and verification tools.

Nitrous oxide – no laughing matter

Nitrous oxide (also known as laughing gas) makes up about a sixth of New Zealand's greenhouse gas output, and represents the second largest source of emissions (after CO_2) above the 1990 level. It is generated from surplus nitrogen in soils, contributed mainly from grazing animal urine and nitrogen fertilisers. New Zealand's dairy cow numbers have increased from 3.4 million in 1990 to more than 5 million with the current boom in dairying. Also, nitrogen fertiliser use has increased sixfold.

The Intergovernmental Panel on Climate Change (IPCC) has designed a system to calculate nitrous oxide emissions throughout the world. However, it is not ideal, as it does not account for differences in climate, grazing regimes and soil type – the three main variables controlling emissions here.

Landcare Research scientist Dr Surinder Saggar leads a project to design a local version of a model for our grazed pasture systems to take account of the above variables. The team used especially designed chambers to collect nitrous oxide samples from dairy cow and sheep-grazed pastures at the Massey University commercial farms near Palmerston North, partly in collaboration with NIWA. They successfully took measurements to paddock scale and developed a model named NZ-DNDC (denitrification-decomposition) to predict emissions.

In a research breakthrough, the team has completed its first preliminary *regional*-scale measurement – for the Manawatu-Wanganui Region.

"Our map of the region shows where, and to what degree, emissions are a problem. It is vital to have such a regional model, as it enables the regional council to fulfil its Kyoto responsibilities through climate change projects and economic initiatives.

"The success with Manawatu-Wanganui means we can upscale to other regions *nationwide*, using the information we now have. The Ministry of Agriculture and Forestry provided us with information on land use, grazing regimes and livestock populations throughout the country. This and other information on climate and soil types has been added to our model database.

Mitigation

Knowing our nitrous oxide emissions is an important step towards mitigating them.

"We now have an extremely useful tool for identifying where emissions could be especially high at regional and national scales, and this will help local authorities to target mitigation efforts. We can also better assess the effectiveness of these efforts.

"Through our research, we have noticed that emission levels are far higher – up to three times higher – where there are problems with soil compaction. Levels are also one-and-a-half to two times higher where soils are very wet. We would recommend keeping stock off wet paddocks where possible, or keeping dedicated paddocks for winter."

Dr Saggar says previously there was thought to be little difference in the effects of sheep and cattle urine. "However, we found that nitrous oxide emissions from cattle urine are up to two times higher!"

Dr Saggar and his team are also researching the effects of nitrogen inhibitors, sold to farmers to reduce nitrate leaching and nitrous oxide emissions. "Research funded by fertiliser companies shows a large range of effectiveness – between 20 and 70 percent. Our research will shed light on this, because inhibitors work differently depending on soil type, soil moisture, time of year, and method of application.

