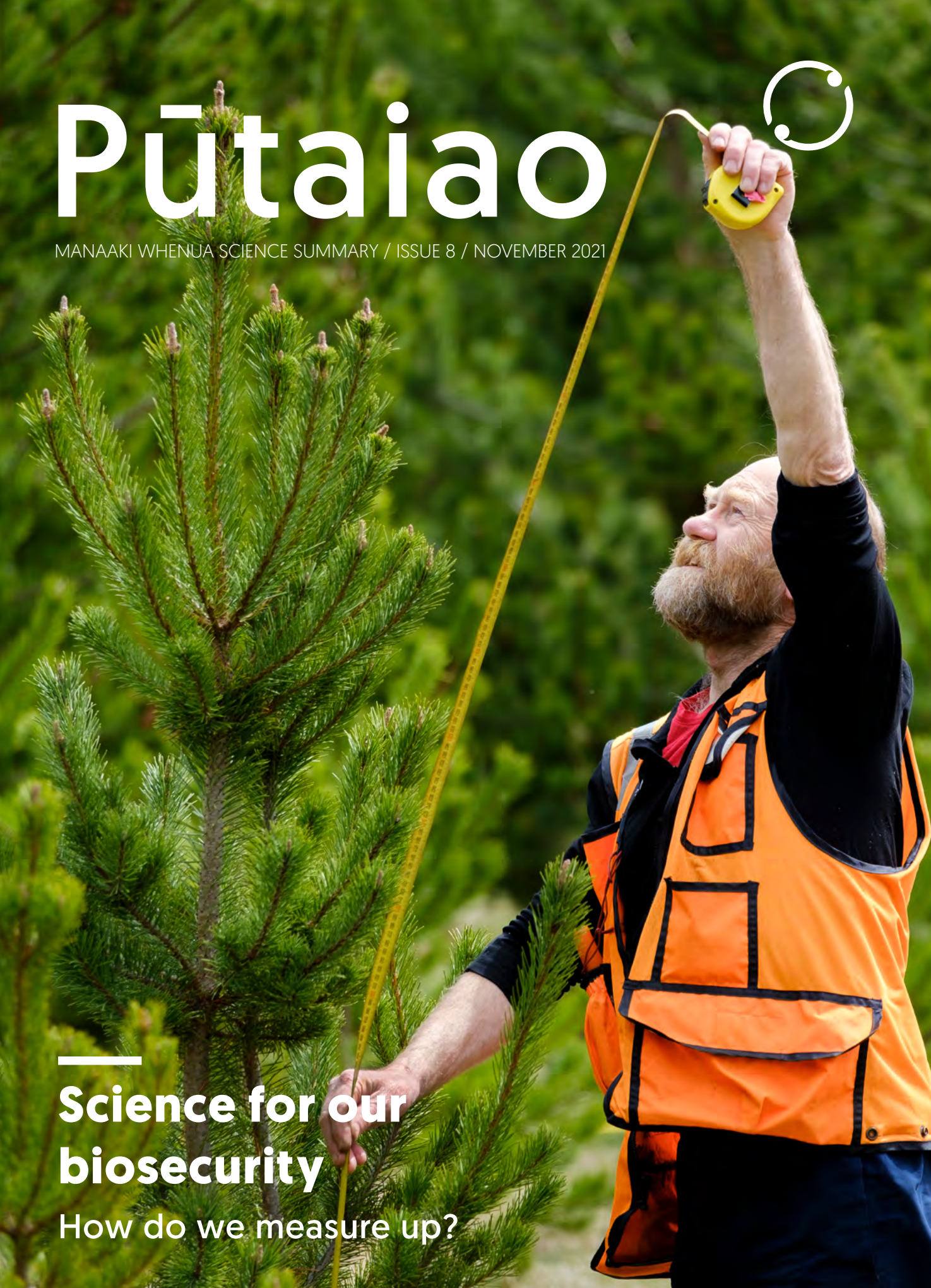
Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 8 / NOVEMBER 2021



Science for our biosecurity

How do we measure up?

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to issue 8 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, biodiversity and climate action. 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* will share the benefits and impacts of our science in helping to ensure a sustainable, productive future for New Zealand. In this issue many of the stories focus on science for our biosecurity – one of our four science ambitions at Manaaki Whenua. 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. Several of the stories highlight our science in biocontrol: controlling pest organisms through the painstakingly careful introduction of other organisms that specifically target pests. We also provide an update on two of our major biosecurity research programmes.

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 Communications Manager Dan Park: parkdj@landcareresearch.co.nz

Cover image: Senior research technician Rowan Buxton measuring wilding pines at Molesworth Station. Photo: Bradley White.

ISSN 2703-3864 (Print) ISSN 2703-3872 (Online)

Winning against Wildings – an update

Introduced conifers are the backbone of commercial forestry in New Zealand, worth around $5 billion a year. However, invasion of land by wilding conifers is arguably New Zealand's most serious and intractable weed problem.

Before 2016 wildings were estimated to be invading the equivalent of nine high country stations, or about 90,000 hectares, each year. Wildings are now thought to occur on at least 1.8 million hectares nationwide, and without control could invade 28% of our total land area within 35 years.

Wildings have profound impacts on our national biological heritage, ecosystem services, economy, and cultural values. As a result, land managers, government agencies, and community trusts collectively spend over $14 million each year managing the problem.
As part of a nationwide response, a team of Manaaki Whenua scientists, led by Dr Duane Peltzer, have undertaken a wide-ranging MBIE-funded Endeavour programme, Winning against Wildings. The programme was a major collaborative effort with Scion, BioProtection Aotearoa, and the University of Canterbury, and it strengthened partnerships with the National Wilding Conifer Control Programme, the New Zealand Wilding Conifer Group, and on-the-ground practitioners. The overall goal of the five-year research programme, which began in late 2016, has been to ensure the long-term success of the National Wilding Conifer Management Strategy, which aims to control or contain wildings nationally by 2030.

New knowledge, evidence, tools and processes developed through our research have generated a wide range of benefits with multiple pathways of uptake – including conferences, webinars and close links with the forestry industry – to ensure our findings, tools, and innovations are widely implemented.

Here are some highlights so far.

- We have quantified spread risk among wilding conifer species, and discovered that their dispersal distance is further than previously known. Spread risk is also driven by variation in seeds within individual trees rather than there being a few 'risky' trees that drive invasion.
- New remote-sensing methods have been developed to detect and map wilding invasions at large spatial scales, including the use of unmanned aerial vehicles (drones) and algorithms that can measure land-use change. These approaches are being used by managers to better plan control efforts, and to help ensure wilding spread is contained.
- Low-dose herbicides to control dense wilding invasion have been developed and tested operationally, reducing the chemicals used in management while effectively controlling over 95% of wilding trees.
- Ernslaw One, the largest Douglas fir grower in New Zealand, is establishing industry trials of a clonal variety of Douglas fir that produces fewer seed cones to test their suitability for forestry use across a wide range of environments and thereby significantly reduce Douglas fir spread risk in the future.

Many of the improvements in wilding control tools we have developed are now an essential part of the good practice guides widely used by managers and contractors to help make control efforts cheaper, safer, and more effective.

Wilding conifers have major impacts on biodiversity, both above and below ground, and can leave persistent legacies in vegetation and soils following management. Social and economic research shows a growing interest in and concern from the public about the negative effects of wildings, and this has, in part, resulted in successful increased investment in national wilding control efforts.

"A major goal of the wildings programme was to integrate ecological understanding with management innovations across the entire invasion curve needed to stop or contain landscape-scale invasions. It is deeply satisfying to look back at how much progress has been made over the past few years, and that new knowledge and collective management efforts have grown quickly over this time", says Dr Peltzer.

