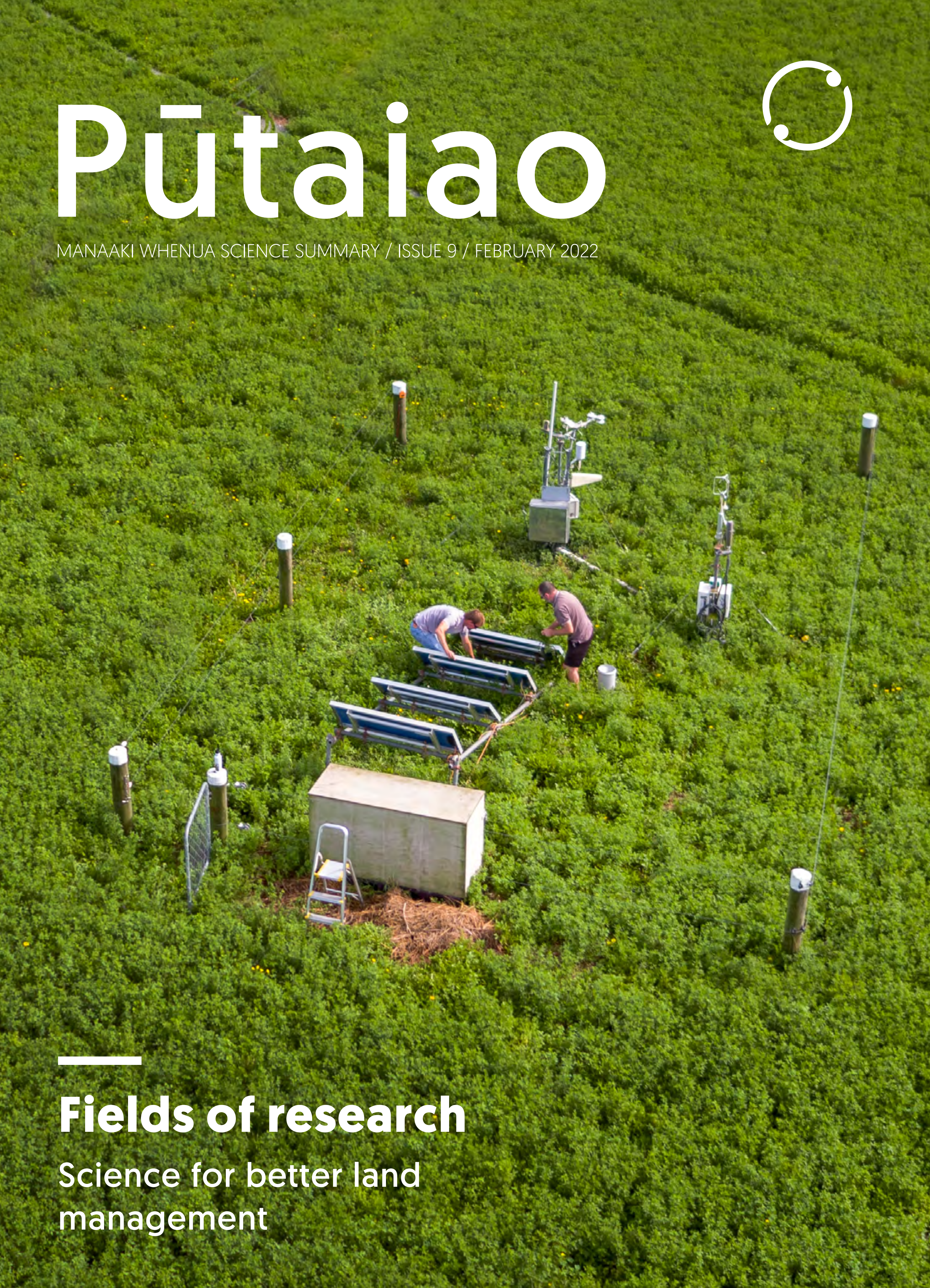


Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 9 / FEBRUARY 2022

Fields of research

Science for better land management

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to Issue 9 of *Pūtaiao* ('science' in te reo Māori), our quarterly publication showcasing the work of our scientists at Manaaki Whenua.

Each issue of *Pūtaiao* shares the benefits and outcomes of our science in helping to ensure a sustainable, productive future for New Zealand. In this issue many of the stories focus on science to enhance our soils, water and land – one of our four areas of research impact at Manaaki Whenua. One of the greatest challenges facing regional and national agencies, and the food and fibre sector, is the integrated management of land and water to provide sustainable production, while simultaneously protecting downstream ecosystems and supporting diverse community and iwi aspirations. Several of the stories in this issue highlight our soil science, including important applied research to improve land management on-farm from our major Endeavour-funded research programme, *Reducing nitrogen losses from farms.*

We also showcase some of our latest research on climate change, and about the relationships between Te Ao Māori (the Māori worldview) and "western" science knowledge systems.

Editor's note: Our latest publication, *Te Āpōpōtanga*, describes our approach to creating value for Aotearoa New Zealand through our research, people and partnerships. https://www.landcareresearch.co.nz/publications/te-apopotanga/

Cover image: At the Ashley Dene Research & Development Station, Lincoln. Photo by Bradley White.

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

Reducing nitrogen losses from dairy farms on stony soils

In the past two decades, much dryland farming has been converted to irrigated dairy farming in Aotearoa New Zealand, notably in eastern areas of Te Wai Pounamu (the South Island). Here, soils are largely shallow, free-draining, and stony, and dairy conversions have contributed to concerns about increased nitrate leaching as well as adding to national greenhouse gas emissions.

A 5-year MBIE-funded collaborative research programme *Reducing nitrogen losses from farms* led by Manaaki Whenua's Dr David Whitehead, set out to investigate what changes could be made to farm management strategies for farmers and rural decision-makers to better understand how to increase soil carbon and reduce nitrogen losses from dairy farms on stony soils. The research was done on-farm at Lincoln University's Ashley Dene Research & Development Station in Canterbury.