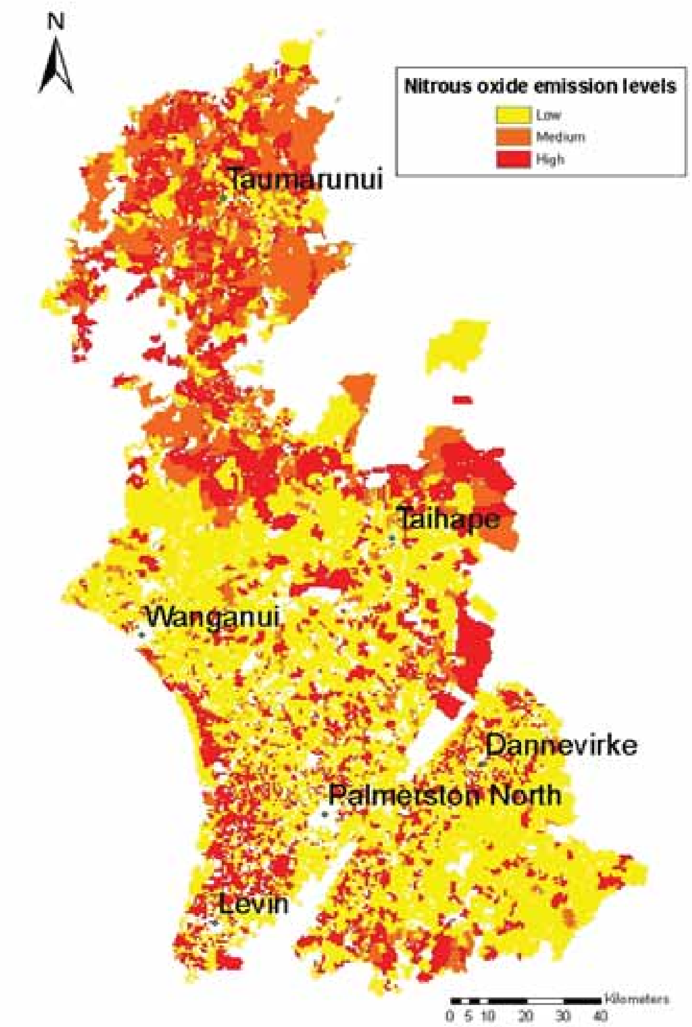
"Many farmers think that using nitrogen inhibitors means you can continue to apply more nitrogen. But that is like taking medication to reduce your cholesterol, but continuing to eat more fat.

"We still don't know how often we need to keep applying these inhibitors, or what they might do to the soil and soil organisms in the long term."

Dr Saggar says future research will uncover more about nitrogen inhibitors, and further refine the NZ-DNDC model to enable New Zealand to verify mitigation strategies.

Methane – a cow of a problem

Meanwhile, methane researchers have been grappling with a similar problem – how to obtain large-scale measurements. In what is believed to be a world first, Landcare Research scientists are measuring methane emissions at a farm scale, moving their instrumentation from paddock to paddock. As is the case with nitrous oxide, the



Map developed by Donna Giltrap

A first for New Zealand: this map shows the varying levels of nitrous oxide emissions for the Manawatu-Wanganui region. Maps for other regions are planned.

Carolyn Hedley

It has to be said - they're outstanding in their field! From left to right: Surinder Saggar; technical expert John Dando; map modeller Dr Donna Giltrap, and technical expert Suzanne Lambie. Surinder and Suzanne are holding glass vials containing nitrous oxide samples collected from special "chambers" in the paddock.

Frank Kelliher

Just part of the scenery: The measuring system for methane emissions, parked in a Canterbury paddock.

information gathered on methane can verify mitigation efforts.

Methane emissions from cattle and sheep are mainly belched (not farted as popularly supposed) as a by-product of their digestion.

Emissions vary according to animal size and the quality and quantity of feed consumed. Consequently, it is challenging to obtain an appropriate sample of animal emission measurements and scale them up to the farm's herd or flock. Landcare Research scientists Drs Frank Kelliher and Johannes Laubach have therefore developed ways to measure methane in the air within and downwind of a paddock populated by grazing dairy cattle, using relocatable equipment.

Drs Kelliher and Laubach set up a van housing a methane analyser, and air sampling and data processing devices. A seven-metre-tall, instrumented mast samples methane carried by the wind, and transmits the samples to an analyser.

Recently, a four-path measurement system was introduced. Ideally, with laser beams deployed around the grazed paddock, air sampling no longer depends on wind direction.

Dr Laubach's three methods of farm-scale measurements have been developed and corroborated against scaled-up measurements made by AgResearch of individual cows' emissions.

"For all methods, statistical uncertainty was in the order of 10%. It is pleasing that our farm-scale methods are of similar precision and accuracy to scaled-up emissions measurements from *individual* cows."

Dr Kelliher says that New Zealand-wide, and reflecting the efficiency of pastoral agriculture despite the strong shift in farming intensity, methane emissions are only about 10% above the 1990 level. The international credibility of this calculation is supported by the verification methods described here.

