Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 18 / MAY 2024

Bait surrender:

Science to solve NZ's wallaby problem

Plus: biocontrol agents make a meal of exotic weeds

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to Issue 18 of *Pūtaiao* (Science), our quarterly publication showcasing the work of our scientists at Manaaki Whenua.

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

AoNZ's indigenous biodiversity evolved in isolation and much is globally unique. We curate national and Pacific collections of biodiversity on land (plants, invertebrates, fungi, and microorganisms), and our research helps users understand and value its richness, observe changes and risks from exotic species, and find new uses for biological materials.

In this issue we share research that provides understanding of how ecosystems function, the threats they face, and how they can be restored. We contribute to national biosecurity through providing capability and confidence in assessing biological threats, and in using control tools – especially at landscape scales – for weeds, pests, predators, and diseases.

If you wish to be included on the mailing list for *Pūtaiao*, or to find out more about any of the stories, contact Manaaki Whenua's Senior Communications Advisor Kim Triegaardt: triegaardtk@landcareresearch.co.nz

*Cover image: A brushtail possum (*Trichosurus vulpecula*) is caught on camera claiming first dibs on the non-toxic cereal bait meant for the dama wallabies (*Notamacropus eugenii*) during a monitoring project at Titoki in the Rotorua district.*

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Hop to it: managing New Zealand's marsupial menace

Wallabies arrived in New Zealand in the late 19th century, courtesy of Sir George Grey (Governor of New Zealand from 1845 to 1853). In later life Grey lived on Kawau Island, north of Auckland, and introduced five species of wallabies among a variety of interesting animals he acquired for his garden.

Around the same time, a farmer introduced Bennett's wallabies near Waimate in South Canterbury for recreational hunting. Wallabies from Kawau were later released in the Rotorua district. Now, more than 150 years on, New Zealand has a wallaby problem. They are a significant agricultural and conservation pest.

While the brush-tailed rock wallaby, and the swamp wallaby, are still contained on Kawau Island, the three wallaby populations on mainland AoNZ – Bennett's wallaby in South Canterbury and dama and parma wallabies in the Rotorua lakes area – have slowly been spreading outside previously contained areas.

In 2015 the total gross economic impact of wallabies was estimated to be $28 million per annum, and if allowed to spread at their current rate this could grow to nearly $84 million per annum by 2025 and to increase each subsequent year.

Field technician Emily Lawrence checks a wallaby bait feeder in Otaio Gorge, Hunters Hill, in South Canterbury.

In 2012 wallabies were declared an unwanted organism under the Biosecurity Act 1993, and an increasing focus has been put on work to keep wallabies in the containment areas designated in regional pest management plans. The current tranche of work is focused on eliminating outlier populations by 2025. This is an escalation of the management efforts regional councils lead.

Manaaki Whenua has been working closely with Biosecurity New Zealand (Ministry for Primary Industries) and other stakeholders as part of the Tipu Mātoro National Wallaby Eradication Programme (Tipu Mātoro) to identify and prioritise research projects to achieve this goal. This includes work done through a research partnership agreement with Biosecurity New Zealand.

There are more than 21 projects underway or recently completed at Manaaki Whenua that are focused on wallabies. These include tracking wallabies as they invade new areas, scent lures, monitoring and detection methods and human behavioural studies conducted through social science surveys of people's motivations for transporting wallabies around the country – which is illegal under the Biosecurity Act.

Technology is playing a key role including satellite GPS tracking collars (see page 6), thermal cameras, and genomics (see page 4) that are all part of a growing arsenal against the invasive marsupial.

The challenge to achieving local elimination is firstly to know where the wallabies are, which means there must be an effective way of detecting them, especially when they are in very low numbers. Manaaki Whenua programme lead and researcher Bruce Warburton says two key concepts are central to this research: detection probability and surveillance system sensitivity. "Detection probability refers to the likelihood of a method detecting an individual wallaby present at one of the specific locations surveyed. Surveillance sensitivity, on the other hand, is the probability that any of the survey methods employed will detect an individual across an entire area of interest," he says.

Bruce and colleague Dr Dave Latham's study evaluated several survey methods, including ground hunters with dogs, helicopter observers, thermal imaging cameras on helicopters, and camera traps. Researchers used detection probabilities obtained in conjunction with search efforts to estimate the surveillance sensitivity for each method, and, subsequently, to calculate the cost per hectare for surveillance.

Because estimating the number of wallabies in the wild is difficult, the researchers fitted GPS collars on captured wallabies, which recorded location data at high frequency (every 5 seconds) after the wallabies were released, providing a known number of wallabies for potential detection.

The results were mixed, says Bruce. "Ground hunters with dogs, and the trail cameras are most effective, although these are limited in scope when it comes to surveying large areas quickly," he says. "Aerial methods, although less effective and more costly

It's in the genes

Researcher Dr Andrew Veale has been looking at how the population genomics of wallabies could assist control programme planning. Andrew led a landscape genomics study using genotyping-by-sequencing (GBS) to help understand invasive wallaby ecology in AoNZ, and to provide tools that will assist in management and eradication efforts.

"From samples obtained from control operations we genotyped 188 wallaby individuals, including 94 Bennett's wallabies, 7 parma wallabies, and 87 dama wallabies," says Andrew.

"We found 29,080 genetic markers or signposts that helped us understand how populations of dama and Bennett's wallabies are structured. We discovered that both species primarily show a pattern called isolation-by-distance, which means that wallabies closer together are more genetically similar than those further apart. Most of their movement seems to happen over short distances, usually less than a few kilometres.

Nevertheless, Andrew says that in some cases the team found dama wallabies in places such as Taranaki and Wellington, far from their usual habitat. "We also identified parts of the landscape where there are fewer connections between wallaby populations. These areas could be useful for deciding where to set boundaries for eradication efforts."

"Interestingly, the study found three pure parma wallabies in the Bay of Plenty. This species hasn't been noticed before among the dama wallabies and might have different effects on the environment. They've likely been in the Bay of Plenty for around 80 years without being identified."

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per hectare, allow for the rapid survey of extensive areas." He says there is a clear need for innovation and the development of new methods to detect animals at very low densities so they can be eliminated.

Current pest control relies heavily on the use of toxic baits. Manaaki Whenua researchers have been working on more subtle behavioural and motivational aspects of predator control and have been identifying and testing a range of novel, food-based, olfactory lures for their ability to attract target species to baits.

These scent lures include a synthetic green-leaf volatile, a colourless, oily liquid with an intense grassy odour of freshly cut green grass and leaves. It is produced in small amounts by most plants and acts as an attractant to many predatory insects. It is also an important aroma compound, often used in fruit and vegetable flavours and in perfumes.

Studying camera footage from the bait traps, researchers noticed a fascinating species interaction at play that could potentially undermine management efforts. A complex dynamic at bait feeders shows brushtail possums are behaviourally dominant over the larger wallabies. This dominance results in a reduced efficacy of bait feeders for wallaby control, because possums often consume or spoil the bait before wallabies can feed, and their presence can disrupt wallaby feeding, potentially leading to sub-lethal dosing and bait shyness in wallabies (see page 5).

As part of Tipu Mātoro programme, Manaaki Whenua also surveyed and analysed data on people's beliefs, attitudes, and

Senior technician Sam Brown with a thermal camera used to detect wallabies.

motivations regarding the illegal catch and release of wallabies.

"We wanted to understand why people engage in this illegal behaviour and what might be done to prevent it," says project lead Geoff Kaine. "Our results are already being used in the Tipu Mātoro programme to develop the programme's strategy regarding the timing, targeting, and content of awareness campaigns seeking to promote reporting by the public of sightings of wallabies and discourage catch-and-release."

Data collected across these programmes can inform management strategies at the boundaries of wallaby distribution, including buffer zones. It can also guide operational planning by identifying dispersal routes, barriers, movement corridors, dispersal distances, and preferred habitats for settling. Understanding all these factors will go a long way towards helping solve the 150-year-old wallaby problem.

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Back off, it's mine!

