Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 10 / MAY 2022

Biodiversity & biosecurity

Science for Aotearoa's unique ecosystems

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to Issue 10 of *Pūtaiao* ('science' in te reo Māori), our quarterly publication showcasing the work of our scientists at Manaaki Whenua.

We are the Crown Research Institute for our land environment, biosecurity and biodiversity, climate action and people's relationship with the environment. We have a clear responsibility to Aotearoa New Zealand: this land, and everything that shares it with us, is our future.

Each issue of *Pūtaiao* shares the benefits and outcomes of our science in helping ensure a sustainable, productive future for Aotearoa New Zealand. In this issue many of the stories focus on science to enhance our biosecurity and biodiversity – important aspects of research delivery and impact at Manaaki Whenua.

In this issue we highlight our progress supporting Aotearoa New Zealand's predator-free ambitions, including early work on developing novel species-specific toxins and the particularly tricky problem of mouse eradication. We show how our micro-organisms collection contributes to national biosecurity as well as being a potential source of future valuable antibiotics and other as-yet undiscovered beneficial compounds. We also summarise our research on Covid-19, when our social scientists and ecosystem modellers were able to pivot from the study of environmental decision-making and predator-prey research to epidemiology and compliance with public health directives.

Other stories showcase our work in soil erosion control, progress in research into Myrtle Rust, and a fascinating tale about the genetic origins of invasive rats.

Cover image by Samuel Purdie: Aoraki/Mount Cook giant wētā (Deinacrida pluvialis) feeding. This species has declined dramatically across most of its range and is now only known in good numbers at a single location.

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ICMP: the good of small things

Manaaki Whenua is the custodian of almost a third of Aotearoa New Zealand's Nationally Significant Databases and Collections. These include biological resources such as reference species collections, and are important scientific, cultural and historical public assets.

The International Collection of Microorganisms from Plants (ICMP) is one of just three major international collections for plant and soil bacteria, with living cultures of more than 22,000 strains of bacteria and fungi from plants and soil across Aotearoa. These cultures not only help to identify and manage potential biosecurity incursions, they can also be screened for potential future uses in, for example, pharmacology. The following examples show how detailed knowledge of microbial taxonomy and cultures can have unexpected and highly beneficial outcomes.

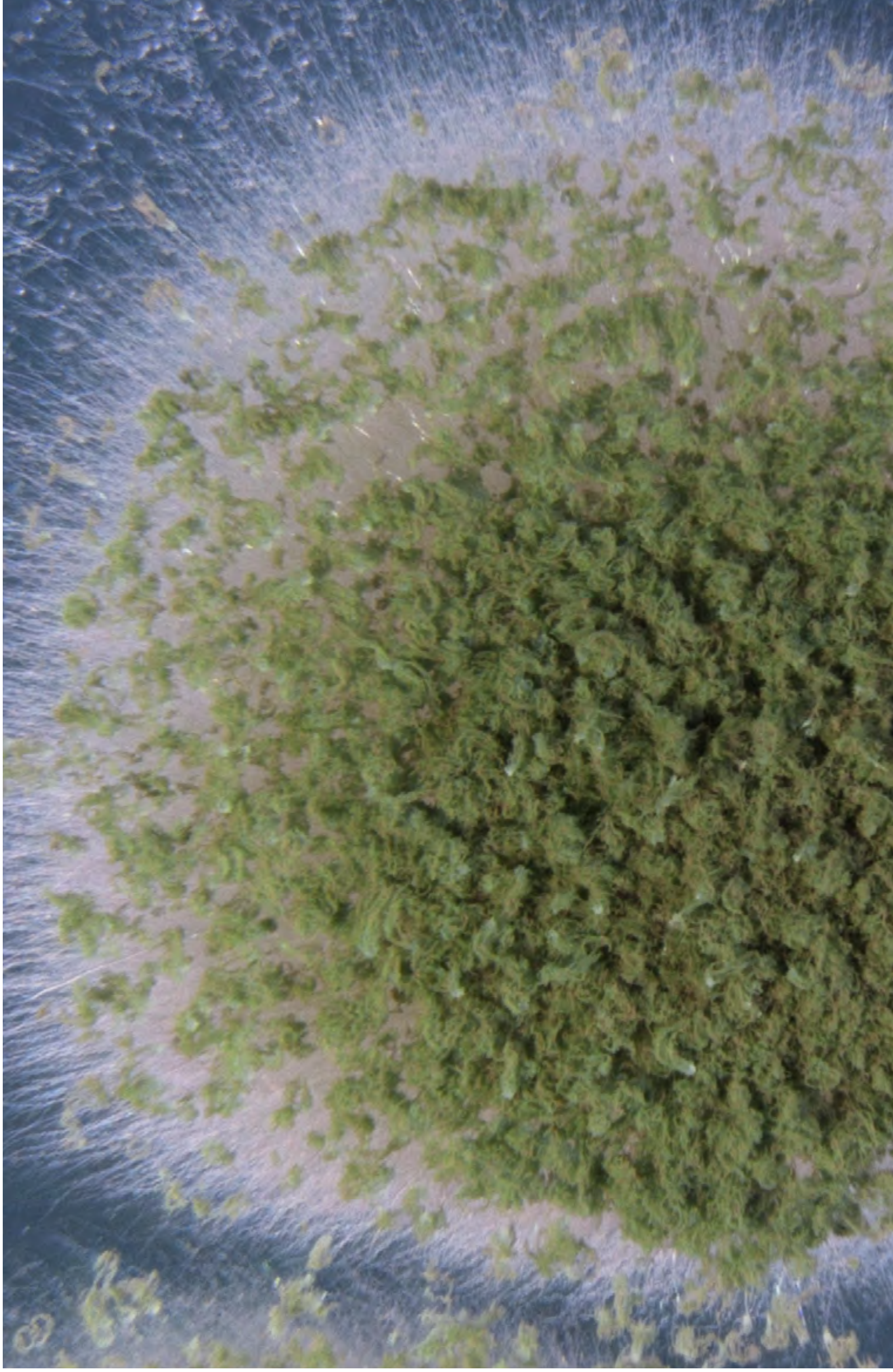
Manaaki Whenua's Dr Bevan Weir and collaborators from the University of Auckland have recently screened several fungi from the ICMP collection and identified two strains of *Penicillium (P. bissettii* and *P. glabrum*) which showed antimicrobial activity against the bacteria *Escherichia coli, Klebsiella pneumoniae* and *Staphylococcus aureus,* all three of which can lead to serious infection in human beings. Further investigation into the natural products of the fungi led to the isolation of five known metabolites: penicillic acid, citromycetin, penialdin A, penialdin F, and myxotrichin B. Although these strains of *Penicillium* may not be native to Aotearoa, knowing that such chemicals can be derived from natural products is an important step in developing, with our Te Tiriti partners, potential future indigenous IP from native species.

