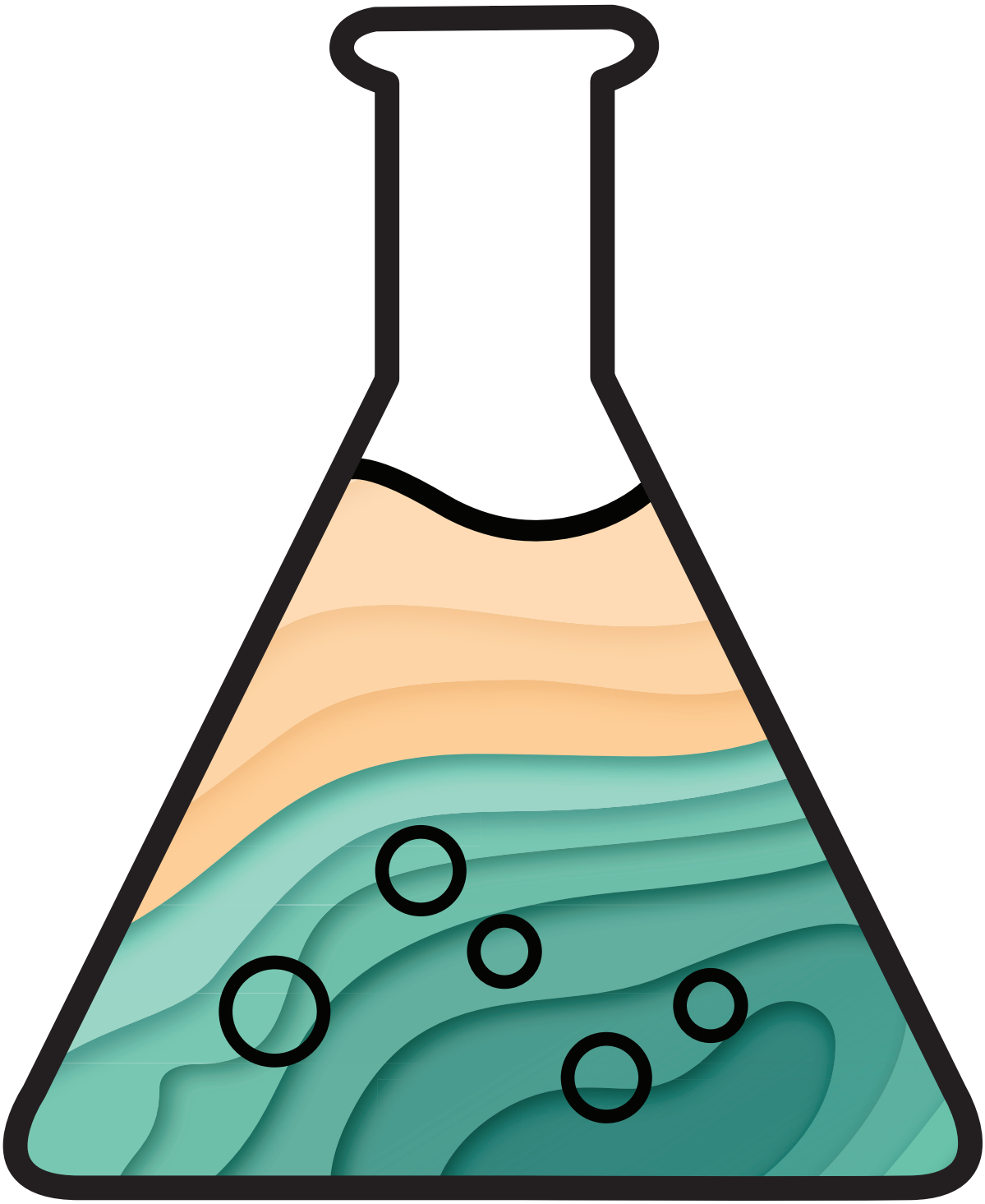
Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 1 / FEB 2020



HEALTHY WATER BEGINS WITH OUR LAND

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to the first issue of Pūtaiao ("Science" in te reo Māori), a new quarterly publication showcasing the work of our scientists at Manaaki Whenua.