Overall, the Winning against Wildings programme has developed a better understanding of the causes and consequences of wilding invasion.

Improved control methods, innovations, and approaches have been developed, as has novel integration with social, cultural, and economic dimensions. During this time the National Wilding Conifer Control Programme has accelerated management from less than 300,000 hectares to around 1.5 million hectares nationally, and in so doing is estimated to have protected over 3 million hectares of vulnerable landscapes.

Longer-term, our findings will be used to support the next investment case to government, now planned for 2022. To fully implement and realise the benefits of wilding management, the next phase of effort (2021–26) will require stopping new invasions and reinvasions, and scaling up wilding management into new areas and regions if the ambitious national goal of stopping or containing wilding spread by 2030 is to be achieved.

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Next-level possum control

The Australian common brushtail possum (*Trichosurus vulpecula*) has invaded most New Zealand landscapes and has established itself as a ravenous and problematic pest. Introduced in 1837 by settlers looking to start a trade in possum fur, the marsupials faced no natural predators and quickly got out of control. They have been linked to defoliation and native habitat die-back and have had a devasting impact on bird life. As potential carriers of bovine tuberculosis (TB), they are also a significant threat to New Zealand's agricultural industries.

Several Manaaki Whenua researchers are working on possum-related projects to meet New Zealand's Predator Free 2050 goal to rid the country of introduced predators and reduce populations to low levels to ensure TB is eradicated.

Genotyping of possums

On the West Coast outbreaks of TB have been recorded in cattle herds despite significant management of possums on-farm and regular possum control operations several kilometres into adjacent forest. In response, Manaaki Whenua was commissioned by OSPRI to assess the extent to which possums infected with TB might be migrating through control buffers.

Possums were surveyed (using chew cards) and captured (using traps or cyanide poison) for DNA genotyping on farmland near Harihari and in forest on both sides of the Wanganui River. We then analysed these tissue samples using genotyping by sequencing (GBS) methods and used these data to assess the inter-relatedness of all possible pairs of the sampled individuals.

We were able to ascertain the precise relatedness of all possums, and from this we were able to extrapolate that long-distance dispersal (over two kilometres) is extremely rare, and we found no evidence for dispersal over four kilometres. These population-level dispersal models would have been difficult to obtain with non-genetic methods.

We also found that the Wanganui River is a nearly complete barrier to possum migration, with the two populations on each side highly genetically diverged from each other. We did, however, identify two migrant possums that had crossed the river, and one 'hybrid', all caught within 350 m of the State Highway 6 bridge.

We found that possum densities in the farmland and buffer zones appeared to be too low for TB to persist. We explained the TB outbreaks as an unexpected spread from uncontrolled deep forest possums to farmland as a result of an unusually high prevalence of TB in valley floor possums upstream from the controlled areas. This has led to much more frequent transmission of TB between possums living in contiguous or overlapping home ranges, and a higher prevalence of TB in the few possums that have moved into the controlled area.

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Tracking urban possums

Predator Free Dunedin (PFD) has a big, hairy goal: eradicate possums in the city by 2050. However, it's hard to do this until you know where the possums are and how trappable the population is. Currently there is a lack of understanding of habitat use and movement behaviour of adult possums in urban and peri-urban environments.

PFD has been working with Manaaki Whenua researchers Deb Wilson, Dave Latham, and Peter Sweetapple to capture, track, mark. and observe possums across the city. After using chew cards to confirm a possum presence and identify clusters of suitable residential properties inhabited by possums, researchers set up live-capture traps paired with motion-sensitive trail cameras in backyards. Two clusters were identified in the suburb of St Clair. Fifteen possums were captured, and eight of these were fitted with GPS collars and released. Unset lethal traps and motion-sensitive

cameras were also set up in the possum home ranges revealed by the GPS data, to monitor individual possum behaviour at different types of trap.

The last few survivors of an eradication attempt can be the most elusive and hardest to track down and kill, because they may be particularly wary of traps and other control devices. If left unmanaged, they go on to become responsible for an increase in possum numbers or reinvasions. Therefore, understanding variation in how animals behave around traps can guide management efforts to trap the final few.

The next steps for the project are to finish the GPS and camera monitoring of possums in the suburbs of Andersons Bay and Corstorphine, and then to establish several new clusters of properties with possums in other suburbs. These data will be added to the information already collected from the St Clair clusters and analysed to understand the optimal spacing for traps and monitoring equipment. The data will also be used to identify movement patterns and corridors that could provide potential routes for reinvasions.

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Motivating the public to support possum trapping programmes

Our researchers have also worked with Predator Free Dunedin (PFD) to understand what stops the public from trapping possums. PFD is working towards the goal of eradicating possums from the city by 2050, so knowing how the public views trapping is an important aspect of this.

Manaaki Whenua researcher Dr Geoff Kaine took an existing framework he had used successfully within farming communities to predict behaviour in response to policy initiatives and reworked it to fit the context of pest control. Drawing on an idea from social marketing called 'involvement' – a measure of motivation – the researchers conducted a large survey in Dunedin. The idea was to measure how motivated people were about the idea of reducing possum numbers, and about using traps as the way to do this.

The survey discovered that only 12% of people in Dunedin currently trap possums. "That means we need to focus on those among the other 88% that think trapping is a good idea but don't trap, and try and identify why they don't trap," says Dr Kaine.

Researcher Dr Nick Kirk led a follow-up project on how to encourage people to get involved with trapping programmes. "We looked at what was needed for people to acknowledge that getting involved in trapping was going to satisfy their personal goal of wanting to reduce possum numbers."

Some of the issues include people not perceiving possums as a problem, animal welfare concerns, and a lack of resourcing to set up and clear traps.

"What we suggested to PFD was that they should develop an education and awareness campaign if they want to achieve their goal. There is a need to reassure people that modern traps are safe for pets, and also to publish maps that show the distribution of possums, especially the areas that are overrun," says Dr Kirk.

"Most importantly, because the research showed people are not strongly involved with the idea of using traps, we recommended that PFD needs to make it as easy as possible for residents to get involved in a trapping programme, for example, by having staff or volunteers who will help monitor and clear traps."