Further investigation of the antimicrobial activities of the natural products and derivatives showed that both penicillic acid and penialdin F inhibit the growth of Methicillin-resistant *S. aureus* (MRSA) – an antibiotic-resistant bacterium common in hospitals and nursing homes, where people with open wounds, catheters, and weakened immune systems are at risk of infection. Although none of the natural products or their derivatives showed enough antimicrobial activity to be of interest as lead compounds for antibiotic development, the study proves that the ICMP collection remains a vast untapped resource for novel bioactive natural products that is worthy of further exploration.

The ICMP again came into its own in August 2021, when the Aotearoa flower bulb industry became concerned about a possible change in our national biosecurity response after visual detection of mould on a minority of imported lily bulbs. Manaaki Whenua's Drs Peter Johnston, Bevan Weir and Peter Buchanan, with Duckchul Park, helped to alleviate disruption of trade at the border by liaising with a concerned importer and with MPI.

Earlier in 2021, MPI had already commissioned Dr Johnston to prepare a literature review updating knowledge of all recorded species of *Penicillium* in Aotearoa, including collation of species yet to be recorded here. Building on this essential groundwork, Dr Buchanan worked with an affected bulb importer and with MPI to seek further understanding of the detected new fungal species on the bulbs. MPI agreed to have the organism's DNA data reassessed by an overseas expert on *Penicillium* taxonomy. The data matched *Penicillium mali-pumilae,* a species already known from bulbs but not previously recorded in this country.

This was initially bad news for the importer, but then our staff at the ICMP were able to deliver much better news. Isolations were also taken from a sample of Aotearoa-grown bulbs. These samples contained the same



A Penicillium *culture at the ICMP.*

P. mali-pumilae, showing that it did already exist in Aotearoa and potentially supporting a relaxation of restrictive measures on bulbs affected by surface mould at the border.

Although *P. mali-pumilae* is not listed in the Official New Zealand Pest Register with a regulatory status, MPI is currently assessing the status of the *Penicillium* genus as a whole. The incursion investigation outcome on this species will be reported in *Surveillance Magazine:* Volume 49, Issue 2.

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HTTPS *doi.org/10.3390/molecules27010240*

Using genomics data to unlock precision pest control

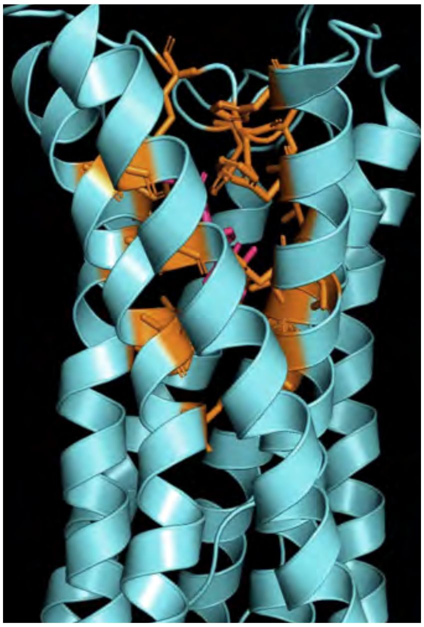
Pest control of invasive mammalian species – rats, mice, stoats, possums, and the rest – is a key priority for Aotearoa New Zealand to prevent further decline of our iconic, endangered native species, and to support the Predator Free 2050 initiative. One limitation of current vertebrate toxins for pest control is that they are relatively broad-spectrum. Although risks to non-target species are carefully mitigated when these toxins are used, there remains a critical need to expand our toxin toolbox by developing new, highly pest-specific toxins.

Toxins work by altering normal chemical pathways in animal or plant cells, disrupting the cellular proteins or processes critical for life. Toxins can be species-specific at a molecular level through having different absorption and processing properties between species – this is why chocolate, which contains a chemical called theobromine, is poisonous to dogs at relatively small doses; dogs can't metabolise theobromine effectively, whereas in people it acts as a mild stimulant.