We are the Crown Research Institute for our land environment, biosecurity and biodiversity, and our role and responsibility to New Zealand are clear: 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 we're focusing on science for our land – one of our four "science ambitions" at Manaaki Whenua.

Although as a nation we're familiar with concerns about water quality – about swimmable rivers and clean drinking water – the land is truly where the story of our water resources begins. Rivers, lakes and streams surround and flow through our land, so how we use our land is critical to our waterways.

As you'll see in the pages that follow, our scientists work with and alongside farmers, iwi, policymakers, the public, and many government and science organisations. Our aims are to enable New Zealanders to use land more sustainably, better use resources for intergenerational well-being (he whenua koiora), better protect and restore land and soil resources, and reduce the impact of land use on freshwater resources.

What's happening on our land?

Land Cover Database: version 5 out now!

In the past six years, more than half a million hectares of New Zealand's land cover have changed, according to the latest version of New Zealand's Land Cover Database (LCDB, version 5).

Researchers say it is one of the biggest shifts in land cover since the first Land Cover Database, a digital map and multi-temporal, thematic classification of New Zealand's land cover, was released nearly 20 years ago.

Land cover describes the extent of vegetation, built environments, water bodies, and bare natural surfaces across New Zealand. Measuring the composition of land cover and its changes is crucial to help decision-makers understand the pressures that different land uses are placing on our land and waterways, along with the implications for biodiversity and the functioning of ecosystems.

"We estimate that three-quarters of the change we've seen since the 2012 version of the LCDB is due to the forestry cycle of harvesting and replanting," says Programme Leader Peter Newsome. "But within that there's over a hundred thousand hectares of true land-use change going on around wetlands, scrub being cleared, and dairy land-use intensification. And that's quite a lot."

One changing land cover concern is the ongoing decline in wetlands. Preliminary results show that wetlands – New Zealand's most depleted and threatened ecosystem – have continued to reduce over the past six years, with only 220,000 hectares remaining.

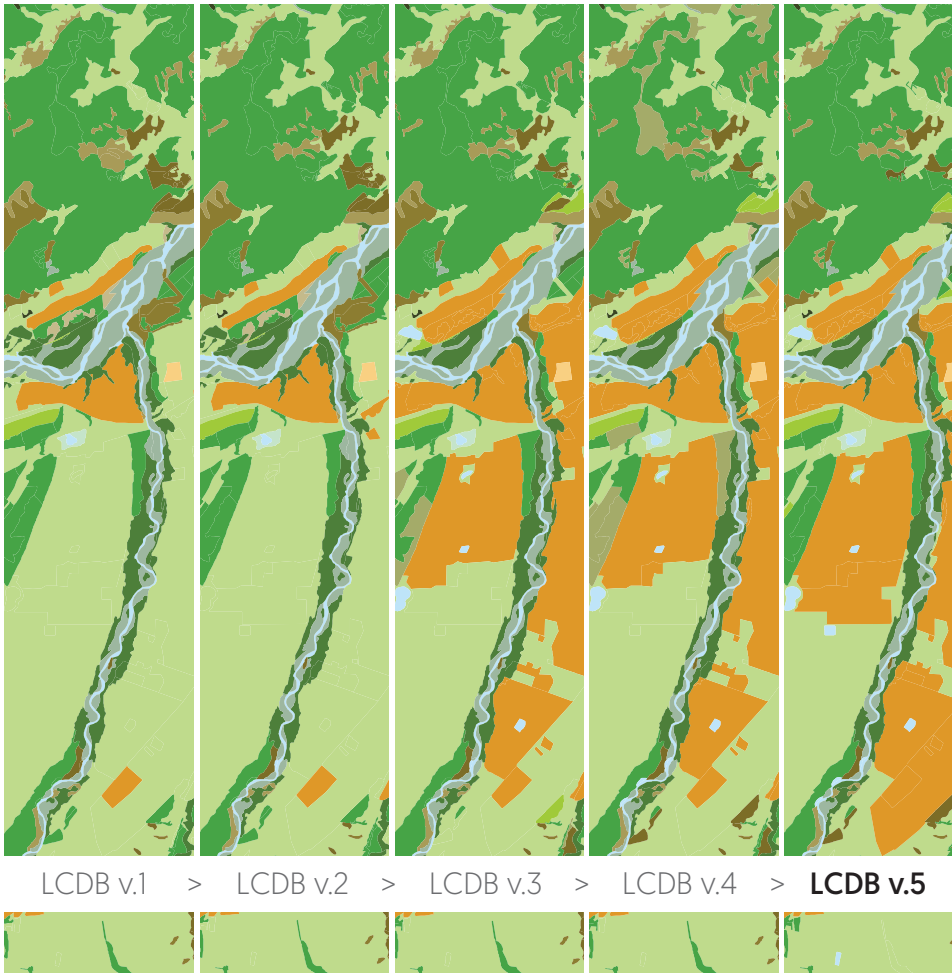
"Records from LCDB v5.0 show a steady decline in wetlands from drainage and conversion to pasture, with 1,660 hectares lost from a combination of 230 wetlands in the period 2013–18," explains Newsome.