Two separate studies on the bait uptake of wallabies, one by Manaaki Whenua senior researcher and wildlife ecologist Dr Patrick Garvey, in Canterbury on Bennett's wallabies, and another by senior researcher Dr Graham Hickling and Dr Tim Day of the Kaharoa Kōkako Trust on dama wallabies near Rotorua and on Bennett's wallabies in South Canterbury, discovered something surprising.

Wallabies are up to four times heavier than possums, but during the different baiting trials conducted by Manaaki Whenua, battles played out over food piles. Cameras captured the action as possums aggressively fought off wallabies. Standing on their hind legs, they clawed and pounced at the larger species, forcing the wallabies to retreat until the possums had their fill.

Graham says interspecific competition is a powerful force in nature. "Animals compete aggressively for resources, such as food, and the winners of these interactions get to dominate the resource."

Which is bad news for wallaby management efforts.

"The challenge for farmers in wallaby-affected areas is that stocking rates are dropping under sustained pressure from wallabies, but to remove wallabies you must first knock down the possum numbers, as they will dominate the toxic bait," says Patrick. The obvious management problem is that wallabies won't gain access to baits until local possums have had their fill, increasing the costs and amount of labour required.

Possums are also messy eaters, so they leave bait on the ground around the bait station. Wallabies eat these partial pellets but in reduced sub-lethal quantities that could potentially generate taste-aversion conditioning that lasts a lifetime. This would create a bait-shy group of survivors that can repopulate an area.

"The issue of possum interference not only leads to primary sector production losses, but results in biodiversity losses, where managers struggle to control wallabies in native forests due to interference by possums," says Patrick.

Graham adds that effective management of invasive species through bait stations may require more sophisticated strategies that consider these behavioural interactions. "This might include designing feeders that minimise possum interference, or scheduling feeding times that align better with wallaby feeding patterns," he says.

This is a good example of how interspecific competition by one dominant species can undermine control of a second. Animal behaviours and interactions fundamentally influence management outcomes, so understanding this behaviour is crucial to successful pest eradication.

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Where's wallaby?

Underpinning Tipu Mātoro programme is the premise that to achieve effective management a deeper understanding of wallaby ecology is crucial, particularly regarding their natural dispersal patterns, says researcher and wildlife ecologist Dr Dave Latham.

A Manaaki Whenua research team used ground-based tunnel nets to capture and collar 80 sub-adult wallabies in Canterbury. The sub-adults are more likely to disperse than adults, providing valuable data on dispersal behaviour.

The captured wallabies were immobilised and fitted with satellite collars to track their movements for up to 12 months. The collars were programmed to balance longevity with frequency of location data collection after the wallabies were released.

As well as analysing and defining dispersal events, looking at movement and settlement ecology, and evaluating habitat selection, the data will be used to compare different methods for assessing dispersal ecology, including genetics and stable isotopes.

"The location data obtained will contribute to understanding the spatial ecology of Bennett's wallaby and may inform other research areas such as genetic modelling. If successful, this methodology could pave the way for a similar research project focusing on the dispersal ecology of dama wallabies," says Dave.

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Part of an awareness campaign seeking to promote reporting by the public of sightings of wallabies and discourage catch-and-release, which is illegal under the Biosecurity Act.

Smile, you're on camera!

The picturesque Bay of Plenty in AoNZ harbours the not-so-charming wallaby invaders, the dama and parma wallaby. A research team plans to capture around 30 wild wallabies at a study site there. The wallabies will be fitted with GPS collars that will provide location data to assess home ranges and movement behaviour for 12 months. The collars "will also detail daily movement patterns across different times of day," says wildlife ecologist Dr Dave Latham.

Also, around 30 to 40 camera traps will be set up in the study area using a grid design and left in place for 2–3 months. This method will help in estimating the probability of detecting collared wallabies and assessing their presence in the area.

The information from the cameras is a crucial component of proving eradication success. "If we search an area post-eradication and find no wallabies, it's essential to know whether survivors truly don't exist or if we simply missed them," says Dave.

A Bennett's wallaby is fitted with a tracking collar as part of a tracking programme.

New partnership targets deadly livestock disease

Sheep on a station in Canterbury.

The fungus associated with facial eczema (FE) is common worldwide, but the toxicity of the AoNZ strain causes much more severe problems. It's a challenging and painful disease that attacks the liver and bile ducts of ruminants and currently has no cure.

Beef + Lamb New Zealand, the Ministry for Primary Industries (through the Sustainable Food and Fibre Futures fund), and other industry stakeholders have launched a $20.7 million programme in partnership with AgResearch and Manaaki Whenua with the bold aim of eliminating the impact of FE on livestock.

The Eliminating Facial Eczema Impacts (EFEI) programme is targeting a $38 million cost saving for AoNZ by the end of the programme, and an additional annual $20 million benefit through improved productivity by reducing disease-related losses, lowering costs, and promoting the overall health and welfare of the animals.

Manaaki Whenua senior researcher Dr Bevan Weir says the programme involves taking a new approach to solving the nearly 100-year-old problem. "Our research will allow us in the future to equip farmers with the tools, knowledge and solutions that they can adopt into their farm systems. While the fungus that causes FE can't be eradicated, we can eliminate the impacts."

Initially, research will focus on unravelling the mysteries of the disease and identifying distinct species, which will pave the way for targeted management strategies. "We need to look at improving the diagnostics of FE, especially as the incidence of the disease is expected to rise along with warming temperatures," says Bevan.

FE is one of farming's hidden killers and can appear with little warning, but increasingly when temperatures and moisture levels are high. For every animal with clinical evidence of the disease, at least 10 or more will be infected but not show any obvious signs. After an FE season, in the past farmers have lost up to 70% of their hoggets, and a loss of 20% of lambs is not uncommon. In an outbreak in 1981 the cost of lost production to AoNZ was estimated to be $266 million.

Beef + Lamb New Zealand programme manager Lucas MacDonald says that currently mitigating the impact of FE can include breeding for increased tolerance, zinc supplementation, pasture management, and vigilant monitoring. "Each measure, if successful, may provide some defence against FE," he says.

"However, new tools and solutions for farmers to manage FE that emerge from this programme will contribute to a more sustainable and economically viable livestock industry."

Importantly, this collaborative effort will involve livestock farmers, sectoral organisations, researchers, extension specialists, veterinarians, and other rural professionals to arm farmers with the knowledge, tools, and solutions to safeguard their flocks.

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Weed-eaters: gains for weed biocontrol in Aotearoa New Zealand

European colonists introduced more than 25,000 species of plants to AoNZ within a 200-year period , and many of these newly introduced species soon naturalised and began causing problems. The first legislation to control weeds in AoNZ was passed in 1854, but weed problems have continued to worsen.

Weed biocontrol has been practised in AoNZ for nearly 100 years, beginning at the Cawthron Institute in Nelson in 1925. The earliest weeds explored as biocontrol targets were agricultural pests: blackberry, foxglove, gorse, ragwort, and one native plant, piripiri.

During the mid-20th century biocontrol faded into obscurity as new herbicides became available, but growing disillusionment with herbicides has led to a resurgence in biocontrol activity since the 1970s. Weeds targeted into the 1990s by the Department of Scientific and Industrial Research, and later Landcare Research, included gorse and ragwort (both for a second time), plus thistles, broom, hawkweeds, heather, mist flower, old man's beard, and the only aquatic species tackled in AoNZ so far, alligator weed.

However, weeds still cost the country more than a billion dollars each year and threaten all of our ecosystems. Today the naturalised vascular flora of AoNZ (2,430 species) exceeds the native flora (2,414 species). This pool of potential new weeds continues to grow as more species continue to naturalise out of the more than 25,000 species of exotic plants already in the country.

Biocontrol is therefore more important than ever in attempting to reduce the impacts of some of the most serious, widespread weeds. This is reflected in the accelerating pace at which new biocontrol agents are being released.

We are currently progressing varying stages of biocontrol solutions for 18 weed species in AoNZ and 10 species in the Pacific, all concurrently. By world standards our success rate for establishing weed biocontrol agents is high – around 85%.