"We aimed to provide management options to manipulate carbon inputs using different grassland and fodder species and irrigation to reduce carbon and nitrogen losses," says Dr Whitehead.

"To understand the carbon inputs to reducing nitrogen losses, we tested whether carbon inputs to two crops could reduce the rate of nitrogen losses. Then, for measuring and modelling paddock water, carbon and nitrogen inputs and losses on stony soils, we used predictive models for irrigated and non-irrigated lucerne and tested the findings against field measurements," explains Dr Whitehead.

Overall, researchers found the concept central to farm management practices is that increasing carbon input to the soil leads to retention of both carbon and nitrogen as soil organic matter.

HTTPS *www.landcareresearch.co.nz/reducing-N-losses-from-farms/*

Research technician Graeme Rogers working in the lysimeters at Ashley Dene.

"The research findings have shown that inputting of carbon to the soil is crucial to retaining nitrogen and carbon in the soil. We found soil carbon has been decreasing, and this depends on the grazing and the irrigation regime. But if we want long-term sustainability in our agricultural systems, it's critical that we maintain increases in our soil carbon. We are also helping to mitigate climate change by removing that carbon from the atmosphere and storing it in the soil," says Dr Whitehead.

Reducing nitrogen losses from farms was a collaboration between Manaaki Whenua, Lincoln University, Plant & Food Research, Scion, University of Canterbury and the New Zealand Agricultural Greenhouse Gas Research Centre. The programme involved 31 research contributors, resulted in 16 scientific publications, saw 3 PhDs awarded and valuable engagement with Environment Canterbury, MPI, Overseer and Taumutu Iwi.

Contact: Dr David Whitehead
whiteheadd@landcareresearch.co.nz

Key management recommendations to reduce C and N losses on-farm:

There is a strong seasonal component to these recommendations. Cooler temperatures and wet conditions in winter lead to low rates of plant growth and increased susceptibility to leaching. Warm and dry conditions in summer lead to increased respiration losses and limitations to plant growth.

Winter

Minimise winter N leaching losses by maintaining winter active growth and N uptake by plants. This can be achieved by planting winter-active Italian ryegrass or oats as soon as forage crops such as kale or fodder beet are grazed or harvested. Winter-active plants also continue C inputs to soil, leading to reductions in annual soil C losses.

Avoid or minimise fallow periods when there are no C inputs to soil, leading to net soil C losses, and no uptake of N by plants, leading to increased leaching.

Spring/Summer/Autumn

Irrigation recommendations:

For stony soils, avoid irrigation in excess of crop water requirements to minimise C and N losses, particularly in late summer and early autumn when temperatures and respiration losses are still high.

Avoid irrigating N-fixing plants such as lucerne with effluent because the plants cannot use the additional N and it will likely increase leaching losses.

For non-irrigated lucerne, consider grazing rather than cut and carry to retain more soil C from dung.

Managing lucerne to fix soil N

Dr Scott Graham in a lucerne crop at Ashley Dene.

Lucerne is a widely used grazing fodder crop, and like other legumes, is able to fix nitrogen (N) in the soil. Well-managed lucerne is highly productive and the plant also has deep roots, which allow water extraction from well below 2 m depth and extract N from the soil.

Lucerne has been used extensively as forage for dryland sheep and beef farms in New Zealand, but few measurements of leaching losses from lucerne have been made, leaving a knowledge gap about whether its use in intensive, irrigated systems could reduce N leaching via extraction of water and nutrients at depth.

This knowledge is important because the irrigated land area of New Zealand has increased by more than 90% over the past 15 years, to nearly 800,000 hectares, primarily to support dairy farming expansion. The intensification of land use associated with irrigation has been most pronounced in the Canterbury region, where shallow, stony soils are prone to nitrate leaching losses. Nitrate leaching for the region is estimated to have doubled between 1990 and 2011.

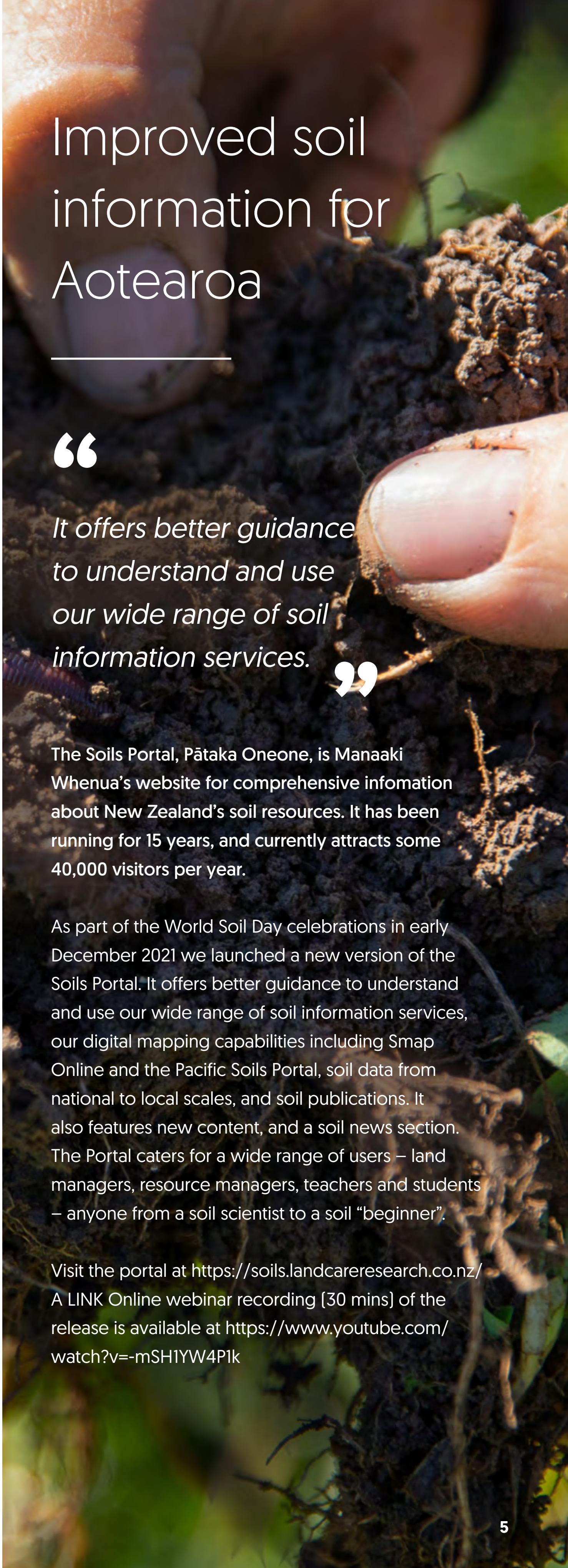
As part of the MBIE Endeavour programme *Reducing nitrogen losses from farms*, Manaaki Whenua's Dr Scott Graham and colleagues aimed to quantify losses of N through leaching and crop harvest for lucerne on stony alluvial soils in two paddocks under different irrigation, effluent, and grazing management: one non-irrigated and one irrigated with water and effluent.