Other preliminary results show growth in the country's built-up area appears to be at a rate of one to three thousand hectares per year, of which 65–75% is from high-producing pastural land and 8–10% from cropland, orcharding and other land covers.

"It also shows indigenous forest is being cleared at a similar rate to previous years; scrublands extent is reducing by two to three thousand hectares per year, with almost all the land being converted to exotic pasture; and pastoral intensification – as indicated by the spread of High-producing Exotic Grassland – may have peaked, with growth in this last interval, 2013–18, just 10,000 hectares," adds Newsome.

There have been four previous versions of New Zealand's LCDB, showcasing the changes in our land cover across 33 classes of land. The LCDB is used for a surprising number of applications, from international and national reporting of the state of the environment, through to the production of better maps, and management and monitoring of land cover and land use. For example, it has been used to monitor changes in catchments, and to decide the amount of bait needed in an area of land for predator control.

The fifth version of the database, which includes land-use data up to December 2018, was released by Manaaki Whenua researchers in early 2020.

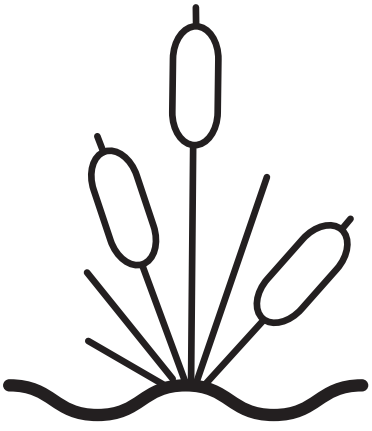


Progressive improvements in land-cover mapping have been made with each new version of the LCDB.

https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/

Wetlands are

DECLINING



ONLY

220,000 ha left

Getting smarter about sediment control

New Zealand is losing 192 million tonnes of soil each year due to erosion, the equivalent of more than 7 million dump-truck loads.

According to the Ministry for the Environment's *Environment Aotearoa 2019* report, almost half (44%) of this loss is from pastoral land. Accelerated by the loss of native vegetation, heavy rain causes landslips, slumps and stream-bank collapses, all of which send huge amounts of fertile soil and sediment into waterways.

The land-based erosion and transfer of sediment is a huge problem for New Zealand. It doesn't just reduce land productivity – it also affects water quality. Fine sediments are the most common cause of contamination in New Zealand's rivers and estuaries. Too much sediment in rivers, lakes, and coastal environments can smother freshwater and marine habitats. Sediments can carry other pollutants, such as heavy metals, nutrients and microbes. Sediment also hampers the growth of aquatic plants and animals, and sediment-choked waterways increase the risk of flooding in towns and cities.

Now, a five-year MBIE-funded programme, 'Smarter Targeting of Erosion Control' (STEC), is exploring cost-effective ways of targeting erosion control and improving water quality. The programme aims to find ways to slow erosion damage, and to better understand sediment origins and volumes, what type of sediments are produced, and by which processes. STEC is led by Chris Phillips and Hugh Smith from Manaaki Whenua, in collaboration with researchers from NIWA, Massey University, Waikato University, and an international research network. The programme also partners with Whanganui iwi (Tamaūpoko community group) and Rangitāne o Manawatū.

