Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 15 / AUGUST 2023

Climate-smart science

A heads-up on our latest research

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to Issue 15 of *Pūtaiao* ('science' in te reo Māori), our quarterly publication showcasing the work of Manaaki Whenua.

In this issue of *Pūtaiao*, we highlight some of our most recent work in environmental management and climate science, including how technology is making it easier to safeguard the future of our vulnerable wetland ecosystems as well as predict landslide risks more accurately, and how New Zealand, and specifically Māori communities, can build resilience in the face of future extreme weather events.

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: Harvesting cauliflowers in Pukekohe, New Zealand's vegetable growing hub.

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Time to build resilience into food production

In the truest sense of chaos theory, where the flapping of a butterfly's wings on one side of the world causes a typhoon on the other, our world is so interconnected now that turbulent world affairs and extreme weather events are no longer TV news stories that happen somewhere else to someone else.

In Aotearoa New Zealand we are feeling this sharply after the COVID-19 pandemic, the war in Ukraine and several extreme weather events that have turned, in the words of Newshub, 'the fruit bowl of New Zealand into a mud bath'. For the first time since 1987, surging food prices in the country hit a 12.5% high in April 2023.

Manaaki Whenua researcher and senior economist Dr Suzie Greenhalgh and former colleague Dr Tarek Soliman say the recent rising cost of living gives more weight to their 2020 argument that New Zealand should pay more attention to food security at a national level.

In their policy brief, *Rethinking New Zealand's food security in times of disruption*, Suzie and Tarek said feeding Kiwis was overlooked in the pressure to produce premium products for the lucrative export market. But the times, they are a changing.

As climate change threatens more extreme weather events globally, staples like sugar, rice, bananas and wheat, and luxuries like coffee could be in short supply.

"People in urban areas generally don't typically notice the slow changes to food production caused by drought and wet weather disruption, or by the loss of highly productive land to housing developments as we simply import any shortfall," says Suzie. "However, these are actually the biggest threats to our food security."

A farmer inspects his sugar beet crop in New Zealand's vegetable growing hub, Pukekohe.

The policy brief proposed several actions that could help the country build resilience into our food systems.

"Addressing consumer issues, such as meeting out-of-season demand and cultural requirements, increasing urban food production, and reducing food waste, are among the first steps we can take as individuals to improve our food security," says Suzie. "We should also be exploring opportunities for greater domestic production of at-risk commodities."

She adds that considering how inventive Kiwis can be, with the right support, it shouldn't be hard to make some of the changes needed. Growing sugar beet could keep us a step ahead of any interruption in sugar supplies that would threaten our baking, brewing and cups of tea.

The food security policy brief formed the foundations for further research to focus on the report's recommendations. Two key areas the brief says need to be tackled urgently are the issues of food waste and the loss of highly productive land.

"Around 77 tonnes of fresh fruit and 74 tonnes of fresh vegetables are wasted each year as consumer leftovers," says Suzie. "Half of all consumer food waste is fresh fruit and vegetables. In 2018 in New Zealand, the waste from potatoes and lettuce alone was estimated at 12 and 5 tonnes respectively."

In the first multi-case study research into the return on investment into food rescue in New Zealand, Manaaki Whenua's Dr Gradon Diprose says the data indicate an investment of $1 in food rescue delivers $4.5 of social value (see sidebar). "This study highlights the transformative potential in

The value of food waste

Collaborative research between Aotearoa Food Rescue Alliance (funded through the Ministry of Social Development), University of Otago's Food Waste Innovation Programme, Manaaki Whenua's Dr Gradon Diprose (funded by the Resilience to Natures Challenges National Science Challenge) and an independent researcher highlighted the importance of research at the intersection of social concerns (food poverty and access) and environmental concerns (reducing food waste and associated impacts like unnecessary emissions etc). "It's the first social return on investment for food rescue that considered multiple organisations and different models across supply chains," says Gradon.

The reseachers used the seven guiding principles of social return on investment (SROI) to examine how food rescue generates value for various stakeholders who included food donors, food recipient organisations, food rescue volunteers, and food rescue recipients. Through interviews and analysing quantitative data, the researchers identified nine primary outcomes. Monetary values were assigned to these outcomes, resulting in an SROI ratio of $4.5:1. This indicates a $1 investment in food rescue yields $4.5 worth of social value.

"The research shows we need to evaluate polices that can reduce food waste, find ways to invest in the food rescue sector, and build relationships in the food rescue network," says Gradon. "By evaluating the outcomes over time in different situations, we can gain more knowledge about the role of food rescue in transforming the overall food system."

addressing food security issues," he says.

The policy brief's primary concern was losing New Zealand's highly productive soils altogether. "Once they are turned into housing, that's it. They're gone," says Suzie.

With just 15% of the country's land considered highly productive, Manaaki Whenua has worked with Ministry for the Environment, Stats NZ and Waikato Regional Council to develop a new environmental indicator for identifying highly productive land. This tool will help councils identify, map and manage highly productive land under the terms of the 2022 National Policy Statement for Highly Productive Land (see sidebar).

Suzie says land-use decisions need to balance the production of export commodities against local food consumption demands. "It's not too late and I am confident there are great opportunities to achieve real change in New Zealand to meet our environmental goals as well as meet the nation's future food demands."

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HTTPS *landcareresearch.co.nz/assets/Publications/Policy-Briefing-Guidance-Papers/Policy-brief-27_Rethinking-NZs-food-security.pdf*

Protecting our highly productive land

Pukekohe as it appears on S-map, the digital soil map for Aotearoa.

Highly versatile soils are found in various locations across New Zealand, such as Pukekohe for vegetable production, Taranaki and Waikato for dairy, Gisborne for citrus, and Canterbury for seed production. Recognising the significance of these soils to the country's export economy, food supply, and employment, the New Zealand Government recently implemented the National Policy Statement for Highly Productive Land (NPS-HPL) that aims to protect the most versatile soils from urban sprawl and rural residential development

The NPS-HPL recognises highly productive land belonging to Land Use Capability (LUC) classes 1 to 3, which makes up around 14% of New Zealand. Manaaki Whenua, the Ministry for the Environment, Stats NZ, and the Waikato Regional Council developed an environmental indicator to monitor the effects of land fragmentation on highly productive land availability that can be used in conjunction with other existing datasets such as the LUC, S-map, the Land Cover Database and Protected National Areas to support a number of government policies, from infrastructure and land-use planning through to farm management.

All of these datasets highlight the invaluable contribution of nationally significant databases and collections to the intergenerational availability of fundamental knowledge about our natural environment.

Climate-smart landscapes and healthy diets

Manaaki Whenua's research into climate-smart landscapes casts a holistic lens on catchments and regions and the people that inhabit them.

Senior researcher and geospatial modeller Dr Alexander Herzig says the characteristics of landscapes, and the location and intensity of human activities within those landscapes all play a role in the country's ability to grow food, provide fresh water, regulate climate, and control erosion.

This landscape knowledge, represented by spatially explicit data on, for instance, climate, soils, and crop performance, can be processed with the Land-Use Management Support System (LUMASS) to help stakeholders develop pathways or management plans for more climate-resilient landscapes.