The study ran for three full growing seasons. It used six large lysimeters at the Ashley Dene Research Station, Lincoln University, for the soil drainage and leaching aspects of the study, and effluent and water inputs from the pivot irrigator were carefully monitored. The fields were initially mechanically harvested for cut-and-carry feed but grazing with animals was slowly integrated into paddock management over the study period. Lucerne within the fenced-off lysimeters was managed to match grazing impacts in the surrounding paddocks.

Using stable isotopic analysis of the N in lucerne biomass, the researchers were able to differentiate between N fixed by the lucerne from soil N, effluent or animal dung and urine sources. This information, along with chemical analysis of the lysimeter leachate, allowed for quantification of the fate of each type of N – whether it was leached out or retained in the soil or the crop.

The study showed that the amount of N leached from irrigated and effluent-treated lucerne each year was from 1.5 to nearly 15 times greater than that from non-irrigated lucerne. N fixed by the lucerne was much less prone to leaching than N from the grazing animals and from the effluent. The progressive change from cut-and-carry to grazing of lucerne also resulted in 3 times more N leached. Surprisingly, a summer rain event that led to soil drainage outside the normal winter leaching season at the irrigated site contributed more to N leaching than the typical winter leaching losses.
This work has important implications for farm management. First, planting lucerne is not an effective strategy for mitigating N leaching losses. The researchers also recommend irrigation practices that maintain a soil water deficit would limit additional soil drainage and leaching as a result of irrigation, particularly for summer rainfall events that contribute to high leaching losses.

Contact: : Scott Graham
grahams@landcareresearch.co.nz
HTTP *doi: 10.1016/j.agwat.2021.107233*



Improved soil information for Aotearoa

> *It offers better guidance to understand and use our wide range of soil information services.*

The Soils Portal, Pātaka Oneone, is Manaaki Whenua's website for comprehensive infomation about New Zealand's soil resources. It has been running for 15 years, and currently attracts some 40,000 visitors per year.

As part of the World Soil Day celebrations in early December 2021 we launched a new version of the Soils Portal. It offers better guidance to understand and use our wide range of soil information services, our digital mapping capabilities including Smap Online and the Pacific Soils Portal, soil data from national to local scales, and soil publications. It also features new content, and a soil news section. The Portal caters for a wide range of users – land managers, resource managers, teachers and students – anyone from a soil scientist to a soil "beginner".

Visit the portal at https://soils.landcareresearch.co.nz/
A LINK Online webinar recording (30 mins) of the release is available at https://www.youtube.com/watch?v=-mSH1YW4P1k

How intensified irrigation affects soil physical properties – a pilot study

New Zealand agriculture has seen rapid land-use change in recent decades, with a decrease in sheep numbers and corresponding rise in dairy cow numbers. This has been matched in the Canterbury region by an expansion in irrigated areas.

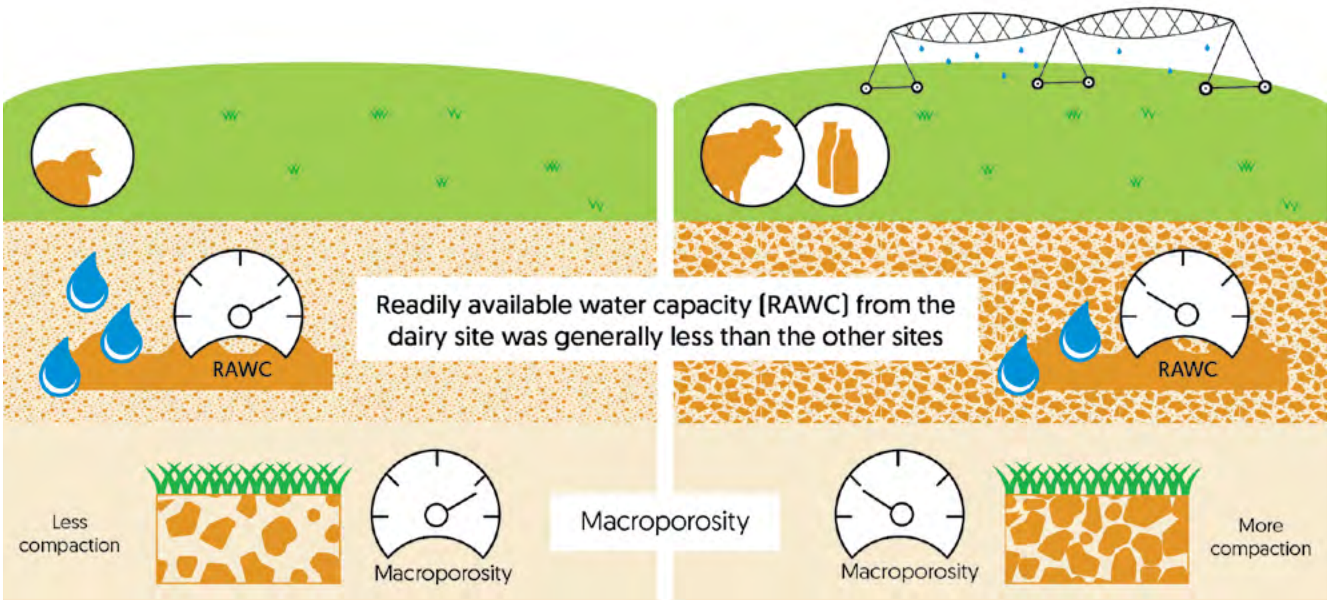
With more intensive land-use practices come increases in farm nutrient inputs and supplements, stocking rates, and conversion of dryland to irrigation. However, there has been limited research, especially in New Zealand, on the effect of irrigation on soil physical properties under modern spray irrigation and intensive pastoral farming.