STEC researchers are working on farms to learn more about effective erosion management techniques. The STEC programme is sampling in four river catchments across New Zealand to collect data for building new modelling tools: the Manawatū, Whanganui, Oreti in Southland, and Wairoa near Auckland. Researchers have recently collected samples from erosion sources in the Oreti River catchment. "These samples

Annual loss of soil from erosion

Extensive earthflow in the upper Tiraumea catchment, a tributary of the Manawatū River.

will provide new data about the source soils contributing sediment to the river network and affecting water quality," says Smith. "The soil samples will be used to 'fingerprint' the sources of sediment in the Oreti River, in collaboration with NIWA researchers, who will collect suspended sediment samples at their river gauging stations."

"We have also made the first set of measurements of the rates at which earthflows are moving in the upper Tiraumea catchment, a tributary of the Manawatū River. This work is based on a network of survey pegs installed in each earthflow. Initial data show earth movements of up to 8 metres in one year," he adds.

The models created from STEC will indicate how sediment – in particular fine sediment – moves through catchments. It will link erosion on the land to sediment transport and instream water quality, ultimately enabling more effective mitigation of sediment issues downstream.

In other research linked to soil erosion control, Manaaki Whenua researchers have also recently completed a temporal analysis of Sentinel-2 satellite imagery to show the amount and persistence of all agricultural bare ground in New Zealand hill country over a typical winter, and to identify and map those hill country pasture and winter forage crop paddocks that were heavily grazed over the winter of 2018 and 2019.

Most paddocks identified as potentially at high risk of soil erosion were in Southland, Otago and Canterbury. Results have shown that 700,000 tonnes of soil were eroded from bare ground over the 2018 winter in New Zealand, and this information has been used to help develop the new *National Environmental Standards for Freshwater.*

Lucerne without effluent for less N and more C

Keeping our waterways healthy has a lot to do with what we apply to our land.

Nitrate leaching has been a hot topic for the past decade. Dairy farming in New Zealand has faced ongoing scrutiny for nitrate leaching following conversion of dryland areas on stony soils to intensive dairy farming, irrigating using dairy effluent as well as water to encourage pasture growth.

One alternative management practice, discovered by Manaaki Whenua's Malcolm McLeod, is for farmers to reduce their nitrogen footprint by converting areas of land to forage crops such as lucerne. Lucerne has deep roots that give access to water lower in the soil profile during dry periods and doesn't need effluent as fertiliser. However, lucerne grows less vigorously in winter when leaching losses are high, and the effects of irrigation and effluent applications are unknown.

In his previous research in the Taupō catchment, McLeod demonstrated nitrogen leaching from cut-and-carry lucerne (where the leafy high-protein forage is harvested and baled into hay or silage) was dramatically reduced to only five kilograms per hectare per year. This was a breakthrough finding and gave farmers an additional land-use option within a highly nutrient-constrained catchment.

> *"Irrigating with effluent is not recommended as a good management practice for lucerne on stony soils."*

Establishing six large lysimeters on an undisturbed soil block at Ashley Dene.

This success in Taupō led researchers to examine the effects of lucerne in a stony catchment. Over the past four years our researchers, in collaboration with Lincoln University, Plant & Food Research, Scion and the University of Canterbury, have been testing the benefits of lucerne on two neighbouring paddocks of newly established crops on stony soil at Ashley Dene Research and Development Station, near Lincoln.

They have been using large lysimeters located on two paddocks to measure annual carbon, water and nitrogen inputs and losses. "In the trial, one of the stony paddocks received irrigation and effluent and the other received only rainfall," says lead scientist David Whitehead.

"Results in the first conversion year in Lincoln showed irrigated lucerne was carbon-neutral despite losses during

Left: aerial view of the six lysimeters at Ashley Dene Research and Development Station.