As part of early research into species-specific toxins at Manaaki Whenua, Dr Erica Hendrikse is using *in silico* (computer-based) modelling to identify potential molecular targets in a range of mammal species that could show promise in the eventual development of species-specific toxins.

Dr Hendrikse's work is taking advantage of recent advances in the sequencing of the genomes of several key mammalian pest species – stoat, ship rat and possum. The complete stoat genome, with over 2.4 billion DNA bases and more than 20,000 identified protein-coding genes, was deciphered and published in 2020 by an international collaboration led by Manaaki Whenua's Dr Andrew Veale.

As a key approach for the project, Dr Hendrikse is developing methods very similar to the ways antibiotic screening is done in the pharmaceutical industry. Screening and comparing "protein target libraries" of various species' genomes enable proteins to be pinpointed that are critical for life and differ between species.



Computer-generated 3D protein structure.

The initial focus is on the G protein-coupled receptor protein family, as these are commonly used as therapeutic targets for human medicine, are already studied extensively and are relatively well understood. Once a promising genetic sequence is identified, high-performance computing is then used to enable it to be modelled in 3D, to visualise how it compares to similar protein structures, and to understand what chemical actions it controls. This underpinning work helps to ensure that any eventual toxins are as humane as possible.

An important question arises: how different do proteins in different genomes have to be, to enable a toxin to eradicate a pest but leave a non-target animal unscathed? Animals can respond differently to toxins or medicines when their proteins vary by as little as one amino acid. However, to be confident that any potential toxins are as specific as possible, Dr Hendrikse is particularly interested in protein targets that are noticeably different between species. More difference makes it more likely that a toxin would have little or no effect on non-target species but would be lethal to target species, even at low doses.

For Dr Hendrikse, this research is an exciting voyage of discovery. “The interesting part of this work is that we are bringing together many different areas of science, from human drug discovery to genomics and conservation biology. This is an innovative approach to finding potential new pest-control toxins. We are taking steps towards new ways of undertaking effective pest management, which will encourage our native species to recover and thrive.”

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Ancient DNA provides a fascinating insight into Aotearoa's rodent history

Aotearoa has at least 34 species of introduced mammals with established feral populations. For some of these introduced mammals we have reasonable documentation about how and when they arrived because they were deliberately introduced, but for those that snuck their way uninvited to our shores in the bowels of ships (mice, ship rats, and Norway rats) we often have little hard evidence of their history. These commensal rodents can often tell us more about our own history than can the sparse documentary records available.

Manaaki Whenua researcher Dr Andrew Veale and Prof Carolyn King from University of Waikato have led several papers examining the genetic ancestry of mice in Aotearoa revealing a complex history of multiple introductions from across the globe. The genetic ancestry of ship rats and Norway rats has similarly been investigated by Prof James Russell (University of Auckland) and colleagues.

These studies threw up unusual results that were difficult to explain from the historical record. How, for instance, did unusual hybrid European/Asian mice arrive in the south of the South Island and on Chatham Island? How did Norway rats from China arrive in the South Island while British Norway rats invaded the North Island? Most shipping to the early colony of New Zealand came via the port of Sydney, so perhaps the answers to these questions could be found there. However, given rodents must have arrived multiple times, and there may have been population fluctuations since their original introductions, ideally these questions need to be answered examining rodents from Sydney from the 19th century.

In a new paper out in *Biological Invasions*, Dr Veale and Prof King teamed up with archaeologist Dr Wayne Johnson and ancient DNA specialist Dr Lara Shephard (Te Papa) to find out what the DNA extracted from ancient rodent bones recovered from archaeological sites in Sydney's old port could tell us about our history. From these long-buried bones, they identified six genetic sequences of Norway rats, showing either multiple early introductions or a diverse initial founding population. One of these was identical to some modern sequences in Australia, and had a sequence common in the North Island of New Zealand, but none was like the Asian sequence found throughout the South Island.

They found three sequences of mice all belonging to the dominant European subspecies established in Australia. This subspecies is also present throughout Aotearoa, with similar sequences found throughout most of the country. Again, no Asian ancestry was found in the mice.

These results support the theory there was early undocumented ship traffic direct from Canton to the south of New Zealand, bringing with it Chinese mice and rats. Given the timing and early invasion evidence, this was earlier than Chinese immigration to New Zealand

related to the Gold Rush in the mid-1860s, and was probably related to the fur trade in seal pelts.

These results provide tantalising evidence of our early colonial history, and also show that (given the apparent continuity in genetic ancestry from ancient rodents to the modern populations in Sydney) we can probably rely on modern DNA to provide evidence for the original invaders.

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Above: Storage facility for the bones archive, Sydney Cove Authority. Left: Identifying rat bones from Box 1092, Bag 56,298. Photos: C M King, University of Waikato.

Hungry mice deplete biodiversity of ecosanctuaries

If it weren't for the mice, then caterpillars, spiders, wētā, beetles and even earthworms would be abundant in Aotearoa New Zealand's ecosanctuaries.

This is the finding of Manaaki Whenua researchers Corinne Watts, John Innes, Deborah Wilson, Danny Thornburrow, Scott Bartlam, Neil Fitzgerald, Mark Smale, Gary Barker, and Mahajabeen Padamsee, who recently published their research in the *New Zealand Journal of Ecology* on the impacts of house mice in an ecosanctuary.