Manaaki Whenua researchers John Drewry and Sam Carrick have led several studies to determine the effect of land-use intensification on soil properties such as compaction and water-holding characteristics. The findings from the first of these studies have now been published in the *New Zealand Journal of Agricultural Research*.

An initial pilot study was conducted at three sites with decreasing land-use intensity on Lincoln University farmland, Canterbury: a seasonally irrigated paddock on the Lincoln University Dairy Farm; a dryland, sheep-grazed farm; and a non-grazed, mown control site. The studies at these adjacent sites were of same type of topsoil, but each site had a different land-use intensity. The Lincoln University Dairy Farm had a centre-pivot sprinkler irrigator.

All sites were located on a Templeton silt loam classed as a Typic Immature Pallic Soil. This soil is characterised as well drained, deep, and stone-free.

For each of the dairy, sheep, and control sites, only one paddock was



The diagram shows readily available water capacity, important in irrigation scheduling, was generally lower in the irrigated dairy site. Macroporosity was generally lower at the irrigated dairy site, showing the soil was more compact than the other sites.

studied, but with 15 sampling pits within each paddock. A range of soil physical indicators were measured, including soil density, water storage, and soil water movement.

The research indicated the irrigated dairy site typically had lower total porosity and macroporosity, and greater bulk density than the control and sheep farm sites. "Our study showed the top 300 mm of soil is vulnerable to compaction under irrigated dairying, and compaction was at greater depth than often assumed to occur or is commonly measured by soil quality monitoring and national environmental reporting," says John.

Readily available water capacity (RAWC), and available water capacity (AWC) are important in irrigation scheduling and production because they indicate the availability of water for plants. RAWC and AWC varied between the sites and depths, with RAWC generally lower in the dairy site, although it was difficult to draw strong conclusions for these two measurements.

"This study strengthens the arguments for irrigators to adopt deficit irrigation practice, where irrigation is applied to not refill the soil back up to field capacity, but to leave a storage 'buffer'," says John.

This research is consistent with earlier studies on compaction from grazing on Pallic Soils. While previous research has focused on Pallic Soils with subsoil fragipans, subsurface layers in the soil that impede soil drainage, and therefore increase the risk of treading-induced compaction damage, the Pallic Soil sites in this study were well-drained with no impeding subsoil fragipan layer, yet they still showed soil compaction occurred on the irrigated dairy farm site. The findings show these soils still need good management, as soil compaction adversely affects pasture production.

"However, the results should be interpreted with some caution, as indicative only. Further research is required across a larger number of paddocks, farms, and soil types, to confirm these results and provide evidence across a range of management practices and climates," says John.

Follow-up work with Plant & Food Research, which focused on regional studies in both Canterbury and the Waikato, is in the process of being published.

Contact: John Drewry
drewryj@landcareresearch.co.nz

HTTPS *doi.org/10.33584/rps.17.2021.3484*
doi.org/10.1080/00288233.2021.1981953

Crowding out: why climate change action depends on more than just doing your bit

Social science research shows that when people decide to "do their bit" for climate change (driving electric cars, recycling, installing solar panels), they may become less inclined to support government policy to combat climate change. This phenomenon, known as 'crowding out', can occur because an initial action by an individual reduces their worry about climate change and so they feel less need for climate change policy. The trouble comes because national climate change policies (such as carbon taxes) are more likely to bring about meaningful mitigation of climate change effects than individual, largely voluntary actions (such as recycling).

However, crowding-out in the agricultural sector is less well understood. Because the agricultural sector produces around 48% of national greenhouse gas emissions, this is an important knowledge gap in New Zealand. Manaaki Whenua's Dr Pike Stahlmann-Brown and colleagues from Lincoln University and the University of Waikato used data from the biennial Survey of Rural Decision Makers to identify the causes of crowding out effects in the agricultural sector, specifically among lifestyle block owners rather than commercial operators. Lifestyle block owners are the single largest rural sector in the country by population and, lacking any industry body, lifestyle block owners are underrepresented in research and their motivations not well understood. The 1,846 survey respondents who self-identified as lifestyle block owners either received a 'prime' with information about the importance of individual action to save energy and reduce waste for climate change, or no priming information. They were then asked to express their support for potential national environmental actions (raising prices of petrol/diesel, pest control operations to improve biodiversity) to identify whether they perceived these actions as burdensome or not. The questionnaire also assessed respondents' personal degree of worry about climate change.

The results were striking: receipt of the prime did crowd out support for climate policy in the agricultural sector, consistent with other studies. Moreover, the prime was more likely to crowd out support for climate policy than biodiversity policy. In addition, people with a higher level of climate worry were more likely to have their policy support crowded out by the prime. According to Pike, "These results can help policy makers target messaging around the uptake of climate change mitigation measures."

However, the researchers caution that more analysis is needed, particularly into whether past support for climate mitigation encourages people to withdraw support in the future (a 'moral credits' model) or to become complacent or less concerned about climate mitigation (a 'moral credentials' model). Pike would also like to see further work extended to New Zealand's entire rural sector.