Current wide-ranging weed biocontrol work includes investigating a range of fungal pathogens for Chilean needle grass, old man's beard, and Darwin's barberry; a range of leaf-, flowerbud-, and root-feeding beetles for Chilean flame creeper, woolly nightshade, and yellow flag iris; a gall wasp for Sydney golden wattle; and a beetle to control air potato in Niue, among numerous other projects.

Dr Ronny Groenteman, a senior researcher at Manaaki Whenua, says it is painstaking work. "The biocontrol agent must be host-specific to the target weed, must be free of hitchhiking organisms such as gut pathogens or mites, and must survive being transported from overseas, being re-synchronised with the southern hemisphere season cycle and being reared in sufficient numbers in containment. Then it must also survive being released and establish a population big enough to control the target weed. These are all big asks for a biocontrol agent, and if one step fails, it's back to the drawing board."

But it's worth it in the long run. For example, 40,000 out of 50,000 hectares of heather in Tongariro National Park have now been successfully controlled using heather beetles, which are native to northern Europe – a much better outcome for a World Heritage Site than chemical control. Biological control of nodding thistle, using two weevils and a gall fly, has resulted in an 80% overall decline of the weed, generating a benefit:cost ratio of 580:1 and a saving of at least $28 million to farmers every year. In addition, half of survey sites have either dramatically reduced their need to control nodding thistle or no longer need to manage it at all.

The biocontrol of St John's wort, via two species of St John's wort beetle, has resulted in a saving of nearly $930 million since the first introduction of the agents in the mid-20th century, and continues to provide savings of $15.5 million annually without any further investment. Indeed, it is estimated that savings provided by the St John's wort biocontrol programme alone have more than paid for all weed biocontrol programmes undertaken in AoNZ so far. These are strong arguments, enabling councils to justify continued investment in weed biocontrol.

Now our work is shifting gears again, with a new focus on whole-ecosystem outcomes. We are increasingly taking a holistic approach to weed management, placing it in terms of ecosystem outcomes rather than the presence/absence of the target weed. We aim to provide more informed approaches to weed control, and better decision-making on the application of control tools – including biological control – to ensure the best ecosystem outcomes.

Underpinning this is a new 'trait-based' framework for weed control, which evaluates the environmental impacts of co-occurring weeds that could be different from when those weeds occur alone. This is essential for risk assessment of new invasions, but also for management, which usually focuses on one weed at a time, though most ecosystems contain multiple weeds. It reduces perverse outcomes from weed control, such as new weeds replacing the old, or increased fire risk from dead vegetation.

Our goal is to fill evidence gaps and support decision-making needs for the management of any weed earlier in an invasion process. This supports uptake of the recommendations for tackling emerging weeds in the Parliamentary Commissioner for the Environment's 2021 *Space Invaders* report.

Woolly nightshade lace bug Gargaphia decoris.

This new focus has become achievable because it builds on lines of evidence and modelling tools that we have developed for established weeds in our past work. It has moved weed control from what is often viewed as being an intractable problem (too many species, overwhelming in scale) to a clearer prioritisation to deliver real gains for biodiversity and agriculture.

Our prioritisation tool for weed biocontrol targets is now being adopted more widely in AoNZ and overseas, and the relative performance index we have developed to inform risk assessment of candidate biocontrol agents is being adopted by Australia and explored by the USA.

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The gospel of St John's wort: a phenomenal weed biocontrol success story

Like so many plants brought by Europeans to augment botanical and kitchen gardens in Australia and AoNZ in the 19th century, St John's wort (*Hypericum perforatum*) duly escaped and by the 1930s was one of the worst invasive weeds in both countries.

In AoNZ infestations of St John's wort were particularly serious in hill country dryland farms, reducing the productivity of pasture and poisoning livestock into the bargain. The plant was a toxic scourge, and its seeds were widely transported around the country, especially in roading gravel. Now it clings on in pasture as a minor weed only in a few parts of Otago.

Where did all the St John's wort go? Our farmers' reprieve is all thanks to weed biocontrol – the release of two beetles with very specific dietary requirements – and a fair amount of patience.

The lesser St John's wort beetle (*Chrysolina hyperici*) and the closely related greater St John's wort beetle (*Chrysolina quadrigemina*) were released in AoNZ in 1943 and 1965, respectively, and quickly set about their work. Only 4 years after release the lesser St John's wort beetle, alone, had cleared over 180 hectares of the weed in the Marlborough district, and today, it's all but gone.

But what if nothing had been done?

Recently, two of our weed biocontrol researchers, Dr Simon Fowler and Dr Ronny Groenteman, along with informatics specialist James Barringer

> *The benefit that we continue to get from biocontrol of St John's wort can be easily overlooked when we are no longer confronted with it as a weed problem. But in the long run, this has been a phenomenal success.*

and Dr Grant Humphries (Black Bawks Data Science Ltd, Scotland), revisited the history books to do a retrospective economic analysis of this flagship biocontrol project.

"The analysis was multifaceted, pulling together predictions on expected modern-day geographical range and the past spread of St John's wort, data on economic losses caused by St John's wort, and annual investment in weed biocontrol research, all cost-adjusted for the year 2022," explains Simon.

The starting point was to estimate the spread of St John's wort by 2022 if biocontrol had never begun. The expected range of the weed for the present day across South Island hill country was simulated using ecological niche modelling and GIS mapping of land use. Overall, 660,000 ha was the final area of potentially highly infested pasture, which would have been reached since 1989 in the absence of biocontrol.

Next, production losses were calculated using stocking rate data for South Island sheep farms, along with estimates of how much pasture would have been displaced by the weed. It was conservatively assumed that farmers would make control efforts, but with serious infestations would still have lost 30% of their productive land to St John's wort.

Overall, the economic analysis predicted that total annual losses to South Island farmers from St John's wort in the absence of biocontrol would have been $119,000 per annum in 1940, increasing to $15.7 million per annum by 2022. Allowing for the cost of developing the biocontrol programme, this translates to savings of $15.5 million per annum. To put this saving in perspective, AoNZ's current annual investment in all weed biocontrol is around $1.34 million, just 9% of the ongoing annual benefit from the St John's wort biocontrol programme alone. Put another way, AoNZ has gained $6,254 for every $1 invested in the beetles – which is a great return, to put it mildly.

Control of St John's wort is now completely self-sustaining. Over about 50 years the plant has been gradually 'winking out' across the hill country, according to Simon, as the beetles systematically find and destroy any emerging patches. "Of course, the benefit that we continue to get from biocontrol of St John's wort can be easily overlooked when we are no longer confronted with it as a weed problem," he adds. "But in the long run, this has been a phenomenal success."

[Top] Chilean needle grass on a hillside near Seddon. [Bottom] A Sydney golden wattle bud galling wasp (see pages 8-9).

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How data science can shape tree modelling for sustainable land management

A four-year data science programme involving a joint AoNZ-Singapore research team working to accelerate the development of data science capability in both countries has wrapped up demonstrating valuable connections between remote sensing, ecology and social sciences.

Funded through the Ministry of Business, Innovation and Employment, MBIE, and Singapore Data Science Consortium (SDSC), the *Bridging the gap between remote sensing and tree modelling with data science* programme has developed methods that are already underpinning projects. These include mapping tasks in urban and native forest environments on tree species identification and large-scale vegetation mapping of entire regions in AoNZ.

Manaaki Whenua senior researcher Dr Jan Schindler says that as well as new ways of detecting trees from aerial imagery and 3D LiDAR point clouds, researchers also developed novel deep-learning approaches, and were able to draw connections between data science, urban trees and wellbeing.

"The developed methods have already found their way into practical applications by enabling and supporting new research and commercial projects," says Jan.

Singapore, the 'City in a Garden', embodies the 'green city' concept with more than 7 million urban trees covering 700 km^2, and New Zealand, with 24% of its 270,000 km^2 land covered in forest, both actively support and promote urban re-greening in many of their cities.