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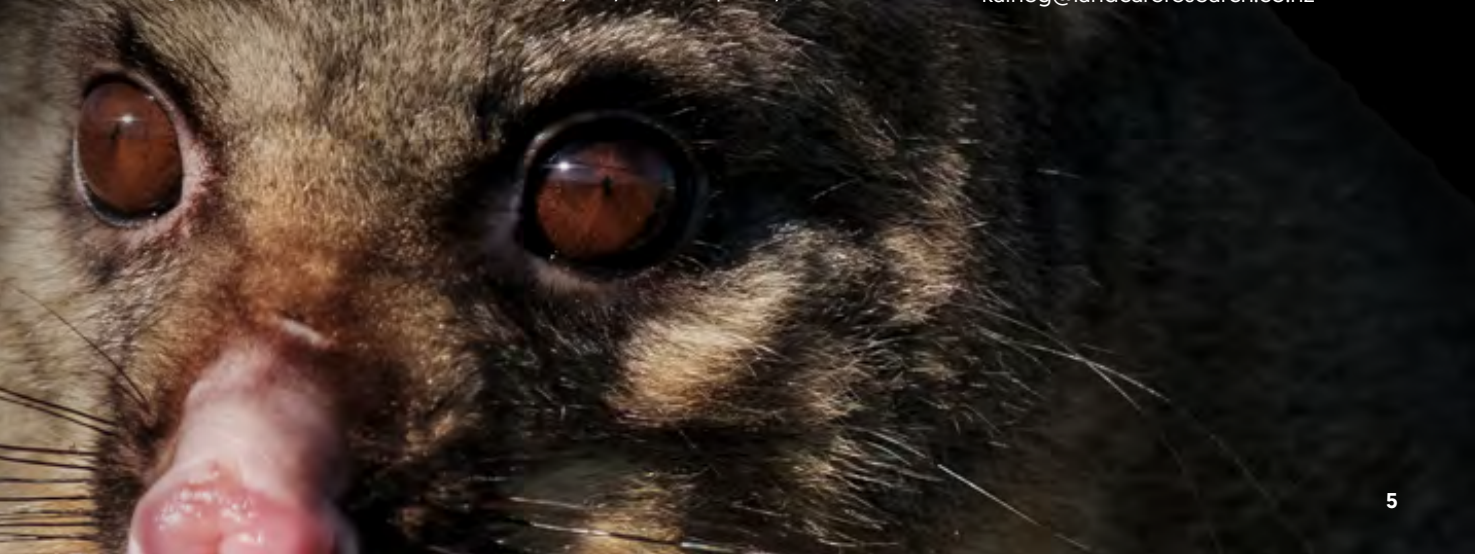
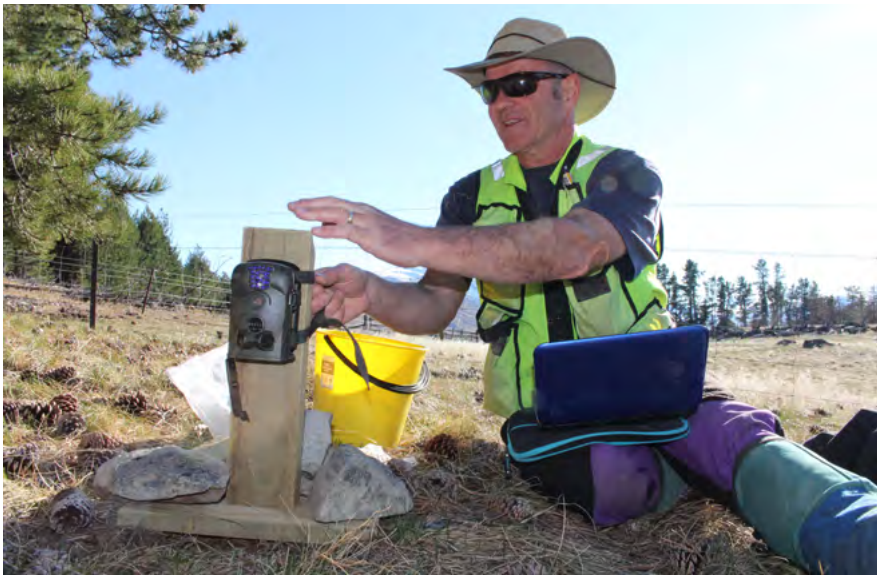


Fake clues: using misinformation about odour to protect rare bird species

Mammalian predators primarily rely on smell as their main cue, enabling them to detect food from a distance. Smell is – usually – a reliable strategy for locating food.

As part of long-running research into the behaviour of introduced mammalian predators in New Zealand and Australia, researchers from Manaaki Whenua and the University of Sydney asked whether it might be possible to manipulate predator behaviour by using misinformation. Could we use unrewarded prey odour cues to fool predators and make them ignore real prey cues? If we could make predators less efficient at hunting, might we also make them miss real prey?

Over two nesting seasons the researchers tested the response of cats, ferrets, and hedgehogs to false odour cues at nesting sites for three shorebird species – the banded dotterel, wrybill, and South Island pied oystercatcher. These native bird species nest on the ground on braided rivers in the Canterbury region, and are highly vulnerable to predators.



Upper photo: Grant Norbury sets a camera trap. Lower photo: Feral cat caught on camera.

The researchers made odorous pastes from bird carcasses and feathers, and tested whether repeated exposure to these odours would affect the predators' behaviours. They set out the pastes at 300 to 400 points across nesting sites before the birds arrived to nest, and also during the nesting season. Predators' behaviour was then compared to that at testing sites without paste. Camera traps were used to monitor predators' interest in the paste, and to monitor the survival of nests with and without odour paste. In the second nesting season the paste/no-paste sites were swapped to increase the reliability of the results.

All three types of predator were attracted by the paste odours, but ferrets and cats, in particular, quickly lost interest when there were no prey associated with the scent cues. As a result, when the birds arrived to nest, the predators had already altered their behaviour by ignoring bird odour, including that of the real birds.

The effects on nest survival were striking for all three bird species: compared with non-treated sites, odour treatments resulted in a 1.7-fold increase in chick production over 25–35 days and doubled or tripled the odds of successful hatching. For banded dotterels, the researchers estimate that this intervention could result in a 127% increase in the population size in 25 years of annual odour treatment. The method is best suited to small areas of vulnerable biodiversity where lethal control methods are difficult to implement.

Lead researcher Dr Grant Norbury of Manaaki Whenua worked with colleagues at the University of Sydney, Dr Catherine Price and Professor Peter Banks, who developed the idea. Dr Norbury says that this field experiment provides clear evidence of altering predators' perceptions of prey availability on a landscape scale, and "could significantly reduce predation rates and produce population-level benefits for vulnerable prey species at ecologically relevant scales, without any direct interference with animals."

This work was supported by a Ministry of Business, Innovation and Employment Endeavour Fund Smart Ideas grant.

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HTTPS *www.science.org/doi/10.1126/sciadv.abe4164*

An update on Eradication Science

Invasive species control routinely removes roughly 95% of a target population. However, as part of the Predator Free 2050 initiative, control operations require complete eradication to be successful. The Eradication Science MBIE programme aims to understand why some individuals survive control operations. Are survivors a random subset of the population, or do they differ behaviourally from most individuals in the population, potentially due to differences in individual personality? Across taxa, personality traits (e.g. boldness, activity, and exploration) can influence factors such as movement, diet, and predation risk. More recently, personality has been shown to influence the likelihood that an animal will enter a trap.

To answer the question of who survives control operations (traps and toxin baits), we have been capturing common brushtail possums throughout 2021 from two study sites. First, animals have been captured before and during a community-run kill-trap operation to investigate whether trapping operations select for certain personality traits. Second, we removed possums (around 120) from a site designated by the Department of Conservation for a toxic-bait operation and quantified personality traits and behavioural responses to baits and traps in captivity. We will now monitor survivorship during the subsequent toxic bait operation.

These two experiments will allow us to determine how personality may act as a mechanism by which some individuals survive control. Understanding why some individuals survive will in turn allow us to develop methods to better target the motivations that drive the behaviour of these individuals.