Malcolm McLeod measuring the waste collected from the large lysimeter on the farm in Tihoi.

the conversion process. In the second and third years carbon losses exceeded carbon uptake, resulting in soil carbon losses up to 3% of total soil carbon, and then in the fourth year the irrigated site continued to lose soil carbon while there was a small net gain at the non-irrigated site," explains Whitehead.

Overall, nitrogen leaching losses occurred at both sites, but they were much greater at the irrigated site.

"So we can now say irrigating with effluent is not recommended as a good management practice for lucerne on stony soils," adds Whitehead.

He concludes that the findings highlight the need for alternative cutting or grazing management to avoid carbon losses, at least during the years following crop establishment.

The data from the trials will be important for validating farm nutrient balance models and to help farmers identify management practices to realise the benefits of growing lucerne while minimising carbon and nitrogen losses.

Reducing the effects of land intensification:

Maximising the Value of Irrigation: applied science at its sharpest

Irrigation usage remains a hot topic in New Zealand. Since the late 1970s the area of farmland in New Zealand under irrigation has doubled every 12 years.

New irrigation systems introduced over the past two decades have given farmers and growers the ability to adapt to demand and accurately apply water at appropriate intensities to their land.

However, the amount of water required on different soil types and pieces of land varies from place to place. Too little or too much water can easily be applied, leading to yield losses, nutrient leaching and wasted water.

In 2013 the MBIE-funded collaborative programme 'Maximising the Value of Irrigation' (MVI), led by Manaaki Whenua with Plant & Food Research and the Foundation for Arable Research, took on the challenge of creating new irrigation scheduling and management systems at the paddock scale. That programme is now drawing to a close, and the results are showcasing what could be a major change in irrigation management.
One group of MVI researchers used high-resolution sensor mapping and in-field soil and crop-sensor monitoring systems to assist with precision irrigation, leading to a water saving of between 9 and 30% when irrigation was varied according to the different soils at the site.

The sensor mapping system was trialled on six farms, where researchers processed the survey data into management zones to record the main soil differences. The soil variability was then tested through physical soil sampling to measure how much water each soil zone could hold.

> *"Water wastage and nitrate leaching was dramatically reduced, and users saved money."*

The team designed, built and used wireless sensor networks for near real-time monitoring at irrigation sites and sent this information via a smartphone app to the participating farmers to inform them of precise irrigation schedules and to monitor daily crop water usage.

"The new systems work alongside existing irrigation scheduling technology, mapping and monitoring a field at sub-paddock scales at near real-time monitoring by calculating exactly how much water is needed at the right time and place," says Manaaki Whenua's Programme Lead, Carolyn Hedley. "We proved that we could dramatically reduce water wastage, save users money, and almost completely stop irrigation-related nitrogen leaching losses," she adds.

Alongside the soil moisture research, another group of MVI researchers used remote-sensing methods to create a technique for monitoring daily crop water usage to help calculate how much water a crop is using each day at the paddock scale. The researchers found that their method reduced drainage to near zero and concluded that it could substantially reduce the environmental impact of irrigation.

MVI is applied science at its sharpest. The new irrigation scheduling and measurement systems developed as part of the programme will enable New Zealand's farmers to make effective irrigation decisions to improve productivity, reduce costs, and lessen the negative environmental impacts of overwatering.

Bit.ly/max-irrigation

Plant & Food Research scientists Peter Jamieson (Left) and Hamish Brown (Right) testing the new sensor technology at the Lincoln trial site.

Building whakawhanaungatanga in Waikato and the Bay of Plenty

In Aotearoa, Māori have a deep relationship and spiritual connection with the natural world, including ngā koiora katoa – all livings things in it.

For Māori, elements of ecosystems and their links form the basis of whakapapa (ancestry) and kaitiakitanga (guardianship/management), and are crucial in upholding their taonga, traditions, health and well-being. Over time, the development and intensification of land has resulted in degraded ecosystem services and loss of biodiversity for tangata whenua and iwi.