"Sustaining and enhancing biodiversity and healthy living environments are priorities for Singapore and New Zealand that require careful management of trees in urban areas and forests, but this is often limited by the quality of available data, tools, and techniques to inform management decisions," says Jan.

The research project successfully translated state-of-the-art AI technologies into practical outcomes for stakeholders. "We strengthened collaborative relationships among all New Zealand and Singapore teams, expanded our network to include external partners, and fostered the growth of a new cohort of researchers in the field of AI and remote sensing by leading over 23 student projects (PhD, BSc/MSc) in New Zealand and Singapore," he adds.

To date, the programme has published 12 journal articles, nine conference

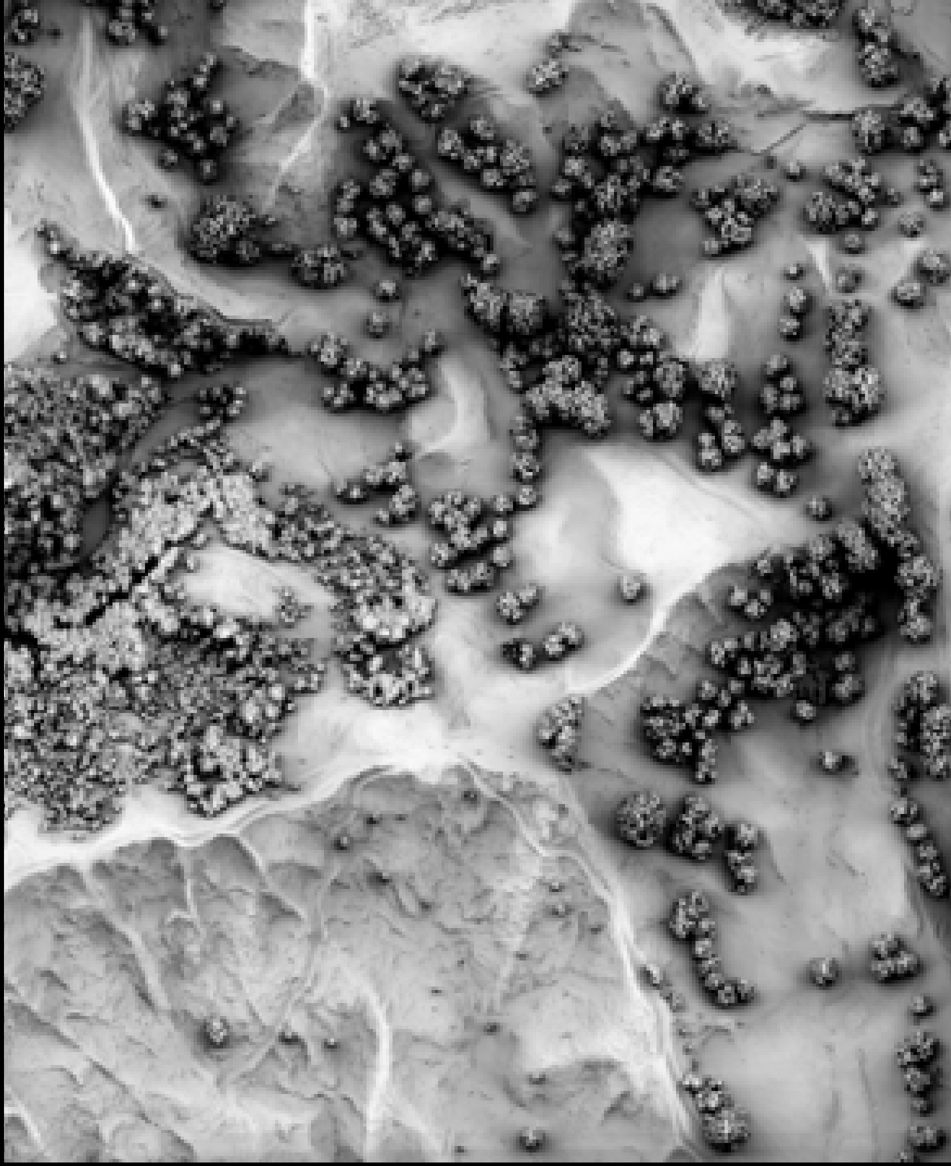
Aerial imagery of the Hawke's Bay region that shows layers of objects classified into at least 5 vegetation classes: forests, standalone trees, shelter belt and riparian wetland down to the smallest detail.

proceedings and delivered over 15 conference talks with many collaborations continuing in the future.

"Over the past four years, we have developed novel data-science methods for extracting tree species information from petabytes of multi-resolution remote-sensing data to model tree species and their interactions with the environment, and subsequently analyse their socio-economic impacts," says Jan.

Thanks to the cultural support of and exchange with Taranaki Whānui ki Te Upoko o Te Ika and Ngāti Maru, facilitated by Kiri Reihana, the researchers gained important insights into how this research can support iwi aspirations in current and future land management practices through several interactive hui in Wellington and with Ngāi Tai iwi in Eastern Bay of Plenty.

Jan says working with such a diverse group of scientists from different fields and organisations is fascinating and provides an opportunity to help understand how this work can have impact at research, government and commercial level. The programmes included research teams from Manaaki Whenua, Te Herenga Waka—Victoria University of Wellington, Te Whare Wānanga o Waitaha — University of Canterbury, Scion, Institute of High Performance Computing / A*STAR and Nanyang Technological University, Singapore.



Processing LiDAR tiles can extract detail at very fine scales.

"Even though we work on the same topics, everyone comes in from a different angle and words can have a different meaning, so it was really important to build personal relationships and come together for joint workshops in New Zealand and Singapore," he says.

This project was supported by the Catalyst: Strategic Fund from Government Funding, administered by MBIE and was New Zealand's largest ever single investment in a bilateral science programme.

The $11-millon NZD investment aimed to accelerate the development of data science capability in both countries and supported the collaboration between a wide range of New Zealand research institutes and leading Singapore researchers across several priority areas. These include health, natural language processing, and 3D temporal-spatial sensing of the environment.

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Why does the pūkeko cross the road?

Waka Kotahi NZ Transport Agency and sector partners contracted Manaaki Whenua to identify, assess, monitor and manage road edge effects on biodiversity. The research emphasised the vulnerability of larger native birds to roadkill due to behaviour and habitat factors.

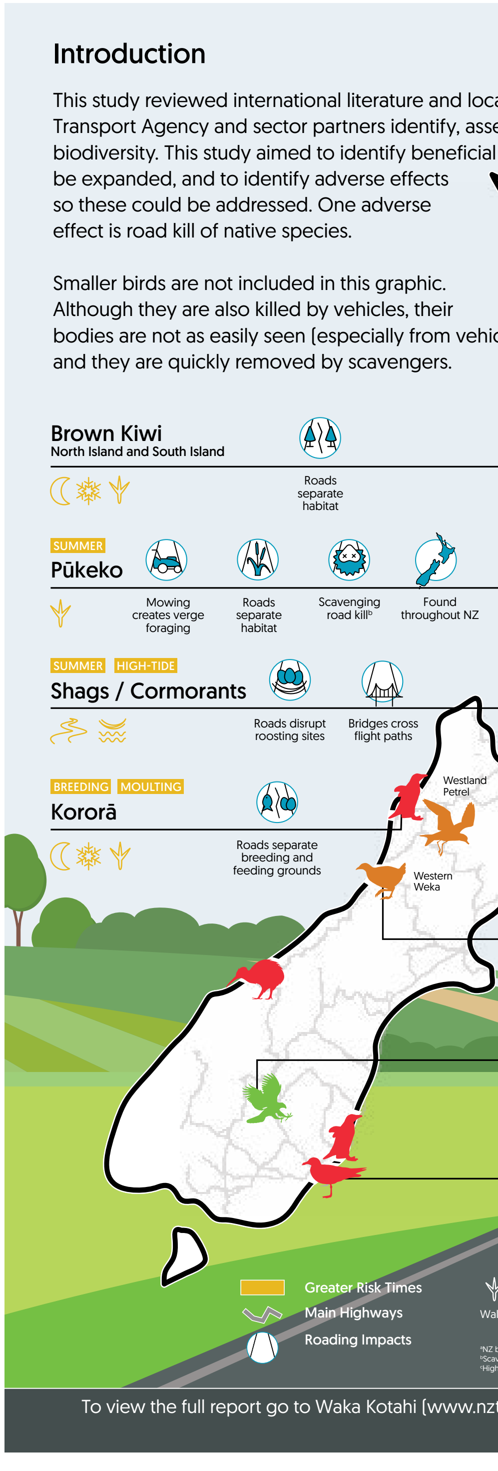
The poster on the right identifies some of the larger native birds recorded as road kill. It proposes why, when and/or where species may be vulnerable, and potential mitigation actions to test. Some threatened native birds are vulnerable to road kill due to their willingness to cross roads (sometimes linked to large home ranges or roads bisecting habitat), unwillingness or inability to fly, freeze behaviour when faced by threats (i.e. vehicles), activity at night, dawn and dusk (making them more difficult to see and avoid), slow breeding rates and/or low natural densities.