Alex and his collaborators, led by Professor Rich McDowell (Our Land and Water), were able to demonstrate the use of LUMASS in a recently published joint study of the Our Land and Water and Healthier Lives National Science Challenges in the *Journal of the Royal Society of New Zealand.*

The study, *Growing for good: producing a healthy, low greenhouse gas and water quality footprint diet in Aotearoa New Zealand*, tested different land-use scenarios to see whether New Zealand could profitably produce enough crops, in the right places, to feed all New Zealanders a healthy diet, and still meet its ambitions to lower greenhouse gas emissions and nutrient losses to water.

For the study, researchers ran tests under two different scenarios. The first scenario, a climate-focused one, aimed to reduce greenhouse gas emissions by removing up to 13% of stock (as outlined by the Climate Change Commission). It replaced dairy land with crops, and sheep and beef systems with forestry. The second freshwater-focused scenario allowed crops and forestry to expand onto all pastoral farming systems until nitrogen and phosphorus losses were low enough to reduce algal growth in rivers, lakes or estuaries.

"In both cases, we targeted areas that currently don't meet environmental standards for nitrogen and phosphorus pollution and that would likely benefit from land-use change," says Alex. "However, we also had to expand into other areas to meet the crop growth targets required by a healthy diet."

Alex says the cost of making these changes to land use was about 1% of the revenue generated by New Zealand's primary sector exports, which is a relatively small amount. "In fact, it was much lower than the estimated savings that could be achieved in the healthcare system by optimising people's diets," he says.

"Being smart about where and how we use the land for food production helps with meeting our environmental goals related to greenhouse gases, nitrogen, and phosphorus pollution, as well as saving money and improving the health of the people in New Zealand," he says.

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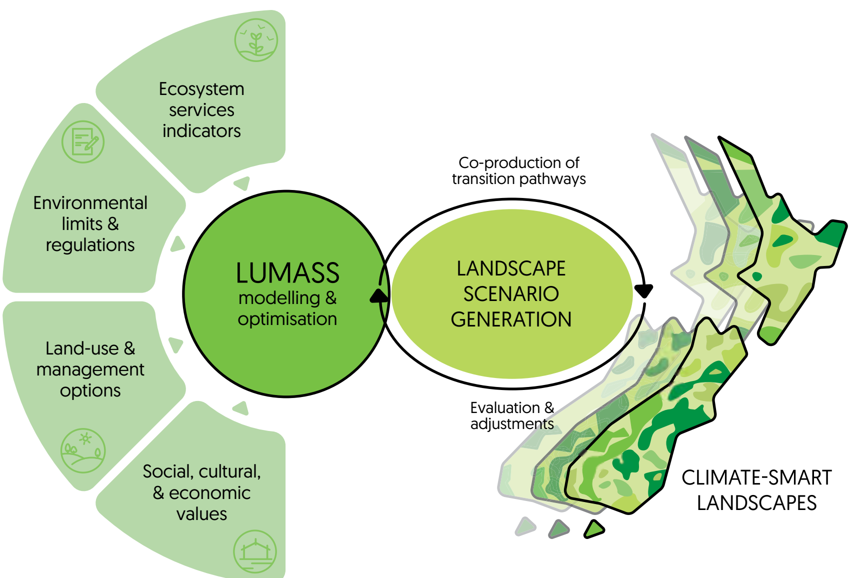
HTTPS *ourlandandwater.nz/outputs/growing-for-good-producing-a-healthy-low-greenhouse-gas-and-water-quality-footprint-diet-in-aotearoa/*



Illustrating the use of LUMASS for land-use scenario generation.

Revolutionising organic waste infrastructure

Are we spending wisely on our waste? A key investment criteria for councils has been diverting as much organic material from landfill as cheaply and efficiently as possible, which means councils tend to favour large single sites that can process a lot of organic material but are often expensive to build.

Following the Transforming Recycling consultation in 2022, the Government plans to make kerbside collection of food scraps available to all urban people by 2030. This will mean significant investment over the coming years.

However, Manaaki Whenua researcher Dr Gradon Diprose says the challenge to making sensible investment is the lack of debate about what criteria should be used to help guide decisions. It doesn't help that there is a lack of data in waste collection, transport, and processing infrastructure across the country.

With funding from the Building Better Homes, Towns and Cities National Science Challenge, Gradon and colleague Pam Booth collaborated with Zero Waste Network researchers Liam Prince and Hannah Blumhardt to understand the existing organic waste infrastructure in New Zealand.

The team ran a national survey of organics operators to first gather data, and then develop a taxonomy to help guide investment decisions. Reflecting on the research, Gradon says the survey, *Scaling-up, scaling-out & branching-out: understanding & procuring diverse organic materials management models in Aotearoa New Zealand*, was designed to get a better sense of what is currently happening with organic waste.

"While we know a bunch of community groups, hapū, marae, social enterprises and business are collecting and processing organic waste, there's virtually no 'official' data about the volume processed, the methods and technologies they use, the challenges they face, and the impacts and outcomes of different models and approaches."

The research follows the release of the NZ Government's recently reworked national Waste Strategy that provides a framework to consider the kinds of organic waste infrastructure New Zealand needs to reduce emissions, improve resilience, and create other co-benefits for people and nature. To deliver action on climate change the Strategy has identified the need to reduce organic waste in landfills to lower greenhouse gas emissions.

"This investment in organics infrastructure over coming years will be significant," says Gradon. "This is an important moment to highlight how we could get a wider range of benefits from our waste infrastructure that is more resilient to things like climate change and natural hazards, and re-connects people with the great outputs from organic waste to help improve soil."

The report proposed a shared and consistent language to categorise different models; plus a taxonomy to help decision-makers consider other factors than just diversion from landfill such as including the geographic distance organic materials travel and associated transport emissions, and if the infrastructure is reliant on a single site, or multiple networked sites. It's data that will help councils and other decision-makers spend wisely on waste.

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HTTPS *drive.google.com/file/d/1EcHIj0OsWJvGO4HLVPfgUI4ASbVi2JXh/view*

4 per 1000 – can it be done?

Non-invasive proximal soil sensing digital data acquisition instruments in action on the Lincoln University dairy farm.

The world's soils contain 2 to 3 times more carbon than the world's atmosphere, and have huge potential for carbon storage. The "4 per 1000" initiative, launched by France in December 2015 at COP 21, estimates that if the amount of soil organic carbon (SOC) in the top 30-40 cm of the world's soils could be increased by just 4 parts per thousand per year, this would nearly compensate for the annual global increase in CO_2 in the atmosphere.

Soil scientist Dr Sam McNally at Manaaki Whenua says mineral surface area is a good indicator of how much carbon a soil can store. The best soils for carbon storage are known to have higher contents of clay – the fine particle size of clays translates to larger mineral surface area – and soils within a farm that have higher surface area could promote carbon storage.