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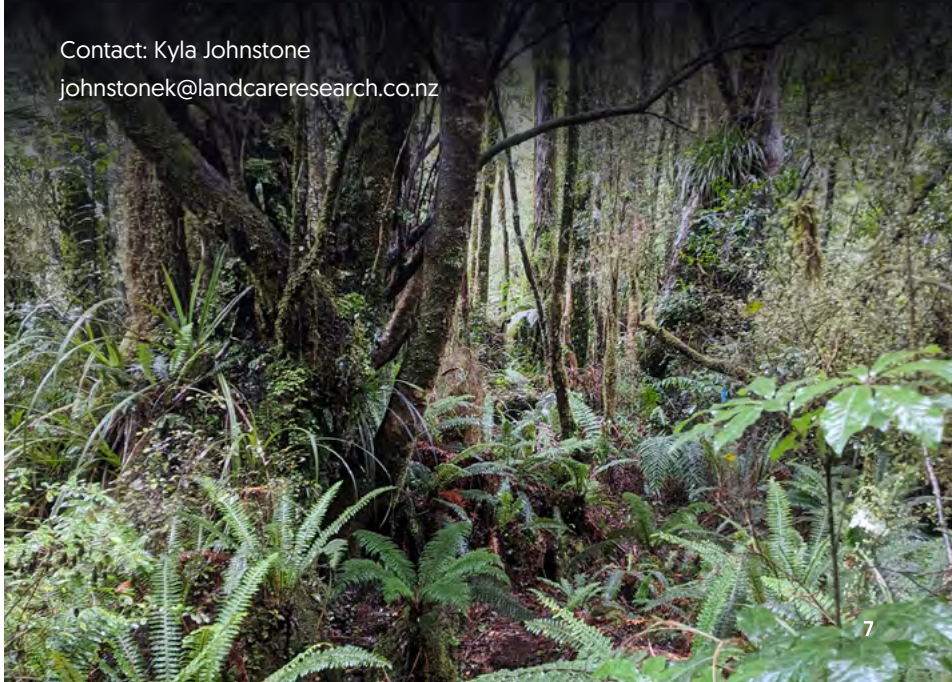

Tucking into Tongariro heather

Heather (*Calluna vulgaris*) was deliberately introduced into New Zealand, on the Central Plateau of the North Island, from 1912 to 1923 in an attempt to re-create Scottish grouse moors. By the 1990s it had spread to cover around 60,000 hectares of land in what is now Tongariro National Park.

The heather beetle, *Lochmaea suturalis*, was first brought into New Zealand to try to tame the invasive plant in 1996, but the beetles took a long time to establish and initially failed to thrive, with only one population surviving.

Manaaki Whenua researchers Paul Peterson and Simon Fowler have now mapped the spread of that beetle population in the park, and found that the beetles have spontaneously spread several kilometres away from known release sites. The mapping shows that vast areas of heather have been affected by the beetles over the past three years, with approximately 20,000 hectares now remaining. As a reflection of the success of the beetles, the NZ Defence Force no longer has to spray herbicide over large areas of its Waiouru Military Training Area adjacent to the Park.

The researchers now plan to check higher-altitude sites that are harder to access to see how high beetles can thrive. Research will also investigate whether any environmental changes over the past 25 years, or a genetic adaptation, have contributed to the recent spontaneous increase in beetle populations.

Researchers are also revisiting sites to monitor if the heather recovers after beetle attack, and if so, how quickly. So far the signs are good that the beetle can rediscover recovering heather and repeat its demolition job.

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New biocontrol tools for wasp pests

Introduced Vespula wasps – the German wasp (*Vespula germanica*) and the common wasp (*V. vulgaris*) – are generalist predators that attack a wide variety of arthropods, including honeybees, butterflies, flies, and spiders. Where they are invasive, these wasps have detrimental effects on normal ecosystem functioning, food webs, and the behaviour of native birds.

The wasps also have a significant impact on New Zealand's beekeeping industry, with wasp damage regularly ranked as the third- or fourth-highest cause of colony loss in beehives. Together with their disruption of the enjoyment of the outdoors and recreational activities, and the health risks of stings, it is estimated that wasps cost New Zealand up to $130 million annually in damage and management.

Fortunately, new biocontrol tools are about to be released to control both types of wasp. The Tasman District Council, acting on behalf of the Vespula Biocontrol Action Group, applied to the Environmental Protection Authority (EPA) in September 2020 seeking permission for two new wasp biocontrol agents to be released in New Zealand: a beetle and a hoverfly, both of which parasitise the brood of the wasps within the wasp nest. The application was prepared and managed by Dr Bob Brown at Manaaki Whenua.

The EPA's decision to allow the new biocontrol agents was notified on 16 February 2021, some five years after the first science was begun. This is a major milestone. The next steps are for Manaaki Whenua's researchers to receive the agents into our insect containment facility for rearing and eventual release.

The process for obtaining an EPA biocontrol approval is long and painstaking. A great deal of research was done to ensure the new biocontrol agents are completely specific to the target organism, do not attack any other organisms, and do not harbour any diseases or parasites that could attack them.

Many different groups are involved in any biocontrol initiative. For this one, stakeholders included South Island iwi, Department of Conservation staff, regional councils, the QEII National Trust, the NZ Landcare Trust, the Ecological Society of NZ, Federated Farmers, the Royal Forest and Bird Protection Society of NZ, the NZ Entomological Society, the NZ Forest Owners Association, Apiculture NZ, and District Health Boards. Public submissions were also heard.

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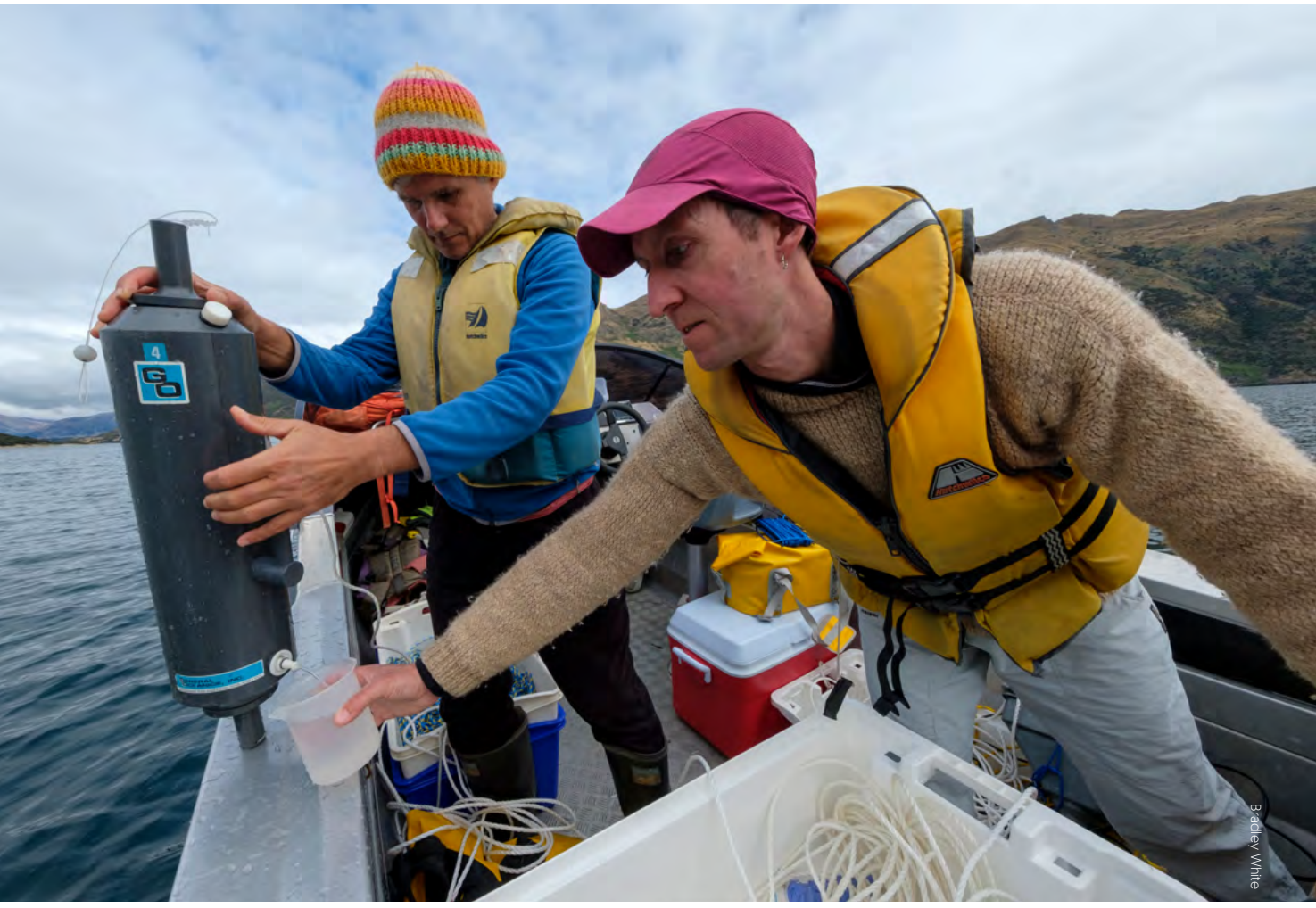
Tracking lake snow across Aotearoa

Lake snow is a sticky, mucus-like substance extruded like threads from cells of the alga *Lindavia intermedia*. Suspended in water, it sticks to fishing gear, boats, motors and people, and if it gets into residential water supplies it can clog filters in household appliances. First noticed in Lake Wānaka in the mid-2000s, it is now known to have infested at least 38 lakes nationwide.