There are very few studies on road kill of small birds.

The level at which road kill has an effect at the population scale is not known for most native birds. In large, contiguous natural areas most native birds are primarily limited by predation from mammals. However, in most lowland areas populations are probably limited by lack of suitable habitat, as only very small areas of native forest and/or wetlands remain; here roadside vegetation may be beneficial or act as ecological traps.

Studies are needed to identify where road kill effects may threaten nationally vulnerable species and to inform development and testing of avoidance, minimisation and mitigation that works for AoNZ fauna. Examples include embedding alternative designs into capital projects that reduce artifical light at night (seasonally or permanently), reducing access to active lanes and providing 'safe passage', or slowing traffic and/or creating habitats in 'safe' areas.

The 2023 study highlighted the need for effective assessment, particularly of 'forever' road edge-effects which include adverse effects that may increase over time, such as pest plants and effects linked to vehicle movements (light, noise, and road kill).



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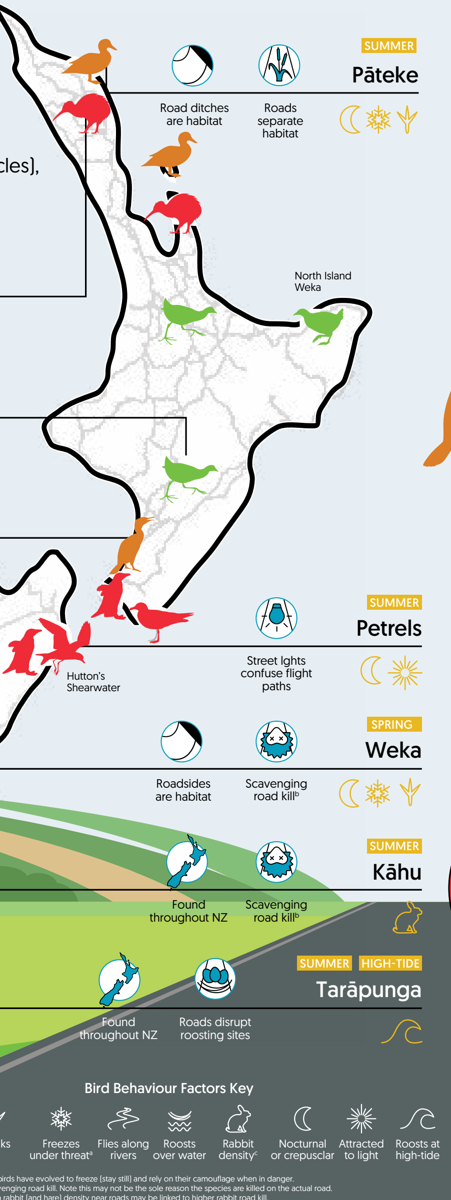

Mitigation

Studies are needed to identify where road kill effects may threaten nationally vulnerable species and to inform development and testing of avoidance, minimisation and mitigation that works for NZ fauna.

The current knowledge gaps on effects of roads on NZ species and environments may deliver mitigation interventions that are ineffective.

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Pā harakeke a spiritual home in Lincoln

Kuia Sarah Tangitu from Katikati (hapu Te Rereatukahia) selecting harakeke for the Western Bay Museum's new pā harekeke.

Te Kohinga Harakeke o Aotearoa – National New Zealand Flax Collection at Lincoln is one of Manaaki Whenua's most visited collections. People want to find out which varieties of harakeke (flax) are most suited to their projects. Weavers come from all parts of AoNZ to harvest leaves for kete (baskets), university students visit to network and share knowledge, and there is an increasing number of schoolteachers looking to establish pā harakeke (flax gardens) at their schools.

"The requests are numerous and various," says Katarina Tawiri, the kaiwhakahaere/manager of the pā harakeke, a senior technician responsible for our live ethnobotanical plant collections.

Recently, representatives of Ngāti Kuia visited the pā harakeke to dig up 28 harakeke bushes to establish their own pā harakeke at Tītīraukawa, Pelorus Sound. Their pā harakeke is part of a larger project involving a plantation of 60,000 kānuka, and a honey production facility, all situated on iwi land at Tītīraukawa.

"It's not a one size fits all solution when people ask for harakeke," says Katarina. After all, the plant's multiple uses are well-documented. "How is it possible to live there without it?" Māori chiefs of the 18th century asked when they were informed that no flax was growing in England. After food, harakeke (*Phormium tenax*, New Zealand flax) was one of early Māori communities' most essential commodities.

It was a plant the early European settlers recognised the value of as well. They quickly set up mills, and in the early 20th century, muka (prepared flax fibre) was AoNZ's biggest export.

In the mid-20th century, as urbanisation of Māori was encouraged and traditional life on marae was disrupted, many pā harakeke and traditional harakeke cultivars were lost. Rene Orchiston, a skilled Gisborne craftswoman with an interest in natural fibre, noticed the use of inferior material due to the shortage of good-quality harakeke.

She visited weavers and whānau, recording the names and uses of different harakeke she was gifted. Gradually she built up a collection of useful varieties on her farm in Gisborne and in 1987 offered her collection to Manaaki Whenua for safe keeping.

There are 50 different varieties of harakeke in the Rene Orchiston Collection, and they have all been DNA fingerprinted. AoNZ flaxes belong to the family Asphodelaceae, and botanists recognise two species: harakeke, *Phormium tenax*, found in lowlands and swamps, and wharariki, *Phormium cookianum*, found in coastal and mountain regions.

While most of the plants in the collection are unique varieties, several groups with identical genetic make-up were identified. These plants are either close kin (originally from the same geographical area or wild population) or vegetative clones (divisions) of the same parent plant.

Māori chose their harakeke depending on its strength, softness, durability, colour, ease of extraction, and quantity of fibre. Favourites were named, and often the name described what the plant was good for, such as the long, orange-edged, slightly droopy, bright-green harakeke makaweroa, meaning 'long hair', which can produce long ribbons of soft fibre with the beauty and lustre of silk.

While there are many traditional uses of harakeke, such as clothing, kete, and mats, research is highlighting new uses. PhD student Jaye Barclay from Victoria University is working with Dr Ben Yin and Dr Nancy Garrity on the use of harakeke leaves for membrane filtration of wastewater. Jaye is of Māori and Japanese descent and brings his cultural knowledge and understanding to his work.

But above all, Te Kohinga Harakeke o Aotearoa and Katarina are in increasing demand for the knowledge and resources they offer communities eager set up their own pā harakeke. Katarina worked with kuia (elder) Kerewai Murray Wanakore and kairaranga (weaver) Sarah Tangitu to choose and harvest seven cultivars that had significance to their iwi as part of an 18-month project to create a pā harakeke at the Western Bay Museum in Katikati, Bay of Plenty.

Darfield High School is also planning to establish its own pā harakeke, with their Year 9 and 10 students acting as kaitiaki. The rural school has an active harakeke weaving programme run by Louise Blakemore who brought the students for a visit to the pā hareke.