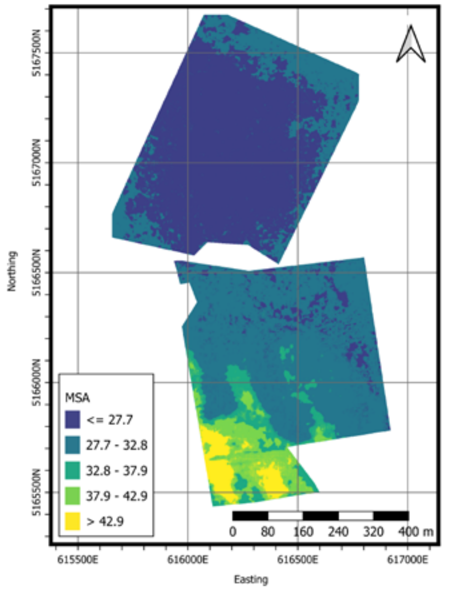
However, determining the best places to store carbon in soil requires extensive sampling and laboratory analysis on a farm. "This is time-consuming and expensive as soil can vary over small areas" says Manaaki Whenua's Managing Land and Water Portfolio Leader Dr John Triantafilis.

John worked with Sam to investigate various non-invasive proximal soil sensing instruments and modelling methods for mapping the mineral surface area at the 160-hectare Lincoln University Dairy Farm in Canterbury. Digital data included LiDAR, gamma-ray spectrometry and electromagnetic (EM) that were explored. The minimum number of soil samples needed to calibrate these datasets was also determined.

The resulting digital soil map showed a broad change across the farm with shallow silty Pallic soil underlain by gravels, synonymous with a small mineral surface area, to the north and larger mineral surface area Gley soils – with higher clay content – to the south where more carbon can potentially be stored. The modelling showed only one soil sample was needed every 4 hectares to enable effective calibration.

As well as mineral surface area, the team is exploring the potential to map other soil conditions using proximal sensed data, including pH (chemical), field capacity and permanent wilting point (hydrological), and carbon (biological).

While the methods being employed are preliminary, digital soil maps of condition will provide insights to farmers into how soil capability might be improved in terms of precision application of fertilisers and ameliorants, irrigation efficiency and monitoring.



Digital soil map of mineral surface area across Lincoln University Dairy Farm.

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What do Māori communities need in the aftermath of extreme weather events?

Post cyclones, flooding, and devastation – what do Māori communities really need in the aftermath of extreme weather events?

A recent Ngā Pae o te Māramatanga New Zealand's Māori Centre of Research Excellence wānanga explored this question by sharing whakaaro from Māori community leaders affected by Cyclone Gabrielle in February.

Facilitated by Manaaki Whenua Kaihautū Māori Research Impact Leader Dr Shaun Awatere (Ngāti Porou), the online wānanga shared the challenges faced by Tairāwhiti (Gisborne), Heretaunga (Upper Hutt) and Te Tai Tokerau (Northland) leaders and what they need for recovery and future resilience after recent devastating events.

Shaun says it was evident from the kōrero that many whānau had suffered significant trauma because of the cyclone and continued flooding in 2023. "With many marae, urupā (burial grounds), kohanga reo and community facilities damaged or destroyed, we heard about the significant loss of cultural health for many whānau – not to mention the hundreds of whānau displaced from their homes."

Shaun also noted a theme from leaders who were frustrated by the lack of local and central government support – or lack of consultation with iwi and whānau.

"There is a sense of distrust from some communities who do not believe these institutions can help them and want the right to assert their own tino rangatiratanga (self-determination) through the recovery process."

A community who has done just that is the Piringa hapū of Omāhu just north of Hastings in Hawke's Bay.

Omāhu Marae chairperson Meihana Watson spoke of the significant

RNZ / Sally Murphy

Flood-damaged property piled up on the streets of Omāhu in Hawke's Bay.

> *We need to frame responses from the needs of the whānau in the area rather than a universal approach.*

Young people helping move damaged property to the roadside ready for pickup by the Army in Omāhu.

devastation caused by the cyclone in his community: 153 homes damaged or destroyed, and 30% of these were either uninsured or underinsured.

There was also damage to urupā, churches, marae, kohanga reo, pā sites and other sites of cultural significance.

The community struggled with a lack of support from local council and other agencies, Meihana told the wānanga. "As a community we are used to being resilient, so we stood up in those first few days."

Omāhu Marae was cleared and a welfare hub was established for whānau, and there have been an average of 45 whānau staying at the marae since then.

It was also not long before the hapū established Utaina – a 10-year recovery plan, which was drafted in March and endorsed by April. Meihana describes this plan as hapu-led and Crown and iwi enabled, seeing the hapū recognise their tino rangatiratanga.

"Nothing about us without us," says Meihana.

The hapū has worked hard since then to source 18 self-contained cabins for displaced whānau and they are working to expedite the progress of shifting yellow-stickered houses to white-sticker status.

Similarly, Willie Te Aho from Toitu Tairawhiti Housing Limited has been instrumental in supporting whānau from Te Karaka, inland from Gisborne, with their recovery efforts.

Toitu Tairawhiti has provided a number of temporary houses for whānau displaced by the cyclone and have offered support around insurance claims for those displaced. They are also working to repair damaged homes and aim to have whānau back in their community by the end of August.

"It is going to be a long road to recovery," Willie told the wānanga. "We have faced similar challenges to Omāhu in terms of council support as well as gaining access to the data we need."

Shaun says this whakaaro highlights the need to frame extreme weather responses for Māori.

"We need to frame responses from the needs of the whānau in the area rather than a universal approach – the opportunity to exercise tino rangatiratanga is what Māori need."

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HTTPS *maramatanga.ac.nz/node/2028*

Weather radar and satellites map out landslide risk

High-resolution imagery from satellites and ground-based measurements from weather radar are providing new insights into the rainfall conditions that trigger landslides.

In research published recently in *Geomorphology*, Manaaki Whenua researcher Dr Hugh Smith provided first-of-its kind analysis of the increasing landslide threat that lurks behind a warming climate.

“We combined mapping of landslides using high-resolution satellite imagery acquired before and after landslide-triggering storms in 2017 and 2018 across the upper North Island with analysis of radar data provided by MetService,” says Hugh. “The radar data was then calibrated against measurements from nearby gauges to estimate maximum rainfall over different durations.”

> “*This model classed locations as either landslide-prone or non-landslide-prone based on their corresponding rainfall and landscape attributes.*”

The team also collected information about areas where landslides occurred and where they didn’t, including details such as the angle of the slopes, directions slopes face and the type of vegetation covering the land.

“We combined all this information into a statistical model that analysed the relationship between landslides and the specific rainfall and landscape characteristics,” says Hugh. “This model classed locations as either landslide-prone or non-landslide-prone based on their corresponding rainfall and landscape attributes.”

Research already shows steep slopes under pasture on weak sedimentary rocks are particularly susceptible to shallow landslides. This new analysis went further by identifying the rainfall conditions that most influence the landslide pattern in combination with landscape factors.