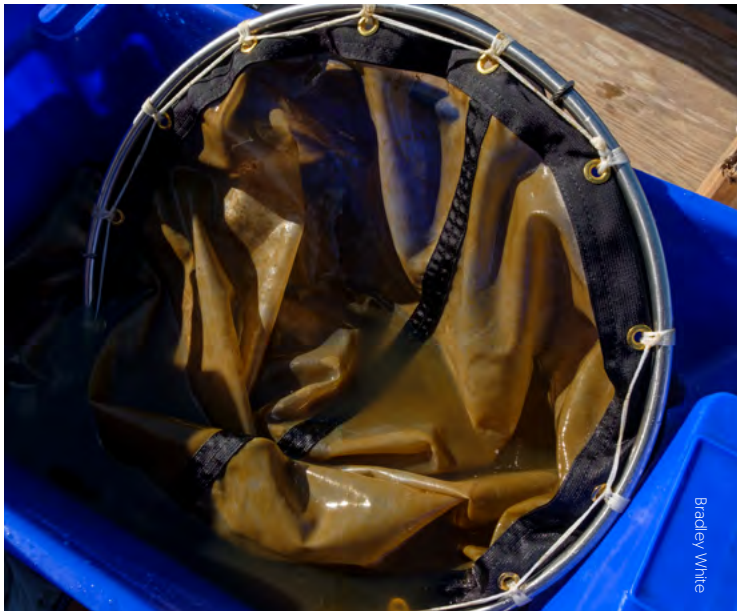
Following detection of *L. intermedia* at Nelson's Lake Rotoiti in 2019, Manaaki Whenua's Dr Phil Novis has spent the past year working with the Tasman District Council to get a better understanding of the threat it poses to the clear, high-water-quality lakes in the Nelson district.

This project used molecular methods developed during a three-year project, supported by MBIE's Endeavour Fund, to create new rapid-screening tools to detect the presence of lake snow. Sampling in the Nelson Lakes National Park was funded by Envirolink and Tasman District Council and carried out with field support from the Department of Conservation. Samples were collected every six weeks between June 2020 and May 2021 at two sites at Lakes Rotoiti and Rotoroa.



Phil Novis and Marc Schallenberg collect water from 15 m depth in Lake Wanaka, using a Van Dorn sampler. The sample contains lake snow and its causative agent, Lindavia intermedia.

> *There is no known control or eradication method for lake snow. While the alga is not toxic to humans or livestock, its impact on the ecology and health of the pristine lakes it favours is likely to be significant.*



Lake snow captured on a zooplankton net, Lake Wanaka.

While lake snow was not detected, the sampling did confirm the invasive alga is present in both of the Nelson Lakes National Park lakes. Sampling has also detected *L. intermedia* in Nelson City's Maitai Reservoir. Council-funded work on understanding the dynamics of *L. intermedia* populations in the Maitai Reservoir and the risk of lake snow development is ongoing.

The good news from wider sampling was that a large number of vulnerable lakes are currently free of detectable *L. intermedia* (and therefore lake snow), probably only because they are inaccessible.

There is no known control or eradication method for lake snow. While the alga is not toxic to humans or livestock, its impact on the ecology and health of the pristine lakes it favours is likely to be significant. The research shows the alga likes cool, deep, nutrient-deficient lakes with low phosphorous concentrations. Results show that cell growth tends to occur in winter, with lake snow synthesis more severe in summer and autumn.

Dr Novis says that a much better understanding of *L. intermedia* ecology is needed. "Now there are the tools to quantify both the alga and the slime it produces, we have recommended the ongoing monitoring of water quality in the lakes, in the Nelson Lakes specifically, to gauge long-term trends for the alga. This would provide much needed data on lakes in forested catchments that could be useful in future incursions by the species."

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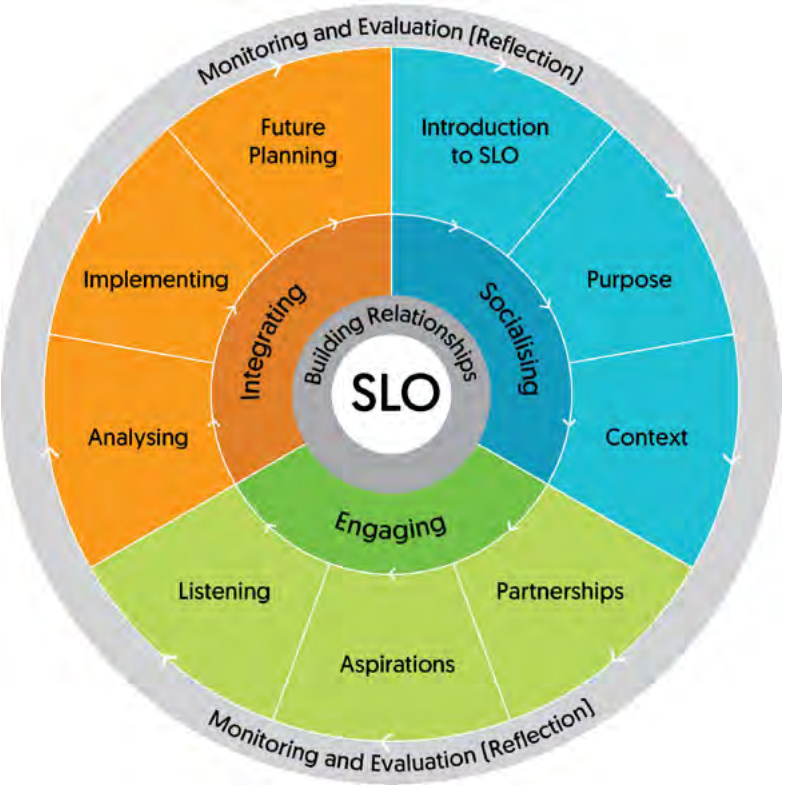
Building social licence to operate

Social licence to operate (SLO) is an essential ingredient in successful applied research, and is sought after by groups and organisations wishing to bring about environmental change. For example, if New Zealand's ambitious predator-free goals are to be realised, SLO will need to be built around the introduction of new pest control technologies.

SLO is much more than good PR and promises: it involves the cumulative building of credibility and trust over time with affected communities of interest. Social licence is not a single specific permission granted by communities to an organisation, but is better thought of as multiple licences achieved across various groups at different times. It is subject to change as opinions and perceptions change, and needs to be continually managed rather than obtained.

Three of Manaaki Whenua's social researchers, Dr Dean Stronge, Robyn Kannemeyer, and Dr Peter Edwards, have developed a practical framework (Figure 1), informed by both Western and indigenous views of engagement, which is now being used to guide organisations that wish to gain and maintain a credible and effective social licence. There is no one-size-fits-all approach, so the framework is intended only as a guide and is adjusted depending on the needs and understanding of the organisation or the issue in question.