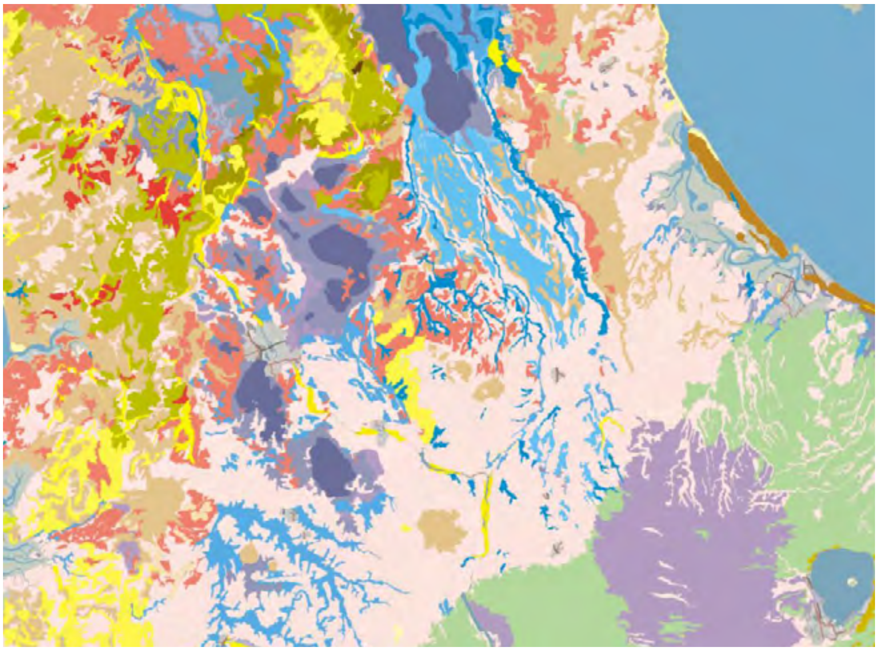
Contact: Pike Stahlmann-Brown
brownp@landcareresearch.co.nz

HTTPS *doi.org/10.1016/j.ecolecon.2021.107239*

Software helps facilitate digital soil mapping

Manaaki Whenua researcher Pierre Roudier is enjoying being both author and contributor on two different software packages in his work on digital soil mapping.

Both packages were developed as extensions to R – one of the leading languages for statistical analysis and graphics. Pierre says one package, clhs (Conditioned Latin Hypercube Sampling), was born from a "selfish need to find an easier way to identify soil sampling points," while the other, aqp (Algorithm for Quantitative Pedology), he discovered while looking for an easier way to handle soil data.



Example of a digital soil map from Manaaki Whenua's Soils Portal.

Pierre says that, as open-source software, R enables people to collaborate and contribute ideas. "You never start from scratch, but a bit like Lego, you build on work other people are doing."

Pierre started working on implementing the cLHS (Conditioned Latin Hypercube Sampling, or "a barbaric acronym" package as he described it) back in 2012.

The challenge he was finding in the context of soil mapping, was that it was hard to identify where to collect samples in the first place. "Because you can't sample widely, you have to be smart about where you sample."

That's where the CLHS algorithm comes in. "It's trying to find the locations that best represent the environmental variations."

To date, the package has been downloaded 700,000 times. And other scientists have also been contributing to enhancing CLHS. "Most recently a student in Canada approached me with an idea to increase the speed of the program," says Pierre.

Pierre found the aqp (Algorithm for Quantitative Pedology) package while searching for a better way to analyse soil data. The package was developed by US-based researcher Dylan Beaudette as part of his PhD project. The researchers met online nearly 11 years ago, and still collaborate today.

It's this collaborative ethos Pierre enjoys most about working on R packages. "I have had a lot of feedback from people at conferences, and CLHS has often been cited in other scientists' research papers. The AQP development team, which has grown from initially just Dylan and I, has also been invited to contribute a book chapter on the software.

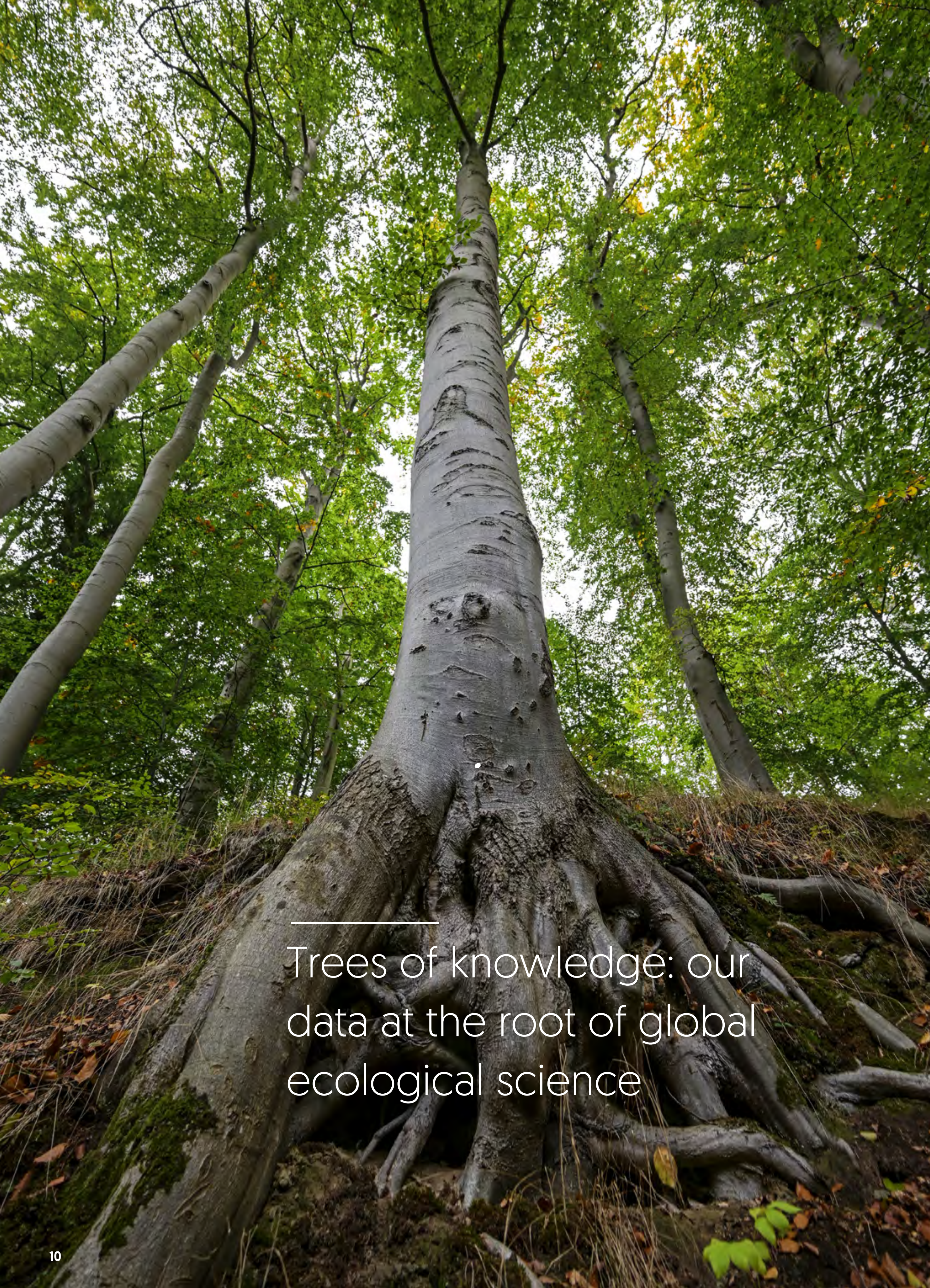
The software is used by the US Department of Agriculture's Natural Resources Conservation Service for its soil surveys, and Pierre is eager to connect this massive database to New Zealand's National Soil Data Repository.