“We found that the maximum 12-hour rainfall intensity and the amount of rainfall over the 10 days prior to the storm were the most influential rainfall variables. Prior rainfall increases soil moisture, which, combined with sustained high rainfall during the storm, leads to saturation and the increased likelihood of slope failure," says Hugh. "If we could identify spatial patterns in rainfall that correspond with increasing numbers of landslides, then this would help us determine potential rainfall thresholds for landslide triggering and estimate how rainfall influences the number of landslides that occur."

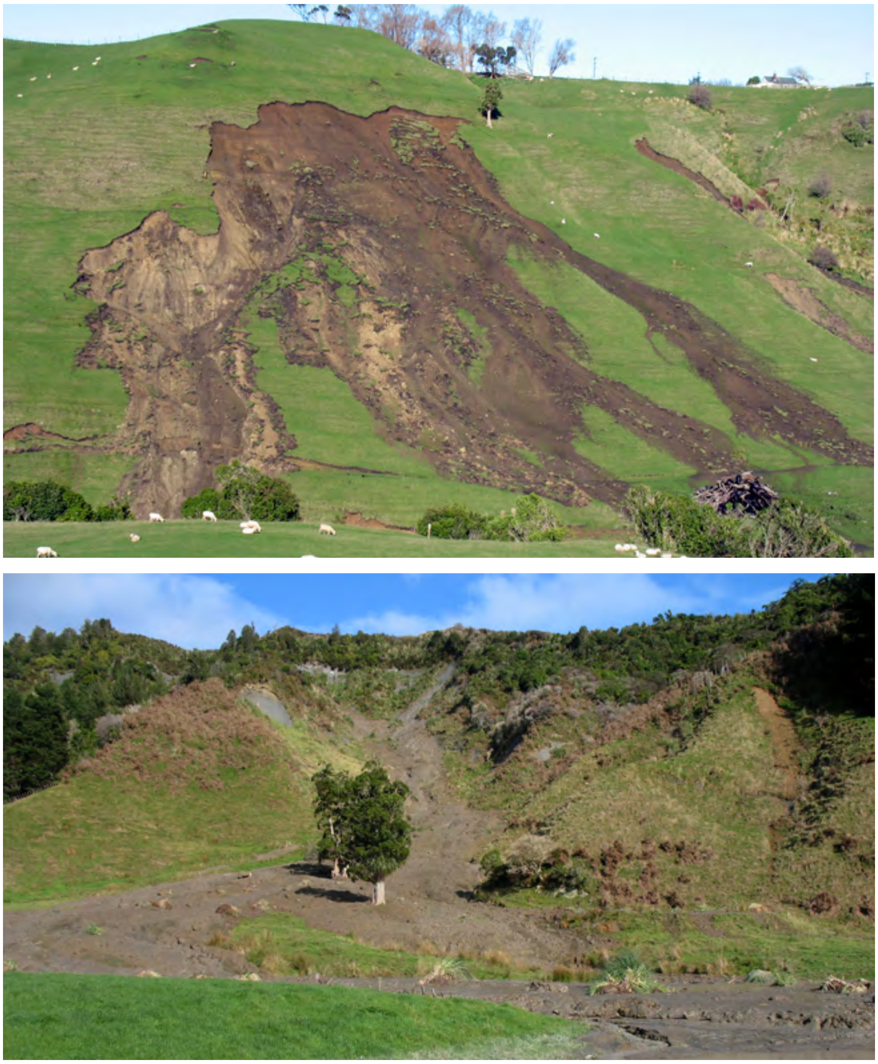
The data indicate that in pastoral areas with weak sedimentary rocks, the number of landslides triples on average when the maximum intensity of rainfall over a 12-hour period is 25% or more than the level that typically happens once every 10 years. This rainfall threshold aligns with the projected average increase in rainfall during a 12-hour period by the end of the century, assuming the highest levels of warming in New Zealand according to climate change predictions from NIWA.

This suggests a significant rise in the number of landslides per storm in this worst-case scenario.

Spatial information on rainfall could allow better assessment of the ability of mitigation measures such as tree planting to reduce the occurrence of landslides across a range of rainfall conditions.

"Our findings also confirmed the important role of forest cover (both native and exotic) in reducing the number of landslides compared to pasture. This reduction in landslides in forested areas occurred irrespective of the slope, rainfall or rock types present within our dataset," says Hugh. "This finding provides further evidence for the use of targeted tree planting to effectively reduce landslide susceptibility."

He says future work in this area will focus on acquiring and analysing more data across a wider range of New Zealand landscapes that will allow researchers to predict the likely landslide response for specific rainfall conditions.



Harley Betts

Top and bottom photos show typical shallow landslides in pastoral hill country areas.

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HTTPS *sciencedirect.com/science/article/pii/S0169555X23002155*

Isaac Larsen (University of Massachusetts-Amherst) on one of the narrow tussock ridges, just before digging a soil pit.

Unearthing the drivers of rock weathering

Chemical weathering of rock and soil is an important mechanism that not only makes nutrients available to plants, but also plays a significant part in the global carbon cycle.

It occurs in multiple ways including by carbonic acid weathering, in which rainwater reacts with CO_2 to form carbonic acid (H_2CO_3), a weak acid that in turn reacts with rocks. This process dissolves the minerals in the rocks and releases mineral nutrients, but the same reaction also removes CO_2 from the atmosphere.

This CO_2 removal function is important on geological (very long!) timescales, preventing a runaway greenhouse effect on Earth.

There is ongoing debate about what is the primary driver of carbonic acid weathering on the Earth's surface.

For a long time, abundant plant cover was regarded as essential for high rates of this process.

However, as with most relationships, the dynamics of the weathering process are complicated, says an international team that included Manaaki Whenua's Dr Andre Eger, in a paper published in *Earth and Planetary Science Letters*. After sampling soils and rocks across vegetation and erosion gradients on the western Southern Alps the team discovered that chemical weathering is driven more by erosion than vegetation.

Erosion breaks up rocks mechanically, creating fractures that allow rainwater to supply carbonic acid directly to the rocks. Plant roots, together with associated microbiota, greatly enhance this process by increasing the CO_2 concentration in the soil, producing even more acids that can react with the rock.

The team sampled soils and rocks across vegetation and erosion gradients on Gunn Ridge in the upper Whataroa valley. To estimate erosion, they measured a rare variant (isotope) of the element beryllium that only forms when particles from supernova explosions collide with Earth.

While it sounds like science fiction, this has become one of the go-to methods to measure long-term erosion rates in earth science.

"We found the highest rates of chemical weathering occurred in the locations with the highest erosion rates, locations of high topographic convexity, like very pointy ridgetops," says Andre.

"The vegetation cover had surprisingly little control over these rates. Thus, it

> *We found the highest rates of chemical weathering occurred in the locations with the highest erosion rates, locations of high topographic convexity like very pointy ridgetops.*

The Whataroa and Butler valleys, South Westland. These river valleys were once U-shaped, sculpted by glaciers during the late Pleistocene. However, rapid fluvial incision into the rock driven by tectonic uplift has since transformed most of them into V-shaped valleys. This is the main force behind the high erosion rates on the slopes and ridges above.

appears that processes that directly shape the topography, like river incision in response to the tectonic uplift of a mountain range, are more important for weathering rates than vegetation, at least in our study area."