A six-year collaborative research programme, 'Biodiversity and Ecosystem Services for Management' (BEST), led by Manaaki Whenua, set out to avoid further degradation of New Zealand's ecosystem services. Their aim was to help land managers make better-informed, smarter natural resource management decisions that preserve options for future resource use and enhance the value derived from New Zealand's landscapes.

As a part of the BEST programme, researchers undertook two flagship initiatives that used participatory community processes and the concept of ecosystem services to underpin decisions at a catchment/local level. The first, in the Rangitaiki catchment in the Bay of Plenty, looked at the potential impact of land-use intensification on the catchment. The second, in the Mangapiko catchment in the Waikato, used the same conceptual framing to develop an ecological restoration plan for the catchment that considered the various uses, needs and aspirations of the whole community.

During the programme, researchers gathered information from a variety of people connected to or using the land and waterways in the two catchments. They also used existing studies to identify relationships between land cover and ecosystem services, alongside socio-economic modelling, to understand the impacts of different decisions or options. Local iwi are an integral part of these catchments.

As part of these flagship initiatives researchers worked with tangata whenua to hear about their whakapapa, history and relationship with their catchment, along with aspirations for their awa, repo and whenua. Iwi involvement in the processes and their knowledge was invaluable to the researchers, but also to the community participants during discussions about land-use intensification in the Rangitaiki catchment and the restoration options for the Mangapiko catchment.

"The discussions with tangata whenua were crucial for building whakawhanaungatanga (relationships), exploring issues, and discussing potential scenarios for alternative land uses or for options to restore the landscape," says Programme Leader Suzie Greenhalgh.

They brought that unique perspective on rongoā (medicines), healing springs/waters, and mahinga kai (food gathering) that others did not have, and their oral history of the catchment gave a greater depth of understanding and appreciation for the surrounding landscape and the interconnections between the land, water, and people of the catchment," she explains.

"In the Mangapiko catchment, as iwi, hapū and most importantly kaitiaki of their place, they were able articulate what had changed for them and helped identify how restoration efforts could be used to enhance the spiritual and physical health of the catchment," she adds.

Within the Mangapiko catchment, restoration efforts led by local farmers and the Waikato Regional Council have started that rehabilitation journey. Alternative methods have been tested for willow removal and native planting developed to meet community needs. Wetlands have been protected and reconnected to native remnants, and sediment traps are being used to reduce sediment loss into the stream – all underpinned by the participatory, collaborative strengths of the BEST programme.

A special mātauranga Māori issue of the *NZ Journal of Ecology*

Manaaki Whenua has contributed to the first special issue of the NZ Journal of Ecology that focuses on mātauranga Māori. The issue, 'Mātauranga Māori and shaping ecological futures', was launched at Lincoln University in December.

"There is increasing recognition that mātauranga Māori and working with Māori communities enhance our understanding of ecology and provide valuable perspectives and frameworks to guide research, management and policy development," says Manaaki Whenua researcher and guest editor of the journal Priscilla Wehi. "The journal aims to combine and showcase the value of this knowledge."

The journal includes an editorial and 13 papers from across New Zealand, with a focus on mātauranga Māori and how it is informing current and future research and decision-making in ecology.

It builds on the virtual issue 'Ka mua, ka muri: the inclusion of mātauranga Māori in New Zealand ecology' published earlier this year. A key theme is discussion on what constitutes a good partnership, which is an important shift from past discussions that have focused on the requirement to partner with Māori communities.

Manaaki Whenua researchers contributed at least three papers as first authors to the journal. These were in the areas of hangarau pūtaiao (technological science) and the development of a mātauranga pūtaiao mobile application; use of te reo and mātauranga Māori in taxonomy; and the use of Māori species names in science communication and reporting.

NZ Journal of Ecology special issue cover, 'Mātauranga Māori and shaping ecological futures.

"Kā kai i taona ai e Rehua."

Embedding indigenous principles in genomic research of culturally significant species: a conservation genomics case study
Authors: Levi Collier-Robinson, Aisling Rayne, Makaimi Rupene, Channell Thoms and Tammy Steeves

With regular connection in the taiao (environment), we will begin to rebuild an intimate relationship with it, and learn to live more sustainably, aligning with tikanga Māori (Māori customs). (Taranaki Whānui iwi member).