Although rain and freezing temperatures meant the students couldn't be outside, a tractor shed provided some shelter while students were taught how to extract fibre from selected cultivars and how to cut down fans before they can be planted.

The job of looking after the pā harakeke also means making sure the plants stay vibrant and healthy. This means every 15 to 20 years a pā harakeke needs to be replanted to rejuvenate the plants. It ensures they grow vigorously and the leaves are long and wide, healthy, disease-free, and able to produce robust new vegetatively propagated plants for distribution to weavers, and leaves for harvesting. Harakeke cultivars do not always grow true from seed, so they must be propagated by root division to ensure the special qualities of the plant are maintained.

The spiritual significance of harakeke was brought home by a request for plants for a particularly poignant reason. In Te Whaiti, near Rotorua, there is a special pā harakeke managed by the Matekuare Whānau Trust, with 10 plants that came from Manaaki Whenua's pā harakeke. The Matariki Tu Rakau programme's Phylis Houia Memorial Park is named after a weaver who died young and who was a trustee of the Matekuare Whānau Trust. The plants were planted by the local schoolchildren.

For Katarina, all these community and personal connections to Te Kohinga Harakeke o Aotearoa – National New Zealand Flax Collection reinforce the importance of this special harekeke garden.

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Helping to replant new harakeke.

News in brief

DNA samples support biomonitoring efforts

Joe Edwards, Stevee Raureti and Te Poari Newton from Tura Te Ngakau with DNA samples.

Leaders of Ngāti Tura – Ngāti Te Ngākau have hand-delivered DNA samples collected from various insects from their rohe to the Lincoln Molecular Lab. Once the samples are processed, they will be used to create the beginnings of a bespoke reference library that will support the iwi's eDNA-based biomonitoring efforts.

Project co-leads Holden Hohaia and Dr Manpreet Dhami welcomed the visitors. Iwi leader Joe Edwards spoke about the iwi's kaitiakitanga of the ngahere (forest) through significant on-the-ground predator control and biomonitoring efforts, and how these efforts have led to the reconnection of their community with the taiao (nature). Stevee Raureti added this included the insects in their ngahere.

Following a mihi whakatau and karakia, the samples were carried to the Molecular Lab, where they were handed into the care of Alex Verry, the key technician who will generate the sequencing library from these DNA samples.

"It's very humbling that the hapū of Ngāti Tura – Ngāti Te Ngākau have entrusted this DNA material to us for safekeeping. This signifies a degree of trust in Manaaki Whenua generally, but in Manpreet in particular," says Holden.

Parasitic wasp found while digitising collections

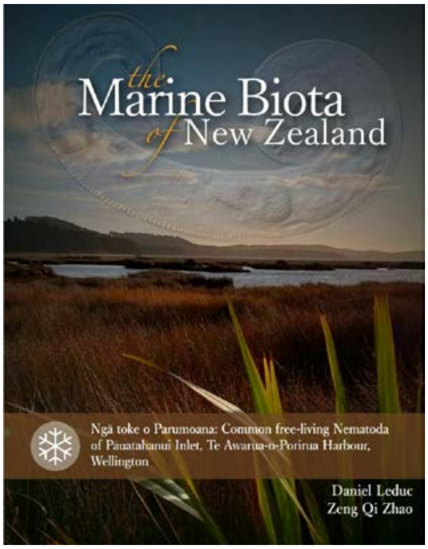
A small parasitic wasp had been flying under the radar in AoNZ until it was caught on camera. The digitising of our nationally significant collections and databases by Manaaki Whenua researchers provided the opportunity for serendipitous discoveries, which is how a species of the Ichneumonidae family (*Amblyaclastus melanops*), a parasitoid wasp within the insect order Hymenoptera, came to be found.

Researchers digitising the New Zealand Arthropod Collection – Ko te Aitanga Pepeke o Aotearoa discovered the exotic wasp, which was first recorded in 1975, when it was found in Arapuni in the Waikato. The record indicates that the specimen had been reared from the egg sac of the knobbled orb weaver spider (*Socca pustulosa*). The spider was accidentally introduced to AoNZ from south-eastern Australia and is now widespread across AoNZ.

Senior researcher and entomologist Dr Darren Ward says there are very few records of Hymenoptera using spiders as a host in New Zealand. "This emphasises the need to not only know what species we have in Aotearoa but to document and understand any new relationships and behaviours, as they give insight into how new incursions may occur."

Over 260 parasitoid wasp species have been accidentally introduced to AoNZ.

A parasitoid wasp Amblyaclastus melanops.



Ground-breaking study reveals rich diversity of nematode species

Manaaki Whenua nematode systematist Dr Zeng Qi Zhao and NIWA marine nematode taxonomist Dr Daniel Leduc have written a major 212-page book, *The Marine Biota of Aotearoa New Zealand: Ngā Toke o Parumoana: Common free-living Nematoda of Pāuatahanui Inlet, Te Awarua-o-Porirua Harbour, Wellington.*

Nematodes, or roundworms, are the most numerous and varied animals found in water sediments around the world. In AoNZ our understanding of these creatures is still very limited, especially in marine sediments. Up until now only 190 species of free-living marine nematodes have been identified in AoNZ's waters. This research identified 55 different species of nematodes, with 26 new to science.

Zhao and Leduc's study focused on free-living nematodes in a drowned river valley of Te Awarua-o-Porirua Harbour, near Wellington. This area is ecologically and culturally important, but is affected by land-use changes and pollution. By studying the nematodes here, researchers can better understand and monitor the health of this ecosystem.

Manpreet Dhami at work on microbiomes in a mobile lab.

New DNA technologies illuminate links between genetic variation and biological invasion

Science needs to put genomes and microbes at the centre of invasion research according to recently published studies.

A consortium of international and Manaaki Whenua researchers including Dr Manpreet Dhami and lead author Dr Angela McGaughran (University of Waikato), as well as Drs Amy Vaughan, Elahe Parvizi and Claudia Lange say human activities are making biological invasions and the spread of species due to climate change faster worldwide. However, scientists still don't know much about how changes in species' genomes help them invade new areas.

While most studies have looked at how physical traits are linked to the ability to invade, new genomic approaches are revealing that genetic differences are also key to invasion success.

Manpreet says that increasingly there is a shift towards using genomic insights to take a more proactive rather than reactive approach to dealing with invasions. This strategy involves more research into why some invasions succeed and others fail, and using this knowledge to develop methods that could slow down invasions, lessen their impact, or even help eradicate harmful invasive species.

In a separate paper authored by Drs Manpreet Dhami, Eva Biggs, Ronny Groenteman, Simon Fowler, Claudia Lange and Quentin Paynter and a consortium of international collaborators, researchers highlight the different ways microbes can spread among insects, but it is uncertain as to how these microbes change. Insects that live in the same area naturally swap microbes, but now, with more non-native insects being introduced into new places, there's a chance for them to pass on new microbial partners to the local insects.

Scientists are increasingly realising just how important these microbial communities are for insects to survive, and adapt to new habitats.

"This could lead to insects that eat plants being able to attack new types of plants and cause more damage, or it could help insects deal better with things like climate change, escape from predators, or resist diseases," says Claudia.