House mice are one of the most widespread invasive mammals on the planet, owing to their rapid population growth rate, varied flexible diet, and close association with humans. While larger predatory mammals keep mouse numbers in check, in areas where mice have no other predators and there is abundant food, populations can rapidly increase and cause substantial damage to the biodiversity of the area.

Over 5 years, researchers examined the impacts of mice alone on biodiversity at Sanctuary Mountain Maungatautari south of Cambridge, Waikato, by comparing two independently fenced forest blocks, one with relatively high numbers of mice (up to 46 mice per hectare) and one where mice were almost undetectable.

Midway through the project, the treatments were reversed. Mice were eradicated from the first site, and allowed to increase on the other. During the project, 42,639 invertebrates were caught in pitfall traps and tracking tunnels were used to detect the footprints of wētā.

The researchers found strong evidence that mice reduced the abundance of ground-dwelling invertebrates, in particular caterpillars, spiders, wētā, and beetles, and reduced the mean body size of some taxa. In addition, earthworm abundance, biomass and species richness increased as the

Male Auckland tree wētā / tokoriro (Hemideina thoracica).

mouse population decreased in one study block.

But it wasn't all good news, as invasive earthworm species made a faster recovery in abundance and biomass compared with native species.

Mice are also a nuisance in ecosanctuaries, because as well as being predators they interfere with monitoring and pest control devices targeting other species. They potentially create burrows that jeopardise pest fence integrity, and attract other predators into the ecosanctuary.

Lead author Dr Corinne Watts says while the primary object of restoration in Aotearoa New Zealand ecosanctuaries is often to restore pre-human ecological interactions and processes as much as possible, it is not about increasing the abundance of all taxa. "Overall, there is substantial biodiversity gain from eradicating the full suite of pest mammals despite mice remaining afterwards. Mice may be catastrophic, however, in ecosanctuaries that focus on the recovery of lizards (e.g. Otago skinks) or invertebrates (e.g. wētā). Nevertheless, we look forward to improvements in mouse control tools to enable the future eradication of mice from large, rugged forest reserves such as Maungatautari."

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How destructive could myrtle rust be to our trees?

Aotearoa New Zealand has 37 native Myrtaceae species, including pōhutukawa and rātā, mānuka and kānuka, ramarama and swamp maire, of which 25 are endemic. But there are many other non-native myrtle species in New Zealand, including eucalypts, feijoa, bottlebrushes, lilly pilly, and monkey apple.

Being able to quantify how important Myrtaceae are in New Zealand is important because some Myrtaceae species continue to be threatened by myrtle rust, an invasive disease caused by the fungal pathogen (*Austropuccinia psidii*), that found its way here from its native South America in 2017.

This is just what Manaaki Whenua ecologist Dr Insu Jo has set out to do. With the help of researchers including Peter Bellingham, James McCarthy, Tomas Easdale, Maj Padamsee, Susan Wiser, and Sarah Richardson, the team analysed data from a nationwide forest and shrubland inventory collected from 2009 to 2014.

"Myrtaceae occurred in 74% of the plots we looked at," says Insu. "And we found its importance value, determined by abundance and species richness, was the second highest after Nothofagaceae, also known as the southern beeches."

The results of the study, published in the *Journal of Vegetation Science,* also discussed the potential role of Myrtaceae as a relatively stable carbon store in local woody ecosystems. The study compared functional plant traits such as wood density with other co-occurring woody families and the significance of Myrtaceae woody climbers, of which six of the eight known Myrtaceae climbing species in the world are endemic to Aotearoa New Zealand.

Researchers are only beginning to understand the differences in susceptibility at a species or even individual level – like with COVID-19, some individuals are more hard-hit than others.

"We cannot definitively predict how myrtle rust will impact forest composition and ecosystem processes yet," says Insu. "It's important to remember there is no functional equivalent, especially in terms of carbon storage, if they are lost. There will potentially be large and deleterious outcomes in forest ecosystems if taxon-specific pathogens, such as *Austropuccinia psidii,* spread and significantly reduce the species."

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HTTPS *onlinelibrary.wiley.com/doi/10.1111/jvs.13106*

Wetland vegetation: the plots thicken

Manaaki Whenua's wetland research team is currently working towards a 'classification' of wetland vegetation. This will turn hundreds of wetland data plot sheets into sets of recognisable 'communities', which can then be linked to soil nutrient gradients.

This work will be invaluable for local and central government agencies that monitor wetlands to understand how the vegetation at sites they administer fit into the national context, and to be able to pick up changes in nutrients in the wetland vegetation.

The project builds on work by Susan Wiser and colleagues who classified the vegetation of Aotearoa New Zealand, but found little data on wetland communities.

To remedy this, the first step was to prioritise sampling. Robbie Price undertook a spatial assessment of data representation across the country by climatic zone using existing data sourced from councils, the Department of Conservation, and a remotely-sensed spatial layer of wetland extent. He found several areas that had plenty of wetlands, but no plot data. In response, the wetlands team selected the eastern South Island and central mountain area of Aotearoa to prioritise for gathering extra data and undertook two field trips in early 2022.

A team comprising researchers Bev Clarkson, Scott Bartlam, Alex Fergus, and Olivia Burge, worked from Dunedin to Christchurch on the eastern side of the Southern Alps for the first trip. "We had big days and lots of logistics – doing plots in multiple wetlands each day, lots of driving between sites, making sure to arrive in rural towns early enough to find dinner still available, then do wetland record sheets and prep gear in the evenings," says Dr Burge. "This trip was valuable as it brought our Hamilton and Lincoln wetland ecologists together to share best practice and expertise."