"I'm interested to see how we can keep connected to the emerging ways we have to store and broadcast soil data," he says.

Contact: Pierre Roudier
roudierp@landcareresearch.co.nz

HTTPS *cran.r-project.org/web/packages/clhs/index.html*

ncss-tech.github.io/AQP/



Trees of knowledge: our data at the root of global ecological science

Researchers at Manaaki Whenua are currently participating in large collaborative research projects starting to answer really big, global-scale questions that tap into data from New Zealand's Nationally Significant Databases and Collections – the biological and geological memory banks of the country, many of which are held and curated by Manaaki Whenua.

As an example, Manaaki Whenua's Dr Susan Wiser is a contributing author to a paper published this month in *PNAS, Proceedings of the National Academy of Sciences* titled *The number of tree species on Earth*. Manaaki Whenua's National Vegetation Survey (NVS) Databank in particular has underpinned New Zealand's contribution to this and several other initiatives (see box).

In the Uppsala University research on palm abundance, our scientists contributed data on Jamaica from Peter Bellingham, and on vegetation plots in the Tongatapu Group, Kingdom of Tonga, from Susan, both of which are archived in the NVS.

"Before this study, the variation in numbers of palm trees among tropical regions had not been quantified," says Susan. "Oceania is often under-represented in such studies, owing to insufficient data. Australasia and Oceania, the Indo Malay and the Afrotropics, where palms are relatively sparse, helped provide this global context to show how important palms are to forests in the Americas versus other tropical areas, and to highlight implications for differential responses to climate change."

Recent international collaborations using NVS data have included:

- a global conspectus of alpine plant species richness and functional diversity (with Riccardo Testolin, Sapienza University of Rome),
- a global analysis of palm abundance and importance (with Bob Muscarella, Uppsala University),
- a phylogenetic classification of tropical forests (with Ferry Slik, University of Brunei),
- a global spatial analysis aimed at concurrently maximising improvements for species conservation, carbon retention, and water quality regulation (with Martin Jung, International Institute for Applied Systems Analysis, Austria)
- a global study of islands, which revealed that the North Island's native monocot flora is highly vulnerable to threats related to climate change (with Simon Veron, Paris, France).

HTTPS *www.pnas.org/content/119/6/e2115329119*

Big data are also highlighting potential climate change impacts on alpine plant species around the world. New Zealand's involvement in a recent alpine species collaboration to discover how alpine species are functionally related was through its membership of sPlot – the largest repository for plant community data in the world. NVS has contributed plant composition data from 19,018 plot locations spanning forests, shrublands, and grassland ecosystems.

Susan says the NVS collection makes a substantial contribution to global ecological informatics work. "We also contribute data and science expertise to international data aggregators such as the Global Forest Biodiversity Initiative, the Global Biodiversity Information Facility, Nature Map Earth / the BIEN consortium, the Long-Term Vegetation Sampling Initiative, and to iNaturalist."

Even though participating in global big data efforts wasn't anticipated when these plot data were collected, it shows how critically important primary data collection is, and how it should be supported, and researchers encouraged and incentivised, to deposit raw vegetation plot data into the NVS databank with a view beyond just immediate needs.

"These collaborations continue to grow New Zealand's reputation and influence within global networks, so data sets from our remote corner of the world have a big impact," says Susan.

Contact: Susan Wiser
wisers@landcareresearch.co.nz

Building Te Ao Māori thinking into science knowledge systems

Indigenous knowledge systems and approaches hold a significant share in the well-being of the planet. Researchers say if we are to achieve our vision for Aotearoa New Zealand to improve the health of te taiao (the environment) and our people, we need to change the way people interact with the environment from a position of extractive resource use to one of reciprocal exchange.

New research from Manaaki Whenua has explored how better incorporating a Te Ao Māori (Māori world view) thinking offers a pathway forward to achieving sustainable livelihoods that enable both the natural world and humans to prosper.