There are four key phases to building social licence:

1. **socialising** the concept of SLO with the organisation
2. **hearing** the views of stakeholders, and understanding that their expectations are essential in building and maintaining SLO
3. **integrating** or co-developing the views and expectations of stakeholders into an organisation's processes and procedures so that they foster SLO and promote participative and learning opportunities
4. **reflecting**: working towards SLO is a dynamic and evolving process, so learning opportunities are important and need to be fed back into the process in a continuous reflecting step.

As an example of this framework in action, our researchers were asked to advise Predator Free (PF) Southland on a pathway that offered a greater potential to gain and maintain a social licence to eradicate possums and suppress mustelids in the Awarua region. The PF Awarua landscape extends from Sandy Point to Fortrose, covering approximately 69,000 hectares and including Bluff and Omaui, two communities with different experiences of previous predator control initiatives.

The recommendations that arose included engagement with the Awarua community early and often; transparency in sharing and communicating information; use of multiple communication channels; and thinking ahead about the legacy PF Southland and the community want to leave for future generations. Other vital factors in building successful SLO for PF Awarua include:

- the appointment of exceptional leaders and continuity of personnel
- an engagement plan that is adaptable and flexible to cater for different values, beliefs, and world views
- engagement and communication with some landowners and communities tailored specifically to those groups or individuals.

During our work on SLO it has become clear that it has many synergies with kaupapa Māori research, which also requires a social licence to engage with individuals, communities, and organisations, and includes building credibility and reciprocity when establishing relationships, empowering communities to build capacity, or leaving something tangible for the community when the project is completed. This is an area that is now being investigated further at Manaaki Whenua.

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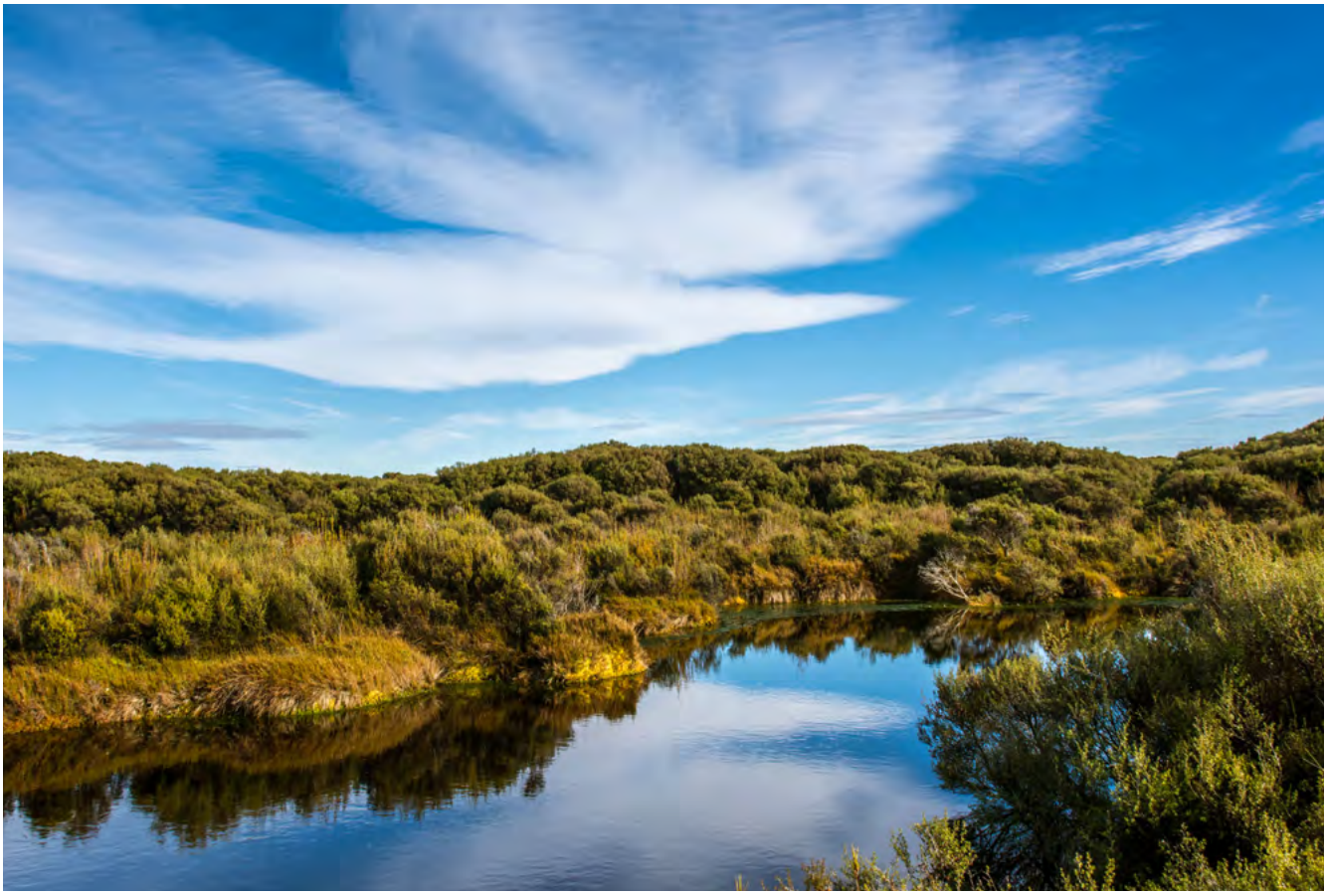

Shellie Evans

Awarua-Waituna Wetlands is one of the largest remaining wetland complexes in New Zealand and is important for its biological diversity and cultural values.

Unite against COVID-19

Modelling the nation's COVID-19 response

Successful contact tracing systems for COVID-19 rely on effective quarantine and isolation

Test, trace, and isolate is a strategy used widely in the fight against COVID-19. On its own, contact tracing is unlikely to contain a COVID-19 outbreak, but it may reduce transmission enough to allow population-wide social distancing measures, including lockdowns, to be relaxed. Our researchers have applied their wildlife disease modelling knowledge to this aspect of the COVID crisis.

Recognising the need for robust ways to measure the effectiveness of contact tracing in reducing the spread of COVID-19, a team of researchers, including Manaaki Whenua's Dr Rachelle Binny and Dr Audrey Lustig, developed a model to investigate the importance of contact tracing, quarantine, and isolation in reducing transmission. "We used an age-structured branching process model for COVID-19 transmission in Aotearoa New Zealand, in the presence of contact tracing and case isolation," says mathematical modeller Dr Binny.

"Our results show that a high-quality, rapid contact tracing system, combined with strong support for people in quarantine or isolation, can be highly effective in reducing the spread of COVID-19. In the best cases we found that contact tracing can reduce the effective reproduction number – the average number of people who are infected by a single infected person – by up to 60%. However, this reduction in transmission relies heavily on having effective quarantine and isolation for cases and traced contacts," she explains.

"If case isolation or quarantine are imperfect, or some contacts aren't traced or are traced more slowly, then the reduction is only around 40%, meaning that stronger social distancing measures would be needed to control an outbreak."

Predicting the elimination of evolving COVID-19 variants

A second research paper involving Dr Binny, 'Predicting elimination of evolving virus variants', models the recent emergence of multiple SARS-CoV-2 variants and the risk these pose to global efforts to control the COVID-19 pandemic. In the study, researchers created a simple model of disease spread, which includes the evolution of new variants and varying vaccine effectiveness for these new strains.