The second trip happened during the Omicron outbreak, so ecologists Gretchen Brownstein and James Arbuckle from Manaaki Whenua's Dunedin site joined the team, instead of the Hamilton staff. This trip involved travelling to wetlands that were more

remote than the first, and had fewer non-native species. Sampling pristine, remote wetlands is vital to build an understanding of ‘reference’ conditions, against which councils can judge human impacts in any wetlands they monitor.

For researcher Bev Clarkson, collecting the new South Island data has been a great chance to compare North Island wetlands, in which she has done extensive work and eastern South Island wetlands. “‘Wetland types and typical ’indicator’ species in eastern South Island and northern North Island (Waikato) revealed many similarities, such as swamps with *Carex secta*, and salt marshes with oioi (*Apodasmia similis*).

“However, there were some notable contrasts - the large, raised lowland bogs characteristic of the Waikato, areas such as Kopuatai, were absent. Instead on our trip we found a wider range of fens, inland saline and ephemeral wetlands, some with especially fascinating turf communities containing threatened species, including *Gratiola concinna* (formerly known as *G. nana*).”

Dr Burge adds that the team has previously tried to calculate national ‘thresholds’ for human impact in terms of nitrogen and phosphorus but did not have enough data from pristine wetlands to establish a baseline, despite this being a highly sought-after metric for councils. “The next step for the project is to calculate how many extra sampling plots are needed to create a full picture of wetland reference conditions, after the data from this trip are analysed,” she says.

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Landslide victory: using satellite data to spot dammed rivers after the Kaikoura quake

Just after midnight on 14 November 2016, New Zealand experienced its most powerful and complex seismic event since the 1855 Wairarapa earthquake. Initially centred close to Culverden, north Canterbury, the magnitude 7.8 quake triggered a complicated series of northward-spreading fault ruptures. The ruptures caused significant vertical and horizontal land displacements and widespread damage to land, buildings and transport links along the Kaikoura and Marlborough coast and as far north as Wellington and the lower North Island.

The quake also caused around 30,000 landslides of varying sizes across 9,600 square kilometres of north Canterbury and Marlborough, ranging in size from a few cubic metres of material to tens of millions of cubic metres of soil and rock. Some of the landslides dammed rivers, with associated lakes quickly appearing.

Following a large hazard event, detection and monitoring of landscape changes is very important for disaster planning, mitigation, and prevention, especially if one hazard may trigger others. The lakes, most of which formed in steep valleys in remote areas, created a potential hazard for upriver and downriver communities and infrastructure, with the dam debris prone to sudden breaching and overtopping.

At the time, GNS Science undertook low-level aerial surveys of the landslides and new lakes, which were invaluable for managing the situation on the ground. More recently, Manaaki Whenua's Raphael Spiekermann and colleagues from the University of Salzburg have investigated whether satellite data could provide an automated and easier way of collecting information about landslide-dammed lakes.

High-resolution Sentinel-2 satellite imagery, which is updated very regularly, allows both the mapping of surface water and analysis of change through time. In addition, since 2016 the handling of big Earth observation data has become easier and more straightforward thanks to cloud computing platforms such as the Google Earth Engine.

Spiekermann and colleagues tested whether a mosaic of monthly images from the Sentinel-2 satellite system could be combined with other data sources to detect and monitor landslide-dammed lakes automatically at a regional scale.

Challenges included having to correct the data for cloud shadows, steep hillside shadows, and false-positives – snow cover, farm dams and river margins being incorrectly detected as new lakes. Nonetheless, with imagery of 10-m spatial resolution, dammed lakes larger than 300 m^2 on relatively flat terrain were swiftly mapped and detected with reasonable accuracy. Although not yet a substitute for low-level aerial flyovers immediately after a hazard event, where data were sufficient and interpretation was unambiguous, this method allowed low-cost detection of landslide-dammed lakes, and monitoring of those often-ephemeral lakes to reveal changes over time.

Landslide-generated lakes on the Leader River, North Canterbury, in 2019.
Photos: Anne-Laure Argentin, Department of Geography and Geology, University of Salzburg.

Raphael Spiekermann is pleased with the results so far. "This study aimed to demonstrate how open-source Sentinel-2 imagery combined with the computing capacity of the Google Earth Engine can be used to support disaster management and risk reduction. Here, we developed an application to detect and monitor landslide-dammed lakes at regional scale. This is an important step in the development of smart, cost-effective tools that can provide valuable data to increase understanding of major landscape-altering events such as that of Kaikoura in 2016."

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Making “un-poplar” decisions: a framework for better tree choices in our hill country

Kunzea robusta, *a species of kanuka, Hawke’s Bay, c. 50 km west of Napier. Photo: Thomas Mackay-Smith.*

Around 20% of Aotearoa New Zealand (5.2 million ha) is classed as “hill country” – much of it marginal pastoral agricultural land with low productive potential. Often steep and treeless, hill country is prone to soil erosion and rapid surface runoff after rainfall.

Land managers in hill country generally resort to strategic tree planting to stabilise soils in places prone to shallow soil slips, earthflows, and gully formation. Poplar and willow are most often chosen, at densities that range from 20 to 200 trees per hectare. Choice of tree has been largely pragmatic – both poplar and willow can be planted as unrooted poles that can survive grazing immediately – with decision-making based on tree performance rather than on wider ecological, economic, and cultural outcomes.