"We are not the only researchers measuring methane emissions on farmed animals at the herd scale. However, to our knowledge, we alone have managed to follow a rotational grazing schedule with our instrumentation. This is important, because rotational grazing is the standard feeding practice in New Zealand."

Dr Kelliher says the farm-scale methane emissions measurement method may also be useful for measuring nitrous oxide emissions from soils beneath grazed pasture. Future research will involve 100% sampling of cow emissions from a herd and a comparison with farm-scale emissions measurements to refine the uncertainties.

Funding:
For nitrous oxide research: Foundation for Research, Science and Technology (FRST), Ministry of Agriculture and Forestry (NZOnet), Summit-Quinphos, Environment Waikato
For methane research: Foundation for Research, Science and Technology (FRST)

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Science seeks solutions for tourism's climate change conundrum

In one of the first such projects in the world, scientists and the tourism industry have joined forces to assess the greenhouse gas impacts of visitors travelling to and around New Zealand. The research has enabled scientists to suggest ways to offset the high energy use generated through tourism here.

Professor David Simmons, Lincoln University

Tourism researcher on location – Susanne Becken.

International tourism to New Zealand is growing by about 6% per year, and energy demands and emissions are increasing accordingly. Carbon dioxide emissions from tourism make up about 6% of New Zealand's total (excluding international flights). A national carbon tax will be introduced in 2007 ($NZ15 per tonne of CO_2), and in the long-term global air travel might be taxed as well. These measures are of financial concern for the tourism industry, particularly the smaller operators.

Landcare Research scientist Dr Susanne Becken is leading a five-year project to find ways to reduce energy use and greenhouse emissions from tourism by promoting less energy-intensive choices. Dr Becken and colleagues from Landcare Research and Lincoln University have been working with an advisory group including the Tourism Industry Association, various businesses and regional and government tourism agencies to research tourists' travel patterns. The team also conducted numerous tourist and business surveys and workshops.

Dr Becken says tourists usually arrive by plane, travelling on average 12,000 kilometres one way. "Also, New Zealand is a 'touring' destination. Once here, visitors tend to drive long distances, usually in rented cars and campervans.

"Coach tourism is particularly fuel-hungry, due to an ageing fleet, long travel distances and low passenger ratios."

Dr Becken says there is scope for reducing tourists' travel distance through encouraging regional tourism. Most visitors currently factor in three to five travel hours per day. Also, tourists tend not to be well-versed on the climate change impacts of their travel.

"Nevertheless, they are potentially interested in mitigation efforts such as tree-planting schemes, for that 'feel-good' factor," Dr Becken says. "There is scope for 'green marketing' that could provide a competitive advantage for New Zealand.

"However, tourist operators also tend to be poorly informed about energy efficiency and climate change.

Dr Becken says the Tourism Industry Association strives to increase environmental awareness of tourism operators, "but businesses are wary of adopting measures that may impact on their already small profit margins, in a fiercely competitive market.

"We need new initiatives that consider climate change issues and promote profitable and sustainable tourism development."

Making it better

Dr Becken says a long-term mitigation option would be to improve the energy-efficiency of vehicles.

"Continuing improvements in fuel efficiency are expected, and international research is underway to develop motors that do not use fossil fuels. In the short to medium term other initiatives are needed.

"The offsetting or sequestration of CO_2 in native forests is an attractive option. The total area required to offset all emissions from international tourism in New Zealand is just over a million hectares. This could cost as little as $40 per international tourist, or 1% of what they spend in New Zealand.

"As it happens there are about one million hectares of marginal land potentially available for native forest regeneration, so it is *just* possible to offset tourism's emissions.

"Restoring native shrubland would also boost native biodiversity. That in itself may create additional tourist attractions around restored native forest areas, underpinning the '100% Pure New Zealand' brand.

"This mitigation option would also buy time for the tourism industry to come up with more effective energy use, to fulfill the tourism industry's own goal of moving towards carbon neutrality."