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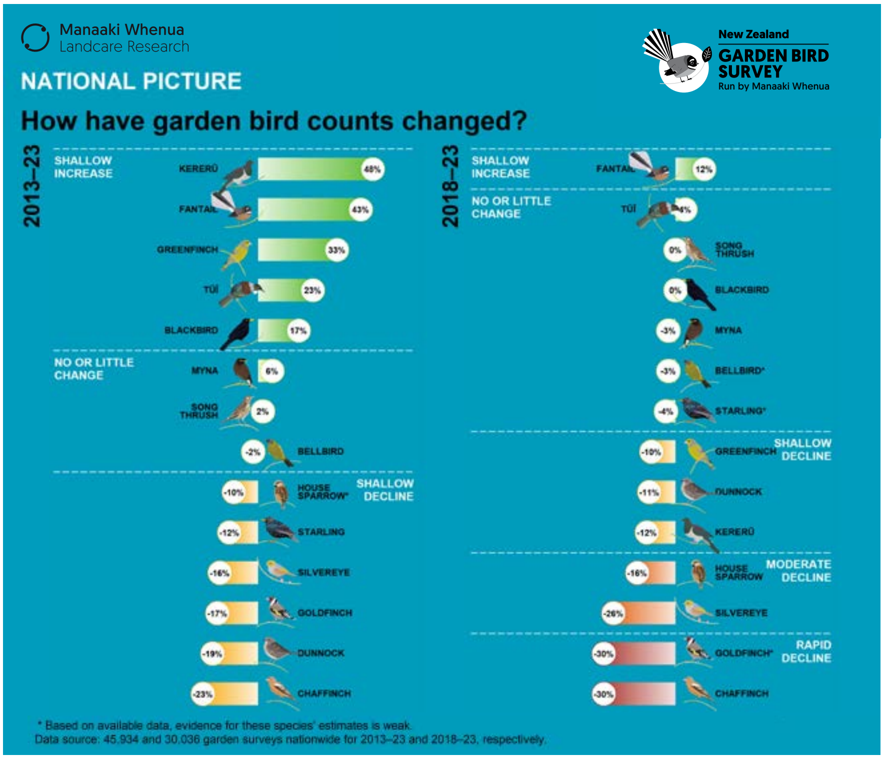
News in brief

Research questions the New Zealand Garden Bird Survey could answer

The New Zealand Garden Bird Survey Te Tatauranga o ngā Manu Māra o Aotearoa (NZGBS) has been running since 2007, engaging tens of thousands of New Zealanders, who have submitted over 70,000 surveys from across AoNZ. There is huge potential for this dataset to help answer important research questions that will support environmental monitoring and decision-making.

Senior researcher Dr Angela Brandt says the team has only begun to scratch the surface of what the data can do to support environmental monitoring and decision-making. “Each year we publish the *State of NZ Garden Birds Te Āhua o ngā Manu o te Kāri i Aotearoa* report. The analysis uses generalised linear mixed models to fit/estimate 10- and 5-year trends in counts or occurrence of 14 common garden bird species (five native and nine introduced species) from the national to the local scale,” she says.

Angela says this approach can be useful for decision makers at multiple scales, using trends produced nationally, for regions and more locally. A more detailed case study on this was published in *Ecological Solutions and Evidence* in 2022 by a research team led by Dr Catriona MacLeod, where three years of NZGBS trends (2017–2019) were summarised and compared nationally, within Otago, and across neighbourhoods managed by Predator Free Dunedin. An interactive map displaying these results can be viewed at https://www.predatorfreedunedin.



A bar graph showing the national picture of how garden bird counts have changed over the past 10 and 5 years.

org/resources/new-zealand-garden-bird-survey.

“To promote wider use of the NZGBS data for research and monitoring purposes, we have begun uploading the yearly data to the Global Biodiversity Information Facility (GBIF). There are now 5 years of data that are publicly available (2018–2022) and we'll soon add 2023.”

The NZGBS data have also been used as a biodiversity indicator in a multidisciplinary study of Nature's Contributions to People (NCP) published by Dr Daniel Richards and colleagues in *Urban Forestry & Urban Greening* in 2023. Three years of NZGBS data (2018–2020) were used to model bird species richness across Ōtautahi Christchurch as one of nine indicators of NCP, to see how these indicators related to economic and social vulnerability across the city.”

The NZGBS is New Zealand's longest-running citizen science project. This year it runs from Saturday, 29 June, to Sunday, 7 July 2024.

New Zealand
GARDEN BIRD SURVEY
Run by Manaaki Whenua

Lizards prosper as predators excluded

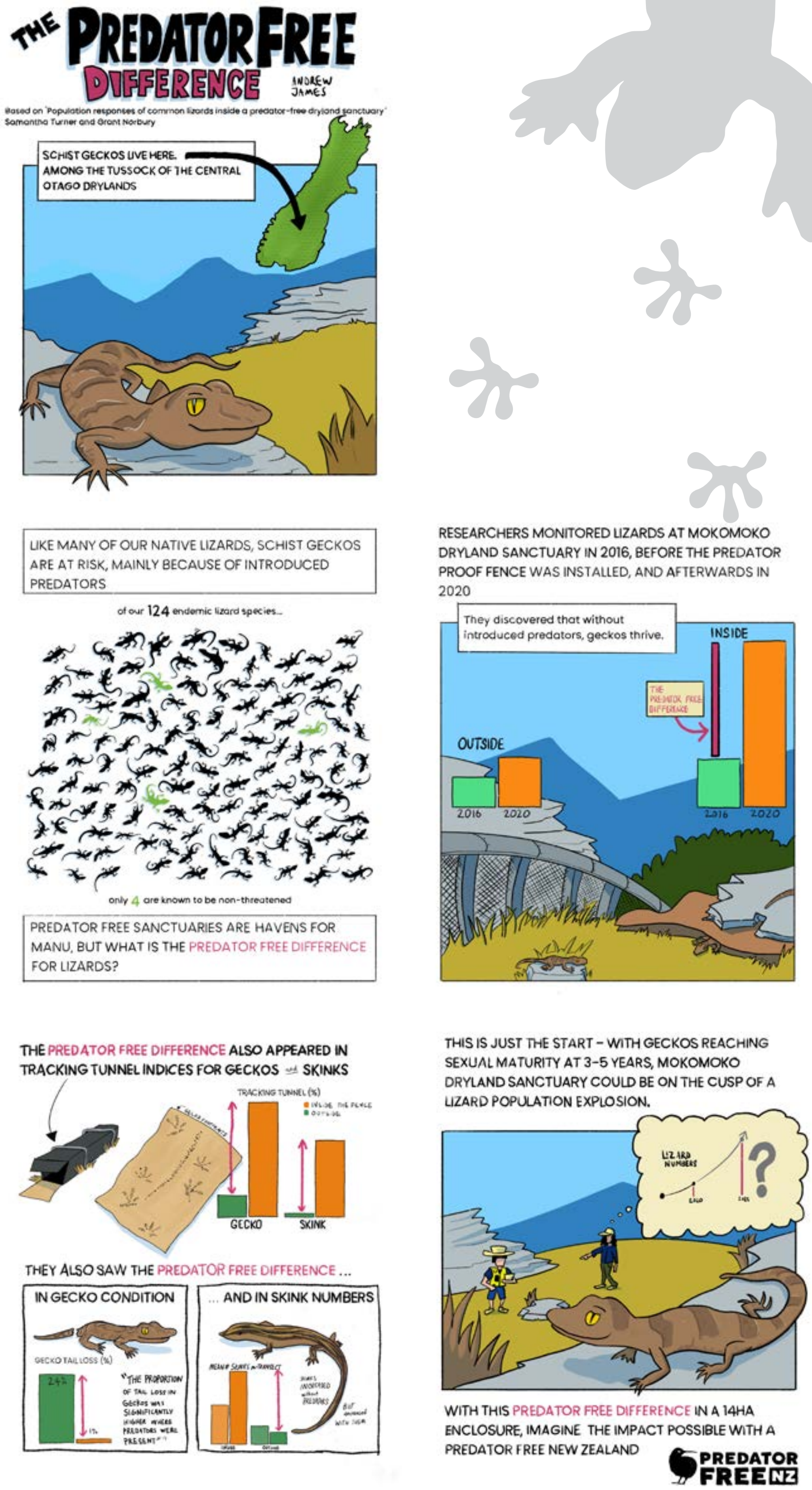
In a study conducted in Central Otago, Manaaki Whenua researchers Sam Turner and Grant Norbury looked at the impact of removing mammalian predators on local lizard populations in a predator-free sanctuary. They specifically monitored three lizard species over a period of six years. Inside the sanctuary, where predators were excluded by a fence, there was a noticeable increase in lizard numbers.