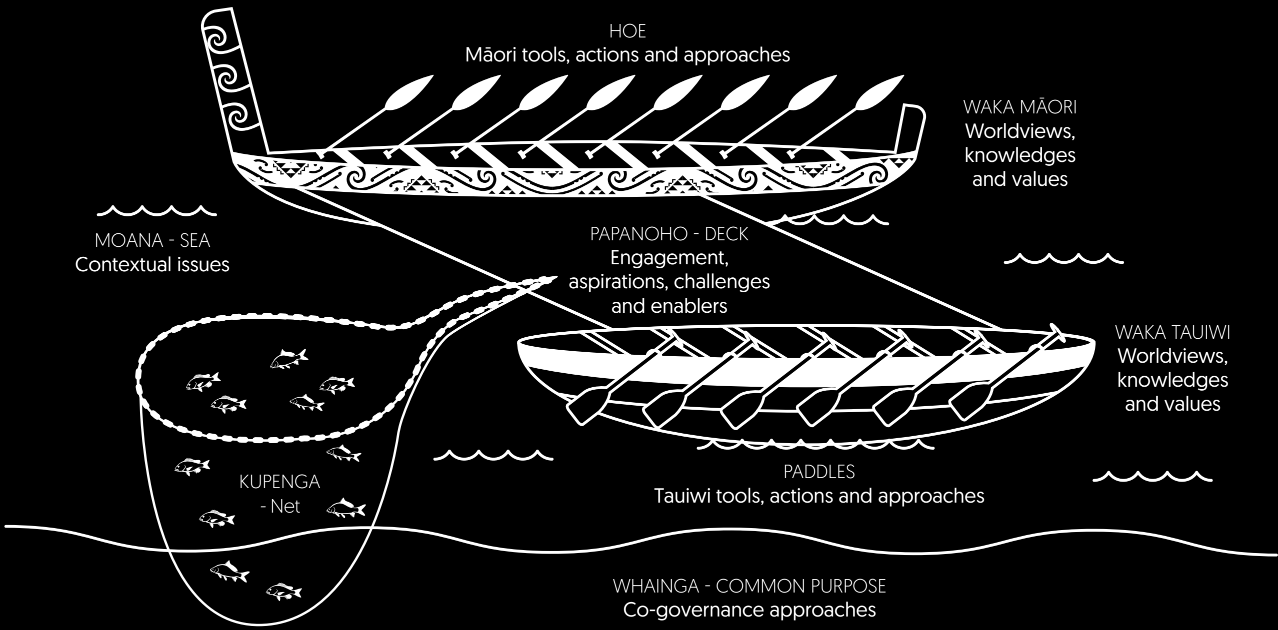
Led by Kaihautū Whenua, Dr Nikki Harcourt, kairangahau (researchers) from the MWLR Manaaki Taiao rōpū (team) have explored how adapting the framework 'He Waka Taurua – the double-hulled canoe' for collaborative partnership can co-produce outcomes based on science and Indigenous knowledge.

"He Waka Taurua is a metaphorical framework that elevates Indigenous worldviews, values, and practices, alongside western science, and knowledge," explains Dr Harcourt. "It explicitly identifies a Te Ao Māori worldview and associated values as a distinct and complete knowledge system, separate from a western science worldview. This is represented by the two hulls, Waka Māori and Waka Tauiwi, and the hoe (paddles), which represent the tools, actions, and approaches relevant to each worldview. These worldviews are kept separate from each other, whilst the papanoho (deck) between the canoes represents a shared or 'negotiated space', where engagement and innovation can occur," she adds.

Researchers drew on a case study on Whakatāwai Station in Waiapu Valley on the East Coast to demonstrate how the He Waka Taurua framework can be operationalised for the co-development of knowledge between a Māori agribusiness and Māori researchers.

"Whakatāwai Station, before European colonisation, was an area of land thriving under a Te Ao Māori knowledge system and framework. It had many different crops under cultivation and was a thriving catchment with high biodiversity of plant and animal species and an intimate connection of people to their land and the natural world," explains Dr Harcourt. But by the late 1970s large areas of land had been cleared for pastoral farming and Te Ao Māori thinking had been marginalised in favour of Te Ao Pākehā (the Eurocentric worldview). Land clearance led to the destabilisation of soils through deforestation, and an increase in erosion and sedimentation of the waterways, loss of biodiversity of plant and animal species, and creation of an exotic grassland.

These changes had a profound impact on the Māori communities' cultural values and their enactment. At the station, blanket grazing is now a land-use deemed unsustainable due to it being at further risk of erosion from climate change.



"Whakatāwai Station's journey and current predicament are testament to the negative consequences that arise from marginalising Māori perspectives and management approaches in ecosystem management in favour of Eurocentric ones. However, using the He Waka Taurua framework to guide the partnership approach between kairangahau and Whakatāwai Station shareholders we were able to co-produce decision-making outcomes, based on both science and indigenous knowledge," says Dr Harcourt.

"This was done by taking a true co-development approach and operating at the research interface where indigenous and non-indigenous knowledge systems share knowledge and perspectives. From this we used a Kaupapa Māori approach to draw on relevant and meaningful knowledge, grounded in local experiences, and in parallel with quantitative data gathering to transform this pastoral grazing unit into a system that better aligned with Māori values and aspirations," she adds.

Contact: Nikki Harcourt
harcourtn@landcareresearch.co.nz

Elements of this diagram are based on: Maxwell KH, Ratana K, Davies KK, Taiapa C, Awatere S, 2020. Navigating towards marine co-management with Indigenous communities on-board the Waka-Taurua. Marine Policy 111, *103722.*

Swapping time for space to track the impact of climate change on soil microbes

The study site: the Wairakei-Tauhara geothermal field near Taupō. Photo: John Hunt

To test the effects of climate change on species at any scale is difficult. Scientists can't manufacture realistic global warming in a test tube or in a lab over a few hours, or a few days. As a result, a big challenge for climate change researchers has always been how to best record potential shifts in species response over timeframes that are truly representative of gradually warming temperatures.

Working with soil microbes, Manaaki Whenua researchers Manpreet Dhami, Gabriel Moinet, and John Hunt wondered what would happen if they turned the problem on its head and swapped geological time for space.