Although the challenges seem daunting, Dr Becken has some encouraging words.

"Few countries have as good a grasp of the impacts of tourism as New Zealand. Through measuring as we have, we are much better placed to manage tourism's effects."

Funding: FRST (Foundation for Research, Science and Technology)

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Fiji faces tourism's double-edged sword

While tourism impacts on climate change through transport and energy use, climate change also impacts on tourism – especially in flood-prone, drought-prone, mountainous or coastal areas. Fiji is vulnerable to hazards related to climate change such as tropical storms, flooding, erosion, and interruptions to transport and communication.

Dr Becken and students and staff of the University of the South Pacific worked with Fiji's Government to assess climate change adaptation and mitigation options for tourism, and help determine policy directions. The research team held surveys and talked with tourism operators about changes they are seeing.

The most severe and immediate risks are from cyclones and storm surges, but in the long term, sea level rise and coral bleaching pose substantial risks to tourism. Dr Becken says there was previously no sector-wide strategy to address these risks. She recommends adding more climate change content in university courses, and says more information is needed on how to make tourist areas less vulnerable. "Some businesses are erecting cyclone-proof structures, and planting trees for shade and to reduce reliance on air conditioners. However, there is a general lack of capital to fix problems. For example, some sites are ideal for wind and solar power but few operators can afford to install it."

Ironically for an island nation, Fiji is grappling with water shortages. "Fiji has a dry season, which is predicted to become more frequent. However, tourists want showers and swimming pools, and grass kept green by irrigation.

"Rainwater collection has begun in some smaller islands. Others try to gain more water through desalination of seawater, but this is expensive and energy-intensive."

Dr Becken says climate change lessons learned in Fiji can also be applied to New Zealand. "Eastern regions are expected to become more drought-prone. Already in Canterbury there is competition between agricultural and tourism interests for water resources. Measures such as rainwater collection could soon become very pertinent in New Zealand."

Funding: European Union Development Grant through the University of the South Pacific; FRST (Foundation for Research, Science and Technology)

Susanne Becken

A stark example of Fiji's sand erosion. This pavilion was once level with the sand.

Research to help vital services run in all weathers

We need robust infrastructure to cope with climate change effects – but how does climate change affect our infrastructure? A pilot study for Hamilton is helping us find out.

New Zealand Centre for Ecological Economics Principal Ecological Economist Dr Nigel Jollands is leading a project called CLINZI – Climate's Long-term Impact on New Zealand Infrastructure systems. Most research on climate change looks at human impacts on climate, but CLINZI is one of the first to investigate climate's impact on infrastructure. Researchers aim to help planners and government to manage risks and plan investments.

Infrastructure systems and services include flood control, water supply, energy distribution, transport, and public health services. Without these our economy would collapse. Research overseas has shown that costs of possible damage to infrastructure because of climate change would be the same or larger than damage to agriculture.

Dr Jollands teamed up with researchers including world-leading ecological economist Professor Mathias Ruth from the University of Maryland, who worked on a similar project in Boston; Environment Waikato and CSIRO (Australia's Commonwealth Science and Industrial Research Organisation). The team developed methods to capture socioeconomic changes such as population growth and relate them to predicted climate dynamics such as increased rain and temperature to predict their possible effects on the cost and reliability of infrastructure. They focused on Hamilton for "proof of concept", and presented their findings to local government and industry leaders.

Dr Jollands says the project demonstrated CLINZI's usefulness. While Hamilton appears robust to gradual climate change impacts on infrastructure, it will experience potential increases in water turbidity, and will need more frequent repairs to roads because of flooding.

The team concluded that population increases would likely put more pressure on the city than climate change would.

Future CLINZI research is likely to focus on the Hauraki Basin, which has multiple local authorities, and more complex development pressures and flood risks than Hamilton City.