They found that viruses that mutate into multiple new variants need fast vaccine delivery in order to be contained. The researchers concluded that rapid vaccine updates to target new strains are more effective than slow updates, and that containing spread through non-pharmaceutical interventions is vital while these vaccines are delivered.

The study also suggested that a continuous vaccination roll-out programme, where updated vaccines

are given to unvaccinated individuals, rather than revaccinating high-priority individuals, may slightly increase the probability of elimination. However, the researchers note that this prediction warrants further investigation using population-structured models to assess the risk this would pose to vulnerable individuals such as frontline workers or those at higher risk of severe disease.

"When enough people in a population are vaccinated, new variants are less likely to arise and outbreaks of existing variants can be more easily controlled with contact tracing and lower alert levels," explains Dr Binny. "If new variants emerge that are resistant to current vaccines, then our model suggests that the faster the vaccines can be updated to target these new variants, the better our chances of elimination. Yet, even when New Zealand completes its vaccine roll-out, there will still be a risk of new vaccine-resistant variants emerging in outbreaks abroad. This could undo a lot of our hard work, so it's also important that New Zealand work with other countries to achieve high vaccination coverage globally."

Ongoing COVID-19 response research highlights:

- Our modellers contributed to two technical reports describing the mathematical modelling that was used in the days following the detection of the Delta Variant in August to provide situational awareness and inform the Government's high-level outbreak response.
- A new paper 'Early intervention is the key to success in COVID-19 control,' led by Dr Binny, modelling the importance of the timing of interventions for containing New Zealand's March/April 2020 outbreak, concludes that the early introduction of stay-at-home orders was crucial in reducing the number of cases and deaths and enabling elimination throughout New Zealand.
- A modelling paper involving Manaaki Whenua modellers concludes that New Zealand may no longer need strict nationwide lockdowns to control COVID-19 if more than 90% of the eligible population are fully vaccinated. Even while vaccine levels are below this high threshold, vaccination still significantly reduces the numbers of infections, hospitalisations, and deaths during an outbreak, and greatly improves the chances of eliminating an outbreak quickly, before it can grow very large.

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Te Reo o Te Repo cultural wetland handbook launched

A new cultural repo (wetland) handbook has been launched to help give a voice to repo throughout Aotearoa New Zealand. *Te Reo o Te Repo – Kei konei tonu au | The voice of the wetland – I am still here* is the second volume of the Te Reo o Te Repo cultural wetland handbook series published by Manaaki Whenua. The handbook, launched at the INTECOL International Wetland Conference, focuses on providing more information on the cultural significance of repo to help define priorities for wetland restoration.

> *"It will be a useful tool in restoring and reconnecting whānau to their local repo."*

"*Te Reo o Te Repo – Kei konei tonu au* continues to advocate the voices of our repo through the voices of our people and provides Māori values, knowledge, and perspectives from across Aotearoa New Zealand, ranging from whānau, marae, hapū, and iwi-led restoration projects and practical demonstrations that illustrate the diversity of our precious wetland ecosystems, to academic research that provide the underpinning of cultural resources and mātauranga Māori-based tools and approaches," says Manaaki Whenua Kairangahau Māori Yvonne Taura.

Repo sustain indigenous biota, filter nutrients, absorb floodwaters, and sequester carbon, providing multiple economic, social and cultural benefits. However, 90% of repo in Aotearoa New Zealand has been lost since European settlement and the remaining wetlands are still under threat of being further degraded by human impacts.

Co-editors say the new addition to the cultural wetland handbook series, funded by Strategic Science Investment Funding for Crown Research Institutes, will be a useful tool in restoring and reconnecting whānau to their local repo.

"Recognising that our repo are still sadly declining, we felt that we needed to maintain their presence in national conversations. It encourages us to build on our remaining indigenous biodiversity by using our own mātauranga gifted to us from our tūpuna," Taura adds.

Te Reo o Te Repo – Kei konei tonu au is available to download at www.landcareresearch.co.nz/te-repo-2

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Exploring the impact of climate change on Māori

Māori governance institutions are increasingly asserting their rangatiratanga (autonomy) to manage climate change risks and meet the well-being of whānau, hapū, and iwi. However, there is a shortage of guidance and understanding on how to prepare for and respond to this changing environment, and how to address the challenge in a way that reflects Māori world views and values.

Manaaki Whenua researchers, including Senior Kairangahau Māori Dr Shaun Awatere, have been part of a multidisciplinary team of Māori researchers, coordinated by Ngā Pae o te Māramatanga, to help fill this knowledge gap, identify risks, and explore climate change mitigation and adaption solutions for Māori. Researchers have produced a report: *He huringa āhuarangi, he huringa ao: A changing climate, a changing world*, which summarises the latest research and guidance on observed and projected climate change impacts on whānau, hapū, iwi, and Māori business throughout Aotearoa New Zealand.

Amid the observed and projected impacts presented in the report, researchers found that many whānau, hapū, iwi, and Māori businesses hold deep concerns about how climate change will affect livelihoods, health, culture, and the environment. The report found that climate change not only threatens the tangible components of Māori well-being, but also the spiritual components and, most importantly, the well-being of future generations. The assessment shows that Māori well-being across all domains will be moderately affected by 2050, but that by 2100 the impacts to ecosystems are likely to be severe, compromising many aspects of Māori well-being.

Researchers say that whānau, hapū, and iwi will need to consider adaptation strategies that protect the integrity of te reo me ōna tikanga (Māori language and customs); future-proof existing cultural infrastructure; and provide flexibility as well as safeguards to enable whānau to engage in social/cultural activities that enhance well-being and ensure an enduring cultural legacy for future generations.

It concludes there is a need for further integrated assessments and understanding of climate change risks from a te ao Māori perspective, and for different groups and communities to develop a more targeted set of adaptation and resilience strategies to address the complex set of multiple stresses, disparities, and inequalities exacerbated through climate change and uphold Māori interests under the Treaty of Waitangi.

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HTTP *www.maramatanga.ac.nz/te-arotahi-07*

An update on our Better Border Biosecurity work

Darren Ward and Quentin Paynter have been funded through Better Border Biosecurity (B3) to assess the non-target impact of biocontrol agents used in New Zealand over the past 100 years to control insect pests. The work will provide the EPA with information when assessing future applications for the release of biocontrol agents, and for the Ministry for Primary Industries (MPI) in advance of a future incursion by insect pest species that could have wide-ranging impacts on native plants, the natural estate, and primary industries. The project finishes next year and has so far found that the vast majority of biocontrol agents used have had minimal negative impact on non-target species. As part of the wider project, the B3 team is exploring the safety of *Trissolcus japonicus* (samurai wasp) as a biocontrol agent against the brown marmorated stink bug and how the wasp might affect a New Zealand native stink bug.