In new research, supported by Manaaki Whenua’s Endeavour research programme *Smarter Targeting of Erosion Control* (STEC), we assisted PhD candidate Thomas Mackay-Smith and colleagues at Massey University

to update a widely used framework for decision-making on tree choice, originally developed for agroforestry systems worldwide in the early 1990s.

The updated framework adopts a broader "silvopastoral" outlook, in which trees are fully integrated into a pastoral system rather than just being used as a tool for soil stabilisation. It includes interactions between trees and livestock, and between the grazing livestock, soil, and pasture. New environmental considerations include biodiversity interactions, greenhouse gas implications, the longevity of the tree, and costs and ease of tree establishment. The framework also accommodates cultural outcomes such as animal welfare, cultural values of tree species, and aesthetic values such as ease of shaping.

The researchers have used the new framework to review and compare the attributes of poplar and kānuka trees in hill country. Little work has been done on kānuka in a silvopastoral context, but the framework shows that kānuka has many benefits compared with poplar. For example, evergreen kānuka potentially provides more shelter for animals and warmth in winter, causes less pasture smothering from leaf fall, is much longer-lived, is known to support native bird populations, is culturally important to Māori, and is also a potential source of extra farm income from honey and essential oils. Kānuka has been studied rather than mānuka because it forms a larger tree when growing isolated in hill country. The framework also highlights surprising knowledge gaps for poplar – a much-researched tree in agroforestry – in terms of biodiversity interactions, livestock shelter, greenhouse gas implications and water and nutrient gains or losses.

The role of trees in Aotearoa New Zealand's pastoral hill country has been contentious for many decades. However, as society explores new ways to combat the effects of rising CO_2, trees will become increasingly important as part of nature-based solutions in our hill country landscapes, and an assessment framework for choosing what tree to use where, and why, is a good starting point.

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Unite against COVID-19

Predator modelling applied to study of Covid health equity

The Covid-19 pandemic has been disruptive of many science activities over the past 2 years. Fieldwork, conferences, hui, workshops – much work has had to be rescheduled or moved online. However, scientists are lateral thinkers. The pandemic has also brought new and wide-ranging opportunities to apply knowledge in different ways.

At Manaaki Whenua, for example, researchers Rachelle Binny and Audrey Lustig turned their skills in the mathematical modelling of predator spread to the epidemiology of Covid-19, as reported in *Putaiao* issue 3, August 2020. More recently, our social researchers have adapted their understanding of decision-making in environmental management to predict likely compliance with public health directives, and our economists have assessed the economic impacts on businesses of government policies aimed at reducing the spread of Covid-19.

Public health and personal engagement

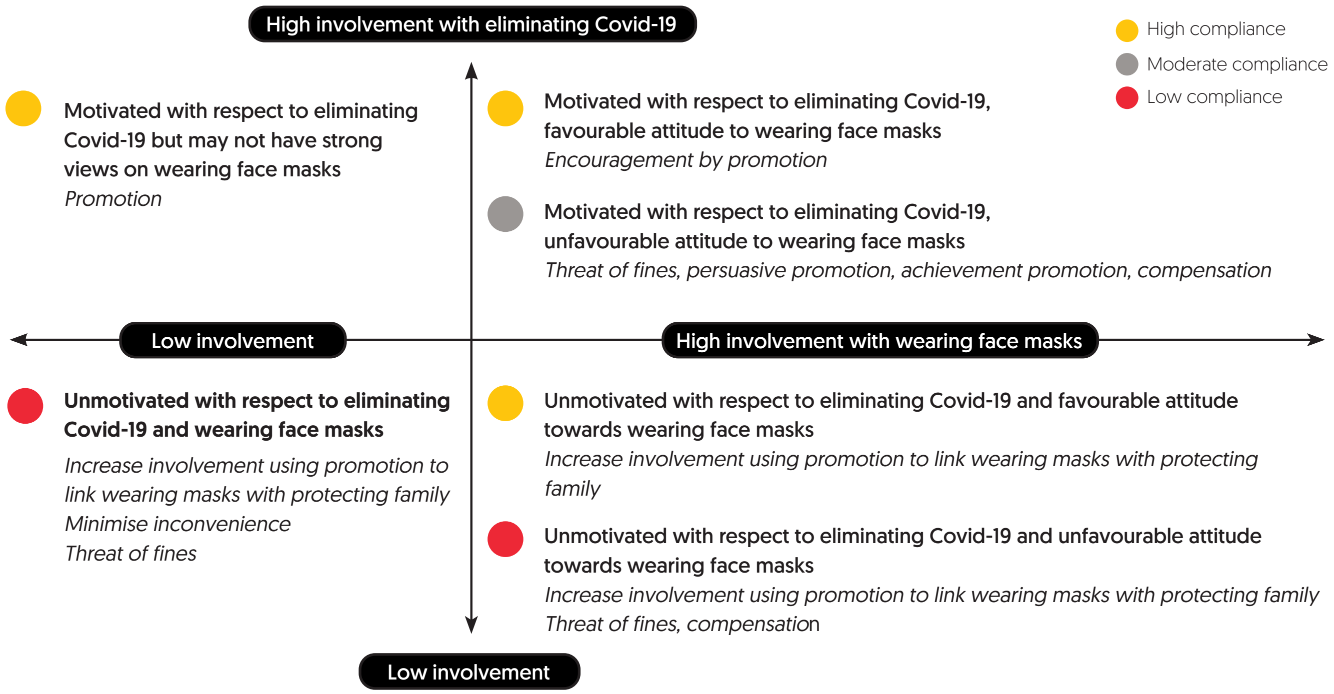
Government policy often requires people to think and act differently, but achieving meaningful behaviour change in practice is difficult. In several recent pieces of work to understand compliance with health measures during Covid-19, Dr Geoff Kaine and other social scientists at Manaaki Whenua have undertaken surveys of the public and applied the findings using the I_3 compliance framework. I_3 is a tool that analyses how strongly people are involved with, or care about, policy outcomes and related policy measures such as regulations, to predict whether they will comply with the measures. It also measures what they believe about policy outcomes and policy measures.