Apart from increasing fundamental understanding of long-term, landscape-scale processes, the work is relevant to current attempts to harness the natural process of chemical weathering of rock as a mitigation technique against anthropogenic global warming.

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HTTPS doi.org/10.1016/j.epsl.2023.118036

Shallow but brown – soils covered by platy schist instead of plants in the alpine zone.

Technology keeps remote eye on wetland threats

Tutaki West Branch Headwaters Wetland, Murchison area.

We need our wetlands. They are critical for climate change mitigation, preserving biodiversity, and maintaining water quality. However, wetlands continue to be lost around the world, and better methods to monitor risks to wetlands are required.

It's only recently that Manaaki Whenua researchers have been able to quantify one of the biggest threats to the existence and function of wetlands: drainage. Drains have historically been seen as an intrinsic component of land management in New Zealand, resulting in extensive construction of drainage systems across the country. This has decreased the natural extent of wetlands by around 90% since human arrival in New Zealand.

While recent regulations restrict new drainage close to wetlands, the national extent of existing drainage in or near wetlands is unclear. The first step Manaaki Whenua researchers took was to use the existing LINZ national drains spatial layer, to assess where known drains occur near wetlands. However, the national drains layer was not designed to delimit drains for ecological purposes. So, the team looked to a new source of data, using LiDAR, which detects very small changes in elevation, such as those caused by drains.

By using LiDAR for this purpose, ecologist Dr Olivia Burge says researchers can get a better assessment of the area of wetlands within 100m of drains. In research published in the *New Zealand Journal of Ecology*, Olivia says not only does this work help to identify where the potential risks from drainage exist, it has the potential to be scaled-up nationally as LiDAR coverage increases to complement the mapping of wetlands down to 0.05ha, which is required to be completed by 2030.

Co-author Dr Janet Wilmshurst, also from Manaaki Whenua, adds "this is good news for small wetlands which are disproportionally important in conserving biodiversity but are currently too small to be mapped. As LiDAR coverage becomes more widely available, this technique will be able to better assess the risks from drainage to all wetland habitats regardless of size over New Zealand and help to safeguard the future of these ecologically important and vulnerable ecosystems."

Paper co-author Dr Hugh Robertson, a wetland ecologist from the Department of Conservation, says they developed a LiDAR-informed model to identify drains, which they then compared with the national drains spatial layer. Both layers were applied to the Waituna catchment in Southland to determine how effective the LiDAR-informed model might be at detecting previously undetected drains, and, therefore, how much more wetland was at risk of drainage-related impacts.

"LiDAR showed the area of wetlands potentially affected by drains is more extensive than the national layer might suggest," says Hugh.

Olivia is also using LiDAR combined with recent improvements to soils mapping in S-map, to improve pre-human wetland extent mapping.

"The historical wetlands layer is critical for understanding and reporting on wetland loss through human activities in New Zealand, including which wetland types have been lost, and where has suffered the most loss," says Olivia.

However, the historical wetlands layer was developed in the 2000s, and relied heavily on now-outdated soils and digital elevation model information. "Fewer wetlands in a catchment increase flooding risk in extreme events, and as such revising the layer is particularly topical to address flood risk."

LiDAR technology is proving to be a useful tool to help safeguard the future of these ecologically important and vulnerable ecosystems.

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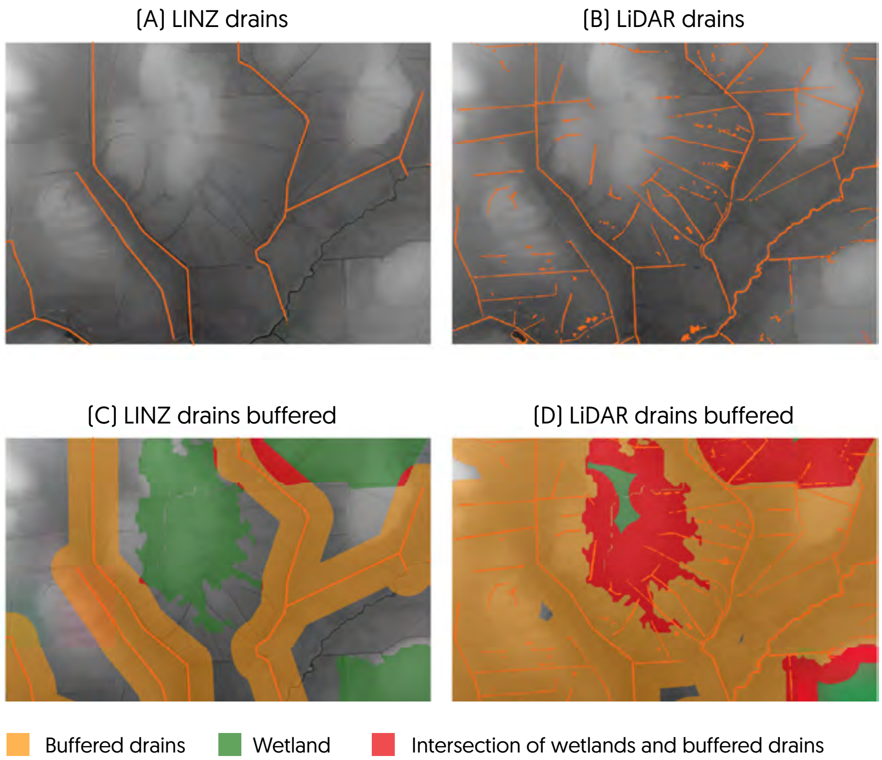
HTTPS *doi.org/10.20417/nzjecol.47.3523*



[A] LINZ drain coverage, clearly showing many drains missing. [B] LiDAR drain coverage with some drains missing, but also a river channel mapped as a drain. [C] LINZ drain coverage buffered by 100 m, showing a small overlap between drains and wetlands. [D] LiDAR drain coverage buffered by 100 m, showing substantial overlap [red] between areas mapped as wetland by FENZ, and the buffered drains. Note little wetland left in green [i.e. not within 100 m of a drain] in this image.

Me ora te ngahere: forest health through an indigenous biocultural lens

Ngā Mōkai Marae, Karioi. Outside the Whakarongo wharenui, the whānau who attended the tool release and trial.

The smell of the wai, the sound of the manu... these characteristics of the ngahere have been the focus of the people of Ngāti Rangi as they monitor the ora of their environment through an indigenous biocultural lens.

A new paper published in *Pacific Conservation Biology*, 'Me ora te Ngāhere: visioning forest health through an Indigenous biocultural lens' presents the work of former Manaaki Whenua researcher and current Waikato University PhD student Kiri Reihana (Ngāpuhi, Te Rarawa, Ngāi Tūhoe, Whakatōhea). Kiri worked with Ngāti Rangi (a central North Island iwi) to create an indigenous framework that captures the state of biodiversity and environment that is informative and trusted by their communities.