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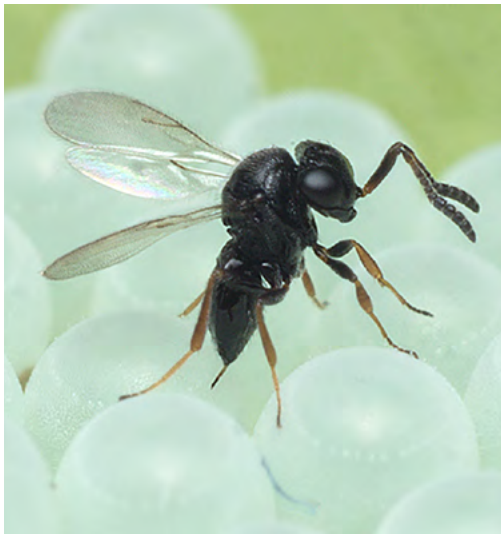
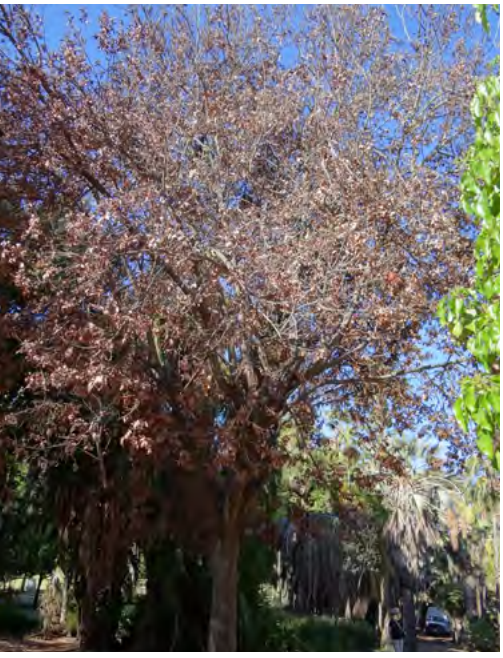


*Samurai wasp (*Trissolus japonicus*).*



Tītoki, Alectryon excelsus, *standing dead following attack by the bacterial plant pathogen* Xylella fastidiosa. *Balboa Park, San Diego, California 2012.*

Ronny Groenteman is leading B3 research to better prepare New Zealand for an incursion of the devastating bacterial plant pathogen *Xylella fastidiosa.* Almost a decade ago Ronny and her Manaaki Whenua colleagues collected samples from New Zealand native trees growing in botanic gardens in California, where *Xylella* has devastated a wide range of crops such as citrus and grapevines. They found *Xylella* present in these offshore natives, but not always causing disease symptoms. To solve this mystery and help New Zealand prepare for a possible *Xylella* incursion, Ronny and the B3 team are sourcing samples of the same natives in California again to sequence the pathogen subtypes and their relative effects on our taonga plants. The research makes use of an international network of botanic gardens, called the sentinel plant network, whereby the impact of biosecurity threats can be studied on our plants offshore. The researchers will also try to develop a test to quickly determine the subtype of *Xylella* from a small quantity of genetic material. This will help agencies such as MPI to quickly adjust their response to an incursion based on the subtype information. Another B3 project is looking at insects present in New Zealand, native and exotic, that can spread *Xylella* and their movement between sensitive crops and the surrounding vegetation.

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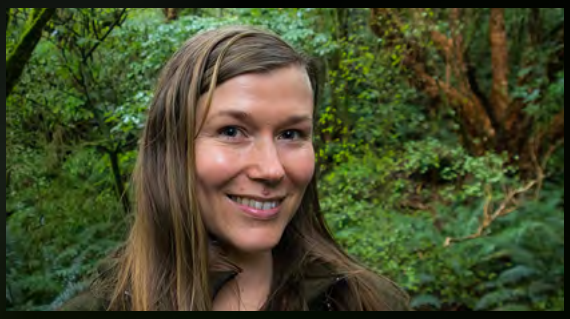
Celebrating our achievements

Jo Carpenter was awarded the 2020 New Zealand Ecological Society award for Outstanding Publication on New Zealand Ecology. Her paper, '*An avian seed dispersal paradox: New Zealand's extinct megafaunal birds did not disperse large seeds*', was published in *Proceedings of the Royal Society B.*

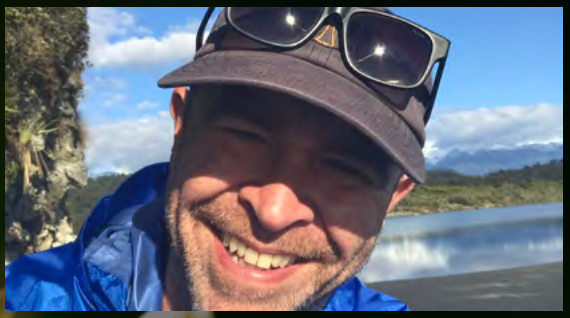
Nick Cradock-Henry As one of New Zealand's foremost experts on climate adaptation, Nick was invited by the Science Media Centre to apply his knowledge of resilience to the social implications of climate change to the IPCC's Working Group 1 Sixth Assessment Report on the physical science of climate change. Nick's comments were quoted in various local and international media, including *The Guardian* and Radio NZ.

Bev Clarkson and husband Bruce Clarkson received the Hamilton Kirikiriroa Medal, one of the city's highest accolades, acknowledging their life's work with wetlands, gullies, Waiwhakareke Natural Heritage Park, and other aspects of urban restoration across the city.

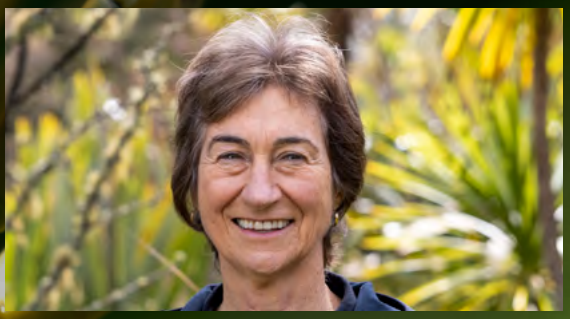
John Innes was recently awarded the Peter Nelson Memorial Trophy at the annual (virtual) meeting of the New Zealand Biodiversity Institute for a "significant contribution to vertebrate pest management within New Zealand over the past 40 years, through John's innovative and management-focused research into how introduced predators interact with native species".



Jo Carpenter



Nick Cradock-Henry



Bev Clarkson

John Innes

Space invaders – revising the management of weeds

Weed management efforts often focus on single, 'priority' plant species because they have known, substantial and detrimental ecosystem impacts. However, globally, most ecosystems have been invaded by multiple non-native plant species.

Even within relatively pristine systems such as New Zealand's forests and shrublands, non-native species make up a large proportion of all plants. From the National Vegetation Survey (NVS) databank, administered by scientists at Manaaki Whenua, we find that around 37% of over 60,000 vegetation survey plots across New Zealand contain at least one non-native plant species, with 56% of these invaded plots containing multiple non-native species.

At present we lack experimental data to properly guide the management of ecosystems that have experienced multi-species invasions. To address this problem, ecologists at Manaaki Whenua, the University of Auckland, the University of Canterbury, and international colleagues in Australia, the USA and Singapore, are investigating how co-occurring plant invaders interact and the consequences of those interactions for the invaded ecosystems.

Because ecosystem impacts tend to increase with the abundance of a weed, how co-occurring weeds affect each other's abundance, as well as total weed abundance at any site, will affect their combined ecosystem impacts. An additional weed at a site can influence total weed abundance at the site or the abundance of the first weed to invade. For example, nitrogen-fixing legumes like Scotch broom or clover can help non-native sward grasses grow more prolifically. Complicating matters, we know that some native plants can also facilitate weed invasion.

However, the impacts of co-occurring weeds can also directly interact – such as where pines and non-native grasses can create a ladder of fire into the canopies of forests.

Co-occurring weeds can therefore have profound, but sometimes unanticipated, effects on plant communities and ecosystems. One weed might suppress the impact of another through competition, keeping a perhaps more problematic weed in check. Different management strategies are needed to effectively mitigate these invasion impacts in systems with multiple weeds.

The researchers suggest that adopting a community ecology framework, which considers the complexity of interactions among all the non-native and native species at a site, might help better identify target weeds for management. Choosing to first manage weeds that have high potential to interact with other invaders and natives could reduce the likelihood of unexpected outcomes for ecosystem functions and processes.

However, more empirical data are needed. Aligning more invasion impact research with management activities such as weed removal would also help to determine how co-occurring weeds interact across a wide variety of systems and feed in to helping practitioners implement the most effective strategies to reduce their impacts.

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