The involvement component of the I_3 framework shows whether someone is willing, or not, to do something (for example, get vaccinated), and the belief component explains why they are willing, or not. The researchers have applied I_3 to several different aspects of people's behaviour in reaction to public health measures: willingness to be vaccinated, compliance with mask-wearing, use of the contact tracing app, willingness to be tested for Covid-19, and self-isolation.

The finding that people's willingness, for instance to be vaccinated, depends on involvement (motivation) as well as attitude has important implications for the design of policy measures, for instance to promote high vaccination rates. It is important to distinguish between those with a lack of interest in getting vaccinated and those who strongly oppose vaccination and therefore deliberately choose not to be vaccinated, and to tailor incentive and enforcement strategies appropriately.

The findings of each survey also have important implications for the design of promotional programmes intended to encourage the participation of the community in mass vaccination

Example of the i3 framework applied to mask-wearing.



programmes. The findings also highlight the difficulty of communicating effectively through mass media with those who have little interest (low involvement) in preventing the spread of Covid-19.

Public health and financial health

In other Covid-related work, Drs Kenny Bell and Maksym Polyakov used GST data and other government datasets to measure the financial effects on businesses of non-pharmaceutical interventions to reduce the spread of Covid-19 in Aotearoa New Zealand, by comparing the revenues and expenses of businesses during the periods of restrictions to those that would have been expected if the pandemic had not happened. Nationally, the introduction of Alert Level 4 in April 2020 was associated with a 60% reduction in revenue (48% when controlling for expenses), recovering to normal by September 2020 (the end of the study period). Auckland, Otago, and Nelson were the regions most affected, while the worst-hit sectors were 'Accommodation and Food Services', 'Arts and Recreation Services', 'Retail Trade', and 'Construction'.

This research is a key contribution to evaluating Covid-19 related government policies and estimating the potential longer-term impacts of the pandemic. Its innovative use of financial data recalls earlier work by Dr Bell in conjunction with the Deep South Challenge on the effects on future drought on farm incomes, which compared farm tax returns with temperature and soil moisture data (see *Putaiao* issue 7, August 2021).

"Analyses like ours open the door to the possibility of more targeted income support for businesses and workers," says Dr Bell. "The next time we face restrictions like we did in 2020, our work may help target spending at those businesses that need it most."

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Kauri dieback going to the dogs

Manaaki Whenua wildlife ecologist Dr Al Glen is working with the Auckland Council and Zach Carter from the University of Auckland to test the ability of trained dogs to sniff out *Phytophthora agathidicida*, the causative organism of kauri dieback.

Phytophthora agathidicida (PA) is a microscopic fungus-like organism that lives in the soil and infects the roots of kauri trees. The fungus damages the tissues that carry nutrients and water within the tree, effectively starving it to death.

The research team hypothesised that if detection dogs already sniff out cancer, drugs, Covid, and pests such as feral cats, could it be possible to add *PA* to the list?

The team is working with two scent detection dogs, Pip and Mawhai, in a biosecure facility. As part of this first stage of testing, the dogs have to sniff 11 different stations to find the right samples. By the end of the testing, they would have done more than 120 runs past the samples.

"Part of the trial is tracking what percentage of samples containing the fungus they detect," says Al, who helped design the procedure and will work on analysing and then writing up the results. "We also look at specificity, so how often will they mistakenly identify something as containing the fungus when it doesn't."

There's currently no treatment for kauri dieback and nearly all infected kauri die. The disease is easily spread through soil movements, for instance when soil is carried on dirty footwear, animals, or equipment and vehicles. With just a pinhead size of soil enough to spread the disease, stopping infected soil before it gets into a disease-free area is vital.

And that's where the dogs will come in. Al says dogs trained to detect kauri dieback could be used at ports, or nurseries. "It's a quick and reliable way to check if infected soil or mud is stuck in the wheels of heavy machinery, or in potted plants."

While the trial is still in its early days, with subsequent testing involving actual soil samples and outdoor locations still to come, the researchers are optimistic about the final outcome. "Early indications are that this project will be successful," says Al. "From the demonstrations I have seen, the dogs nail it every time."