Kiri's research was co-authored by Manaaki Whenua Kaihautū Māori Impact Leaders Dr Phil Lyver (Ngāti Toarangatira ki Wairau) and Nikki Harcourt (Ngāti Maniapoto) as well as senior researchers Dr Andrew Gormley and John Innes, Kairangahau Māori Mahuru Wilcox (Ngāti Awa, Ngāti Ranginui), Megan Younger (Ngā Waihua o Paerangi Trust) and Morgan Cox (Kiwis for Kiwi Trust). The researchers explored developing a biocultural monitoring tool – in the form of an app – based on Māori knowledge to inform Ngāti Rangi about the health of separate, but ecologically similar forests within the tribal estate.

This was achieved through a series of noho taiao (community workshops) and interviews to collect the values that expressed a Ngāti Rangi world view to measure the health of the forest. Gradients and indicators were developed to apply a measure of ngahere health and trialled in three forests to create a group understanding.

Kiri says a traditional practice of walking in complete silence to an allocated site, (such as the forest lake), to enable deep connection and listen to the voice of the forest, was revived from the noho taiao.

"You can smell in a dry year the pirau (rot) of the forest because the moss is crying, because there is no moisture in there. That is the indicator," said Che Wilson (Ngāti Rangi) during one of these sessions.

"It was amazing to see people who had hunted in the ngahere their whole lives have a renewed appreciation for their environment," says Kiri.

"They took the time to stop and connect with the forest, and realised they were returning manaakitanga to the ngahere through things like pest eradication programmes."

Kiri says the monitoring supported the Ngāti Rangi connection to place and cultural heritage through taking time to connect with their forests.

"By its nature, we acknowledge our biocultural monitoring tool, or app, is a living process that will evolve as the local practitioners refine and adapt it for their specific purpose and future use."

Kiri also says future research needs to have a focus on building capacity for mana whenua to undertake these kinds of projects.

"We also need to look to the future and provide career pathways for rangatahi into science and environmental work, internships and apprenticeships to embed this mahi and knowledge for future generations."

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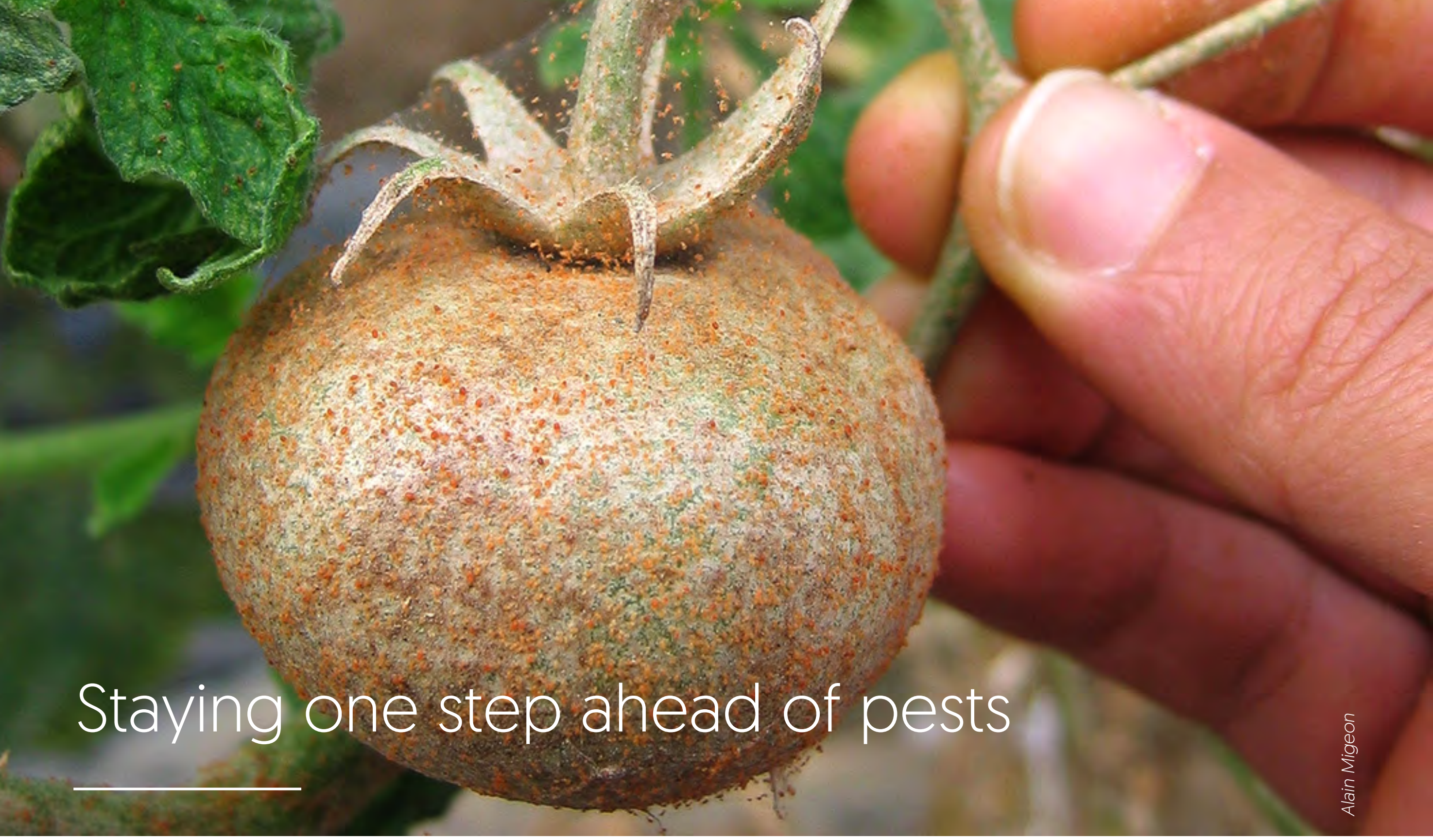
Tribal territory of Ngāti Rangi and the three forest monitoring sites (Makatote, Pōkākā and Old Coach Road), North Island, Aotearoa New Zealand.

Trial app tests with local kaimahi and team leader / co-author Megan Younger, at Mangaehuehu Reserve, Ohakune.



Staying one step ahead of pests

New Zealand is home to more than 50,000 exotic species that have become naturalised in the country. While most of these species are not currently considered invasive, it is challenging to predict which ones may pose a threat to natural ecosystems and primary industries in the future, or when they might become invasive.

Manaaki Whenua's Senior Researcher Ecosystems and Conservation, Dr Norm Mason, says having decision support tools that allow for the rapid development of management responses to these "sleeper pests" when they emerge is one way to stay ahead of these threats.

However, Norm says one major obstacle to successful invasive species management is social resistance. "Understanding reasons for social resistance and developing engagement strategies to increase public participation in monitoring and controlling these pests is vital."

"Current tools for assessing the effectiveness of management strategies have limited capacity to incorporate social factors and interventions."

To address these challenges, Norm collaborated with Dr Geoff Kaine from Manaaki Whenua's Landscape Policy and Governance team on research to introduce a new approach to documenting and predicting people's willingness to manage invasive species; and then on designing appropriate public engagement strategies.