The reconnection between mana whenua and urban freshwaters to restore the mauri/life force of the Kaiwharawhara
Authors: Pascale Michel, Awia Dobson-Waitere, Holden Hohaia, Amber McEwan, Danielle F Shanahan

https://newzealandecology.org/nzje/j43_3

Sharing our knowledge abroad

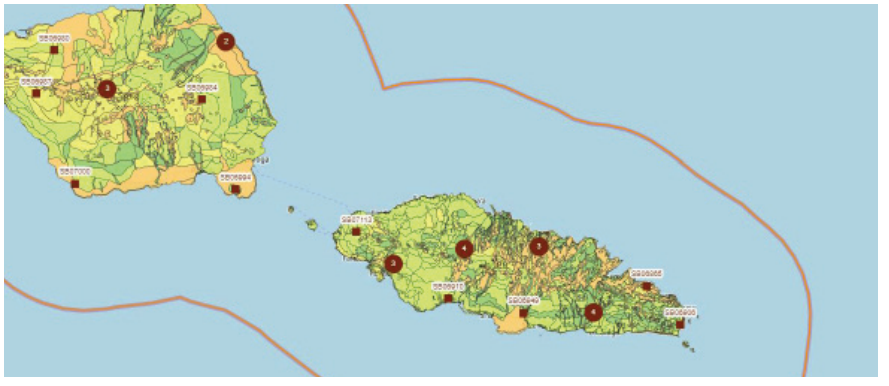
Now online – the first Pacific Soils Portal

For decades, soil scientists from Manaaki Whenua have been visiting Pacific Island countries and territories (PICTs) to collect soil samples and map soil patterns. This work is vital to help decision-makers improve their soils knowledge and land-management practices.

As new online tools have been developed, such as S-map Online (an interactive tool for understanding soils and how they vary across the New Zealand landscape), researchers have also been championing the concept of an online Pacific soils tool.

Now that vision is quickly becoming a reality. The Pacific Soils Portal (PSP) has been developed by Manaaki Whenua in collaboration with CSIRO Agriculture and Food, the Secretariat of the Pacific Communities Land Resources Division, and PICT agriculture departments. It will be ready to launch early in 2020.

Manaaki Whenua's James Barringer showcasing the Pacific Soils Portal to representatives and decision makers from PICTs.



Soil mapping of Samoa as shown on the Pacific Soils Portal.

"The Pacific Soils Portal brings together soil data, dating back to the 1960s, for five Pacific countries," says Manaaki Whenua Project Lead James Barringer.

"The development is a major milestone for agricultural extension officers, land users, and decision-makers, because it means individual users can access location-specific interpretive knowledge of soil properties, and find out whether a soil is suitable for a proposed agricultural use, all at the click of a button," adds Barringer.

The PSP currently covers Fiji, Samoa, Tonga, Kiribati and Tuvalu, and will also link to the New Zealand and Australia portals to showcase and compare soils across the entire South Pacific. It will align with activities under the FAO (Food and Agriculture Organisation of the United Nations) Global Soil Partnership.

The PSP is funded by the Australian Centre for International Agricultural Research (ACIAR), and can be viewed on computers, tablets and smartphones.

https://psp.landcareresearch.co.nz

Predator Free 2050

Science to lure the last survivors

A new research programme has recently got underway aimed at eliminating the last predator survivors in New Zealand to help achieve the goal of Predator Free 2050.

Pest control targeting possums, rats and stoats with traps and poison can remove the vast majority of target animals, but a small proportion survive.

Manaaki Whenua's Grant Morriss with a radio transmitter.

Max Harvey

A radio transmitter attached to a wild ship rat.

Eradicating these last survivors is crucial to achieving predator freedom. However, complete eradication is expensive and almost impossible to achieve on the mainland using current methods, because surviving animals are sparsely distributed and often wary of traps or poison baits, prompting the need for new methods and approaches.