Gecko populations, for instance, more than tripled inside the sanctuary compared with outside areas where predators remained present. Similarly, the number of skinks observed also increased in the absence of predators. There were fewer incidents of tail loss among geckos inside the sanctuary, suggesting reduced stress and predation.

This study shows sanctuaries can significantly benefit lizard species by protecting them from mammalian predators, says Grant.

“We were pretty blown away by these results, given the lizard species we monitored are considered to be relatively robust to predation by introduced mammals. Clearly their populations are being supressed and will respond where we can effectively remove predators,” he says.

Predator Free NZ has created a series of graphic illustrations to communicate the results of the research to a wider audience.



Natural solutions to weed control across the Pacific

Manaaki Whenua's Natural Enemies–Natural Solutions (NENS) weed biocontrol team had a busy start to 2024. The team has visited Niue and Tuvalu and has been involved in a Kiwi-Australian collaboration in the Republic of the Marshall Islands.

In Tuvalu, stakeholders at a prioritisation workshop wanted to find better ways to control tamalini or leucaena (*Leucaena leucocephela*). In the Marshall Islands chromolaena (*Chromolaena odorata*) is a serious issue, while in Niue farmers are struggling to hold back the invasive air potato (*Dioscoria bulbifera*).

In April, the NENS team headed to Tuvalu with the island nation's first ever natural enemy – a colony of leaf-feeding psyllids, *Heteropsylla cubana*, which will be used to control the leucaena.

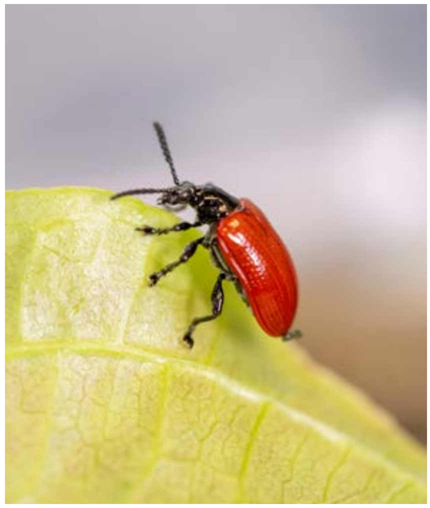
NENS Programme leader Lynley Hayes says the team worked with Tuvalu's National Invasive Species co-ordinator Sam Panapa to release the psyllid – a tiny insect that can rapidly kill seedlings of susceptible leucaena plants, at suitable sites.

Sam underlined the importance of the NENS project through the help it provides Tuvalu to identify invasive weeds and promote the use of natural enemies. "This method is safer than using chemicals, as they do not harm other desirable species or cause other unwanted issues."

Manaaki Whenua collaborated with Biosecurity Queensland in Australia to release a gall fly to combat the spread of chromolaena on Bikini Atoll in the Marshall Islands. The Chief of Quarantine in the Marshall Islands, Ms Silver Wase, says chromoleana outcompetes preferred grasses in grazing pastures, and affects the establishment of bananas, papaya and cocoa trees.

"It was agreed then that natural enemies should be considered for use against the largest known infestation of chromolaena in the country, which is on Bikini Atoll," says Ms Wase.

Michael Day, Principal Entomologist (Honorary) Biosecurity Queensland undertook the long journey - three flights and a 4-day boat trip – with a colony of gall flies in his carry-on. The flies were bred by Biosecurity Queensland, which released the fly in Australia in 2018 in its efforts to control the smothering plant. New Zealand is fortunate to be free of this weed.



*A natural enemy of the air potato (*Dioscoria bulbifera*), the air potato leaf beetle (*Lilioceris cheni*) eats the leaves, which stops the vines from growing large.*

*NENS programme lead Lynley Hayes inspects an air potato vine (*Dioscoria bulbifera*) that is weighing down a palm tree in Niue with National Invasive Species Co-ordinator Huggard Tongatule and colleague Shiloh Pasisi.*

Australia and New Zealand have been collaborating in the field of weed biological control since the 1930s, which saves costs by not having to reinvent the wheel in terms of the research, funding and testing of agents.

While in Niue, the team surveyed potential release sites for the air potato leaf beetle (*Lilioceris cheni*), a natural enemy of the air potato. Colonies of the beetle will be taken to Niue in October.

The NENS work falls under the Pacific Regional Invasive Species Management Support Service (PRISMSS) supported by the Ministry of Foreign Affairs-funded Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) and GEF-6 Regional Invasives Programme.

Celebrating our achievements

Mathematics Research award for senior researcher Dr Rachelle Binny

Rachelle was awarded the 2023 NZ Mathematical Society Early Career Award for Mathematical Research. The NZMS Early Career Research Award was set up in 2006 to foster mathematical research in New Zealand and to recognise excellent research carried out by early-career mathematicians (within 10 years of PhD confirmation). Rachelle was presented the award for work that has driven advances in applied mathematics, as well as having impact in real-world applications including New Zealand's COVID-19 response.

Senior Researcher Rachelle Binny

Honorary academic role for senior researcher in ecology Dr Peter Bellingham

Peter has accepted an honorary academic role at the School of Biological Sciences, University of Auckland for the next four years. This is to support Peter's ongoing projects and co-supervision of students at the University.

Senior Researcher – Ecology Peter Bellingham

Dr Hadee Thompson-Morrison wins **Zonta award**

Hadee, a researcher in environmental contaminants at Manaaki Whenua, has been awarded the 2024 Zonta Science Award. The Zonta Science Award was established to further the status of women in scientific fields and recognises early career performance.

Researcher Hadee Thompson-Morrison

Supporting Māori engagement in tech talks

Stakeholder engagement is fundamental to a project's success. Increasingly it is also a regulatory requirement. This is especially the case in weed biocontrol, where the Environmental Protection Authority requires full consultation with mana whenua groups when a proposal is lodged to bring a new biocontrol agent into the country.

The challenge is that there are limited resources to help communities understand highly technical scientific concepts and information in a way that resonates with them and gives them the tools to engage with agencies in these discussions.

Recognising this gap, Manaaki Whenua researcher Dr Luise Schulte secured support from the Impact Enterprise Fund to create user-friendly tools tailored to Māori communities. "These resources will help Māori communities be on an equal footing to scientific research agencies when it comes to discussions about weed biocontrol," she says.

Kaihautū Māori Research Impact Leader Dr Nikki Harcourt says Māori communities are hungry for resources that translate this complex information into formats that Māori can relate to their ways of knowing and interacting with the world.

"Mana whenua groups often don't understand highly technical scientific concepts that come with issues like the

> *"These support tools need to be developed in collaboration with stakeholders, and those tools need to be tailored to their decision-making needs"*

biocontrol of weeds," she says. "These support tools need to be developed in collaboration with stakeholders, and those tools need to be tailored to their decision-making needs."

Through wānanga (meetings), participants from different hapū and iwi environmental groups have helped to shape the look and feel of resources, including a booklet and animated video to ensure they are useful and meaningful for Māori communities.

"Not only have I had huge capability gains from the experience to date, but the opportunity to design resources with Māori partners has increased my own understanding about an ao Māori framing of inherently techno-scientifically framed concepts," says Luise.

One of the participants in the weed biocontrol wānanga, Graeme Atkins (Ngāti Porou, Rongomaiwahine, Raukūmara Pae Maunga Restoration Project), was very clear that Manaaki Whenua needs to target all the social media platforms and channels to reach communities. "Having trusted faces communicating these key messages in ways that resonate with Māori communities will save endless hui," he says.

Tāne Houston (Ngāruahine, Tāngahoe, Ngāti Ruanui. Ngāti Manuhiakai, Ngāti Tupaia, Ngāti Tānewai, and Taranaki Mounga Project) celebrates resources that use a storyline to carry an important narrative. "Our people are storytellers, so using a video to deliver key points is key to obtaining the emotional connection needed to inspire people to act."

"The kaihautū or Māori leaders are investing Strategic Science Investment Fund money into the production of te ao Māori-centric resources because they know that this is key to achieving impact for our Māori partners, and that means making sure our outputs are aligned with our partner's needs," says Nikki.

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