The researchers worked closely with AgResearch and received guidance from biosecurity professionals spanning industry bodies, local and central government, consultants and subsequent correspondents. They also ran two workshops.

Their aim was to incorporate social factors and interventions under changing climates to develop new simulation tools capable of modelling sleeper pest management responses.

[Left] Tomato red spider mite damage on black nightshade, Solanum nigrum.
[Right] Tomato red spider mite, Tetranychus evansi.

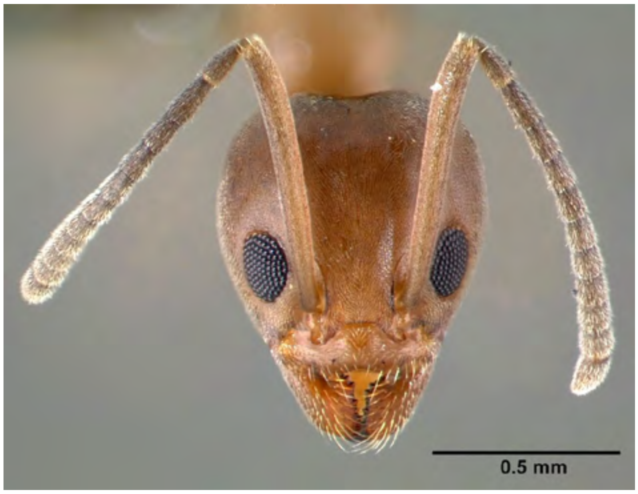
> *It is possible to develop relatively simple and generalisable simulation tools that integrate climate effects, land use changes, and attitudes towards pest monitoring and control.*

The research work included surveying several communities to gather data on their involvement in monitoring and managing three different species, Chilean needle grass (*Nassella neesiana* – a pasture weed), tomato red spider mite (*Tetranychus evansi* – a horticultural pest), and the Argentine ant (*Linepithema humile* – a residential and horticultural pest).

They developed a decision-tree approach that integrated survey results, pest ecology, and available technologies to design public engagement strategies that would enhance community participation in monitoring and management.

The project also developed two generalised simulation functions to model pest spread and management responses in the face of changing land use, climates, and social interventions. Both functions divided the management response into detection, management adoption, local eradication, and spread reduction components. The key difference was that one incorporates local population dynamics in estimating dispersal probabilities between locations.

Norm says the study demonstrated that using innovative approaches to documenting community willingness to participate in management programmes could enable the use of simple decision-tree methods to identify appropriate engagement strategies to improve monitoring and control programmes.“ The study also showed it is possible to develop relatively simple and generalisable simulation. tools that integrate climate effects, land use changes, and attitudes towards pest monitoring and control,” says Norm. “These tools can support effective management strategies in the face of changing land use/cover, climate and external invasion pressure (e.g. from changing international trade patterns).”



April Nobile

Argentine ant.

Chilean needle grass.

The research has been presented in a technical report that will be available in due course.

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Earthflow monitoring reveals movement drivers and sediment loss

Intersection between the earthflow and the stream network, showing active erosion and ready supply of sediment.

Earthflows are a type of landslide that occur throughout New Zealand's soft-rock hill country. They contribute sediment to our network of waterways, affecting water quality and increasing channel sedimentation.

Researcher Dr Andrew Neverman says understanding what drives the movement of earthflows and how much sediment they contribute to their receiving environments, and when, is key to improving erosion mitigation targeting, and to forecasting changes in erosion and sediment loads under projected climate change.

This is just what a research project under the Smarter Targeting of Erosion Control (STEC) MBIE programme is planning to achieve. "Our aims are to better understand the patterns and hydroclimatic drivers of earthflow movement and also better understand the contribution of earthflows to catchment sediment budgets," says Andrew.

The research team has deployed a range of sensing technologies over the past 4 years to monitor an earthflow in the Haunui research catchment, situated within the Tiraumea River catchment, Manawatu. "These technologies provide data on sub-daily to multi-year earthflow movement rates, annual changes in earthflow volume, and their hydroclimatic drivers," says Andrew. "These include IoT sensors (Internet of Things) sensors that gather information remotely and share data in real time) that have been deployed to continuously record meteorological variables (rainfall, wind speed, temperature, humidity), pore water pressure, and earthflow movement."

Earthflow movement is monitored using a continuously operating GNSS (satellite) receiver, which records its location every 30 seconds, and a network of monitoring pegs that are surveyed annually. Andrew says "peak earthflow movement rates of 0.25 m per day, and 17 m per year have been recorded during the monitoring period."

Drones are also used to create surface elevation models of the earthflow. "These are used to estimate the volume of sediment lost from the earthflow," says Andrew.

He adds that findings show the earthflow becomes mobile when soil

pore pressure/soil moisture crosses a threshold, with a period of continuous movement from June to November when pore pressures and soil moisture levels remain high. Heavy rainfall events further speed up the movement.

Andrew says this study suggests the combination of future changes in mean annual rainfall, evapotranspiration (the processes by which water moves from the land surface to the atmosphere), and the frequency and intensity of rainfall will determine how the movement and sediment contribution of earthflows and other shallow slow-moving landslides respond to climate change, which is likely to vary between regions.

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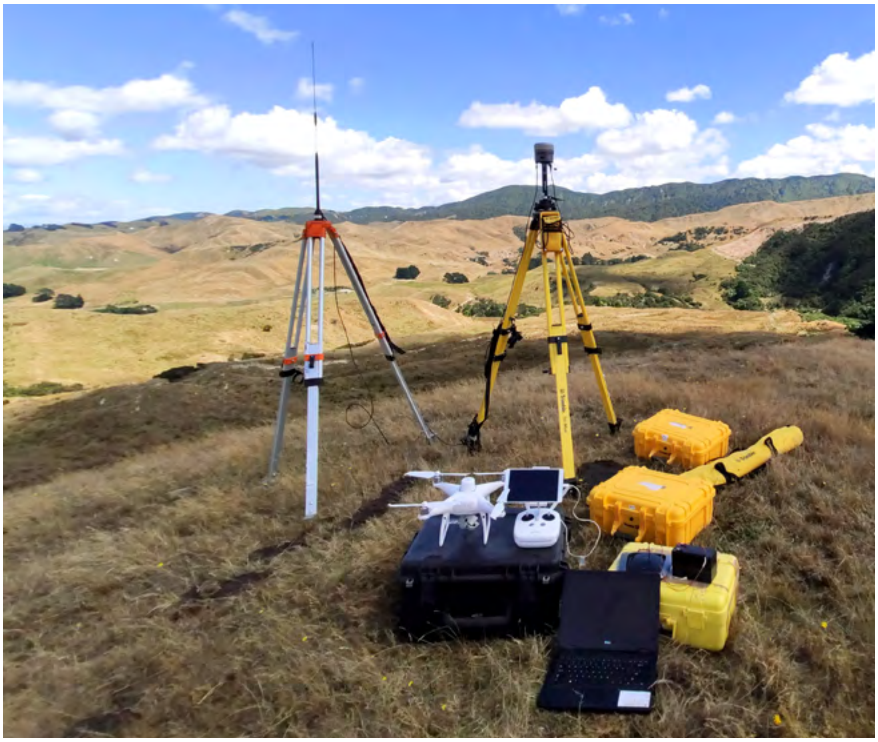

Drone and survey equipment used to survey and measure earthflows within the Tiraumea River catchment.