Funding: FRST (Foundation for Research, Science and Technology), Environment Waikato. CSIRO (Commonwealth Scientific and Industrial Research Organisation)

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Image courtesy of Environment Waikato

Hamilton: Pembroke St and Lake Rotoroa as viewed from hospital.

Forests become focus for future-proofing Marlborough

"What's all this nonsense about climate change got to do with my business?" This blunt phone inquiry has resulted in a multi-pronged project with champions from many sectors of the Marlborough economy.

When Queen Charlotte Sound eco-tourism operator Ron Marriott made this phonecall to Ian Turney at Landcare Research, little did he expect that some years later "the Marlborough Story" would be taken to international forestry negotiations at the United Nations.

The story goes like this. Forests act as carbon sinks by taking carbon dioxide from the atmosphere and fixing the carbon as wood. As long as the forest continues to grow the carbon sink continues to function. On average, 140 tonnes of carbon are stored in every hectare of native New Zealand forest.

If the forest is made up of species typical of the area, then it has biodiversity value. It may have landscape and cultural values, too.

The forest will contribute to erosion control on susceptible slopes. And soil runoff into streams and estuaries will be reduced compared to forests that are clear-felled.

This is a forest that provides multiple benefits. In Kyoto Protocol discussions, such multiple benefit forests are fast becoming essential, not just desirable, for countries planning to trade forest-based carbon credits.

But what does that mean to Ron Marriott and his eco-tourism business? Two things: firstly, he can restore native forest on his land and get revenue from selling the carbon credits. And secondly, he can promote his business as offsetting its greenhouse gas emissions.

Mr Marriott's "green" business is particularly interesting to his visitors, who tend to be concerned about the natural environment. Moreover, there was something in this story for all Marlborough's exporters.

Enter Tony Smale of the Marlborough Regional Development Trust. Mr Smale quickly got his head around the story and saw the implications for the region of what is known as the "food miles" issue. "It's not yet discussed much in New Zealand, but type 'food miles' into 'Google' and you'll find thousands of references, especially in Europe, where labelling 'country of origin' is likely to become mandatory," says Mr Smale.

Why the interest in that? Well, it comes back to climate change and the greenhouse gas emissions caused by shipping produce to market. "Our wine, seafood, fruit, and tourists are shipped about 20,000 kilometres

Ron Marriott

Larry Burrows

An example of environmental benefits that can come out of the opportunities identified in the Marlborough project. This is Queen Charlotte Wilderness, a registered EBEX21® forest regeneration site. These photos are taken approximately 5 years apart, and illustrate forest regeneration in action. The site is used for sequestering carbon, which earns carbon credits which can be sold, hence providing an alternative land use revenue.

to market – that puts us at risk of having to confront trade barriers," says Mr Smale.

"This is a risk for our exporters, and we want to be proactive in dealing with it. We're far better to address the issue here."

So the three men talked to the major export sectors and quickly found a group of champions to work on a plan of action.

"It's a great story to tell," says Mr Smale. "Our exporters are getting help from Landcare Research to both measure and reduce the emissions from producing and shipping their products. Then we have the option of paying a relatively small amount to have the remaining emissions offset by restoring native forest in the region.

"This way, we can promote our products as being CarboNZero® through reducing emissions and regenerating multiple-benefit forest in the EBEX21® programme".

The EBEX21 forest programme is a working example of the government's proposed Permanent Forest Sinks Initiative, for encouraging landowners to create more carbon sinks. And it was EBEX21 that the Minister for Economic Development referred to in his speech at the United Nations Forestry Forum in New York in May 2005.

The Marlborough Story has drawn in many other players, from schools and a hospital, to producers of low-energy light bulbs and wool-based home insulation products. There is a region-wide network of champions who see the value in being proactive about climate change. "It's about seizing opportunities and managing risks and costs," says Mr Smale, "and it seems to work best from the bottom up, when our people are supported by organisations such as Landcare Research."

For more on EBEX21® and CarboNZero® see www.ebex21.co.nz.