Because microbes are vital to the decomposition of organic material, and the subsequent release of carbon into the atmosphere, the ability to measure the physiological response of microbes to warmer temperatures will help to solve the puzzle of whether soils will lose or gain carbon under warming temperatures.

The researchers decided a 'conceptual trick' was needed. Instead of heading to the lab to try to replicate the effects of climate change on microbes, they looked for a geothermal feature that could represent a continuum of warming temperatures.

A steam-heated depression that enabled sampling along a transect from the hottest areas closest to it all the way to the cool areas further out was identified in a field near Taupō, a volcanic area in New Zealand's North Island.

"The gradient mimics what would happen to the soil in different climate warming scenarios over very long periods of time," says Moinet, now an Assistant Professor based at the University of Wageningen in the Netherlands. "This allowed us to sample the microbes along the transect, to see if, and how, they adapted and measure what, if any, physiological differences there were in response to changing temperatures."

As well as having having access to a unique geothermal environment the researchers built a mobile molecular lab that was towed to Taupō. The field lab was set up complete with pipettes, sterilised bench, and DNA extraction tubes to collect and process samples.

Moinet and Dhami say that these findings bring them a little bit closer to fully understanding the role soil plays in climate change. "We were able to show that while communities of microbes in the soil do adapt in response to temperature, the physiological response to temperature in warm-adapted microbes (thermophiles) and other microbes (mesophiles) was the same. If this is confirmed at other sites and other conditions, then predicting the microbial feedback to climate change can be done from short-term studies after all," says Dhami.

Contact: Manpreet Dhami
dhamim@landcareresearch.co.nz

HTTPS *doi.org/10.1111/gcb.15878*

Celebrating our achievements

The 2021 Science New Zealand Awards ceremony, held online in December, recognised research excellence across the CRIs. **Kenny Bell** won an Early Career Researcher award for his work in climate econometrics – the future economic and social impacts of climate change. **David Whitehead** was awarded a Lifetime Achievement award for his outstanding contributions to plant physiology, ecosystem carbon exchange, and greenhouse gas emissions. Manaaki Whenua's internationally acknowledged **Weed Biocontrol Team won a Team** award for their wide-reaching work over many decades in the development and release of biocontrol agents to control serious intractable weeds across New Zealand and further afield.

Kenny Bell

David Whitehead

Kia Whakanui te Whenua: People, Place, Landscape, a Māori landscape classification framework book with contributed chapters from **Garth Harmsworth**, **Shaun Awatere**, and **Nikki Harcourt**, was the runner-up in the non-fiction category at the 2021 New Zealand Heritage Literary Awards in October 2021. Garth (with Jonathan Procter) wrote *He Tatai Whenua: Towards Developing a Māori Landscape Classification Framework*. Shaun and Nikki wrote a chapter on *Whakarite Whakaaro, Whanake Whenua: Kaupapa Māori Decision-making Frameworks for Alternative Land Use Assessments.* The judges commented: 'This fresh and timely Māori-led collection is bursting with knowledge that focuses on ideas concerning whenua, tinana and wairua to intervene in ways of thinking about people and landscape. The result is a beautifully produced and powerful intervention into current debates concerning the fields of traditional science and western science that extends how heritage itself is defined.'

Garth Harmsworth

Shaun Awatere

Nikki Harcourt

Prepare to arrive as guests: being manuhiri in the production of knowledge

New research led by Manaaki Whenua's Dr Alison Greenaway has focused on how non-indigenous scientists embrace the geographical, cultural, and social places they find themselves as manuhiri (guests).

The researchers discuss the need for non-Indigenous researchers 'to prepare to arrive as guests' in a co-production of knowledge process and to adopt methodological sensitivities for such work.

In this discussion, nine signs emerged to help primarily non-indigenous researchers and practitioners navigate the co-production of knowledge and practices shaping environmental outcomes.

1. Alternative worlds are becoming visible and possible
2. Power asymmetries are being made visible
3. Invitations from Indigenous peoples are accepted, and challenges are being responded to
4. Indigenous ways to represent non-Indigenous people are at the centre
5. Stumbling, failures, and mistakes are acknowledged and redressed
6. Care is taken when moving insights from one context to another
7. Shared leadership is remaking institutional spaces
8. Shared values are explored for points of connection
9. Relationship building is prioritised.

As Dr Greenaway explains, this work supports those in the research system to move towards an unknown and as yet unknowable knowledge destination, solution or outcome. "It may also help groups move beyond the paralysis generated when non-indigenous partners become cognisant of the enormity of devastation their Indigenous partners are working through," she notes.

The research also supports environment and recreation groups who are navigating a shift from linear, siloed environmental management to collective management. "As co-management of (and with) places becomes more typical, community groups such as tramping, pest control, and mountain biking groups find they are changing how they relate with places, tangata whenua, and Crown agencies involved with these places. In some parts of Aotearoa New Zealand this is a journey of learning to be manuhiri," she explains.

Co-management of places is being enabled through Te Tiriti o Waitangi settlements establishing co-governance agreements, the Resource Management Act (1991), related memorandums of understanding, or special legislation supporting collaborative decision making driven by tangata whenua. Behind all these initiatives is an increase in capacity for more relational ways of caring for the environment and generated momentum for co-produced environmental and cultural practices.

"Co-produced knowledge opens alternative worlds and develops new social contracts," Dr Greenaway says, as she and colleagues attempt to work with an ethic of reciprocity. "We respond to invitations from Indigenous scholars, kairangahau Māori colleagues and those intentionally creating spaces in organisations, budgets and funding processes, and review practices, for Indigenous knowledge and practices."

The social knowledge has been crafted into a discussion guide ('Arriving with Care') and related resources (Being Manuhiri) to support environmental researchers and practitioners to arrive with care in the places they are exploring. This work contributes to the conversation in Aotearoa New Zealand about how we can know we are building enduring trustful Tiriti o Waitangi-based partnerships.

Contact: Alison Greenaway
greenawaya@landcareresearch.co.nz

Access the resources: https://www.landcareresearch.co.nz/partner-with-us/iwi-and-maori-partners/being-manuhiri/