The newly funded five-year MBIE programme 'Eradication Science: Eliminating the Last Survivors to Achieve Predator Freedom', led by Manaaki Whenua, will focus on achieving just that. The team will use recent advances in characterising 'animal personality' to develop a new understanding of individual animal behaviours that make surviving pest animals resistant to current control methods. This knowledge will help develop new lures specifically to manipulate survivor behaviours and to increase their interactions with control devices such as traps or bait stations.

"We know survivors have some distinctive behaviours, such as bait shyness. Understanding these behaviours enables us to identify new lures and ways to attract these animals, such as using recorded animal calls, animal scents, or visual lures like artificial bird nests or LED lights," says Programme Leader Chris Jones. "For these to be successful in the wild, we will explore the use of novel devices that use image recognition and artificial intelligence to recognise the approaching animal, to automatically present the appropriate lure for that species and behaviour type, and then deliver the appropriate kill mechanism," he adds.

The programme will work with iwi and hapū to co-develop methods that are culturally acceptable to tangata whenua and draw on traditional and current knowledge about luring animals.

Celebrating our achievements

Senior Kairangahau Māori **Shaun Awatere** has been appointed as a Kāhui Māori member of the Deep South National Science Challenge. The Kāhui Māori members provide the Deep South Governance Board and Science Leadership Team with strategic advice and input into their science strategy and priorities. They also help with the assessment of science quality, performance and responsiveness to iwi, hapū, whānau and Māori business goals. Shaun Awatere took over from Garth Harmsworth.

Shaun Awatere

Senior scientist **Andrew Fenemor**, has been appointed as one of five members of the Government's Freshwater Independent Advisory Panel. The panel, chaired by retired Environment Court judge David Sheppard, is tasked with considering submissions on the *2019 Essential Freshwater* proposals and making recommendations to the Government on the form and content of the proposed new *National Policy Statement on Freshwater Management, the new National Environmental Standards for Freshwater*, and supporting regulations under s360 of the RMA. Andrew is carrying out this role independently of Manaaki Whenua.

Andrew Fenemor

Andrew has over 35 years' experience in hydrological research and water management. He was appointed a member by the Minister for the Environment, Hon. David Parker. The appointment is in place until 30 June 2020.

Peter Buchanan has received an award from the Governor General for his support of student science communication. The Paul Harris Fellow Award was presented at the annual Eureka Forum at Government House in Wellington in September 2019. The award is named after the founder of Rotary, and honours people who demonstrate an outstanding contribution to the community.

Peter Buchanan

Role playing:

Could this be the next way of thinking?

Manaaki Whenua's Peter Edwards.

Recently I led the development of a serious role-playing game called Catchment 2030, inspired by the complex erosion problems in the Waiapu catchment. The game was designed by a multi-disciplinary team, who brought a wide variety of knowledge, to help local and central government, iwi and community members explore new ways of thinking and solving these problems.

It was one of the first serious role-playing games we had developed to think about complex problems in New Zealand. But what are serious games? And how can they be a tool to help us think about environmental problems? Serious games aim to educate and engage users, and allow them to test out solutions to 'wicked' problems without real-world consequences. They can be a computer, board, card or role-playing game.

When I was introduced to the concept of serious games as a tool, at first I was sceptical, but after exploring serious games more thoroughly I was converted to their power.

For catchment-related issues, games may sound like a panacea for the likes of catchment managers, for example, but they do have drawbacks. These can include 'play' not being taken seriously by professionals, not providing an immediate solution, and the large amount of resources needed to design and develop games. However once created, they can be adapted to different contexts.

I found that the tricky part of the Catchment 2030 game is to embed the complexity of the problems while also helping players to understand the game's context, their role, potential solutions, and the rules.

But taking the time to do this pays dividends, as shown by some of the feedback we received: "The meaning of this was that we actually do need to spend more time on the big thing, the picture, if we can, the big picture ..."

After extensive testing and refining we have played Catchment 2030 with over 200 people and found that serious games can provide a safe environment to try new approaches, empower community members, engender empathy, and create a new and better understanding of complex problems.

Peter Edwards

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If you wish to be included on the mailing list for Pūtaiao, or to find out more about any of the stories, contact Dan Park: parkdj@landcareresearch.co.nz

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