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Scenario researchers explore the future

For us to be able to discuss the future of New Zealand, it must first be imagined. A new Landcare Research project has taken bold steps in this direction, without simply projecting past trends forwards.

Thinking about the future is difficult. The image we construct in advance and what eventually happens is seldom the same, and forecasts from trends are often wrong.

Scenario building provides a *range* of possible futures, based on information from divergent trends. Unlike forecasting, scenarios embrace uncertainty. They provide a framework for discussions about the future, and lead us to question our values and assumptions. Scenarios may also sensitise us to early signs that may eventually influence public opinions or become major trends in their own right.

Dr Bob Frame at Landcare Research is leading a project on sustainability scenarios. Dr Frame is supported by Christchurch sustainability researcher Rhys Taylor, and one of Australia's leading futures strategists, Kate Delaney. The key question: can we meet our needs today without compromising the ability of future generations to meet their needs?

The researchers assembled a working group of 25 people, mainly policy staff from government agencies, universities, and the commerce sector. Over several months, the group developed four fictional (but plausible) futures for New Zealand. They paid special consideration to modes of

Susanne Becken

A brainstorming session for the scenario builders. From left to right: Andy Reisinger, New Zealand Climate Change Office; Bruce Bassett, Ministry of Tourism; Bob Frame (at the easel); Francois Barton, Ministry for the Environment and Fiona Luhrs, Tourism Industry Association of New Zealand.

government, national and cultural identities and the country's resources.

The four scenarios range from an increasingly insular society that finds little benefit in diversity, to one where multi-cultural aspects are central. Between these extremes, the natural environment, upon which so much of our economy depends, either comes under increasing stewardship or is subjected to increasing exploitation.

"We believe the seeds for each of these scenarios are present in New Zealand today," Dr Frame says. "The actual future is unlikely to match any exactly, but it will probably fall within the possibilities the scenarios explore.

"The New Zealand of today appears to be heading towards Scenario B. However, we do not identify any one scenario as more likely than any other.

"Each scenario assumes environmental degradation, relative to today. Participants were keenly aware of climate change issues for example, and a sense that environmental resources are finite.

"Demography, culture and ethnicity emerged as important factors also affecting the way we use resources. Sustainability is not just about economic and environmental resources, but social structures as well.

"On the other hand, there is also awareness that New Zealand is a small player on the global scene, and that we will be greatly influenced by events abroad."

Dr Frame hopes the project will stimulate open, well-structured debate on the range of issues raised by the scenarios.

Researchers plan to refine and extend the scenarios through input from policy staff in the health, education, tourism and transport sectors, with particular focus on how global catastrophes may affect sustainability.

THE FOUR SCENARIOS

A: THE SHIRE

Geopolitical instability and cultural/social change override incentives for economic globalisation. However, New Zealand is marked out from other countries by a strong shared national drive for a sustainable lifestyle. Continued material growth is seen as unsustainable, and individuals strive to preserve nature for future generations.

B: *HOMO ECONOMICUS*

Market orthodoxy holds sway, with a global bias for consumption. 2055 sees intensified economic competition and interdependence with other countries. Resource limitations are disputed because substitutes are still being found whose costs can be externalised – although some come back to bite.

C: LIVING ON N°8 WIRE

New Zealand reacts too late to sustainability challenges, and science and industry lag behind. People pursue personal wealth, and environmental quality and sustainable development are distant memories. Ecosystems start to collapse through long-term overloading. New Zealanders then must adapt and restore, and live on N°8 wire.

D: FRUITS FOR A FEW

Globalisation and open markets benefit only some nations, businesses and people. Most are casualties and relatively powerless. New Zealand has little ability to shape world views on sustainable development, which are firmly embedded in global business thinking. Our sustainability debate has however broadened to include social, economic and cultural aspects. Rather than a series of negative trade-offs and constraints, sustainability is seen as crucial to prosperity and growth by 2055.

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