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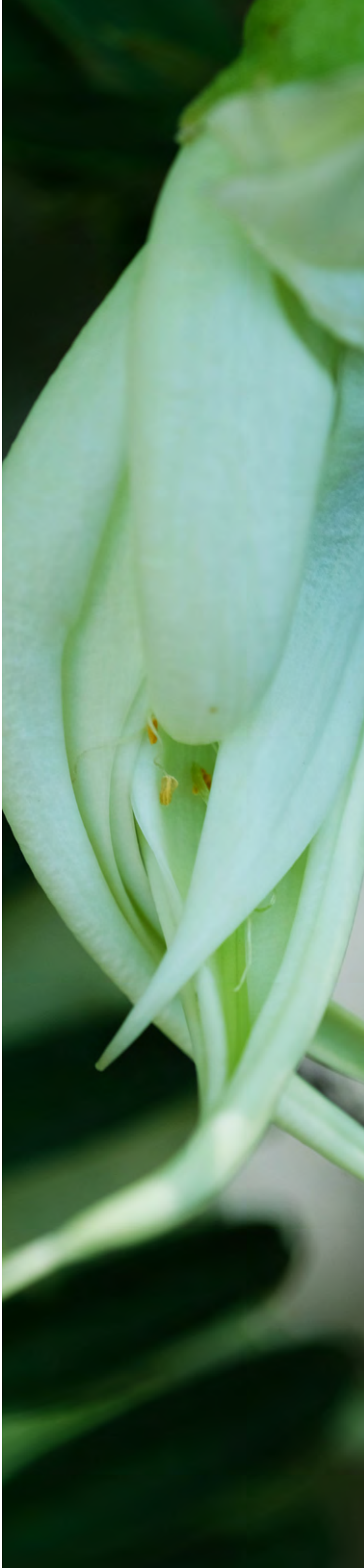
Celebrating our achievements

During 2021 **Angela Brandt** was seconded to work with the Parliamentary Commissioner for the Environment on a major new report: *Space invaders – A review of how we manage weeds that threaten native ecosystems.* The report, which sets out whether Aotearoa New Zealand is doing the best job it can to manage the risks exotic plants pose to our native ecosystems, was released in November 2021. The report reviews the way in which central and regional government agencies tackle native ecosystem weeds under the Biosecurity Act 1993. Angela's expertise and vast knowledge in plant invasion ecology was invaluable to the development of the report.

Yuxin Ma, a soil scientist at Manaaki Whenua's Palmerston North site, has been awarded the Dan Yaalon Young Scientist Medal by the International Union of Soil Sciences for her significant contribution to soil science. The award honours Dan Hardy Yaalon (1924–2014), a professor of soil science at the Hebrew University of Jerusalem, who contributed to some of the most fundamental issues of soils in space and time as well as the theory and history of soil science.

Congratulations to **Nikki Harcourt**, **Phil Lyver** and **Shaun Awatere** who have been appointed to three newly established Kaihautū (Māori leadership) roles across our four research impact areas: land, soils & water; biodiversity & biosecurity; climate action; and people & environment. Creating these new positions is a major step forward that reflects our recent Tauākī Ngākau Titikaha ki Te Tiriti o Waitangi - our Statement of Commitment to Te Tiriti. Part of this commitment is the need for greater Māori co-design and co-development of our research agenda.



Angela Brandt

Yuxin Ma

Nikki Harcourt

Phil Lyver

Shaun Awatere

From collect to connect – rebalancing our collections and databases

Manaaki Whenua is the custodian of a number of Nationally Significant Collections and Databases (NSCDs) on behalf of everyone in Aotearoa New Zealand. These biological collections comprise: the Allan Herbarium, Te Kohinga Harakeke o Aotearoa (the living National New Zealand Flax Collection), the Ngā Tipu Whakaoranga Ethnobotany Database and the National Vegetation Survey at our Lincoln site, as well as the International Collection of Micro-organisms from Plants, the New Zealand Fungarium and the New Zealand Arthropod Collection in Auckland. Each of these collections and databases are of great national and international value and underpin a broad range of scientific research on biodiversity and biosecurity.

> *"Our collections approach needs to expand from one where we simply "collect, curate and classify" to include moves to also "connect, create and collaborate" with our Te Tiriti partners."*

In November 2021 we undertook a review of our biological collections and databases to explore how we can deliver greater value from them for Aotearoa New Zealand. The review was co-chaired by Jason Tylianakis and Aroha Mead and comprised two parts. First, we held a hui to explore how Manaaki Whenua can be a better Te Tiriti partner in the way we use our collections and databases. This was followed by discussions with an international review panel to consider best practice overseas.

The review culminated in a report with a series of recommendations that were presented to and approved by the Manaaki Whenua Board in December.

To implement all the recommendations in full would take far more funding than is available, so some hard strategic choices will need to be made. A key finding of the review was that our collections are an important taonga and that a "significant rebalancing" is required to give our Te Tiriti Māori partners greater oversight of, and connection to, the collections. This rebalancing was summarised by the notion that our collections approach needs to expand from one where we simply "collect, curate and classify" to include moves to also "connect, create and collaborate" with our Te Tiriti partners.

We are now establishing a Te Tiriti Partnership Group to help us determine priority actions we need to address while implementing the review recommendations. The role of the Group will be to:

- Consider the recommendations of the review and develop, in conjunction with Manaaki Whenua staff, a strategic plan for their implementation and agree on priority actions and the allocation of funding from the Strategic Science Investment Fund (SSIF) to support them
- Engage in periodic reviews of progress of the priority actions, future priorities and funding allocations
- Act as a bridge into existing and new end-user communities (with a priority focus on iwi and Māori communities) to help raise the profile of the collections and databases.

To find out more about the Nationally Significant Collections and Databases at Manaaki Whenua, visit: https://www.landcareresearch.co.nz/tools-and-resources/

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