Using plantain to reduce on-farm nitrous oxide losses

Searching for optimal grazing systems continues to be a major motivation for researchers focused on finding ways to mitigate nitrous oxide (N_2O) emissions to help combat climate change.

In the agricultural sector, understanding the impact of different feed crops is key when it comes to making decisions about pasture management and reducing greenhouse gas emissions.

Recent findings from a study led by Massey University New Zealand Agricultural Greenhouse Gas Research Centre scholarship student Chi Vi, who was co-supervised by Manaaki Whenua researcher Dr Surinder Saggar, have shown that adding plantain (*Plantago lanceolata*) to mixed pastures with perennial ryegrass and white clover in dairy-grazed pastures has several benefits. Surinder says plantain is known for its ability to improve the productivity of summer feed and reduce N_2O emissions.

This was a complex research project that ran over 2 years and involved the capture of urine from cows grazing swards with different plantain compositions.

Plantain works in two ways, one in the animal and one in the soil. In the first effect in the animal, not only is more of the nitrogen from the plant excreted in dung than urine, but plantain also has a higher moisture content than other grazing plants and a diuretic effect. This makes the cows urinate more frequently, creating more urine spots, but they are much less concentrated.

The second effect is in the soil where the chemicals in the plantain and plantain roots slow the rate at which the urine breaks down to nitrate, which allows more time for the nitrate to be taken up by plants. This contributes to improving pasture production, particularly during dry periods in the summer when feed availability is typically low.

“The challenge,” says Surinder, “has always been knowing how much plantain should be included with perennial ryegrass and white clover in mixed pastures to maintain consistent productivity and how to measure the reduction in N_2O emissions.” He adds the loss of plantain plants in ryegrass/clover pastures is inevitable with time, so broadcasting fresh seed at the end of each growing season is needed to maintain a sufficient proportion of plantain in mixed pasture.

The results of the study, published in the journal *Agronomy*, showed pastures with a mixed pasture containing between 50% and 70% plantain content were the most efficient at creating a stable pasture system and improving feed productivity, while reducing N_2O emissions from cow urine patches. Surinder says this information can be useful for farmers and policymakers in making decisions about pasture management that will contribute to reducing greenhouse gas emissions from agriculture.

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Dr Sole Navarrete

Chi Vi collecting gas samples to measure nitrous oxide emission from plantain treatment plots.

HTTPS *doi.org/10.3390/agronomy13061447*

Celebrating our achievements

Dr Al Glen and **Dr Manpreet Dhami** have been appointed to the School of Biological Sciences, University of Auckland within the Joint Graduate School in Biodiversity and Biosecurity. These co-appointments mainly involve supervising postgraduate students. Al and Manpreet will also continue in their existing roles with Manaaki Whenua.

Al Glen

Dr Peter Johnston was unanimously elected to receive the Mycological Society of America's (MSA) Honorary Member Award, which is awarded annually to a distinguished senior scientist with significant contributions to fungal biology. This award was established in 1951 and has been awarded to an elite group of fewer than 60 mycologists by the Honorary Awards Committee of the MSA. For decades, Peter has been a primary force in developing a well-regarded mycology programme in New Zealand and has contributed greatly to the field of mycology through his outstanding research publications, his active participation in international organisations such as the International Commission for the Taxonomy of Fungi, and his kind hospitality to the numerous mycologists who have visited and collected fungi in New Zealand. He has been an advocate for fungal taxonomy and diversity studies promoting the study of indigenous fungi and protecting New Zealand against fungi that might be introduced. Peter is the first New Zealand mycologist to be honoured with this award.

Manpreet Dhami

Peter Johnston

Manaaki Whenua's **Dr Paul Mudge** recently gave an overview of research underway in New Zealand around climate change mitigation to Ireland's Minister of Agriculture, Food and the Marine, Charlie McConalogue. The presentation highlighted the collaborative nature of research in this area between the CRIs and universities. Potential opportunities exist for collaboration between Manaaki Whenua and Ireland in relation to paddock-scale measurements of carbon and greenhouse gas balances using the eddy covariance technique – a key atmospheric measurement technique to directly observe the exchanges of gas, energy, and momentum between ecosystems and the atmosphere.

Paul Mudge

Living with nature for a sustainable future

Cyclones Gabrielle and Hale remind us we live in a country where natural hazards are part of our lives.

With the first 6 months of 2023 the wettest for the longest duration on record, parts of New Zealand have faced a significant period of weather-related landscape adjustment.

The Ministerial Inquiry and its report (*Outrage to Optimism*) into the devastating impacts of these weather events offer pathways for the future. Like many, I found this report was well-balanced and a fair representation of the current state. However, unlike some, I cannot agree with the sentiment that "we must never let this happen again". Because it will. That is what history teaches us.

New Zealand has a history of these events and their impacts. We need to understand such events will occur and cannot be completely mitigated. What we can do is better understand how landscapes respond to them, and then develop management and land use solutions that are more sympathetic to, and embrace the diversity in, those landscapes. A "mosaic of sustainable land uses" is one of the report's recommendations, as is the procurement of high-resolution soil erosion and landslide susceptibility maps to aid in future land management decisions. Manaaki Whenua can, and is, helping with research in these areas.

Recent rain has created further landslides and areas of instability, including large deeper-seated landslides, which have caused significant disruption and damage to main roads, especially in the Gisborne region.

If there is a silver lining, our science suggests that following such significant landscape adjustment, the next few decades may be a bit quieter with fewer landslides. This is in part because the landscape has had a reset, but also because in many places there is not much left in the way of soil to fall off the hillside.

But does this mean woody debris will cease being delivered to the region's beaches? No. There are more trees in the landscape now than there have been in the last 150 years. If the big storms that cause landslides and flooding continue to occur, as they will, woody debris will still remain a problem, because there is now more wood to be recruited, whether from an exotic or a native forest or from a soil conservation planting. It may not be as great a problem in the future, but it can't be reduced to zero.

As the report highlights, a future pathway will involve retreat from some areas and perhaps transition to a different forest cover in others. What is not so clear is who pays for this transition. It is imperative to recognise that, regardless of the future land use, ongoing management, such as weed and pest control in reverting or planted native forest, will be needed. This will involve ongoing costs. The owners of many steepland farms and forests, are also demanding, and will continue to demand, a say in what type of tree goes where.

"*What we can do is better understand how landscapes respond, and then develop management and land use solutions that are more sympathetic to, and embrace the diversity in, those landscapes.*"

If we look back in 100 years, will we see the outrage caused by these natural events moderated by land users and their communities who sought new pathways to live with and adapt to their environment? Let's hope so.

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